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INSTITUTE OF GEOGRAPHY

UNDERSTANDING THE PROBLEMS OF INLAND WATERS: CASE STUDY FOR THE CASPIAN BASIN

12-14 May 2018, Baku, Azerbaijan



UNDERSTANDING THE PROBLEMS OF INLAND WATERS: CASE STUDY FOR THE CASPIAN BASIN (UPCB)

**12-14 May 2018 Baku,
Azerbaijan**

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The Caspian Sea, like the Aral Sea, Black Sea, Lake Urmia, and Lake Van, is a remnant of the ancient Paratethys Sea. It became landlocked about 5.5 million years ago due to tectonic uplift and a fall in sea level. During warm and dry climatic periods, the landlocked sea almost dried up, depositing evaporitic sediments like halite that were covered by wind-blown deposits and were sealed off as an evaporate sink when cool, wet climates refilled the basin. One of the most vulnerable ecosystems to climate change is the enclosed and inland seas.

The climate change trends observed in these waters are generally more complex than that characteristic for the open ocean. The **Caspian Sea** is the largest enclosed inland body of water on earth by area, variously classed as the world's largest lake or a full-fledged sea. It is in an endorheic basin (it has no outflows) and located between Europe and Asia. It is bounded to the northeast by Kazakhstan, to the northwest by Russia, to the west by Azerbaijan, to the south by Iran, and to the southeast by Turkmenistan. It is now -28 m below the normal sea level.

Due to the current inflow of fresh water, the Caspian Sea is a freshwater lake in its northern portions. It is more saline on the Iranian shore, where the catchment basin contributes little flow. Currently, the mean salinity of the Caspian is one third that of the earth's oceans. The Karabogazgöl embayment, which dried up when water flow from the main body of the Caspian was blocked in the 1980s but has since been restored, routinely exceeds oceanic salinity by a factor of 10.

The **Aral Sea** was an endorheic lake lying between Kazakhstan (Aktobe and Kyzylorda provinces) in the north and Uzbekistan (Karakalpakstan autonomous region) in the south. The name roughly translates as "Sea of Islands", referring to over 1,100 islands that once dotted its waters; in Old Turkic *Aral* means "island". The Aral Sea drainage basin encompasses Uzbekistan and parts of Tajikistan, Turkmenistan, Kyrgyzstan and Kazakhstan. The shrinking of the Aral Sea has been called "one of the planet's worst environmental disasters". The region's once-prosperous fishing industry has been essentially destroyed, bringing unemployment and economic hardship. The Aral Sea region is also heavily polluted, with consequential serious public health problems. The departure of the sea has reportedly also caused local climate change, with summers becoming hotter and drier, and winters colder and longer.

In the late 1990s, **Lake Urmia**, in north-western Iran, was twice as large as Luxembourg and the largest salt-water lake in the Middle East. Since then it has shrunk substantially, and was sliced in half in 2008, with consequences uncertain to this day, by a 15-km causeway designed to shorten the travel time between the cities of Urmia and Tabriz. Historically, the lake attracted migratory birds including flamingos, pelicans, ducks and egrets. It's drying up, or desiccation, is undermining the local food web, especially by destroying one of the world's largest natural habitats of the brine shrimp *Artemia*, a hardy species that can tolerate salinity levels of 340

grams per liter, more than eight times saltier than ocean water. Desiccation will increase the frequency of salt storms that sweep across the exposed lakebed, diminishing the productivity of surrounding agricultural lands and encouraging farmers to move away. Poor air, land, and water quality all have serious health effects including respiratory and eye diseases.

As a starting point of the proposed Project by the Riparian Countries of the Caspian Sea on a theme of “Dynamics of the Caspian Sea Water Level Fluctuations During Holocene Until the Present Affected by the Climate Change: Impact on the Ecology and Socio-Economics of the Region”, the aim is to increase the exchange of the international scientific cooperation on Caspian Sea, Aral Sea, and Urmia and Van lakes. This International Conference “***Understanding the Problems of Inland Waters: Case Study for the Caspian Basin***” will take place in Baku during 12-14 May 2018.

SCIENTIFIC THEMES

- (I) The impact of climate change on: sea level, bio-resources, bio-diversity, marine invasive species, ecology and food web: past, present and future.
- (II) Climate and hydro-meteorological features of the basin.
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- (III) International cooperation, socio-economical development, Industry and energy-food, water-ecosystem nexus and the state of fishes and fisheries in the Caspian region.
- (IV) Physical and chemical characteristics of the Caspian Sea.
- (V) Geology, geomorphology and paleogeography.
- (VI) Marine geophysics, seismology, seismic hazard assessment.
- (VII) The application of remote sensing and GIS on investigation of modern climatic trends.
- (VIII) Archeology and paleoarcheology of the Caspian region.
- (IX) Sustainable development, disaster and risks of the Caspian Sea Region.
- (X) Changing ecosystem health of Caspian Sea under multiple stressors.

Abstract Submission

The Scientific Committee of the “International Conference -Understanding the Problems of Inland Waters: Case Study for the Caspian Basin” invites abstract submissions for oral and/or poster presentations. The submission process ends on **15 April, 2018**.

Please download an extended abstract form from here.

<http://www.upcm2018.org/abstract-submission.html>

In order to avoid time loss and getting confirmation of delivery of your extended abstracts in time, we strongly recommend send your extended abstracts to the both of listed mails:

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Terms and conditions, guidance for Poster presentation will be announced at <http://www.upcm2018.org/> very soon.

Authors whose abstract has been received and successfully processed will receive an acknowledgement regarding the receipt and status of their contribution (Oral/Poster presentation).

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**Student Workshop
May 11, 2018
Baku, Azerbaijan**

An International Student Workshop will be held on 11 May 2018 in Baku prior to the International Conference (***Understanding the Problems of Inland Waters: Case Study for the Caspian Basin***) which will be held in Baku, Azerbaijan, from 12 to 14 May 2018). It is a Scientific Meeting organized by INOC and ANAS kindly supported by COMSTECH, ECOSF, BP, IUGG, AZERCOSMOS, The Ministry of Culture and Tourism of Azerbaijan, COSPAR, OFISAIT, AZ-GREEN and others. The contribution of the Student Workshop will mainly be coming from the Economic Cooperation Organization (ECOSF) with our great gratitude.

The goal of the workshop is to gather students from the Caspian Sea region and students who work on Caspian basin in order to meet each other which give them opportunity to share the knowledge and research experience on the earth sciences, natural sciences and marine research.

There are a lot of different topics on Caspian Sea of professional significance. The workshop will address the problems of the Caspian Sea and Region research that students and young scientists may observe7expeirence. Students can share their thoughts on how to solve these problems. As the students follow the scientific presentations/lectures and other peoples' ideas, they may find inspiration that can help them in their research. In the workshop they may come up with a new way to handle problems or new ideas that they never considered before.

The aim of this Workshop is to help to students and young researchers from all over the world especially the riparian countries of the Caspian Region, specialized on

Geosciences and its application by Remote Sensing and to get familiar with the latest research results obtained during investigations of the Caspian Basin region. It is expected that participants comprising local and international student/researchers.

One of the best local and international experts specialized on the Caspian basin environment, geology and remote sensing (also experts from COSPAR, CNR and AZERCOSMOS) will give lectures focussing on studies of the Caspian Basin Region.

This workshop is focused on the following themes:

- Climatic and environmental changes and Milankovitch cycles
- Sedimentary Basins and Sea Level Caspian Prospective and Beyond
- Marine Sonar and Seismic Surveys: Fundamentals and Applications
- Satellite monitoring of ocean climate parameters
- Development and exploitation of modern satellite radar altimetry over coastal zones and inland waters
- Modelisation of an endorheic basin based on satellite observations
- Azersky Earth observation satellites and projects realized due to obtained satellite imagery
- Caspian Sea paleogeography and correlation with the Black Sea.

FINANCIAL SUPPORT

A very limited amount of money will be available to facilitate participation in Student Workshop in Baku during 11 May 2018 and followed by the Conference (12-14 May 2018).

Participants of the Workshop are reminded that they should rely on their own national sources to finance travel and living expenses. In exceptional cases partial support (depending on the funding accommodation, travel cost and registration fee and other) may be available to those participants who have submitted his/her abstract to conference and in need of funding. Priority for the grants will be given to:

1. Scientists under 35 years of age on 1 January 2018
2. Scientists from developing countries (In Priority to the ECOSF member countries in the Caspian Basin Region countries but other region participants also can apply).

To qualify for financial support, the applicant should:

1. Submit an abstract to present a paper (poster or oral) on Baku Conference which will be held during 12-14 May 2018, of which he/she is the principal author, in one or more of the Conference scientific events and have submitted, by the deadline for financial support applications, the abstract should be sent to appropriate mails for submitting,
2. Secure most of the required financial support from national sources,
3. Should submit proof of age if a scientist under 35 and dated proof of student status showing current enrollment if registering at the student rate, and

4. Is strongly encouraged to submit in a timely manner after the Conference a manuscript for publication in Pre-Reviewed journals recommended at the end of the Conference.

All applicants will be informed by the Conference Secretariat of the outcome of this process in April 2018. Successful applicants depending the on the support level will be provided with accommodation, travel ticket and other types of support selected by Conference Organizers.

Sponsors

UPCB 2018 would like to thank the following companies and organizations for their generous support:



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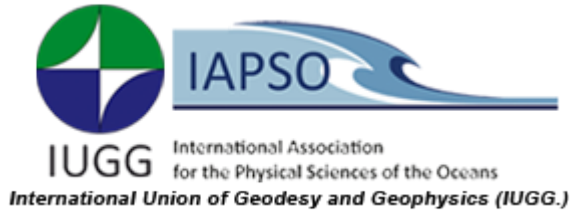
Economical Cooperation Organization Science Foundation (ECOSF)



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LIGHTHOUSE SpA



Exhibition

In the framework of the International Conference “Understanding the Problems of Inland Waters: Case Study for the Caspian Basin” which will be held during 12-14 May 2018 will provide an opportunity for companies and other organisations to demonstrate research, share solutions, and showcase their products.

Opportunity to participate as a Sponsor and/or Exhibitor

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The sponsorship prospectus outlines the many options available to companies and organizations to support the UPCB 2018 and promote their products and services. Please do not hesitate to contact us for the prospectus or for any specific opportunities you would like to discuss.

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For an electronic copy of the prospectus or additional information, please contact to UPCB2018 Organisation Commite:

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ABSTRACTS

THEME I

The Impact Of Climate Change On:
Sea Level, Bio-Resources, Bio-
Diversity, Marine Invasive Species,
Ecology And Food Web: Past,
Present And Future

Change in the level of the Caspian Sea and its socio-ecological impact on the coastal zone of Azerbaijan Republic

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Keywords: level of the Caspian Sea, Azerbaijani coastal zone

Abstract. During the years 1977-1995, the level of the Caspian Sea grew rapidly, approximately 130 mm per year. It is now established that more than half of the coastal territory of the Republic of Azerbaijan is below the level of the world ocean. For a detailed study of the state of flooding of the Azerbaijani coastal zone when raising the level of the Caspian Sea, we compile maps of flooding of all extents of coastal lines. The map of the flooding of the Azerbaijani coastal zone is made up of aerospace photographs using the literature and materials of the fund, as well as topographical and thematic plans.

Introduction: The Caspian Sea is of particular interest to scientists because of its history of fluctuations in both area and depth, which offer the key to the complex geological and climatic evolution of the region.

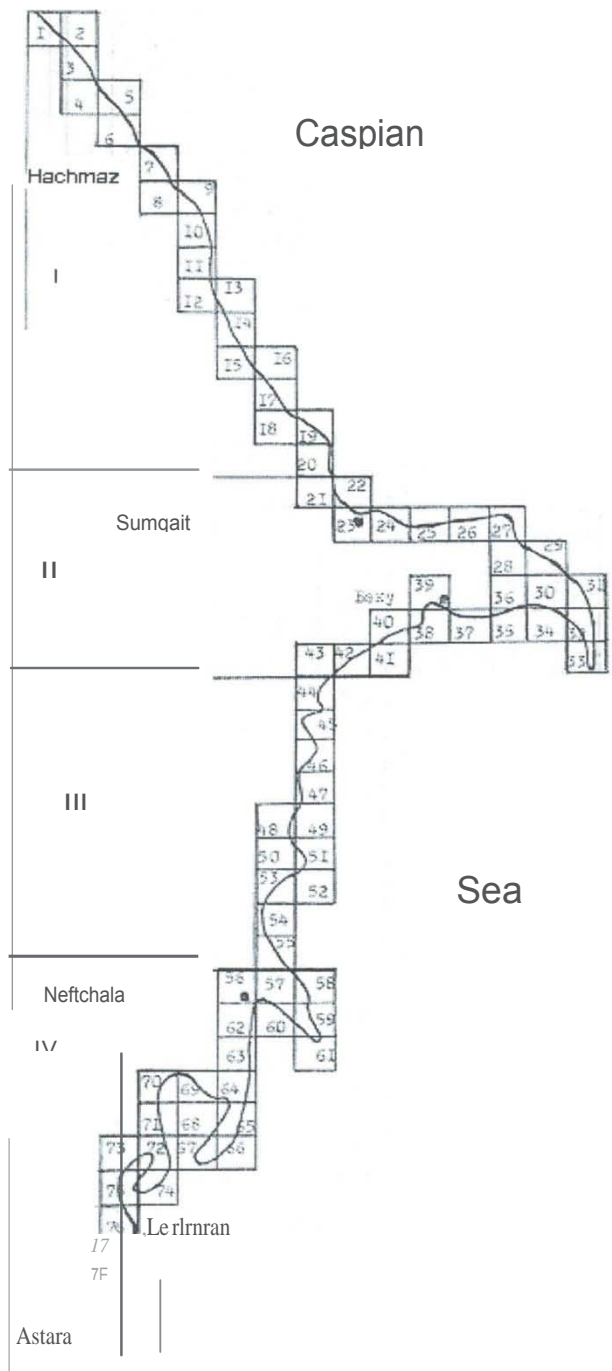
Approximately 5 million years ago, the Caspian Sea separated from the Black Sea as a result of tectonic and climatic processes and formed its own independent basin. Today it is the largest lake in the world. More than 80% of its shoreline within the area that was once part of the Soviet territory, and which now includes four Republics – Azerbaijan, Russia, Turkmenistan and Kazakhstan – the remaining shore borders belong to Iran.

Its elongated form extends almost 750 miles (1200 km) from north to south, and its average width is about 200 miles (320 km). At present, it covers an area of about 145,000 square miles (391,000 km²). The Caspian Sea is not only an economic source, but also a climatic regulator of this region.

Base part. During these many years, there have been considerable fluctuations of the sea level. Short – term wind fluctuations can cause rises up to seven feet, although the average is about two feet. Barometric pressure changes can cause such fluctuations. Tidal variations are only a few inches. And the seasonal rises, induced by high spring water in rivers, are not much more.

It is revealed that more than half of the coastal territory of the Republic of Azerbaijan was in the condition of flooding during the rise of the Caspian sea level by 2,5 meters in the period from 1978 — 1996. Flood maps of the entire length (about 800 km) of coastlines were compiled. The layouts of the maps are shown in Fig.2. For this purpose the aerocomic photos, data of regular instrumental sea level measurements and expedition work in the coastal zone were used. The map of the flooding of Azerbaijani coast is drawn up with materials of decoding aerocomic photo, references and fund materials, also with topographic and subject plans. So, about 100 maps of flooding in 1:25,000 scales were drawn up. On the basis of the coastal zone of the Republic of Azerbaijan, 26.5 mBS (the maximum sea level for the last 70 years, observed in 1996) and the possible rise in sea level to the level of 25.00 mBS (abs.) were compiled at two sea level values.

Table 1 shows the morphometric characteristics and flood square of 11 administrative regions of the Republic of Azerbaijan situated in the coastal zone of the Caspian Sea.



Pic. 1. General scheme of the arrangement of the coastal zone flood map

Table 1 Areas of flood of the coastal zone in the administrative regions

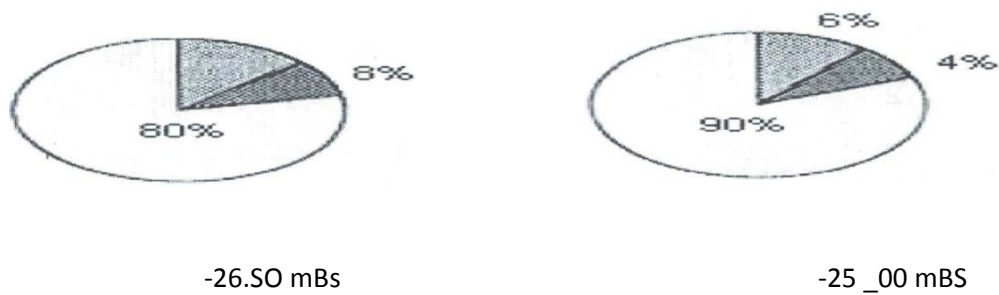
<i>The name of areas</i>	<i>Length of a coastal line, km</i>	<i>The area of flooding, sq. km</i>		
		- 26,50 mBS	- 25,00 mBS	THE GENERAL
Khachmaz	66,0	20,70	11,70	32,40
Divichi	20,7	10,40	6,30	16,70
Siazan	39,6	6,10	4,70	10,80
Hyzy	26,1	5,10	6,70	11,80
Baku	289,6	38,20	21,90	60,10
Saljan	11,7	0,60	0,60	1,20
Neftchala	94,6	132,70	375,60	508,30
Qizil - Aqag	102,0	239,00	369,50	608,50
Masalli	31,5	26,70	19,40	46,10
Lenkoran	35,1	4,10	7,70	11,80
Astara	21,1	0,90	1,00	1,90
Total	738,10	484,50	825,10	1309,60

It is received, that at flooding the coastal zone of the Azerbaijan Republic is divided into 4 characteristic areas: (In F. 1, they are shown by the Roman signs).

- From river Samur to Apsheron (I)
- Apsheron peninsula (II)
- From Apsheron peninsula to delta of the river Kur (III)
- From the river Kura to river Astara (IV)

It is revealed that as a result of the rising in the level of the Caspian Sea for the period 1978 - 1996 on all extent of the Azerbaijani coastal zone the processes of flooding occurred. The total area of the flooded territories is 484,5 square kilometers. If the level of the Caspian Sea rises by 1,5 m - i.e. to the mark of minus 25.00 mBS, then the flooding area will in addition increase by 825,1 square km and total flooding area will be 1309,6 square kilometers. Thus, sea level of 1.5 m on the Azerbaijani coast increases the flooding area nearly three times.

The greatest flooding raises the sea level, and the coastal region threatens from the delta of the Kur to Astarachay., The area of possible flooding is about 80% at sea level of mark - 26.50 mBS, and 90 % at rising level of the Caspian Sea at- 25.00 mBS. (F. 2.)



Pic. 2. Dynamics of the area change in various regions of the sea coast at two values of level

By the flooding Atlas the housing and economic objects located on all extent of a coastal zone which is under the threat of flooding and flooding is defined:

- 50 settlements
- 250 industrial enterprises
- 60 km of highways
- 10km of the railway
- 30000 hectares of winter pastures
- 10000 hectares of the irrigated soils
- recreational objects on 200 thousand persons.

Sea level fluctuations are caused by changes of the sea water balance. The water balance of the Caspian depends directly on climate changes occurring throughout the Caspian Sea basin to which the Volga river provides more than 80% of the water volume. Some scientists suggested that sea level variations are due to tectonic processes taking place in the region of the Caspian Sea. But the study of geomorphologic processes for the last 200 years shows that the tectonic activity in the region is very weak. Some have even suggested that there is a relation between the Caspian Sea's rise and the Aral Sea's dramatic fall (Kazakhstan), even suggesting there might be an underground canal, linking the two seas. But such ideas don't have scientific basis. Many scientists confirm that contemporary science cannot predict level fluctuations up to 5 - 10 years. Even in countries with higher technologies used for forecasting, it is usually no more than 3-6 months.

Main environmental problems arising in connection with the increase in the level of the Caspian Sea

The modern ecological condition of the Caspian Sea is defined, on the one side, by the influence of rising of sea level, on the other side - increasing anthropogenesis load.

The following main processes influencing the ecological condition of the coast are occurred as a result of sea level rise.

Was there any flooding and inundation of the coastal part of the territory on which the settlements, communications, agricultural objects, landing stages, etc. are located?

Flooding shallow waters change internal water with the high sea, and the newly formed shoal becomes an additional receiver transporting pollutants from the ground that will cause a deterioration of the ecological condition.

Filling of oil - gas deposits by mineral oil and their spread will lead to additional pollution. Covering subsoil waters, contributing to a sharp increase in the waterlogging of the territory and the increase in the evaporation of groundwater, increases the processes of soil salination and groundwater.

The basic sources of pollution of the Caspian Sea which are:

- Superficial drain
- Dump of crude sewage
- Emergencies on sea transport and the pollution on water area of the sea
- Superficial flushing

Conclusion:

The total area of the flooded territories is 484,5 square kilometers. If the level of the Caspian Sea rises by 1,5 m - i.e. to the mark of minus 25.00 mBS, then the flooding area will in addition increase by 825,1 square km and total flooding area will be 1309,6 square kilometers. Thus, sea level of 1.5 m on the Azerbaijani coast increases the flooding area nearly three times.

The basic volume of polluting substances arrives to Caspian Sea with a river drain which makes 90 % and more of its total volume. This parity is traced practically on all components: petro bones, phenols, detergent, organic substances, heavy metals. According to the pollutants of oil and the total amount of more than 90 % prevails. The second considerable pollution of seas is phenol.

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The impact of climate change on the Caspian Sea ecosystem

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Key words: Caspian Sea, climate change, marine ecosystem, impact of climate change on the marine biota

Introduction

The Caspian Sea biota is sensitive to climate change, which affects it via different routes: water temperature, ice content, surface runoff, sea level, water circulation etc (Hydrometeorology, 1996). The climate change affects some of the species, the marine ecosystem as a whole as well as its integral components (Katunin, 2014). Current scientific views on this issue are fragmentary; they have to be generalized and systematized, which is the aim of this paper.

The Caspian Sea climate is continental and is determined by its location in the mid latitudes of the Northern hemisphere, in the central area of Eurasia, far from the Atlantic Ocean (Hydrometeorology..., 1992). This particular fact is a reason for a wide range of interannual fluctuations of air and water temperature. At the moment, the Caspian Sea is not linked to the World Ocean, and this affects the Caspian Sea climate; it has to exchange warmth and moist with atmosphere only. The relief of the surrounding land, lowland in the north and highland in the west and the south, plateau-like in the east, plays an important role - it affects the movement of the air masses and distribution of precipitations along the coast. Finally, due to the meridional outstretch of the depression occupied by the sea (more than 1000 km), its northern and southern coasts are located in different climatic zones: the former - in the moderate climate zone, and the latter - in the subtropical zone (Kosarev, 2005).

The Caspian Sea biota has adapted itself to its climate. A typical instance is the Caspian Seal *Phoca caspica* (Gmelin), breeding on the ice of the North Caspian and feeding in the warm waters of the South Caspian. The life cycle of the major sea inhabitants is adapted to the seasonal and long-term changes of hydrometeorological conditions. The example can be set by the Caspian Sea fish species migrating within the sea and inflowing rivers, whereas migrations are initiated by the changes of water temperature (Caspian Sea, 1989). In addition, most of the Caspian Sea inhabitants are eurythermic: they can live at a wide range of temperatures (Yablonskaya, 2007), which is also a sign of adaptation to the climate.

Materials and methods

The study is based on the following CASPCOM data catalogues: mean annual air temperature (HMS, Derbent, 1961-2016). mean annual water temperature (HMS, Makhachkala), mean annual Volga runoff, 1961-2016). Mean values of each of the time series were distracted from source time series. The series of "residual" values were compared to one another. According to the results of comparison, four states of Caspian Sea climate were identified: "cool and dry", "cool and wet", "warm and dry", "warm and wet".

Results

The climate impact on the marine biota is not limited to the impact of temperature on biochemical, physiological activity and behaviour of the organisms. The climate affects the functioning of the marine ecosystem on the whole. The sensitivity of the Caspian ecosystem to the climate and its changes (not only the climate, but the sea as a whole) is determined by several factors: isolation, morphology, homogeneity of the water column etc.

Due to its isolation, the sea has no sources of water apart from the river flow and precipitations. The volume of river flow is by several times higher than that of precipitations. That is why the sea is particularly sensitive to the increased water content in the water catchment, not in the sea water area. As the volume of the Volga runoff exceeds the runoff of all of the remaining rivers, the fluctuation of the Caspian Sea level mostly depends on the changes of the Volga water content. As a result of its isolation, the Caspian Sea is an indicator of moistening of the East European Plain, which is mainly occupied by the Volga river catchment (it is as well the indicator of other large-scale climate changes).

North Caspian, being the smallest sea sector by its volume (0.5%) and average depth (4.4 m), is the least inertial sector of the Caspian Sea, which immediately responds to the atmospheric changes above its water area. In addition, the North Caspian is strongly dependent on the hydrological regime of the Volga and its runoff fluctuation. The flow of warmth and moist to the atmosphere is the most intensive in the northern sea part. Therefore, the North Caspian is serves as the main route of moist and air exchange. The South Caspian is the largest in volume (65.6%), area (39.5%) and average depth (345 m) part of the Caspian Sea, which is the opposite of the North Caspian in its responsiveness to external factors. Thus different sea parts differ from each other not only in their hydrometeorological parameters, but also in their response to their changes.

The water column of the Caspian Sea, with the exception of its northern freshwater part, is quite homogeneous in its salinity. This is an important factor, due to which the depth of the water mixing and, consequently the volume of biogenous elements entry to the zone of photosynthesis and bioproductivity of the water area mainly depend on the climate change. Climatic drivers ensuring deep water

mixing in the Caspian Sea are of various nature (Tuzhilkin, 2008). These are the regional atmospheric circulation, which leads to the formation of eddies, upwelling and downwelling and all the factors leading to the increase of the surface water density and its sinking (summer evaporation, winter cooling, ice cover formation). Deep water mixing is also affected by fluctuations in salinity of the surface water layer conditioned by the changes in the volumes of river runoff and atmospheric precipitations.

Any of these factors is sufficient for full water mixing (its indicator is the emergence of oxygen in the near-bottom layer of deep water depressions). The most active water mixing (and, as a result, the enrichment of the bottom layer with oxygen) was observed in the 70s of the past century, when it was caused by several factors (severe winters, reduction of the river flow etc.). Today, as well as 100 years ago, the near-bottom waters of the Middle and the South Caspian are enriched with hydrogen sulphide, which replaces oxygen when it runs out.

The ideas presented above make it possible to suppose that during cool and dry years bioproductivity rises in the Middle and the South Caspian (due to increased vertical circulation) and decreases in the North Caspian (as a result of the Volga flow reduction). Dry and warm years are the least favourable for the marine ecosystem. The data in Table 1 show that in such periods bioproductivity falls in all the sea parts (in the North Caspian as a result of runoff decrease, and in the Middle and the South Caspian due to reduced vertical circulation).

Climate	Surface runoff	Temperature regime	Sea level	Vertical circulation	Bioproductivity	
					North Caspian	Middle and South Caspian
Dry, cool	Below normal	Below normal	Reduces	Deep	Low	High
Dry, warm	Below normal	Above normal	Reduces	Surface	Low	Low
Wet cool	Above normal	Below normal	Rises	Average	High	Average
Wet warm	Above normal	Above normal	Relatively stable	Surface	High	Low

Table 1 - Climate status and bioproductivity of the Caspian Sea

The comparison of the time series of the "residues" of air temperature, Caspian Sea water temperature and the Volga runoff has shown that in 1964-1977 cool and dry years prevailed (11 out of 14 years), cool and wet years dominated in 1985 - 1994 (6 out of 10 years), warm and wet years prevailed in 1995-2005 (7 out of 11 years), and warm and dry years - in 2006 - 2015 (6 out of 10 years).

Discussion

Thus the climate change observed from 1964 to 2005 was relatively favourable for the marine biota: 60-70's period was favourable for the deep water sea part, and in the following period (up to 2005) - for the North Caspian. The period starting from 2006 to 2015 was generally unfavourable for the marine bioproductivity. There is a growing concern that climate warming, if it occurs in future, will raise the occurrence of warm and dry years and thus will lead to the reduction in the marine bioproductivity.

Summarizing the facts stated above, we can say that Caspian Sea sensitivity to climate change is determined by its isolation, geomorphology, homogeneous vertical salinity distribution and other factors. The bioproductivity of the Caspian Sea is in direct proportion to the Volga runoff, and the bioproductivity of the Middle and the South Caspian is related to vertical water circulation, and in particular to the depth of the autumn-winter convection. On this basis, one can single out four kinds of climate status affecting the marine biota: "cool and dry", "cool and wet", "warm and dry", "warm and wet". Using CASPCOM data catalogues, one can trace all the above mentioned statuses in the Caspian Sea climate change throughout the past 50 years. The objective of further research is to determine biological indicators of different statuses of the Caspian Sea climate.

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Fatty acid composition of sponges as biomarkers of stress factors

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Key words: sponges, fatty acids, biomarkers

Introduction

Understanding of the mechanisms responsible for adaptation of living organisms to changing environmental conditions has always been one of the main tasks of ecology and systematic biology. As our knowledge of the complex processes that determine evolution, speciation and species adaptation continues to grow, need to study the mechanisms underlying resistance of living organisms to stress factors becomes more and more evident (Hoffmann & Parsons, 1997). The life of organisms is limited to a specific temperature range in which, theoretically, increasing on 10°C leads to a two- to fourfold increase in the response time of metabolic processes. Numerous physical and chemical studies show that the mechanisms of survival at abnormally high temperatures include changes in the lipid components of cell membranes. The degree of involving of lipids in the adaptation processes depends on biological features of various species, including marine and freshwater sponges (Temperature..., 1994; Velansky & Kostetsky, 2009; Gladyshev et al., 2011).

Because of increasing anthropogenic impact on natural ecosystems, adaptations developed by various organisms have recently received growing attention from researchers, but adaptive biochemical characteristics of organisms representing taxa of lower phylogenetic ranks are still poorly studied. Sponges as a symbiotic community of various microorganisms are a unique object for such studies. During millions of years, Baikal sponges have adapted to living in a narrow temperature range from 0.5 to 11.5°C (at depths of 4 m and below).

The aim of the research is comparative analysis of the fatty acid composition of the Baikal freshwater sponge *Baicalospongia bacillifera* from different depth and upon a rise of temperature in its natural habitat by 6°C.

Materials and methods

Field sampling

Deep water sponges *B. bacillifera* were collected from the depth of 750 m from Barguzin Bay (Lake Baikal) in July-August by using manned submersible "MIR" (during the International Research Expedition «MIRs on Lake Baikal», 2008-2010). Shallow sponges *B. bacillifera* were collected from a depth of 15 m in the southern part of Lake Baikal in August. The collected samples were stored at -18 °C for less than seven days prior to laboratory analyses.

A living sponge colony was adapted for 14 days to the artificial conditions of glass aquariums with flowing Baikal water at 10.5°C and 12-h photoperiod without additional feeding. The water to the aquariums was supplied from a homemade refrigeration unit (Glyzina et al., 2016). After adaptation, sponge samples were taken for biochemical analysis.

Sample derivatization

In laboratory, weight samples of sponges were placed into glass tubes with anhydrous methanol containing 2 M HCl. The tubes were filled with argon, then securely closed, and heated for 2 h 90 °C for complete methanolysis (Meier et al., 2006). After cooling to room temperature, the tubes were opened and the methanol was evaporated under a stream of nitrogen, and distilled water was added to reduce the solubility of the FA methyl esters formed, which subsequently were extracted with hexane.

Fatty acid analysis

Fatty acid analysis was performed using an Agilent 6890 gas chromatograph equipped with a mass-selective detector 5973 N, HP-5MS column with a thickness of 0.2 µm and helium as the mobile phase. The oven was programmed as follows: 90 °C for 4 min, 30 °C min⁻¹ up to 165 °C, then 3 °C min⁻¹ up to 225 °C, and kept isothermal at this final temperature for 10.5 min before cooling for the next run.

The chromatographic peaks of the methyl ester derivatives were identified by retention time and mass spectra (NIST 14.0). A standard mixture of 37 FAMES (Supelco 37 component FAME Mix, USA) and 26 bacterial acid methyl esters (Bacterial Acid Methyl Esters CP Mix (Supelco, USA)) was chromatographed for each tenth sample.

Results

B. bacillifera is an endemic large-sized mushroom-shaped sponge that is widespread in Lake Baikal. The FA compositions of lipids from studied sponges were compared by using GC with mass spectrometry. More than 40 FAs from lipid extract of sponges were identified and main fatty acids are listed in the table 1.

Location	Barguzin bay	Southern part of Lake Baikal	
Depth, m	745	15	aquarium
Temperature, °C	3.7	4.5	10.5
14:0	1.93	2.17	2.40
i15	1.92	0.38	0.33
16:0	4.12	7.05	12.00
i17	1.60	0.11	0.60
a17	1.42	1.14	1.45
17:0	1.39	1.53	1.8
18:0	2.41	1.45	0.51
14:1n11	4.14	0.13	0.49
16:1n7	0.34	0.12	1.13
16:1n9	2.94	1.67	0.92
17:1n8	0.12	2.2	5.35
18:1n9	18.05	16.24	25.5
18:1n7	2.60	1.81	0.14
18:1n11	0.21	0.13	0.52
20:1n9	2.17	0.34	1.23
24:1n9	3.18	3.7	2.94

18:3n3	8.22	7.12	10.3
18:2n6	2.72	2.28	6.45
22:6n3	0.15	0.22	0.12
26:3n3	18.99	14.65	10.11

Table 1. Contents of main fatty acids in *Baicalospongia bacillifera*, rel. %

Discussion

It was revealed that deep water sponges *B. bacillifera* inhabiting at a depth of 750 m contain higher levels of unsaturated FAs. Structural modifications of membrane lipids are acknowledged to play a central role in the thermal adaptation of hydrobionts' tissues, and the physical properties of the lipids are largely determined by their FA composition (Hazel 1995). To achieve enhanced membrane fluidity hydrobionts can utilize diet-derived unsaturated FAs or increase the degree of their FA unsaturation by inserting new double bonds into the existing acyl chains by using desaturase enzymes (Trueman et al. 2000; Hsieh et al. 2007). As shown previously, *B. bacillifera* contains a sufficient amount of eicosapentaenoic acid (Dembitskii, 1981) and their isomers, whereas the majority of other marine and freshwater sponges contain only a small amount of these compounds. In our experiments, this acid was detected only in trace amounts. The pool of polyunsaturated acids in *B. bacillifera* is mainly represented by demospongiic acid 26:3(5, 9, 19), which contains a characteristic 5,9-diene fragment of the carbon chain. The content of this acid is reduced as the temperature increases which indicates that the sponge is depressed.

Acids 18:1n9 and 18:2n6 are the most prominent markers sensitively responding to rise in ambient temperature. Linoleic acid actively participates in the functioning of chloroplasts, so it can be assumed that the process of photosynthesis in symbiotic algae is sharply intensified as the temperature increases. The total content of polyunsaturated fatty acids in the samples decreased by 10.5 rel.% upon a 6°C temperature rise. The relative content of iso- and anteiso-branched i15:0, i17:0, ai17:0 acids which are of bacterial origin (Kaneda, 1991) are much higher in deep water sponges. Probably, the contribution of symbiotic algae in sponges' diet at great depths at low temperature, high pressure and absolute darkness is insignificant and the contribution of symbiotic microorganisms increases.

The results of this study may be used for further research on biochemical adaptations in hydrobionts, including taxa of lower phylogenetic level. Specific features of biosynthesis and metabolism under temperature stress in sponges, which often synthesize biologically active compounds via nonstandard biosynthetic pathways, may attract the attention of many ecologists who study the problems of inland waters.

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Probability long-term forecast of the Caspian Sea's water level

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Keywords: Caspian Sea, water line, long-term fluctuations, probability forecast, fiducial interval, river runoff, evaporation, morphometry

In the report the method of probability prediction of level of the Caspian Sea is considered. The short review of methods of prediction of long-term fluctuations of level of water in the sea is provided. Stochastic models of principal components of water balance are considered (river inflow, evaporation from the water surface). Features of morphometric dependences are discussed (the areas of the water surface from the water level). Within Markov models of hydrological processes imitating and analytical approaches to modeling and prediction of long-term fluctuations of the water level in the sea are considered.

Possibility of preservation from extinction of sterlet sturgeon, *Acipenser ruthenus* (vulnerable) in the Caspian basin using genetic manipulation

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Key words: sterlet sturgeon, Siberian sturgeon, heterologous sperm, gynogenesis, preservation.

Introduction

Sterlet, *Acipenser ruthenus* belongs to the smallest, freshwater species of Acipenseridae. It has originally inhabited the rivers flowing into the Caspian, Black, Baltic, White, Barents and Kara Seas and the Sea of Azov. Currently, all the sturgeon species, including sterlet, are highly endangered due to water pollution, construction of the dams and overfishing, and they are on the Red List of Threatened Species IUCN (Gessner et al. 2010). Also, it may be caught for artificial hybridization between other sturgeons such as Siberian sturgeon, Russian sturgeon and beluga (Urbányi et al., 2004). So, overfishing could be caused extinction of this species in the Caspian Sea and its basin. The aim of this study is possibility of male sex production in sterlet sturgeon using gynogenesis and Siberian sturgeon's heterologous sperm for the recovery of its deficiency.

Materials and methods

Seminal fluid of Siberian sturgeon's sperm was separated by centrifugation and was concentrated to 10%. Then, it was exposed to UV radiation (at which wavelength) with 473 $\mu\text{W}/\text{cm}^2$ intensity and 30, 60, 90, 120, and 150 sec interval duration. Then these sperm were inseminated with normal eggs of sterlet sturgeon. In this mode, haploid gynogen was induced. For diploidization of haploid eggs, heat shock 34°C was used for 2 min duration. Gynogen progeny verified using DNA microsatellite markers and maintained to 18-months age for histological analysis of gonads.

Results

Results show that 60 sec UV- exposed is more suitable than other durations because sperm motility saved for egg activation. Also, diploidization was successfully performed by heat shock exposing in the haploid eggs of sterlet sturgeon. The results of the microsatellite DNA analysis showed that there was no genetic contribution from the paternal genome in the gynogenetic progeny. Histology analysis of 17 gonads of gynogenetic progeny has shown that sex

determination system in sterlet sturgeon is female heterogamety (ZW). In this sex determination system, both females and males produced and population and descendant of sterlet sturgeon could recover.

Discussion

Sturgeons with female heterogametic sex determination system (ZW) could be recovered using induction of gynogenesis, namely by presence a female only, both female and male can be produced (Saber et al., 2014). For induction of gynogenesis, it is sufficient using UV-irradiated heterologous sperm and inseminated with normal egg of threatened species. Then diploidization carried out using retention of the second polar body. Such a methodology in a species with female heterogamety would produce both females and males simultaneously, making population recovery possible; for example, inducing gynogenesis in eggs from endangered species such as Japanese sturgeon (Sakhalin) *Acipenser mikadoi* using UV-irradiated sperm of the bester (Omoto et al. 2005). Irradiated Siberian sturgeon's sperm could be used as a heterologous sperm for gynogenesis induction in other sturgeon species. Also, inducing diploid gynogenesis of endangered sturgeon populations in which their males cannot be recovered could be reproduced with genetically inactivated donor sperm from other sturgeon species, and this method would save them from extinction.

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ADAPTATION OF DIATOMS (IN CLONIAL CULTURE) TO THE CHANGE OF THE IONIC COMPOSITION OF THE MEDIUM

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Key words: *diatoms, clone culture, salinity, growth rate, ionic composition.*

Introduction

Salinity is an important mediational factor in the marine medium [Kinne, 1964; Odum, 1975]. Salinity of water as a mediational factor can be considered in two aspects: osmotic and ionic. For the growth and development of algae is no less important than the total salinity, has the ionic composition of water, the ionic ratio. The significance of this factor was recognized long ago [Provasoli et al., 1954, Droop, 1958]. So, V.N. Beklemishev and V.P. Baskin [Beklemishev et al., 1933] noted that the nature of the ionic relationships is, in some cases, a decisive mediational factor. But researchers working mainly with algae from the saline seas, naturally, did not give him due attention either in experiments or in the treatment of the spread of algae in nature. It was not possible for experimentalists Experiments dealing with the same species dealing with the of desalinated Black (average salinity -17‰) and Caspian (12‰) seas, to ignore this factor. In these brackish-water seas, not only dilution of fresh sea water takes place, but also a qualitative change of the salt composition: the ionic ratios vary greatly with respect to oceanic waters. In each of these seas, the salt composition of water has its own peculiar features and, accordingly, other ionic relationships.

Materials and methods

The objects of research were four clonal cultures of marine diatoms isolated from phytoplankton of the Caspian and Black Seas at points with a salinity of 12 and 17‰, respectively. These Caspian clones are *Thalassionema nitzschioides* (Grun.) Hust., *Coscinodiscus granii* Gough and the Black Sea *Ditylum brightwellii* (West) Grun., and *S. granii*.

The method of research and the scheme for setting up experiments (I and II series) are covered in our publication. For the first time, a serious study of this factor, called rapic was used by the Romanian researcher E. Pora [Pora, 1961; 1969]. L.A. Lanskaya [Lanskaya, 1969] also noted that "some algae reproduce more intensively in the water of that pond from which they are isolated".

The salinity of the medium prepared on the White Sea water was calculated according to the formula of M. Knudsey [Harvey, 1948]. In calculating the salinity for medium prepared on Caspian water, the chlorine coefficient A.A. Lebedintsev was used [Zenkevich, 1963]. When preparing medium using the Black Sea water, salinity calculations were made using the formula taken from the work of Nikitin et al. [Blinov, 1962]. In the described series of experiments "(III series) we attempted to cultivate Black Sea and Caspian clones ion water with an ionic composition which is characteristic of a typical marine, for which the White Sea water was used, which is close to the oceanic one in chemical composition to the oceanic one [Воронков, 1939]. In some experiments of the third series of. T the number of saline points was reduced due to a shortage of the White Sea water.

Results

A number of researchers [*Proshkin - Lavrenko*, 1963; , *Williams*, 1964; , *Braarud*, 1965] based on the study of diatoms both in experiment and in natural conditions, suggests that marine euryhaline species are capable of the formation in the nature of local populations of phytoplankton that are characterized by different salinity. However, there are experimental studies that contradict this assumption. Thus, E. Paasche [Paasche, 1975] studied two clones *Skeletonem costatum* (Grev.) Cl., isolated from the Baltic Sea (6‰) and Oslofjord (20‰), found

that both grew well in the range of 8-40‰ and did not show growth at 2‰ and below. Based on these experiments, the author concludes that although in the Baltic local populations are constantly exposed to low salinity in the Baltic local populations are constantly exposed to low salinity; this does not lead to the selection of special brackish races.

Discussion

Analyzing the findings of E. Paasche in the light of the hypothesis of E.Pora [Pora, 1961], it can be assumed that the cause of this behavior of the clones of seaweeds is apparently sought in the ratio of ions in the Baltic water (which, as is known, is close to the full-salt oceanic water in composition to the full-salt oceanic water), which allows them to tolerate low water tonicity (2 - 8‰); This explains the presence in the Baltic Sea of the oceanic representatives of other groups of organisms in the Baltic Sea.

In the Black Sea, and even more so in the Caspian Sea, diatom populations are under the double influence of osmotic and ionic factors, which apparently should lead to the formation of local populations characterized by physiological responses, somewhat different from those of populations from fully saline seas.

Preliminary experiments were conducted to establish the presence of growth of clones on water with a different ionic composition, in which only a qualitative estimate of growth was given. In these experiments, the cultures were exposed on the northeasterly window at room temperature (18 °C). After establishing the fact of growth of the Black Sea and Caspian clones on the White Sea water, the ratio of clones to salinity by the fission rate was experimentally estimated.

The culture of the Black Sea clone *C. granii*, previously cultivated at 17‰ on the Black Sea water, was transferred to medium with a salinity of 12 and 17‰, prepared in the Caspian water (control was the culture of *S. granii* cultivated at 17‰ on its own lead). In the experimental cultures, a mass of "bare" small spherical bodies and a slow cell death were observed for several days. Similar was the behavior of the Black Sea *D.brightwellii*, whose culture in this experiment also died. Thus, the Caspian water proved to be unsuitable for the Black Sea clones under study; this indicates that the Experiment Black Sea clones are not able to carry water of a different ionic composition. We believe that it was the rapist factor that was the barrier to the growth of the Black Sea clones to the Caspian water.

Similar results demonstrating the importance of ionic ratios for algae were obtained by L.A. Lanskaya [Lanskaya, 1969], in whose experiments algae isolated from the Red and Mediterranean seas were not easily adopted and soon died off with the same salinity, but on the Black Sea water.

In subsequent experiments, we transferred two Black Sea clones into the White Sea water. Preliminary experiments showed that both clones carry the White Sea water, and in the

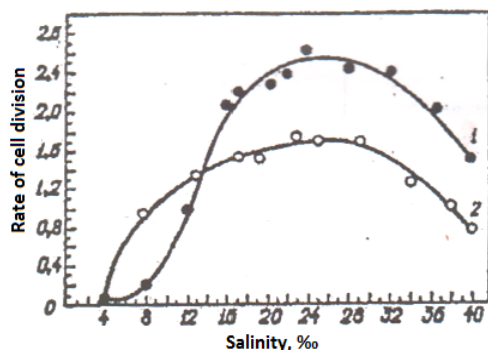


Figure 1. Rate of cell division of the Black Sea clone *Ditylum brightwellii* (West) Grun. on the Black Sea (1) and White Sea (2) waters of different salinity

appearance of the culture, no noticeable changes were observed in the visual observation. One of these clones (*D.brightwellii*) was further tested for 8 days at 11 saline points. Controls were cultures on medium with a salinity of 17‰, prepared both on the Black Sea and on the White Sea water. The growth rate constants were calculated for all salinity points. It is interesting to note that, on the whole, the Black Sea clone on the White Sea water showed the same range of optimum (10-29%) as on the Black Sea water, however, the rates of division of its cells at both the control and optimal points were much lower than on the Black Sea water (Fig.1). Thus, the results of the experiment

described agree with the thesis of Z.Z. Finenko and L.A.Lanskaya [Финенко et al., 1972], that algae are more intensively divisible by the water of the reservoir from which they were isolated.

In this experiment, *D.brightwellii* cells died at a salinity of 4%. In the lower limit of the salinity range (13%), this seaweed in the White Sea water showed higher fission rates compared to the same salinity on the Black Sea water. There are data [Guillard R, 1970] that a small change in the ion composition stimulates the growth of diatoms in dilute media. Thus, the form of the growth curve with a salinity of 4-8% can be different and depends to a large extent on the ionic composition of the medium.

Microscopy of cultures in this experiment (to assess their state) showed that *D.brightwellii* cells excellently tolerated salinity from 19 to 29%. Moreover, cells, usually single, and in this range of salinity were connected in chains (8-16 cells each).

The Black Sea clone of *S. granii* was also previously tested in medium on the White Sea water and showed the ability to grow. Growth experiments with this clone were carried out on the White Sea water at four salinity points corresponding to the average salinity values of the Caspian (12‰), Black (17‰) and White Sea (25‰), and average salinity of oceanic water - 34‰. Control was a culture that grew on the Black Sea water (17‰). The Black Sea clone of *S. granii* on the White Sea water also showed lower rates of cell division than on the Black Sea water; the fission optimum was observed at average salinity values, approximately repeating the growth optimum on the Black Sea water.

Caspian clones of *S. granii* and *Th. nitzchioides* in preliminary experiments showed the ability to grow on the White Sea water. The main experiments were also carried out at four salinity points. The control was a culture growing on a medium with a salinity of 12‰, prepared in the Caspian water. The results of the experiments are evident that the rates of division of both Caspian clones on the White Sea water were lower compared to the rates of division in the Caspian water (Fig. 2). Optimum fission rates on the White Sea water were observed approximately in the same salinity range as in the Caspian water.

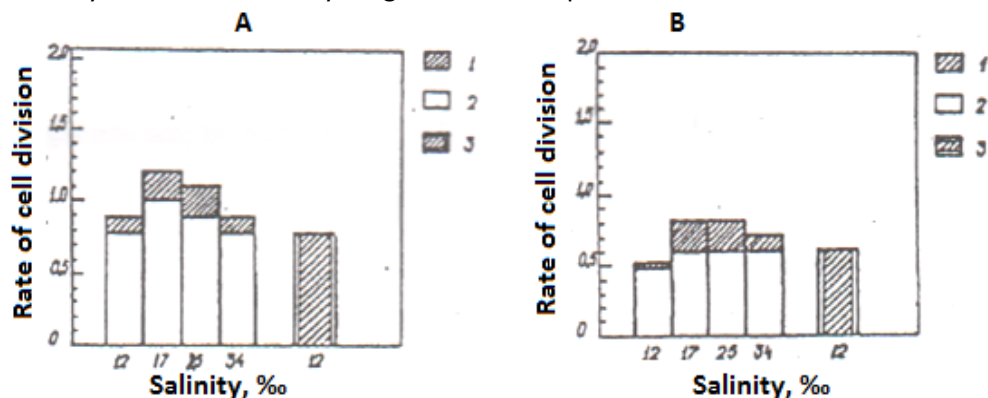


Figure 2. A- The rate of division of the cells of the Caspian clone *Coscinodiscus granii* Gough in the Caspian (1) and White Sea (2) waters of different salinity (3-control); B- Rate of cell division of the Caspian clone *Thalassionema nitzchioides* (Grun) Hust. on the Caspian (1) and White Sea (2) waters of different salinity (3-control).

A comparison of the growth of the Black Sea and Caspian clones of *S. granii* clearly shows that the rates of division of both clones on the White Sea water were lower than on the water of the reservoir from which they were isolated.

The cultivation of Caspian and Black Sea clones on the White Sea water, close in ionic composition to typically marine, showed that the general nature of the growth of cultures under these conditions did not change, but the rate of cell division decreased markedly. The

good growth demonstrated by Black Sea and Caspian clones on the White Sea water is clear evidence that these seaweeds in the freshened seas operate in a narrower salinity zone than the genotype allows.

Black Sea clones did not grow on the Caspian water, which indicates the inability to transfer the ionic relationships inherent in the Caspian water.

Undoubtedly, the reason for the inability of the Black Sea clones to grow on the Caspian water is explained by other ionic relationships of the latter; The Black Sea water is not so deeply metamorphosed and somewhat closer to the oceanic water than the Caspian Sea, but the White Sea water is the closest to the oceanic water by the ionic composition [Voronkov, 1939].

Differences in the ratio of salts of the Caspian water in comparison with the oceanic one, which resulted from the separation of the Caspian from the ocean and formed under the influence of river runoff, led to radical changes, which are an essential barrier to a number of marine algae.

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Investigation On Population Genetic Structure Of Caspian Lamprey (*Caspiomyzon Wagneri* Kessler 1870) In The Caspian Sea Using Microsatellite Molecular Technique.

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Key words: *Caspiomyzon wagneri*, genetic population, Caspian sea, microsatellite.

Lamprey (petromyzontiformes) are a significant ecological cultural ,and economically important fish groups in the world. There are about 43 lamprey species in 9 genera with only 1 recorded from Iran(Coad, 2016).Caspian lamprey ,*Caspiomyzon wagneri* ,is a Eurashian anadromous non -parasitic specise(Imanpoor & Abdollahi, 2011). the Caspian lamprey is endemic to the Caspian sea and related river system in its northern ,western ,and southern watersheds(Holcik, 1986) .The Caspian lamprey in the southern Caspian sea basin migrates to such rivers as Shirud ,Talar Babolrud ,Karganrud ,Tajan ,Haraz ,Sardabrod ,Aras ,Tonekabon ,Polrud,Sefidrud ,and safarud rivers and the Anzali lagoon(Kiabi, Abdoli, & Naderi, 1999).This species migrate upstream from the sea where they spend the feeding stage and when migration starts ,lamprey stop growing and beginning to mature sexually (Larsen, 1980).Adults die after spawning .During the spawning migration ,the lamprey undergoes certain morphological changes ,some of which have been linked to the sex of the fish The Caspian sea lamprey is listed as vulnerable in Europe(Renaud, 1997) and in Iran because it migrates into rivers which are polluted and dammed and because of its restricted and declining distribution(Coad, 1998). Also this species to near threatened in the southern Caspian sea according to the IUCN criteria .because of the valuable ecological importance of Caspian lamprey (Nazari & Abdoli, 2010)

The main of this study was the following: obtaing information about population differentiation of this species in four rivers at the reproductive migraton time in the southern Caspian Sea.

The genetic diversity of *Caspiomyzon wagneri* population in the Caspian sea was studied using microsatellite technique .A total of 120 caudal fin samples were collected from adult *Caspiomyzon wagneri* specimens caught in the southern Caspian sea ,including specimens from Shirud river ,Babolrod river ,Talar river ,Kheyrod river . about 2-3 gram of fin tissue was removed from each caudal fin sample, stored in 96 % ethyl alcohol and transferred to the genetic laboratory of the mazandaran university.

Genomic DNA was extracted using acetate ammonium method. The quality and quantity of DNA was assessed using 1% Agarose gel electrophoresis and Polymerase Chain Reaction (PCR) was conducted on the target DNA using 10 paired microsatellite primer. PCR products were electrophoresed on polyacrylamide gels 6% that was stained using silver nitrate.

Electrophoretic patterns and bands were analyzed with Bio Capt software. Allele count and frequency, genetic diversity, expected heterozygosity and observed heterozygosity, allele number and the effective allele number, genetic similarity and genetic distance, F_{ST} and R_{ST} were calculated. It is evident from

reference

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Forecasting Caspian Sea level for 10 years' time using periodicity method

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Key words: Caspian Sea, level fluctuations, forecast, periodicity method

Introduction

The problem of very long-term (exceeding 1 year) Caspian Sea level forecast (CSL) has not been solved despite continuous attention towards this issue [1]. One of the methods used for very long-term forecasting of the Caspian Sea level is the periodicity method based on the assumption that the CSL changes can be presented as overlaid cyclic fluctuations of different amplitude and time. i.e., the harmonics [2]. The method was first suggested by B.Shlyamin who predicted the sea level rise in the period from 1975 to 2032 in 1962 using the combination of 4 harmonics with the periods of 11, 35, 100 and 500 years with the amplitude ratio of 1:2:4:7 [4]. However CSL forecasts with such advance time are more of scientific than of practical interest. From the practical viewpoint, the forecasts not exceeding 10 years' time are more significant. The use of the periodicity method for making such forecasts is hampered because of the "noise" in the high-frequency spectral range of the CSL fluctuations. The objective of the paper is to compare the CSL forecast made in 2015 with the actual data.

Materials

The forecast was prepared on the basis of long-term observations data of the sea level collected at the marine hydrological posts and contained in the General Catalogue of the Caspian Sea level created by CASPCOM and displayed on its website <http://www.caspcom.com/>. The study was based on the long-term series of sea level data in January, February (etc. for every month) and annual data (mean, maximum and minimum values). The harmonics were identified on the basis of periodograms plotted by means of MEZOZAVR software.

Results

At the moment, numerous harmonics in the long-term fluctuations of the Caspian Sea level have been determined. Selecting the harmonics which can be used for making a forecast, we based on the assumption that the cyclic fluctuations common for all the above mentioned time series of the sea level, are of high prognostic value. The prognostic harmonics must:

- have a big contribution to the sea level variability within a time period equal to the forecast lead-time;
- have a significant occurrence in space (at different posts) and time (in different months of the year);
- have coinciding frequencies in the temporal series of the mean, minimal and maximal sea level;

The data analysis shows that if the forecast lead time does not exceed 20-25 years, these requirements are met only by the harmonics with the period of 12-13 and 17-19 years.

By means of different combinations of these harmonics we have received 6 prognostic models. By applying them to different posts (Makhachkala, Baku, Krasnovodsk and Aktau) we received the ensemble of 24 prognostic models. Alongside with this, we have identified the only one (solo) harmonic which best reproduces the actual changes of the sea level in 1996 - 2015. To

draw up the Caspian Sea level forecast we have used both solo and ensemble models (mean value in the ensemble)

The results of the forecast employing 6 basic ensemble models (mean value for 4 posts) presented in Fig. 1 show that the sea level curves calculated by different models are in close fit to 2025, after that they diverge. Therefore the numerical forecast presented in Table 1 is restricted by this date.

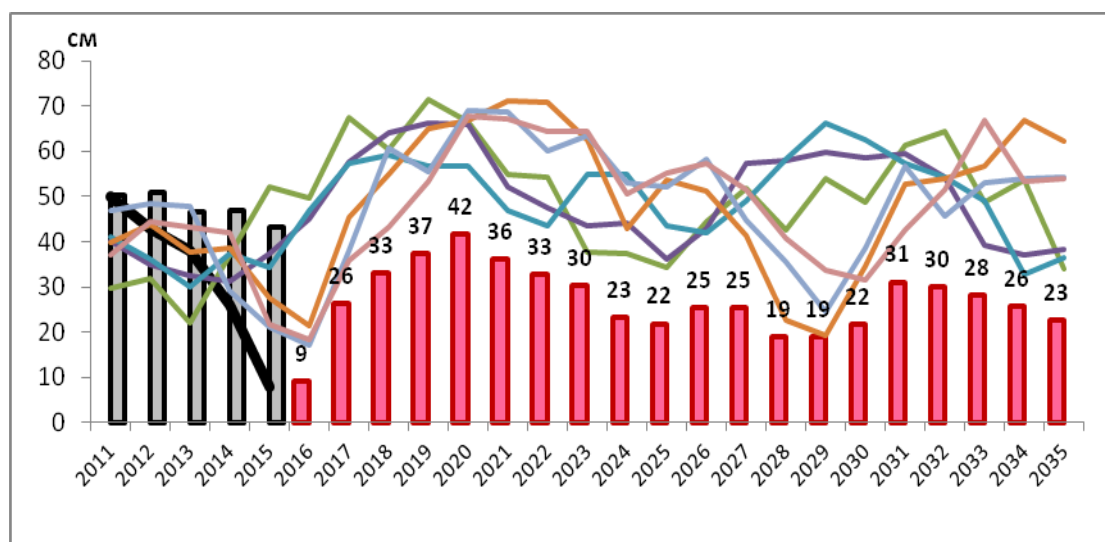


Fig. 1. Actual (black bold line) and calculated by means of a models ensemble (thin lines) sea level in 2011 - 2035. The bar chart shows the mean level for the ensemble reduced to the reference point. The reference point for 2011 - 2015 is the actual sea level in 2011, the reference point for 2016 - 2035 is the actual level in 2015.

Forecasting method	Years									
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Solo	-12	30	10	24	1	-5	-1	-15	-14	-2
Ensemble	1	17	7	4	5	-6	-3	-3	-7	-1

Table 1 The forecast of the annual increment of the Caspian Sea level for 2016 - 2025 (cm)

Discussion

According to the sea level forecast made in 2015, the sea level will be rising from 2016 to 2020 and slowly falling in the following 5 years. The solo and the ensemble forecasts were inconsistent by their signs in 2016; on three occasions they significantly differed from each other by the increment value (more than 10 cm); in other cases they were consistent. In 2016 the sea level actually stabilized at the mark close to zero (minus 28.0 m BS), to be more specific, it fell just by 1 cm, which is in compliance with the ensemble forecast (2 cm discrepancy).

According to the observations data at Makhachkala marine hydrological post, the sea level in 2017 rose by 6 cm against its elevation in 2016. The increment value of the average sea level will be specified in the oral presentation, but it is obvious that it will be significantly lower than

the forecast value. The assessment of the significance of the suggested very long-term forecasting method will mainly depend on the sea level fluctuation pattern in the forthcoming years. At the moment we should note that this forecast made in 2015, in contrast to other forecasts predicting further fall of the sea level [3], was justified by the fact that in 2016-2018 the sea level actually stabilized and started to rise.

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HORMOGONIOPHYCEAE (CYANOPROKARYOTA) IN PLANKTON OF AZERBAIJANI SECTOR OF THE CASPIAN SEA

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Key words: Cyanoprokaryota, Hormogoniophyceae, phytoplankton, Caspian Sea, Azerbaijan

INTRODUCTION

The Caspian Sea is the largest inland, brackish water body on the planet located at the junction of Europe and Asia. The current state of the Caspian Sea is characterized by the instability of environmental conditions which has a direct influence on aquatic ecosystems. Changes in the ecology of the sea significantly affect the species composition of algae and the structure of phytocenosis. Phytoplankton is the most widespread ecological group of algae and represent one of the main parts of the modern hydroecosystem of the Caspian Sea. The blue-green algae (*Cyanoprokaryota*) including *Hormogoniophyceae* are an integral component of the aquatic ecosystems of the Caspian Sea which play an important role in the life of the sea.

The article provides updated information on species diversity and the distribution of *Hormogoniophyceae* algae in the plankton of the Azerbaijan sector of the Caspian Sea, taking into account the nomenclatural changes of J. Komárek et K. Anagnostidis [4].

MATERIAL AND METHODS

The material for this work was the results of generalization and analysis of literature data of the floristic-systematic and hydrobiological nature [1,11 and others] and long-standing original studies [7-10 and others] of the *Hormogoniophyceae* algae of the Azerbaijani sector of the Caspian Sea. The class *Hormogoniophyceae* is presented according to the nomenclatural changes of J. Komárek et K. Anagnostidis [4].

RESULTS

The oldest organisms of phytoplankton is blue-green algae (*Cyanoprokaryota*) including the *Hormogoniophyceae* ones, which are an integral component of the Caspian water ecosystems and play an important role in the life of the sea. Being autotrophs, they are the primary creators of organic matter, the source of oxygen, which is necessary for the breathing of animals and plants, serve as food for hydrobionts, including for fish, creating fish abundance of the sea. Blue-green algae play an important role in the sedimentation of the Caspian Sea forming an oil-like combination of sapropelles which is quite possibly, is a precursor of oil in the Caspian Sea.

However, *Hormogoniophyceae* in the Caspian Sea play a negative role causing practical damage. Harm is possible with "blooming" of water in the sea which is the result of fish kill. Summarizing the results of the analysis of literature data and long-term original studies of *Hormogoniophyceae* algae of plankton of Azerbaijani sector of the Caspian Sea, 41 species (43 intraspecific taxa) of 2 orders -*Oscillatoriales*, *Nostocales*, 6 families, 6 subfamilies and 19 genera are registered. It was revealed that in the studied sea area *Oscillatoriales* occupies a leading position on the species richness - 31 species (33 intraspecific taxa) belonging to 3 families - *Pseudanabaenaceae* Anagn. et Komárek, *Phormidiaceae* Anagn. et Komárek, *Oscillatoriaceae* (S.F.Gray) Harvey et Kirchner; 6 subfamilies-*Pseudanabaenoideae* Anagn. et Komárek, *Spirulinoideae* Gomont, *Leptolyngbyoideae* Anagn. et Komárek, *Heteroleibleinioideae* Anagn. et Komárek, *Phormidioideae* Anagn. et Komárek, *Oscillatorioideae* and 12 genera - *Jaaginema* Anagn. et Komárek, *Limnothrix* Meffert, *Pseudanabaena* Lauterborn, *Spirulina* Turpin ex Gomont, *Planktolyngbya* Anagn. et Komárek, *Heteroleibleinia* (Geitler) Hoffmann, *Arthrospira* Stizenberger ex Gomont, *Phormidium* Kützing ex Gomont, *Planktothrix* Anagn. et Komárek, *Porphyrosiphon* Kützing ex Gomont, *Lyngbya* Agardh ex Gomont, *Oscillatoria* Vaucher ex Gomont. Out of families the most differently represented are *Phormidiaceae*-13 species (14 intraspecific taxa) and *Oscillatoriaceae*-10 species (11

intraspecific taxa). The largest role belongs to the genera: *Phormidium* - 10 species (11 intraspecific taxa) and *Oscillatoria* - 6 species (7 intraspecific taxa). Despite that *Oscillatoriales* is represented by the greatest species diversity in the studied sea area but in plankton they occur, mainly sporadically, singly, in the form of separate confervoid individuals. Confervoid blue-green alga *Limnothrix redekei* (Van Goor) Meffert was encountered quite frequent in the summer-autumn period and in some years reached a large number of up to 755.2 ths. cell/l [10]. N.V.Kondratieva [5] notes that this species develops intensively in lakes and can cause "blooming" of water. Of the toxic species of this order, the typically marine species *Lyngbya majuscula* Harvey ex Gomont is found which is also represented in the plankton in the form of separate filaments.

Nostocales in Azerbaijani sector of the Caspian Sea include a considerably smaller number - 10 species of 3 families - *Tolypothrichaceae* Hauer, Mareš, Bohunická, Johansen et Berrendero-Gomes, *Aphanizomenonaceae* Elenkin, *Nostocaceae* Agardh ex Kirchner and 7 genera - *Tolypothrix* Kützing ex Bornet et Flahault, *Anabaenopsis* (Woloszyńska) Miller, *Aphanizomenon* Morren ex Bornet et Flahault, *Chrysoosporum* E. Zapomelová, O. Skácelová, P.Pumann, R.Kopp. & E.Janecek, *Dolichospermum* (Ralfs ex Bornet & Flahault) P. Wacklin, L. Hoffman & Komárek, *Nodularia* Mertens in Jurgens ex Bornet et Flahault, *Anabaena* Bory ex Bornet et Flahault. According to species diversity the family *Aphanizomenonaceae* is distinguished - 8 species. *Nostocales* is represented by a small number of species but plays an important role in the life of the sea, in phytoplankton. Some species as *Aphanizomenon flos-aquae* are found in Azerbaijani sector of Sea and known for their toxicity. Under favorable conditions every year at the end of summer it causes the "blooming" of water. Developing massively in the Northern Caspian it penetrates into the Middle and Southern Caspian and extends along the western coast. In the period of intensive reproduction algae is toxic to fish, all aquatic animals, it can cause conjunctivitis in humans and irritates the human skin [6]. Species of *Anabaena flosaquae* (*Brébison* ex Bornet et Flahault), *Nodularia spumigena* Mertens ex Bornet et Flahault also belong to toxic species that can cause "blooming" of water. The second forms toxin nodularin, which acts on fish and prevents the development of caviar [2,12]. Local "blooming" of water in the form of small spots in the life of the sea plays a positive role, as its waters are enriched with biogens. But strong "blooming" often leads to deterioration of the quality of water and ultimately leads to the death of animals. In humans, poisoning with these types of toxins develops an allergy, conjunctivitis and food intoxication [3,12]. With prolonged use of water and fish from water bodies exposed to intensive "blooming" of water, a person becomes ill with diseases as "Gaffian" or "Yukovsky-Sartlan", during which kidneys, nervous and muscular system are affected, movement functions are disrupted, that often leads to fatality [2,13]. The toxins of blue-green algae are several times superior to such poisons as curare and botulin.

The most often encountered species: from the genera *Chrysoosporum*-*Ch. bergii* (Ostenfeld) E. Zapomelová and others, *Ch.minor* (Kiselev) Komárek; *Anabaenopsis* - *A. cunnigtonii* Taylor, *A. tanganyikae* (G.S.West) Woloszyńska & V.Miller; of the genus *Nodularia* 2 widespread, halophilic species - *N. harveyana* (Thwaites) Thuret, *N.spumigena*. *Nodularia spumigena* lives mainly in the northern part of the Caspian Sea, rarely in the Middle and South but *Nodularia harveyana* occurs frequently throughout the entire water area of the sea.

Thus, so far, 41 species (43 intraspecific taxa) of *Hormogoniophyceae* of 2 orders- *Oscillatoriales*, *Nostocales*, 6 families, 6 subfamilies and 19 genera have been recorded in the plankton of the Azerbaijani sector of the Caspian Sea. The leading position occupies *Oscillatoriales* - 31 species (33 intraspecific taxa) belonging to 3 families, 6 subfamilies and 12 genera. *Nostocales* is represented by the smallest number -10 species of 3 families, 7 genera but representatives of this order play an important role in the life of the sea.

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Impact of climate change on sea level, bioresources, biodiversity, marine invasive species, ecology and food web: Past, present, and future

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Abstract

Caspian is the largest enclosed brackish inland water system, rich in oil and gas, with salinity up to 13.7 percent, experiencing significant changes in water level and embodying diversified habitats from vast river systems to extensive wetlands. The presence of large shallow areas pose a potential threat to biodiversity and especially endemics in the sea. Its biodiversity together with the coastal zone make it one of the most valuable ecosystems in the world. Biological endemism rate in the Caspian is extremely high. Most important species is the sturgeon, with a standing stock of 85 percent. Illegal and overfishing are dramatically reducing its population size. Loss of spawning grounds and nesting sites follows the sea-level changes. Pollution and introduced species are also effective. Caspian lies on the crossing of migration routes of millions of migrating birds and offers refuge to a number of rare and endangered ones. Threats like regulation of its rivers are leading to a loss of reeds, cattail and bushes, as well as aquatic and coastal fauna. A detailed ecological survey of the coastal and marine species and habitats, their uses, values and threats, all along the Caspian Coast is needed. Some anadromous and semi-migratory species have been deprived of their natural spawning grounds.

Keywords: Inland Waters, Caspian, Biodiversity, Invasive Species, Ecology

Introduction

A series of changes in the planet’s characteristics have been identified as a consequence of a warming climate. Some of these include an increase in global surface temperatures (0.4 to 0.8 °C); an increase in precipitation; an increase in the intensity and frequency of El-Niño events and a decline in Arctic sea-ice extent. The impacts of climate change on wetlands will come from alterations in hydrological regimes, including the frequency and severity of extreme events; increased temperature and altered evapotranspiration rates, altered biogeochemistry. Major impacts to inland waters include warming of rivers. Species in small rivers and lakes are expected to be more susceptible to these changes than those in large rivers and lakes. It may also affect the wetland carbon sink. The combined effect of climate change and human-induced alterations to the aquatic systems has not been studied in detail. The extent of biodiversity loss or dislocation from inland water habitats will be difficult to discern from other existing pressures. Large-scale changes to these habitats will result in changes of species composition. The vegetation zones and species will change in response to temperature and other impacts, the extent of such change is however unknown. Most apparent faunal changes will possibly occur with migratory and nomadic bird species that use a network of wetland habitats across or within continents. The cross-continental migration of many birds including the Caspian is at risk of being disrupted by changes in habitats. We will focus here on the sea level, biological resources, biodiversity, marine invasive species, ecology and the impact on the food web in the Caspian Sea under this context.

Study Area

This data published by several researchers listed in the references part was evaluated in this study in the light of latest findings, together with other different investigations undertaken on the Caspian.

Some Ecological Characteristics of the Caspian Sea

It is located in an inland depression on the border of Europe and Asia, as the largest enclosed sea in the world, with a catchment area of 3.5 million km². The Caspian Sea is reported to have got separated for the first time from the Black Sea in the early Pliocene. The primary marine fauna was therefore partly eliminated and partly modified. The typical brackish-water Caspian fauna formed then and has persisted till now. It can be divided into the northern, shallow part (5-6 metres deep) covering 80 000 km², a middle part (average 190 m) covering 138 000 km² and a southern part (up to 1 025 m) covering 168 400 km². The northern shoreline is strongly undulating and includes the deltas of the Volga, Ural, Emba and Sagiz rivers. The middle and south Caspian shorelines vary, ranging from narrow beaches fronting seacliffs to broad sandy regions. In the south relatively smooth western coast is composed of small grained sands and silt. Another important feature of the Caspian is its changing water level. It has significant effect on its biodiversity. The level is below that of the World Ocean, highest - 22 m has been reported to have reached nearly 38 000 years ago, but may have been as low as - 64 m. In the last century the level fluctuated around - 26.2 m, later decreasing to - 29.0 m. Some regression have been observed from 1995 onwards, the level currently stands around the -28.8 m. Almost 130 rivers of various sizes drain into the Caspian with an annual input of about 300 km³. The cold arctic air, moist sea air masses forming over the Atlantic Ocean, dry continental air masses from Kazakhstan, and warm air masses coming from the Mediterranean Sea and Iran determine the climate of the Caspian.

Biodiversity Status in the Caspian

The Caspian is a productive sea with 22.7 million tonnes of primary production of organic carbon a year in the northern parts, 50.9 in the middle and 41 million tonnes in the south. Its coastal zone shows diversified range of habitats from vast river systems to extensive wetlands makes it one of the most valuable ecosystems in the world. Many endemic taxa are present here showing high endemism together with representatives from almost all major groups on earth. Its diverse flora and fauna shows high natural productivity. It lies at the crossing of migration routes of millions of migrating birds and offers refuge for a number of rare and endangered species. Most important element of the fauna is the sturgeon. Several indigenous species are found in the middle Caspian because of its relative stability over time, salinity regime fluctuating between 0.12 to 10 percent and central location. consequently the highest number of endemic species are found there. However, the North Caspian This part shows the greatest diversity of habitats and species. The Volga River system is accepted as the ancient route for the penetration of Arctic and Mediterranean species, still found in the Caspian. One comes across different ecological niches with high species diversity. Nearly 379 species from 13 different classes of animals contribute in the bottom macrofauna. In the north the benthic fauna is less diverse than in the middle and south. There are approximately 76-126 species of fish belonging to 17 families. Two species, the flounders and a mullet are the introduced aliens. The origin of pipefish and a sand-smelt is unknown. Most diverse are the families of goby, carp, herring and sturgeon. The local rare endangered species are; Caspian lamprey, spiny sturgeon, Volga herring, Caspian salmon, and few others. The four primary groups of fishes are; sea, anadromous, semi-migratory and river fishes. Out of a total of 466 bird species, 120 are nesting, 68 are wintering and 278 are migratory or summer residents. Marine birds include gulls, cormorants, pelicans and flamingoes, congregating along the coast. The Caspian seal is the only mammal within the aquatic fauna. Thousands of Caspian seals have died during the last two decades, most probably due to canine distemper virus infection. Nearly 450 taxa of phytoplankton have been recorded, all a mix of marine, brackish and freshwater forms. A total of 315 zooplankton taxa have been reported as the representatives of Arctic, Mediterranean and endemics. The algal taxa are represented by approximately 64 species from green, red and brown algae. The new algal species introductions from the Black Sea is recorded as to have started with the opening of the Volga-Don canal in 1954.

Potential Biosources of the Caspian and Impact of Pollutants on Food Web

The fish populations have suffered significant changes during the past 5 decades due to human activities, fisheries and habitat alterations. Traditional Caspian sturgeon is well known for its valuable caviar. The Caspian held more than 85 percent of the world's sturgeon nearly 40 years back, but has decreased dramatically from 30 000 tonnes to approximately 5000 tonnes.

The level of contamination in the sea has increased during the last 4 decades. The reason being anthropogenic activities because, the entire drainage basin contributes towards this. Nearly 80 percent of the total load of contaminants directly enters through river flow, atmospheric input, groundwater flow and direct input. Major sources are, untreated waste from industry and agriculture along the Volga River, offshore oil and gas production, processing, extraction and transportation, and marine dumping. All these drastically effect the biological processes in particular growth of fish. The dam constructions have already changed the hydrology of the Caspian. These have seriously effected the biodiversity, in particular a reduction in the spawning grounds for some fishes. The delta vegetation too has changed. There has been a loss of reeds, cat's tail and bushes. This loss has lead to a loss of aquatic and coastal fauna. Several anadromous and semi-migratory species have been deprived of their natural spawning grounds.

Invasive species

Their damaging effects are increased by the near isolation of Caspian. Species reach here through the Volga-Don canal, but cannot leave as easily, predators too cannot be easily introduced. This places the Caspian at risk. This invader feeds on fish eggs and larvae. It will have significant effect on the fish population in the Caspian. The comb jellyfish can survive the salinity levels of Caspian, it was first recorded here in 1999, presumably after introduction through ballast waters of oil tankers. Its large blooms are observed in the northern and central parts of the Caspian.

Almost no specific data about the timing, routes, and means of species migrations. Most likely, migration occurred as a result of direct or indirect human activities because the Caspian Sea lies along the ancient caravan routes of the Silk Road that connected Europe and Asia. Some species are weeds of agricultural fields: *Sonchus arvensis*, *Convolvulus arvensis*, *Solanum nigrum*, *Chenopodium album*, *Acroptilon repens*, etc. These species likely entered the territory with grain and fodder as well as during agricultural development of the region in the 20th century. For the two *Xanthium* species that originated from the Americas, *X. strumarium* is widespread and usually is in waterways in the Caspian region. *Xanthium spinosum* initially was rare after introduction, but it is becoming more abundant now in disturbed habitats. Along the Caspian coast, this species prefers well drained habitats along roads, wetlands, and canals. In addition, *Amaranthus albus* and *A. retroflexus* have invasive features. Anthropogenic disturbance complicate natural ecological processes, and new alien species have the potential to reach the area through accompanying increases in transportation, trade, and economic activity. Monitoring of alien plants is an important task for the future.

Discussion

The diversity of inland waters and habitats is a complex subject because of several constraints, as well as differences in classification and terminology. Their temporal aspects of ecosystem diversity are especially difficult to quantify (Revenga, 2003). The climate changes in future are expected to lead to an increase in the temperatures together with a modification in the precipitation regimes. This will lead to an increase in the sea level. Inland waters will get their share from all these changes however, they are not considered adequately in many of these scenarios. The occurrence, structure, pattern, process, and function of these waters will undergo variations by the changes in temperatures, hydrology, biogeochemical cycles, and evapotranspiration. All these will lead to a shift in the species distribution, altering community structures and species interactions. These changes will contribute to the changes in carbon storage, trace gas emission, biogeochemical variation, and changes in species composition .

Major threats to these ecosystems are; land reclamation for food production as well as infrastructure construction, water abstraction for irrigation and industrial as well as domestic uses, disconnection from parent rivers, overuse of resources, eutrophication and pollution and invasive species. These threats will include increases in temperatures, changes in the total amount and distribution pattern of precipitation, and sealevel rise. The dominant drivers of change affecting aquatic ecosystems include rise in water temperature and hydrological changes, followed by an increase in the nutrient loading and salinization. In some cases temperature increase will end up with an extinction of characteristic species. The biotic communities in standing waters will cause an increase in the frequency of stratification periods, productivity and algal blooms together with eutrophication. Other factors include invasions of exotic species and the exploitation of aquatic biota such as harvest of fish, crustaceans and other organisms, as well as fibres from the reeds. Freshwaters mainly in Asia are increasingly used for aquaculture, effected by eutrophication, pollution, escape of cultured organisms to the wild and spread of diseases as well as local habitat changes, acidification, salinization, organic pollution, genetic disruption and toxic stress (Janse et al., 2015).

Caspian is the largest enclosed brackish inland water system, rich in oil and gas, with salinity up to 13.7 percent, experiencing significant changes in water levels and embodying diversified habitats from vast river systems to extensive wetland systems. The presence of large shallow areas, pose a potential threat to biodiversity and especially endemics in the sea. Its biodiversity together with the coastal zone make it one of the most valuable ecosystems in the world. Biological endemism rate in the Caspian is extremely high, with a large number of representatives from almost all major phyla on earth. It abounds in diverse flora and fauna with high natural productivity. Most important species is the sturgeon, with a standing stock of 85 percent from the world's sturgeon population. Illegal and overfishing are dramatically reducing the sturgeon population. The loss of spawning grounds and nesting sites follows the sea-level changes. Pollution and introduced species are also effective. The Sea lies on the crossing of migration routes of millions of migrating birds and offers refuge to a number of rare and endangered birds of the world ornithofauna. The threats like regulation of its rivers, leading to a loss of reeds, cattail and bushes, as well as aquatic and coastal fauna are needed. A detailed ecological survey of the coastal and marine species and habitats, their uses, values and threats, all along the Caspian coastal areas is needed. Some anadromous and semi-migratory species have been deprived of their natural spawning grounds. An inventory of its ecological resources must be prepared in detail to develop the strategies for the management of transboundary biodiversity, including threatened or endangered migratory species.

The Caspian Sea is a unique ecosystem, but is facing enormous pressure from several anthropogenic stressors. It is facing a multitude of ecological challenges like; industrial and biological contamination, sea level fluctuation, fisheries overexploitation, management failure and collapse of commercial fish stocks, illegal fishing and poaching, invasion of *Mnemiopsis leidyi*, eutrophication, loss of biodiversity, and environmental mismanagement. Moreover, the Caspian Sea environment and bio-resources have been - and will be - inevitably exposed to on-going global climatic changes which is still a largely-ignored issue in the management in this region.

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Diversity and Abundance of Zooplankton in Surface Offshore Waters of the South Caspian Sea

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Keywords: Plankton- Cladocera- Copepod- Diversity- Abundance

Introduction:

The Caspian Sea is the biggest land-locked saltwater lake in the world with a catchment area of 3.5 million km² (Mamaev, 2002). It is located between 36° N and 62°N. The basin of Caspian Sea is divided into three distinct physical regions: Northern, Middle, and Southern Caspian. The northern Caspian that only include the Caspian shelf is very shallow and accounts for less than 1% of the total water volume. The middle Caspian accounts for 33% of the total water volume. The southern Caspian is the deepest with oceanic depths of over 1000 m and accounts 66% of the total water volume. (Kosarev and Yablonskaya, 1994; Aladin and Plotnikov, 2004). Environmental conditions in the Caspian Sea significantly changed under the impact of human activities. Caspian Sea has significantly altered during the past 30 years, apart from natural changes attributable largely to sea level variability (Rodionov, 1994). Anthropogenic pollution is a significant threat on the biodiversity of the Caspian Sea (Salmanov, 1999; Aladin and Plotnikov; 2004). Impacts on the ecosystem notably are from domestic pollutants including various detergents, industrial pollutants, especially heavy metals and agricultural pollutants, in particular nutrients owing to over fertilization and pesticides. The faunal composition of Caspian Sea has changed totally during last decades (since 1970) because of its water level fluctuations, human manipulation and the entrance of an alien invasive species of a Ctenophore jellyfish.

Material and Methods:

The study was carried out in offshore water of south Caspian Sea (Fig. 1). One transect with 8 stations were selected. The distance among sampling stations was 30 km. sampling was conducted in winter season (April 2014). Samples collected in both day and night [7 stations at day and in 1 station (S₅) at night].

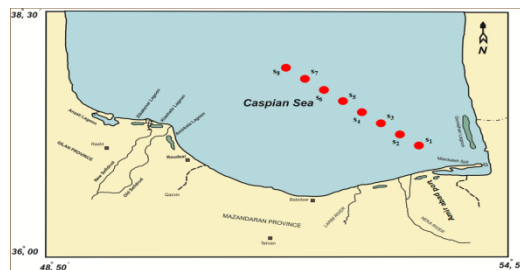


Figure 1. Map of sampling stations in the south Caspian Sea waters.

Samples were collected by zooplankton net (100 μm mesh with a 0.36 m mouth diameter) by vertical hauling from 10m depth. After collecting, specimens were preserved in a 4% formaldehyde seawater solution. In the laboratory samples were studied in a Bogorov tray contained 0.5 ml of each sample. Biomass of zooplankton was estimated from the shape of each species (Petipa 1957) and an invert microscope was used for identifying them.

Results:

Physico-chemical parameters of sea water are shown in (Fig. 2). In this study a total number 4 Holopelankton and 6 meroplankton were identified, including: (*Acartia tonsa* and Nauplius of *A. tonsa*; Copepoda – *Asplanchna priodonta*; Rotifera – *Podon polyphemoides*; Cladocera - Larvae of *Nereis diversicolor*; Nereididae - Cypris, nauplius and cirrus stages of *Balanus improvises*; Cirripedia - Lamellibranch larvae; bivalvia and Fish larvae). As shown, *Acartia tonsa* has the highest abundance at station 5 ($1545 \pm 181 \text{ ind.m}^{-3}$) followed by Nauplis of *A. tonsa* ($1168 \pm 232 \text{ ind.m}^{-3}$) at the same station. The lowest abundance belongs to Cypris of *Balanus improvisus* ($64 \pm 22 \text{ ind.m}^{-3}$) at station 4. Among all stations, $S_{5/N}$ has the highest abundance of total zooplanktons ($426 \pm 524 \text{ ind.m}^{-3}$) and S_8 has the lowest abundance of total zooplanktons ($43 \pm 48 \text{ ind.m}^{-3}$).

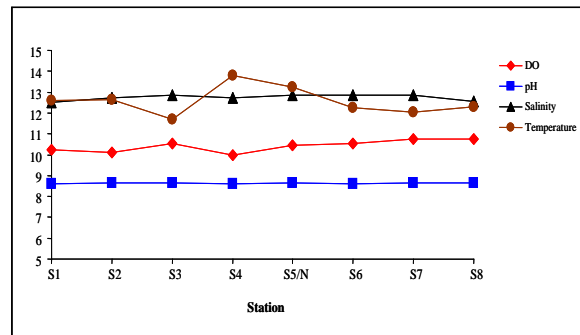


Figure 2. Physico-chemical parameters measured in all stations.

Discussion:

In this study the abundance, biomass and species composition of zooplankton in the southern part of Caspian Sea were investigated. The last station (S_8) was very close to border of south and middle Caspian. Based on our results, abundance of zooplankton significantly correlated with the physico-chemical parameters of water, except in the case of pH. While, this correlations did not found for copepods, and they did not showed significant correlation with any of measured parameters. It seems that after invasion of *M. leidy*, composition and abundance of zooplankton in south Caspian Sea waters greatly changed. Some of the species have been vanished from ecosystem and some others have been dominant. Generally, invasive ctenophore deeply affected on planktonic community and ultimately on total food chain of Caspian Sea.

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Investigation of elements of water balance of lakes of Shchuchinsko-borovsky resort zone in conditions of climate change.

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Keywords: Water balance, air temperature, precipitation, evaporation and lakes.

Introduction

The calculation of the water balance of the main lakes in the Shchuchinsk-Borovoye resort zone (Burabai, Shortan and Ulken Shabakty) and its elements over a long period, revealing changes in the water balance of lakes at the beginning of the 21st century compared with the second half of the 20th century under conditions of climate change is considered. The lakes of Kazakhstan from the point of view of economic interests are one of the most important sources of natural resources. Their waters are widely used for water supply of various kinds, fishing, chemical industry and other purposes. In connection with the newly created socio-economic and political conditions, the development of international relations and tourism, the interest of the local population and foreign citizens to use the lakes of the Republic as places of treatment and recreation has increased. These circumstances require a detailed hydrological study of the lakes for their rational, integrated use and protection.

Materials and methods

The aim of the work is to calculate the water balance of the main lakes in the Shchuchinsk-Borovoye resort zone and its elements over a long period, to reveal changes in the water balance of lakes in the early 21st century in comparison with the second half of the 20th century and the reasons for the changes. Methods used in the work:

- restoration of passes by the analogy method;
- analysis of difference-integral curves of annual precipitation sums, average annual air temperature and humidity deficit;
- construction of communication curves;
- the method of water balance for blind lakes.

Meteorological and hydrological data of Kazakh Hydrometeorology Service were used in the work.

Results

The carried out researches of the lakes Shortan, Burabai and Ulken Shabakty showed that by the beginning of the 21st century, under the conditions of climate change in the water balance, there were significant changes, namely, evaporation from snow and water surface of lakes. The temperature rises by 1..1.5 0 C, which increases the deficit of air humidity.

Kazakhstan is a country with a scarcity of water resources, the Shchuchinsk-Borovoye resort zone is of national importance. Calculations carried out during my work show the state of the water balance of lakes and give grounds for implementing measures to preserve the beautiful corner of Kazakhstan.

Discussion

Lakes Shortan, Burabai and Ulken Shabakty are located in the north of the Akmola region of the Republic of Kazakhstan, they are included in the system of lakes Shchuchinsko-Borovskoy resort zone (SHBKZ). In addition to these reservoirs, this system includes: Kishi Shabakty, Qatarkol, Zhukey, Maibalyk, Tekekol, Karasye and Sulukol. In 1956, seven out of ten lakes, including Shortan, Burabai and Ulken Shabakty, were surveyed during the work of the virgin and fallow lands development expedition in Northern Kazakhstan [1]. Systematic observations of the level of the ShchBKZ lakes at the beginning of the 21st century were made only on the lake. Shortan, Burabai and Ulken Shabakty. Lakes of SCBKZ are drainless, the number of flowing lakes is small [1]. The state of the lakes is mainly determined by climatic conditions: the amount of precipitation and the amount of evaporation depending on the temperature and humidity deficit. Figure 1 shows the difference-integral curve of the annual precipitation sums for the Shchuchinsk meteorological station for 1935 ... 2017.

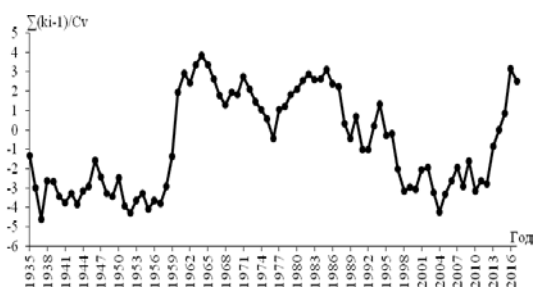


Figure 1 - Difference-integral curve of the annual precipitation sums of the weather station Shchuchinsk for 1935 ... 2017.



Figure 2 - Difference-integral curve of the mean annual air temperature of the weather station Shchuchinsk for 1935 ... 2017.

The curve in Figure 1 indicates the absence of certain, both positive and negative trends, changes in moisture. Figure 2 shows the difference-integral curve of the mean annual air temperature for the weather station Shchuchinsk for 1935 ... 2017. During the analysis of the integral curve, shown in Figure 2, 3 periods were identified:

1. The first period of 38 years (1935. 1973) is 1.030C, which characterizes the climatic conditions of the mid-20th century;
2. The second period of 20 years (1974 ... 1993) is 1.470C, shows the increase in the average annual air temperature during the transition to a new climatic period;

3. The third period of 19 years (1994 ... 2014) - 2,030C, which characterizes the increase in the average annual air temperature in the late 20th century and the beginning of the 21st century.

The difference-integral curve of the average annual air temperature shows a trend of an increase in the average annual air temperature by 1.0 ... 1.5 ° C. In a modern climate, an increase in air temperature over a warm period leads to an increase in water temperature and evaporation from the water surface of lakes. The results of calculating the water balance of the lakes Shortan, Burabai and Ulken Shabakty are given in Table 1.

Table 1 - The main characteristics of the water balance of Lake Shortan in the middle of the 20th century and at the beginning of the 21st century

Characteristics of water balance	In the middle of the 20th century		in the early 21st century		Change	
	Layer per lake area, mm	Volume, million m ³	Layer per lake area, mm	Volume, million m ³	mm	million m ³
Inflow of water from the catchment and water exchange through the lodge of the lake	390	7,25	281	4,00	-109	-3,25
A stock of water in the snow on the surface of the lake at the beginning of the spring snowmelt and precipitation falling on the surface of the lake during the period from the beginning of snowmelt to the beginning of freezing	290	5,40	351	5,00	61	0,40
Evaporation from the water surface of the lake during the period from the beginning of snowmelt to the beginning of freezing	680	12,65	726	10,1	46	-2,55

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Identification and Comparison Sea Cucumber Species in the Northern Coast of the Persian Gulf in Different Seasons

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Key words: sea cucumber, spicules, Persian Gulf

INTRODUCTION

Sea cucumbers are a diverse group of echinoderms belongs to class Holothuroide, that traditionally consumed as a food with high nutritional value and for medicinal purposes such as inflammatory conditions, in Asia (especially in East Asia, as China, Japan, and South Korea) and the Middle East for many years (Trinidad-Roa 1987; Canicatti & Roch 1989; Hawa et al. 1999; Castro & Huber 2000; Mamelona et al. 2007; Purcell et al. 2010; Wen et al. 2010; Al Marzouqi et al, 2011; Bordbar et al. 2011; Salarzadeh et al, 2012; Wijesinghe et al, 2013; Purcell et al. 2014a, b).

Considering few studies conducted to this context on sea cucumbers in the Persian Gulf, thus further studies will be need for better understand of these organisms, which due to vastity and high diversity of the Iranian coast of the Persian Gulf and Oman Sea, more new species will be identified. The important aim of this research was to identify rocky shores sea cucumber species in the northern coast of the Persian Gulf with compare of the internal skeletal structure. The other goal of this study is to evaluate influence of physiochemical factors on frequency and density of these species.

MATERIAL AND METHODS

Four physiochemical factors including temperature (°C), salinity (ppt), dissolved oxygen (DO mg/l) and pH were measured during the four season spring, summer, fall and winter, using digital multimeter model SP701. Measurement of these factors was in three replicates at each station.

Specimens of the sea cucumbers were collected at all seasons 2012, in the intertidal rocky shores of the Persian Gulf. According to vast area of the Persian Gulf, were selected and examined 6 stations and in each station 3 transects perpendicular to the coast, coverage all tidal zone (table 1 and Figure 1). Transects position was determined using GPS devices. Sampling was carried out in the highest tidal range, and during lowest tide. Using of quadrat, is one of the methods for counting individuals in biological communities. For investigation on sea cucumbers has been used of this method in many studies (Al-Rashdi et al. 2007; Ceesay et al. 2012; Dereli et al. 2015). In this research, Specimen collection on each transect was performed by quadrat 10×20 m² (Conand et al. 2005).

RESULTS

Temperature, salinity, DO and pH as 4 environmental factor were investigated. The average temperature values measured in season's spring, summer, fall and winter were $32.60 \pm 2.32^\circ\text{C}$, $37.13 \pm 1.98^\circ\text{C}$, $27.45 \pm 2.00^\circ\text{C}$ and $25.76 \pm 2.41^\circ\text{C}$, respectively. There was significant differences for temperature in different seasons (Kruskal-Wallis, $P < 0.05$). Maximum and minimum temperature, respectively detected in summer and winter with values $39.40 \pm 0.17^\circ\text{C}$ and $21.60 \pm 0.19^\circ\text{C}$. The average salinity amounts were measured in different seasons $42.68 \pm 0.10\text{ppt}$ (spring), $44.48 \pm 0.17\text{ppt}$ (summer), $41.32 \pm 0.15\text{ppt}$ (fall) and $42.03 \pm 0.09\text{ppt}$ (winter). Kruskal-Wallis test show significant differences for salinity among 4 season ($P < 0.05$). The highest salinity values were observed in spring ($45.72 \pm 0.16\text{ppt}$) and lowest in summer ($39.82 \pm 0.16\text{ppt}$). The highest and lowest DO were recorded in winter ($13.78 \pm 0.16\text{ mg/l}$) and summer ($5.88 \pm 0.16\text{ mg/l}$), respectively. The mean DO values in four season spring (10.73 ± 2.09), summer (9.57 ± 2.93), fall (11.30 ± 1.69) and winter (11.51 ± 1.09) were calculated, which detected significant differences between different seasons (Kruskal-Wallis, $P < 0.05$). Maximum and minimum pH were recorded in Nayband Gulf (8.99 -winter) and Bushehr (8.19 - summer), respectively. Mean pH for 4 season was estimated 8.52 ± 0.18 (spring), 8.44 ± 0.17 (summer), 8.68 ± 0.17 (fall) and 8.60 ± 0.29 (winter). There was no significant differences for pH in different seasons (Kruskal-Wallis $P < 0.05$).

In this study, were observed two species of sea cucumbers *Holothuria parva* and *Holothuria arenicola* during different seasons. Both species belongs to the Genus and Orders *Holothuria* and *Aspidochirotida*, respectively. *H. parva* (Kraussin Lampert 1885), has a fusiform body with dark green color to black, that live in the intertidal zone under rocks. During the study, the species have been observed at all sampling of Dayer port and Bostaneh Port stations, while were not observed in Bushehr and Nayband Golf stations in the spring season. Mean frequency for parva was 18.54 individual in 200 meters. Number of their legs was smaller and fewer in dorsal body surface (papillae) compared to ventral surface (pedicle). Mouth of *H. Parva*, is located in abdominal position, and anus is the type of terminal. They have bar-shaped spicules with small thorns in body wall. Their feet have small spicules similar spicules in the body wall, and also other type of spicules like to perforated plate. In Tentacles, also be observed bared spicules. Noteworthy, Length of radial plates in calcareous ring is greater than their width. This species, mostly distributed in the Indian Ocean. *Holothuria arenicola* (Semper 1868) usually have seen filthy white, but sometimes has been accessed to the yellow and red colors. In this species on the dorsal body surface can be seen two rows of black spots. Another characteristic of this species is medium size, cylindrical shape body with two narrow end, central mouth and terminal or subterminal anus. Calcareous rings were relatively large and thick, and length of radius plates more than plates between the radius. The species distributed in the Western Indian Ocean, Red Sea, Persian Gulf, the Maldives, Bay of Bengal and Hawaii. Mean frequency of this species detected low in different seasons and all stations (mean frequency: 2.29 in 200 meter). In Tables 2 to 6, brought shape and type of different spicules in various body pieces of two species *H. parva* and *H. arenicola*. Clearly can be seen differences between two species studied in term of type and shape of their calcareous ossicles.

DISCUSSION

In this study, were observed two species of sea cucumber from the northern Persian Gulf coastal tidal zones. Both species observed in the study area, belongs to *Aspidochirotida* order and *Holothuriidae* family. Relative abundance of *H. parva* was so much more than *H. arenicola*. According to the findings and observe *H. parva* in research conducted by Heding (1940), this

species have a stable and favorable stock in the study area. Characters such as bed type, light intensity, energy levels, food availability, salinity fluctuations, presence of predators and conspecific adults of the major factors and variables which affect the distribution of sea cucumbers (Mercier, 2000). Additionally, high mortality rate of sea cucumbers during the initial establishment is also considered as another factor affecting the presence of sea cucumbers.

Generally, in terms of appearance and morphological can be seen specific differences in calcareous spicules of different body parts in two species of sea cucumber. There are different methods for identification of sea cucumber species including molecular phylogeny (Uthicke & Benzie 2003; Uthicke et al. 2004; Džeroski & Drummb 2003), morphology of species (Cherbonnier 1980, Conand 1990; Dubrovskii & Sergeenko 2002), spicules and skeletal characteristics (Cherbonnier 1980; Conand 1990; Uthicke et al. 2004); which all these methods are useful for identification in the most cases. Investigations on fresh samples with fixed samples, did not show any specific structural changes in the structure of spicules. The highest frequency and distribution of spicules in *H. arenicola* related to Mensal, Buttony and Barbed, respectively. While, the most abundance spicules in all body parts of *H. parva* was Barbed wire rod, and no observed any mensal spicules. Accordingly, in addition to appearance and morphological characteristics of these sea cucumbers, for convenience to identification they can be used of their Bone structures (calcareous ossicles); because both species in all sections investigated represent considerable difference in spicules type and shape.

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Invasive micro-organisms and Harmful Algal Bloom of Caspian Sea in Iranian waters and their effect on the environment (a mini review)

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Abstract

Invasive species are factors thought to be contributing to ecosystem stress, loss of biodiversity and depleted fisheries. Invasive species have direct and indirect impacts on many ecosystem components, including productive fisheries and the economy. In the last two decades various invasive micro-organisms have affected the Caspian Sea and have impacted certain amount of loss on the environment and other species such as fish, zooplankton and phytoplankton. Some of the invasive species introduced to the Caspian Sea include the cyanobacteria *Nodularia spumigena* and the Ctenophores *Mnemiopsis leidyi* and *Beroe ovata*. The occurrence of this phenomenon in the Caspian Sea is important and indicates an alarming signal on the well-being of the Caspian environment and leads to mass mortality of Caspian seals and fish species, as well as the sharp decline in sturgeon stocks.

Key words: Invasive species, harmful algal bloom, Caspian Sea, *Nodularia spumigena*, *Mnemiopsis leidyi*

Introduction

The Caspian Sea, the largest landlocked body of water in the world with an area of 386,400 square kilometers and 7,250 kilometers of coastline is under severe environmental threats. The southern Caspian water basin with an area of 17,700 square kilometers (7% of the total Caspian water basin) provides about 5% of incoming waters to the Caspian Sea. The rapid growth of population in the Caspian water basin is one of the factors threatening its aquatic biota. Algal blooms in the south Caspian Sea were previously reported. In 2005 a bloom of the cyanobacteria *Nodularia spumigena* extended over an area of 2 km². Bloom of *Nodularia spumigena* appeared as masses of cotton like opaque filamentous algae easily visible to the naked eye with 90% of the algae being *N. spumigena*. The occurrence of Bloom of *Nodularia spumigena* in the Caspian Sea is important and could indicate an alarming signal on the well-being of the Caspian environment. It is possible that the formation of algal blooms in the Caspian Sea is related to other phenomena like mass mortality of Caspian seals and fish species, as well as the sharp decline in sturgeon stocks (CEP, 2006).

In addition to *Nodularia spumigena*, other species such as the Ctenophores *Mnemiopsis leidyi* and *Beroe ovata* also had an invasive bloom history during late 1990's (1999) and early years of 2000 (2001-2004) (Roohi and Sajadi, 2011). In the early 1980s, the comb jelly *Mnemiopsis leidyi*, a ctenophore that normally resides off the eastern United States, was accidentally introduced into the Black Sea via ballast waters from cargo ships. This voracious zooplanktonic predator (with extremely high rates of reproduction and growth) reached enormous biomass levels (a few hundred million tons for the entire basin!) devastating the pelagic (i.e. in water column) food chain in the entire Black Sea basin by the end of 1980s (Vinogradov et al., 1989). One of the dramatic consequences of the *M. leidyi* invasion was the sharp drop (from about 630,000 tons in 1988 to steadily 150,000 tons in 1991) in commercial catches of planktivorous fish (mainly the anchovy *Engraulis encrasicolus* L.) in the Black Sea (Kideys 1994; Prodanov et al., 1997). The yearly economical damage to the fisheries sector alone were estimated to be about

250-500 million USD during this period. *M. leidy* did not only affect the quantity of animals but also of plant organisms, known as phytoplankton. A warning that *M. leidy* might also invade the Caspian Sea had been voiced during the Geneva meeting as well as by Dumont (1995). Unfortunately, at the end of the 1990s the invasion of *M. leidy* in the Caspian Sea was already being reported (Esmaeili et al., 2000; Ivanov et al., 2000; Roohi, 2000). It must have also been transported in the ballast waters of ships traveling from the Black Sea (salinity 18 ppt) to the Caspian Sea (max. salinity 13-14 ppt) through the Volga Don Canal. Investigations in the Caspian Sea showed by September 2000, it was found everywhere including the northern Caspian where the salinity can be as low as 4 ppt (Shiganova et al., 2001a).

Materials and Methods

During the cruise samples were collected. Afterwards, the laboratory analysis of the samples was conducted and the complete data on hydro-chemical status of the samples was obtained. Also, the phytoplankton samples from the scientific cruises were analyzed and their biomass was determined.

Ctenophore samples were collected with an METU (Medalist Technology University) net having a mouth opening of 0.2 m² and a screen with a mesh size of 500 m, from the same depths as the Juday net (Vinogradov et al., 1989; Kideys et al., 2001). On completion of each tow, the cod end was immediately passed into a container and ctenophores counted by eye. The body length of each individual with lobes was measured lying flat (out of water) onboard, and the density of *Mnemiopsis leidy* (per m² and m³) was calculated from the net diameter and tow depth. The ctenophores were sorted in length groups of 5-mm intervals to determine the abundance of different size groups. Length measurements were converted to wet weight using an appropriate equation (Kideys et al., 2001). Samples of *Mnemiopsis* were collected from 20001 along few semi- transects perpendicular to the Iranian coast of the Caspian Sea.

Results

The ctenophore *Mnemiopsis leidy* was found at all stations from 2001–2009. There was a seasonal succession of ctenophore densities every year, the maximum being observed in August and September, and the minimum density in the winter months. A significant correlation was found between the water temperature and the abundance of *Mnemiopsis leidy* ($P < 0.005$) (Fig. 1).

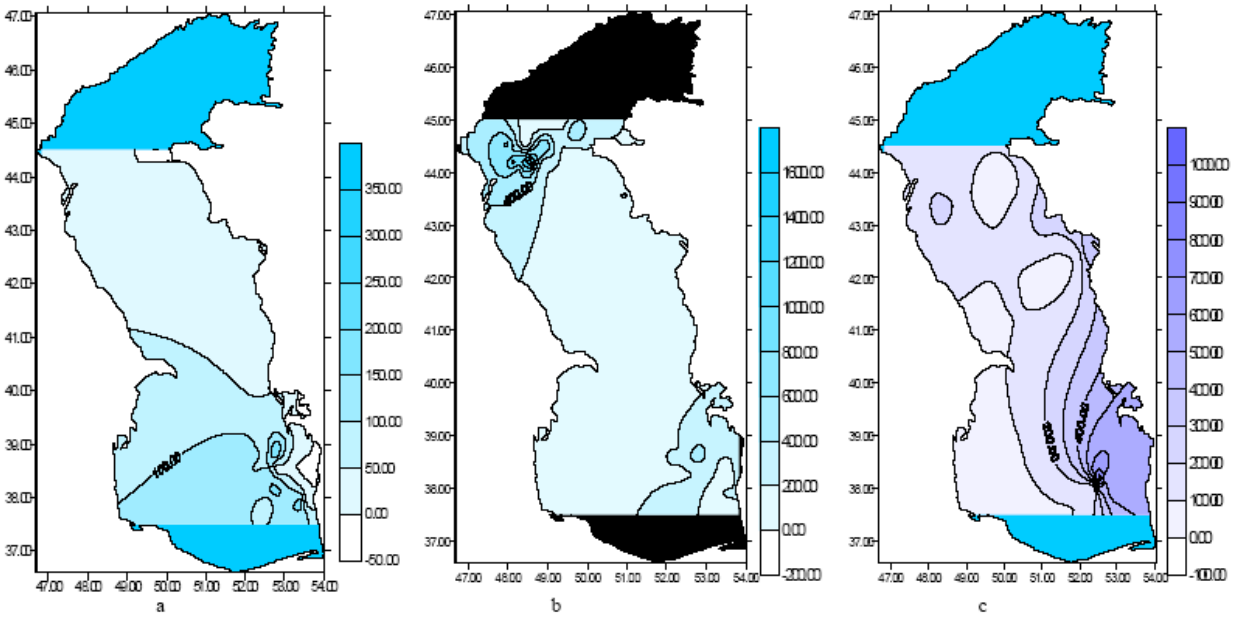


Fig. 1. Seasonal distribution of the Caspian population of *Mnemiopsis leidyi* (ind.m³) in 2003 (shiganova et al., 2004)

The highest summer– autumn average of *Mnemiopsis leidyi* abundance was observed in 2002 (760 ± 1148 ind.m³), although the biomass during this period (23.2 ± 23.3 g.m³) was lower than in 2001 (41.5 ± 44.3 g.m³). In addition the zooplankton and phytoplankton species were affected by the bloom. The highest monthly mean phytoplankton abundance and biomass were $396 \times 10^6 \pm 299 \times 10^6$ cells m⁻³ in January 2002 and $1,789 \pm 1,761$ mg m⁻³ in May 2002. Minimum abundance and biomass values were observed in August 2003 ($1 \times 10^6 \pm 1 \times 10^6$ cells m⁻³ and 7 ± 5 mg m⁻³).

An unprecedented bloom of the toxic cyanophyte *Nodularia sp.* was observed between the second half of August and the end of Ecosystems Biodiversity 188 September in 2005. The bloom area covered $\sim 20,000$ km² (CEP 2006). According to the sampling on 20 September 2005, in addition to *Nodularia sp.*, another cyanophyte *Oscillatoria sp.* was also high in abundance. Abundance of *Nodularia sp.* was 18×10^6 cells m⁻³ at 7 m depth and $1,006 \times 10^6$ cells m⁻³ at 20 m depth. Average cyanophyte abundance and biomass at 7 and 20 m depths were 582.9×10^6 cells m⁻³ (of which 512 cells m⁻³ was *Nodularia sp.*) and $1,655$ mg m⁻³ (Fig. 2).

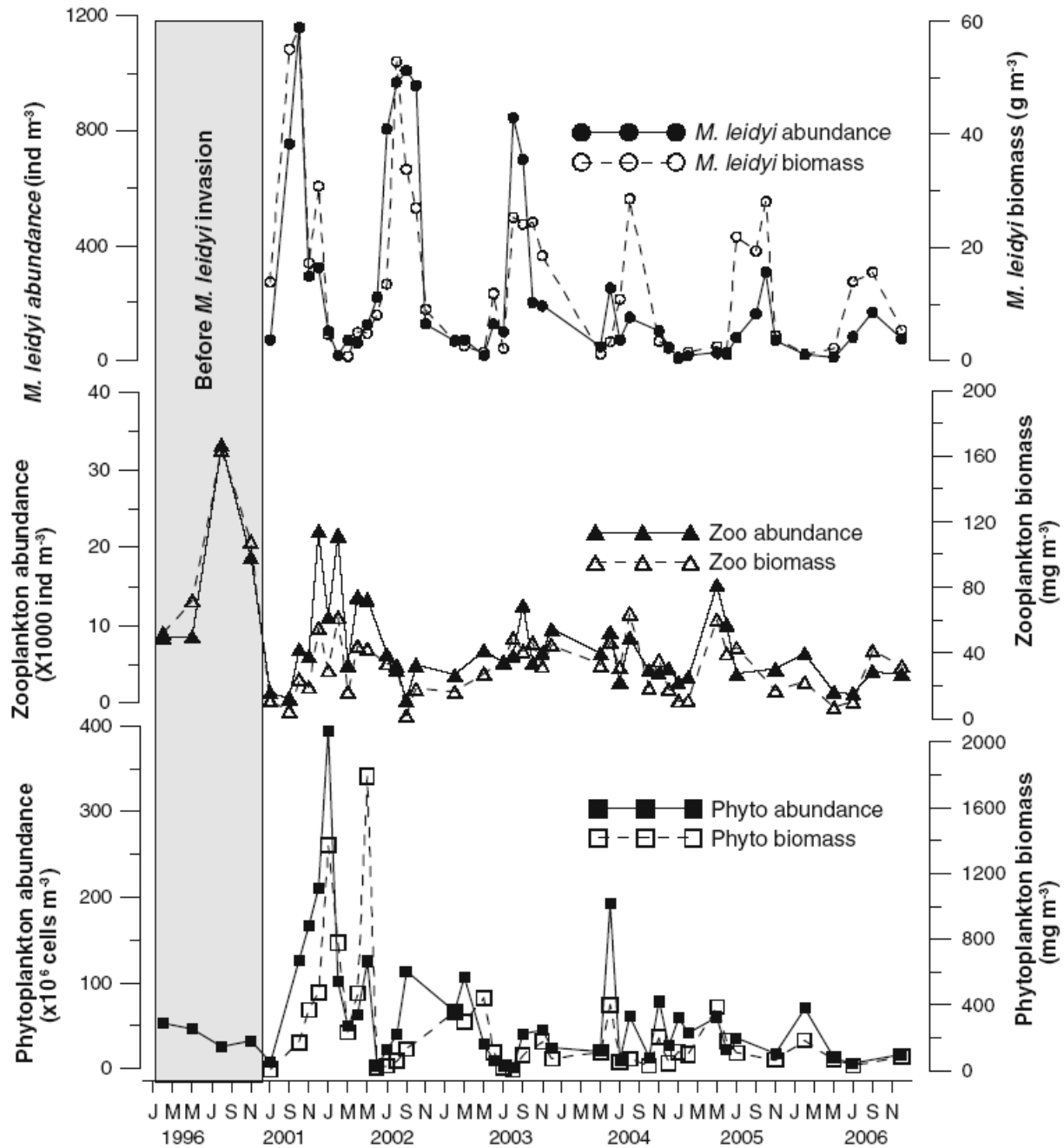


Fig. 2. Annual variations in the abundance and biomass of phytoplankton, zooplankton and *Mnemiopsis leidyi* in the southern Caspian Sea during 2001–2006 (values are depth and station averages). 1996 values are from Hossieni et al. (1996), spring 2001 values are from Kideys et al. (2001).

As known, microorganisms compete with each other for nutrients and oxygen more than natural situation during a bloom occurrence; since the population of the species has increased some even struggle to survive. The different group of zooplankton species before and after the *M. leidyi* invasion has been depicted in Table 1.

Table 1. Species number of zooplankton before and after *Mnemiopsis leidyi* invasion in the Southern Caspian Sea (Roohi and Sajadi, 2011).

Zooplankton group	Before <i>Mnemiopsis</i> Hossieni <i>et al.</i> (1996)	After <i>Mnemiopsis leidyi</i> invasion					
		2001	2002	2003	2004	2005	2006
Copepoda	7	3	3	3	3	2	4
Cladocera	24	0	1	1	1	1	1
Merozooplankton	5	5	11	9	7	7	8
Total	36	8	15	13	11	10	13

Discussion

According to the reports of Iranian Fisheries Research Organization, the algal bloom of *Nodularia spumigena* was first seen at northwestern waters of Gilan Province and then it moved towards Anzali and Nowshahr Ports. The observed algal bloom was quite large and covered an area of 150 square kilometers from Anzali to Nowshahr Ports. The calm sea conditions and appropriate water temperature (25 degrees Centigrade) contributed to its formation (CEP, 2006).

A review of *Mnemiopsis* investigations of the Caspian Sea over the last decade (Roohi and Sajadi, 2011).

After *Mnemiopsis* invasion into the Caspian Sea via the ballast water from the Black Sea and/or the Sea of Azov in 1999 (Roohi et al., 2008a), some objectives of this alien ctenophore was taken into account in several local or national projects such as follows:

- Distribution and abundance of *Mnemiopsis leidyi* in the Caspian Sea (Iran- Russia - Azerbaijan)- in 2001-2004 and 2009
- Feeding, respiration, reproduction of *Mnemiopsis leidyi* in the Caspian Sea- in 2001-2009
- Comparative feeding study of *Mnemiopsis leidyi* and *Kilka* in the Caspian Sea- in 2003 -2004 and 2008/9
- Zooplankton and phytoplankton changes after ML invasion

The situation in the Black Sea has been one of the most striking examples in marine bioinvasion history. Due to scale of the problem, UNEP intervened and gathered international experts in Geneva in 1994, for investigating methods for solving this problem (GESAMP, 1997). The futility of physical and chemical methods for this problem were noted and therefore, biological control seemed the only workable remedy. And, based on the literature knowledge of feeding specificity, another ctenophore species (*Beroe ovata*) rose as the best candidate for dealing with *M. leidyi* problem. Indeed, *B. ovata* reported feeding only on other ctenophore species (Kremer and Nixon 1976), most notably on *M. leidyi*. However, scientists from the Geneva meeting could not stress on using a new predator species for Ecosystems Biodiversity.

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Plankton and benthos of the Caspian Sea under different hydrometeorological conditions

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Key words: North Caspian, water renewal, phytoplankton, zooplankton, zoobenthos, abundance, biomass

Introduction

A few years ago several organizations lead by KaspNIRKh Research Institute created a database of hydrobiological observations for the northern part of the Caspian Sea. The database covers the period of 1961-2012 and is aimed at the study of impact of natural and anthropogenic factors on the status of biological communities, feasibility studies for exploration and development of oil and gas fields and assessment of vulnerability of this highly productive ecosystem to oil spills etc. (Kolmykov et al., 2016)

Throughout 1961-2012, the hydrological conditions in the North Caspian changed dramatically several times: in 1961-1977 the sea level fell by more than 0.5 m; in the following 17 years it rose fast by almost 2.5 m, and throughout 1996 - 2012 it fell again by about 1.0 m. In line with the morphometric dependency relation (Caspian Sea..., 2009), the volume of North Caspian water throughout this period varied from 315 to 532 km³, its area ranged from 741 to 109 thousand km², and the volume of the Volga runoff varied from 166 to 333 km³ (according to CASPCOM catalogues of the surface runoff).

To study the impact of hydrological conditions on the North Caspian plankton and benthos, we suggest using the index "rate of North Caspian water renewal" (Asaeva, Kashin, 2018) which is the ratio of the Volga flow volume (W , km³) to the volume of North Caspian water (V , km³). The objective of the study is to look into the relationship of this index (W/V) to the dynamics of plankton and benthos of this sea part.

Materials and methods

The study is based on the data on abundance and biomass of phytoplankton, zooplankton and zoobenthos in the western part of the North Caspian for 24 sectors evenly distributed in the studied water area, including the shallow zone (less than 5 m), the slope (5-10 m) and the steep coast (more than 10 m). The study is based on the data received during the high-water season (May- June). The median (Me) and the mean arithmetic value (X_{mean}) of abundance and biomass were calculated for every year if the data for at least 12 sectors were available. The median was required due to asymmetric distribution of hydrobiological data in the time series, when the mean values of X_{mean} and Me diverged. The use of both values facilitates the characteristics of the compared aggregates. Both values (X_{mean} and Me) were then averaged for the above mentioned time periods (1961-1977, 1978-1995, 1996-2012), characterized by different hydrological conditions in the Caspian Sea.

Results of the study

Within the considered time period, the Volga flow annually renewed 0.34- 0.88 of the North Caspian water volume. The fastest water renewal rate was recorded in the 70-80s of the past

century against the background of the sharp Volga runoff rise and the relevantly low sea level and, consequently, the low volume of the North Caspian water (Fig. 1). A rapid growth of the sea level throughout 1978-1995 was accompanied by the decrease of water renewal rate, which was typical for the considered period as a whole, but in 1961-1977 and in 1996-2012 was not so pronounced. The main reason of reduction of the water renewal rate in these years was the reduction of the Volga runoff.

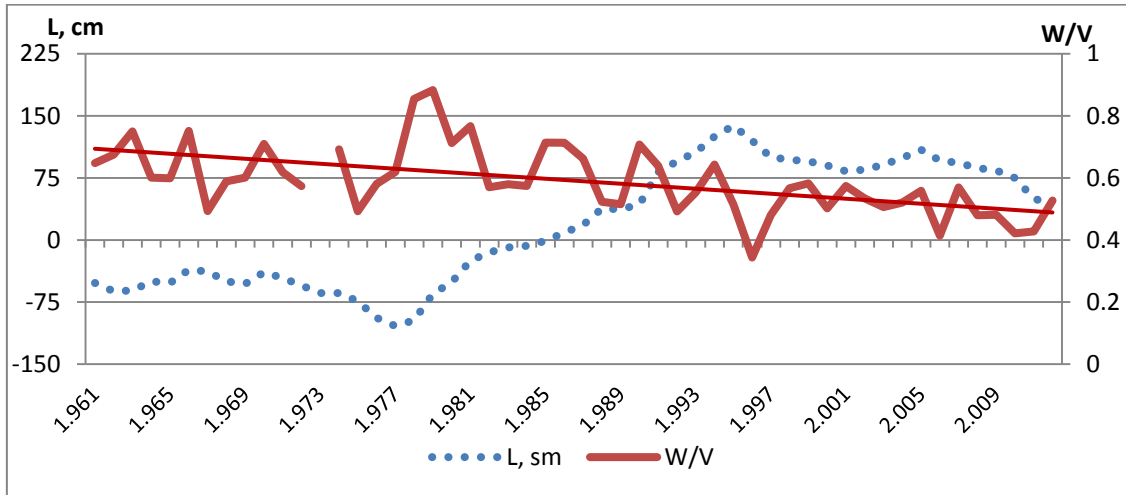


Fig. 1 - Changes of the Caspian Sea level (L, cm) and the rate of North Caspian waters renewal (W/V. cm, text) in the period 1961-2012.

The data presented in Table 1 point to the gradual growth of phytoplankton abundance in the western part of the North Caspian Sea during the flood period. Phytoplankton abundance growth in the period of 1996-2012 was accompanied by the growth of its biomass as compared to the sea transgression period (1978 - 1995). However the highest value of phytoplankton biomass was recorded during the period of low sea level (1961-1977), when the large-cell diatomic algae dominated in the biomass formation (Caspian Sea..., 1985). The abundance and biomass of zooplankton in the north-western part of the Caspian Sea during the flooding periods of 1996-2012 were significantly higher than in 1961-1977, but the highest values of zooplankton abundance, as well as its biomass (as per the median value) were recorded in 1978-1995. There was a slight difference between the second (1977-1995) and the third (1996-2012) periods as per average zooplankton abundance and biomass. Moreover, the arithmetic mean of biomass in the third period was higher than that in the second (due to rarely occurring high values, i.e. "spotty" distribution).

Periods	Abundance		Biomass	
	Me	X_{mean}	Me	X_{mean}
Phytoplankton, m specimen/m ³ , mg/m ³				
1961-1977	107.7	269.1	704	1590
1978-1995	161.2	377.9	274	638
1996-2012	197.6	450.5	573	1406
1961-2012	170.9	397.1	457	1089
Zooplankton, thousand specimen/m ³ , mg/m ³				
1961-1977	24.6	45.6	127	292
1978-1995	48.8	99.7	239	636
1996-2012	31.2	85.9	213	689

1961-2012	33.1	73.5	186	518
Zoobenthos, thousand specimen/m ² , g/m ²				
1961-1977	6.94	11.32	36	88
1978-1995	15.62	22.81	63	124
1996-2012	5.44	9.23	19	141
1961-2012	9.7	14.94	41	117

Table 1 - Abundance and biomass of plankton and benthos in the western part of the North Caspian Sea during the flooding period in 1961-2012 under different hydrological conditions

In contrast to zooplankton, the abundance and biomass of zoobenthos in the western part of the North Caspian during the flooding period in 1996-2012 were significantly lower than those in 1961-1977 (if the biomass dynamics is estimated by the median). Similarly to zooplankton, the highest values of zoobenthos abundance and biomass were recorded in 1978-1995. We should note that the highest arithmetic mean of the biomass was recorded in the third period, whereas it was by an order higher than the median, which points to the extremely uneven distribution of the benthic organisms - occasional accumulations against the relevantly scarce background.

Further research was aimed at the study of impact of North Caspian water renewal rate on the dynamics of abundance and biomass of plankton and benthos. For this purpose, the time series of the biological parameters were ranged by water renewal rate (in the ascending order). Judging by the lack of statistically significant trends in the ranged series of phytoplankton abundance and biomass, we can conclude that its quantitative development is irrelevant of the water renewal rate.

The zooplankton abundance and biomass series ranged by water renewal rate display diagram peaks at the minimal, average and maximal renewal rate (Fig. 2). This points to the existence of three ecological zooplankton groups, which quantitative development is accelerated at a certain water renewal rate.

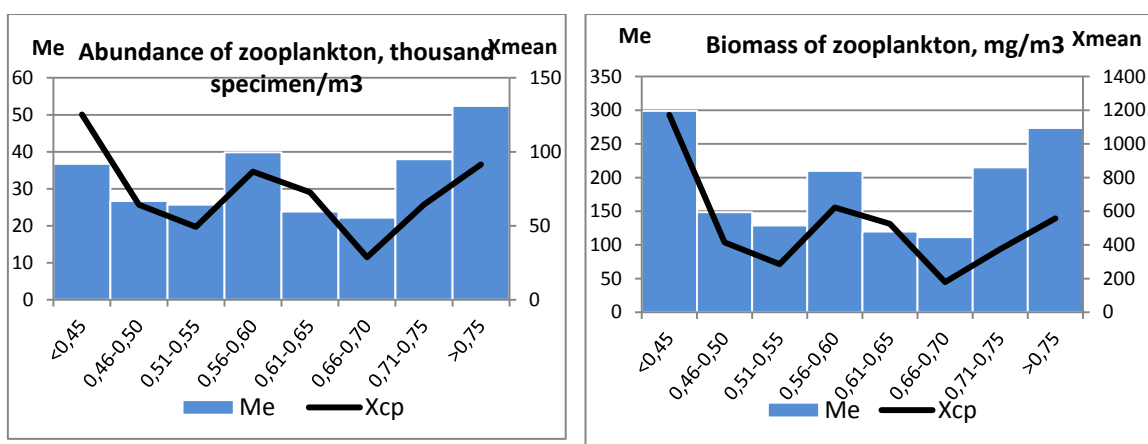


Fig. 2 - Changes of zooplankton abundance and biomass in the north-western part of the Caspian Sea in 1961-2012 depending on the water renewal rate (its values are plotted along the X axis).

The series of zoobenthos abundance and biomass ranged by the water renewal rate clearly show that its quantitative development grows with the increase of the water renewal rate. As for zoobenthos biomass, this dependence refers only to the median (Me), and the changes of X_{mean} of the zoobenthos biomass were of the opposite nature. The highest value of X_{mean} was

recorded at the minimal rate of water renewal and it decreased with its growth (Fig. 3). If we consider the difference between X_{mean} and Me as an indicator of heterogeneity of zoobenthos distribution, then this heterogeneity was the most pronounced at the minimal water renewal rate and levelled off with its growth.

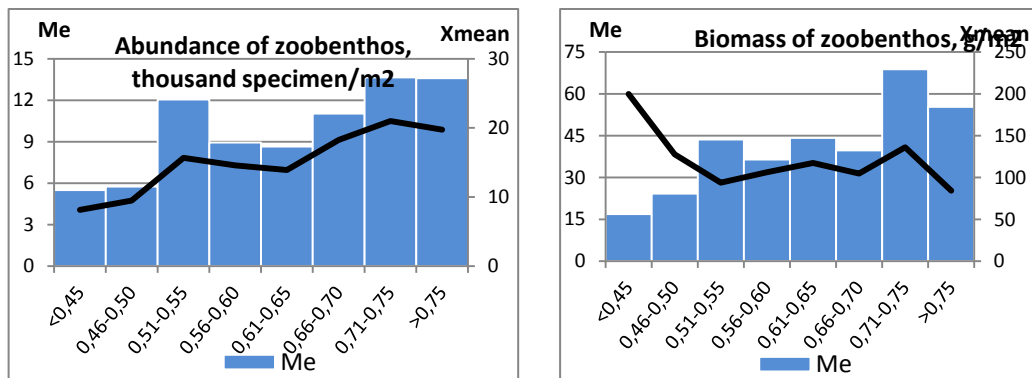


Fig. 3 - Changes of zoobenthos abundance and biomass in the north-western part of the Caspian Sea in 1961-2012 depending on the water renewal rate (its values are plotted along the X axis).

Discussion

Some characteristics of the long-term dynamics of abundance and biomass of plankton and benthos in the western part of the North Caspian still have no definite explanation (Caspian Sea..., 1986). Having studied the causes of the long-term changes, we extended a number of factors which can affect the status of plankton and benthos. One of these factors is the rate of North Caspian water renewal.

The results presented above show that this rate obviously does not affect the abundance and biomass of the phytoplankton in the western part of the North Caspian during the flooding time. The dependence of zooplankton abundance and biomass on the water renewal rate is of complicated nature. To look into this nature, zooplankton should be subdivided into separate ecological groups.

The direct dependence of zoobenthos abundance on the rate of water renewal proves the fact that allochthonous organic substance plays an important part in zoobenthos feeding (here, the abundance and biomass median should be considered). On the contrary, the decrease of water renewal rate promotes the formation of rare and dense accumulations of zoobenthos. Thus, the more abundant the benthos is, the poorer are its local accumulations and vice versa. The abundance and distribution of zoobenthos in the western part of the North Caspian during the flooding period depend on the water renewal rate.

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THEME II

Climate And Hydro-Meteorological
Features Of The Basin

Assessment of the changes in average wind speed in the south Caspian Sea, due to climate change

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Keywords: CMIP5, CORDEX, RCP, climate change, Caspian Sea

Introduction

Caspian Sea is the biggest enclosed body of water on Earth, with approximately 7000 km coastline, a surface area of 371,000 km², and a volume of 78,200 km³. It also bordered by five countries including Iran. The Caspian Sea can be subdivided into three distinct physical parts, the northern, middle and southern parts. The southern and middle parts are characterized as deep water, with a depth more than 1000 m in the southern region and 500 m in the central region. The Northern part is also known as shallow water with average depths of less than 5m (Kostianoy et al. 2008; Kroonenberga et al. 2000). Climate change causes global warming and consequently changes meteorological conditions, wind field characteristics, wave and ocean currents dynamics, and sea level variations. The increasing awareness of the hazards related to climate change impacts on coastal zones and the need for impact assessment, mitigation and adaptation strategies have been driving the development and implementation of several climatological modelling efforts at global to regional scale (Slott et al., 2006; Tol et al., 2008; Nicholls, 2011). This allowed to draw some estimates on possible changes in different features, such as temperature and precipitation patterns (Giorgi et al., 2004), wave storminess, surge hazard (Benetazzo et al., 2012; Conte et al., 2014) and sea level fluctuations (Ardakanian & Alemohammad, 2008). The capability of capturing wind climate variability over a decadal time scale is crucial for providing a realistic quantification of wave dynamics and coastal sediment transport processes, identifying possible erosional and depositional hotspots and setting intervention priorities for coastal management (Bonaldo et al., 2015).

There is a large number of studies within the last few years assessing the impacts of climate change on wind patterns and sea wave regimes such as Mori et al. (2009), Kamranzad et al. (2013), Alinejhad-Tabrizi et al. (2017) and Davy et al. (2017), using different global or regional climate models, which illustrate increasing or decreasing of wind speed in different areas in the world. However, the studies on the effects of climate change on the wind field over the Caspian Sea are limited. In the context of climate change, this study assesses the impact on the wind field along the southern part of the Caspian Sea. For this purpose, wind characteristics obtained based on *CORDEX* (a project for World Climate Research Program) are used based on two greenhouse gas presentative concentration pathways (*RCP4.5* and *RCP8.5*).

Materials and methods

Assessment of the effect of climate change on the wind field over the Caspian Sea was carried out in 3 points in different latitudes and longitudes in the southern part of the Caspian Sea (Fig. 1), these point are located far from the coastal areas.



Fig. 1. Study Area

Global Climate Models (GCMs) can provide prediction information on scales of around 1000 by 1000km covering what could be a vastly differing landscape (from very mountainous to flat coastal plains for example). Regional Climate Models (RCMs) and Empirical Statistical Downscaling (ESD), applied over a limited area and driven by GCMs can provide information on much smaller scales supporting more detailed impact and adaptation assessment and planning. The impacts of a changing climate, and the adaptation strategies require to deal with them on regional and national scales. This is where Regional Climate Downscaling (RCD) has an important role to play by providing projections with much greater detail and more accurate representation of localized extreme events. The Coordinated Regional Climate Downscaling Experiment (*CORDEX*) has served as a catalyst to achieve this goal. *CORDEX* wind data developed by *Max Planck* Institute for the new Earth system model (MPI-ESM) based on context of the *CMIP5* process (Coupled Models Intercomparison Project Phase 5) was used to produce the data for the historical period from 1976 to 2005 and also for the future (from 2071 to 2100) in two Representative Concentration Pathways (*RCPs*), Containing *RCP4.5* and *RCP8.5*, based on the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). The spatial and temporal resolutions were about 0.5 degree in latitude and longitude and daily average, respectively (<https://esgf-index1.ceda.ac.uk/projects/cordex-ceda/>).

Results

Variations of the daily wind speed was evaluated in the southern part of the Caspian Sea using 10m wind speed for the 30-year period 2071–2100. The evaluation was done with respect to the reference period 1976–2005 based on *RCP4.5* and *RCP8.5* scenarios obtained from *CORDEX* wind field. For this purpose, daily wind speed of *CORDEX* data were obtained and the variation was assessed using statistical analysis. This comparison was carried out in three points in the Caspian Sea (Fig. 1). These points were selected based on the spatial resolution of the models. The standard deviation, averages, maximums and minimums of wind speed were obtained and shown in table 1.

Table 1. Wind speed statistics for two periods (2071-2100 & 1976-2005)

Points		Statistical index (m/s)			
		Average	Max	Min	St Dev
A	His	4.733	22.687	0.024	2.945
	RCP4.5	4.597	21.913	0.061	2.858
	RCP8.5	4.440	19.712	0.014	2.784
B	His	4.752	20.269	0.025	2.633
	RCP4.5	4.646	19.350	0.093	2.552
	RCP8.5	4.534	17.096	0.043	2.495
C	His	3.769	16.291	0.020	2.162
	RCP4.5	3.727	18.999	0.046	2.095
	RCP8.5	3.637	14.968	0.051	2.053

Also the changes in wind directions were assessed using wind roses. Wind roses are shown in Figure 2 for all the 3 points for historical period (1971-2005) compared to the period of 2071 to 2100 base on *RCP4.5* and *RCP8.5* scenarios for future.

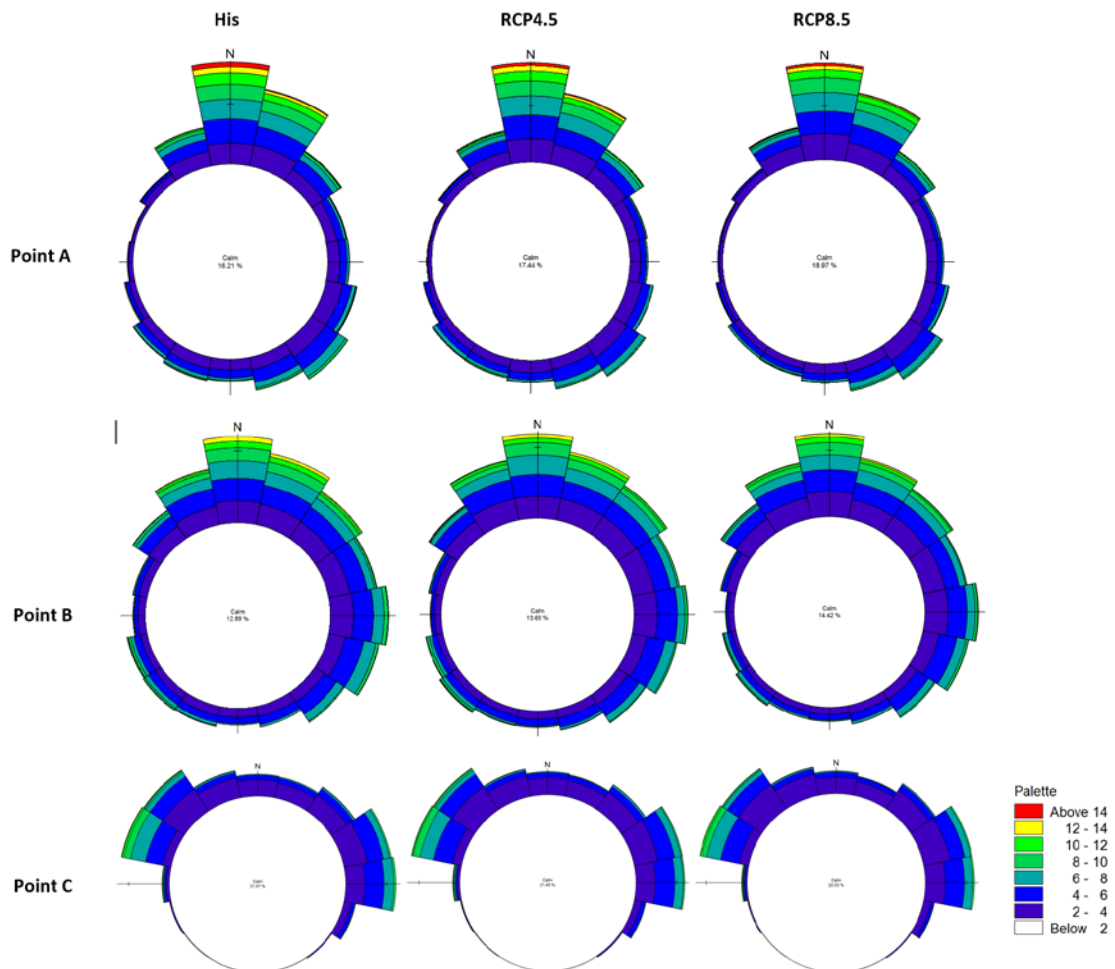


Fig. 2. Wind roses in 3 points for the period 2071-2100 compared to 1976-2005

Discussion

Assessing the effect of climate change on wind regime in the Caspian Sea, *CORDEX* wind data were compared for two 30-year period (2071-2100 compared to 1976-2005) at three points in the southern

part of the Caspian Sea. According to results (Tab. 1), the future maximum and averaged wind speed will be decreased at about 2.5% base on *RCP4.5* and about 7.5% base on *RCP8.5* at the end of the century while minimum wind speed will increase according to both future scenarios. In general, in comparison to the 1976-2005 period, in the 2071-2100 period there is an insignificant change in the average wind speed in all three points, however even small changes in average wind speeds can lead to large variations in the wave characteristics and sedimentation in the area.

Directional analysis using wind roses (Fig. 2) indicated a similar dominant direction for both time intervals of Historical (1976-2005) and future (2071-2100) base on both *RCP4.5* and *RCP8.5*. Therefore, wave direction remains mostly unchanged during 21st century due to climate change.

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FLOOD PROCESSES IN LOWLAND AREAS OF AZERBAIJAN AND MEASURES OF PROTECTION

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Key words: flood, destruction, adverse effects, factors, prevention

Introduction

Climate change at global scale is reflected in the increased air temperature, as well as the decrease and change of precipitation regime. The growth of the intensity of destructive natural events in many parts of the world is observed as well. The intensity of the occurrence of floods can be noted in particular. The scale of coverage of destructive floods as well as their negative impact is increasing. This natural phenomenon may take place at different levels in the low plains of the territory of Azerbaijan, and mostly in lower flow of Kura River, close to the Caspian coasts like Neftchala, Salyan, Sabirabad, Saatli and other regions. The main plain in Azerbaijan is Kura-Aras that occupies about one fourth part of the country's territory.

The Kura-Aras plain covers mainly the territory of the Aran economic-geographical region and has favorable economic-geographical position and situated in the central part of the Republic of Azerbaijan. The Aran region is 21.15 thousand km², accounting for 24.42% of the country's territory, while the population number makes up 1,910.4 thousand people (2014) or 20.16% of the country's population.

Driven by the natural and geographical conditions, including climate and relief properties of the Kura-Aras lowland and also the improper land use led here, floods typically happen in the spring season. Though a collector-drainage network has been established in the region, irrigation is not properly conducted, while excessive water supply toward the fields and also the drainage of collectors and the decrease in water had adverse environmental effects in the region (Babakhanov & Pashayev, 2004). Therefore, study of relevant conditions and opportunities for prevention of losses, and carrying economic and geographical researches are needed in order to develop scientifically substantiated measures and at least mitigate the effect of destructive floods in the future.

The warmness and moderateness of winter, as well as long history of the region's irrigation agriculture and pasture livestock are notable factors favoring the formation of and size of rural settlements in the area. Since the area is crossed by Kura and Aras rivers, there is a suitable condition for the development of irrigation agriculture (Musayeva, 2014). Eventually, there are big opportunities for the development of labor-consuming areas such as cotton growing, melon farming and vegetable growing. This factor favors the formation of large system of rural settlements in the study area. Part of the rural settlements in foothills and plains of the Kura-Aras lowland has been formed in the mid-20th century, and was related to the liquidation of ancient settlements in the mountainous areas of the Greater and Lesser Caucasus, as well as the movement of the population towards the plains. In the Kura-Aras lowland, the collector-drainage network has been established along with large irrigation systems. However, irrigation has not been properly managed over many years, and the excessive and irregular water supply has led to the increase in groundwater levels (Aliyeva, 2014).

Relatedly, the all above-mentioned factors contribute to the intensification of anthropogenic impact on the nature, as well as favor the occurrence of floods.

Materials and methods

The study was carried out based on comparative analysis, as well as the materials of direct observation. The past studies dealing with combating these events and reduction of related damages in Azerbaijan, including scientific justifications and thoughts, reflected in these works were considered as well. Importance of social security is grounded in order to prevent the consequences of the disaster through indicating the ways of protection of the population and economic entities from destructive natural events in the lowland areas of the country. The control measures taken against such events within the framework of governmental programs on socio-economic development of the regions are analyzed. The materials of this analysis served as a basis for proposing recommendations on mitigating the effects of floods in the low plains of Azerbaijan.

Results

It was defined that because of the flooding, in 2003-2010, associated total damages in average made up 250-300 million manats, of which 51% were accounted by agriculture, 33% by residential areas, 12% by facilities of social infrastructure, 3% by transport, and 1% by industrial areas of the region.

Along with the areas of potential flood risk, the areas that can be exposed to floods in the Kura-Aras lowland, was also determined. The number of population living in those areas was measured as well. Thus, 35553 people in Sabirabad district, 17442 people in Saatli district, 37807 people in Imishli district, 2902 people in Kurdamir district, 36299 people in Salyan district, 24286 people in Neftchala district, 25052 people in Hajigabul district, 6281 in Yevlakh district, and 27060 people in Shirvan city live in areas where floods have taken place in the past. 19,780 people in Sabirabad district, 5783 people in Saatly region, 12613 people in Imishli, 37203 people in Kurdamir, 18217 people in Salyan, 14242 people in Neftchala, 64,841 people in Yevlakh, 8726 people in Beylagan, 16757 people in Zardab, 44534 people in Goychay, and 11218 people in Bilasuvar district are residents of areas that can be affected by floods in the future.

It was found out that the floods occurring in the Kura and Aras rivers in 2010 were responsible for the damages at over 40 million manats in Sabirabad, Saatli and Imishli districts. In Shirvan city and the districts of Zardab, Beylagan, Bilasuvar and Neftchala, the corresponding figure made up about 20 million manats. The cities of Sabirabad and Saatli, as well as the villages of Ulajali and Azadkand have experienced more damages, while the least affected districts included the Salyan district, Neftchala and Shirvan cities, as well as Beshdeli and Minbashi villages.

As the carried studies show, the main reasons of the increase in the damage caused by the destructive natural events are the expansion of the lands acquired, the construction and expansion of new economic facilities in these territories, the enlarging of residential areas, and the increasing number of population. As the observations and the review of materials show, in most cases, these destructive events and processes are not taken into account, as a result of which, the material damage and the number of affected people increases.

The carried study shows the urgency of determination of the general regularities in spread and intensity of occurrence of destructive natural events and processes typical for the plain areas of Azerbaijan. The study of the possible ways of protection seems topical as well.

In the study area, the water leaked from the ground floor of the existing dams along the banks of the rivers may elevate to the surface in opposite side. As the observations show, often, the water level on both sides of the dams is equal. This situation primarily destroys the top layer of soils, washes the humus layer, and may entail destruction of buildings and installations. Even after the withdrawal of water, fertility of lands cannot be restored for years, remaining unusable for agriculture.

In order to eliminate the adverse effects of floods in the districts situated in low plains, it is necessary to strengthen safety of buildings and installations, construct buildings in higher areas, enlarge coverage of dams, as well as move the land use to special protection zones and safe locations, far from rivers.

It should be added that another natural event, seriously affecting land use in low plains areas of Azerbaijan is water level fluctuation in the Caspian Sea. Because of changes in climate, geological and geomorphological features, hydrological nature of the flowing rivers, changes in water level may occur that leads to flooding of surrounding areas and elevation of groundwater levels, enlarging actual coverage of irrigation.

Discussions

In regard to floods occurring in the Kura-Aras low plains, the measures on protection must be prepared regarding every settlement that faces threat of natural disaster. To achieve this, it is necessary to manage efficient territorial regulation of sub-sectors of the secondary industry, properly select systems of population settlement, and take into account opportunities for protection from natural disasters.

It is necessary to draw attention on the identification of the causes, areal of occurrence, origination, intensity and duration of destructive natural events, as well as associated challenges. Beside with this, the durability of economic facilities and public buildings, roads, bridges and other transport and communications systems should be checked regularly in order to be ready regarding risks of floods, mudflows, landslides, torrential rains and earthquakes. Protective systems should be established, and

protection measures should be taken if needed. Along with the general guidelines for protection from destructive natural events, the most important tasks should include also the identification, study and development of action plans towards the different sources of threat separately.

In order to minimize the impact of natural disasters on the settlement of population and economic branches, the development of conception on protection from these events should be developed at state level. In the low plain areas, every settlement, facing potential threat of flood and inundation by different scenarios must be a subject of special control. A program on their future development and protection should be developed.

To prevent and effectively manage floods in the Kura River, the previously existing water reservoirs should be re-established, and mechanisms on their efficient management should be developed. A special plan on the development of fisheries in these reservoirs should be exploited and implemented.

It is necessary to explore the amount and yearly regime of precipitations in order to reduce the damage caused by floods in the Kur and Aras rivers and regulate the flow during a period of high water. Taking into consideration the fact that the rivers are fed mainly with snow waters of mountain areas, it is necessary to increase regular observations over them.

Factors affecting the spread and intensity of destructive natural events and processes occurring in the Kura-Aras lowland must be determined.

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INVESTIGATION OF THE PERENNIAL WIND REGIME IN THE SOUTH-WESTERN AND KRASNOVODSK-CHELEKEN WATER AREA OF THE CASPIAN SEA

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Keywords: perennial, wind, direction, velocity, reiteration, distribution, connection, strong

Research water area and compilation of materials

The research areas are the central part of the Southern Caspian, which consists of the South-western and Krasnovodsk-Cheleken water areas in the synoptic-climatic zone of the Caspian Sea [6].

The main objective of the research is to determine the regime's regularity and the existence of links between the long-term winds in these water areas of the southern Caspian Sea. In order to achieve the goal, multiple annual analog wind data, compiled for the intersection points of the meridian 50, 51, 52 in the 39th parallel, were used, as well as synoptic maps and ship observation data.

The perennial wind regime of the south-western water area

The study revealed that, for a long time (during 10 years), the recurrence of winds in the 1st station of the South-western water area has been as follow: northeast 36.1%, east 9.8%, southeast 17.5%, southwest 5.6%, west 3.9% and northwest 9.4%.

Wind velocities have been observed in perennial wind speeds of up to 5-6 m/sec (38.8%). Generally, 98,8% of all winds were $v \leq 14$ m/sec and 1.0% in the range of 15-21,5 m/sec. During this period, the maximum wind speed was 21.5 m/sec, which was observed in the north and north-east directions.

During long-term period of time (10 years), there were 39 days of strong winds and 540 quiet, windless days. This means that on average, in the water area of research 3, 9 days pass in hurricane, 54 days are quiet, windless days. When we compare the annual wind regime with Sand Island, we can see that strong windy days are three time less, and quiet, windless days are 19 times more [1, 2].

Statistical analysis of perennial wind regimes on the 2nd station in the water area shows that here winds blew with a velocity of up to $v \leq 14$ m/sec (98, 6%). Repeated strong winds in the long-term period were equal to 14%. Such strong winds (expect eastern and southern directions) were observed in all direction and the maximum wind speed was close to 25.9m/sec. Generally, winds in the range of 5-6m/sec (39.2%) were observed in the research water area. It should be noted that at least (3.4%) west, and most (35.4%) northern winds have been repeated here. Winds in the north-east (16%), south-east (12.6%) and north-west (12.5%) are sufficiently observed.

The study found that for a long period of time 44 days in the water area were days of strong wind, and 560 quiet, windless days. This is an average of 4, 4 and 56 days a year.

The perennial wind regime of the Krasnovodsk-Cheleken's water area

In result of statistical analysis, it has been discovered the recurrence of winds on the directions has been as follow: northwest 28,2%, north 21,8%, northeast 12,6%, east 11,6%, southeast 11,8%, south 3,2%, south-west 4,2% and west 5,9%.

At the time of research, the maximum wind speed in the water area was about 21, 5 m/sec.

It should be noted that for ten years, in the water area there were about 36 days of strong winds and 292 days were quiet, windless days. This means an average of 3, 5 and 29 days per year [1].

Distribution of strong winds in the south-west and Krasnovodsk-Cheleken water area

The statistical analysis of strong winds observed over the long-term period in both water areas have revealed that the annual repetition of strong winds is estimated to be 4,5 days in the South-western water area and 3,3 days in the Krasnovodsk-Cheleken water area.

Scientific sources indicate that the average annual wind speed in the central part of the Southern Caspian Sea has been varied between 4-5 m/sec [3]. In result of calculations it was obtain that the average of wind speed at the eastern coast of the water area is 3,5-4,0 m/sec, in the south-east 2,5-3,0 m/sec, in Astara-Lankaran sea area is equal to 2,5-4,0 m/sec. In the western coast of the water area, replications of north-western winds are of 25-45%, and in its center, the recurrence of eastern winds in summer varies in the range of 20-50% [5].

Relationships between the wind regimes in the south-west and Krasnovodsk-Cheleken water area

Relationships between the winds regimes in the study area were conducted by statistical analysis of 3 compiled conventional analog wind speeds ranges.

It has been revealed from calculation that there is a good correlation relation between wind velocities in the 1st station and the wind velocities in the 3rd station ($r_{v,\varphi} = 0,7$). This is a sign that winds in water area are very close to one another. Another weak link ($r_{v,\varphi} = 0,54$) was found between wind directions of the 2nd and 3rd stations.

In general, there is a weak correlation between the winds in the southern part of the Caspian Sea and even the existing opposite connection is the indicator of the volatility of the wind direction in water area. In other cases, it has been derived from calculation where there is a very weak positive relationship between direction and speed. All these relationships show that the wind regimes in the water area are different.

It should be noted that the pair correlation coefficients were also calculated between the velocity and directions of strong winds (March 19-23, 1997), which lasted for a short period of time (1-3 days).

The calculations show that there is a weak relationship between the speed and direction of the winds observed at the stations.

There was a weak relationship between wind direction in the 1st and 2nd stations, and a weak relation between their speeds.

There was a very good feedback between wind speeds at 1st and 3rd stations. At the same time, there was a good correlation between the wind direction in the 2nd and 3rd stations.

According to the indications of the speed and direction of winds in the research water area, regardless of the strong winds direction, both the direction and speed changes in the Southern Caspian water area are observed, and even reverse winds are observed [1,2].

Synchronous analysis of wind regimes in south-west and Krasnovodsk-Cheleken water area

Synchronous analysis of strong winds observed in south-west and Krasnovodsk- Cheleken water area has been carried out on numerous strong winds.

It can be seen from the statistical analysis that each watercourse in the Caspian Sea has a unique wind regime.

The following results were obtained from the study:

1. In the repetition of the strong winds from the northern part of the Southern Caspian (from the Sand island), there is a gradual decline from north to south, and from the west and east to the central part of the sea.
2. In the research water area, the wind velocity weakens along the western coast (southward) and changes its direction mainly to the east. As these winds move towards the center of the South Caspian, their orientation does not change, and their speeds are weak. However, in most cases, the speed of the wind that moves toward the center of the South Caspian is higher than the wind speed on the west coast.

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Assessment of the effects of climate change on air temperature over the Caspian Sea

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Keywords: Climate Change, CORDEX, ECMWF, Caspian Sea, Air temperature

Introduction

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time. Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have been identified as primary causes of ongoing climate change. Climate change can make changes in air temperature characteristic, ocean circulation, sea ice area, species extinction and sea level. (National Research Council, 2010)

General Circulation Models (GCMs) are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations. There is a wide range of statistical and dynamical downscaling and bias-correction methods available to generate local climate projections. (Dahm et al., 2016)

The effect of climate change on air temperature has been assessed in several regions such as Central Asia (Ozturk et al., 2012), South Africa (Zhao et al., 2005) and seas like Baltic Sea (Jouni, 2017).

Currently, the Coordinated Regional Climate Downscaling Experiment (CORDEX) program, initiated by the World Climate Research Program, provides an opportunity for generating high-resolution regional climate projections, which can be used for assessment of the future impacts of climate change at regional scales using both statistical and dynamical techniques. (Giorgi et al., 2009)

This paper presents the assessment of impacts of climate change on air temperature over the Caspian Sea, by using CORDEX project data.

Materials and methods

The Caspian Sea (36° to 47° N and 46° to 54° E) is a totally enclosed, landlocked body of water on the Euro-Asian continent. (Gunduz and Özsoy, 2014)

It is bounded by Kazakhstan to the northeast, Russia to the northwest, Azerbaijan to the west, Iran to the south, and Turkmenistan to the southeast. It is 1200 Km long, 200 Km to 480 Km wide and has a surface area of 370000 Km^2 and is 28 m below sea level. (Cullen, 1999)

The natural resources of the Caspian Sea are of high economic value. There are many species of fish, aquatic birds and the Caspian seals in this area, which are sensitive to any changes in temperature.

CORDEX is a WCRP-sponsored program to organize an international coordinated framework to produce an improved generation of regional climate change projections world-wide for input into impact and adaptation studies within the AR5 timeline and beyond. CORDEX will produce an ensemble of multiple dynamical and statistical downscaling models considering multiple forcing GCMs from the CMIP5 archive. (www.meteo.unican.es)

CORDEX focuses on the GCM experiments using emission scenarios known as RCP4.5 and RCP8.5 which represent a mid and a high-level emission scenario. Ideally CORDEX simulations will span 1951 to 2100. (Evans, 2011)

In order to evaluate the impact of climate change on the variation of air temperature over the Caspian Sea, the CORDEX model results for the period of 2080-2100 with 6-hourly temporal resolution and spatial resolutions of 0.44 degrees longitude and 0.44 degrees latitude in Central Asia domain were used.

In order to know about present air temperature in the mentioned region, local air temperature was obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF), with 0.5 degree and 6-hourly spatial and temporal resolutions, respectively, for the period of 1980 to 2000.

Results

ECMWF and CORDEX air temperature data over the Caspian Sea, during the period of (1980 - 2000) were compared to assess CORDEX data accuracy. As it is shown in figure 1, seasonal average air temperature of CORDEX data is almost matching ECMWF data, in both northern and southern part of Caspian Sea.

The ECMWF and CORDEX temperature data over the Caspian Sea during the periods of (1980-2000) and (2080-2100) were also compared, in order to assess the effect of climate change on air temperature of this area. The future data have been downloaded for the RCP 4.5 scenario, which represents a mid-level emission scenario.

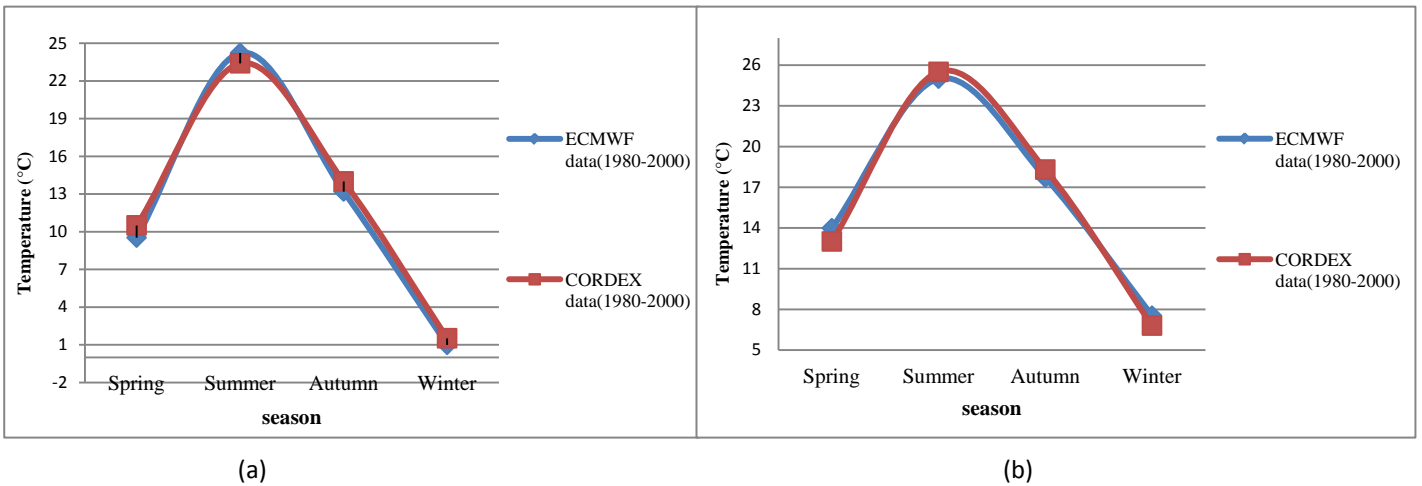


Figure 1: Seasonal average air temperature comparison in (a) Northern part (b) Southern part of Caspian Sea

Figure 2 shows the monthly average of ECMWF and CORDEX air temperature data for the periods of (1980-2000) and (2080-2100), respectively.

The graphs show the increment of air temperature in future in comparison to the present, in all months. The lowest increase in air temperature in northern part of the Caspian Sea, will occur during May-September, with the range of 0.2-1.5°C. In July the minimum change is observed with the value of 0.2°C. The maximum variation is observed in February with the value of 6.4°C.

According to graph b, in southern part of the Caspian Sea in most months of the year except February, July, September, October and December the temperature increment is not noticeable (0.1-0.7°C). The highest variation will occur in February with value of 2.98°C.

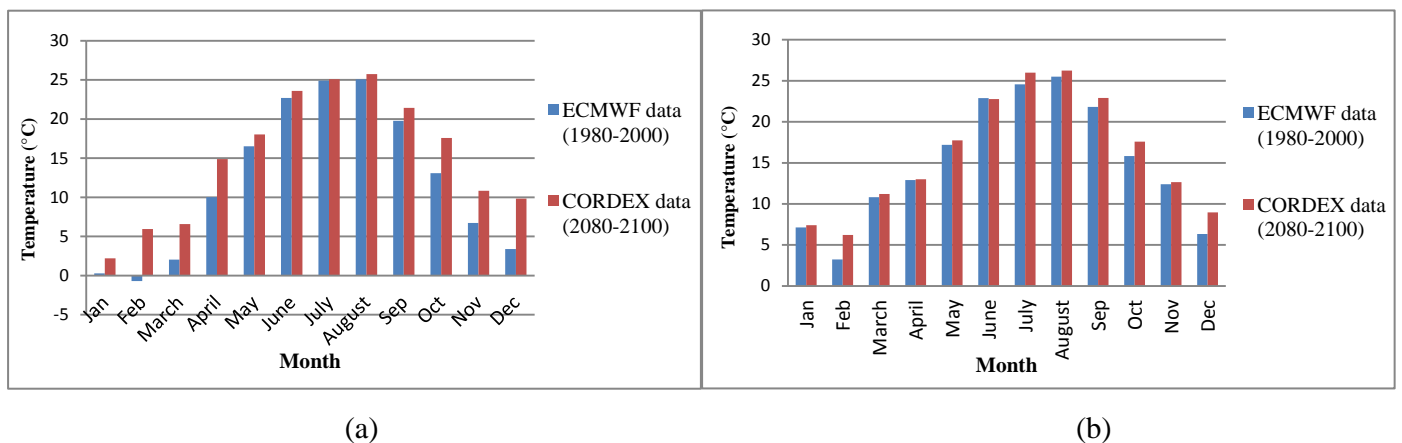


Figure 2: Monthly average air temperature comparison in (a) Northern part (b) Southern part of Caspian Sea

Discussion

Air temperature from CORDEX Project, which has downscaled CMIP5 future climate data, are used to determine the impact of climate change on air temperature over the Caspian Sea, comparing with ECMWF data for (1980-2000). Seasonal and monthly average air temperature were compared for the mentioned periods. The comparison of seasonal average air temperature in period of (1980-2000) for two sets of mentioned data, showed high accordance between CORDEX data and ECMWF data.

Results showed that air temperature in future, will have an increasing trend over the Caspian Sea. August has the highest temperature in current and future climate. In addition, the maximum value of increment in northern and southern part of Caspian Sea will occur in February with the value of 6.4°C and 2.98 °C; respectively. The minimum variation in northern and southern area will be in July and June with the value of 0.2 °C and 0.15°C; respectively. The air temperature in northern part of the area will increase more than the southern part.

This increase in air temperature in future can affect the air-sea heat exchange and will result in water temperature changes. It may also affect the wind field, wind wave field, sea level and dynamics of currents in the Caspian Sea. These side effects can be studied in future researches.

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Interannual variability of the Caspian Sea hydrometeorological parameters (the 1990th – 2017)

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Keywords: Caspian Sea level, river discharge, sea surface temperature, atmospheric precipitation, air temperature

Introduction

The Caspian Sea is the largest enclosed water basin of the world. The changes in its natural state are determined to a large extent by climatic factors and characterized by considerable interannual variability. This long-term variability of the Caspian Sea regime, as well as need of control of an ecological condition of the sea necessitates comprehensive monitoring of changes in its main parameters (sea level, sea surface temperature (SST), ice cover) as well as the determining factors (river discharge, air temperature, atmospheric precipitation, etc.). With a sharp decrease of the number of ship-borne measurements and the number of hydrometeorological stations on the Caspian Sea coast since the beginning of the 1990th, the known data systems using satellite measurements and modeling became a reliable source of regular information on various parameters of the Caspian Sea. In the present study, long-term dynamics of different hydrometeorological parameters of the Caspian Sea based on such data bases and available instrumental measurements is considered, namely, changes in sea level (1993-2017), Volga river discharge (1992-2016), SST (2003-2017), surface air temperature (2003-2017), and atmospheric precipitation (2003-2017). Trends of the listed parameters for the indicated time intervals are compared with those obtained earlier (Kostianoy et al., 2014) for the period from the beginning of the 1980s to 2009-2012.

Materials and methods

- Data on the variability of the level of the Caspian Sea and Kara-Bogaz-Gol (KBG) Bay were obtained from the DAHITI (Database for Hydrological Time Series of Inland Waters) (Schwatke et al., 2015).
- Data on annual discharge (km³) in the delta apex of the Volga river mouth are provided by L.P. Ostroumova (N.N. Zubov State Oceanographic Institute).
- The Caspian Sea monthly SST time series are produced with the Giovanni online data system using measurements with Modis-Aqua radiometer. These data are analyzed for the three regions of the Caspian Sea (Northern, Middle and Southern) and the KBG Bay separately.
- Time series of basin-averaged monthly surface air temperature and total atmospheric precipitation (mm/month) are taken also from the Giovanni online data system using MERRA-2 Model.

Results

The variability of the Caspian Sea level (CSL) according to the altimetry data of the DANITI system was traced from September 28, 1992 to March 24, 2018. The performed comparison of these data with those obtained earlier using the software of the Geophysical Center of the Russian Academy of Sciences for the period 1993-2012 (Kostianoy et al., 2014) showed that, with the same character of the interannual variability, CSL values in the DAHITI system were overestimated by approximately 0.4 m. Average rate of the Caspian Sea level decrease during the 25-year period 1993-2017 has appeared to be about -5 cm/year. The highest rate of fall of

the level of about 16 cm/s was observed in the period from 2010 to 2015. In 2016 and 2017, CSL practically was not changed. The character of the interannual variability of the KBG Bay level since 1996 (the completion of the refilling of the bay after the destroying the dam separating it from the sea) was the same as in the Caspian Sea. The level of the KBG Bay was about 0.5 m lower than in the Caspian Sea.

Annual discharge of the Volga River, which accounts for 80% of the river inflow to the Caspian Sea, during the period 1992-2016 corresponding to the period of altimetry observations of CSL changed within 68 km³ ranging from a maximum of 346 km³ in 1994 to a minimum of 178 km³ in 1996. The negative trend of the discharge in 24-year time interval was about -2.46 km³/year.

The time series of the monthly mean SST have shown that warming of the Caspian Sea and the KBG Bay, on the average, occurred in 2003-2017. Positive SST trends during this 15-year period in the Northern, Middle, Southern Caspian Sea and the KBG Bay were about 0.05, 0.07, 0.09 and 0.11 °C/year, respectively.

The trend of surface air temperature during the period 2003-2017 was found to be +0.04 °C/year. The lowest winter air temperatures were observed in the winters 2007-2008 and 2011-2012, the highest winter temperature was related to the winter 2015-2016. The highest summer temperature was observed in 2010, the lowest one was in 2009.

The trend of atmospheric precipitation during the same period appeared to be about -0.22 mm/month/year. Thus, precipitation over the Caspian Sea from 2003 to 2017 has dropped by about 10%.

Discussion

Over the 25-year period from January 1993 to December 2017, the average level of the Caspian Sea dropped at a rate of approximately 5 cm/year on the background of alternating periods of CSL rise and drop. This rate exceeds the value of -2.78 cm/year obtained for the period 1993-2012 (Kostianoy et al., 2014). In 2013-2017, CSL changed within 1.3 m from a maximum of about -26.6 m BS in 1995 to a minimum of about -27.9 m in 2015-2017. The character of the annual variability of CSL did not correspond to the interannual variability of the Volga discharge, except for a period of sharp rise in the level and an increase in river discharge in 1993-1994. The sharp drop in the level of the Caspian Sea in 2010-2015 occurred with an alternating increase and a decrease in the Volga discharge in the range from 234 to 184 km³.

During the period from 1992 to 2016, Volga discharge decreased by an average of 59 km³, which for a sea area of 371,000 km² corresponded to a mean drop in the sea level of about 16 cm. The maximum discharge of 346 km³ was observed in 1994, the minimum 178 km³ corresponded to 1996.

The trend of the amount of precipitation from January 2003 to December 2017 (-0.22 mm/month/year) turned out to be an order of magnitude greater than that determined earlier for the period 1979-2010 (-0.01 mm/month/year) (Kostianoy et al., 2014). The average amount of precipitation in 2003-2017 decreased by 38 mm/year.

Thus, both components of the incoming part of the water balance of the Caspian Sea during the period of CSL drop from 1994 to 2015 decreased. However, the proportion of precipitation in the water balance is much lower than that of the Volga River. Therefore, significant decrease of precipitation in the last 15 years (and, in particular, in the period of 2010-2015), with a relatively small negative trend of the Volga's flow in this period, does not explain the sharp drop in CSL in 2010-2015. Apparently, the main role here was played by increasing surface evaporation which is the main component of the expenditure part of the water balance. This assumption is supported by an increase in SST trend in the Middle and Southern Caspian Sea from 0.06 and 0.05 °C/year, respectively, in 1982-2009 up to 0.07 and 0.09 °C/year

during the period from January 2003 to December 2017. The warming of the Caspian Sea corresponds to global warming. According to NOAA, the five warmest years on the Earth (relatively the 1951-1980 mean) have all taken place since 2010. The decisive role of evaporation in CSL increase and drop during the periods 1979-1995 and 1996-2015, respectively, was demonstrated by Chen et al. (2017).

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THE HYDROPOWER POTENTIAL ASSESSMENT: EVALUATION OF RUNOFF RIVER RESOURCE POTENTIAL OF AZERBAIJAN

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Keywords: hydropower potential, theoretical hydropower potential, technical hydropower potential, economical hydropower potential

Introduction

Hydropower is a key source for renewable electricity generation and has an important potential to be marketed as green power. The energy of flowing water is harnessed by turbines, which are placed in the path of the water flow. It can be converted in the form of electricity through hydroelectric power plants. Hydroelectric plants are classified commonly by their hydraulic characteristics, that is, with respect to the water flowing through the turbines that run the generators (Landy, M., 2016).

The notion "hydropower potential" is utilized to evaluate the potential energy what a water stock presents. There are in use several definitions for the hydropower potential:

- The theoretical potential, with three levels:
- The exploitable hydropower potential, with two levels:
 - technical potential
 - economical potential

Hydropower's theoretical potential includes the total potential energy from all water resources within specified spatial boundaries without any physical, technical and economic usage limitations. In practice, only a small percentage of theoretical potential can be harvested (Modi, S. & Lallement D., 2009).

Hydropower's technical potential is defined as the total energy that can be generated under the technical, infrastructural and ecological constraints. Usually, technical potential ranges from 20 to 35 percent of theoretical potential. Hydropower's economic potential is defined as the energy capacity that is economically exploitable relative to alternative energy forms.

Materials and methods

The power potential of flowing water is a function of the discharge (Q), the specific weight of water and the difference in head (H) between intake point and turbine. In Equation (1), the two parameters, Q and H, need to be calculated. If Q and H are known for a given segment of a stream, the hydropower potential can easily be estimated for that segment (Bahadori A. et al. 2013).

The geometric or statistical pressure is equal to the difference between the upper ΔYB and the lower AB level:

$$H_0 = \Delta YB - AB \quad (1)$$

The water discharge Q is used to generate electricity in the m³/sec. The power is measured in N - units of work divided by time. The power measured in W(Watt).

$$P = \rho g Q H = \gamma Q H = 9810 Q H \quad (2)$$

Where, ρ -the density of water, g -acceleration of gravity, m²/san

$$P = 9.81 Q H$$

Potential hydroenergy resources (theoretical reserves) are determined by the following formula:

$$E = 8760 \sum_{i \in n} 9.81 Q_i H_i$$

Where, E is energy, in kWh; Q is average annual water consumption, m³ / s; H is the fall of the river in according section, m.

Result

55 small hydroelectric power stations were built on the small rivers of Azerbaijan in the 30s-40s of the last century. However, after the launch of the Mingachevir hydro power station in 1953, these small HPPs were essentially lost and their operation was discontinued (Imanov F.A., 2007; Rustamov S.G. & Kashkay R.M. 1989). At present, it is planned to construct new small HPPs in several rivers to effectively use alternative energy sources.

This assessment uses hydrological data from 68 observation stations on the 42 rivers of Greater Caucasus region of Azerbaijan, from 62 stations on the 34 rivers of the Lesser Caucasus region, 26 stations on the 12 rivers of the Nakhchivan and data from 39 stations on 28 rivers of in the Lankaran province. In general, hydrological observation data of 195 observation stations on 116 rivers of Azerbaijan were used. The results of the calculations are shown in Table 1 for a few river examples.

Table 1. The hydropower potential of small rivers of Azerbaijan

No	River	Station	River basin area, km ²	Rive's lengt, km	Power of the river kWt	Special power, mln kWt hour/km ²	Energy of the river, mln kWt hour	Special energy, mln kWt hour/km ²	Special power, kWt/km
1	Gusarchay	Guzun	250	34	85	340	745	2.98	2500
2	Gudyalchay	Kupchal	517	47	134.6	260	1179	2.28	2864
3	Balakenchay	Balaken	146	20	58.6	401	513	3.52	2930
4	Katexchay	Qebizdere	236	22	185.3	785	1623	6.88	8423
5	Qoshqarchay	Dashkesen	798	15	4.4	5.51	39	0.05	293
6	Gencechay	Zurnabad	314	36	62.6	199	548	1.75	1739
7	Kurekchay	Dozular	439	39	55.5	126	486	1.11	1423
8	Naxcivanchay	Bichenek	94	17	24.5	261	215	2.28	1441
9	Paragachay	Paragachay	16.3	7	4.4	270	39	2.36	629
10	Lenkaran	Lenkaran	1040	69	203.1	195	1779	1.71	2943

The total hydropower potential of all small rivers of Azerbaijan is 4.508 billion kW/hours (Table 2).

Table 2. Evaluation of hydropower potential of the rivers of Azerbaijan according to provinces

Provinces	Power of the river, mln kWt	Energy of the river, billion.kWt.h
Greater Caucasus	2,10	1.838
Lesser Caucasus	2,08	1.823
Nakhcivan	0,61	0.535
Lenkaran	0,36	0.312
Total	5,15	4.508

The main findings of the research are:

to assess the hydro energy potential of small rivers has been created (hydrological and morphometric) data base

- Hydropower potential of small rivers is estimated (5.15 million kWt).

At the next stage it is proposed to carry out the following tasks:

- Calculation of technical and economic indicators of hydropower resources of small rivers;
- Creating a hydroenergy cadastre of small rivers for each administrative district;
- Preparation of proposals for the protection of river ecosystems, when small HPPs are built on small rivers.

Discussion

However, it should be noted that the small HPPs that don't have the capacity to regulate flow are in line with the river regime. Therefore, in the dry and poor water period, such HPPs have significantly less power than the design capacity (up to zero). Such conditions create a breakthrough in energy supply of consumers. Therefore, small HPPs must be connected to local power lines fed from other sources.

Small HPPs can be built not only on small rivers, but also on irrigation canals that aren't very large. Sometimes, the small rivers are important for water economy. The use of height differences created by these points in order to obtain energy doesn't require much spending.

At present, interest in small hydropower in different countries is increasing day by day. Thus, state commissions, committees, institutions are created to conduct research to use energy of small rivers.

Rivers as traditional energy source have some advantages. The main advantage is that hydroenergy is environmentally friendly.

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Assessment of water resource use and management in Azerbaijan

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Key words: water resource, water use, water supply, irrigation, sustainable development

Introduction

It is known that our republic has limited water resources. The cause of so weak country's water supply of our Republic is unfavorable natural conditions. However, research shows that the potential water resources of our republic can afford the water needs of industry, agriculture and population. Water resources are 27-31 km³ per year. In many regions, especially in the Absheron the water shortage mainly connected with the improper use of water. The analysis shows that, each year 12 km³ water is taken from water basins and 1,1-1,2 km³ freshwater is taken from underground layers in our republic. The republic's water demand is 11.0 -13.0 km³. 20-25% of transferred water is used for industrial and domestic purposes. Volume of waste water which is thrown into water objects is hesitates about 160-170 million m³.

Efficient use of water resources is based on the principles of proper use of water resources in extreme conditions. So that, water resources assessment should be planned according to drought conditions, especially for agriculture.

Drought is an insidious hazard of nature. It is often referred to as a "creeping phenomenon" and its impacts vary from region to region. Drought can therefore be difficult for people to understand. Its impacts result from the interplay between the natural event (less precipitation than expected) and the demand people place on water supply, and human activities can exacerbate the impacts of drought. Because drought cannot be viewed solely as a physical phenomenon, it is usually defined both conceptually and operationally.

Materials and methods

According to the Azerbaijan Melioration and Water Management Company OJSC, 6430 million cubic meters of water is spent on irrigation and agricultural supply in Azerbaijan.

In 2014, about a one of third of the water supply was lost while transporting to consumers, and most of these losses are related to the water which used in agriculture. In fact, 89 per cent of the total water which supply in the agricultural sector and about three quarters of lost water can be attributed. The main reason for the losses is that, there are plenty of soil channels (especially in rural areas), which are less efficient compared to the modern infrastructure.

In order to increase efficiency in water use, rehabilitation of old pipelines in Azerbaijan (pipelines causing large losses during water transportation) will be invested; the soil canals will be cleaned every two or three years to reduce leaks, investments will be channeled to irrigation canals rather than land canals and a development plan will be developed to prevent excessive irrigation in rural areas.

According to the Azerbaijan Melioration and Water Management Company OJSC, capital investments in this field have increased in recent years, the material and technical base of the site has been significantly strengthened, rehabilitation, reconstruction and construction of thousands of kilometers of irrigation canals and collector-drainage networks has been carried out in 266,000 hectares irrigated lands, improved reclamation status in 218,000 hectares, 43,000 hectares of new irrigated areas were involved in agriculture, 1493 subartesian wells were drilled, more than 1,000 km of coastal ponds and dams were repaired in Kur, Aras and mountain rivers was held.

Results

If we talk about drought conditions limitations, the water use restriction, which reflected in world practice, should be taken into account. This includes the use of water restrictions in outdoor areas such as water use, fountains, golf courses, pools, and so on. These prohibitions may be of the following form:

- Restraining the water from the lawn
- Car washing control
- Reducing the use of recreational water, such as filling of pools and use of water entrances

- Planting of pastures, watering of sidewalks and so on.

Such prohibitions can be applied by local authorities. These prohibitions can often be applied to maintaining water for major purposes during drought. These restrictions may be of the following form:

- Single / double system, where single or double numbered addresses are used alone or in pairs on water usage.
 - Prohibition of water use can be applied on concrete days of the week
 - The use of water can be prohibited in the second half of the day, when the evaporation is more
- Implementation of more prohibition of irrigation by flooding compared to those using the drip irrigation system

Such prohibitions have been used in the practice of many countries. For example, Australia, UK, etc. Some Australian states have been banned by irrigation of lawns, irrigation by water spraying, washing machines, and pools due to lack of water. Due to this trying to be paid to the demand for water.

At the same time, limitation and development of water use in all sectors means agriculture, domestic supply, industry and so on. taking into account the water use restrictions in the water supply, as well as the proper formulation of public consciousness in the field of water use. Particularly, the full application of the water supply system, based on water legislation, promoting a clean production mechanism in the industrial sector, and the assessment of the potential for agriculture in non-irrigation farming is one of the key conditions. At present "Azersu" OJSC is using waste water which cleaned industrial area, thus saving freshwater.

In connection with the adoption of the Law AR No. 759-VQD of June 30, 2017 on Amendments in the Water Code of the Republic of Azerbaijan, the following measures are taken:

- a) Determine the rules for drawing up water economy balances on republican, water basins and administrative territorial units
- b) Approval of annual water economy balance in the compiled republic
- c) determination of water use rules in Azerbaijan

Discussion

It should be noted that one of the most commonly adopted development concepts in the world is the concept of Sustainable Development. In fact, the emergence and adoption of this concept has been linked to the UN's nature protection activities. The essence of the concept of "sustainable development" is the social, economic and ecologically normal payment of the needs of today's generations, without endangering the lives of future generations. Generally there are two types of tariff estimation methods. One of them is the tariff method currently used in Azerbaijan. In this method, the price of water is the same for all users. At the same time, various tariffs for agriculture, industry, the private sector and population are defined. This tariff is based on the company's annual maintenance and operating costs. The user is also paying for the amount of water he / she uses.

This tariff method is applied in Soviet times in Azerbaijan. However, this method is obsolete and ineffective. Currently, this tariff is improved, taking into account the population's financial situation and comparing prices in the regions. This method does not encourage the water supplier to improve quality and performance. Also, this tariff system does not allow the use of spare resources. Thus, the water user charges the amount specified in the industry and household irrespective of the use of water. Therefore, in some countries the differentiated tariff system is used. The principle of scrutiny has improved water use effectively. At present, Azerbaijan uses a similar tariff system for gas and light supply. This tariff is defined by monthly or annual norms.

Advice about professional legal and regulatory rules ought to hear in situation as management application of clean technologies, to live people in healthy natural condition, full using natural resources for the welfare of the world's population today. Within these priorities, application of technologies which are effective using energy, water and ecologically favorable – "green" technologies are widespread. "Green technology" which is the preparation of facilities that benefit from nature and completely harmless or minimal damage for the environment. Principles of waste water recycling include these measures, too. Considering this, application of "green" technologies is one of the ways to solve problems in some countries.

Environmental policy of Azerbaijan was focused on national features during the years of independence. Azerbaijan is implementing local policy and necessary improvement of the legislation according to decisions of Rio and Johannesburg Palace Summits. There are adoption of some state programs and laws, better management, expansion of specially protected areas, national park networks, perfection of people's water supply and actions prevention of environmental pollution among them.

Azerbaijan had been signed global sustainable development agenda for years of 2015-2030, with other member states of United National Organization, in september of 2015, in Sustainable Development Summit which held in New York. This summit has approved the 17 Sustainable Development Goals.

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Analysis and assessment of the current changes of the Caspian Sea climate

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Key words: Caspian Sea, current climate change, analysis and assessment, methods and results

Introduction

Currently the 2nd Report on the State of the Caspian Sea environment is being prepared under the umbrella of the Interim Secretariat of the Tehran Convention. One of the Report sections will be devoted to the current changes of the Caspian Sea climate change. In this respect, the publication of the relevant materials on the website of the Coordinating Committee on Hydrometeorology of the Caspian Sea (CASPCOM) is timely and can be used for the preparation of the 2nd Report. The objective of the report is to give an overview of the approach used in CASPCOM materials for the analysis and assessment of climate change, and to present some of the results obtained while implementing the approach.

Materials and methods

The materials for the analysis and assessment of the current climate change were based on annually updated CASPCOM data catalogues: catalogues of air and water temperature, surface runoff and sea level, most of which date back to 1961 (some of them even earlier). CASPCOM data catalogues include the data provided by hydrometeorological services of all the five Caspian littoral states.

In the course of the analysis, the time series were smoothed by moving 30 year periods (1st derived series), then annual anomalies were calculated as a difference between the mean (monthly and/or annual) value of a parameter in the current year and for the previous 30 years (2nd derived series). The next step was to determine the annual increments as a difference between the following and the previous values (3rd derived series) and smoothing of this series by moving 30 year periods (4th derived series). To analyse the changes in the amplitude of annual anomalies and increments, them modulo series were used (5th and 6th derived series).

All the derived series were visualized and approximated by linear and non-linear (polynomial) trends. The statistical validity of the linear trends was assessed by Student's and Fisher's methodologies using different significance levels (0.1; 0.05; 0.01). To assess annual anomalies and increments, it is important to calculate quartiles, which allows subdividing them into weak, moderate and strong. Conducting comparative assessment of the growth rate of the climatic parameters can be implemented for n years, where n equals 0, 15, 20, 25, 30, 40, and 50 years

Results and discussion

According to CASPCOM data, the ongoing global warming has affected the Caspian Sea area, where the average air temperature for the past 30 years (1987 - 2006) has grown in comparison to the mean temperature for 1961-1990 from 9.9 to 10.7 °C in Astrakhan, from 12.2 to 12.5 °C in Makhachkala and from 12.7 to 13.5 °C in Derbent. In the first thirty-year intervals of the period under study, the average temperature fell slightly (by 0.1 - 0.2°C). Long-term positive linear trend of air temperature (an example is set by the graph made by observations data in Derbent) http://www.caspcom.com/files/climate/climate_en/Air_temperature/Derbent/1_air_temp.pdf is statistically valid, but the significance level is low ($p=0.10$).

CASPCOM materials contain data on annual air temperature anomalies on the Caspian Sea coast starting from 1991. According to CASPCOM data, air temperature anomaly was generally positive in all the years starting from mid 1990s. In some years (1997, 2003, 2011) the anomaly was close to zero (weakly positive or weakly negative), but in Derbent, for instance, it was positive during all the years starting from 1995. http://www.caspc.com/files/climate/climate_en/Air_temperature/Derbent/2_anomalia.pdf We should also note positive air temperature anomaly during 2012-2016, though its value in these years was not so significant as in 2010.

Smoothed by moving 30-year periods, the rate of air temperature increment is increasing. The linear trend which approximated this increase is statistically valid at $p=0.01$ http://www.caspc.com/files/climate/climate_en/Air_temperature/Derbent/6_temp_30.pdf According to the data of Derbent HMS, the average rate of air temperature increment for the past 30 years amounted to 0.07°C . An obvious fact is that when the averaging period increases (up to the past 50 years) or reduces (to the past 10 years), the mean rate of air temperature increment decreases, and it is negative for the 5 past years (2012-2016) http://www.caspc.com/files/climate/climate_en/Air_temperature/Derbent/7_temp_n.pdf It points to the deceleration of the Caspian Sea climate warming in the recent years.

According to CASPCOM data, the Caspian Sea water temperature in 1961-2016 was rising as fast as the air temperature above the sea area (CASPCOM data catalogues include the data of coastal observations of the temperature of the sea water surface layer). In particular, in Makhachkala area in 1986-2015, it measured on average 12.9°C , which is by 0.4°C more than the average for the period of 1961-1990. http://www.caspc.com/files/climate/climate_en/Water_temperature/Makhachkala/1_water_temp.pdf The positive linear trend is statistically valid at $p=0.01$ (by Student) and $p=0.1$ (by Fisher).

However the time series of water temperature anomalies is different from that of the air temperature. Stable positive anomalies of water temperature were observed only throughout 1997-2007; before and after this period positive anomalies alternated with negative ones. http://www.caspc.com/files/climate/climate_en/Water_temperature/Makhachkala/1_water_temp.pdf

Smoothed by moving 30-year periods, the rates of water temperature increment, despite the positive linear trend, are not so convincing as the rates of air temperature increase (which is confirmed by the statistical estimate). Only the 30-year periods which fell in 1968-2009 interval were characterized by positive water temperature increment rate. Before and after this period the increment rate varied from positive to negative and vice versa http://www.caspc.com/files/climate/climate_en/Water_temperature/Makhachkala/6_temp_30.pdf

According to the data of Makhachkala HMS, the average rate of sea water temperature increment for the past 30 years amounted to 0.06°C . Similarly to air temperature, when the averaging period increases (up to the past 50 years) or reduces (to the past 10 years), the mean rate of water temperature increment falls, and it is negative for the past 5 and 10 years. http://www.caspc.com/files/climate/climate_en/Water_temperature/Makhachkala/7_temp_n.pdf This fact points to the deceleration of the Caspian Sea climate warming in the recent years.

Throughout 1961-2015, the curve of the Volga flow smoothed by moving 30-year periods points to its continuous growth and the following decrease, though the linear trend

approximating the runoff changes in this time period is generally positive and statistically valid. The break point of the curve is the period 1978-2007, when the Volga runoff measured on average 260.3 km³/year. In contrast, in 1968-2015 interval, the Volga flow made on average 248.8 km³/year.

http://www.caspc.com/files/climate/climate_en/River_flow/Volga/1_stok.pdf

The smoothed fluctuations of the Ural flow in 1961-2015 were synchronous to those of the Volga flow: it was increasing for some time, and then fell. The breaking point was as well in 1978-2007, when the Ural runoff measured on average 8.68 km³/year. In contrast, in 1968-2015 interval, the runoff of the river was on average 8.28 km³/year.

http://www.caspc.com/files/climate/climate_en/River_flow/Volga/1_stok.pdf

The flow of the Kura river in 1961-2010 was decreasing (negative linear trend, valid statistically at p=0.01). The sharp decline was observed in the first half of this period. In 1961-1990 the flow of this river made on average 14.7 km³, while in 1970-1999 it measured 13.2 km³. In the following 30-year periods, the flow stabilized at this average value

http://www.caspc.com/files/climate/climate_en/River_flow/Kura/1_stok.pdf

The analysis of annual anomalies and increments of the river runoff and its average growth rates did not reveal any signs of its future growth. However, according to the information published in CASPCOM Bulletin, the Volga runoff in 2016 after an extended low-water period rose to 261 km³, which is by 5% higher, than the average for 1961-2015.

http://www.caspc.com/files/CASPCOM_bulletin14_2.pdf

Currently, this is the only fact in favour of the desired and probable increase of the surface runoff to the Caspian Sea

The changes of the water flow to the Caspian Sea in 1961-2015 were accompanied by its level fluctuations. This fact is confirmed by the data of the Caspian Sea level catalogue created by CASPCOM.

<http://www.caspc.com/index.php?razd=sest&lang=2&sess=17&podsess=62> Throughout 1961-1977 the sea level fell by 52 cm, and its highest fall rate (9 cm/year) was recorded in 1971-1977. Then, the sea level was rising at a high rate (14 cm/year) for a long period of time (from 1978 to 1995). In 1996 the sea level started to fall: first at a slow rate (by 10 cm for 1996-2005), and then rapidly (by 11 cm/year in 2006-2015). In 2016 the sea level finally stabilized at the elevation of -28.0 m B.S.

Conclusion

Summarizing the facts stated above, we can say that in the last quarter of the 20th century the Caspian Sea was affected by the global climate warming, which led to the increase of air temperature above its water area by 0.7-0.8°C, while the surface water temperature rose by 0.4-0.5 °C. First, the warming was accompanied with the rise of the Volga and the Ural runoff to the Caspian Sea (whereas the Kura flow reduced) and a rapid growth of the sea level. The flow to the sea decreased at the turn of the century, and the sea level started to fall slowly first, and rapidly since 2006. Simultaneously, the warming rate decreased, which resulted in normalization of the runoff in 2016-2017 and stabilization of the sea level.

Assessment of Freshwater Ecosystem Services connected to the HPP dams in Azerbaijan

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Keywords: sustainable ecosystem management, targeted scenario approach, irrigation, flood management

ABSTRACT

This study focuses on freshwater ecosystem services that support hydropower plants (HPP)/dams development in the Kura-Aras River Basin in Azerbaijan. The study assesses the HPP/dams sector, and reviews additional sectors including nature-based tourism, irrigated agriculture, and drinkable water supply. In addition, the study briefly discusses the role and value of ES that help to mitigate natural hazards related to poor ecosystems management.

The study used a basic Targeted Scenario Analysis (TSA) approach. The TSA assesses current “business as usual (BAU)” ecosystems management practices and its current value of ecosystems services under BAU. It uses sector output indicators and compares with potential “sustainable ecosystems management (SEM)” outputs to assess losses and potential gains (or losses) of shifting from BAU to SEM. The BAU approach is characterized by a focus on short-term gains (e.g., < 10 years), externalization of impacts and their costs, and little or no recognition of the economic value of ES, which are typically depleted or degraded. Under SEM, the focus is on long-term gains (> 10 years); also under SEM, the costs of impacts are internalized. Ecosystem services are maintained, thus generating potential for a long-term flow of ecosystem goods and services that can enter into decision making. SEM practices tend to support ecosystem sustainability as a practical and cost-effective way to realize long-run profits.

The main features of temperature changes, occurring over the territory of Caspian Sea in Azerbaijan

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Keywords: Global warming, the anomaly of the temperature, the difference-integral curve.

Introduction

The global warming, occurring last years, and the climate changes, connected with it, are reflecting their results over the great part of territories of the world, including Azerbaijan. Despite of the fact that there observes the common increase of the air temperature over the great part of the territory of the world, the quantity of this increase is different for different territories (Climate Changes, 2014). For example, the increase of the temperature over the high latitudes of North hemisphere is more sensitive (Climate Changes, 2014; Vilesov, 2017). On the other hand, the anomalies of the temperature are differing in different months of the year and the study of the change character of these anomalies for different periods makes a big deal.

In regions over the Caspian Sea, especially, in western territories of the sea, the climate change of last years has been fewer studied. On the base of researches, held over the eastern coastal territories of Middle and North Caspian Sea (Kazakhstan), there has been defined that over 1990-2015 and 2000-2015 periods the mean annual air temperature has been increased correspondently, on 1.0-1.6 and 1.4-2.0 degree in some hydrometeorological stations in comparison with base period. When we say the base period we mean the period, from the beginning to act of the observation station to 1989 (Ivkina et al, 2017).

The aim of this paper is to study the character of contemporary temperature changes over western coastal areas of the Caspian Sea in Azerbaijan.

The method and materials of research work

Naturally, the coastal zones of Caspian Sea in Azerbaijan are divided into two parts: western part of Middle Caspian Sea and western part of Southern Caspian Sea.

In the research work there have been used observation information of the air temperature for 1961-2016 in Khachmaz, Sumgayit, Pirallahy, Mashtaga, Neftchala and Lankaran hydrometeorological stations, also Neft Dashlari and Chylov sea stations. By the aim to define the character of changes in the temperature over discussed period there have been calculated and compared average annual and months temperature anomalies for some periods (1991-2004, 2005-2016 and 1992-2016) in comparison with the climate norm (1961-1990) (table 1). There have been built temporal change graphics and corresponding trend curves of the air temperature for each station (Fig.1).

For the comprehensive research of the change character of the temperature there has been built the difference-integral curve, calculated by the formula (1), for each station (Fig.2):

$$f(t) = \sum_{i=1}^t (T_i - T_n), \quad (1)$$

where, t – range number of considering year, T_i – the mean temperature of i year, T_n – the climate norm of the annual mean temperature.

Results and discussions

As we see in the fig.1 for the all of considering stations the temporal movement of annual mean temperature has been synchronal characterized and over 1992-2016 there observes the common increase of them. Over considered period high temperatures have been observed in 1995, 1998, 2001, 2005 and 2010 and lower temperatures in 1993, 1997, 2003 and 2011 years. So, it generally, responds to other changes, which are observed over other territories of Azerbaijan (Safarov et al, 2017). Over the period since the period of observations till today the highest temperature has been noted in 2010.

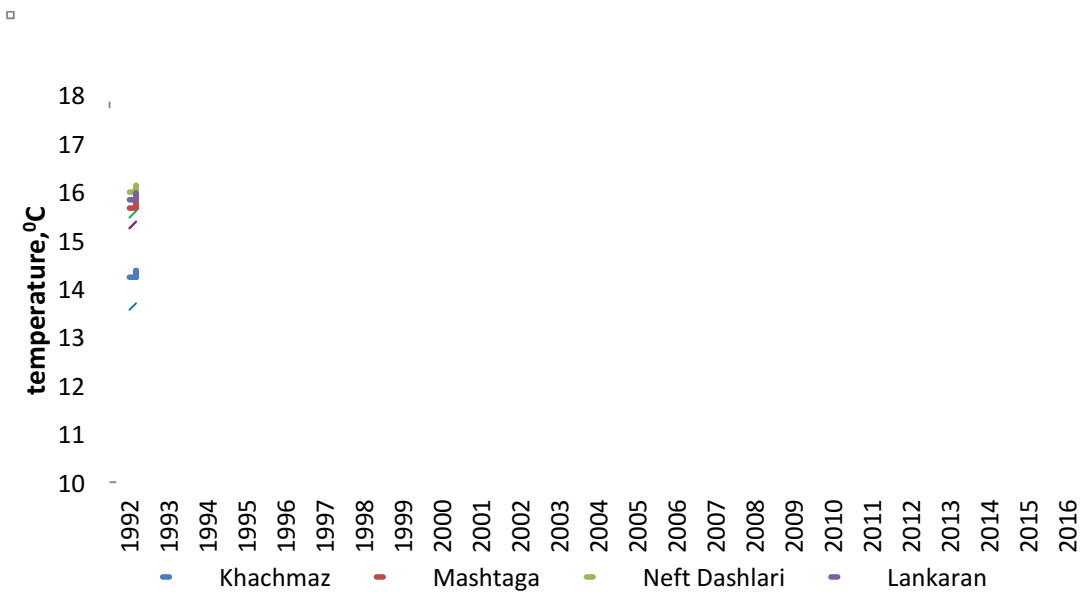


Fig. 1. A time course of the average annual temperature for the period 1992-2016

In the Fig. 2 there has been presented the differential-integral curve of the change of the annual mean air temperature in Lankaran. As we see over the period from 1960 till 1994 the change of the annual mean temperature has been accompanied by the supersession of negative and positive anomalies each other by short periods. It shows that from that year on the considered territory the warming of the air has been sharply characterized. So, since 1994 as in the other territories of Azerbaijan (Safarov et al, 2017), also over the coastal zones of Caspian Sea there observes the increase of the temperature, and it results in the acceleration of the evaporation on the sea surface (Chen et al, 2017) and correspondently, the decrease of the level. The increase of the temperature by this tension would create sharp ecological problems in blind water drainage, including Caspian Sea.

Also, in the research work there has been studied the change of annual and month's mean air temperature over different periods. By this aim for those periods there have been calculated temperature anomalies in comparison with climate norms (table 1).

As we see in the table over considering territory the annual mean air temperature for the 1992-2016 period in comparison with climate norm (1961-1990) has been increased averagely, 0.7 degree. But if over 1992-2004 this increase has been consisted of totally, 0.6 degree, then over 2015-2016 it has been sharply increased and averagely, consisted of 1.0 degree. It shows that the raising temp of the warming is increasing gradually.

The study of the change character of the temperature in some months makes a big deal.

As we see in the table the increase of the temperature in January and February is more stable, and anomalies are consisted of correspondently averagely, 0.8 and 0.9 degree.



Fig. 2. The difference-integral curve of the annual mean air temperature for Lankaran station

If over 1992-2004 in March the increase of the temperature is consisted of averagely totally 0.9 degree, then over 2005-2016 it has been sharply increased and reached to 1.4 degree. For the 1992-2016 period it has consisted of 1.2 degree. In April the increase of the temperature is more stable and consists of 0.3-0.5 degree.

In May and June, the increase of the temperature moves by its peculiarly dynamics. So, if over the same months of 1992-2004 period there have not been observed noticeable changes of the temperature, then for the 2005-2016 period this increase has been consisted of correspondently, 0.9-1.7 degree, but correspondingly, 0.5-1.2 degree for the 1992-2016 period.

There has been noted the increase in the anomalies of the temperature in June. So, if for the 1992-2004 period the anomalies of the temperature are not noticeable, then for the 2005-2016 period there has been noted their increase averagely, on 1.1 degree, for the 1992-2016 period there has been noted 0.7 degree.

In August the anomaly of the high temperature, which has been observed over 1992-2004 period (averagely, 0.9 degree), has been additionally increased and reached on 1.7 degree and for the 1992-2016 period it has been consisted of 1.3 degree. As we see in the table, the anomaly of the highest temperature has been noted exactly in August. The high temperature anomalies, which are observing in July and especially, in August, create conditions for the forest fires, the ecologically sharp condition, the drought and the acceleration of deserting processes.

The mean temperature of September demonstrates increasing dynamics. So, if over 1992-2004 the anomalies of the temperature is not noticeable, then over 2005-2016 yet it has been consisted of 1.2 degree, for the 1992-2016 period – 0.8 degree.

For October the anomaly of the mean temperature over 1992-2004 has been consisted of averagely, 0.8 degree, but it has been gradually increased and consisted 1.1 degree in the 2005-2016 period and 1.0 degree for the 1992-2016 period.

As we see in the table there have not been observed any noticeable anomalies in the temperature of November and December.

Table 1

The change of mean temperature anomalies for some months in the different period

Periods	Stations	Anomalies												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
1992-2004	Khachmaz	1.1	0.8	0.9	0.1	0.1	0.5	0.5	1.1	0.4	1.0	-0.4	-0.6	0.4
	Sumgayit	0.7	0.9	0.8	0.4	-0.2	-0.1	0.0	0.6	0.2	0.7	-0.2	-0.6	0.3
	Mashtaga	0.9	1.0	1.0	0.7	0.3	0.4	0.3	1.0	0.3	0.8	-0.1	-0.4	0.5
	Pirallahy	0.4	0.9	1.0	0.6	0.3	0.3	0.2	0.8	0.1	0.6	-0.5	-0.6	0.4
	Neft Dashlari	0.6	0.8	0.8	0.4	0.1	0.2	0.2	0.6	0.1	0.6	-0.2	-0.3	0.3
	Chylov	0.8	0.9	0.8	0.4	0.1	0.1	0.2	0.7	0.2	0.7	-0.1	-0.3	0.4
	Neftchala	1.0	0.8	0.9	0.5	0.0	0.0	0.0	0.8	0.4	0.7	-0.2	-0.4	0.4
	Lankaran	1.0	0.8	0.7	0.6	0.1	0.4	0.4	1.3	0.5	0.9	-0.1	-0.3	0.5
	Average	0.8	0.9	0.9	0.5	0.1	0.2	0.2	0.9	0.3	0.8	-0.2	-0.4	0.4
2005-2016	Khachmaz	1.0	1.0	1.6	0.3	0.8	1.8	0.8	1.7	1.4	1.3	0.0	0.5	1.0
	Sumgayit	0.7	0.7	1.5	0.7	1.0	1.4	1.0	1.6	1.2	1.0	0.0	0.5	0.9
	Mashtaga	1.0	0.9	1.7	0.9	1.5	1.9	1.0	2.0	1.3	1.2	0.4	0.5	1.2
	Pirallahy	0.9	0.6	1.3	0.7	1.2	1.7	1.1	1.7	1.1	1.1	0.3	0.8	1.0
	Neft Dashlari	0.7	0.5	0.9	0.3	1.1	1.9	1.2	1.8	1.2	1.0	0.2	0.4	0.9
	Chylov	0.6	0.4	1.3	0.6	1.4	1.9	1.2	1.4	1.1	0.9	-0.1	0.5	1.0
	Neftchala	0.9	0.9	1.5	0.8	1.5	1.6	0.8	1.5	1.1	1.0	0.0	0.3	1.0
	Lankaran	1.0	1.1	1.7	0.7	1.4	1.7	1.3	1.8	1.4	1.1	0.0	0.3	1.1
	Average	0.9	0.8	1.4	0.6	1.2	1.7	1.1	1.7	1.2	1.1	0.1	0.5	1.0
1992-2016	Khachmaz	1.0	0.9	1.2	0.2	0.5	1.1	0.6	1.4	0.9	1.2	-0.2	0.0	0.7
	Sumgayit	0.7	0.8	1.1	0.6	0.4	0.6	0.5	1.1	0.7	0.8	0.2	-0.1	0.6
	Mashtaga	0.8	0.9	1.3	0.8	0.9	1.2	0.7	1.5	0.8	1.0	0.1	0.1	0.8
	Pirallahy	0.6	0.7	1.2	0.6	0.7	1.0	0.6	1.2	0.6	0.9	-0.1	0.1	0.7
	Neft Dashlari	0.6	0.7	0.9	0.3	0.6	1.0	0.7	1.2	0.7	0.8	0.0	0.0	0.6
	Chylov	0.7	0.7	1.1	0.6	0.9	1.1	0.8	1.2	0.8	1.0	0.1	0.2	0.8
	Neftchala	1.0	0.9	1.2	0.6	0.7	0.8	0.3	1.1	0.7	0.9	-0.1	-0.1	0.7
	Lankaran	1.0	1.0	1.2	0.6	0.7	1.0	0.8	1.5	0.9	1.0	-0.1	0.0	0.8
	Average	0.8	0.8	1.2	0.5	0.7	1.0	0.6	1.3	0.8	1.0	0.0	0.0	0.7

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Climate Change impact to water resources of Kura river Run-off and ways of its mitigation.

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Keyword: water discharge, temperature, precipitation, climate

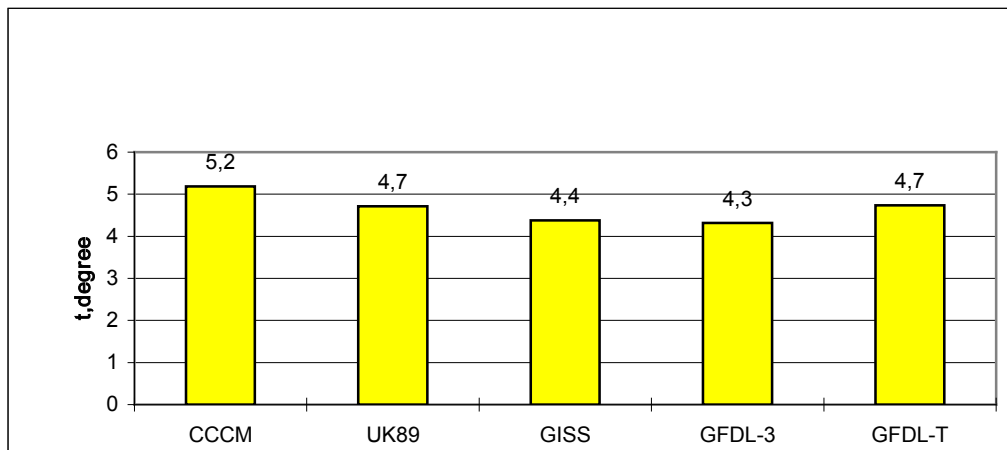
Introduction

Kura with its vast river system is the key water provider or, as hydrologists say, is the main water artery of the Caucasus. The river flows through the territories of Turkey, Georgia and Azerbaijan Republics. Total water resources of the Kura river are 26.6 km³ and of the Araz river are approximately 10 km³. At present water resources of Kura in Georgia and Turkey and water resources of Araz in Turkey, Iran and Armenia are decreased by more than 20% as a result of water intake. Also by taking into account of water loss from the channel (river-bed) of Kura river lower course, one may find that available at Azerbaijan Republic water resources of transboundary rivers of Kura basin at present is less than natural ones by 30%. About 11-12 cubic km of water in the Kura river basin is being used for different purposes. Of which 60-70% goes to agriculture, 20-25% to economy and the rest for water supply of cities and other residential areas/1-2/.

Materials and methods

Climate change impact assessment on run-off of rivers falling into the Caspian Sea within the Azerbaijan Republic is also estimated in this work. In this purpose the annual and seasonal value of natural and disposed river run-off is estimated by using a large number of initial material. The spartial-temporal assessment of change of run-off, temperature and precipitation over the river basin have been undertaken. Annual, seasonal and ecological run-off amounts of Kura river in Salyan station and other rivers of the Republic were restored/1-3/.

In accordance with GISS(Increase of annual air temperature by 4.8-5.3⁰ and annual precipitation by 6 - 12%), and GFDL-3 (Increase of annual air temperature by 4.2-4.4⁰ and annual precipitation by 1 - 4%) climate change models and scenario recommended by specialists of Azerbaijan Academy of Science about air temperature increase by 2 degrees by the end of the century.



Taking into account changes of air temperature and precipitation in accordance with climate change scenarios based on amounts of the available for today at the territory of Azerbaijan (observed) annual run-off of Kura and potential water resources of the it(Natural run off amounts) the climate change impact to the water resources of Kura has been estimated.

Taking into account changes of air temperature and precipitation in accordance with climate change scenarios based on amounts of the available for today at the territory of Azerbaijan (observed) annual run-off

of Kura and potential water resources of the it(Natural run off amounts) the climate change impact to the water resources of Kura has been estimated.

As it is seen from the table below(Table 1) by all models from 10 to 20% decrease of water resources of the river is expected in the future if there is now adequate measures of adaptations.

Table 1. Change of water discharges of Kura river under climate change models.

Run –off ranges	Water discharges , m ³ /sec				
	Winter	Spring	Summed	Autumn	Annual
	XII-II	III-V	VI-VIII	IX-XI	XII-XI
Initial scenario (1961-1990 rr)					
Natural	403	1528	897	524	840
Percent of seasonal values of natural run-off from their annual sum	12.1	45.8	26.8	15.6	100
Available on territory of Azerbaijan water resources of Kura	334	1233	684	400	663
Percent of seasonal values of available run-off from their annual sum	12.6	46.5	25.8	15.1	100
$\Delta t=2^{\circ}\text{C}$, $\Delta R=0\%$ (scenario supposed by the Azerbaijan Academy of Science)					
Natural	398	1391	766	460	755
Percent of seasonal values of observed run-off from their annual sum	13.2	46.0	25.3	15.1	100
Observed	306	1075	592	354	583
Percent of seasonal values of observed run-off from their annual sum	13.1	46.1	25.3	15.1	100
GISS					
Natural	357	1273	756	412	698
Percent of seasonal values of natural run-off from their annual sum	12.8	45.0	27.1	14.8	100
Available on territory of Azerbaijan water resources of Kura	255	966	574	312	527
Percent of seasonal values of available run-off from their annual sum	12.8	45.3	27	14.7	100
GFDL-3					
Natural	341	1319	682	390	682
Percent of seasonal values of natural run-off from their annual sum	12..5	48.5	25.0	14.3	100
Available on territory of Azerbaijan water resources of Kura	272	1081	437	291	520
Percent of seasonal values of available run-off from their annual sum	13.1	52	21	14	100

As it is seen from the table below by all models from 10 to 20% decrease of water resources of the river is expected in the future if there is now adequate measures of adaptations.

Results of undertaken work show that annual(and seasonal)amounts of natural flow to be left in the river as an ecological flow(the minimal monthly run-off necessary for existence of river ecosystem) of Kura river also get reducing by given climate change models with the air temperature increase from 354 cub.m/sec (currently) to 305 cub.m/sec(GISS) and 284 cub.m/sec(GFDL-3).

Identification of adaptation feasibility of water resources to remove negative consequences of climate change is the final stage of quantitative assessment of vulnerability. Basic task of this stage is to identify

feasible adaptation measures which should be realized with purpose to prevent climate change consequences and to contribute stable development of the country.

It is shown that without measures of adaptation occurs hard situation with water provision under all climate change scenarios and more difficult situation is caused by GFDL-T scenario, that is water resources may be reduced about by 40 % . In this case the most vulnerable economic branches become energy, agriculture sectors and provision of population with fresh water.

For different branches of economy the climate change impact assessment carried out and ways of its negative consequences mitigation determined. Several adaptation measures are given .

As one of way to execute necessary adaptation measures to facilitate water resources management in condition of water deficiency has been identified some measures of adaptation.

The main directions of these adaptation measures are as followings:

1. Development of IWRM plans.
2. Decrease of water deficits resulted with low efficiency of existing water distribution network by their reconstruction.
3. Use of underground waters and water recycling.

Based on assessment of authors even implementation of part of these measures may lead to solve existing water deficit problem. Below is given water economy balance of Kura on the territory of Azerbaijan Republic for different climate change models (Table 3) and also way of reduction of water deficit by implementation of 50% of needed adaptation measures (Table 4).

Table 2. Change of water economy balance of Kura river on territory of Azerbaijan republic for different climate change models and measures of adaptation

Amounts of water	Existing mln. m ³	Expected, mln. m ³		
		dT=2 ⁰ C, dR=0	GISS	GFDL-3
Water economy balance				
Water Use(including losses)	12000	12000	12000	12000
Environmental flow needs in Kura Downstream	11500	11500	11500	11500
Water use and environmental flow Together	23500	23500	23500	23500
Existing surface waters(including water abstract plans by upstream countries)	21000	20000	19000	18000
Water deficit	2500	3500	4500	5500
Adaptation measures				
Use of 50% of available capacity of ground water available for yearly exploitation	2000	2000	2000	2000
Increase of water use efficiency(about 30%) in result of reconstruction of water supply network	1500	1500	1500	1500
Treatment and reuse of about 50% of polluted waters	2000	2000	2000	2000
Reduction of water deficit in result of measures	+3500	+2000	+1500	0

Results

In result of climatic changes water resources in Kura River basin may reduces for about 15-20% by the end of this century. In this work are identified different adaptation measures to reduce existing and expected by climate change sceneries water deficit.

As is shown at the table if undertake this measures there wouldn't be water deficit today and in the future in accordance with climate change models.

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Hydrological classification system according to EU WFD

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Keywords: environmental flow, ecosystem, water quality, ecological status, water discharge

Introduction

Identification of ecological status of river waters is considered very important factor and currently, in this sphere in all European Union countries is applied an approach required in Water Framework Directive (acting as a unique document). According to that approach, when determining the ecological status of water bodies, relevant requirements are also set for physical-chemical and hydro morphological supporting elements in parallel with biological quality elements. For instance, if biological quality elements and physical-chemical water indicators have high status, in order ecological status of water body to be high (or close to natural conditions). it is required that hydro morphological quality indicators to be high as well, Otherwise, water status will be decided to be good, not high. And in further stages, it is considered that if based on initial two elements (biological and physical-chemical) water quality is good, then there is no need for checking hydro morphological quality/7/.

Based on all those aforementioned items, one can say that hydro morphological quality elements being the part of environmental quality indicators also should meet relevant requirements same as biological and physical-chemical quality indicators used in classification system that is envisaged in Water Framework Directive/8/.

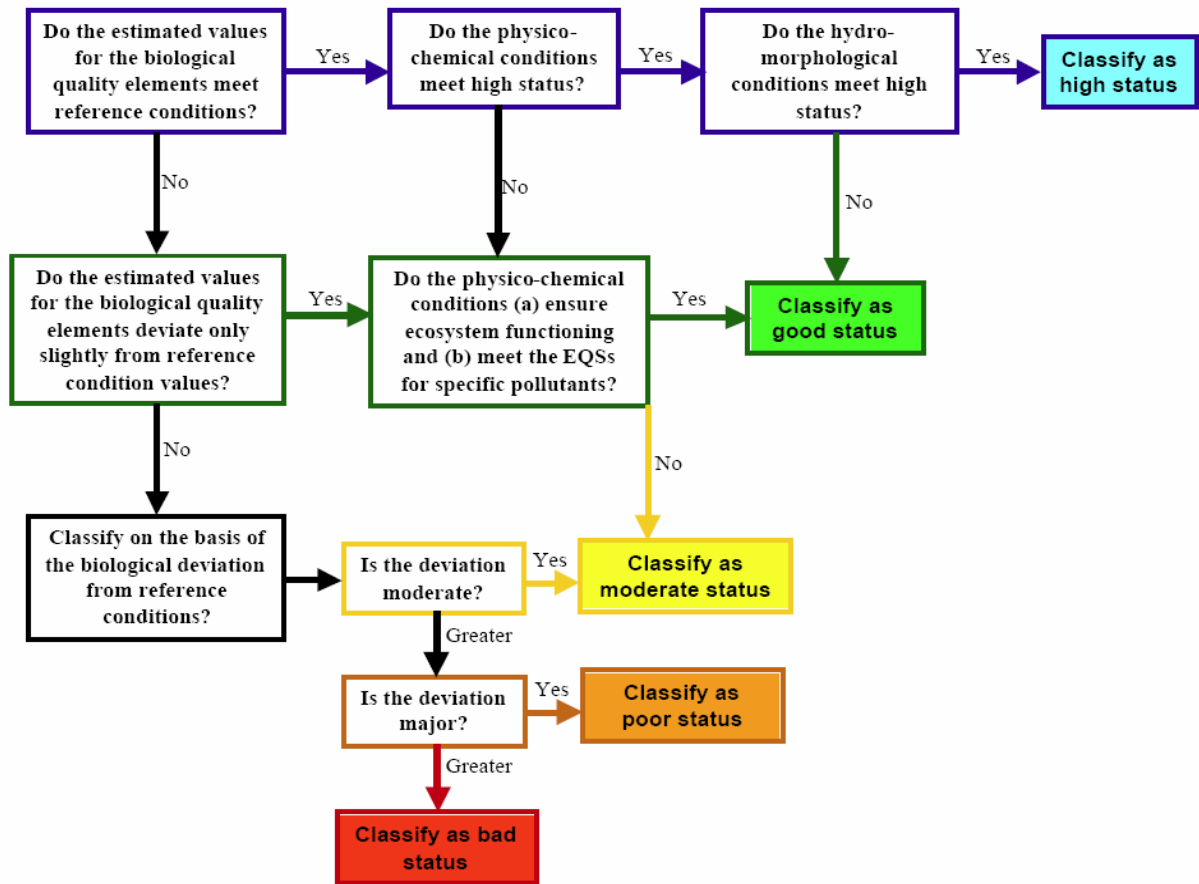
In hydrological classification system based on changes of water quantity in riverbed compared to previous period, water bodies can be classified into various hydrological categories. For each hydrological class category biological indicators can be identified and if in the future change of hydrological status occurs in result of water abstraction then based on related change of corresponding biological elements related ecological classification can be conducted.

Methodology

In this proposed methodical approach hydrological classification system is developed to support the classification of ecological status of water bodies according to Water Framework Directive.

According to approach required in Water Framework Directive, when determining environmental status of water bodies, relevant requirements are also set for physical-chemical and hydro morphological quality indicators of water in parallel with biological quality elements (Figure 1).

In the proposed classification system the diapason between the least for the entire observation period values of the minimal (often corresponding to period when river is fed by ground waters only) and maximal (corresponding in many cases to period when river is fed by both ground and surface waters) daily water discharges ($Q_{\min, \min} \div Q_{\max, \min}$) and also water discharges lower than $Q_{\min, \min}$ and those higher than $Q_{\max, \min}$ are divided into different categories. It is supposed that low values of water discharges may correspond to and provide of lower living environment for lower ecological status and higher water discharges in oposite may provide the higher living environment for water organism and consequently higher ecological status of river water body.



All water discharges equal and higher than $Q_{\max,\min}$ will provide enough condition for high ecosystem status (as provided by them condition for living organisms will not differ from **the widest living environment** with high biological quality observed in natural period), therefore corresponding water discharges can also be considered to belong to HIGH hydrological quality class. In this case $Q_{\max,\min}$ will be a border between the HIGH and GOOD ecological status classes and in turn serve as a **“High Ecosystem Flow”**. All water discharges which are below $Q_{\max,\min}$ in result of water abstraction will correspond to lower classes.

Half of $Q_{\min,\min}$ and $Q_{\max,\min}$ as an average value (Q_{mean}) is proposed to be **“Mean Ecosystem Flow”**. Water discharges lower than $Q_{\max,\min}$ and equal and higher than Q_{mean} can be considered to belong to “GOOD” hydrological class (as provided by them condition for living organisms will only slightly differ from **the widest living environment** with high biological quality observed in natural period) and water discharges which in result of water abstraction are below Q_{mean} and equal and higher than $Q_{\min,\min}$ can be considered to belong to “MODERATE” hydrological class (as they will provide for living organisms **the moderate living environment** from biological quality point of view). In this case Q_{mean} will be a border between GOOD and MODERATE statuses. In its turn $Q_{\min,\min}$ is proposed to be **“Low Ecosystem Flow”**. All water discharges which in result of water abstraction are below it will belong to lower hydrological status classes.

Water discharges which in result of water abstraction are lower than $Q_{\min, \min}$ and equal and higher than $0.5 * Q_{\min, \min}$ can be considered to belong to "POOR" hydrological class (as provided by them condition for living organisms will significantly differ from **the widest living environment** with high biological quality observed in natural period) and water discharges below $0.5 * Q_{\min, \min}$ or equal to "0" (when river dries) can be considered to belong to "BAD" hydrological class (as provided by them condition for living organisms will be very bad and have significant deviation from **living environment** observed in natural period). In this case $Q_{\min, \min}$ will be a border between MODERATE and POOR statuses and $0.5 * Q_{\min, \min}$ between POOR and BAD statuses and also will play role of "**Critically Low Ecosystem Flow**".

Biological quality indicators as the main characterizing element of ecological status depend from quality and quantity of water in the water body. Depending on geography, geology, relief, climatic conditions and etc. ecological status differ from water body to water body. Therefore by use of hydrological classification system for each hydrological status class can be assessed corresponding ecological status and based on that one can assess if character of future change of ecological status is related to natural or antropogenic impact

Relationship between the hydrological and ecological status can be established by use of hydrological and biological monitoring data collected in natural period of observation.

As is noted above HIGH hydrological status provides water environment that correspond to **wide living environment** with high biological quality observed in natural period which according to EU WFD is characterised with "HIGH" ecological status. Therefore required for this hydrological condition will be provided by all water discharges corresponding to "HIGH" hydrological quality status of the Hydrological Classification System (water discharges equal and higher than $Q_{\max, \min}$ identified as a "High Ecosystem Flow").

Next stage will be to check if for water discharges below $Q_{\max, \min}$ and equal and higher than Q_{mean} any changes in biological quality elements or ecological status take place. If no changes then ecological status can be kept as HIGH if there are some changes then it is necessary to check if biological quality elements meet requirements of GOOD or lower ecological status classes according to EUWFD. Similar rule can be applied for classifying of ecological status corresponding to water discharges between Q_{mean} and $Q_{\min, \min}$ (to check if ecological quality elements correspond to MODERATE or higher or lower ecological status) and then for discharges between $Q_{\min, \min}$ and $0.5 * Q_{\min, \min}$ (for POOR or higher or lower ecological status) and also finally for water discharges smaller than $0.5 * Q_{\min, \min}$ (for BAD or higher status)

The ecological classification can be carried by use of biological monitoring data corresponding to different water discharges in the natural period. If there is no such data the new bio monitoring needs to be carried to assess ecological status corresponding to different water discharges. In this case one needs to conduct monitoring in areas with low level of antropogenic impact.

Established relationship between the hydrological and ecological statuses may help to assess any future change of ecological status by human impact.

Based on above approach relation of hydrological and ecological status classes can be identified by use of below table.

Table 4. Relation between the hydrological and ecological status classes

N	Daily water discharge (m ³ /s)	Hydrological status	Biological quality indicators	Ecological status provided by hydrological condition
1	≥High Ecosystem flow (Q _{max,min})	HIGH	If biological quality elements are as in natural period	HIGH
2	≥Mean Ecosystem Flow (Q _{mean})	GOOD	If biological quality elements are as in natural period	HIGH
			If as result of reduction of area of living environment biological quality elements slightly differ compared to natural condition	GOOD
3	≥Low Ecosystem Flow (Q _{min,min})	MODERATE	If as result of reduction of area of living environment biological quality elements don't differ compared to natural condition	HIGH or GOOD
			If as result of reduction of area of living environment biological quality elements differ compared to natural condition moderately	MODERATE
4	≥Critically Low Ecosystem Flow (0.5*Q _{min})	POOR	If as result of reduction of area of living environment biological quality elements don't differ significantly compared to natural condition	MODERATE or higher
			If as result of reduction of area of living environment biological quality elements differ significantly compared to natural condition	POOR
5	≤ Critically Low Ecosystem Flow (0.5*Q _{min})	BAD	If as result of reduction of area of living environment biological quality elements don't differ very significantly compared to natural condition	POOR or higher
			If as result of reduction of area of living environment biological quality elements differ very significantly compared to natural condition	Bad

If river water body is located in protected area (National Park, Natural Reserve or is considered as a strategic water body and environment protection organizations decide to prevent any decoration of its ecosystem according to identified in EU WFD "HIGH" ecological status then required for this least hydrological condition will be provided by water discharges corresponding to "HIGH" hydrological quality status of the Hydrological Classification System. In this case all water discharges should be equal and higher than Q_{max,min} identified as a "High Ecosystem Flow".

According to EU WFD currently all EU Member countries are required to provide "GOOD" ecological status of all river water bodies at their territories. In this case required hydrological status should be GOOD or HIGHER to provide needed quality of biological elements to meet GOOD ecological status requirements.

As it is not easy to provide "GOOD" ecological status for all water bodies in short period of time therefore stepwise approach can be applied to water bodies which have "MODERATE" or lower classes to improve corresponding them status of hydrological quality elements according to steps described

below:

- If some water discharges are between “Mean Ecosystem Flow” and “Low Ecosystem Flow” of Hydrological Classification System because of water abstraction then any unauthorised water use should be prohibited and water use by sectors should be reduced to the level that allows to have “GOOD” status during first 6 years of WFD implementation cycle. If this is because of natural reasons (such as climatic change, drought and etc) then in addition also in this planning cycle relevant measures (planting forest strips, measures to combat drought, climate change impact mitigation and other water protecting measures) should be realized to provide needed quantity of water in the rivers that corresponds to “GOOD” ecological status.
- If some water discharges are below “Low Ecosystem Flow” of Hydrological Classification System then in addition to above measures some others (establishing possible water reservoirs in order to increase river water during dry run periods or using ground and other alternative water sources and etc.,) also need to be implemented to have “MODERATE” status in first 6 years period and “GOOD” status in second 6 years period of WFD implementation cycle.

Results

methodology hydrological classification methodology can be used to establish environmental flow rates for different rivers depending the type of water uses on prioritised basis

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Seasonal Variation of Temperature in the Southern Coastal Waters of the Caspian Sea, off Anzali, Gilan in Iran.

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Keywords: Caspian Sea, Temperature, Seasonal variation

Introduction

The Caspian Sea, as the largest inland water body on the Earth, is a very important marine environment for the world and in particular for the lateral countries around it. The marine ecosystem of the Caspian is unique and has a large stock of sturgeon. These living fossils are of high biological, ecological, genetic and commercial importance (Dumont, 1998).

There is no doubt that having a good knowledge about water temperature in the Caspian Sea and its seasonal variation are among the basic requirements for environmental and any other marine related studies in this water body.

This paper presents the results of seasonal scale CTD measurements of coastal water temperature in the western part of the southern Caspian Sea adjacent to Iran. The data were collected over the period of autumn 2004 to spring 2005, but have not been published before.

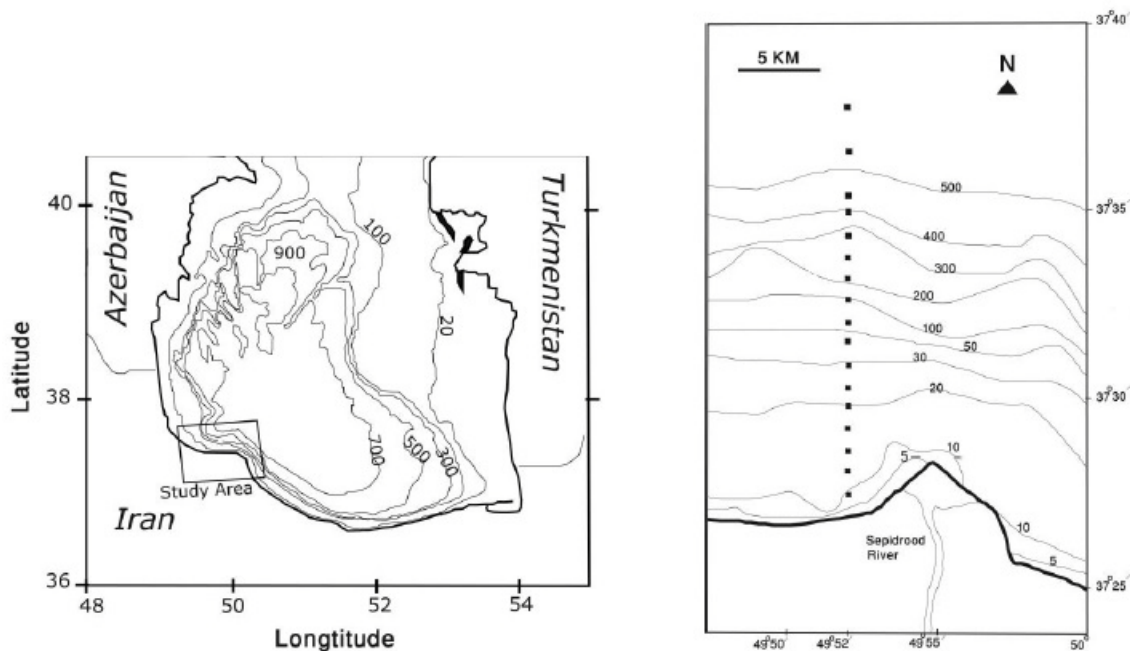


Figure 1. Study area and the position of CTD sampling stations (square dots).

Materials and methods

Field investigations were carried out by CTD profiling across the southern continental shelf of the Caspian Sea off Anzali, Gilan in Iran (Figure 1). In this area the continental shelf has a width of about 12 km. The depth from the coast increases gently to about 50 m near the shelf break, after that the depth sharply increases to 500 m (Figure 1).

The southern coast of the Caspian Sea has a subtropical climate characterized by warm summers and mild winters (Rodionov 1994; Kosarev and Yablonskaya 1994). The air temperature is maximum in August and minimum in January (Kaplin 1995; Kosarev and Yablonskaya 1994). The surface temperature in the southern basin attains its annual minimum of about 7 °C in February. During the summer, the maximum surface temperature is greater than 27 °C in the south (Kaplin 1995; Tuzhilkin and Kosarev 2005). Currents over the southern continental shelf are dominated by low frequencies less than 0.33 cpd with peak energy at 7-9 days periods (Zaker et al, 2011)

CTD profiling was conducted during the period of October 2004 to April 2005 and covered 3 seasons of autumn, winter and spring. The CTD data profiles were collected at 17 stations along one transect perpendicular to the coast (Figure 1). The CTD data were collected in a free fall mode and covered the top 200m of water column. The CTD probe was released into the water column with a speed of 1 m/s. The instrument was adjusted to collect data with a time interval of one second.

Results

In autumn, vertical temperature structure showed a thin thermocline located between depths of 30 m and 40 m. The temperature above and below the thermocline were 19 °C and 11.5 °C, respectively. The temperature in the surface mixed layer ranged between 19 °C and 21 °C. Below thermocline temperature reduced to 8.5 °C, 7.5 °C and 6.5 °C at depths of 80 m, 120 m and 200 m, respectively.

In winter no thermocline was observed across the depth in the study area. In This season, the water temperature ranged between 10.5 °C at the surface and 7.2 °C at the depth of 180m and was almost uniform over the top 100m of water column.

In mid spring, the temperature data showed a thin thermocline located between depths of 10 m and 20m. The temperature above and below the thermocline were 16.5 °C and 11 °C, respectively. In the surface mixed layer, temperature ranged between 16.5 °C and 17 °C. Below the thermocline the temperature reduced to 10 °C and 6.8 °C at depths of 50 m and 200 m, respectively and vertical temperature gradient reduced with increase in depth.

Discussion

The CTD data collected during autumn, winter and spring in the coastal waters of the Caspian Sea off Anzali, Gilan in Iran, showed a reduction in the thickness of seasonal thermocline in autumn, disappearing of it in winter and re-formation of the thermocline in spring. This procedure was in accordance with the temperature data collected by Zaker et al (2007) off Babolsar, Mazandaran in Iran. Zaker et al (2007) data also showed the presence of a strong seasonal thermocline in mid-summer between 20 m and 50 m depth with 15 °C temperature difference across it. The two data together indicate that the vertical temperature structure of southern waters of the Caspian Sea adjacent to Iran are characterized by formation of a seasonal thermocline in spring which becomes strong in summer and disappears in winter.

Acknowledgements

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THEME III

International Cooperation, Socio-Economical Development, Industry And Energy-Food, Water-Ecosystem Nexus And The State Of Fishes And Fisheries In The Caspian Region

Investigation and analysis of the impact of hazardous natural processes on the linear infrastructure of Azerbaijan

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Keywords: infrastructure, natural disasters, floods, hazardous natural processes, economic relations.

Introduction

Article is dedicated to the investigation and analysis of the impact of hazardous natural processes on the linear infrastructure of Azerbaijan. The problems in the sphere of infrastructure were comprehensively investigated in given article; the causes that created these problems and their solution ways were widely analyzed and corresponding recommendations were given. However, the role of flood protection constructions from influence catastrophic mudflows is considered, recommendations about struggle with mudflow phenomena, etc. similar processes are given in given article.

Materials and methods: Research was conducted using statistical materials, literary sources, comparative analysis and author's personal field researches.

Results Infrastructure is one of the significant and leading branches in dynamic and proportional development of the economy. Infrastructure is considered the main factor in development of economic relations. While creating transport infrastructure, the flood event should be taken into account besides its economic and social efficiency and the necessary safety laws accepted by the country should be observed while building roads.

Discussion

Modern problems arisen in infrastructure haven't lost their urgency even nowadays. Investigating this field and giving corresponding recommendations play an important role in improving the country economy.

Motor transport being the leading branch in the transport system of our republic connects all of the branches of economy. In comparison with other transport types, motor transport has the ability of maneuverability and rapid delivering of goods. First of

all, for reaching this purpose, the technical-economic indicators of the roads should meet the world standards level.

Natural disasters creates great problems in the activity of transport network of our republic. When of natural disasters happens, the event creates conditions on occurring material economic harms in development of transport, its normal activity, transporting of people to settlements and work places [7]. Highways built on mountainous and foothills areas constantly confront with of natural disasters danger, and they also undergo devastating influence of natural disasters. Natural disasters causes the roads falling into disrepair.

Studying the effects of natural disasters on Azerbaijan's economic spheres and creating complex defense facilities against them is scientifically-practical. Although research on the effects of natural disasters on farms in Azerbaijan, there is a great need for new scientific studies by applying modern technologies in this field. In recent years, natural disasters in the country have been intensified, their frequent repetition, increased damage to the area, minimization of technogenic accidents, and so on. as well as investigate other issues, such as research.

The territory of Azerbaijan is intensively exposed to natural disasters. Thus, gravity relief-forming processes in the southern slopes of the Greater and Minor Caucasus, such as earthquakes, avalanches, sliding, floods, erosion, glaciers and so on it is manifested.

The intensity of the development of natural disaster phenomena, manifestation of relief, the distribution of salient and so on. the geological structure of the surface, the tendency to surface, the degree of vertical and horizontal degradation, the lithological content of the rocks, the degree of cracking, the interrelationship of the atmospheric precipitation and hydrogeological conditions. In the event of natural destructive processes, economic objects, settlements collapsed, damage to the yard areas, sowing areas are under water, cattle are destroyed, and in some cases they result in death.

One of natural events – flood events having rapid motion speed and devastating strength which result in terrible tragedies arise in the result of heavy rains on the river basin of mountainous areas. 65-70 percent of republic is considered the territories always being under the flood danger [1]. We know that Azerbaijan is a country having

dense river net and these rivers influence negatively on country economy and life activities of the people while bursting their banks.

For example, the motor roads of Dashkasan-Khoshbulag, Dashkasan-Amirvar, Gushchu-Zaylik were seriously damaged, some parts being washed down were fell into disrepair (*Picture 1.*); The road section on the 76th km of the Baku-Shemakhy highway is destroyed (*Picture 2.*); The mudflow caused extensive damage to Pirsaatchay at Pirsaat region (*Picture 3.*).



Picture 1. The motor roads of Gushchu-Zaylik were seriously damaged, some parts being washed down were fell into disrepair, 2009.



Picture 2. The road section on the 76th km of the Baku-Shemakhy highway is destroyed, 2018.



Picture 3. The mudflow caused extensive damage to Pirsaat region 2012. (Pirsaatchay the **a)** right and **b)** left coast).

Being always under flood danger, protection of transport net, lowering to minimum harm are the significant matters. That concrete flood protection dams are construction in even big territories. It becomes clear once again from mentioned above that the field having importance in internal and external goods and passenger transportation and being mostly damaged by floods is motor transport. Motor transport is more sensible against floods. Floods break the rythmical work harmony of the motor transport. Therefore, protection of motor roads from floods has great economic significance [1, 3].

It should be paid attention to reconstruction of the existing bridges, cleaning surroundings of bridges and river basins. At present, on the account of Asian Development Bank protection dam of 1.6 km was built for the purpose of protecting motor roads and bridges from flood, and also for this purpose protection dam in distance of 17,2 km is being built in the territory of Nakhchivan Autonomous Republic [3].

Table 1.

Flood events happened in the Azerbaijan Republic,
their causes and disturbances

Years	Location	Arise cause	Disturbances
2008	Akhstafa	Heavy rain	The old railway and Poylu bridge connected 7 villages of Akhsafa with highway crashed down as a result of flood happened in Akhstafa river
2008	Lankaran	Incessant rains	A number of bridges collapsed on the roads leading to Gargiran and Gunahir mountainous villages. The bridge on Pancachai passing from Duriyya village crashed down, the river bursted its banks of 10 m.
2008	Gusar	Heavy rain	The roads of Gusar-Zindanmurug, Gusar-Kuzun, Gusar-Imamgulukand were fell into disrepair being under flood waters.
2008	Dashkasan	Heavy rain	1 person died, about 60 home basements remained under flood waters, intervals arisen in highways in the motion of the transport.
2008	Shamakhy	Heavy rain	Central streets of the region, bus terminal and the hospital in the city centre were seriously damaged.
2009	Guba	Incessant rains	Flood damaged the building of the administrative territory unit of Chich village, 2 cars, 10 cattle, 5 bridges. Lines of electric and communication of the village were spoiled.
2009	Dashkasan	Heavy rain	The motor roads of Dashkasan-Khoshbulag, Dashkasan-Amirvar, Gushchu-Zaylik were seriously damaged.
2015	Gabala	Heavy rain	About 20 home basements remained under flood waters.
2016	Gabala	Heavy rain	Bus terminal and the hospital in the city centre were seriously damaged.
2016	Shamakhy	Heavy rain	The roads of Mashadkanlı and Agalarbaylı were fell into disrepair being under flood waters. The bridge on haza and uqur rivers seriously damaged.
2018	Shamakhy	Heavy rain	The roads of Kachmaddin, Archiman and Talishnuru were fell into disrepair being under flood waters. Lines of electric and communication of the village were spoiled.
2018	Agsu	Heavy rain	On February 21 the mudflow caused extensive damage to Agsu region.

**The Ministry of Emergency Situations. Baku, 2017*

It is clearly seen from the top table that flood events happened in the Azerbaijan Republic are mostly accompanied by the heavy rains and incessant rains [3]. Their damages were to motor roads and bridges (*Table 1*).

More than 1000 km highways were built, 600 km roads of republic importance and 2700 km of local importance were repaired, 69 new bridges were built, and 34 bridges were fundamentally repaired during last 5 years in the regions [1]. However, more than 1000 km highways of republic importance, hundreds bridges are always under flood danger.

With a view of maintenance of execution of point 1 with the Decree of the President of the Azerbaijan Republic number 792 from July, 4th 2008 in the corresponding organisations offers "about motor transport" in the Azerbaijan Republic, "Plans of measures" on development of system of motor transport are prepared and presented [3]. Devastating power of floods should be taken into account while building roads or reconstructing roads in mountainous and foothills areas of the republic, complex safety measures should be carried out for normal activity of transport net not depending on the influence of floods.

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Unsustainable fisheries as present and future disaster of the Caspian Sea

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Keywords: Caspian Sea, fisheries, Sturgeon, Kilka, Caspian Seal

Introduction

Caspian basin is the largest enclosed body of water on the world, containing some 44% of all inland waters on the Earth (370,000 km², 1,200 km long and 466-204 km width). This sea hasn't connection to the oceans and its surface level is 27 m below mean sea level. Some 130 rivers flow into the Caspian Sea, the largest is the Volga River. Physically, the Caspian Sea is one of extremes (Several climatic zones, salinity varies from 0.1 ppt to 12, 50 and 300, oxygenated and anoxia waters and Temperature variations). Due to long-term isolation from other water bodies, the Caspian Sea is characterized by many endemic species (Stolberg *et al.*, 2006). The number of endemic aquatic taxa is over 300 and there are over 100 species of fish. The best known of these are the six species and subspecies of sturgeon and the endemic Caspian Seal. Caspian basin is surrounded by five riparian countries and several cultures, religions and rituals with principal economic activities same as fisheries for provide much needed protein and for the delicacy of the Caspian sturgeon's roe called Caviar. As well as Kilka is the important Caspian Sea crop (CEP, 2005). The aim of this study is to find out the effect of unsustainable fisheries on the main fish resources in the Caspian Sea region.

Materials and Methods

In this present study the available data regarding to fisheries in the Caspian Sea from 1990 up to now specially Sturgeon and Kilka as well as Caspian Seal and IUCN Red List reports has been analyzed and the main causes of fish decline in the region discussed.

Results

According to the data *Hoso hoso* (Linnaeus, 1758) the main sturgeons fish in Caspian Sea in the red list of IUCN is in critically endangered level (Gesner *et al.*, 2010), global fisheries statistics show that there has been a 93% decline in catch from 1992 (520 tonnes) to 2007 (33 tonnes) and in the Caspian Sea catch from 1,380 tonnes in 1950 decline to 60.8 tonnes in average of 1996-2003 (Gesner *et al.*, 2010). As well as Killka fish catches fell from 95,000 tonnes in 1999 to 16,700 tonnes in 2008, although there are some signs of slow recovery in 2014 (FAO, 2016). And results for Caspian Seal or *Pusa caspica* (Gmelin, 1788) show this mammal in the red list category of IUCN is in endangered level from 2008 until now (Goodman and Dmitrieva, 2016), estimated the total population of adult females as 354,210 in 1945 to 34,000 in 2015, and in another calculator show period 1955 to 2015 declined 91.5% (Goodman and Dmitrieva, 2016).

Discussion

The giant Beluga sturgeon (*Hoso hoso*) is threatened due to over-fishing and loss of spawning grounds mainly resulting from dam construction on the major rivers of the Caspian Basin (CEP, 2005; Gesner, *et al.*, 2010). And for reasons of decline of Kilka we can point to over-fishing too, for example in the Iranian part there are 5 main landing sites for Kilka vessels, an also a jellyfish, *Mnemiopsis leidyi*, feeds on the larvae and eggs of kilka and other fishes so stocks of kilka have diminished as have the fisheries (FAO, 1016). As well as Caspian Seal, unsustainable hunting was the main driver of Caspian Seal decline during the 20th century (Goodman and Dmitrieva, 2016) and the another reason for Caspian Seal mortalities due to Canine Distemper Virus (CDV) and possibly due to high concentrations of certain organochlorinated pollutants found in the tissues of many dead specimens (CEP, 2005). Some of the natural resources like fisheries depend on a healthy environment. Environmental pollutions of the Caspian Sea not only have negative impact on the sea, but also influence the population of all neighboring countries (Nasrollahzadeh, 2010). Classifying all the major sturgeon species as critically endangered by the IUCN in its red list of threatened species as well as reduction of *Pusa caspica* population and Kilka stocks in the Caspian Sea are the results of unsustainable fisheries in the past and at the present time. If this trend continues a disaster will happen. To solve this problem an urgent for the five member states of the Caspian Sea to develop a strategy to rebuilt fish stocks and *Pusa* population is essential.

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ASSESSING THE RISKS OF LANDSLIDES IN MOUNTAINOUS AREAS

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Keywords: *environmental, landslide, morphodynamic, natural disasters, economic losses.*

1. Introduction

In recent years, mountain geosystems were under the influence of considerable anthropogenic load, driven by such factors as the rapid development of new settlements, the laying of new asphalted motorways, the construction of industrial facilities as well as the development of mining industry. In this regard, the investigation of landscape- and geomorphological processes, posing a hazard to the sustainable development of the natural-economic systems in the mountainous areas, as well as the forecasting and the prevention of this processes are regarded as topical issues. High seismicity in the southeastern part of the Greater Caucasus favourably affects the occurrence of morphodynamic processes, including the landslides. The preliminary assessment of hazards and risks posed by landslides in the mountain areas through the application of up-date methods may prevent or reduce damage.

This work has been carried out due to financial assistance of the Science Development Fund under the President of the Republic of Azerbaijan (Grant No. EIF-2012-2(6)-39/15/2).

2. Materials and methods

The GIS-based landslide risk model of (Mora et al., 1994) was used. The first group of reasons includes are the main reasons of while the second group takes are responsible for the activation of landslides. The morphometric parameters of relief along with the lithological composition of rocks and the soil moisture index are listed as the main reasons of landslides, while the average perennial precipitation and seismicity were considered as activating factors. The factors were analysed through GIS in accordance with the following formula:

$$A(\text{fet})_{\text{landslide}} = (S_d \times S_{lc} \times S_{sm}) \times (T_{al} + T_{sr}) \quad (1)$$

where S_d is the degree of inclination of slopes; S_{lc} is the lithological composition of rocks; S_{sm} is soil moisture index; T_{al} is the average monthly amount of precipitation in multiyear period; and T_{sr} is the seismicity rate.

Landscape- and environmental risks of landslides were identified with taking into account the specific characteristics of the studied southeastern slope of Greater Caucasus as well as such factors as anthropogenic loading, land use, relief, vertical and horizontal fragmentation, indices of landscape's ecomorphological density and factors of landscape- and environmental assessment. Relatedly, the following formula was used:

$$S_i = \frac{\sum S}{\sum S_{fic}} : N \quad (2)$$

where S_i is the landslide intensity index; S is the area affected by landslides; S_{fic} is the total area of factors, involved to the comparison; and N is the number of measurements.

Researchers note that the correlation between the indicator of landslide intensity index and the level of landslide-related risk and hazard is available. Then the gained data was analysed through GIS. The last phase of was carried out based on the following formula:

$$S_i = \frac{S_a + S_l + S_{vt} + S_i + S_e + S_{si} + S_{sd} + S_{vc} + S_{lc} + S_{tf} + S_{dr} + S_{eb}}{S_{fic}} \quad (3)$$

where S_a is the anthropogenic loading; S_l is the use of lands; S_{vt} is the vertical fragmentation of relief; S_e is the eco-geomorphological tension; S_{si} is the inclination of slope; S_{sd} is the direction of slope; S_{sc} is the curvature of slope; S_{vc} is the vegetation cover; S_{lc} is the lithological composition of the rocks; S_{tf} is the tectonic fracture; S_{dr} is the distance from rivers; S_{dr} is the distance from roads; and S_{eb} is the environmental balance.

3. Results

In order to assess landscape- and environmental risks and hazards, posed by landslides in the study area, the existing areals of landslides were compared with the maps of land use (I), extent of vegetation cover (II) and also landscape and environment (III) of large scale (1:10000). Based on this comparison and the above-mentioned formula, the intensity indexes of spread of active landslides through ArcGIS program were measured (Fig. 1).

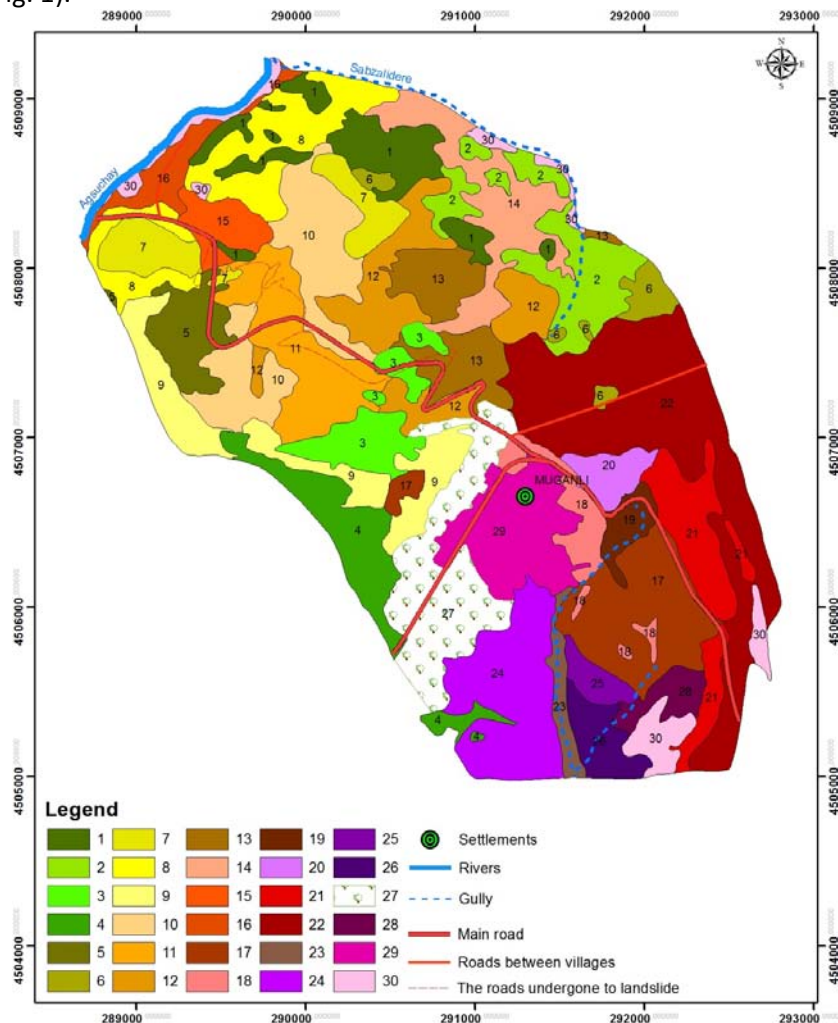


Figure 1. Landscape and environmental risks and hazards caused by landslides

The legend of map of landscape- and environmental risks and hazards caused by landslides:

I. Landscapes of mountainous forests in low mountain areas. 1. Secondary forests, composed of oak and hornbeam and widespread over brown forest soils of highly shattered slopes of medium hazard of sliding (25°-35° of inclination). 2. Secondary sparse arid forests, composed of hornbeam, elm, oak, hawthorn, shattered at medium extent, with medium hazard of sliding (20°-25° of inclination). 3. Trees and shrubs like elm, hornbeam, hawthorn, blackthorn, etc. widespread on brown

forest soils of slopes with wavy surface, shattered at medium extent, with very high hazard of sliding (25°-35° of inclination). **II. Landscapes of secondary forest and bush in low mountain areas:** 4. Secondary meadows, bushes, pastures and hayfields, covering brown forest soils of extremely shattered and wavy south-western slopes with medium hazard of sliding (25°-35° of inclination). 5. Forest bushes, covering light brown and partially carbonate soils on hilly and highly shattered slopes of medium hazard of sliding (20°-35° of inclination). **III. Landscapes of shrubby meadows and steppes in low mountain areas.** 6. Meadow bushes, separate trees and pastures, spread over light brown, blackish and carbonate forest soils of slightly shattered south-western and north-western slopes of with high hazard of sliding (20°-25° of inclination). 7. Complexes of field and garden, composed of sparse blackthorn, on slightly carbonate brown soils of smooth and weakly shattered watershed areas with less hazard of sliding (5-10° of inclination). 8. Cereals, clovers, sparse shrubs, growing over brown carbonate mountain forest soils of highly shattered and eroded steep slopes with very high hazard of sliding (30-35 of inclination). 9. Arid forests and shrubs of blackthorn, buckthorn, sparse oak, elm, etc. spread over dark-brown mountain forest soils of lower mountain slopes, shattered at medium extent; with high hazard of sliding. 10. Post-forest steppe plants, pastures and hayfields on brown forest soils of slopes, shattered at medium extent and affected by ancient landslides; with medium hazard of sliding. 11. Post-forest shrubberies, spread on mountain forest soils of western slopes; shattered at medium extent; with high hazard of sliding. 12. Mogpog, oat, various shrubs, etc., spread on brown mountain forest soils with medium hazard of sliding. 13. Hawthorn, blackberry, blackthorn and various kinds of grasses, covering slightly carbonate brown soils of averagely shattered mountain slopes, violated due to anthropogenic impact; with very high hazard of sliding. 14. Cereals and shrubberies and southwestern slopes with wavy surface shaped in post-forest areas and shattered considerably; with high hazard of sliding (25° of inclination). 15. Various grasses and sparse shrubs spread on brown soils of weakly shattered slopes of dry river valleys, with very high hazard of sliding. 16. Anthropogenically violated grassland shrubberies, safe in terms of sliding. 17. Various grasses, cereals and partially vineyards, smooth and a little wavy watershed areas of lesser hazard of sliding. 18. Grassland and steppe vegetation, pastures and hayfields on brown- and meadow soils of eastern and southeastern slopes of medium hazard of sliding. 19. Post-forest mountain steppes covering brown- and meadow soils of high hazard of sliding. 20. Various herbs, clovers and bushes, spread on brown soils of low-incline and wavy mountain slopes of very high hazard of sliding. 21. Pastures, widespread in weakly shattered and less-incline smooth watersheds of low hazard of sliding. 22. Sparse shrubberies, pastures and hayfields, spread on brown mountain soils of slopes of high hazard of sliding (20-25° of inclination). 23. Vegetation, presented by poplar, elm, blackberry and etc. on brown meadow soils of dry river valleys. 24. Grasslands and steppes with sparse shrubberies covering eroded brown soils of ancient southern, southeastern and south-western slopes of very high hazard of sliding. 25. Various herbs, cereals and mostly pastures covering blackish and light chestnut soils of slopes of smooth watershed with less hazard of sliding. 26. Post-forest shrubberies, meadows and steppes, with smooth and less-incline surface (5-6°). 27. Orchards and vineyards covering brown forest soils in weakly fragmented southwestern watershed with smooth surface; with hazard of sliding at medium extent. 28. Reeds, shrubberies and tall grasses covering brown meadow soils of expanded dry valleys. 29. Sandy areas with poor soil cover in accumulative river valleys. 30. Landscapes of residential areas of low-incline and smooth watersheds of active hazard of sliding.

Based on the map, natural complexes were grouped in 5 classes. 1. Landscapes of very high hazards. 2. Landscapes of high hazard. 3. Hazardous landscapes. 4. Landscapes of low hazard. 5. Landscapes of very low hazard.

5. Discussion

1. The used model enables to carry out this research as well as similar works in a shorter time based on decipherment of satellite images.

2. In recent years, the study of the sensitivity of landslide areas was widely reported by various aspects in scientific works of researchers (Kumtepe et al., 2011; Moreiras, 2005) from European countries, North America and Central America. These researchers have taken into account four or eight factors at

best. As a result of this, the extent of accuracy and reliability, as well as the possibility of application of the carried out research were increased.

3. These results can be used in the implementation of the future regional development programs, landscape planning and also the organization of transport infrastructure in the southeastern part of the Greater Caucasus.

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A local participatory plan for protecting the natural spawning area of the anadromous fish in Dinachal River (Caspian Basin)

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Keywords: Participatory protection, Biodiversity, Dinachal River, Caspian Basin, Spawning area

Introduction

Caspian Basin is one of the most important watersheds in Iran. Today's data and research indicate that the environmental degradation of chemical and physical contamination, negative effects of climate change, the destruction of natural spawning area, unplanned fishing and the presence of barriers, such as dams, have greatly reduced indigenous and valuable fish stocks, and species diversity they have been threatened. So that the valuable fish such as sturgeon and *Rutilus frisii kutum* migration in the river basin of the Caspian Sea is very limited or impossible. Also, some species, such as *Salmo trutta caspius*, *Aspius aspius*, *Abramis brama* and *Barbus capito* of the Caspian Sea, are subject in extinction for mention reasons. Caspian commercial stocks are showing decreasing trend, except Kutum, wels (catfish), pike, and small freshwater fishes (Khodorevskaya et al. 2014). The rivers of the Caspian Sea, as the spawning place of fish, have an important role in the survival of various species of fish.

Considering that each year Iran's fisheries spend a large amount on artificial propagation of valuable fish such as sturgeon, R.f.Kutum and some species, despite these valuable efforts it seems that restoring stock and protecting natural habitats as is not enough.

As human factors can play a negative role in the destruction of habitat, indigenous people can play a very important role in protecting their natural resources. In fact, the key to sustainable conservation is the empowerment and awareness of local communities.

The plan seeks to support the promotion of indigenous and migratory aquatic communities along the river in order to protect and restore natural spawning grounds by fostering trust, participation, reflection, education and support for local communities along the river. As Conservation aquaculture is a branch of science derived from conservation and population recovery studies on endangered fishes, the major goal of this plan was the protection the natural spawning area of indigenous and migratory fish of the Dinachal River, by fostering trust, participation, reflection, education local communities. Field of this plan was biodiversity protection, capacity building for the use of data for the purpose of promotion, Strengthen accountability and project type was capacity building and empowerment.

Materials and Methods

Project location

Dinachal River (37° 35'0''N, 49° 3'0''E) is one of the major rivers of south of Caspian Sea (IRAN, Guilan province) (Mohammadighaleni, 2015), located in Rezvanshahr, a place for migrating fish to spawn. Project was done in January to March 2017.

Project tools

1. Software and necessary information
2. Vehicle
3. Educational supplies (white paper, banner, whiteboard, marker, poster, replica, video projector, etc.)
4. Requirements for holding workshops (training tools, receptions, etc.)
5. Workshop location

Performing project

1. Determining the river for the project
2. Collecting essential information and holding specialized meetings for decision making
3. Visit the village adjacent to the river and initial acquaintance with the Village Council, rustic chairman
4. Conduct a symposium for cooperation and the formation of a local group and increase the sensitivity of the local community
5. Establish a local organization to examine the status of the village especially the river using the participatory Rural Appraisal (PRA) method
6. Provide a method of enforcement by the local organization
7. Evaluation of measures
8. Reporting
9. Presentation of the second phase of the project based on the results of the first phase

Results

The PRA method results showed this River is adjacent to the village of Safar Mahallah, which has a population of 500 people. The main occupation of rural people is agriculture (rice) and animal husbandry (cattle and buffalo) and free occupations. Unauthorized fishing is not in desirable condition and about 20-30 local fishermen (about 10-11 boat) has been fishing in this river in March. There are two gravel harvesting workshops along the way, which work according to the license. Agricultural water drain is often not considered a forest area and is not a threat to the river. The Dinachal River is not hunted by a fishing rifle, and the catch is carried out only by net and hook.

The suggestions and comments provided were; To prevent the entry of motor vehicles to the coastline near the river mouth until the end of the project (March 2017) (with the necessary coordination), Demand from indigenous fishermen to shut off the boat engine from the entrance to the river and on the river, Installation the banner, the theme of the project, which was previously presented to the respectable village dignitaries at the parking.

Many illegal fishermen aren't local people and for River protect indigenous people should prevent people coming to this place but realizing need to military and governmental officials strongly support. Although good support was provided by the Guilan Provincial Environmental Protection Agency, legal protections from other organizations were not enough.

Discussion

Despite the laws and regulations on rivers protection and the time limit for catching fish during spawning, illegal and overfishing has led to a significant reduction in the resources of migratory and native fish in the Caspian Sea basin.

In addition to overuse of bio-resources, such items including invasive species, Pollution, Unsustainable coastal area development, Lack of or weak stakeholder participation in Caspian environment initiatives the cause extinction of native species. Although the restocks management through artificial propagation can partly compensate for this, but effects of climate change, high costs, and reduction of genetic variation are one of the limitations of this method.

In order to prevent this destructive phenomenon, the researchers suggest the genetic reserves should 25-30% of be restored through natural replication (Pourkazemi, 1379).

Create informal protected areas just is a way out of this problem. Some experience in Iran such as protect of *Crocodylus palustris* (Pars Herpetofauna Institute. 2014) and *Eretmochelys imbricata* (Plan 4land NGO, 2015) showed good local people governance can improve bio resource management and protected.

The exchange of experiences and knowledge about the rule of informal protected areas and its effectiveness and dynamism, government strongly support, as well as the strengthening of the responsibility of local people can be the best way to manage the sustainable conservation aquatic biodiversity of the Caspian Sea.

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The economic importance of the Caspian Sea's relationship with the Black Sea to the region's countries

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Keywords: The Black Sea Region, the Caspian Sea Region, economic relations, energy resources, regional partnership

Introduction

Recently, extraction and export of existing hydrocarbon resources in the Caspian basin has been exported to the European and world markets through the Black Sea. It is also important from the point of view of socio-economic, as well as security of the two region's countries. The article provides detailed information on the work done and projects in this direction. This can be illustrated by the work done by oil and gas pipelines, as well as within the Great Silk Road, TAP, TRACECA projects.

Materials and methods

Following the collapse of the USSR, a number of cooperation organizations were established with the participation of regional states and with the support of global power centers. One of them is the Black Sea Economic Cooperation Organization, whose main purpose is to promote mutual economic and political cooperation among the region's states and to protect the security of the region as a result of joint efforts.

Energy resources and their transportation are the main geopolitical point of view for the Black Sea and Caspian Regions. Also, the Black Sea is of crucial importance as a key intermediary in the export of Azerbaijani oil to the European market. Thus, a number of projects have been developed and successfully implemented in this direction. As an example, we can show the Baku-Supsa oil pipeline (Western Route Export Pipeline). Thus, the oil extracted from the Azerbaijani sector of the Caspian Sea is transported to the world market via the pipeline via Georgia. Crude oil is loaded into tankers at the Georgian Supsa terminal and goes to the European markets through the Bosphorus Strait. There are 3 pump stations in Azerbaijan, 3 in Georgia, 6 pump stations, 2 pressure stations and one supply station. The WREB has 4 reservoirs in Supsa. The total volume of reservoirs is 1 million barrels. The ship's capacity to ship is about 600,000 barrels per barrel. The Baku-Supsa oil pipeline plays an important role in the economic and political life of Azerbaijan and Georgia. The western pipeline has its own place in increasing investment in the region, raising the social welfare of the population, and ensuring political stability. The economic effectiveness of the pipeline for oil companies was conditioned by the defined transportation tariffs. If the North Pipeline for Novorossiysk was \$ 15.67 per ton of oil, while the Baku-Supsa Western oil export route was \$ 3.14 per ton. Thus, the lower tariffs for transportation compared to the northern route significantly increased the Western pipeline's competitiveness. Therefore, the use of the Baku-Supsa export pipeline was economically advantageous for both foreign oil companies and Azerbaijan. The economic

significance of the oil pipeline, of course, was not limited to its transit revenues. Successful implementation of the project created favorable conditions for the rapid implementation of the "Contract of the Century". At the same time, the commissioning of the second export pipeline gave additional stimulus to the implementation of other agreements on exploration and extraction of hydrocarbon resources in the Caspian basin. Because expanding access to the global market promotes new investment, leading to acceleration of economic development and social welfare. The political and geostrategic role of the West Pipeline's economic importance was complementary. Former US President Bill Clinton, who paid great attention to its realization, said in his congratulatory message to the participants of the Baku-Supsa pipeline: " The opening of the Baku-Supsa line is the long-awaited goal - to create a network of oil pipelines to deliver Caspian oil and gas to the world markets. However, the scope of the energy sector in the pipeline than the benefit goes beyond that. It will be a cornerstone of the line East-west corridor and will contribute to the development of the countries of the Caucasus and Central Asia. " As you can see, Azerbaijan and the Western pipeline linking the Caspian Sea and the Black Sea Basin to Georgia through the territory of Georgia was an important factor in the economic development of the two countries and the strengthening of its political position in the region, as well as the role of the South Caucasus in the expansion of Central Asian states relations with Europe. The Baku-Supsa pipeline is technically-economically viable, enabling the AIOC to use the capabilities of this route maximum. But the commissioning of the Baku-Tbilisi-Ceyhan oil pipeline in 2005 and the decline in production within the framework of the "Contract of the Century" have led to a decline in oil transportation via the Baku-Supsa pipeline. If in 2012, the Baku-Supsa route was planned to export 4 million tons of oil, the volume of oil transported via that pipeline was 2 million 742 thousand tons. The commissioning of the Baku-Supsa pipeline has contributed to the development of the East-West energy and transport and communications corridor. Finally, the western pipeline, along with the northern route, played a role model for the implementation of the main export pipeline . Technical, economic, security, etc. in the process of operation of these routes. The experience gained in the fields was crucial in resolving various issues related to the export of large oil in the future.

Results

At the moment, the international interest in energy resources and transit issues in the region after the gas supply as a key energy source in the world economy is characterized by the increasing influence of global powers on energy security decisions. Energy security in the use of gas is formed not only with decisions of the countries of the region, but also with the decisions of global power centers, which have interests in large gas reserves in the region. Transition from coal to oil in the fuel and energy market in the middle of the 20th century is economical and so on . the transformation of oil into natural gas is a transitional period for future environmental transformation into energy. Therefore, transition to natural gas is still considered the fastest phase in history. Transition to natural gas in the world economy, in turn, contributes to the strengthening of geopolitical relations in the region. The natural gas reserves, production, transportation and utilization of the Caspian

Sea and the Black Sea region make the Mediterranean basin closer in terms of geopolitical interests. Transportation of natural gas in the Caspian region to the European Union countries further increases the transit importance of the Caspian and Black Sea region. In recent years, interest in natural gas has not been compressed, and the flow of pipelines has increased the geopolitical relations of the region's countries. The South Caucasian states (Azerbaijan and Georgia) play an important role in the implementation of pipeline projects that will extend to Western Europe. TANAP and TAP projects will play an important role in the development of the Southern Gas Corridor in this direction. The Southern Gas Corridor is a project to expand the South Caucasus gas pipeline (Baku-Tbilisi-Erzurum), as well as the construction of the TANAP gas pipeline in Turkey and the TAP gas pipeline project in Europe. TANAP is directly linked to the Southern Gas Corridor on the Tukiye-Georgia border and the TAP on the Turkish-Greek border. The TANAP project has significant economic value for its natural gas transportation potential from Shah Deniz, as well as from other gas fields in Azerbaijan. The length of the pipeline will be 1,813 km and the launch will commence at the end of this year. The initial annual capacity of 16.2 billion m³ will be transported.

TAP will merge directly with TANAP on Turkey-Greece border and transport natural gas to Southern Italy through Greece, Albania and Adriatic Sea. It is expected that TAP will play a key role in the energy security of the European Union as it organizes the shortest and direct route of natural gas export from the Republic of Azerbaijan to European markets . The length of the TAP pipeline will be 878 km and the launch will begin in 2020. The initial transportation capacity will be 10 billion m³ .



Figure 1 .Southern Gas Corridor

Azerbaijan has closely participated in the organization and implementation of the TRACECA program in the field of rehabilitation of the Silk Road in cooperation with many countries, the European Union and other international organizations. TRACECA is a project within the technical assistance provided by TESIS to the Commonwealth of Independent States with the support of the European Union. The reconstruction of the Eurasian Silk Road has

proven itself in the TRACECA project. Participation of the Republic of Azerbaijan in the TRACECA program is important for our country and opens important opportunities for Azerbaijan to strengthen and expand economic relations with Europe, integration into the world market and transformation into international transport junction. Implementation of the TRACECA program has resulted in closer cooperation and dialogue between states. Agreements have been reached on transit of transit cargo along the TRACECA corridor. Partner countries consider TRACECA as an important tool for integrating national transport systems into the world. Starting from Central Asia, the Caucasus, the Black Sea to the targeted region of Trans-European networks and other points on the East-West corridor linking carry out a large volume of cargo transportation. The favorable geographical position, especially main roads in the country, all vehicles (air, rail, sea and road) Given the good development of its leading position in the silk road would understand.



Figure 2 .TRACECA

Discussion

At present, the Black Sea and the Caspian Sea, closely linked to it, are the region where conflicts of interest are often overlapping by global and regional powers. In recent years, interest in this region has grown dramatically, and the areas shown are the crossroads of the interests of regional powers and global power centers. As a result , new projects are being prepared in the region and investments are strengthened. This will give impetus to the economic development of both Azerbaijan and the region.

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The hydrometeorological security of Caspian Sea and TRACECA

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Key words: Caspian Sea, wind, hydrometeorological service, wave,

Introduction

The develop a transport corridor on a west-east axis from Europe across the Black Sea, through the Caucasus and the Caspian Sea to Central Asia needs TRACECA's hydrometeorological security till China. The restoration of the historic silk route on a west-east axis from Europe across the Black Sea, through the Caucasus and the Caspian Sea to Central Asia requires the integrated development of an appropriate infrastructure in the countries involved. The hydrometeorological services for the safety of haulage is an integral part of this infrastructure.

Materials and methods

For the preparation of the paper there has been used the information of some hydrometeorological stations in Caspian Sea, also Southern Caucasus, Middle Asia, Eastern Europe and comparison analysis methods.

Results

Gales and rough seas affect the Caspian Sea region differently. Differing levels of wind speed can affect vessels, dams and locks and other structures. Large vessels and free-standing platforms on the open sea are at risk when winds blow stronger than 10 on the Beaufort scale. Information is provided when gales on the Caspian Sea exceed 10, 15 and 20 m s⁻¹ and, in some cases, 25 m s⁻¹. The Caspian regions most affected by gales are Makhachkala, Absheron (western shore), Fort-Shevchenko and Kara-Bogaz-Gola (eastern shore). Gales and the resulting storm waves seriously threaten the normal operation of marine transportation, especially of those vessels serving free-standing oil platforms.

Very high waves can occur on the Caspian Sea. Generally, five-meter waves are recorded every year and 10- meter waves or higher about every five years.

Five-meter waves or higher can occur almost any time of the year; summer gales are no less intense than winter ones.

Discussion

The Transport Corridor Europe-Caucasus-Asia (TRACECA) Programme, launched by the European Union in collaboration with a number of Member countries is of strategic importance for improved trade and economic development of its partner States.

At the International Conference on TRACECA: Restoration of the Historic Silk Route, held in Baku in 1998, 12 States signed the Basic Multilateral Agreement on International Transport for the Development of the Transport Corridor Europe Caucasus- Asia. As a result, the Permanent Secretariat of the Inter-Governmental Commission was established in Baku to facilitate its implementation.

TRACECA's economic effectiveness depends to a large degree on the activities of the NMSs in ensuring that vehicles can travel the entire route safely and that loads arrive intact. The NMSs of the Central Asian and south Caucasian countries have, therefore, approved the hydrometeorological Safety of TRACECA (HYMES-TRACECA) Project which was designed by experts from Azerbaijan and Georgia with the help and support of WMO.

The TRACECA route goes through areas with a variety of landscapes, some of which have complex and dangerous terrain and diverse meteorological and hydrological phenomena. These may include mudflows, floods, avalanches, landslides, glazed frosts, thick fog and dust storms. On the maritime sections of the TRACECA route, phenomena such as gales, destructive waves and surges can seriously threaten vessels and can lead to delays or temporary forbiddance of sailing. These phenomena can have a disastrous effect on the transportation infrastructure, thus leading to considerable economic losses.

Dangerous phenomena at sea include large amounts of ice, ship icing, surge, rough sea with wave height of over five meters, and wide fluctuations in level of over 2 to 2.5 meters. Except for rough seas, the other phenomena are relatively rare on the Caspian Sea. Rough seas can occur at any time of the year in any part of the central and southern Caspian which is crossed by the TRACECA routes.

In Romania, marine storms are the most dangerous phenomena. They affect coastline areas (seaside buildings, harbour platforms, the coast), marine buildings and installations (marine platforms, underwater pipes) and navigation on the Black Sea. Marine storms result from strong winds (over 10 m s^{-1}) which can create high waves (over 4 meters height) with strong currents and gusts on the shore.

As a consequence of the interaction between the wind, the surface of the water and the effect of the waves, the sea-water level in coastal areas fluctuates depending on the velocity and the direction of the wind. In the Constanta area, sea-water level can reach 79 centimeters. One of the disastrous effects of storms is damage or destruction of marine constructions and installations, some of them having been badly designed or built. Examples of destruction by marine storms include damaging sea walls on the southern coastline as well as of the oil extraction installations at large. Another negative effect of marine storms is the erosion process that takes place in the Romanian coast of the Black Sea both in the shoreline and underwater.

In terms of ice, the Caspian Sea may be classified into the following four areas:

(a) An area covered every year by fast ice, which prevents navigation;

- (b) An area covered every year by floating or unstable fast ice, through which navigation in winter can be maintained with the help of ice breakers;
- (c) An area which in certain years has ice which has drifted from the north or has formed locally and which causes temporary difficulties for navigation; and
- (d) An area in which ice never forms, including the deep-water (over 200 m) sections of the central and southern Caspian. During cold and extremely cold winters, the first three areas are totally covered by ice. In the central Caspian, the probability of ice formation falls from 70 per cent in the Makhachkala region to 20 per cent in Sumgait and from 36 per cent in the Aktau region to 30 per cent in the Gulf of Kara-Bogaz-Gol. Apart from the shallow Gulfs of Krasnovodsk and Turkmenia, ice formation in the southern Caspian is extremely rare (the probability is about 5 per cent). The probability of significant drift ice moving in is 47 per cent in the Makhachkala region, 37 per cent in Derbent, 25 per cent in Nizovaia Pristan and Kyzyl-Buruna, 14 per cent in Sumgait and 6 per cent in the northern coast of Apsheron. Ice-breaking tugs are used to get the ports working again and the fleet continues to sail under difficult ice conditions.

The icing of vessels occurs in rare cases during severe winters on the Caspian Sea. Dangerous icing zones can occur from December to February when air temperature is between -5° and -10°C and water temperature is between 0 and -1°C . Where the sea is calm, icing cannot occur no matter how low the temperatures are. Wave splashing combined with a strong northerly, north-westerly or north-easterly wind and low water and air temperatures cause icing and loss of vessel stability. Vessel icing in November 1910 led to the loss of many ships and barges and over 300 human lives. Icing also occurred in the winter of 1968-1969 and in 1976.

A characteristic feature of the Caspian Sea, the world's largest inland reservoir, is the considerable fluctuation of its water level. In the period from 1930 to 1941, the water level decreased to a century-low 1.8 meters, while a century - high 2.4 meters was recorded in the period from 1978 to 1995 – with both extremes leading to enormous economic losses. A decrease in water level can cause loss of depth in canals and affect mooring operations, hinder the operation of ports, increase the distance, the time and the cost of shipping, and reduce the size of the area that can be exploited by the fishery industry and the feeding-ground for the fish, etc. When water levels rise, large areas are flooded, including villages, industrial and commercial buildings and lands used for agriculture. Over the past century, the level of the Caspian Sea has risen eight times as a result of severe surges. An especially severe surge, with disastrous consequences, took place on 10-13 November 1952. When this occurs, 20 to 30 kilometers can be affected.

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DEMOGRAPHIC AND SOCIO-ECONOMIC PROBLEMS OF DEVELOPMENT IN THE CASPIAN REGION OF THE AZERBAIJAN REPUBLIC

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Key words: The Caspian Sea, development, socio-economic problems

Introduction. The coasts of the oceans and seas, deltas and valleys of rivers, plains, foothills of mountains have favorable natural-geographical conditions and economic and geographical position and are the most densely populated areas. The increase in demographic pressure, the rapid increase in the objects of the material and social infrastructure, is not only a cause of environmental tension and risk, but also a significant complication in the rational organization of productive forces on a global, regional and national scale, which sometimes leads to problems of their management.

Materials and methods of research.

Natural resources potential, demographic problems of Caspian Sea 'coastal region of Azerbaijan and contemporary development problems and its solutions ways have been studied. For this purposes, the following methods such as collecting of statistical data and analyzing of them, systematic approach and scientific literature, as well as case study has been carried out.

The main sources of information on the rural population and demographic indicators were data from the State Statistics Committee of the Republic by districts[1, 2, 3, 4, 5].

The Caspian coast of Azerbaijan with a length of 825 km, having a favorable economic-geographical position, natural conditions and resources, is a well-developed and populated region of the republic and cover the territories of Khachmaz, Shabran, Siyazan, Salyan, Neftchala, Masally, Lenkaran and Astara, Sumgayit town, Baku (Big Baku), but is more than 13% of the country (about 14.65 thousand km²). In this region live 3858.4 thousand people or 39.3% of the population of the republic (2017).

Discussing topic. The majority of the population is urban and lives in 14 cities, 102 townships and 655 villages. By the level of concentration of the population in the region four areas are distinguished: Khachmaz-Siyazan, Absheron (Sumgayit-Big Baku), Salyan-Neftchala, Masally-Lenkaran (Table 1).

Table 1

Demographic and resettlement indicators of the Caspian region of Azerbaijan

Administrative-territorial units	Area, thous km ²	Population thousand people (2017)	Density population sq.km	Number of settlements		
				City	Township	Village
Khachmaz	1,06	174,8	165	2	12	137
Shabran	1,09	58,0	53	1	-	68
Siyazan	0,70	41,4	59	1	1	32
Baku (Big Baku)	2,14	2245,8	1049	1	59	-
Absheron econ.reg.	3,73	563,1	151	3	13	32
Salyan region	1,60	135,6	74	1	2	48
Neftchala region	1,45	86,5	60	1	3	48
Masally region	0,72	221,5	308	1	2	118
Lenkaran region	1,54	225,2	146	2	8	83
Astara region	0,62	106,5	172	1	1	89
By region	14,65	3858,4	263,4	14	102	655
Azerb. Rep.	86,6	9810,0	113	78	261	4248

Reference: Statistical collection "Population of Azerbaijan-2017" Baku, State Stat.Kom. 2017.

The main part of the country's economic potential is concentrated in the Caspian region. These high indicators, first of all, are due to the high concentration of the country's economic potential in Baku. The share of administrative regions situated in the Caspian region accounts for about 65.1% of industrial enterprises operating in the country, 93.9 % of manufactured industrial products, 92,7% of the basic production funds of the industry and 72.3% of industrial and production staff.

The Caspian Sea plays an important role in the country's socio-economic development and formation of the economic structure. In the years of independence, foreign companies were attracted to develop and operate deep-sea oil and gas fields located in the Azerbaijani sector of the sea, which was a powerful impetus in the development of industry. At the same time, measures are being taken to increase the exploitation and processing of oil, deposits on the land of Absheron, Siyazan and Neftchala regions. As a result, 98.8% of the oil produced in the country and 99.9% of natural gas falls to the share of the Caspian region.

The oil industry has a significant influence on the formation and development of other branches of the economy. Mechanical engineering, chemical, petrochemical, the industry of building materials, which are the main branches of industry, are essentially concentrated on Absheron.

Absheron economic-geographic region is the most densely populated area. Here live 2808.9 thousand people or 73% of the total population of the Caspian coast. On Absheron, that is, in the Baku agglomeration, the population is formed due to mechanical and natural growth. In recent years, the role of migration has significantly increased in the development of demographic potential. In comparison with other regions of the country, Baku always had a low natural increase in population.

The formation of the economic structure in Absheron and the use of labor resources in this sphere are significantly different from other regions. The coastal position, the capital factor, political and administrative functions, the development of the oil industry, machine building, metallurgy, petrochemical industry, infrastructure development at a rapid pace led to the creation and increase of these differences.

Recently, the ongoing changes in the territorial structure of industry have led to the increasing role of the Absheron Economic Region. This is due to the fact that the restoration of industrial facilities, the creation of new ones, their role in production and employment of the population in other region is proceeding at a slow pace.

At the same time, the majority of oil and gas enterprises, established with financial and technical support with the participation of foreign companies, are located in Absheron. Other branches of the economy, including food, and partly light industry are also located on Absheron, Baku and adjacent areas.

Results. The Caspian region of Azerbaijan, in comparison with the average republican indicators, has a high demographic potential and is a more assimilated and densely populated area, and the following complex measures are required to manage the continuing growth of population pressure and socio-economic congestion.

Discussion.

1. From the point of view of rational territorial organization of productive forces in the territory of Azerbaijan, the pace of demographic and socio-economic development of the Caspian region should not only outstrip other regions of the country, but in some cases even fall behind.
2. In existing and prospective state programs of social and economic development of the regions, special attention should be paid to the policy of reducing demographic pressure in the coastal region of the Caspian Sea, especially in the Absheron economic region. To this end, it is necessary to limit the development of labor-intensive branches of the economy, which attract additional labor in the Caspian Sea region. In regions, especially in the border regions, it is necessary to develop labor-intensive and manufacturing industries and to support this policy organizationally and financially at the state level.
3. Despite the fact that placing new industrial or free economic zones in Absheron is attractive to investors because of the relatively favorably located consumption area and its economic and

geographical situation, but it is strategically incorrect in terms of the rational location of the productive forces in the country, territorial integrity, and excessive population of the Caspian region. It is advisable to place new production objects in the regions in which additional labor resources will be attracted.

The concentration of population and economy in Absheron creates the following problems:

- First, the accelerated development of Absheron leads to the decline of the country's regions, and the disparity between the regions socio-cultural development is exacerbated.
- Concentration of population and economy in a small area create ecological, demographic problems in supplying water, natural gas and electricity. Therefore, the tense ecological situation on Absheron has created serious problems in the provision of water, heat, housing and resettlement of population.
- The prolonged concentration of the population in Absheron leads to a monocentric form of population distribution. This ultimately leads to the emergence of unpromising settlements.
- The decline of the role of manufacturing industry in Absheron will lead to an increase in the dependence of the economy on oil. It is necessary to open new enterprises in the regions for reducing this dependence.

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THEME IV

Physical And Chemical Characteristics Of The Caspian Sea

Bioavailability phosphorus in surface sediments of the Southern Caspian Sea

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Keywords: Bioavailability, Phosphorus, Surface sediment, Caspian Sea

Introduction

Phosphorus as a substantial element, plays a crucial role in the regulation of bio-community structure and biogeochemical cycle of other elements in an aqueous environment. In sediments, phosphorus is discovered as Loosely-P, Fe-bound, Authigenic-P, Organic-P and Detrital-P. Hence, identification of phosphorus forms in aqua environment is of great importance (Ruttenberg, 1992). Various studies have been conducted on different forms of phosphorus in several regions so, but little information is known in the Caspian Sea. Therefore, the present work aimed to identify different forms of phosphorus in the Caspian Sea sediments and their relations with environmental factors.

Material and methods

Surface-sediment sampling was conducted at 12 stations along four transects (3 stations at each transect) using a Van Veen Grab in autumn 2015. For chemical differentiation of phosphorus, sediments were firstly sieved through a mesh-size screen of 63 μm and then 0.5 g freeze dried sediment of each sample in 50 ml extractant were analyzed using Ruttenberg method (Ruttenberg, 1992). In each phase and after extraction, samples were centrifuged at 4000 rpm for 20 minutes and phosphorus content was measured according to the method of molybdenum blue/ascorbic acid (Murphy and Riley, 1962) at 880 nm wavelength using a UV-VIS spectrophotometer.

Results

In this study, the lowest and the highest level of loosely-P was found at stations 1 and 7, respectively, ranging from 35 to 55 ppm (Table 1). The average amount of loosely-P in the studied sites was 46.42 ± 7.10 ppm. Loosely-P proportion to total phosphorus load (%) was least at station 1 (7.02) and most at station 7 (10.09). Also, mean percentage of loosely-P load from all sites was 8.68 ± 1.12 %. No significant difference was observed in loosely-P at various depths ($P > 0.05$) (Table 2). In the present trial, this form of phosphorus ranged from 50 to 94 ppm with an average value of 73.50 ± 14.59 ppm (Table 1), as its greatest and least proportions were discovered at stations 8 (15.96%) and 6 (10.73%), respectively. Proportionally, iron-bound P at the whole stations averaged 13.68 ± 1.97 %. In addition, Iron-bound P content indicated no significant difference at various depths ($P > 0.05$) (Table 2). Authigenic-P was most at station 2 and least at station 4 (Table 1) but the lowest content of this phosphorus as proportion to total phosphorus load (%) was detected at station 8 while the highest content was seen at station 3. Average amount of this ratio was 29.61 ± 3.11 %. The lowest and the highest amount of detrital-P to total phosphorus ratio was 29.78 % and 37.22 %, respectively, with a mean value of 33.18 ± 2.59 %. Organic-P content in the present investigation showed a range of 62-99 ppm, with the lowest amount at station 7 and the highest at station 11

(Table 1). This phosphorus range was 431-594 ppm with an average amount of 535.25±45.05 ppm (Table 1). In the present trial, inorganic-P ranged from 365 to 522 ppm with the lowest at station 2 and the highest at station 11. Inorganic-P was the most abundant form of phosphorus in sediments of the studied area as it comprised 81.90 to 88.53% of total phosphorus. In the current research, the ratio of TOC to OP ranged from 264.23 to 495.6 with the lowest content at station 11 and the highest at station 7. The present investigation revealed bioavailable-P content in a range of 153-240 ppm with the highest and the lowest levels at station 11 and 4, respectively, and average value of 199.41±25 ppm. The largest proportion of bioavailable-P to total phosphorus (%) was detected at station 8 while it was least at station 6. Bioavailable-P proportion throughout the studied sites ranged from 32.57 % to 42.65% with mean level of 37.21±3 %.

Table 1 general characteristics of sediments and content of different forms of phosphorus sampled in the Southern Caspian Sea

Sampling sites	Depth (m)	Loosely-P (ppm)	Fe-P (ppm)	Authigenic P (ppm)	Detrital P (ppm)	Organic P (ppm)	IP (ppm)	TP (ppm)
1	5	35	69	147	152	89	403	492
2	10	39	74	189	166	88	365	557
3	15	38	62	187	158	73	479	518
4	5	37	50	125	152	66	467	431
5	10	51	60	148	176	89	469	525
6	15	49	59	167	206	72	435	553
7	5	55	85	148	191	62	463	541
8	10	53	89	143	178	96	495	558
9	15	50	94	161	217	72	445	594
10	5	52	69	157	190	84	481	551
11	10	47	94	161	193	99	522	594
12	15	51	77	164	154	63	446	509

Table 2 Comparison of different forms of P concentrations (average ±SD) in different depths

Depth (m)	Loosely-P (ppm)	Fe-P (ppm)	Authigenic P (ppm)	Detrital P (ppm)	Organic P (ppm)	Inorganic-p (ppm)	Bioavailable P	TP (ppm)
5	44.75±10.21 _a	68.25±14.31	144.25±13.60	171.25±22.23	75.25±13.25	428.50±53.90	188±23.81	503.75±54.93
10	47.50±6.19 ^a	79.25±15.39	160.25±20.61	178.25±11.15	93.00±5.35 ^b	465.50±24.62	220.25±21.66	558.50±28.20
15	47.00±6.06 ^a	73.00±16.06	169.75±11.76	183.75±32.40	70.00±4.69 ^a	473.50±36.41	190±18.85	543.50±38.65

Different letters in each column indicate significant difference in each column (P<0.05)

Discussion

Total-P load changes in different marine ecosystems and is affected by sedimentation rate and primary production. Sediment phosphorus content comprises of inorganic and organic phosphorus. Generally, phosphorus is discharged into marine environments either directly from the atmosphere or via rivers. Atmospheric transport is markedly considered in oceanic areas and off-shore. Total-P load was least at station 4 and greatest at stations 9 and 11. Total-P load obtained in this research was compared with other regions which indicated a higher content rather than some areas but also less than the others. Furthermore, in a previous research by Samadi-Maybodi et al. (2013), the range of total sediment phosphorus was from 124.5 to 328.2 ppm which was less than the one obtained at the present investigation in the studied area.

The application of element ratio in order to determine organic matter origination is regarded as one of the common methods for geochemical researches (Ruttenberg and Goñi, 1997). Recent investigations have suggested that the ratio of TOC/OP in organic matter from land is greater than 106 but this ratio in marine organic matter reaches up to 106. When TOC/OP ratio varies from 300 to

1300, the organic matter comes from plants with soft tissue; more than 1300 from wooden tissue; and in the range of 7-80 reveals that it belongs to bacterial community (Ruttenberg and Goni 1997). According to TOC/OP ratio, organic matter in sediment of the studied stations proposed a land source.

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Numerical modeling of long waves in the Caspian Sea

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Keywords: the Caspian Sea, long waves, tsunami, seiche, storm surge, tide, numerical modelling

Introduction

In the present study results of the numerical modeling of the long waves in the Caspian Sea are presented. The main types of these waves are tides, storm surges, seiches, and tsunami. All mentioned processes are well reproduced by 2D numerical models, which are based on the equations of motion averaged by depth in the longwave approximation. The modeled results were compared with measurements of the sea level of the Caspian Sea.

Materials and methods

In the present study, the 2D version of the Princeton Ocean Model (POM) (Mellor, 2004) was used for analysis of the barotropic tides, storm surges, and seiches. In the tidal version of the model, the forcing is specified in the momentum equations through the gradients of the tidal potential fields over the Caspian Sea, which were calculated for spherical harmonics via the formulas provided by Munk and Cartwright (1966). For the analysis of the storm surges and seiches, the meteorological forcing was specified in the form of the tangential stress of the wind and through the gradients of the sea level pressure fields. To compute meteorological impact on the sea surface, the data of reanalysis NCEP/CFSR (Saha et al., 2010) were used. The reanalysis data bases contain information about the fields of the air pressure and wind with the spatial resolution of 0.5° and 0.3125° respectively and the hourly temporal resolution.

Based on the GEBCO Caspian Sea bathymetry data with the spatial resolution 30" grid was created with a constant step in latitude and longitude: $\Delta x = 1'$ и $\Delta y = 1'$. This grid was used in tidal and meteorological versions of the model. The data from 12 tide gauges in the Caspian Sea were used for verification of these models.

For tsunami analysis, the modified version of TUNAMI model with the finite-difference approximation of the shallow water equations was used (Fine et al., 2011). The grid for tsunami model had spatial resolution 300 m and based on the land and bathymetry data.

Results

The numerical modelling allowed to obtain a spatial structure of the diurnal and semidiurnal tides in the Caspian Sea. The M_2 wave in the Caspian Sea forms a counterclockwise amphidromic system with a nodal point near the Apsheron Threshold. Maximum amplitudes of harmonic M_2 were found in southeastern part of the sea – 5 cm.

The spatial and magnitude structure of the fundamental eigen modes of the Caspian Sea was revealed by the spectral analysis of the numerical modeling results. Numerical experiments were carried out with different mean sea level (MSL) of the Caspian Sea. The numerical results indicate that the MSL variations from -26 m to -29 m (below zero point of the Kronstadt gauge) strongly affect to the frequency properties and amplitudes of the eigen modes of the Caspian Sea.

In tsunami modeling, the deterministic approach was applied. The worst case for the Apsheron Peninsula is the scenario when a tsunami happens in the Middle Caspian Sea near its deep part on the west coast. If we consider the tsunami source caused by an earthquake with magnitude with force 8 the height of the wave can reach 5-6 m. Also, the sources located in the south part of the Caspian Sea southward the Apsheron Peninsula can cause dangerous situations for this area. The Apsheron Threshold is the zone of maximum seismicity, but historical earthquakes weren't strong there (with magnitude 6.5) and for the Apsheron Peninsula these sources can't cause high tsunami wave.

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Distribution of chemical parameters in water column of the Southern Caspian Sea (Iranian side)

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Keywords: South Caspian Sea; hydrochemistry; nutrients; total alkalinity.

Introduction

The Caspian Sea is the largest inland water body on earth with a surface area of about 380,000 km² and approximate volume of 78,000 km³ (Nasrollahzadeh et al. 2008). About 130 rivers with various sizes flow into the sea with an annual freshwater inflow of about 300 km³. The main input is the Volga River in Russia (85% of the total volume of inflow), while all rivers from Iran contribute only 4–5% of the annual inflow (CEP 2002). The outflow in the Caspian Sea is mainly by evaporation at the sea surface. The sea level in the Caspian Sea displays a clear seasonal cycle, generally reaching its lowest seasonal value in winter and increasing during May–July, following the spring floods (Biol Kara et al. 2010). Thus, it is mainly a function of evaporation–precipitation and these local effects can be important in predicting the upper ocean variables (Rodionov 1994).

In this work the results of hydrochemical studies aboard the R/V Iran Behshahr in southern Caspian Sea in late-winter 2014 were presented. Salinity, temperature, dissolved oxygen, pH, dissolved inorganic carbon, total alkalinity, nitrate, phosphate and silicate concentrations in water column of Neka-Amir Kabir oil platform section in the southern Caspian Sea were measured to study the status of hydrochemistry of this area. Results showed that the hypoxia continues to intensify in the deep-water basin of the South Caspian Sea. Near-zero concentration of dissolved oxygen and accumulation of phosphate, silicate and dissolved inorganic carbon in near-bottom layers in the study area showed that vertical winter mixing of water column did not reach the near-bottom layers at the time of this survey. Nitrate showed its maximum concentration at the intermediate maximum depth of 300 m.

Materials and methods

The sampling was performed at 5 stations in a section at the south of Caspian Sea from Neka (Mazandaran province, Iran) to the Amir Kabir oil platform in March 2014 (Fig. 1).

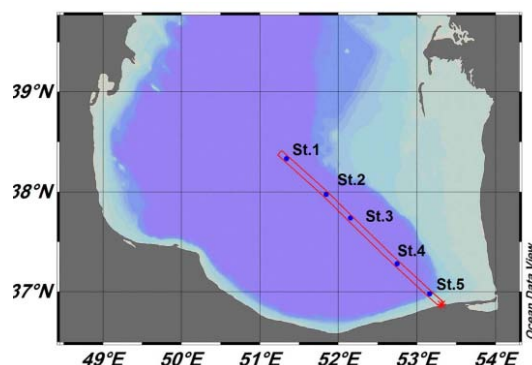


Fig. 1. The position of the sampling stations in the southern Caspian Sea.

Seawater temperature, salinity, pH and dissolved oxygen (DO) were measured onboard by a portable multimeter (HACH, model HQ40d) and CTD probe (Idronaut, Ocean Seven 316). Water samples for determination of dissolved inorganic nutrients (nitrite, nitrate, phosphate and silicate), total alkalinity (A) and total dissolved inorganic carbon (CTT) were taken with Rosette water sampler (Hydro-Bios) equipped with twelve 2.5-liter bottles to collect discrete water samples. Samples were taken from the standard horizons and in the horizons that were chosen according to the presence of specific features on the temperature-salinity curves. Water samples for determining dissolved inorganic nutrient were filtered by syringe filters (0.45 μm , cellulose acetate), collected in 100 mL high density polyethylene bottles and quickly frozen till analysis (Klaus Grasshoff and Ehrhardt, 1999). Water samples for determining A_T and C were collected in 500 mL glass bottles and poisoned by 200 μL saturated mercury(II) chloride (HgCl_2) solution to stop the biological activities (Andrew Gilmore Dickson and Christian, 2007). Samples were stored in refrigerator at 4 $^\circ\text{C}$ until laboratory analysis. Dissolved inorganic nutrients were determined using spectrophotometric techniques (ROPME 1999) with a UV-Vis spectrophotometer (Analytikjena, specord 210). A was determined by Gran potentiometric titration technique using an automatic digital 715 Dosimat titrator (Hydro-bios). An ANATOC series II (SGE Analytical Science) was applied to measure C_T based on acidification of a fixed volume of sample followed by IR determination of released CO_2 in a closed loop. Ocean Data View program was used to analyze the data and plot the figures (Schlitzer, R., Ocean Data View, <http://odv.awi.de>, 2012).

Results and discussion

Temperature was decreased from about 12 $^\circ\text{C}$ at the surface to the minimum value of 6.04 $^\circ\text{C}$ at the near-bottom layer in station 1. Salinity was at the range of 12.34 to 12.55 which the minimum was occurred at horizon level of 100 m near the Iranian coast of southern basin of the Caspian Sea. Data of temperature and salinity showed significant thermohaline stratification in the South Caspian Sea at the time of this study (March 2014). Dissolved oxygen was found to be at the range of 0.08–13.16 mg/L. Almost in all stations, the concentration of DO was reduced to about 3.4 mg L^{-1} (30% saturation) at horizon level of 300 m and reached to 0.08 mg L^{-1} at near bottom water in the station 1. Results showed that the hypoxia continues to intensify in the deep-water basin of the South Caspian Sea. Since 1960s, hypoxia in the Caspian Sea first recorded in the mid-2000s (Dukhova et al. 2015). pH of water in the section was recorded to be at the range of 7.86–8.62. The average amount of pH at surface water was 8.60 and reached below 8.0 at horizon level of 300 m. At sea surface, primary production activities (photosynthesis) followed by CO_2 consumption is the main reason for higher pH, while, in the bottom waters of the basin, degradation activities followed by production of CO_2 results in lower values of pH. Phosphate, total dissolved inorganic carbon (C_T) and silicate were accumulated in the bottom waters of the basin as a result of organics mineralization and dissolution of SiO_2 particulates.

The concentration of phosphate was found to be at the range of near zero (below detection limit) at the surface to about 2.31 μM at the bottom water of the station 2. Average C of the surface water in the (production–destruction) and dynamical (advection–diffusion) processes

in the water column. The concentration of nitrate increased from $< 1 \mu\text{M}$ at the surface to the maximum value of $13.8 \mu\text{M}$ at the horizon level of 300 m in station 1. The lower nitrate concentrations in the near-bottom layers of the South Caspian compared to the concentrations in the intermediate waters (300–400 m) could be explained by the deficiency of dissolved oxygen required for the studied section was $3500 \mu\text{mol kg}^{-1}$ and increased to about $3900 \mu\text{mol kg}^{-1}$ at the bottom water of station 4. Dissolved inorganic Si was found to be at the range of 2.11 to $3.6 \mu\text{M}$ at the surface to $82.4 \mu\text{M}$ at the bottom layer in station 2. The extent of accumulation of phosphate, silicate and C in bottom waters of the southern basin of the Caspian Sea is characterized by the role of the biochemical (production–destruction) and dynamical (advection–diffusion) processes in the water column. The concentration of nitrate increased from $< 1 \mu\text{M}$ at the surface to the maximum value of $13.8 \mu\text{M}$ at the horizon level of 300 m in station 1 (Fig. 3d). The lower nitrate concentrations in the near-bottom layers of the South Caspian compared to the concentrations in the intermediate waters (300–400 m) could be explained by the deficiency of dissolved oxygen required for the oxidation of ammonia and nitrite to nitrate (Andrey G. Kostianoy 2005). On the other hand, in low oxygen conditions, the processes of nitrate reduction and denitrification led to a decrease in the concentration of nitrate down to the surface values in the near-bottom layers (Dukhova et al. 2015). A_T was found to be at the range of 3690 to $3975 \mu\text{mol kg}^{-1}$. Results demonstrated the maximum amount of A_T in the intermediate levels near the Iranian coast of southern basin of the Caspian Sea which probably was due to the underground water discharge from the southern coast of the Sea. The average amounts of difference between A_T and C_T ($A_T - C_T$) were 250 and $94 \mu\text{mol kg}$ for the near surface (0–200 m) and deeper layers (> 200 m) of seawater, respectively, which could be the result of higher ratio of $[\text{CO}_2]/[\text{HCO}_3^-]$ in surface waters with higher value of pH compared to the more acidic deep waters.

Data from this study (dissolved oxygen, pH, temperature, dissolved nutrients and total dissolved inorganic carbon) showed that in the southern deep-basin of the Caspian Sea, water column was strongly stratified in term of measured parameters in 2014. The accumulation of phosphate, silicate and total dissolved inorganic carbon in the bottom layers was observed as a result of the organic mineralization in the absence of effective vertical winter mixing. The data on nitrate intermediate maximum depth and its concentration confirmed that the hypoxic condition was growing to reach higher horizon levels in 2014. Mineralization of organic dissolved and suspended materials in the absence of effective ventilation resulted in expansion of the hypoxic condition layer up to a horizon level between 300 and 400 m.

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Thermophysical Properties of Caspian Seawater

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Keywords: Seawater, thermophysical data, salinity, vapor pressure, pollution.

Introduction

The Caspian Sea is the largest lake on Earth by both area and volume with a surface area of 371,000 km³ and a volume of 78,200 km³. It is a landlocked endorheic body of water and lies between Azerbaijan, Russia, Kazakhstan, Turkmenistan and Iran. It extends about 1210 km in a northern and southern direction and about 210 to 436 km in an eastern and western direction. It has a maximum depth of about 1025 meters (Lenkeran Trench). It is called a sea because when the Romans first arrived there, they tasted the water and found it to be salty. It has a salinity of approximately 1.2%, about a third the salinity of most water from the ocean.

The Caspian Sea is rich with energy resources. Oil and gas are extracting from the Caspian Sea during the many years. At the results of these exports and flowing of rivers with municipal waster waters play more roles in the polluting of Caspian Sea water. Caspian Sea has not concrete border with world oceans and in this case all polluted materials is settling in the depth of Caspian Sea, change the quality and vaporisation of sea water. At the results of polluting, the vaporisation of water is decreasing; the level of Caspian Sea is increasing dramatically and creating the ecological problems in the border regions. In this case, the thermophysical and ecological study of the Caspian Sea waters is necessary for the analysing of their structure and decreasing of ecological polluting of Caspian Sea water.

The main purpose of the investigations described in this work is to investigate the thermophysical properties of the Caspian seawater dependence from salinity, temperature and pressure. We have analysed thorough evaluation of the thermophysical properties of the Caspian seawater:

- (p, ρ, T) properties, vapor pressure, viscosity and speed of sound of the Caspian seawater with various salinities over the parameter range of interest.
- A comprehensive and accurate thermophysical equation of state of the Caspian Sea water over a well specified range of parameters.

The constructed equation of state is used for the calculation of the various thermal properties. The osmotic coefficients and activity of solvent will be calculated from the vapor pressure results of seawater and oil components. The obtained results are useful for practical purposes in the oceanographic research.

This work is continuation of our research investigations in the field of thermophysical properties of Caspian Sea water [1-4].

Experiments

The (p, ρ, T) measurements are carried out using a new modernized high pressure – high temperature Anton Paar DMA HPM vibration tube densimeter build up by Dr Javid Safarov in the University of Rostock, Germany (in Safarov et al. 2009) [5]. The temperature in the

measurement cell, where the U-tube is located, is controlled using a thermostat F32 - ME from Julabo, Germany with a $\Delta T = \pm 10$ mK uncertainty of the measurement and is measured using the (ITS-90) Pt100 thermometer with a $\Delta T = \pm 15$ mK experimental uncertainty of the measurement. Pressure is measured by pressure transmitters P-10 (WIKA Alexander Wiegand GmbH & Co., Germany) with an APD in 0.1 % of the measured maximum value. The sample in the oscillating tube is part of a complex system. The force of inertia shear forces occurs on the wall, influencing the resonant frequency of the oscillator. The mPDS2000V3 control unit measures the vibration period with an accuracy of $\Delta \tau = \pm 0.001$ μ s. According to the specifications of Anton Paar and calibration procedures the observed repeatability of the density measurements at temperatures $T = (273.15 \text{ to } 413.15)$ K and pressures up to $p = 140$ MPa is within $\Delta \rho = \pm(0.1 \text{ to } 0.3)$ $\text{kg}\cdot\text{m}^{-3}$ or APD in (0.01 to 0.03) %.

The vapor-liquid equilibria (VLE) measurements of Caspian Sea water were measured using the two high-accuracy static experimental set ups build up by Dr Javid Safarov in the University of Rostock, Germany (in Safarov et al. 2015, 2017) [6,7]. The glass cells are used for vapor pressures lower than ambient pressure at temperatures ranging from 274.15 K to 323.15 K and the metal cell for vapor pressures at the temperatures between 323.15 K and 373.15 K. The glass cell method consists of absolute and differential parts. The vapor pressure is measured using a calibrated high accuracy sensor head [Type 615A connected to the signal conditioner Type 670A, MKS Baratron, USA] attached to the top of the cell. The experimental uncertainty of the pressure in the absolute vapour pressure measurement using the glass cell is $\Delta P = \pm (10 \text{ to } 30)$ Pa (MKS Baratron pressure sensor, USA). The temperature inside the cell is measured by a platinum resistance thermometer PT-100, connected to a signal conditioner Omega PT-104A, with an accuracy of $T = \pm 0.001$ K. If the vapor pressure of the solution is smaller than 30 Pa (uncertainty of measurements), the measurements are carried out using another cell in the differential part of the system. In this part, two cells are contained in one external reservoir. The temperature inside the cells is measured by a platinum resistance thermometer PT-100, connected to a signal conditioner Omega PT-104A, with an accuracy of $T = \pm 0.001$ K. The measuring cells are equipped with injection ports. The vapor pressure is measured using a calibrated high accuracy sensor head [Type 616A connected to the signal conditioner Type 670A, MKS Baratron, USA] attached to the top of the cell. The experimental uncertainty of the vapor pressure in the differential part is $\Delta P = \pm (1 \text{ to } 3)$ Pa (MKS Baratron pressure sensor). The pressure signal received from signal conditioners and temperature signals from the Omega PT-104A are sent to a PC. All systems are controlled using the LabVIEW program [6,7].

The experiments to determine the vapor pressure of liquids at temperatures of $T=(323.15 \text{ to } 473.15)$ K are performed in a metal cell installation using the static method experimental set ups build up by Dr Javid Safarov in the University of Rostock, Germany (in Safarov et al. 2015, 2017) [6,7]. The installation consists of a stainless steel DIN 1.4571 (V4A) measuring cell. The internal volume of the measuring cell is approximately 140 cm^3 with the connected tube, hole of the pressure transmitter, and $\frac{1}{2}$ volume of the valve. The temperature of the measuring cell and heat transfer reservoir with KORASILON oil M50 (Kurt Obermeier GmbH & Co. KG, Germany) is controlled using a thermostat (LAUDA ECO RE 415 G, Germany) with an accuracy of $\Delta T=\pm 0.01$ K. Temperatures are measured using two different platinum resistance thermometers, PT-100. One of them is directly connected to the thermostat via PT-100 Libus Modul. This thermometer transfers information from the measuring cell. The second platinum resistance thermometer, PT-100, transfers the measured temperature in the computer via an Omega PT-104A Channel RTD Input Data Acquisition Module (Omega Engineering, inc., USA) for the measuring of temperature, with an accuracy of $\Delta T=\pm 0.001$ K. The vapor pressure is measured using two various Keller pressure

transmitters (Model: SERIE 35 X HTC, Omega GmbH & Co., Germany) ranging from a maximum pressure of 300000 Pa with uncertainty $\Delta P = \pm(400 \text{ to } 1500)$ Pa to a pressure of 1600000 Pa with uncertainty $\Delta P = \pm(2000 \text{ to } 8000)$ Pa.

The dynamic viscosity $\eta(p_0, T)/\text{Pa}\cdot\text{s}$ of Caspian seawater at $p=0.101$ MPa and temperatures at $T= (273.15 \text{ to } 413.15)$ K are measured using an Anton Paar SVM 3000 Stabinger Viscometer and Anton Paar Rheometer MCR 302 [8,9]. The accuracy of measured dynamic viscosity η values at $p=0.101$ MPa according the SVM 3000 Stabinger Viscometer manufacture instructions is $\Delta\eta/\eta = \pm 0.35 \%$ and of Rheometer MCR 302 - $\Delta\eta/\eta = \pm 1 \%$.

The SVM 3000 Stabinger Viscometer is a rotational viscometer with cylinder geometry. It is based on a modified Couette principle with a rapidly rotating outer tube and an inner measuring bob which rotates more slowly [8]. The measurement principle is based on a torque and speed measurement. A rotating magnet in the SVM 3000 produces an eddy current field with an exact speed-dependent brake torque. The eddy current torque is measured with extremely high resolution. Combined with the integrated thermoelectric thermostating, this ensures unparalleled precision. The torque resolution is an unmatched 50 pico-Nm. In this case, it only requires a very compact measuring cell with 2.5 ml for the measurements of dynamic viscosity and density in the same temperature. Using the platinum resistance thermometer make possible to measure the temperature with high accuracy. After the washing and drying of installation the measured sample in syringe connecting to the installation. The sample is filling to measuring cells. The stabilization of temperature going automatically and every time the values of dynamic and kinematic viscosities, also density of sample in the same temperature are recording. After this procedure, the next temperature is installing. At the end of measurements installation again washing and drying using its air pump [8].

Plate-Plate Systems was used during the viscosity measurements with Rheometer MCR 302. The correct filling with sample for a plate-plate system is shown in Figure 4. The sample should be just outside the rim of the measuring system. Ideally, all excess sample is removed at a position just above the measuring position; then the measuring system is moved to the measuring position. If the sample will be too much and too little, it will lead to large errors of the measurements [9]. The over disk is rotating and press the sample. The thinness of sample h/mm is measuring with high accuracy. The sample also rotating with over disk. The rotation speed $v/\text{m}\cdot\text{s}^{-1}$ keeping as constant. It is clear, if the viscosity of sample will be higher, the force need for the rotation will be also higher. In this case, the accuracy measurement of the force F/N is very important. The shear stress is defined as the force F/N applied to the upper plate divided by this plate's area A/m^2 :

$$\tau = \frac{F}{A}. \quad (1)$$

To obtain the shear rate, the velocity $v/\text{m}\cdot\text{s}^{-1}$ of the upper plate is divided by the distance h/m between the two plates:

$$\dot{\gamma} = \frac{v}{h}. \quad (2)$$

Newton's Law states that shear stress is shear rate $\dot{\gamma}/\text{s}^{-1}$ times viscosity. Consequently, shear stress divided by shear rate is dynamic viscosity $\eta/\text{mPa}\cdot\text{s}$:

$$\tau = \eta \cdot \dot{\gamma} \Rightarrow \eta = \frac{\tau}{\dot{\gamma}}. \quad (3)$$

Installation work in the single temperature regime or in the concrete temperature interval. The results of dynamic viscosity η measurements recording in PC.

The speed of sound values $u(p_0, T)/\text{m}\cdot\text{s}^{-1}$ of Caspian seawater at $p=0.101$ MPa and $T = (278.15$ to $343.15)$ K were investigated using the Anton Paar DSA 5000 M vibration tube densimeter and sound velocity meter with $\Delta T= (5$ to $10)$ K temperature intervals and an uncertainty of $\Delta u= \pm 0.1$ $\text{m}\cdot\text{s}^{-1}$ [9]. These high accuracy values are necessary to check the accuracy of calculated speed of sound values u at $p= 0.101$ MPa.

Results

The (p, ρ, T) properties of Caspian Seawater samples with absolute salinities $S_A = (2.5024, 2.8956, 3.3111, 3.6872, 4.0831, 4.6621, 5.1265, 5.5923, 6.0248, 6.4247, 6.7776, 7.2698, 7.8124, 8.4126, 9.0785, 9.6161, 10.1947, 10.5467, 10.8515, 10.9323, 10.9538, 11.0466, 11.2623, 11.2735, 11.2961, 11.3036, 11.3040, 11.3256, 11.3821, 11.9457, 12.4857, 13.0842, 13.4986, 13.9416)$ $\text{g}\cdot\text{kg}^{-1}$ are measured at temperatures $T= (274.15$ to $343.15)$ K and pressures, p , up to 40 MPa.

The set of 3672 measured (p, ρ, T) values of seawater with absolute salinity $S_A = (2.5024$ to $13.9416)$ $\text{g}\cdot\text{kg}^{-1}$, also the (p, ρ, T) values of IAPWS-95 pure water as a function of pressure, temperature and salinity are used for the mathematical fit of the parameters in the equation of state (1) (Safarov 2003, Safarov *et al.*, 2009):

$$p/\text{MPa} = A(\rho/\text{g}\cdot\text{cm}^{-3})^2 + B(\rho/\text{g}\cdot\text{cm}^{-3})^8 + C(\rho/\text{g}\cdot\text{cm}^{-3})^{12} \quad (4)$$

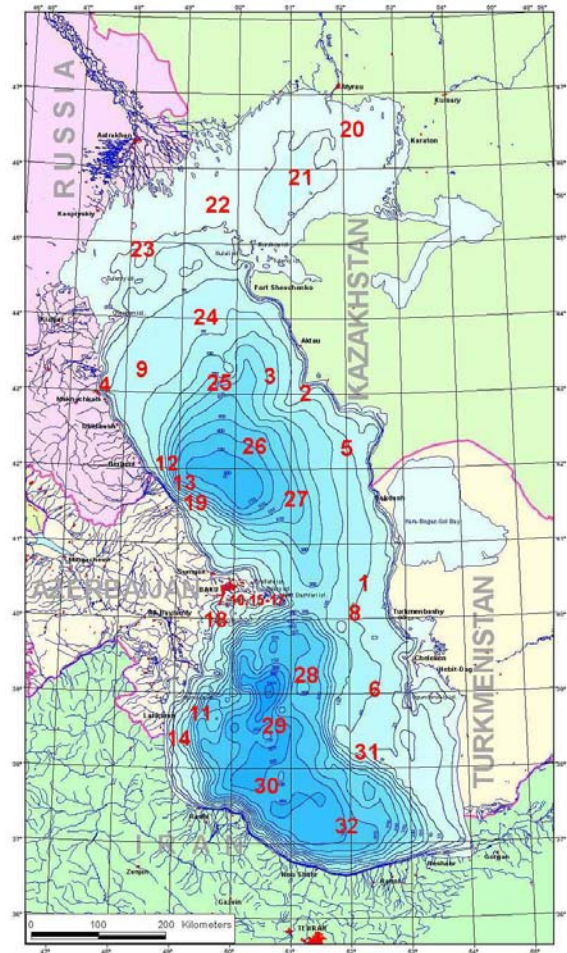
First the coefficients of the EOS (4) are connected together in the dependence of temperature and salinity:

$$A = \sum_{i=1}^4 T^i \sum_{j=0}^3 a_{ij} S_A^j, \quad (5)$$

$$B = \sum_{i=0}^3 T^i \sum_{j=0}^3 b_{ij} S_A^j, \quad (6)$$

$$C = \sum_{i=0}^3 T^i \sum_{j=0}^3 c_{ij} S_A^j. \quad (7)$$

The coefficients a_{ij} , b_{ij} and c_{ij} of the EOS (4) are describes the experimental (p, ρ, T) results of seawater with absolute salinity $S_A = (0$ to $13.9416)$ $\text{g}\cdot\text{kg}^{-1}$ within $\Delta\rho/\rho = \pm 0.0078$ % average percent. The temperature dependence of the density values of seawater samples at the various pressures exhibits similar anomalies as those of pure water. This is not very surprising since the major mass fraction of seawater, appr. 96.5 %, is pure water. In a typical liquid the compressibility decreases as the structure becomes more compact due to lowered temperature. In water and all aqueous salt solutions in which the concentration of water is very high, the cluster equilibrium shifts towards a more open structure, for example an expanded structure - ES, as the temperature is reduced due to preference for a more ordered structure, that is, ΔG for $\text{ES} \rightleftharpoons \text{CS}$, collapsed structure, becomes more positive (Chaplin, 2009). As the water structure is more open at these lower T temperatures, its capacity to be compressed increases (Kell, 1975). Since the compressibility depends on fluctuations in the specific volume, these will be largest where water molecules have a more open structure. At high pressures, for example ~ 200 MPa, this compressibility anomaly, although still present, is far less apparent (Kanno and Angell, 1979).



This EOS (4-7) is applied successfully for fitting of (p, ρ, T) values of our various research results during the last 20 years. The graphical analysis of the temperature dependence of the coefficients of EOS (4) revealed that, at $T \rightarrow T_c$, $A \rightarrow 0$. Such behavior of $A = f(T)$ may be explained by the fact that, according to the theory by Putilov (Putilov, 1971), the first term on the right-hand side of eqn. (4), $A\rho^2$, is the attractive force, attractor pressure, and the second $B\rho^8$ and third terms $C\rho^{12}$ are the repulsive force, repulsive pressure. As the temperature rises, the mean kinetic energy for all individual molecules increases which weakens the relative attractive force. As the relative attractive force tends to zero, $A \rightarrow 0$, molecules under the effect of the repulsive force are capable of increasing their relative distance to each other. Only the density of the substance, i.e., external pressure, defines the extent of their displacement. As a result, the aggregate state changes. Note that the form of eqn. (4) is derived from Putilov's molecular-kinetic theory.

The values of isothermal compressibility $\kappa_T(p, T)$, isobaric thermal expansibility $\alpha_p(p, T)$, difference in isobaric and isochoric heat capacities $(c_p - c_v)(p, T)$, thermal pressure coefficient $\gamma(p, T)$, internal pressure $p_{\text{int}}(p, T)$, isobaric heat capacity $c_p(p, T)$, isochoric heat capacity $c_v(p, T)$, speed of sound $u/\text{m}\cdot\text{s}^{-1}$ and isentropic exponent $\kappa_s(p, T)$ of Caspian Seawater samples were calculated from the Eqs. (4-7) using the fundamental equations of thermodynamics:

- isothermal compressibility $\kappa_T(p, T)$:

$$\kappa_T(p, T) = \frac{1}{\rho} \left(\frac{\partial p(T, \rho)}{\partial \rho} \right)_T^{-1} \quad (8)$$

$$\kappa_T(p, T) = \frac{1}{2A(T)\rho^2 + 8B(T)\rho^8 + 12C(T)\rho^{12}}. \quad (9)$$

- isobaric thermal expansibility $\alpha_p(p, T)$:

$$\alpha_p(p, T) = \frac{1}{\rho} \left(\frac{\partial p(T, \rho)}{\partial T} \right)_\rho \left(\frac{\partial p(T, \rho)}{\partial \rho} \right)_T^{-1}. \quad (10)$$

$$\alpha_p(p, T) = \frac{A'(T) + B'(T)\rho^6 + C'(T)\rho^{10}}{2A(T) + 8B(T)\rho^6 + 12C(T)\rho^{10}}, \quad (11)$$

where: A' , B' , and C' are the derivatives of the A , B , and C :

$$A'(T) = \sum_{i=1}^4 ia_i T^{i-1}, \quad (12)$$

$$B'(T) = \sum_{i=1}^3 ib_i T^{i-1}, \quad (13)$$

$$C'(T) = \sum_{i=1}^3 ic_i T^{i-1}. \quad (14)$$

- thermal pressure coefficient $\gamma(p, T)$:

$$\gamma(p, T) = \frac{\alpha_p(p, T)}{\kappa_T(p, T)}. \quad (15)$$

- internal pressure $p_{\text{int}}(p, T)$:

$$p_{\text{int}}(p, T) = \frac{T \cdot \alpha_p(p, T)}{\kappa_T(p, T)} - p. \quad (16)$$

- specific heat capacities [at constant pressure $c_p(p, T)$ and constant volume $c_v(p, T)$] at high pressures and temperatures:

$$c_v(p, T) = c_v(p_0, T) - T \int_{\rho_0}^{\rho} \left(\frac{\partial^2 p(T, \rho)}{\partial T^2} \right)_{\rho} \frac{d\rho}{\rho^2}, \quad (17)$$

$$c_p(p, T) = c_v(p, T) + \frac{T \left(\frac{\partial p(T, \rho)}{\partial T} \right)_{\rho}^2}{\rho^2 \left(\frac{\partial p(T, \rho)}{\partial \rho} \right)_{T}}, \quad (18)$$

$$c_p(p, T) - c_v(p, T) = \frac{\alpha_p^2(p, T) \cdot T}{\rho \cdot \kappa_T(p, T)}. \quad (19)$$

Definition of $c_v(p_0, T)$ in Eq. (17) makes it possible to calculate $c_v(p, T)$ in Eq. (17) and $c_p(p, T)$ in Eqs. (18-19) at high pressures and temperatures in which the density of Caspian Seawater samples has been experimentally investigated. $c_v(p_0, T)$ can be calculated using $c_p(p_0, T)$ values at the ambient pressure and experimental temperatures of (p, ρ, T) data, see also Eq. (19) for the ambient pressure situation. The calculated differences in specific heat capacities $c_p(p, T) - c_v(p, T)$ at high pressures were used for the calculation of constant pressure heat capacity $c_p(p, T)$ in Eqs. (18-19) at high pressures and temperatures.

After determination of specific heat capacities of samples, it is possible to establish the speed of sound at high pressures and various temperatures $u(p, T)$ using the following thermodynamic equation:

$$u^2(p, T) = \frac{c_p(p, T)}{c_v(p, T)} \left(\frac{\partial p(T, \rho)}{\partial \rho} \right)_{T}. \quad (20)$$

Further the isentropic exponent $\kappa_s(p, T)$ can be obtained using the following relation:

$$\kappa_s(p, T) = \frac{\rho(p, T)}{p} \cdot \frac{c_p(p, T)}{c_v(p, T)} \cdot \left(\frac{\partial p(T, \rho)}{\partial \rho} \right)_{T}. \quad (21)$$

Conclusion

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An Example of the Results of Field Measurements in the Western Part of the Southern Caspian Sea, off Mouth of Sepidroud River

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Keywords: Caspian Sea, Continental Shelf, Seawater Properties, Dissolved Oxygen.

Introduction

The Caspian Sea, largest continental water body on earth, is distinguished by special conditions, contains rich hydrocarbon and biological resources, and plays an important role in the region (Dumont 1998; Kosarev & Kostianoy, 2005; Zonn 2005). There are extensive oil fields within and close to the Caspian Sea. Oil industry is growing fast and becoming a major component of the economy of the littoral countries of the Caspian Sea. Fishing and caviar production is the second large industry in the Caspian Sea (Zaker et al. 2007). This sea is the unique world reserves of endemic sturgeons giving 85% of world black Caviar supplies region (Dumont 1998; Zonn 2005). Nowadays, the Caspian Sea is one of the polluted seas and its marine environment, due to extensive human exploitation and discharge of large magnitude of human waste, is under extensive pressure (Zaker et al. 2007; Zonn 2005). Heavy metals, hydrocarbons, pesticides, nutrients such as phosphate, nitrate and other human wastes introduced into the Caspian Sea are threatening marine life and the recreational potential of the sea (Zaker et al. 2007). In addition, pollution caused by industrial, agricultural and municipal wastes, offshore and coastal production of oil and gas, shipping companies and other circumstances, has lead into degradation of its biodiversity, exhaust of fish resources and increased fluctuations of the sea level. The above-mentioned problems change the properties of seawater and environment of the Caspian basin. In this condition, the physical oceanographic studies of the Caspian Sea water have become necessary (Zonn 2005; Safrov et al. 2008; Kara et al., 2010). These studies are among the basic requirements for environmental and any other marine related studies. By the way, they play an important role for designing the appropriate measures for pollution reduction and sustainable development of the Caspian Sea (Zaker et al. 2007).

Material and Methods

In the last decade, there has been an extensive amount of oceanographic research in the southern coastal waters of the Caspian Sea. This paper presents the field measurements results of variations of seawater properties in the southern Caspian Sea. Article focus on results of field work over the southern shelf of the Caspian Sea based on the field data collection. Field measurements in the southern boundary of the Caspian Sea were carried out at onshore stations along transects perpendicular to the coastline. Seawater parameters were measured by equipment such as Ocean Seven 316 portable CTD probe.

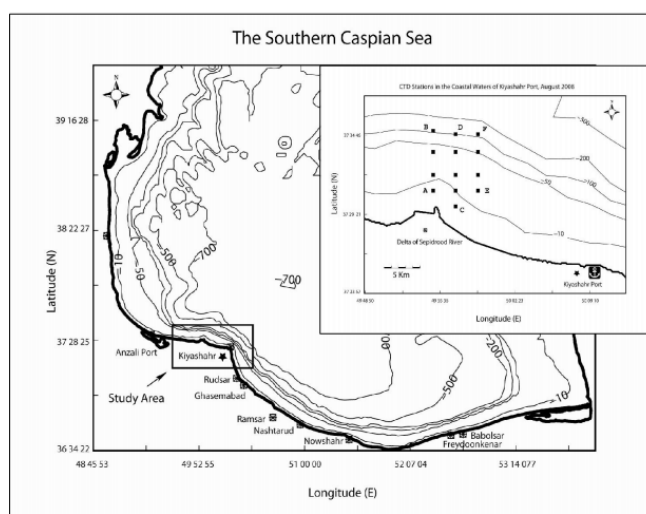


Fig. 1. Caspian Sea and sampling stations

Results and Discussion

Results of a sample of variations in dissolved oxygen and active reaction (pH) in the southern coastal waters of the Caspian Sea near mouth of Sepidrood River were presented in figure 2. PH values of the Caspian Sea water in this area was affected by the River. Especially over the continental shelf, distribution of the pH values in the sea surface layers and near mouth of the Sepidrood River are related to the effect of river discharge. Active reaction ranges between 8.3 – 8.5 in the mouth of the River. Outside of the shelf, vertical variation of active reaction is from 8.55 at the sea surface and 8.7 in the 40 m depth (in the end of thermocline layer) and then reduces to 8.6 near bottom. Horizontal variation of pH is about 0.3 in the sea surface mixed layer (10 m of upper layer). The structure of pH is regular and vertical gradient of pH is about 0.3. PH values generally increases from 8.4 at the sea surface to 8.7 in the 40 m depth and after that reaches to 8.6 near bottom layer. Horizontal gradient of pH is clearly about

0.2 in the sea surface layer. Vertical structure of temperature shows a strong seasonal thermocline located between 10 m and 40 m depths with 20°C temperature gradient across it. Temperature of sea water in the surface mixed layer is about 29°C. Vertical structure of the pH shows a gently increasing in its value with depth across the thermocline. PH value ranges between 8.5 – 8.7 across thermocline in water column. In the time of observations, salinity found to vary between 12.2 psu and 12.6 psu with a dominant value of 12.4 psu in the study area. The salinity structure indicated a gradient of salinity values about 0.4 psu in the area. The salinity in the surface mixed layer was mainly around 12.4 psu. A gentle decrease of salinity with depth increasing can be observed in the some of the sampling stations. Analysis of the CTD data in this region showed that thermal stratification of seawater contained surface mixed layer and thermocline. The temperature structure was characterized by a thin seasonal thermocline in the 10-40 m layer (With more than 20°C temperature gradient). The salinity in the thermocline layer was slightly more than salinity in the surface mixed layer. The density of seawater through the thermocline layer was more than density values of surface mixed layer. Results indicated that variation in water density inversely related to the temperature ratio. According to the small salinity values of the Caspian Sea and high correlation between temperature and density of seawater, temperature is an important and effective physical property of seawater over the southern continental shelf of the Caspian Sea. Atmospheric processes and local rivers inflow mainly affect vertical stratification of seawater in the coastal area.

Since the beginning of the twentieth century, the large river discharge into the Caspian Sea was characterized by reduced concentrations of dissolved oxygen and increased nutrient contents. Enhancement in nutrient supply (due to increase of rivers inflow) and reduction of winter severity are the most important factors for unfavorable ventilation of deep waters of the Southern Caspian Sea. Amounts of dissolved oxygen in the Caspian Sea deep-waters are unsuitable to most aquatic organisms. Dissolved oxygen levels of below 3 mg L⁻¹ are stressful to most marine biota. Oxygen concentrations of at least 5-6 mg L⁻¹ are usually required for growth. Moreover, seasonal variations of the dissolved oxygen from sea surface to bottom were correlated to seasonal changes in vertical structure of water temperature. Concentrations of dissolved oxygen at surface layers ranged around 5.5 mg L⁻¹. In midsummer, the dissolved oxygen concentration below thermocline was recorded

about 4.9 mg L^{-1} at depth of 50 m in offshore stations. Discharge of large amounts of industrial, agricultural and urban wastes threatens the Caspian Sea ecosystems. As a result of the elevated pollutants and nutrients loading to the Caspian Sea, average of dissolved oxygen concentrations in the deeper layers of the Caspian Sea was reduced. Outflow of local rivers and port activities change seawater properties in the study area.

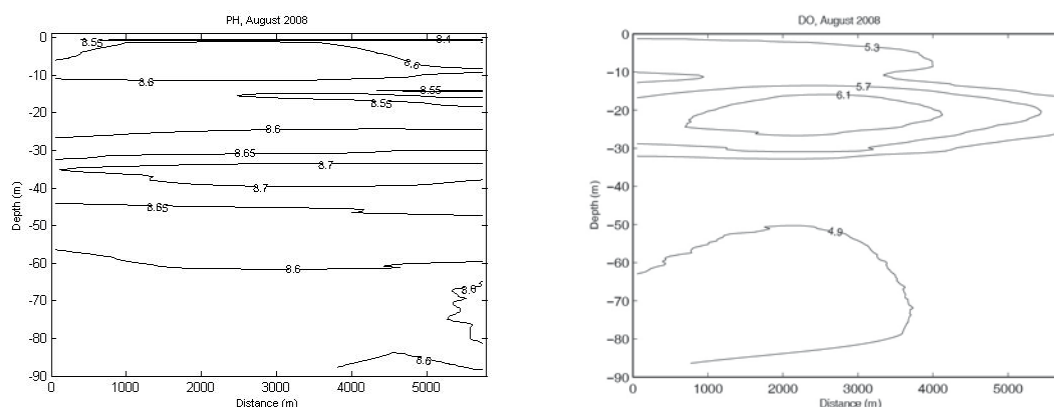


Fig. 2. Variations of pH and dissolved oxygen over the continental shelf

Vertical structures of seawater properties showed that the variations of seawater parameters across upper 100 m depth were considerable. Vertical salinity variations were very small and ranged mainly around 12.4 with very slight variations. The dissolved Oxygen and active reaction are two important factors for evaluating the level of safety of marine environments. The results of the study represent preliminary information on vertical structure and variability of seawater characteristics in the region during the year. The formation and destruction of seasonal thermocline affect the distribution of dissolved oxygen in water column. Moreover, variations of dissolved oxygen from sea surface to bottom were correlated to changes of water temperature. Characteristics of river outflow was one of the important factors for changing active reaction and dissolved oxygen levels in seawater over the continental shelf near the mouth of Sepidroud River.

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Physical Oceanography Researches in the Southern Boundary of the Caspian Sea

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Keywords: Caspian Sea, Physical Oceanography, Coastal Waters, Southern Boundary.

Introduction

The Caspian Sea due to its unique characteristics is very important in the region of Eurasia (Dumont, 1998). Iran is located in the southern coasts of the Caspian Sea and has very important position and role in the western part of Asia. In the last decades, utilization of the Caspian Sea with purpose of mineral and hydrocarbons resources, fisheries industry and food, economic and transportation and cooperation of coastal countries is very important in the Eurasia region and world (Kosarev and Kostianoy, 2005; Zonn, 2005). Iranian shoreline of the Caspian Sea is covers approximately 900 km between Astara in west and Khajenafas area in east. Sustainable development of coastal areas and ports, and optimal operation of the Caspian Sea requires environmental and oceanography knowledge in shallow and deep waters of the sea.

Some actives of Caspian Sea Oceanography Research Center (in the middle part of the southern boundary of the Caspian Sea) cover different fields of oceanography; such as physical, biological, chemical and sediment aspects. Article focus on results of physical oceanography researches over the southern shelf of the Caspian Sea based on the field data collection. Field measurements in the southern boundary of the Caspian Sea were carried out at onshore and offshore stations along transects perpendicular to the coastline. Distance between stations reached an average of 2 km along transects. Physical and dynamical parameters of seawater were measured by equipment such as Acoustic Doppler Current Profiler (ADCP), Recording Current Meter (RCM9) and CTD probe (Ocean Seven 316).

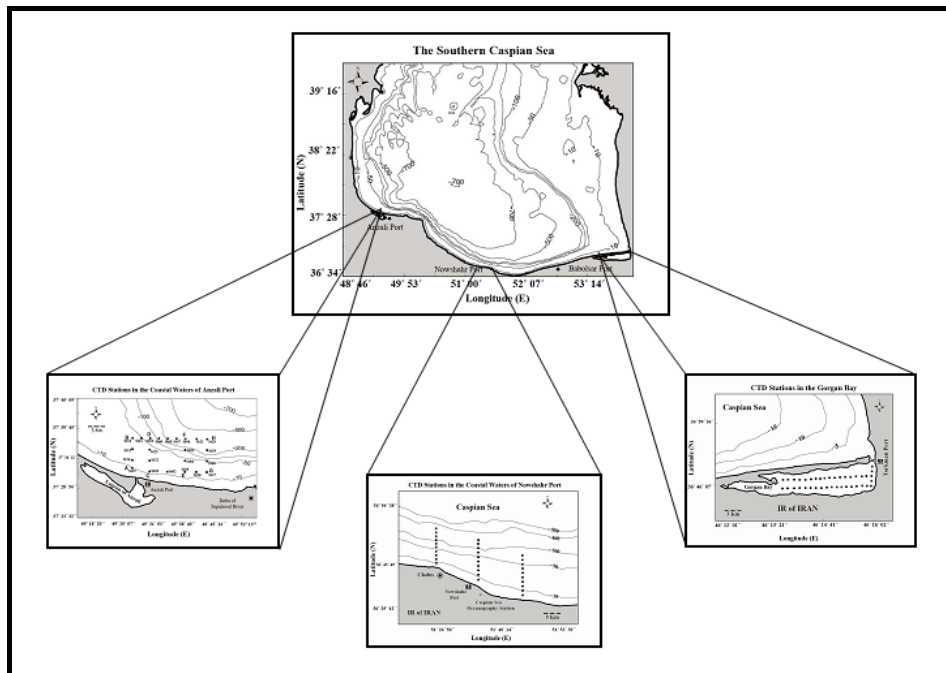


Fig. 1. Map of stations in the southern boundary of the Caspian Sea

Results and Discussion

Our studies in last decade were based on experimental field measurements and sampling in the southern part of the Caspian Sea. Physical properties such as temperature, salinity, density and water column stability and dynamical parameters such as current and wave were studied. Substantial changes in the physical components of the seawater properties occurred primarily within the upper 100 m, below which most seawater properties remained little-changed. The findings indicated a remarkable range of seasonal variations in the physical components of the seawater properties (such as temperature, sound speed, and density) of the southern coastal waters of the Caspian Sea. In addition, slight variations in seawater salinity were observed in areas far from the mouth. The seawater temperature in the surface layer mostly ranged between 9-10°C in March, 17–18°C in April, 27–29°C in August, and 19–20°C in November. The seawater temperature rapidly decreased with depth before reaching a constant value of about 6°C in the deeper part of the water column (Jamshidi₍₁₎, 2017). Seawater temperature is the primary factor that controls other physical components of seawater properties, as well as marine environmental components. Thermal stratification and its seasonal variations are also important environmental factors in biological studies, as well as in the study of the mixing processes and distribution of lagoon and river discharges into coastal areas (Jamshidi₍₂₎, 2017). Temperature affects the changes in water quality and biological reactions in the area. Salinity is also an important seawater property in the southern Caspian Sea. Unlike the pattern of seawater temperature, the salinity exhibited an increasing trend with depth and at a much smaller range. To a smaller extent, variations in the seawater salinity affected the seasonal

changes in the physical structure of the water column. The structure of the water density exhibited a high vertical gradient of density, which consequently reduced the vertical mixing process but increased the vertical stratification of the water column. Generally, seawater temperature, salinity, and density are important physical components of seawater properties in controlling stratifications in water columns (Jamshidi and Soheilifar, 2016). Among these factors, however, temperature imposes a stronger effect. Sound speed reached a maximum value of 1520 m s^{-1} at the sea surface during summer, and generally decreased with depth. The sound speed showed small variations during the period of measurements in the deep water layer. Changes in sound speed were considerably dependent on the seawater temperature variations in the southern Caspian Sea.

Vertical structure of sea water over the southern shelf of the Sea indicated a stratified water column including surface mixed, thermocline and deep layer between midsummer and mid autumn. The results of the projects showed existence a strong seasonal thermocline located across 60 m upper layer in summer with 16 degree vertical temperature gradient. During autumn, the thickness of the thermocline reduced to 15 m and thermocline was located above 45 m depth (Jamshidi₍₁₎, 2017; Zaker et al., 2007). It was not observed strong and significant halocline over the southern shelf of the sea. Due to slight vertical salinity variations, vertical density changes were highly correlated with vertical temperature variations. Mean values of water density was measured less than 1010 kg/m^3 across the 60m upper layer. One of the most features of physical structure of water column is stability and mixing. In the southern Caspian Sea both of temperature and the salinity distribution stabilize the water column. Below thermocline, the contribution to stability by the temperature gradient is slightly larger than that by the salinity gradient. Results indicated that the maximum values mostly were recorded during upper layer which was occurred stratification including several layers. This is important point that, the pikes mainly were at down boundary of thermocline layer during warm months. During the cold months in winter season, the profiles of stability were much frequently. The main factor to mixing water column in the region was wind driven forces while near the coastline salt transport in vertical and horizontal directions also plays important role. Especially, eddy turbulent and flux gradient is contaminant phenomena for transferring water properties in the area over the western part of the southern continental shelf near the mouth of Anzali Lagoon in the western part of southern boundary of the sea. In the eastern side of the southern continental shelf that the slope of the sea bed was not very sharp, entrance of Caspian Sea water in the Gorgan Bay was considerable. According to the results it seems that diffusion effects were strongest in the southern boundary of the Caspian Sea with high concentration gradient of seawater properties such as salinity. The dissolved oxygen and active reaction are two important factors for evaluating the level of safety of marine environments.

The characteristics of the Caspian deepwater were different compared to its shallow waters area. The formation and destruction of seasonal thermocline affect the distribution of dissolved oxygen in water column. Moreover, seasonal variations of the dissolved oxygen from sea surface to bottom were correlated to seasonal changes in vertical structure of water temperature. Concentrations of dissolved oxygen at surface layers ranged around 7.5 mg L^{-1} . In midsummer, the dissolved oxygen concentration below thermocline was recorded about 7.5 mg L^{-1} at depth of 50 m in offshore stations. It is possible that there was enough light to allow a phytoplankton bloom development. Concentrations of dissolved oxygen at depth of 470 m were recorded around 1.25 mg L^{-1} with little changes in comparison to midsummer.

Discharge of large amounts of industrial, agricultural and urban wastes threatens the Caspian Sea ecosystems. As a result of the elevated pollutants and nutrients loading to the Caspian Sea, average of dissolved oxygen concentrations in the deeper layers of the Caspian Sea was reduced. In addition, outflow of local rivers (as sources for entrance the urban and industrial wastes) and port activities change seawater properties in the study area. The results indicated the need for serious efforts to reduce entry of pollutants into the Caspian Sea environment. The Caspian Sea environment and in particular its southern coastal waters from various points of view such as fisheries, economics, commercial and tourism play important role in the region. Therefore, in future, it is necessary to develop the oceanographic studies to providing good understanding about its conditions, optimize utilization of reserves and conserving its marine environment. It is recommended that continuous data collections be carried out in order to fill up the gap in data in this thesis. In addition the survey area could also be extended to cover a larger area i.e. the southern Caspian Sea. After providing a great volume of data on various seawater properties over several years it would be useful to develop an appropriate model on current and water circulation. Measurements of currents and waves in several offshore stations in the deep water can be interesting items in the physical oceanographic studies in the region. An extensive data set reduces the influence of anomalies and represents a clear pattern of the variations. Additionally, by gathering data over several years the inter-annual variability will be identifiable which will lead to an accurate understanding of the system especially in deep waters. In addition, measuring the nutrients in seawater is an important factor for study on biological components of seawater such as chlorophyll-*a* concentrations.

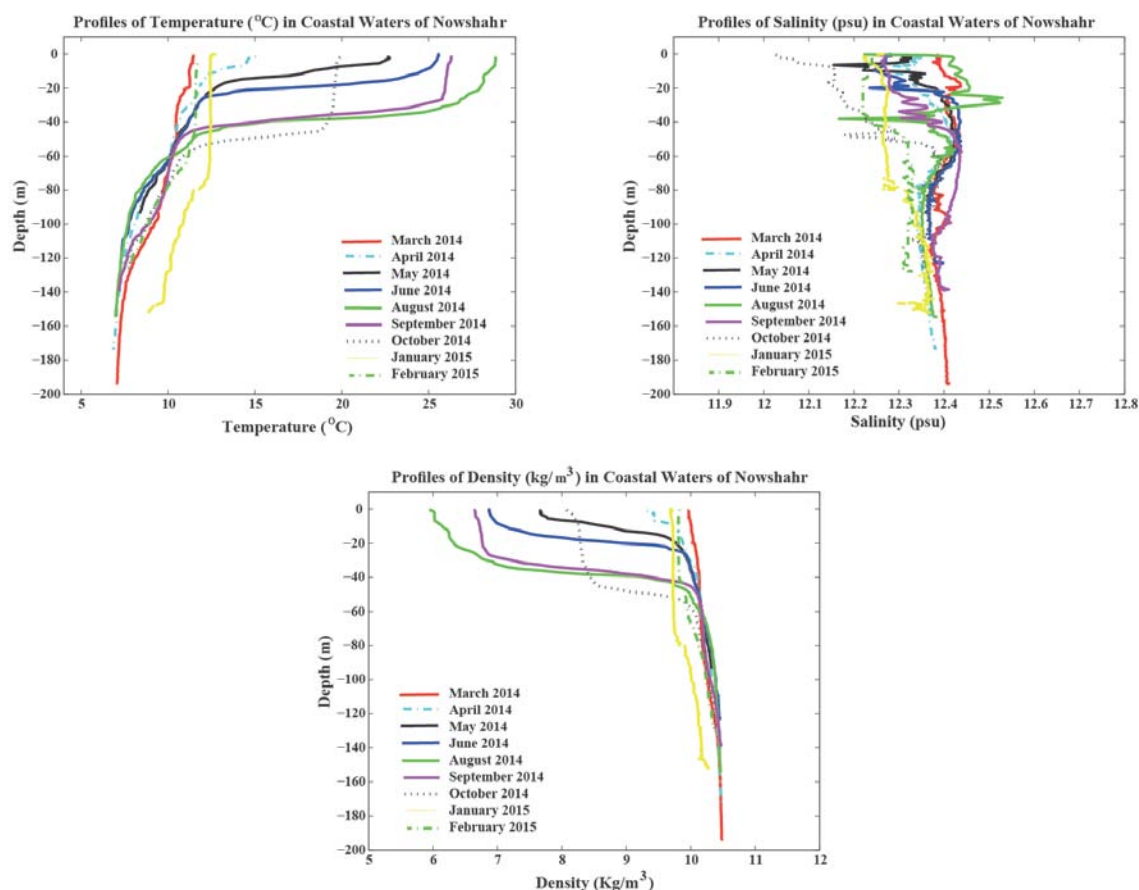


Fig. 2. Vertical distribution of temperature, salinity and density in deepest stations in the southern shelf

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THEME V

Geology, Geomorphology And
Paleogeography

Formation of the Sefidrud delta in Khvalynian time against the background of gradual lowering of the Caspian Sea level after the Khazarian transgression

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Keywords: sections, clays, coastal zone, sea level fluctuations, paleogeography

Introduction. In recent years there have been several new articles on the structure of the Caspian Iranian coastal plain (Kazanci & Gulbabazadeh, 2013; Kakroodi et al., 2015). Despite this fact in the history of its development at the end of the Pleistocene, there are, in our opinion, a number of unresolved problems. One of them is the history of the Caspian Sea level fluctuations. In a recently published work by one of the authors of this article stated that it was not a deep Atelian regression and hence the subsequent Great Khvalynian transgression (Badyukova, 2017). From these new positions, the data on the structure of the Iranian coastal plain, published in recent years, are considered.

Materials and methods. During the field work a detailed geomorphological description of the seaside plain and the coasts of Gilan was carried out with the taking of the mollusks shells, as well as the drawing the profiles from the coastline to the Novocaspian terraces. In total, 64 areas located in the Western Gilan part of the Iranian coast were chartered and described, about 50 profiles were made (Fig.1). A number of published works examined the geological and geomorphological structure of the shore and concluded that there were extensive lagoons on the coastal plain, which were later blocked by alluvial and alluvial fan deposits, which formed the aggradation plain (Badyukova et al., 2012).

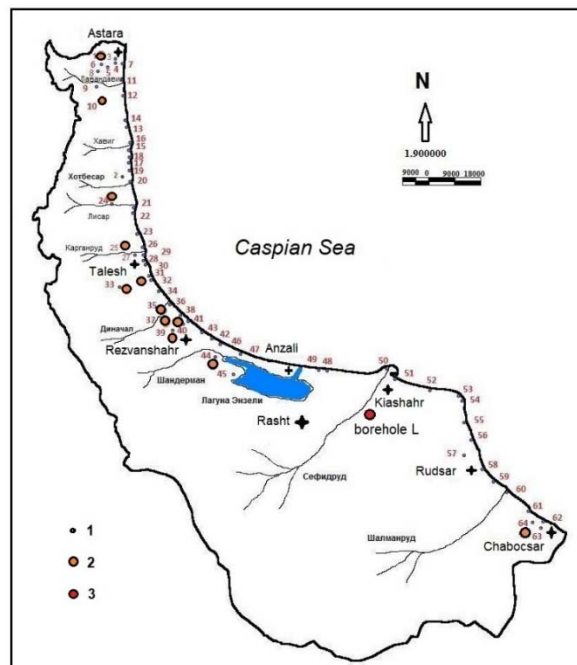


Fig. 1. Study area: 1-points of the coastal zone detailed description; 2-sections where dense heavy clays are exposed; 3-borehole L (Kazanci & Gulbabazadeh, 2013).

The aggradation plain occupies almost the entire coastal plain, except the recent marine terrace and the areas near towns Astara, Anzali and Amir-Abad where lagoons of the Novocaspian and modern age are located. Judging by the investigated sections (Fig.1 - p. 3, 4, 6), silty lacustrine deposits with a lot of shells (including *Cerastoderma glaucum*) with a sharp contact overlain in boulder-gravel deposits composing the regressive terraces.

Results. Interesting data were obtained from the outcrops on the sides of erosion cuttings of many rivers, in wells and quarries, lying at higher levels (Fig.1 – p. 1, 10, 24, 25, 31.33, 35, 37, 39, 40). In all outcrops located at different hypsometric levels, under thick layers of alluvial and alluvial fan deposits with a clear contact over red-brown or bluish-gray very dense clay and silt are found (which is important to emphasize as this clay not at all similar to the lagoon sediments) These deposits are very poorly eroded, so often observed not only on the banks of rivers, but even directly in their beds (Fig.2). Clays with visible layers in some sections have thickness up to 4 m or even more (for example, in p. 35). Unfortunately, the deposits do not contain shells of mollusks, which precludes the possibility of determining their absolute age.

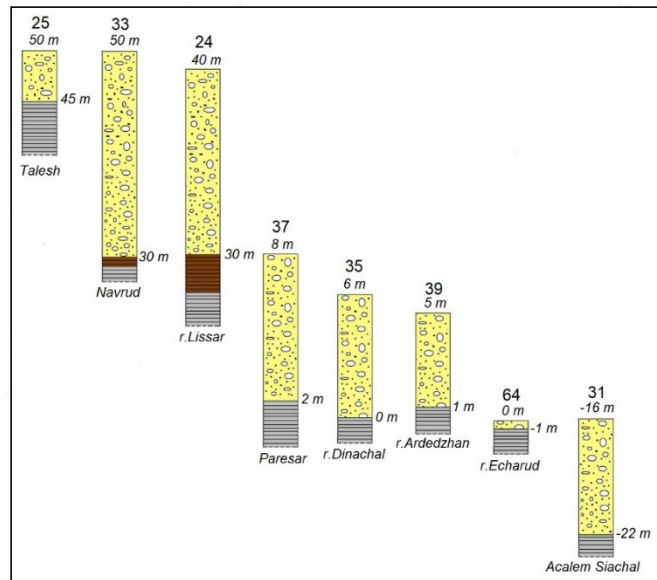


Fig. 2. The outcrops along the rivers and in the career.

Early Khvalynian marine terraces on the surface of the coastal plain are not revealed, as they are covered by a thick layer of alluvial and alluvial fan material. Accumulation of this material continued for a long time, currently, it forms the surface of the coastal plain up to the foothills. After the deposition of massive layers of boulder-pebble sediments erosion phase began. As a result, incised valleys were formed, and later a series of terraces and wide floodplains were developed in them.

Analysis of the geological and geomorphological structure of the coastal plain suggests that the accumulation of such massive alluvial-alluvial fan deposits, followed by their erosion and then the formation of wide valleys with series of terraces and wide floodplains requires a long time. Unfortunately, we could not find any shells of mollusks, which could allow to determine the age of the terraces. Fragments of the sea terraces are preserved only on the slopes of mountains and on the sides of river valleys at their exit to the plain (Fig.1 – p. 1, 5, 8, 9, 10).

An interesting detailed study of the Sefidrud rivers delta and the southern coast of the Caspian Sea are given in the article of Kazanci & Gulbabazadeh (2013) which allow to suggest another history of the Caspian Sea level fluctuations in the Late Pleistocene. This assumption is

consonant to our ideas about the history of the development of the Northern Caspian plain during the Late Pleistocene.

Discussion. Previously, a detailed study of literature and field studies showed that in all known sections along the Lower Volga and the rivers of the Volga-Ural interfluvium there are no Khvalynian transgressive sediments of an open sea. This allowed to conclude that there were no deep Atelian regression and the ensuing Great Khvalynian transgression.

The following suggestions were made. There was a Great Early Khazarian transgression, the level of which, according to the literature and field research data, was slightly lower than the Early Khvalynian transgression (Badyukova et al., 2015). Then, against the background of a gradual Caspian Sea level fall, there were its positive oscillations. Early and Late Khvalynian transgression were some of these oscillations.

Each regression led to the rivers incision, increasing the accumulation of alluvial materials at the mouths, the formation and extension to the Caspian Sea new deltas and avandeltas. Here, according to the data of Kazanci & Gulbabazadeh (2013), alluvial-delta deposits with a clear contact lie on the very plastic compact gray clays (Fig. 3). These offshore sediments are exposed in the borehole Log L (Kazanci & Gulbabazadeh, 2013) and, probably, in most of the outcrops along rivers described in this thesis (Fig. 2). Possibly the comparable offshore deposits were in the borehole at the depth of about 28 m in the south-eastern part of the Iranian coast. Grey plastic clay and loam were discovered here, whose age at the Pliocene-Pleistocene ostracodes, is 20 120 cal yr BP. (Kakroodi et al., 2015).

During the latest transgressions there were flooding of river mouths and formation of extensive lagoons on the surface of the low-lying regressive terraces formed by that time. The development occurred according to the same scenario that we observed in the Caspian Sea coastal zone at the end of the twentieth century, and that is also discovered in the analysis of the borehole L (Kazanci & Gulbabazadeh, 2013).

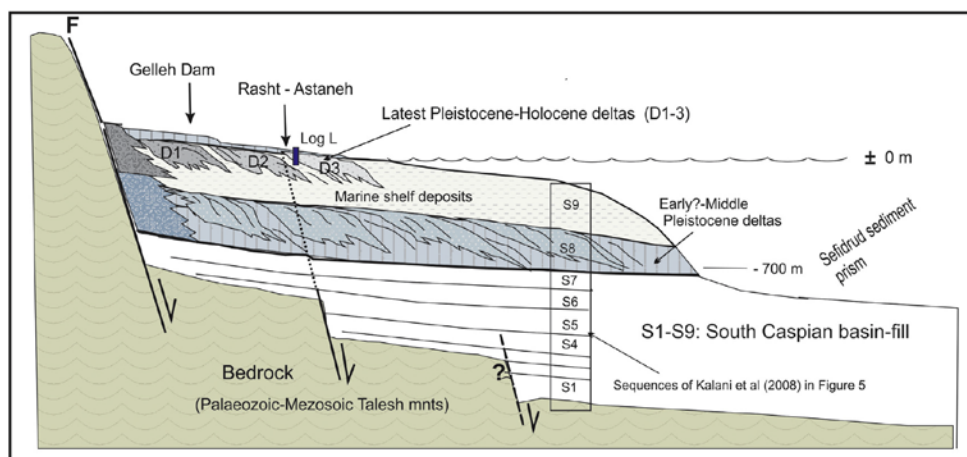


Fig.3. Cross section and model of the Sefidrud delta (Kazanci & Gulbabazadeh, 2013)

As can be seen in Fig. 3 a deep regression in the Late Pleistocene (Atelian), between the Khazarian and Khvalynian transgressions is not fixed. The delta series consistently moved towards the sea, lying on the offshore sediments formed during the high transgressions of the Caspian Sea.

Conclusion. Thus, against the general background of the sea level retreat in the Khvalynian time there were transgressive oscillations. Early and Late Khvalynian transgressions were some of these oscillations. During this time stairs of marine terraces were formed. So it is impossible

to correlate deposits exposed in outcrops and boreholes located across the stretch of coastlines. In contrast to the Northern Caspian plain, lagoons were not formed on the Iranian coast during the Khvalynian time, as there was large pitch of the coastal plain. In this case lagoons are not formed. Presented thesis constitutes only a preliminary view, it requires further studies in order to confirm or refute the presented schema of the Caspian Sea level fluctuations in the coastal zone of Iran during the Late Pleistocene.

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Stages of Volga and Amu-Darya deltas formation in the Late Pleistocene – Early Holocene

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Keywords: boreholes, chocolate clays, delta plain, sea-level oscillations, barrier-lagoon system

Introduction. The geological structure of the Volga Delta is considered. The presence of the chocolate clays suggests the presence of a large lagoon, into where the Volga flowed during the Late Pleistocene. At the same time, paleo delta of Amu-Darya was located off the coast of Turkmenistan.

Materials and methods. Volga delta. The great number of drilled boreholes in the Volga delta (according to the data of the Astrakhangiprovdokhoz) enabled to make the map and plot the profiles across the delta showing the distribution and the bedding character of the chocolate clays (CC). Earlier we proved that CC are lagoon sediments (Badyukova, 2007). The analysis of the obtained data has shown that, within the whole territory where the CC have been protected from erosion, they lie in a sharply discordant manner above the yellow well sorted marine Khvalynian and sometimes Khazarian sands (Figs. 1 and 2).

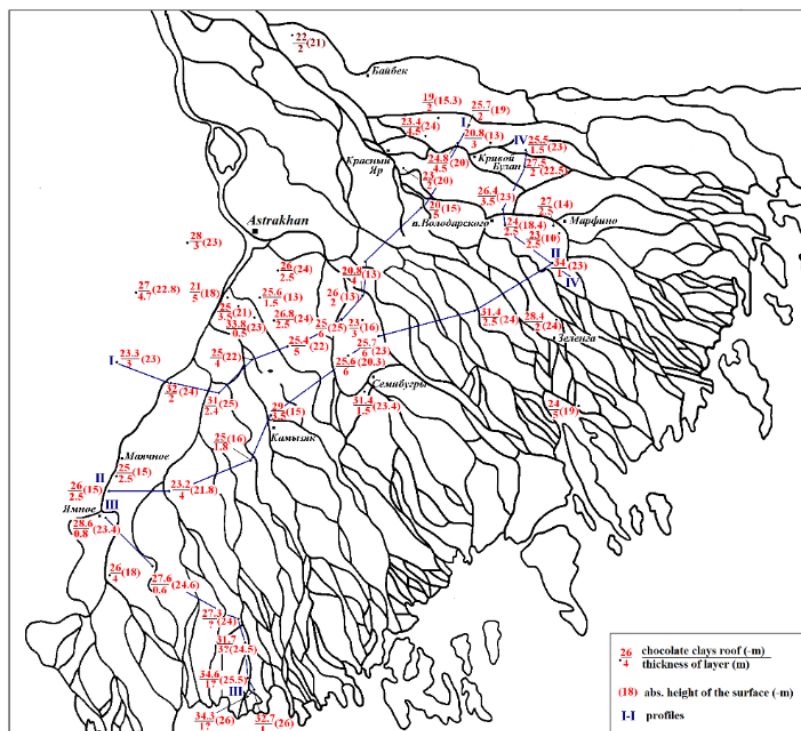


Fig. 1. Boreholes in the Volga Delta.

Thickness of the CC is small and usually varies from one to three meters, reaching 5–10 meters in several cases when filling erosion cuts. The alluvial deposits of the Volga delta or the deposits of the Baer knolls (in the places where they were not eroded) directly overlie the CC.

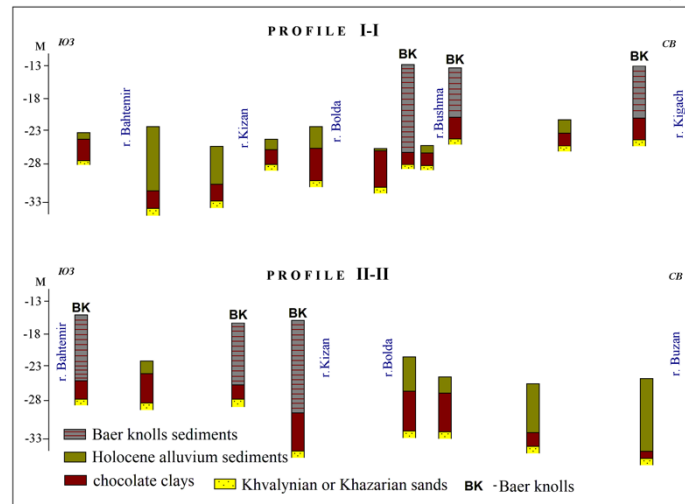


Fig. 2. Schematic profiles across the Volga delta.

In recent years detailed seismic works on the study of sediments have been conducted in the North Caspian Sea. The most detail seismoacoustic profiling was done for the Late Khvalynian and Novocaspian deposits, their thickness in the NE of threshold is 25 m, and in the SW – up to 90 m. (Bezrodnykh & Sorokin, 2016). The formation of these sediments occurred in both relatively low and relatively high sea level due to the sediment load of the Kuma, Volga, Ural, Emba.

One of the features of the bottom topography of the North Caspian are numerous islands and banks. They stretch out in the form of a wide line on the border of the Northern and Middle Caspian Sea, where the Mangyshlak threshold is located. The islands are: Tyuleniy, Chechen, Kulaly. The banks are: Bolshaya and Malaya Zhemchuzhnaya, Bezmyannaya and others. There are some evidences that the islands and banks are fragments of the former barrier system. For example, on the island Kulaly flint tools of ancient man were found, then there is good fresh water on it. On the island Tyuleniy detailed study of vegetation and insects have been conducted (Abdurahmanov et al., 2010). There are families of plant that are specific to the deserts of Central Asia. 40 species of beetles were found, among which is relict beetle *Pentodon algerium bispinifron*, its habitat is in Central Asia, 500 km from the island. Also, there is an endemic species from Turkmenistan - *Pentoclon bidens*. Kovalevsky (1933) wrote, that, according to the legend, earlier in historical time you could go from the western to the eastern shores of the Caspian Sea, right in the region of the Mangyshlak threshold.

Paleodelta of Amu-Darya. A similar genesis has the Ogurchinsky island. This is indicated by a number of geomorphological and historical data, but unfortunately, we have no geological materials yet supporting this conclusion. The island is located on the eastern, Turkmenistan shores of the Caspian Sea on the extensive shoal, with a width of more than 150 km that is similar to the Northern Caspian Sea. The island, as well as other islands in Northern Caspian Sea, lies near the 15-20 m isobaths. From these depths a steep slope extends. Between the island and the eastern Turkmenistan coast the depth is no greater than 15-16 m, the same as in the northern Caspian Sea. On the old maps there are several islands near Ogurchinsky, which have not remained to our time. On the island as well as on the island of Kulaly there is good fresh water and rather good soil.

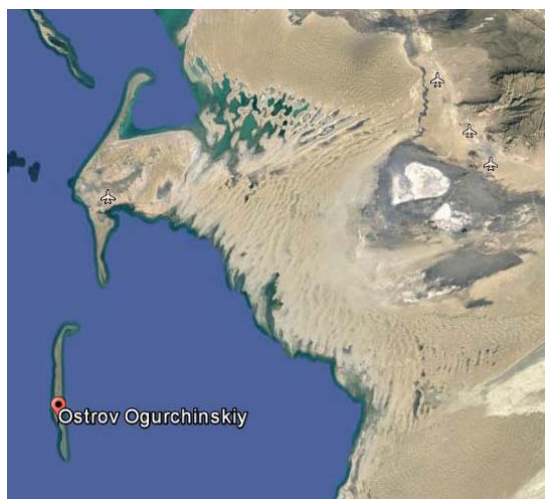


Fig. 3. Paleodelta of Amu-Darya (from Google)

The Mikhailovsky Gulf to the east of Ogurchinsky Island looks like the delta of a big river: showing the same branched, narrow waterways streaming between underwater spits. Together with the Balkhansky Gulf the Mikhailovsky Gulf represents a mouth of the paleoAmu-Darya (Fig.3).

Results. *Volga delta.* The almost common presence of the CC beneath the delta deposits allows one to make the supposition that the Volga River flowed into a vast lagoon, and its delta in the Late Pleistocene–Early Holocene was a silt delta. This supposition is indirectly proved by the data from other coasts where the sea-level variations were also observed. For example, in the Middle Holocene, the Danube River flowed into a vast lagoon divided by a bar from the sea. The Vistula River also entered into a lagoon, and, just recently, its delta's formation began in the coastal zone of the open Gulf of Danzig. A silt delta is formed by the Neman River in the Curonian Gulf, etc.

Many field data indicate that the islands and banks are fragments of the former barrier system. The islands and banks are fragments of the large bar which contoured the edge of delta plain and separated lagoon from the Caspian Sea. This bar was partly submerged and eroded by the sea-level rise after the Derbent regression (Badyukova et al., 1996).

Thus, the Mangyshlak threshold is paleodelta of Kuma, Volga, Ural and Emba rivers. Deposition of the alluvial material in the threshold is due to the lowering of the Middle Caspian Sea depression and the Terek-Caspian trough and uplift of the North Buzachi uplifted structure and Mangyshlak folded zone (Kuprin et al., 1991).

Amu-Darya paleodelta. Based on the study of the geomorphological situation, historical literature and cartographic materials, the opinion about the relatively recent inflow of Amu-Darya in the Caspian Sea was expressed. (Badyukova, 2013). On the maps of the 18th-19th centuries, south of Balkhansky Gulf is Khivisky Gulf (width more than 40 km, length more than 100 km). The gulf penetrated into the continent and stabilized opposite Ogurchinsky Island.

Conclusion. Islands and banks in the North Caspian Sea and island Ogurchinsky (with some banks, which are situated near the island) located on the edge of the relatively shallow underwater areas on the slope near the isobaths 15-20 m. All of them are associated with the

mouth areas of large rivers, where it has been and is now (in Volga delta) active sedimentation of alluvial material. The islands and banks are fragments of coastal bars located on the edge of the coastal delta plains. Caspian Sea level rise after Derbent regression led to catastrophic consequences: in the Turkmenistan the marine waters were flooding of the seaside plain and Amu-Darya delta, destruction of villages and cities occurred; in the Northern Caspian Sea the great part of the barriers were eroded and by now there are only some islands and banks.

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Application of geochemical proxies of the Late Quaternary sediments to paleoweathering reconstruction in the South Caspian Basin

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Keyword: South Caspian Basin, Bulk rock geochemistry, Provenance, CIA, Salinity

1. Introduction

The Caspian Sea is the largest enclosed water body on Earth by its surface area of 371,000 km² (Abdullayev et al., 2016). It is endorheic basin located between Europe and Asia and the costlines are shared by Kazakhstan, Turkmenistan, Iran, Azerbaijan and Russia. (Fig 1.) The water level of the basin is 28 m below sea level. Although 130 rivers provide inflow to the Caspian, it is mainly fed by the Volga, Ural, Samur and Kura rivers. The basin is divided into three regions: the Northern, Middle, and Southern Caspian basins. The Caspian Basin was one of marginal seas of Tethys paleocean, located between the European platform and the Afro- Arabian plate. The thick deposits (15-20 km) in the basin have recorded the regional environmental and climatic changes over time. Thus, they can provide insight into the Quaternary climatic history and its relationship with global climatic changes.

Our study presents the first detailed multi-element geochemical data from the late Quaternary sediments of the South Caspian to understand the palaeoclimate conditions in the basin and identify the provenances of the detrital fractions. Combined with previous researches on the palaeoclimate of this region, a variety of commonly used weathering indicators (Chemical Index of Alteration-CIA, Al-(Ca+Na)-K ternary plot), discrimination function analysis and element ratios were applied to estimate weathering intensity, provenance and environmental conditions, respectively.



Fig.1 Location map of the research area. (Pierrete et al., 2012)

2. Materials and Methods

Sediments were sampled from different points during the INCO-Copernicus French- Russian cruise in 1994. The Kullenberg core GS05 is composed of fine silt sediments and is 957 cm long. The uppermost sediment of the last millennia was lost during core penetration. The measured dates of the study section are presented in Table 1. The chronology of sediments is reliable above 115 cm depth, but the large amount of detrital carbonate prevents the application of depth-age model below this depth. A total of 45 samples were collected from the section at different depth intervals of 957 cm long core representing the different units of the sedimentary column. The mineralogical analysis of the samples was performed using X-ray diffraction. The major element composition were determined by ICP-AES at a precision of $\pm 5\%$, and those of the trace elements by ICP-MS at a precision of $\pm 10\%$. The carbonates in the samples were removed from the samples using 3 different weak acids (HCl 0.5N, HCl 1N, Acetic acid 1N).

3. Results

The changes in the mineralogy along the core allow us to identify 4 lithological units (Unit1, Unit2, TZ and Unit3). Based on previous studies by Pierret(2014) the ages for Units: TZ: 11,800-9,920 yr BP, Unit 2: 9,920-7,660 yr BP and Unit 3: 7,660-3970 yr BP. According to the ICP-AES the abundance of oxide compounds in the South Caspian Basin region is as follows: $\text{SiO}_2 > \text{Al}_2\text{O}_3 > \text{Fe}_2\text{O}_3 > \text{CaO} > \text{MgO} > \text{K}_2\text{O} > \text{TiO}_2 > \text{Na}_2\text{O} > \text{MnO}_2$.

4. Discussion

Discrimination function analysis are used to discriminate between various tectonic environments and sedimentary provenances with using chemical composition of sediments (Roser and Korsch ,1988). These functions discriminate among four sedimentary provenances, P1-mafic (ocean island arc), P2-intermediate (mature island arc), P3-felsic (active continental margin) and P4-recycled (granitic-gneissic or sedimentary source). All sediments of the South Caspian Basin plot in P4 section of this diagram reflecting recycled orogenic terrain (granite – gneissic or quartzose sedimentary provenance). For this reason, we estimate that the source area of the sediments was Russian Platform during the time of deposition.

The chemical index of alteration (CIA) is a good indicator of weathering intensity in the source area, which mainly indicates the progressive alteration of plagioclase and potassium feldspars to clay minerals (Young ,1982).

The CIA index is calculated as $\text{CIA} = \text{Al}_2\text{O}_3 * 100 / (\text{Al}_2\text{O}_3 + \text{CaO} + \text{Na}_2\text{O} + \text{K}_2\text{O})$

High values of CIA indicates the removal of labile elements (Ca, Na, K) relative to the immobile elements like Al during intense chemical weathering and suggests humid and warmer climate condition in the source area, while the low values show weak or absence of chemical weathering.

CIA values for Unit 3 range from 9.2 to 11.4 (average 10.3), for Unit 2 from 7.3 to 10.5 (average 8.4), for TZ from 12.6 to 25.5 (average 22.4) and from 23.7 – 29.7 (average 26.9) in Unit 1. This overall range of CIA values of sediment samples, suggests that the rocks in

provenance are very weak weathered and might have only undergone physical breakdown without any chemical weathering and consequently cool-arid condition in source area.

Other way to evaluate the chemical weathering trend and investigate possible source rock composition is A-CN-K ternary plot, where $A = Al_2O_3$, $CN = CaO + Na_2O$, $K = K_2O$ (Nesbit, 2003). Plot of sediments shows parallelism to A-CN line and appear to originate from the point on the calcite, clinopyroxene and hornblende join. It indicates that provenance for the sediments underwent very low weathering. This reflects that the intensity of weathering had not reached to the stage of removal of alkali and alkaline earth elements from the clay minerals.

The U/Th ratio can be used to estimate weathering condition, as the ratio is expected to decrease with decrease in weathering (Sheldon, 2009). Highly reduced sedimentary environments show enrichment of U leading to high U/Th, weathering results oxidation of insoluble U+4 to soluble U+6 thereby losing U to solution and decreasing U/Th ratio. In Unit3 it shows average 1.1, in Unit2 avg. 1.55 and in TZ avg. 1.3 and in U1 avg 0.9. High values the ratio of units could be an indicator of very low weathering in the source area or a change in redox conditions as U concentration is high during oxygenated conditions.

The Ba/Sr ratio is a proxy for trace-element leaching related to weathering intensity (Gastaldo, 2014). The values of the ratio for Unit1 and Unit2 are very low (average 0.22) relative to for TZ and Unit1 (average 0.80). The range of values indicates weak weathering and extreme condition in the provenance.

The Ti/Al is commonly used for understanding climatic condition in provenance of sediments as well as the acidification/alkaline during the weathering (Sheldon, 2009). Although these 2 elements are immobile, in the case of extreme weathering conditions this ratio reflects high values because of removal of Al under alkaline conditions and acidic conditions. The ratio indicates the constant values in the units with average number of 0.06. The increased value is indicative of mobility of Al and reflects arid condition in the source area and the development of an alkaline environment.

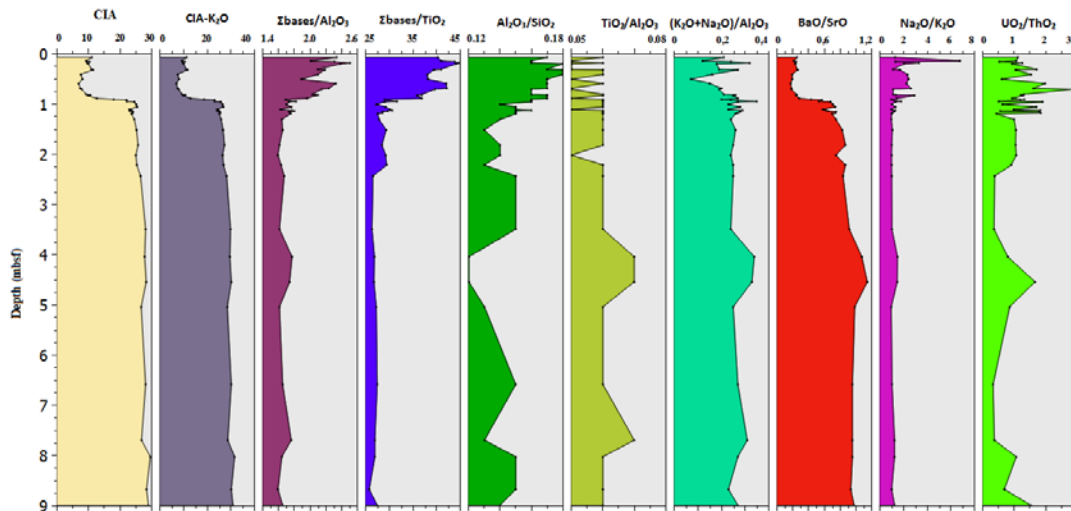
Al/Si is the measure of "clayeyness" because Al is mainly associated with clay minerals, whereas Si reaches in silicate minerals. Higher values of the ratio are indicator of more clay formation with the loss of feldspar and other less resistant minerals. The values of clayeyness for Unit3, Unit 2 and TZ between 0.16 and 0.18, whereas for Unit1 ranges from 0.12 to 0.15. These values indicate that sediments of Unit 3 and Unit 2 have relatively high clay contents compared to the underlying sections.

We used Na_2O/K_2O ratio to deepen our understanding of the climate changes evidenced by the geochemical elements. The values of the ratio for Unit3, Unit 2 show 2.5 and 2.0 respectively, whereas for TZ and Unit1 ranges from 1.02 to 1.8. The ratio was relatively lower for Unit 1 and TZ, indicating that the climate was less arid. A strong cooling event occurred in this region, indicated by suddenly increasing Na_2O/K_2O for Unit2 and 3.

Salinization ($(K_2O + Na_2O)/Al_2O_3$) is the indicator of evaporation versus precipitation conditions. High values of salinization reflects more evaporation compared to precipitation. In our study, the average salinization values for Unit3 and Unit2 are 0.22, 0.19 and for TZ

and Unit1 show average 0.27, indicating that relatively less precipitation with high evaporation was presenting at the time of accumulation of sediments. Maximum negative deflection (0.07-0.16) occur between 40 and 58 cm depths.

Graph 1. Geochemical proxy profiles of the core



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Lake level and climate records of Lake Van (Eastern Turkey) over the last 90 Kyears: comparison with regional and global records

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Keywords: Lake Van, paleoclimate, geochemical proxies, lake level, ICDP PaleoVan

Introduction

Lake Van is the fourth largest terminal lake and largest soda lake on earth having a volume of 607 km³, area of 3570 km² and a maximum depth of ca 450 m. It is located at an altitude of 1648 m above sea level (masl) on the East Anatolian Plateau in eastern Turkey (Fig. 1a). The lake is surrounded by Quaternary Volcanoes to the west and north, and the Bitlis metamorphic massif to the south. It occupies the eastern part of the Van-Mus depression. The depression was separated into Van and Mus, basins by the eruptions of the Nemrut Volcano, and thereafter the Van Basin started accumulating fresh waters at ca 600 ka BP (Yılmaz et al., 1998; Litt and Anselmetti, 2014).

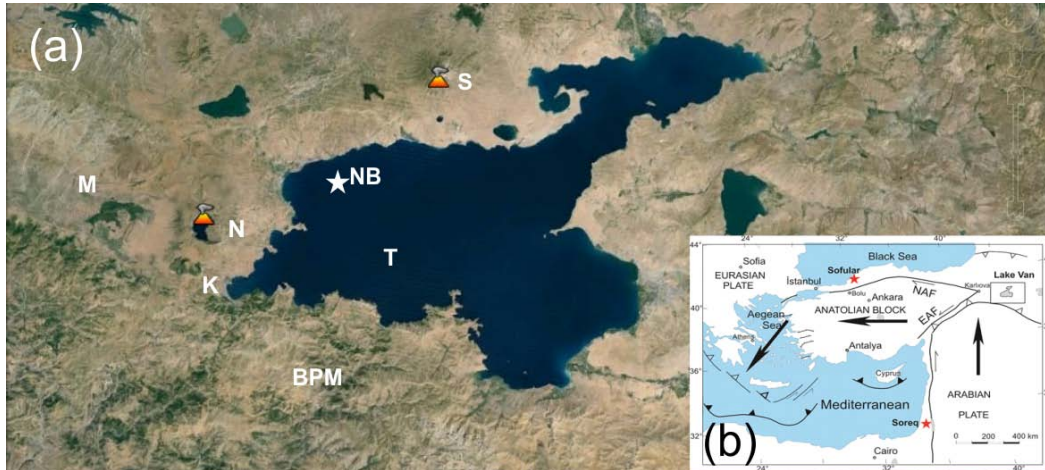


Fig. 1. Google earth map (a) of Lake Van on the Eastern Anatolian plateau, showing the location of the ICDP NB drill site. N: Nemrut volcano, S: Süphan Volcano, M: Muş basin, BPM: Bitlis-Pötürge Massif, K: Kotum sill, T: Tatvan Basin Inset map (b) shows the plate boundaries and their motions in the eastern Mediterranean, location of Lake Van and Sofular and Soreq caves are also shown.

Lake waters have a salinity of 21.4‰ and a pH of 9.81 (Reimer et al., 2009). Lake Van is presently a monomictic lake and anoxic below 300 m (Kipfer et al., 1994). Van region has a continental climate with cold and wet winters and warm and dry summers. The annual precipitation is ~400 mm/yr. The total fresh water input by direct precipitation and river runoff is 4.2 km³/year (Degens and Kurtmann, 1978). Lake Van is situated in a key continental position at the crossroads of North Atlantic, Siberian high pressure and mid-latitude subtropical high pressure systems near the boundary between the continental Eastern Anatolian and continental Mediterranean zones (Türkeş, 1996; Akçar and Schlüchter, 2005). The strong sensitivity of the Lake Van to climate change has long been established with its continuous, well preserved varved sedimentary sequence (e.g., Landmann et al., 2011; Wick et al., 2003; Litt et al., 2009, Litt and Anselmetti, 2014). Lake levels higher than today have been evidenced by the widespread presence of lake terraces located up to 107m above the present lake level (mapll) around Lake Van (Valeton, 1978; Kempe et al., 2002; Kuzucuoğlu et al., 2010). With its annually laminated (varved) sediments

and location at the crossroads of the different climate systems in the Near East, Lake Van was drilled in two locations (Ahlat Ridge and Northern Basin) within the framework of the International Continental Drilling Program (ICDP) "PaleoVan" Project in 2010 (Fig. 1). (Litt et al., 2009; Litt and Anselmetti, 2014). The paper presents the results of multiproxy analyses of 144.5 m-long (composite) cores in Northern Basin (NB) site, extending back to 90 ka. The main objective is to reconstruct the lake level and palaeoclimatic changes over the last 90 ka, and compare the Lake Van multiproxy records with the global and regional records.

Materials and methods

The ICDP PaleoVan NB cores were studied by multiproxy analyses involving stable oxygen and carbon isotopes, total organic carbon (TOC), total inorganic carbon (TIC), μ -XRF elemental, XRD mineralogical and MSCL physical property analyses. The resolution of our multi-proxy data on average ranges from about 300 years for the TOC, TIC and stable isotopes to \sim 3 years in the case of μ -XRF analysis. For details of the analytical methods see Çağatay et al. (2004). The age model for the composite section was obtained by AMS radiocarbon datings of terrestrial plant remains, tephrochronology (Sumita and Schmincke, 2013a, b), varve counting and correlation with the NGRIP oxygen isotope data and its GICC05 time scale (Wolff et al., 2010).

Results

Four lithofacies are discerned in the stratigraphic section, based on visual observations, μ -XRF elemental analysis and physical properties. These are: a) banded and/or laminated silt, b) homogeneous clay-bearing silt, c) tephra, and d) graded (turbiditic) sand-silt (Fig. 2). The first two of the lithofacies were deposited by normal lacustrine sedimentation, whereas the last two by event sedimentation. According to the age model derived from various chronostratigraphic data, the NB composite section extends back to \sim 90 ka BP (Çağatay et al., 2014). The multi-proxy records (Ca/Fe, $\delta^{18}\text{O}$, TOC, lithology) of the NB section plotted against the age show good temporal correlation with the global $\delta^{18}\text{O}$ records of ice, ocean, and lake cores, indicating robustness of our age model (Wolff et al., 2010; Lisiecki and Raymo, 2005).

Calcite is commonly the most abundant carbonate mineral. It has particularly high abundances during 71.5 ka BP, 80 ka BP and 28-18 ka BP, and low relative abundances during 17 ka BP-present and 70-50 ka BP. Aragonite is the second most abundant carbonate mineral. It shows relatively high abundances during 15-4 ka BP, 48-33.5 ka BP (marine isotope stage 3; MIS3) and 80-58 ka BP (mainly MIS4 and MIS5a). Aragonite abundance correlates positively with the $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values and negatively with dolomite and quartz abundances. These relations suggest the association of aragonite with evaporative phases of the lake. Dolomite is the least abundant mineral with its relative abundance varying between 3 and 54%. Relatively high (>10%) dolomite abundances are found at 4 ka, 11.5 ka, 42.5 ka, 48 ka, 50 ka and 51 ka, suggesting high salinity and Mg/Ca conditions during these periods.

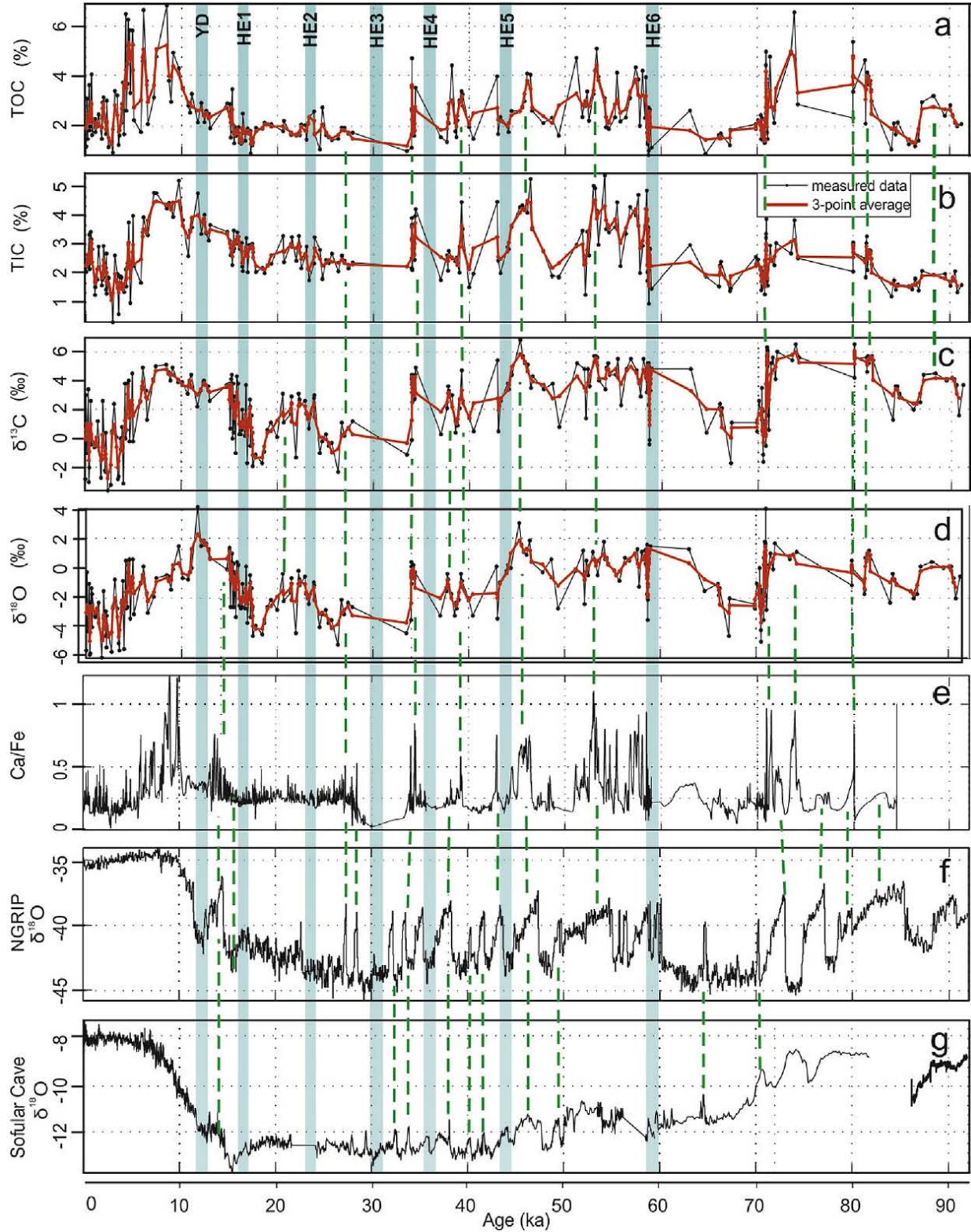


Fig. 2. TOC (a), TIC (b), $\delta^{13}\text{C}$ (c), $\delta^{18}\text{O}$ (d), and Ca/Fe (e) profiles along the Lake Van NB composite stratigraphic section representing the last 90 ka. Also shown are the Northern Greenland Ice Project (NGRIP) $\delta^{18}\text{O}$ record (f) (NGRIP, 2004), and Sofular speleothem $\delta^{18}\text{O}$ record (NW Turkey) (g) (Fleitmann et al., 2009). In samples with relatively high dolomite at 4 ka, 11.5 ka, 42.5 ka, 48 ka, 50 ka and 51 ka, dolomite contribution to $\delta^{18}\text{O}$ value is 0.5‰, 1.3‰, 2.0‰, 1.1‰, 1.2‰,

0.5 and 0.6%, respectively. HE: Heinrich event. The discontinuities in the Ca/Fe data represent the coarse tephra intervals where m-XRF analysis could not be performed.

Discussion

Multiproxy core analyses of the NB stratigraphic section of Lake Van provide evidence of orbital, North Atlantic Dansgaard-Oeschger (D-O) and Holocene abrupt climate events and lake level changes (Fig. 2). The early Holocene, 80-70 ka BP (MIS5a) and to a lesser extent 60-33.5 ka BP (MIS3) were relatively warm and humid periods, characterized with laminated sediments and high organic productivity (TOC). The variability during MIS3 was caused by the D-O events. The sediments deposited during 90-85 ka BP (MIS5b), 70-60 ka BP (MIS4) and 33.5-14.5 ka BP (MIS2) are mainly grey homogeneous clayey silt that have low TOC, TIC and Ca/Fe values, indicating cold and dry climate with high detrital influx and relatively low lake levels. The glacial and stadial periods have relatively lower $\delta^{18}\text{O}_c$ and $\delta^{13}\text{C}_c$ values than those for interglacial and interstadial periods. The low values of the glacial/stadial are the result of low seasonality of precipitation and relative increase in the contribution of the ^{16}O -rich winter precipitation rather than overall increase in the precipitation-evaporation. On the contrary, during interglacial/interstadial periods, higher temperature and seasonality of precipitation and evaporation result in heavy isotope values in the lake waters.

The D-O interstadials during 57, 53, 46, 43 and 34 ka BP are characterized by high $\delta^{18}\text{O}_c$ and $\delta^{13}\text{C}_c$ values and low detrital input (high Ca/Fe), which suggest relatively high evaporation and low erosion rates caused by warm and humid conditions and dense vegetation cover in the drainage basin (Fig. 2). During the period between 33.5 and 14.5 ka BP (MIS2) mainly grey homogeneous clayey silt, with low TOC, TIC and Ca/Fe values, was deposited. This sediment composition in general indicates cold and dry climate, low lake level, low vegetation density and high detrital influx. However, some high lake levels are indicated by the presence of coastal terraces 50 mapll, formed during the interstadial intervals.

The presence of low stand deltas extending down to ~200 m below the present lake level (Cukur et al., 2014), together with multiproxy core data from the NB site, suggest a significant regression between 20 and 15 ka BP. Such a dramatic regression probably isolated the NB from the rest of Lake Van, but did not completely desiccate the lake. Deposition of faintly laminated sediments and multiproxy records indicate an evaporative regression of Lake Van during the Younger Dryas (YD). This was followed by rapid millennial scale climate and lake level oscillations during the Holocene. High lake levels with some brief regressive intervals prevailed during the early Holocene. The early Holocene transgression is well represented by distinctly laminated sediments with high TOC and TIC contents and coastal terraces rising ~50 mapll. This transgressive period was followed by a relatively arid and regressive period during 4-1 ka BP.

The NB Lake Van climate records are conformable with the NGRIP ice core and the Sofular speleothem records, indicating teleconnections with the North Atlantic system. On a regional scale, the NB Lake Van records correlate with climate records from the Urmia and Zeribar lakes in Iran and the Sofular Cave in NW Anatolia (Stevens et al., 2001; Djamali et al., 2008; Fleitmann et al., 2009), but are mainly in anti-phase to the YD and Holocene climate and hydrological conditions in the Dead Sea Basin (Lake Lisan) in the Levant (Bartov et al., 2002; Stein et al., 2010; Litt et al., 2012).

The relatively low $\delta^{18}\text{O}_c$ values during glacial and Lateglacial periods and negative $\delta^{18}\text{O}_c$ excursions during the Holocene are likely to result from decreases in spring and summer precipitation and increased winter (snow) precipitation. The rapid oscillations in the Holocene climate, Lake Van level and seasonality of precipitation are all probably related to changes and

feedbacks associated with changing temperatures in the vapour source regions (i.e., North Atlantic and Mediterranean) and in the strength of the Siberian anticyclone.

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General Tectonic/Geologic Framework of the Caspian Sea and its water connection with the Black Sea and Mediterranean

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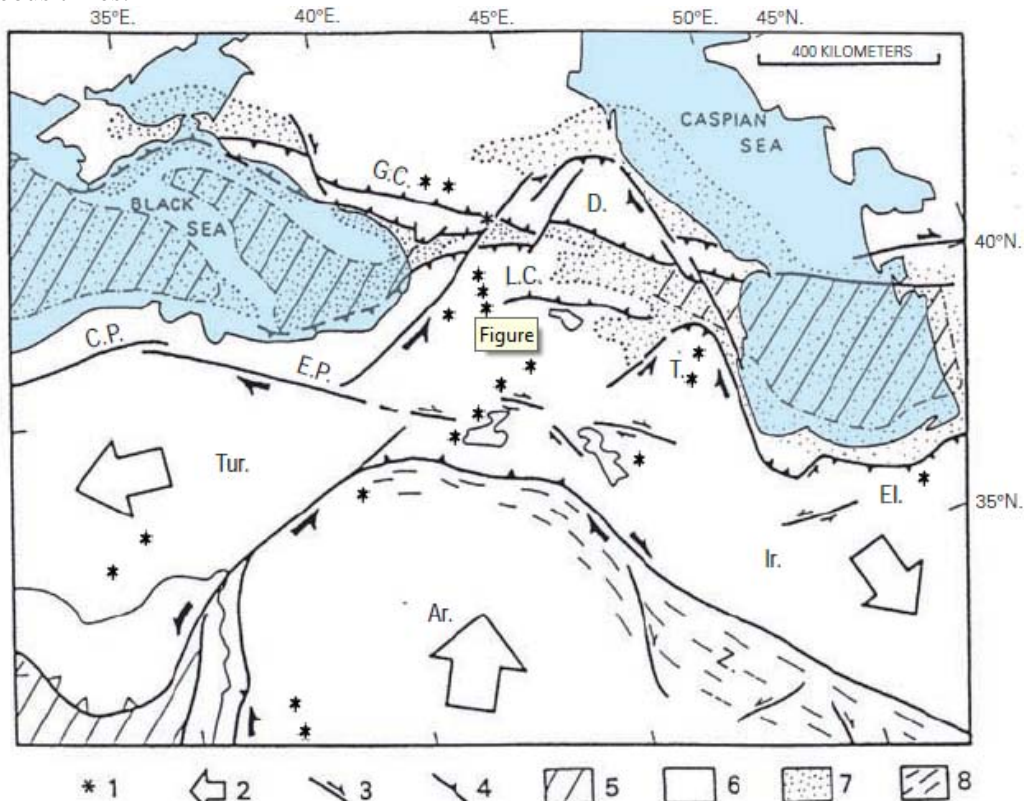
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Keywords: Endoheric basin, Caspian Sea, Manych-Kerch spillway, Paratethys, Glacial-deglacial cycles

Abstract

The Eastern Mediterranean and the Middle East make up the southern boundary of the Tethys Ocean for the last 200 Ma and witnesses the disintegration of the Pangaea and closure of the Tethys Ocean. It covers the structures: Hellenic and Cyprus arcs; East and North Anatolian Faults zones; Bitlis Suture Zone and Zagros Mountains. The northern boundary of the Tethys Ocean is made up the Black Sea and the Caspian Sea, and it extends up to Po valley to the west (Pontides, Caucasus, and Alburz). Between these two zones the Alp-Himalayan orogenic belt is situated where the Balkan, Anatolia and the Iranian plateaus are placed as the remnants of the lost Ocean of the Tethys. The Caspian Sea and the Black Sea were part of the Mesozoic chain of back-arc basins stretching over a distance of 3,000 km which also included the Carpathian basin in the central Europe and the Vallesian trough in Switzerland. This chain was located between the continental margins of Eurasia to the north and Mesozoic-Paleocene basin was the south of the island-arc system. These basins were formed during three separate tectonic episodes: Middle Jurassic, Late Jurassic, and Late Cretaceous times.



PRINCIPAL TECTONIC FEATURES IN THE CASPIAN SEA-BLACK SEA REGIONS (SMITH-ROUCH). SYMBOLS: 1. VOLCANOES; 2. RELATIVE MOTIONS OF CRUSTAL BLOCKS; 3. MAJOR STRIKE-SLIP FAULTS; 4. MAJOR THRUST FAULTS; 5. OCEANIC OR INTERMEDIATE CRUST; 6. CONTINENTAL CRUST; 7. MAIN SEDIMENTARY BASINS; 8. ZONE OF FOLDING

From Middle Jurassic to Early Cretaceous time, extension occurred of the Pontic-Trans-Caucasus arc, resulting in rifting and the formation of the early Black Sea and South Caspian basins. To the east, the rate of spreading was more rapid and resulted in the development of the oceanic basin, the remnants of which now form the south Caspian Sea basin. The combined Caspian Sea-Black Sea paleo basin reached its maximum extent during the Paleocene, occupying an area 900 km wide and 3,000 km long.

The Caspian Sea is the largest enclosed inland body of water on Earth by area, variously classed as the world's largest lake or a full-fledged sea. The sea has a surface area of 371,000 km² (not including Karabogazgöl Embayment) and a volume of 78,200 km³. It is in an endorheic basin (it has no outflows) and located between Europe and Asia. It is bounded to the northeast by Kazakhstan, to the northwest by Russia, to the west by Azerbaijan, to the south by Iran, and to the southeast by Turkmenistan. The Caspian Sea lies to the east of the Caucasus Mountains and to the west of the vast steppe of Central Asia. Its northern part, the Caspian Depression, is one of the lowest points on earth.

The Caspian Sea, like the Aral Sea, Black Sea, Lake Urmia, is a remnant of the ancient Paratethys Sea. It became landlocked about 5.5 million years ago due to tectonic uplift and a fall in sea level. During warm and dry climatic periods, the landlocked sea almost dried up, depositing evaporitic sediments like halite that were covered by wind-blown deposits and were sealed off as an evaporite sink when cool, wet climates refilled the basin. Due to the current inflow of fresh water, the Caspian Sea is a freshwater lake in its northern portions. It is more saline on the Iranian shore, where the catchment basin contributes little flow. Currently, the mean salinity of the Caspian is one third that of the Earth's oceans. The Karabogazgöl embayment, which dried up when water flow from the main body of the Caspian was blocked in the 1980s but has since been restored, routinely exceeds oceanic salinity by a factor of 10.

The Manych-Kerch Spillway is a large trough, deeply eroded into solid rock, which connected the Caspian and Black Seas. It was inherited from an older strait between the two seas, which existed (with interruptions) since the Late Pliocene Akchagylian (White Waterfall) basin. The total length of the spillway amounted to 950-1000 km (depending on the location of sea level), with maximum and minimum width of 50-55 and 10 km, respectively. Its depth attained 30-50 m.

Although the rise of the sea after the last glaciation took about 15,000 years BP, the change would nevertheless have been perceived as a continuous retreat of the shoreline and loss of land which was quite noticeable in one generation. These matters were more devastating for the marginal seas such as the Black Sea and the Caspian Sea as well as the Sea of Marmara because the fall of sea level was much more the open ocean waters. Given the fertility of coastal plains, both for the terrestrial fauna on grasslands and resources in marshes, deltas, and wetlands, the continuous loss of such land must have been an unfortunate aspect of life in the Late Palaeolithic and Mesolithic periods. However, it should be noted that a rising sea level would occasionally inundate an area of low gradient such as the North Caspian seafloor, creating massively extensive new marshlands and new environments which could support adapting coastal and aquatic life styles. Populations certainly moved and adapted in response to such change of climate and sea level and there is a need for significant further research to track these movements. In order to understand where people could live and hunt or forage in the Caspian area at different dates and different stages of the glacial-deglacial cycles, we need to analyse the details of sea level change and ice cap limits through time.

We cannot understand the whole story by studying only the present dry land record and ignoring the submerged seabed of the continental shelf and vice-versa. Did the fluctuating climate zones and migrating coastlines and river valleys influence where people lived? Did the falling and rising sea level create cultural experiences and responses that are still felt on and had impact in the historic world of writing and oral history.

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Digital outcrops to bring geology into the center of subsurface decision making

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Keywords: Digital Outcrops, LIDAR

Introduction

Digital outcrops or virtual outcrops as some may call them, are 2D or 3D models of exposed rocks, which can be manipulated in interpretation software. Digital outcrops allow for interpretation and reproducible measurement of different geological features, e.g. orientation of geological surfaces, width and thickness of layers. The quantity of identifiable and measurable geological features highly depends on the outcrop model resolution and accuracy.

Materials and methods

These models are based on the data collected by laser scanning (LIDAR), high resolution digital cameras or their combination. Photorealistic, spatially precise, and geometrically accurate three-dimensional models of exposed rocks can be used to understand the sedimentological and structural architectures. Also, when integrated with hyperspectral imaging, it is possible to map mineral and chemical variations on the face of outcrop. Creation of the digital outcrop surface model consists of the following steps: 1) Data acquisition, 2) Merging point clouds and georeferencing 3) Point cloud cleaning and decimation 4) Triangulation and triangle mesh optimization.

Results

The presentation provides brief information on technology used by BP AGT to acquire the data, as well as preliminary results and examples of digital outcrop interpretation and integration into subsurface models.

Discussion

BP AGT recently kicked off the project on digital outcrops in Azerbaijan. It is anticipated that acquisition of outcrop data using novel collection techniques will ultimately improve the quality of the analog models. This in turn, will help to address reservoir related challenges more effectively.



Fig. 1. Photorealistic 3D Outcrop Model in Yasamal Valley

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New results on absolute age of Khvalynian transgression of the Caspian Sea

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Keywords: Khvalynian transgression, Caspian Sea, sea-level change, OSL dating, quartz, feldspar

Introduction

The stratigraphy and palaeogeography of the northern Eurasian Pleistocene is recorded in Caspian Sea sediments. They contain a unique record of major regional and continental phenomena (e.g. glacial-interglacial cycles of the Russian plain, the Caucasus and Central Asia, and links to the oceans during marine high-stands) as well as of global climate change. To fully understand this record there is an urgent need for an accurate numerically-based chronology for the marine history. This will allow a more accurate analysis and prediction of the regional and continental changes in the environment.

Forecasting the development of marine and coastal ecosystems is also of great economic significance. Based on the instrumental record, sea-level was incorrectly predicted to fall systematically during the middle of the twentieth century; in fact sea level rose >2.5 m in 20 years. Even now, when the level has become more stable, sea-level forecasts appear to be inaccurate. We must understand the underlying long term history of this complex natural system if we are to make accurate predictions of the future behaviour of this very important resource.

The Lower Volga is ideally suited for understanding the Caspian Sea Pleistocene history. Quaternary sections are continuous, containing fluvial, marine and subaerial sediments, that contain considerable palaeontological diversity. As a result the Lower Volga region has been studied intensively over a long period resulting in a considerable body of basic palaeogeographical information for the region (Yanina, 2014).

However, the chronology of these palaeogeographic events remains very controversial. Existing Late Quaternary age estimates for various transgressive/regressive events have been obtained using electron paramagnetic resonance spectroscopy, thermoluminescence, uranium-thorium, and radiocarbon (Arslanov, etc., 2013; Tudryn et al, 2013; Yanina et al, 2018); with the various methods often providing contradictory results. The main purpose of this research is develop a new chronology for the group of sections exposed by the Volga River ~50 km downstream of Volgograd.

The timing of the Early Khvalynian has always been one of the most controversial issues of the Late Quaternary history of the Caspian Sea. There are currently two main views: (a) the transgression is old, perhaps between 70 and 30 ka.

In the Lower Volga region Early Khvalynian deposits are represented by readily identifiable marine clays with clear specific characteristics: a red-brown colour with banded structure, interbedded with sub-mm layers of silt that gives it a characteristic 'chocolate' structure. In general this type of facies in Northern Caspian is found in topographic depressions of various configurations and size, the largest of which is the Lower Volga valley (Makshaev, 2017).

Materials and methods

Three sites with thick Late Khvalynian chocolate-clay strata, with characteristic Khvalynian fauna were selected for sampling. These strata, sandwiched between loess above and sandy marine sediments below, are located in the northern part of the Lower Volga (Fig. 2), on both sides of the Volga-Akhtuba valley near Volgograd. Figure 3 shows the Srednyaya Akhtuba, Raigorod and Leninsk sections respectively. Field work was undertaken in 2015 and 2017.

During field work all three sections were sampled for OSL-dating of the marine clays, the underlying loess and the overlying modern soil. Because the sediments were very compact, sampling was undertaken at night, with blocks of sediment placed directly in opaque plastic bags. Initial sample preparation took place in Moscow under orange LED lights. After sieving, the fine and medium sand

fractions (90-250 μm) were treated with 10% HCl and 10% H₂O₂, followed by 10% HF before transferring the samples to Denmark for final separation of quartz and K-rich feldspar using heavy liquids and concentrated HF. Finally both the quartz and K-feldspar fractions were treated with HCl (10%).

Results

For the first time in the Caspian region we obtain an unambiguous age for the Early Khvalynian chocolate clay marker horizon. This horizon is widespread throughout the Lower Volga, and has previously been dated to both before and after the LGM; our ages clearly place this important unit at the end of MIS2. We conclude that OSL dating has the potential to resolve many of the major chronological questions in the Caspian Sea basin.

These results argue for a younger (13-16 ka) age for the transgressive stage of the Early Khvalynian era, when the marine clay layers in the northern part of the Lower Volga region were deposited on the sea bottom. Sea level during this period must have been well above the sampling altitude of 9.33 m (Srednyaya Akhtubya), 8.51 m (Raigorod) and 6.98 m (Leninsk) to explain the absence of significant alluvial sand in the drowned river valley and to allow the deposition of fine clay. These results clearly place a time frame to this extreme event which occurred relatively recently in the evolutionary history of the Caspian Sea. The 28.0 ± 1.6 ka age of the underlying marine grey sandy clay (layer 6) in the 40 km downstream Leninsk section presumably describes an earlier, relatively stable stage in the Early Khvalynian transgression. This stable stage took some 10 ka for sea level to reach the Raigorod and Srednyaya Akhtubya locations, today only 3 m higher in elevation.

The young (13-26 ka) age for the largest late Quaternary transgression now provides a foundation for further research into the broader Eurasian palaeogeographical mechanisms and implications of such an extreme sea-level rise (from ~ -150 to $\sim +40-50$ m) in just a few thousand years.

Acknowledgements

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ECOGEOMORPHOLOGICAL EVALUATION OF RELIEF OF NORTH-EASTERN SLOPES THE LESSER CAUCASUS

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Keywords: *morphosculptures, morphostructures morphogenesis, tension , hypsometric levels, endodynamic, exodynamic.*

Given the urgency of studying of the environmental conditions of the North-Eastern slope of the Lesser Caucasus, it has accepted the attempt to do ecogeomorphological zoning on the basis of the results of geomorphological research conducted here. For this purpose, along with endo- and exodynamic factors of morphogenesis, the morphometric parameters, particularly the depth and density of the broken relief and the slope of the surface are analyzed and ecogeomorphological zones of weak, moderate, medium and high tension are isolated.

The relief manifesting an abiotical (biocostical) basic elements of the ecosystem, is playing an important role on the differentiation of landscapical sphere possess for substantial environmental formation function. The complication and diversity of the natural conditions and geology-geomorphological structure of the north-east slopes of the Lesser Caucasus mountain system are creating a sweeping possibility to consider the present matter on the basis of its territory, the ecological conditions which are predetermined by the characteristics of the relief.

On the spread and development of exogenous processes we could note the impacts of lithological characteristics of relief, modern and new tectonic movements, soil-plant cover and anthropogenic factors. The exogenous processes such as, erosion, denudation, accumulation, fluvial, gravitation are widespread in the studying area and play an important role in the formation of environmental conditions. Nowadays widespread antrhopogenic impact is also giving strong influence on the course of these processes.

Exogenous factors of morphogenesis play an important role in changing the primary forms of relief formed by endogenous processes (morphostructures) and formation of morphosculptures in the studied areas.

The basis of the fluvial erosion morphosculptures in low and middle mountain belts is made by river valleys, ravines and gorges. And their development is related to climate, plane inclination, tectonic and lithologic factors. There are also distributed common gravitational morphosculpture (loops, landslides, etc.) at different hypsometric levels, as well as ancient leveled surfaces.

Accumulative modifications of morphosculptures in the territory are replaced by denudation ones and the specific forms of mountainous reliefs are formated connected with the conditions of origin and formation of them.

There are developed karst morphosculptures (caves, groves, funnels, etc) in the territories with carbonate rocks.

The alpine zone of the territory is situated in the cold climate belt so solifluction processes and appropriate relief forms are typical for this territory.

The erosion processes in the Lesser Caucasian plain are usually developed in the slopes of the river valleys and this situation is related to inclination of the slopes and low basis of the local erosion. The erosion processes are represented by linear form of erosion and sheet wash. The intensity of linear form of erosion depends on power of surface current, the amount of atmospheric precipitation, the level of evaporation, lithology of rocks, nature of tectonic movements and other factors and forms valleys, ravines and gorges.

Due to the location of the Gazakh synclinorium along more immersed eponymous synclinoria, the depth of the Aghstafachay is small despite the fact that the bed of the river corresponds to tectonic

fracture. In similar physiographic conditions, the depth is determined by the location of the riverbed in certain tectonic settings.

Ravine erosion covers a wide territory. It occurs in the plains on the existence of soft, easy washing sediments. Ravine erosion in the mountains is connected with morphodynamic activity and relatively high humidity.

Ravines in mountainous areas correspond to ridge, beam and plateau slopes. The more their steepness, the greater the density of the ravine and the density reach its maximum along tectonic stages.

Ravine erosion is locally distributed in plains. It mainly appears in steep slopes of the river beds, and sometimes it is the reason for creating of badlands landscapes. The ravines are usually registered at the bottom of the valleys. This is due to the rhythmic characteristics of tectonic movements.

Because of the lack of necessary conditions for the formation of valley morphosculpture they do not develop on the mountain part of the territory with the exception of plain surfaces. Valleys are observed in the planes and slopes. It is related with the alternation of extinction and recovery of erosion.

In development of surface wash the water permeability of rock is of great important. Sheet erosion is observed in the entire territory except for places with constant accumulation. Slope of a surface and necessary amount of atmospheric precipitation is of great important in formation of sheet erosion.

Weathering processes play an important role in the development of morphosculpture. The intensity of their appearance depends on the thermodynamic conditions of formation and destruction of rocks exposed to weathering in the same geographic and climatic conditions. The deluvial - proluvial clay deposits in the places where they completely cover the lowland and foothill areas create conditions for the development of planar flushing because of high coefficient of waterproof.

Physical weathering is a common type of weathering in the study area. The congelifraction occurs intensively in the alpine part of the study area and depending on high diurnal temperature fluctuations in the warm seasons of the year. Decomposition occurs intensively in the mineralization areas where carbonate strata disseminated.

Mass accumulation in the South Caspian Basin –impacts on depositional ages, rates and lake level change

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Keywords: South Caspian Basin, subsidence, mass accumulation

Introduction

The landlocked South Caspian Basin is characterized by unusually high mass accumulation and sedimentation rates in Pliocene and Pleistocene. These rates are in order of magnitudes larger than most sedimentation rates in Asia and Europe at the time and are only second to Bengal fan accumulation rates. More than 20 km of sediment accumulated of which at least 10 km accumulated in the last 5Ma. Caspian lake is unique because of so much periodic sediment input.

Materials and methods

Author mapped more than 30 seismic events in the South Caspian Basin. Rock volumes that were calculated for separate time intervals between mapped events, each of which has an assigned most likely age. These volumes were then “upscaled” (recalculated) for 8 general time periods for simplicity. These periods are between 145-36 Ma. ago, 2) 36-6 Ma, 3) 5.3-4Ma., 4) 4.0-3.0Ma, 5) 3.0-2.71 Ma, 6) 2.5-1.8 Ma, 7) 1.8-0.9 Ma, 8) 0.9-0 Ma, respectively. These volumes have been reduced on account of porosity loss in compaction to leave only net rock volumes.

More than 1.6 million cubic meters of net rock volume (or a solid sediment mass to $4.42 \cdot 10^9$ tons) have accumulated in the basin since its inception; of which 492 thousand km³ was in Pliocene and 282 thousand km³ in Quaternary. The Pliocene age Productive Series, represents significant increase in sedimentary volume after a base level fall in Early Pliocene during a relatively short period of time between 5.3 Ma and 2.71Ma. This mass budget shows that sedimentation in the basin started to rise in the Late Miocene and increased drastically at the Miocene-Pliocene boundary. More than 40% of sediments in the Caspian were accumulated after this time.

Results.

The net sedimentation rates continued to rise dramatically through Pliocene, rising from 200 m/Ma in Miocene to 1300 m/Ma in Pliocene-age Lower Productive Series and then to maximum net sedimentation rates of 2400 m/Ma during Middle Productive Series. During the Akchagyilian, sediment accumulation rates decreased to 200 m/Ma, but then rose to 800 m/My in Absheronian.

We interpret the increase in the sedimentation rates at the Miocene-Pliocene boundary as related to exhumation and erosion of geographically large hinterland areas of Eastern European craton (Paleo-

Volga system); Central Asia and possibly West Siberia (Paleo-Amudarya system) and Caucasus (Paleo-Kura system) following large scale base level fall. Two integrated drainage network systems, the Paleo-Amudarya river drainage system and Paleo-Volga drainage system, played the dominant role in filling the basin with sediments.

The role these two river systems played supplying the basin with sediment mass also seemed to have changed over time. Thus, during the deposition of Pliocene Productive Series Paleo-Volga supplied about much of all sediment mass, its influence waning through to Pliocene. Paleo-Amudarya, on the other hand brought increasing amounts of sediments into the Caspian through to Pleistocene comprising significant part of all sediment volume coming from Paleo-Amudarya in the Pleistocene (during last 2.4 Ma). During well age constrained Akchagylian period between 2.71 and 1.8 Ma more than 40 thousand km³ was accumulated in the basin, all of it supplied from Paleo-Amudarya.

Discussion

Increase in sediment volume and sedimentation rates this period are coeval to increase in sedimentation rates recorded during last 2 to 4 Ma around the globe in a variety of settings, implying increasing erosional rates related to a change from a period of climatic stability to a more variable period of frequent and abrupt changes in climate related to Milankovich forcing. More than 30-fold increase in sedimentation rates in the South Caspian Basin at the Miocene-Pliocene boundary, however, is an extremely unique event that requires further study.

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Palaeoenvironmental evolution of the Volga River delta and the Northern Caspian basin inferred from diatom assemblages

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Keywords: *palaeogeography, microfossils, diatoms, sedimentation*

Introduction

The Volga delta, one of the largest deltas in the world, experienced several migrations due to Caspian Sea level changes during the Holocene. Despite a wide range of publications on this territory (Bolikhovskaya and Kasimov, 2010; Rychagov, 1997) the problem of palaeoenvironmental conditions of sedimentation during the Holocene is still not solved. The diatoms, as one of the leading micropaleontological groups, are widely used in biostratigraphic and paleogeographic researches. This paper reports on the diatom-inferred palaeoecological evolution of the water basins and comparison of the results using the sediments of the lower part of the Volga delta and two parts of the adjacent shelf of the Northern Caspian.

Materials and methods

The material for the study of the Holocene deltaic diatom assemblages was obtained from the core DM-1 in the lower part of the Volga delta, near the settlement of Damchik (Figure 1).

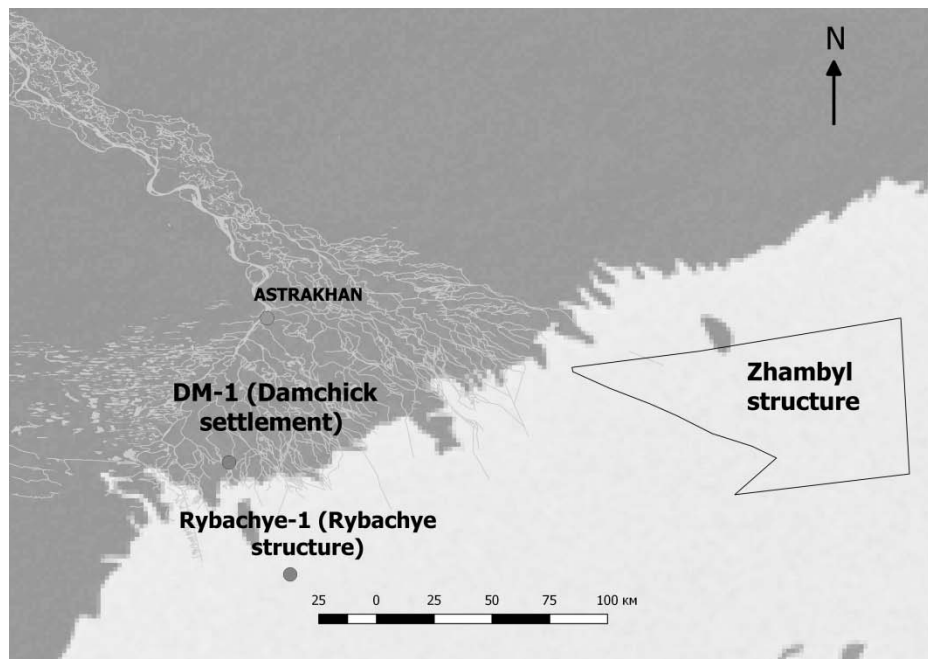


Figure 1. The location of the boreholes which cores were used in this paper.

Core DM-1 is 5.7 meters long, the lower part of the core (5.2-5.7 m) consists of minimally-variable sand layers. A detailed selection of samples for diatom analysis was carried out: every 20-30 cm from sand deposits and every 10 cm from clays. In total 20 samples were selected and analyzed. During the fieldwork, the samples for the study of modern diatom associations were also selected in order to obtain a “database” for comparison with fossil assemblages.

Cores Zb-1 (from the Zhambyl structure) and Rybachye-1 (Rybachye structure) were obtained using the method of vibratory drilling within the framework of engineering and geotechnical studies on the shelf of the Northern Caspian. The selection of the Holocene deposits with a thickness of 5.8 (Zb-1) and 6.4 (Rybachye-1) meters is based on stratigraphic studies. From the core Rybachye-1 for the purposes of diatom analysis 12 samples were carried out from each of the selected lithologic layers. Due to the high water content from the core Zb-1 only 5 samples were carried out.

The sediments were prepared for diatom analysis by treatment with 10% hydrogen peroxide solution for 1.5 hours. The residues were mounted on glass slides using the resin NAPHRAX. The taxonomic determination of diatoms based on their valves structure was carried out examined under a JENAVAL (Carl Zeiss) light microscope using ×1000 magnification. Palaeoecological reconstructions were based on the abundance of species in the samples and valve concentration (number of valves per gram of dry matter) as well as analysis of dominant species and their ecological affinity.

Results

The diatom analysis of the Holocene deltaic sediments, obtained from the core DM-1, identifies eight diatom assemblages (DA), which characterize several lithological and facies conditions of sedimentation. Diatom assemblages yielded 60 species and varieties. According to the results of diatom analysis, the accumulation of the sediments mostly occurred in stagnant (with low hydrodynamics), shallow, fresh reservoirs. Such diatom assemblages demonstrate rather high abundance of the benthic freshwater species from genus *Epithemia* and *Eunotia* Ehrenberg, which are rather common in lake and boggy sediments. The influx of marine waters is probably distinguished in the VI DA due to the increased abundance of the following brackish species: *Stephanodiscus astraea* var. *intermedia* Fricke and *Cyclotella meneghiniana* Kützing (Fig. 2)

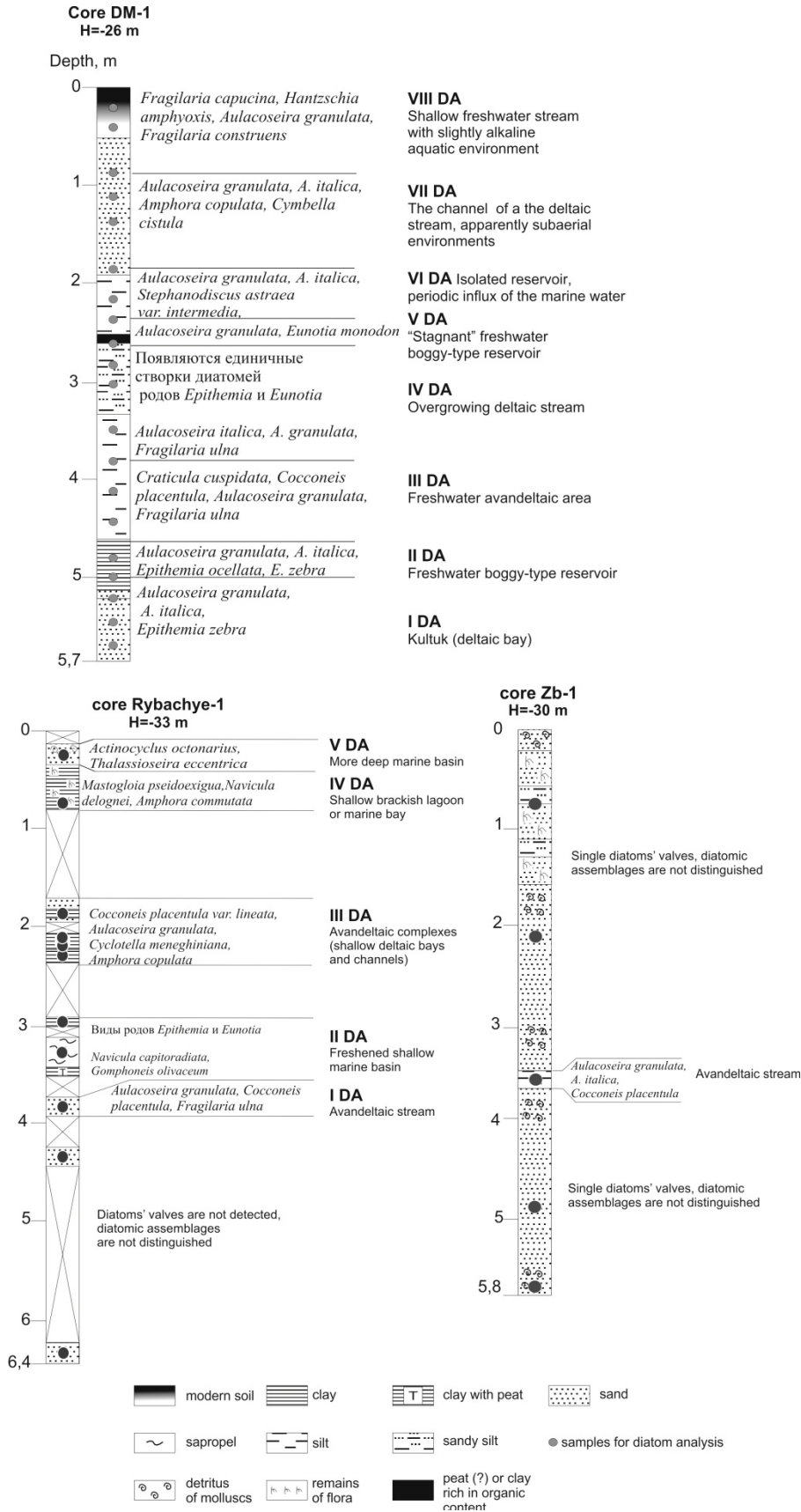


Figure 2. The results of diatomic analysis.

Besides, the conditions of sedimentation within the channels of the deltaic streams were identified. The valves of riverine planktonic taxa (*Aulacoseira granulata*, *Aulacoseira italica* (Ehrberg) Simonsen) predominate in the samples. The species are typical inhabitants of freshwater eutrophic environments and are widespread in modern deltaic streams and sediments.

The core Zb-1 obtained from the shelf of the Northern Caspian in the alignment of the northeastern part of the delta contained mostly sandy material and was rather poorly characterized by the remains of diatom flora. It was possible to reliably distinguish only one diatom assemblage from the investigated interval of 0.0-5.8 m. DA I (3.5-3.6 m) was identified in the interlayer of silt. It was characterized by relatively poor taxonomical diversity (41 species and varieties). The diatom assemblage differs in its high abundance of planktonic species *Aulacoseira granulata*, *Aulacoseira islandica* (18.7% in total) and benthic brackish *Cocconeis placentula* Ehrenberg and its variety (12.7% in total), which are typical inhabitants of the modern avandelta. The sediments probably accumulated within the channel of the avandeltaic stream. The reconstructions correspond to the malacofauna and microfauna analysis performed by professor T.A. Yanina and A.V. Dmitrieva.

The core Rybachye-1 obtained from the shelf of the Northern Caspian in the alignment of the northwestern part of the delta differs in relatively high concentration of valves in its sediments. The diatom analysis identifies five diatom assemblages. Despite the typical "marine" conditions of sedimentation, the periods of sedimentation in the freshwater avandeltaic complexes (shallow deltaic bays and channels) were distinguished.

I DA (3.8-3.87 m) is distinguished within the layer of silty sand and characterizes by relatively low concentration of diatoms, which apparently is a result of extremely high sedimentation rate, which prevents the formation of tafocenoses. Single valves of the following riverine: *Fragilaria capucina* Desmazieres, *Aulacoseira granulata* and brackish (*Cocconeis placentula*) diatoms were identified. The sediments could be formed in the avandeltaic stream. The statement corresponds to the stratigraphic position of the interval practically at the same depth as in the core Zb-1. This conditions of sedimentation apparently identify the regressive stage of the Novocaspian Transgression (Rychagov, 1997).

II DA (3.54-2.99 m) is represented in clays and sapropels with an admixture of peat and characterized by a high abundance of benthic diatoms (up to 100%). The periphyton species of *Epithemia* prevail (70%). Subdominant species are brackish *Navicula libonensis* Schoeman and *Mastogloia pseudoexigua* Cholnoky. The low preservation of valves and the increasing abundance of alkaliphilic and alkalibiontic diatoms may indicate alkaline aquatic environment. The sediments probably accumulated in a freshened marine basin. The concentration of valves sharply increases in the interval and demonstrates the highest rate among the all analyzed samples. Some researches (Zhakovschikova, 1974) assumed it was a result of an increased nutrient runoff of the rivers flowing into the Northern Caspian. This statement corresponds with the reconstructions of a freshened marine basin.

III DA (2.37-1.73 m) is distinguished in clays (coarsening upwards). The following predominate taxa correspond to the avandeltaic environments: *Cyclotella meneghiniana*, *Cocconeis placentula* var. *lineata*. The relatively high abundance of benthic brackish species *Navicula avenacea* (Rabenhorst) Brébisson ex Grunow in O.Schneider (18,8%) indicates low hydrodynamics of the aquatic environment, which is apparently a

result of less progradation of the delta in comparison with I DA. The sediments could form during the slight sea level regression.

IV DA (0.80-0.30 m) is represented in sapropels and characterized by a high abundance of benthic riverine species *Lyrella lyra* (Ehrenberg) Karajeva (44%), which is an inhabitant of shallow waters. Subdominants are the following taxa: alkaliphilic benthic species *Craticula cuspidata* (Kützing), D.G. Mann in Round, R.M. Crawford & D.G. Mann (14,2%) and mesogalobic planctonic *Amphora commutata* Grunow in Van Heurck (7%). The sediment apparently formed in freshened shallow marine bay or lagoon. The low preservation of valves and relatively high abundance of alkaliphilic and mesogalobic diatoms may indicate alkaline aquatic environment.

V DA (0.3-0.2 m) is distinguished in within layer of sand rich in detritus. It contains valves of the following planctonic marine diatoms: *Actinocyclus octonarius* Ehrenberg (30,2%) and its variety *A. octonarius var. tenellus* (4,3%). These species are typical for the Caspian Sea (Karaeva, Makarova, 1973). Mesogalobic benthic species *Grammatophora oceanica var. macilenta* (W.Smith) Grunow (17,2%) is subdominant in V DA. The high abundance of planctonic diatoms (55.6%) may indicate the environments of deeper than in IV DA marine basing.

Discussion

The avandeltaic complexes distinguished in both cores Zb-1 and Rybachye-1 approximately at the same depth may indicate the regressive stage of the Novocaspian basing. The statement requires an approval by the methods of geochronological dating. The II DA in the core Rybachye-1 which corresponds to freshened marine basin conditions of sedimentation may approve the theory of climatic causes of the Holocene Caspian transgressions. Due to the lack of data on fossil diatoms in the Northern Caspian sediments, the conclusion requires further consideration.

Acknowledgements

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Mudflow processes in mountain geosystems of coastal zones of the Caspian Sea (on the example of the north-eastern slope of the Greater Caucasus)

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Keywords: mudflow phenomena, risk, deciphering, space image

Introduction

Currently, the process of intensive development of mountain areas, observed in Azerbaijan leads to the intensification of natural destructive processes, including mudflows that cause huge economic losses. The main role is played by intensive modern tectonic movements, features of the morphostructure, climatic, hydrological conditions and the presence near the large closed basin — the Caspian Sea. Mudflow is widely common in almost all mountain and foothill areas of the country. In the northeastern slopes of the Greater Caucasus, mud flows as well as mudflows of water and stone composition happen when intense rains fall. Often mudflows are catastrophic in nature, entailing destructions of settlements and engineering structures in valleys and areas where outlets are passing to foothill plains.

At the moment, there is no unequivocal answer to the cause of the mechanism of occurrence of mudflows. Typically, even if all the necessary conditions for the occurrence of the mudflow is available, its occurrence is hardly possible without additional impulse, regardless an impact is made from one process (abundant snowmelt, rainstorm, etc.), or a complex of processes [1,2,3]. Any mudflow can be shown as an example for this. Some territories, despite all the prerequisites, may remain stable for years. Some others, on the contrary, quite unexpectedly become the arena of the formation of catastrophic mudflows. However, “unexpectedly” does not mean “not naturally”. The main causes of occurrence of mudflow are heavy rains and intense snowmelt.

By the degree of mudflow hazard we mean the probability of formation of mud flows in the studied mudflow basins and their possible scales. Five categories of mudflow hazard are identified, each of which corresponds to a certain amount of flow and volume of removals of mudflows. The first category includes very tense areas with high mudflow hazard (once in 2-3 years; one heavy mudflow is possible) – V points. The second category concerns tense territories with medium mudflow hazard (once in 3-5 years; one heavy mudflow is possible) – IV points. The third category includes territories of weak mudflow hazard (once in 5-10 years; one heavy mudflow is possible) – III points. The fourth category concerns the territories with potential mudflow hazard – II points. The fifth category concerns the territories where no mudflow is observed – I point.

Materials and methods

One of the effective methods for these studies is environmental-geomorphological mapping based on the interpretation of space images (SI) and aerial photographs (Aph) interpretation materials with using landscape-indicative features. Through this method, it is possible to accurately determine the position of the areas of development of mudflow processes and assess the grade of their hazard.

Results

The results of the carried out researches and the analysis of the received results can be formulated as follows:

1. The basin of the Gusar River is one of the most hazardous areas in the north-eastern slope of the Greater Caucasus. Here mudflow processes develop in a complex natural landscape condition, where geological and geomorphological factors, sharp contrast of physical and geographical conditions, as well as climatic features are of decisive importance;
2. In recent years, anthropogenic impact has sharply increased, which significantly activates mudflow activity in the territory of the studied region. This, in turn, intensifies ecological tension and causes huge damage to settlements and the economy of the Pre-Caspian zone.
3. It is important to conduct a long-term study on the dynamics of development and growth of mudflow foci; the features of the accumulation of mudflow materials and their readiness for demolition; the nature of changes in river beds; the state of shores and protective structures; potential ways of motion of mudflows, as well as the implementation of ecological and geomorphological works to stabilize the environmental situation. Timely informing about the threat of mudflow development along with using of remote methods would reduce the risk considerably and volume of related losses.

Discussion

First, we will review the geomorphological structure of the north-eastern slope of the Greater Caucasus, namely the valley of Gusar River as a key area of this study.

The north-eastern slope of the Greater Caucasus is characterized by the stretching of the orographic elements of the relief parallel to the Main Caucasus Ridge. Of them, the largest is the Lateral Ridge that creates a huge variety in the spread of intensity of water-erosion processes. Between the Main Caucasian and Lateral ridges, the intra-mountain such structural basin as Khinalig, Rustov, Shahnabad, Khaltan, Gilgil and others are present. The foothill part is represented by the Gusar inclined plain, which in the east passes to the Samur-Devechi lowland. When leaving the mountains, all the rivers form cones of removal, which, merging with each other, form a single plume. The northeastern slope of the Greater Caucasus is composed of sedimentary rocks of the Jurassic, Cretaceous, Tertiary and Quaternary periods [4,5].

The modern exogenous relief-forming processes include glaciation, physical weathering, erosion, rockfalls, taluses, landslides, mudflows, etc. In the headwaters of the rivers, the watershed surfaces are subject to intensive destruction due to sudden fluctuations in daily temperatures, almost complete absence of vegetation cover, fracture of rocks and other factors. As a result, the slopes of river valleys become the areas of accumulation for huge amount of coarse clastic materials in the form of placers, taluses, and landslides. The accumulated material is carried to the river valleys during heavy rainstorms and heavy snowmelt, as a result of which powerful mudflows are formed. On the northern slopes of the Lateral Range, landslides are widespread, the formation of which is facilitated by such factors as the composition of rocks, the presence of tectonic cracks, the excessive moistening of rocks driven by atmospheric precipitation, groundwater, steepness of slopes, seismicity, etc.

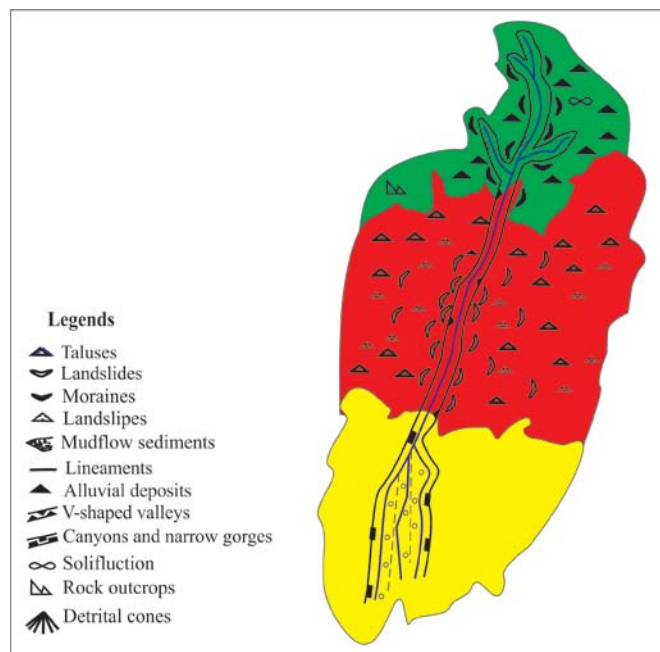
In the northeastern slope of the Greater Caucasus, at an altitude of 1000 m, the average annual precipitation is 710 mm, whereas to the higher areas it reaches 590 mm only. From 2500 m of altitude, the annual amount of precipitation increases again, making 1000-1200 mm and more at altitude of over 3000 m. The territory is characterized by the availability of two

maximums of precipitation in a year. The first is observed in the spring (May–June), and the second is observed in autumn (September). Comparison of the annual course of atmospheric precipitation with the water regime of rivers and also the regime of runoff of suspended sediments revealed the following: there is a similarity in their distribution within a year; during the spring, the water flow and hence the flow of suspended sediments increases in the rivers.

Regarding the condition of river basins of the northeastern slope of the Greater Caucasus, it can be concluded that high precipitation forming a powerful surface runoff and also sufficient steepness of the slopes, as affecting factors, together lead to the development of mudflows. Moreover, the presence of rockfall- and landslide materials on the slopes of river valleys affects the volume of solid material carried by rivers. Flows of mud- and stone composition are characteristic for almost all high-altitude belts of the northeastern slope of the Greater Caucasus.

Below, an analysis of the Gusar River's basin as the most mudflow-resistant basin of the northeastern slope of the Greater Caucasus is given.

Geomorphologically, the entire valley of the Gusar River is divided into three parts. The first upper part (1) is the center of feeding and the formation of mudflow. Foci of mudflow formation are typical for a height of 2500 m. This part of the basin is composed mainly of clay shales and Jurassic sandstones. A characteristic feature of the upper part of the mudflow basin is the presence of old talus materials on the exposed surface layers, which are composed of mainly clay shales of the high mountains, where the rocks are crumbled to the state of fine dust. During showers, dust is wetted, turns into mud and drains in a trickle form from slopes. The streams, merging with each other, form a flow in the river bed, filled with silts. The middle part (2) is a transit area where additional feeding of a mudflow takes place due to crumbled and destructed slopes of the river valley. Here the Gusar River runs in a narrow gorge, often passing into an inaccessible canyon. The width of the valley varies from 10-25 m to 100-200 m. The slopes of the valley are steep, reaching 45-60°, in some cases truncated by valleys of tributaries with 100-200 m of depth. The bottom of the valley is everywhere covered with rocks and fragments of rocks. Before reaching the cone, the river valley expands. The lower part (3) is the drift cone, where the solid materials transferred from the first two parts of the basin is deposited [6,7,8]. Mudflow phenomena are often observed in the basin of the Gusar River. Their development is facilitated by the destruction of grassy vegetation in the mountain meadow zone, as well as also deforestation in the forest zone. Mudflows are mainly observed in early spring, due to rainfall. By the nature of the mudflow mass, the Gusar River belongs to the category of mud-stone flows (Figure 1.2), (Table 1).



- high, strongly partitioned mountains
- high and medium, strongly partitioned folded mountains
- low, strongly partitioned folded mountains

Fig. 1. Geomorphological scheme-map of the Gusarchay river

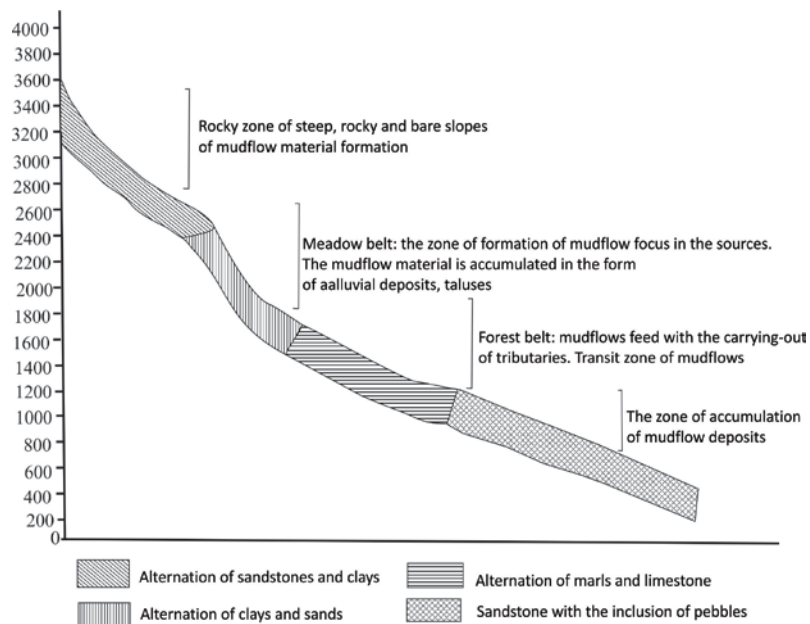


Fig. 2. Longitudinal geological-geomorphological profile of the Gusarchay River

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Structure of Holocene deposits in the Northern Caspian Sea as reflection of climate changes (drilling data)

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Keywords: Northern Caspian Sea, Mangyshlakian, Neocaspian deposits, paleogeography

Introduction

Studying of the Holocene history of the Caspian Sea is important for understanding of its current state and evolution in terms of climatic changes. The structure of the Holocene deposits in the Northern Caspian Sea fully reflects the level fluctuations of different scale. Their studying will clear up some debatable questions of history of the Caspian Sea.

Materials and methods

In the North Caspian region the sedimentary series have been studied mostly within the limits of oil producing fields in the course of prospecting works. The present paper is based on the processing of high and low frequency seismic-acoustic profiles, as well as on the cone penetration tests. The results provided the basis for the sequence stratification, the identified lithological and stratigraphic units being traced all over the region and beyond it. Taking into account the above-mentioned data, the exploratory boring to a depth of 80 m has been carried out in some areas. The obtained core was studied using an integrated approach, with lithological, faunistic, palynological, and geochronological methods being applied. The Holocene thickness makes up 10 m. The materials of the research were compared with those obtained by the authors from studies of the Caspian deposits in terrestrial sections on the coasts, as well as with earlier published data.

Results

The Holocene deposits are presented by Mangyshlakian regressive and Novocaspian transgressive layers. The Mangyshlakian regression is one of important paleogeographic events in the Caspian Sea; it is a large regression of the basin with the fall of the level to the mark 50 m lower than its current level. Based on an interpretation of high-frequency seismic acoustic data, it was established that the Mangyshlakian deposits fill paleo-lows in the strata of the Khvalynian deposits in the interval of the present-day sea depth 3-33 m, similar to the modern ilmeni water bodies of the Volga delta, paleo-valley and the cover of paleo-deltaic deposits in the southern part of the Northern Caspian Sea (Bezrodnykh et al., 2016). Organogenous sediments are widespread in the composition of the freshwater Mangyshlakian deposits, represented by high-carbonate sapropel and low-carbonate peat-like varieties. The formation of the investigated Mangyshlakian deposits took place under the arid climate conditions, in the shallow-water lacustrine water bodies with flowing and stagnant regimes, with a different role of the macro- and microalgae. Complexes of freshwater and weakly brackish water mollusks and diatom algae were discovered in the composition of paleontological remains. The absence of representative of the *Didacna* genus is its characteristic feature. Based on the data of radiocarbon dating, the age of the Mangyshlakian deposits is in the interval between 10,5-11,9 cal ka BP (Bezrodnykh et al., 2016).

The Neocaspian deposits lie on the Mangyshlakian horizon. They are represented by various shallow facies with abundant shells of mollusks. According to seismoacoustic profiling, the

Neocaspian horizon at sea depths up to 10 m contain uneven-age cuttings into the Neocaspian, Manyshlakian, and even into the Khvalynian deposits (Fig. 1). The cuttings reveal depths to several meters and, apparently, have an alluvial genesis. Three sub-horizons (nk1, nk3 and nk5) are identified on the basis of mollusk composition. In the lower sub-horizon (nk1), the abundance of *Didacna* mollusks sharply decreases, and only *Didacna barbotdemarnyi* is represented, but slightly brackish-water mollusks *Dreissena polymorpha*, *Monodacna caspia*, and *Hypanis plicatus* dominate. The middle sub-horizon (nk3) is characterized by the existence of different species of *Didacna*, *Monodacna*, *Hypanis*, *Adacna*, and *Cerastoderma glaucum*. The upper sub-horizon (nk5) differs in the presence of modern species: *Abra ovata*, and *Mytilaster lineatus*. The mollusks shells from depressions (nk2 and nk4) contain freshwater species of *Viviparus*, *Unionidae*, *Lymnaea*, *Planorbis*.

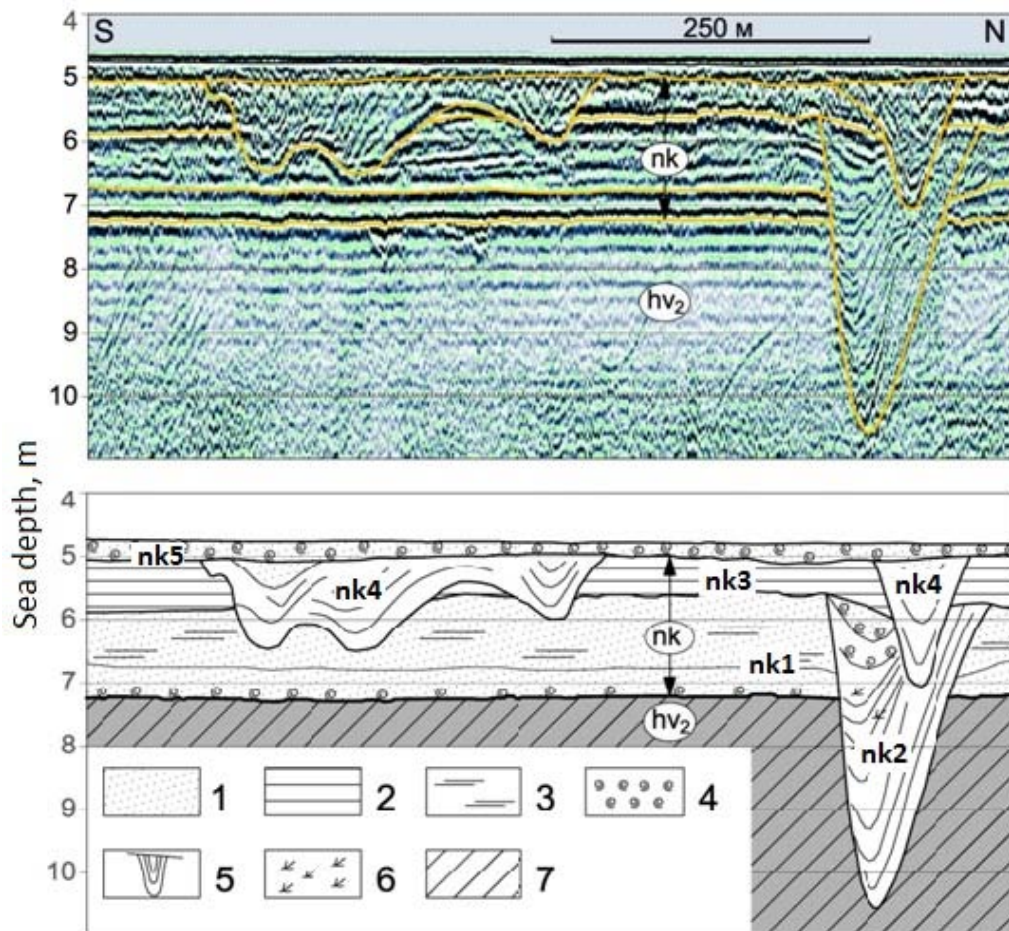


Fig. 1. The geological structure of the Novocaspian deposits in the Northern Caspian Sea.

1 – sand, 2 – clay, 3 – clay interlay, 4 – shells, 5 – sediments of deposits, 6 – vegetable detrit, 7 – Khvalynian and Mangyslakian deposits

According to data from the radiocarbon dating, the age of the base of the faunistically confirmed New Caspian deposits is in the interval of 8002-7736 cal. Years. The age of the vegetable remains and shells buried in the nk2 sediments is in the range 4900–3500 years. Age of nk3 deposits more than 3 ky BP. For upper Novocaspian layer (nk5) age interval varies between 1.5 ky – modern time. The presented materials reflect the regressive-transgressive events during the Neocaspian. The Neocaspian deposits accumulation was interrupted by two stages of the sea-level lowering, which are shown in formation of Neocaspian erosional cuttings.

Discussion

The regressive trend in the beginning of the Holocene began to develop against the background of increasingly dry climate in the region, as is apparent from the pollen assemblages (Bolikhovskaya, Kasimov, 2010) distinctly showing the transition from diversified tree species to xerophytic grasses and herbs. Such was the Caspian response to increasing continentality of the climate in the Boreal period of the Holocene.

The Novocaspian transgression developed in three stages divided by two (to 5 m) falling of level. The first stage of rise answered the Atlantic period of the Holocene. The next two highstands appear to coincide with two periods of increased precipitation in Eurasia, the 2600 BP event and the Little Ice Age. The last regression was coeval with the Warm Mediaeval Period.

Acknowledgments

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THEME VI

Marine Geophysics, Seismology,
Seismic Hazard Assessment

Probabilistic seismic hazard assessment of the oil and gas deposit areas in Caspian Sea (Azerbaijan)

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Keywords: Azerbaijan, Caspian Sea, cumulative earthquake number, statistical earthquake analysis, clusterization

Introduction

Azerbaijan is situated in the middle of the active plate tectonic collision zone of the Arabian with the Eurasian plate. Seismicity is the severest stress-induced geohazard in the Azerbaijan. Occurrence of earthquakes create hazard not only to the cities, villages, state enterprises and objects, but also threatens oil and gas deposits of the Caspian Sea.

This study presents the analysis of earthquake hazard for the oil and gas deposits areas of Caspian Sea (Azerbaijan) in terms of assessment of change of the seismic regime. Seismicity depends on the type and intensity of the tectonic processes and site effect where these processes are developed. Caspian Sea seismogenic zone represents potential seismic hazard both to the off-shore oil and gas deposits of Azerbaijan, and also to the Absheron peninsula with the capital of Baku city. Oil and natural gas extraction plays one of the key roles in strengthening the economic potential of Azerbaijan. With regards to the mentioned circumstances, there occurred a necessity to start a new stage in seismic hazard assessment of the oil and gas deposit zones of the country. The weak earthquakes occur mainly after the strong earthquakes with the decreasing number. Statistically, when strong earthquakes are rare, it is very difficult to prepare a representative database of recorded strong motion signals that could be analyzed to define valid ground parameters for seismic hazard estimations (Nunziata et. al., 2012). This region is subject to seismic hazard from the earthquakes, which can strike at any time, most severely from the adjacent and local seismic zones confirmed by historical seismicity (Babayev et.al., 2014).

There are a number of potential seismic focal zones in the Caspian Sea. Those are Caspian earthquakes, such as Central Caspian 1986-1989 ($M_s=6.1-6.3$), North Caspian 1963 ($M_w6.3$) and South Caspian 2000 ($M_s6.2-6.3$) (Kondorskaya and Shebalin, 1982; Gasanov, 2003; Babayev, 2008; Babayev, 2010; Babayev et.al., 2010, Babayev et.al., 2014; Telesca et. al., 2012) (Fig. 1). Using this seismic catalogue Telesca et al. (2012) performed a clustering analysis of the seismicity of the Absheron-Prebalkhan area for the earthquakes from 1842 to 2012 with event moment magnitude (M_w) ranging from 2.5 to 6.8, considering only the sequence of events with magnitude $M \geq 4$ by using the methods of the Allan Factor and the coefficient of variation. The results pointed out to the presence of time-clusterized structures in the time dynamics of large events occurred in the area, suggesting a non-Poissonian behavior of the seismicity and contributing to a deeper knowledge of the time dynamics of the seismicity and to a better assessment of the relative seismic hazard (Babayev et. al., 2014).

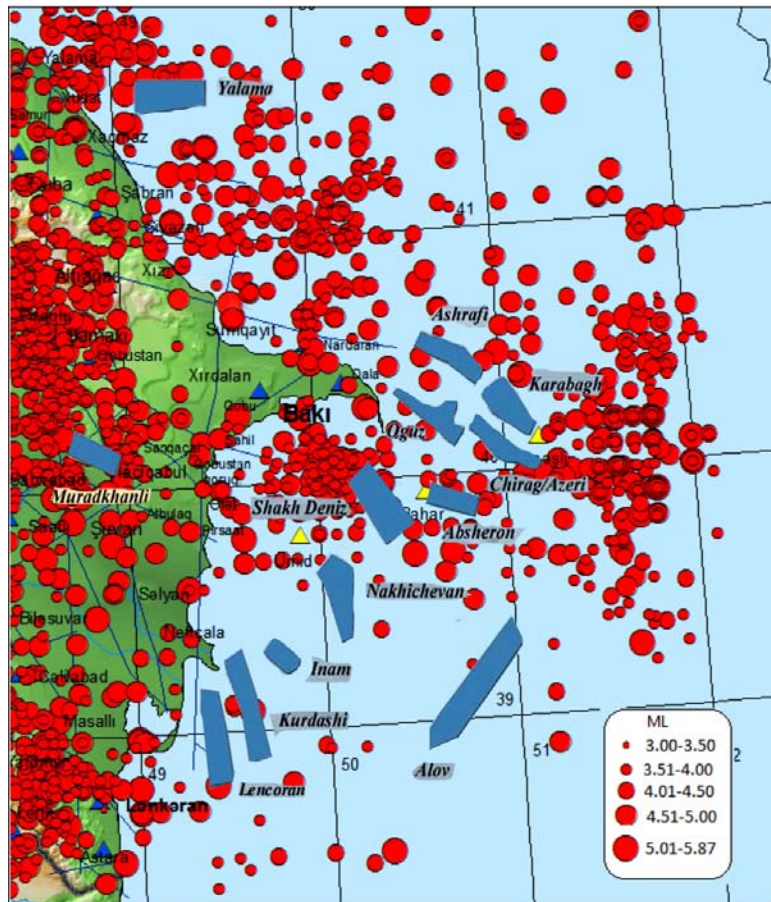


Figure 1. Earthquake distribution map for the events between 1963-2017 with the ML magnitude $ML \geq 3$ with existence of oil and gas deposits in the Caspian Sea

Revealed peculiarities of the seismic process development with the grouped earthquake testify high earthquake occurrence of the Central-Caspian seismic active zone. In this study, we researched the application techniques for probabilistic seismic hazard assessment (PSHA) for the Caspian Sea. Tectonically, Absheron peninsula is complicated by tectonic fractures, which can be divided into major (folded zones) and secondary fractures which are mainly cross faults, not extending beyond one fold and being confined to their top portions (Shikhalibeyli, 1996; Kadirov et.al., 2012; Alizade et.al., 2016; Babayev et. al., 2017; Telesca et.al., 2017) (Fig. 2).

The aim of the paper is to assess the change of the seismic processes based on the cumulative analysis (statistical-mathematical formulations) of the occurred earthquake within the period of 1935-2017. The stationarity of the seismic processes for the period of 1842-2017 years was researched. The graphs describing the reoccurrence and “representativeness” of the earthquakes were plotted. The obtained results with the application of new methods (statistical-mathematical) will contribute to a deeper knowledge of the time dynamics of the seismicity and to a better assessment of the seismic hazard.

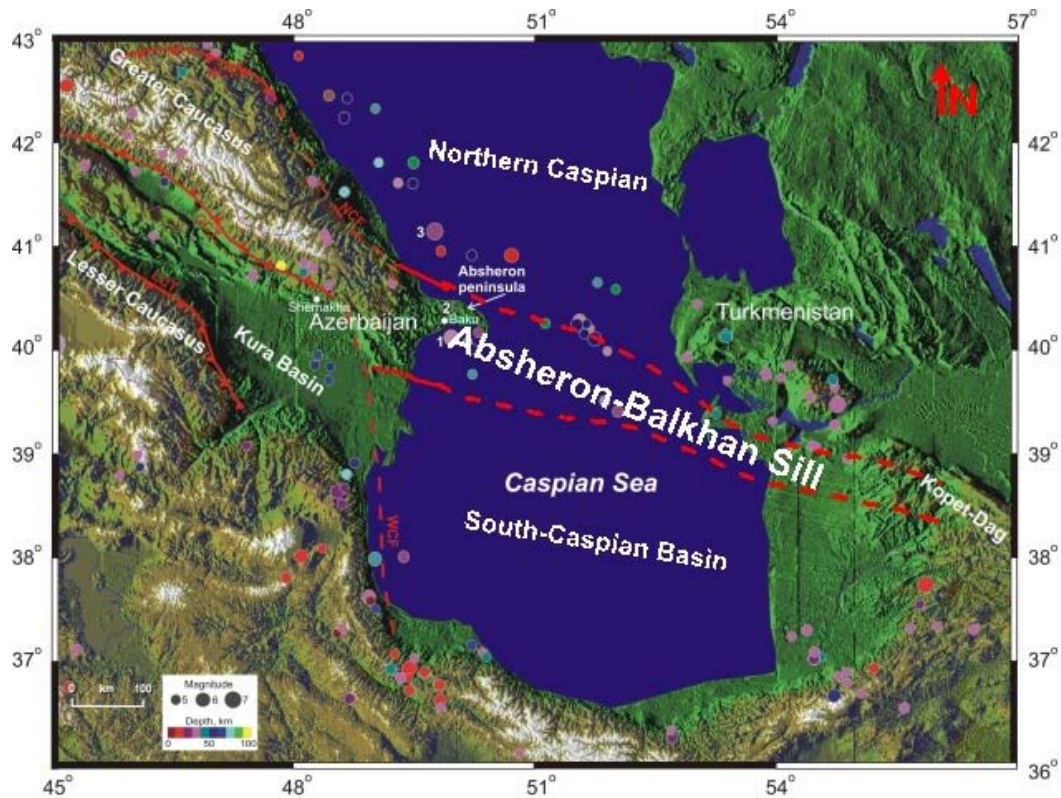


Figure 2. Topography, simplified tectonics and seismicity of Caucasus to Kopet-Dag (by Babayev G. et. al., 2010) with overview of Azerbaijan and Absheron-Balkhan Sill. Earthquake epicentres are marked by circles, and the colors of the circles provide information on the depth of the earthquake hypocenters (earthquakes of magnitude 5 and greater for the period of 1950–2006 are plotted here). By numbers there marked important earthquakes affected Absheron peninsula: (1), the 2000 $M = 6.3$ Caspian earthquake; (2), the 1935 Surakhani earthquake; (3), the 1963 $M = 6.5$ Caspian earthquake. Abbreviations: NCT, North Caucasus thrust fault; GCT, Greater Caucasus thrust fault; LCT, Lesser Caucasus thrust fault; WCF, West Caspian fault and NCF, North Caspian fault. Faults are positioned according to the researches done in previous years (Borisov, 1967; Gadjiyev, 1965; Kadirov, 2000; Jackson et al., 2002; Kadirov, 2004; Babayev et al., 2010; Kadirov et. al., 2012).

Materials and methods

For researching the statistical regularity of the regional seismicity and frequency-magnitude dependence, 1935-2017 earthquake catalogue was used. With the catalogue, graph of cumulative number of earthquakes on the basis of summing and grouping of events for energy classes $K=11\div 14$ was plotted (Fig. 3). Studied the statistical dependence of the regional seismicity and parameters of the seismic regime, it was necessary to figure out the change of the seismic process. As it is known, the change of the process is characterized by the equality of the medium value of the events calculated for the various timing interval (Dubinina et. al., 1975). Aiming to research the seismic regime change in the current work, it is suggested to use the graph of the cumulative number of earthquakes for the different energy class with magnitude $M > 4$ for the instrumental period 1935-2017 years.

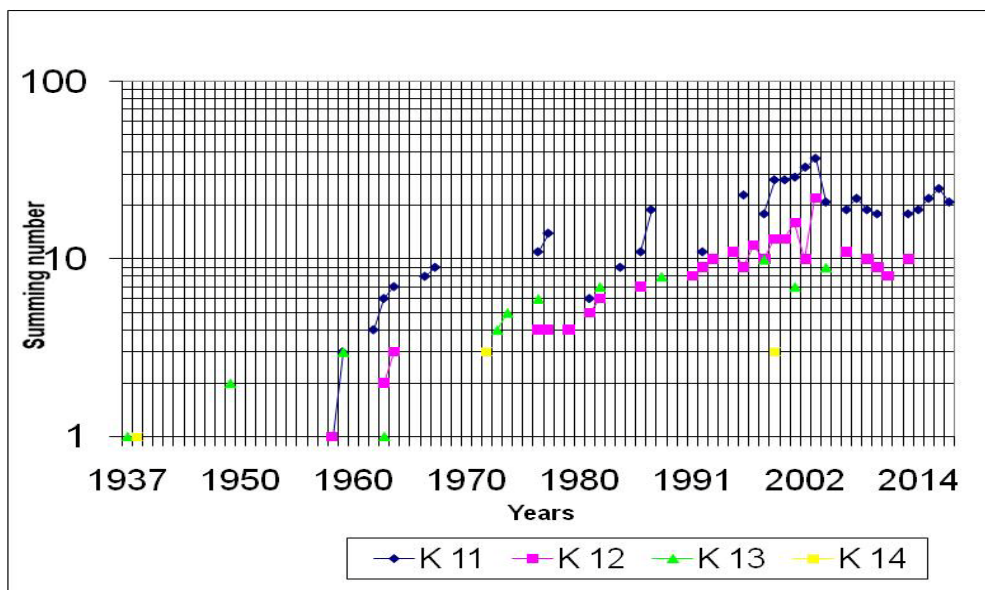


Figure 3. Graph of cumulative number of the earthquakes

Results

The “sensitivity” of the suggested method allows applying it for the accentuation of the oscillation generated by the strong earthquakes in the complex of the weak ones (Dubinina et al., 1975). As it is seen from the graph, the occurrence of the strong earthquake (K=13) causes the sharp variation of the inclination which is not commensurable with the variation at the quiescent course in the process. The method allows revealing the “representativeness” of the earthquakes and their consistence to the law of the repetition, and also researching the changing course of the seismic process.

Discussion

The observation results and researches allowed defining the high-moderate seismicity level of Caspian zone. It can be concluded that the weak earthquakes occur mainly after the occurrence of the strong ones with the decreasing number afterwards. For the researched region, the “representative” earthquakes are the ones with the energy class of $K=12$, on average. In most cases, their lapse invariably goes according to the event reoccurrence law, with observation of the quiescent course in the process. The research results are of great importance to the seismic hazard zoning of the oil and gas deposit areas which allows conducting the further preventive countermeasures towards diminishing the level of possible technogenic catastrophe as a result of strong earthquake.

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The model of observing systems application for inland waters investigation

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Keywords: supervisory control systems, mountainous terrain, rationally deployment, mathematical model, 3D vector data

Introduction

Nowdays, the various types of electron-optical supervisory control systems (SCS) have been used in many advanced countries for many ecological problems solution. The mission of these SCS is to supervise day and night inland water ecological conditions with high precision a great and middle distance [Merlin & Savitha,2014; Nasibov, 2014].

With goal of optimal (rationally) SCS deployment in mountainous terrain by using of the digital altitude model of terrain the viewsheld analysis is possible to carry out [Sabziev et al.,2018]. This viewsheld analysis helps to select optimal points (posts) on the terrain. The SCS optimal deployment in mountainous terrain makes possibility to use rationally SCS number, because SCS has very much costs. Using the rationally SCS number we can reduce a necessity of the specialist number. Also, it accelerates a correct decision making. The correct post's points and rational number deployment help to observe and to detect the inland water ecological changes on the terrain.

Taking into account above, in present paper the mathematical model of the rationally deployment of technical observing systems in mountainous terrain has been developed and offered.

Methods

The determination method of visibility level between selected terrain points has been developed. The assesment criterion of rationally deployment and the algorithm of fast solution have been offered.

For task solution the below method has been offered:

- 1) It is offered a net of terrain, the net point junctions are heights of the terrain;;
- 2) We adopt that arround of the each height all point junctions are a SCS deployment set;
- 3) We determine visible and invisible point's sets for each selected SCS deployment point;

From set of the deployment point junctions we select deployment points for minimal (rational) SCS number determined maximum visible zones of inland water.

For analysis, let us use the 3D digital vector model of some terrain relief. Considered file has the values of elevations of the relief set in points of regular grid. There are four neighbours around of each relief's points. For example, the points with knot's number of $(i - 1, j)$, $(i + 1, j)$, $(i, j - 1)$ and $(i, j + 1)$ are neighbours for point with knot's number of (i, j) .

Let us denote the height of relief in knot of (i, j) by $h(i, j)$, It is obvious, we can take such $Oxyz$ coordinate system that $\{(i, j), (i \pm 1, j), (i \pm 2, j), \dots\}$ knots set is located parallel to Ox axis for each j , and $\{(i, j), (i, j \pm 1), (i, j \pm 2), \dots\}$ knots set is located parallel to Oy axis for each i , and $h(i, j)$ elevations are indicated along Oz axis. The Oxy plane included $h(i, j) = 0$ points, and let us call it as basic plane.

Neighbour's points are connected by straight lines, and in result, the 3D digital vector model of relief of the terrain is generated. These segments are called relief lines and their projections on side plane are called edges.

All these edges can be divided on two classes. Let us consider if the first numbers of connected (i, j) , $(i \pm 1, j)$ knots of some edge are coincide then the this edge belongs to P class. If the second numbers of connected (i, j) , $(i, j \pm 1)$ knots of some edge are coincide then the this edge belongs to M class.

Let A and B are some knots. Let $Pr(A, B)$ is the projection of AB segment on the Oxy base plane. The edges set, the projection of which are crossed on the $Pr(A, B)$, is called incidental.

Let us consider that for any i, j the relief in range of space quadrangle with (i, j) , $(i + 1, j)$, $(i + 1, j + 1)$, $(i, j + 1)$ knots has such shape that any two points of its boundary edges can be connected by line not crossed on relief plane. So, we consider that always the knots see each other in range such space quadrangle.

Results and discussion.

We consider that 3D map of terrain relief is presented in vector form, that is, for considered terrain the $h(i, j)$ heights are set in (i, j) knots. Let the necessary be search terrain's zones are known and connected to (i, j) knots. Let us consider that the possible knots of SCS installation are marked.

It is obvious, in the range of each observation place the most suitable observation point can be selected. For example, if the observation of nearest lowland is priority then the observation point can be placed nearer to observed points. However, if the observation of far lowland is priority then the observation point can be placed in highest point, etc. Therefore, we can adopt that observation points set is grouped around of N separate high-altitude knots. Let they are called initial knots. In real conditions usually $N \leq 10$.

It is required to deploy n SCS ($n < N$) on the terrain that they would provide the maximum range of observation zone. Not intersection the line segment connecting A and B points on the relief plane is condition of visibility B point from A point. That is, if AB segment is placed above all incidental edges then A point sees B point.

The next method for solution this task is offered:

- Development of \wp procedure for the each other visibility checkup of two given knots;
- By application of \wp procedure for each A knot from the set of possible SCS deployment places to determine the set of visible and invisible points in range of technics possibilities of SCS;
- Assessment of visibility level of zone and determination of the most suitable SCS deployment in the set of initial knots;
- Improvement of computed solution by variation of knots in the range of group.

Let denote the set points of under obligatory observation terrain zones by V_0 .

As stated above, the observation set points will be grouped around separate altitude knots of A_m ($m = 1, 2, \dots, N$), which are taken as initial knots. Let V_m are set knots, which can be observed from A_m knot in the case of ideal flat relief, the ranges of which only are depended on technical characteristics of observation devices. By use \wp procedure for each initial knot of A_m we will get $U_m \subseteq V_m$ sets.

The various tasks are set when devices are placed. Let consider two examples of these tasks.

Task 1. To deployment SCS such way that to embrace widest zone observation.

In this case, we can take a following functional as the assessment criterion of zone observation range:

$$\mathfrak{S}(m_1, m_2, \dots, m_n) = mes(\bigcup_{m=1}^N V_m \setminus \bigcup_{k=1}^n U_{m_k}) \rightarrow \min,$$

Here: m_1, m_2, \dots, m_n are serial numbers of taken A_m sets in number n , $mes(\mathcal{L})$ is a measure of \mathcal{L} set.

As far as, all considered sets are limited and discrete then an operator $mes(\mathcal{L})$ is a number of elements of appropriate set.

Task 2. To deployment SCS such way that to embrace widest zone required observation.

In this case, we can take a following functional as the assessment criterion of zone observation range:

$$\mathfrak{S}(m_1, m_2, \dots, m_n) = mes(V_0 \setminus \bigcup_{k=1}^n U_{m_k}) \rightarrow \min.$$

Thus, first of all, by application of \wp procedure all sets included in functional are described. Then, by the method of m_1, m_2, \dots, m_n exhaustion, \mathfrak{S} is calculated and the most suitable is determined. At this time, the number of all various observation devices on the initial peaks can be calculated as in combination N with n [Erosh,2001]:

$$C_N^n = \frac{N!}{(N-n)!n!},$$

Here: N is a number of initial knots, n is a number of observation devices. In real case, usually $N \leq 10$ and $n = 3$ or 4 , therefore, at this stage the total number of calculations is ≤ 240 .

Further, by varying knots in the range of m_1, m_2, \dots, m_n groups we can improve obtained solution.

It is obvious, that from the point of view of mathematics it is possible to prove that in common case such algorithm not leads to potimal solution. However, in practice such solution is satisfactory. Therefore, this solution is called rationally.

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Evaluating earth rotation impacts on sea level fluctuation and seismicity in the Caspian Sea region

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Keywords: Caspian Sea, Earthquake, Sea Level, Length of Day.

Introduction

Gravity force and centrifugal force of earth rotation are two important forces which affect earth system process. The centrifugal force is perpendicular to the axis of the Earth and neglecting its small horizontal vector component, it is opposed to gravity. This force depends on the rate of earth rotation. As the earth rotation increases, it is expected that the effect of gravity force on earth's particles decreases and so materials on earth (rocks and waters) expand which itself may trigger movement on fault surface or may cause sea level rise.

In the past, it has been tried to find out the interaction of earth rotation and earth system process and phenomenon. Flatte, 1965 believed that the decrease in the earth's angular velocity over the last 100 million years has had an effect on sea level and tried to show this effect. Chao and Connor (1988) believed that sea level changes have an effect on earth rotation. Xu et al., 2013 tried to formulate the effect of huge earthquakes on earth rotation. Zotov et al, 2016 presented some evidence of interrelation between earth rotation and climatic variability at decadal time-scale.

In spite of these studies, it seems that very huge scale factors such as earth rotation has significant effects on phenomenon on earth and should be considered more than before. Here, changes in earth rotation rate are compared with sea level fluctuation and seismicity in the Caspian Sea region during 1962 to 2016.

Materials and methods

Earth rotation rate determines length of day (LOD), so in practice, LOD is measured to calculate earth rotation. LOD changes (Δ LOD) increase when the earth rotates slower and decrease for faster rotation. So, in the present study, opposite value of Δ LOD was used to compare with sea level changes and seismicity. Daily data of Δ LOD was downloaded from website of International Earth Rotation and Reference Systems Service available from 1962. Δ LOD varies between -0.0011 s to 0.0044 s in the period of study (1962 to 2017). Monthly average of Δ LOD was calculated and multiplied by -1 to prepare a graph to show the variation of earth rotation rate.

In this work, data of Caspian Sea level (CSL) was extracted from the study of Chen et al., (2017). Chen and co-authors concatenated a historical record of CSL change from tide gauge measurements (Kostianoy et al., 2014) and satellite altimeter CSL change time series (Lebedev and Kostianoy, 2008; Cretaux et al., 2016) to generate a CSL change time series covering the period from 1840 to 2015.

The northern part of the Caspian Sea Basin is almost without earthquake (Jackson et al. 2002) and most of the events happen in the Apsheron belt, Alborz Belt in the south, Kopeh Dag in the east and Greater Caucasus in the west.

The frequency-magnitude distribution of earthquakes in a given region can be described by a power law equation which was proposed by Gutenberg and Richter (1944) as: $\text{Log}(N)=a-b(M)$. Where N and M are cumulative number of earthquakes and magnitude, respectively. The constant "a" known as a-value, describes the general level of seismicity over a period of time in a study area. The parameter b, known as b-value, is the slope of the equation describing the relative number of large earthquakes to smaller earthquakes. For instance, a low b-value in a region indicates that the number of large earthquakes is more than that of small earthquakes.

In the present study to evaluate the seismicity of Caspian region, "a" and "b" values were estimated using the database of earthquakes from International Institute of Earthquake Engineering and Seismology (IIEES). Earthquake distribution map is presented in figure 1.

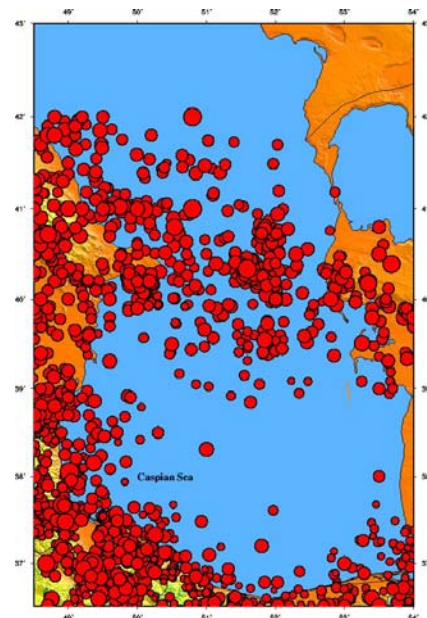


Fig. 1. Earthquake distribution map of study area

Results

Four parameters including: $-\Delta\text{LOD}$, CSL, a and b values, are illustrated in figure 2 to evaluate their correlation during the period of study. In this figure, moving average trend lines are fitted to "a" and "b" values to make them comparable with other parameters.

According to $-\Delta\text{LOD}$ variations, earth rotation rate decreased from 1962 to 1972 and then increased until 1986. The rate of earth rotation after 1986 felled down for 9 years and again in 1985 started to decrease until 2003. It has decreased since 2003 up to now. Caspian sea level felled down from 1962 to 1977 which was generally in accordance with decreasing of earth rotation rate. After 1977, CSL raised until 1995 and then

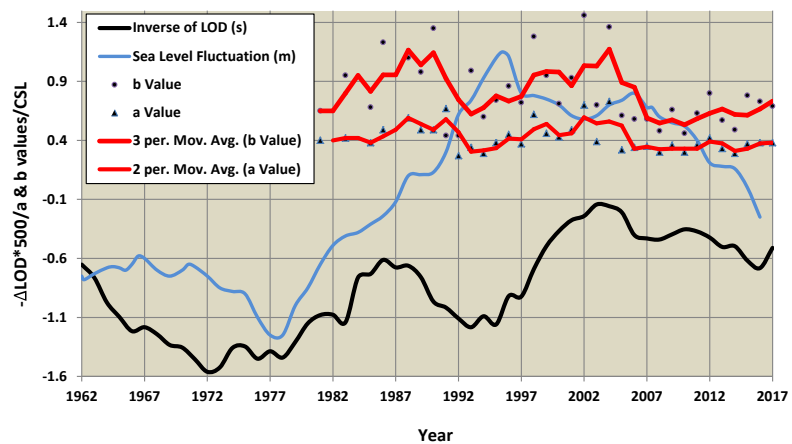


Fig. 2. Comparison of earth rotation rate (presented by inverse value of length of day (LOD)) with sea level fluctuation and seismicity (presented by a and b values) in Caspian Sea region.

has decreased again up to now with some fluctuation. In the period 1986 to 2003, graph of CLS shows a maximum peak while earth rotation rate make a downfall. In spite of this period, general trend of CSL varies in accordance with earth rotation rate.

The values of a and b show two peaks around 1988 and 2003 which are in accordance with two peaks of earth rotation rate.

Discussion

As mentioned before, in spite of general accordance between CLS and earth rotation rate, those went in opposite directions during 1986 to 2002. According to the estimation of yearly budget of Caspian Sea studied by Chen et al (2017), the budget increased up to 1994 and then decreased sharply in 1995 and 1996. After 1997, the mean budget was clearly lower than those in years before 1994. These results suggest that, during 1986 to 2003, CLS probably was mainly under the effect of climatic parameters.

Seismicity presented by "a" and "b" values increased in Caspian Sea region during high rate of earth rotation. This means that not only more earthquake events happened but also average magnitude of earthquakes increased. It seems that high rate of earth rotation triggered faults to release their accumulated stress.

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Classic technologies for geodetic provision in the Azerbaijani sector of Caspian Sea

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Control system

Introduction

In order to develop the prosperity and sustainability of humanity and to establish and improve for these purposes the new directions for the improvement in the field has been identified and the regions and areas previously not studied have been target of different investigations since the second half of XX century. Specially, intensive exploitation of energy-raw materials resources in the continents (onshore) created the necessity to look to the seas and oceans for vital resources. As a part of this global trend in our country also shift of focus from onshore to offshore areas such as sea, lakes, rivers and other water bodies started since the 1940s and in this regard, numerous full-scaled scientific research and industrial activities has happened since that date and still is ongoing.

Generally in all engineering activities on the surface of earth (either onshore or offshore) the geodetic provision (coordinate reference system) has crucial importance. Moreover, in the sea it is not imaginable to carry out any geophysical-geological investigation of oil and gas fields, study of oil-gas well cross-sections (directional survey), execute well drilling, acoustic profiling, sonar planning, bathymetry, mapping of sub-sea surface and many other investigative works.

This article thoroughly reviews the classical geodetic and hydrographic referencing systems which is utilized in the geodetic provision of scientific research and industrial sub-sea activities and is still the topic of interest.

1. Classic methods of marine geodetic and hydrographic provision systems

To ensure the efficient exploitation of oil and gas fields in the Caspian Sea and un-interrupted transportation to onshore and then delivery to the world market is pressing issues in the sustainable development of country's economy. As a part of complex activities carried out in the Azerbaijani sector of Caspian Sea, also including in the implementation of two-dimensional (2D) and three-dimensional (3D) seismic investigation activities using the geological-geophysical methods, the geodetic provision plays key role. For these purposes coordinates (x and y) and elevation (h) indicators of locations of specific points on the plan or map are identified for the

projects implemented in the Azerbaijani sector of Caspian Sea (both in shallow and deep water areas).

It should be noted that besides the fact that the maritime environment is different from continental one in terms of physical-geographical conditions, also the geodetic referencing tools and methods used in maritime environment is critically different from the ones utilized onshore for similar purposes. So that, if it is possible to visually observe the external features of investigated objects onshore, it is quite difficult to express the same about natural or man-made objects offshore. At the same time onshore objects are static however, in offshore environment there is always movements (waves, currents and etc.). All above mentioned aspects influence the methods used in sub-sea geodetic and hydrographic referencing systems. The geodetic referencing surveys are implemented with the support of integrated management and control systems and with the application of high precision positioning equipment (SP 11-114, 2004). In general, for the sub-sea geodetic and hydrographic referencing purposes the below given activities are implemented:

- Establishment, update and enhancement of onshore (on the islands, coastal areas and artificial structures) geodetic referencing points/stations based on plan and elevation;
- Establishment of satellite (GPS) geodetic referencing network ;
- Establishment of local geodetic referencing network based on seabed plan and depth;
- Civil hydrographic surveys;
- Topographical (bathymetry) survey works;
- Sonar and profiling surveys;
- Establishment of temporary sea surface level markers and observation of sea surface fluctuations;
- Depth measurement works and seabed topographic planning/mapping;
- Sub-sea and surface communication lines and objects planning;
- Seabed ground survey.

In order to support geological-geophysical investigations with topo-geodetic and hydrographic measurements in sea shelf and also in the deepwater areas according to the classic methodology usually the local geodetic referencing network which consists of hydroacoustic buoys mounted on artificial subsea floating objects or other mobile subsea objects is established. Using this network of the radio-buoys the positions (coordinates) of moving or static scientific research or industrial ships or other objects are identified and the slant range distances (or distance differences) between these objects and buoys are identified. This identification process is called hydroacoustic trilateration method(Nikiforov, 1965). The main principle of this method is measurement of distance or distance differences between buoy and receiver using hydroacoustic navigation systems in 'long base' or 'short base' modes. (ATNAV-II,

1979). The mean square error (MSE) in the application these methods for the identification of positions of objects is around 3-20 metres.

In addition, other radio-hydroacoustic and radio-navigation positioning methods and tools such as ultra short base system, hyperbolic system, dopler system, pulse-dopler system are used. (Qaloşin və Qlumov, 1995).

Another method is called “Intelligent GPS buoys”. This method is mainly used for military purposes for the identification of positions of underwater objects, ammunition targets and for their tracking since the 90s of XX century (Kayser, Cardoza et al., 2005).

The operation principle of intelligent buoys is very simple. OEM type small GPS receiver is installed on the ordinary hydroacoustic buoy and then this modernized equipment dropped into the sea or ocean from the helicopter, plane or other aircrafts (figure 1). After GPS data is recorded by GIB, the acoustic information flow is modulated using the ultra short frequencies (VHF) supported by frequency switch key (FSK). The modulated acoustic information flow with the support by GPS waves transferred to the Global navigation system’s satellites and from there measurement data is delivered to the VHF receivers through the contact channels.

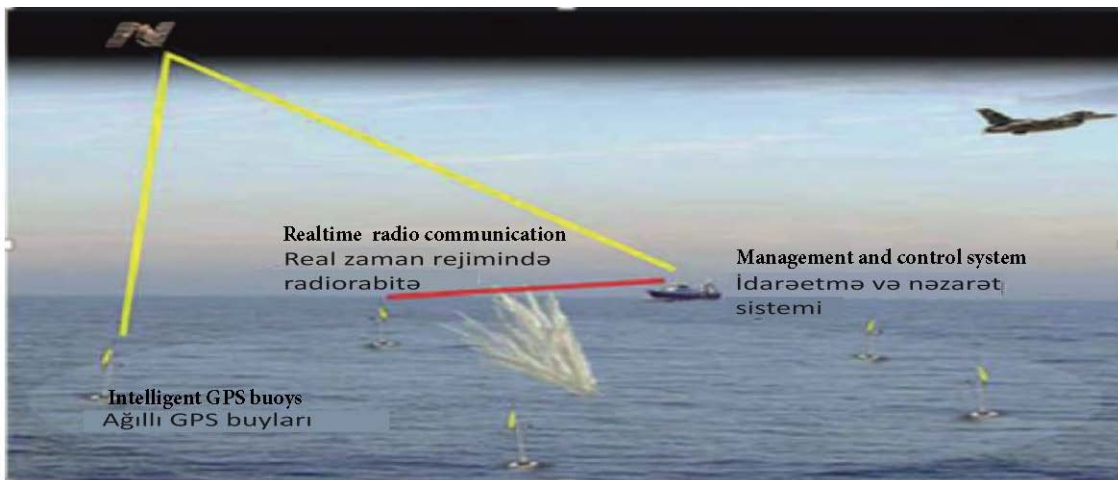


Figure 1. Schematic location of intelligent GPS buoys

“ATNAV”, “LBLATNAV” and HNS “ATNAV” and HNS “MARAC-LF” softwares with greater memory capacity is used as a classic technologies in maritime geodetic and hydrographic referencing (Milne, 1983). As mentioned above, in specific cases the maritime geodetic referencing can be carried out using the pingers. The practice indicates that, even though it is possible simultaneously to determine the positions of many ships and other objects with the pingers, there are systematic errors and the tendency of accumulating indicators due to the pingers’ standard time systems sequential-shift response to the signals received from the ships. (Godjamanov and Hasanov, 2015). However it is not the case when using transponders because, transponders are designed for a extended use.

One of the widely applied sub-sea geodetic referencing system is pulse-doppler hydroacoustic navigation system (PANS). As the name indicates, this system consists of pulse and dopler sub-systems. The pulse sub-system determines the position of the ship or any other object based on/relative to reference transponders (responsive buoy) network established in the seabed. The dopler sub-system identifies the current position of the ship with high accuracy relative to its previous position. The positioning is done based on three channel successive approximation method with the exchange of information between transducer and transponder at specific contact frequencies.

The experimental calculations made by us during the seismological investigation project in 2008 at the “Bahar” deposit which is in the Azerbaijani sector of Caspian Sea, it was found that the coordinates of ship are determined with the 4.7m mean square error while it floats with speed of 4 nautical miles and at the distance 3.5-7.0km from transponders (figure 2). This result is quite high indicator and meets the maritime geodetic referencing requirements.

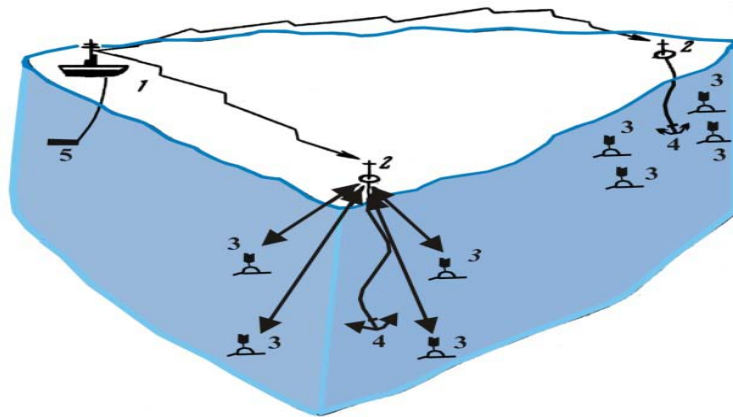


Figure 2. Operational principle of radio hydro acoustic navigation system: 1-ship; 2-radio acoustic buoys; 3-seabed hydroacoustic buoys; 4-anchor of radio acoustic buoy; 5-towed search tool.

Results and proposals

The following results and proposals can be made based on investigations and analyzes carried out:

1. Geodetic referencing has important role in realization of complex activities including the seismic investigations using geological-geophysical methods in the Azerbaijani sector of Caspian Sea and the reliability of geodetic referencing system depends on utilization of modern equipments for measurements and on the accuracy of locally established geodetic referencing network.
2. The experimental trials indicate that with the support of integrated management and control systems such as “GATOR” and “TRİ NAV” and with application of high precision positioning equipments it is possible to track and manage more than 20 ships or any other floating objects at the same time with decimeter accuracy.
3. According to the gained experience, even though it is possible simultaneously to determine the positions of many ships and other objects with the pingers, there are systematic errors and the tendency of accumulating indicators due to the pingers’ standard time systems sequential-shift response to the signals received from the ships.

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Modern methods of geodetic provision in the Azerbaijani sector of Caspian Sea

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Keywords: seismic survey, bathymetry, geodetic provision, monitoring-control system, intelligent GPS buoys

Introduction

In order to exploit the offshore oil and gas fields in the Azerbaijani sector of Caspian Sea since the 40s of previous century large scale scientific research and industrial works has started and is still ongoing. It should be mentioned that while implementing all kinds of engineering activities both onshore and offshore the geodetic referencing (coordinate referencing) has crucial importance. While choosing the geodetic referencing methods (geodetic support) the content and main characteristics of respective engineering issues should be thoroughly considered.

As a part of large scale geophysical and geological investigation of oil and gas fields in the Azerbaijani sector of Caspian Sea various scientific and applied practical activities carried out such investigation of oil and gas well cross-sections (directional survey), drilling works in oil and gas deposits, seismo-acoustic profiling, Sonar survey, bathymetry, seabed mapping and others.

In order to provide geodetic provision for above mentioned activities modern combined methods (satellite, surface and seabed) are applied and with their support seabed geodetic referencing networks are established. This article also provides information about integrated navigation monitoring-control systems (INS) applied in geodetic and hydrographic works, high precision positioning equipments, their software support, methods and technologies of implementation for offshore geodetic and hydrographic works. It also gives examples of cameral processing of site measurement results, estimation of accuracy of measurement results and its graphic representation.

1. Modern methods of offshore geodetic referencing and hydrographic surveying

Currently navigational-hydrographic and radio geodetic measurements in the Azerbaijani sector of Caspian Sea are carried out simultaneously in combination with geological-geophysical and seismic surveys and it includes the following activities:

- Seabed surveying;
- Placement of seabed system on the seabed surface and bringing it to operational condition;
- Continuous measurement of depth based on lines and seabed mapping;
- Implementation of acoustic operation (double pinger application);
- Seismic observation and collection of geodetic data;
- Collection of SBS from the seabed;

- Preparation of catalogue of coordinates of observation points and reporting plan in suitable scale.

During this process continuous geodetic support also provided for the executed works. It should be noted that there has been rapid development in the number of geodetic measurement tools and their software support field since 90s of XX century. New electronic and laser based tools and modern Technologies based on satellite navigation systems have been created (Mammadov and Ahmadov, 2012). All these innovations have not bypassed the offshore geodetic measurement tools and methods. As a result many modern methods are being applied in offshore geodetic backup activities such as long base (LBL), ultra short base (USBL) and combined – long/ultra short based (L/USBL) Ranger-2 type hydroacoustic hydrographic-navigation systems, intelligent GPS buoys applied underwater (GPS ACSA) and on the sea surface (TARGET GIF) (Kayser and et al, 2005), RFID TZ seabed acoustic transponders, differential positioning systems (DGPS) based on global satellite navigation systems and surface (triangulation) geodetic methods and many others. (Генике and Побединский, 2004) (figure1).

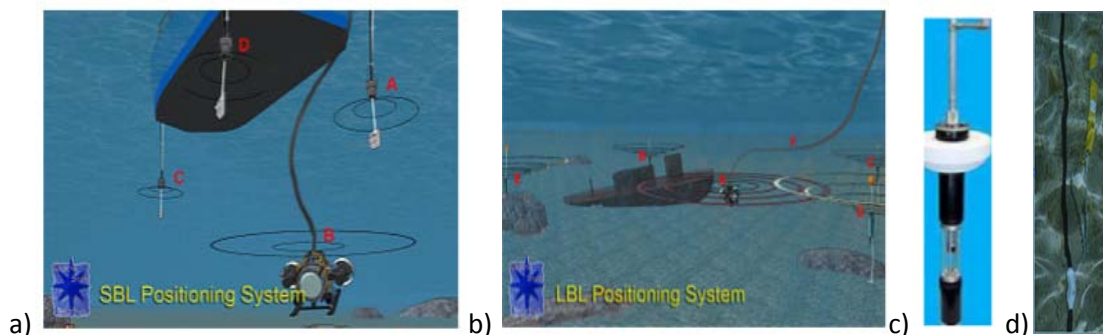


Figure1. View of modern underwater and surface (water) positioning systems: a) (SBL) short base positioning system; b) (LBL) long base positioning system; c) TARGET type intelligent GPS buoy; d) RFID TZ seabed acoustic transponder

Even though the the improvement of quality of offshore position-attribute data accuracy is directly linked with application of above mentioned tools and software, the issue of choosing the right methods and procedures for the execution of works are also playing important role and not widely researched. Therefore, it is better to use intelligent GPS buoys and RFID TZ seabed acoustic transponders in shallow water and transitional zones (TARGET GIF) of Caspian Sea. With their support the seabed positions of seismic cables, receivers and underwater hydrophones are determined with high accuracy (Gojamanov and Hasanov, 2015). One of the major factors influencing the final measurement result is the identification of time differences occurring between GPS buoys or transponders. This can be done with the least squares method.

2. Combined model of geodetic referencing system

Nowdays, the geodetic support of scientific-research and industrial activities carried in the sea and oceans are mainly based on the use of combined geodetic reference networks that are seperately functioning in three different locations: satellite (space), continent (onshore) and seabed (underwater) (Robert D.C. and Robert L.W., 2007).

As indicated in figure 2, even though each network is seperate in combined model, they complement each other and united in asingle system. In order to ensure the unity of system at least two points of combined geodetic reference network are connected to the State Geodetic Netwrok (SGN). Before every geodetic survey as a verification, lines have to be re-connected to the State Geodetic Network (SGN) or at a single reference point double measurement

operation has to be implemented. The verification results are recorded as 'C' (checked). Standard mean differences among the repetitive measurements have to be within the following tolerances: $\Delta x \leq 0.6$ m, $\Delta y \leq 0.6$ m, $\Delta h \leq 1.0$ (SOCAR, 2012). If the accuracy of measurement results meet the requirements, then calculation and balance operation of network are carried out. The most suitable method for this purpose is the least squares method (Gojamanov, 2014).

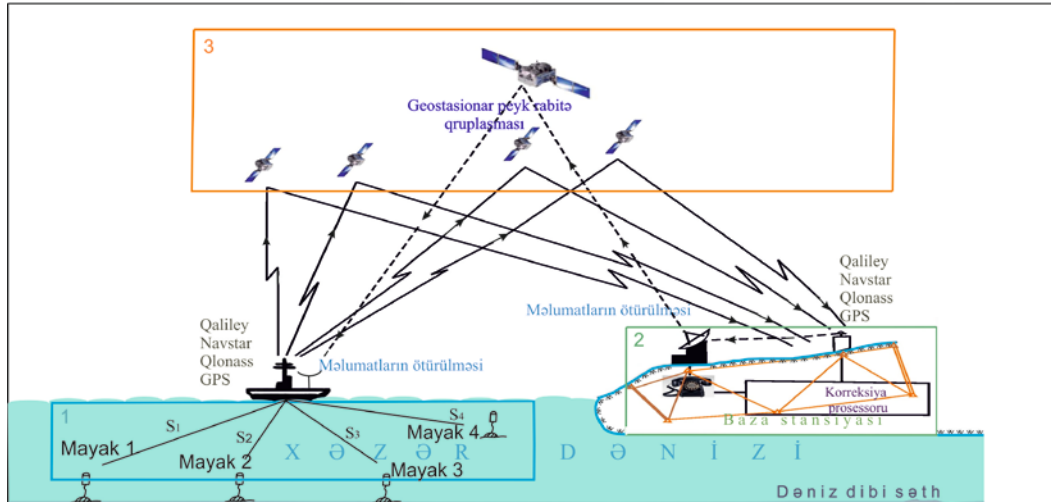


Figure 2. Combined model of offshore geodetic referencing: 1-satellite (space) network; 2-surface (water) network; 3-seabed (underwater) transponder network

Currently, the geodetic backup in the Azerbaijani sector of Caspian Sea is provided with the support of GPS CNAV-2050 navigation and GPS CNAV-1000 monitoring systems. The collection, classification and preliminary processing of data from other sources is done by 'GATOR' and 'TRI NAV' integrated monitoring-control navigation systems.

"GATOR" system consists of below given main softwares, triggers and virtual interfaces:

- DTN - communication system between ships: *deploy və shooter*;
- GRN - the software which loads the Project coordinates into the server;
- TCN - the software transferring the data to the memory;
- DLN/CDBNLOG- the software that records the *SPS, P1/94 və P2/94 type coordinates in the memory;
- CDBN - the software for keeping address and memory numbers of transponders;
- APN - the software starting the pinger equipment (transducer) to operate;
- PPN - the software for processing of pinger data;
- SNN - recording of offsets of GPS antennas installed on the ship;
- LCN - the software for loading designed profiles and visualization on the screen;
- DN - visual representation of ships and profiles on the screen;
- QCLN - used for creation of QC (quality control) files after shooting;
- R1_TRIGGERS - gun, Trigger Timing QS;
- R1_RFID - acoustic TZ, Standart RFID interfacing

GATOR system is regularly synchronized with sub-systems. For this purpose, each equipment and tool included in the monitoring-control system is calibrated with the support of alternative measurement methods. After necessary amendments, corrections, comments and additions to the obtained measurement results, they are loaded to the server in a suitable format (Фирсов, 2007).

In a table 1 below, the calibration results in a relation to Trimble GPS 5800 (TSC 3) receiver of C-NAV-2050 GPS system carried out by us during the geological-geophysical works on the 'Sangachal sea – Duvanni sea' field (2016) in the Caspian Sea and data regarding the estimation of their accuracy is given. The measurement results of noise which impacts the accuracy of CVS-118 fathometer and its diagnostic graph is given in figure 3 below.

Calibration of C-NAV2050 system and estimation of its accuracy

Table 1

C-NAV 2050 DGPS								
Name	Tarix	X	Y	H	Nos. of satellites	PDOP	HDOP	VDOP
Geophysic 1	03.05.16	849,476	097,355	-40,00	15	1,3	0,7	1,1
Geophysic3	04.05.16	890,052	105,799	-39,41	16	1,3	0,7	1,1
Trimble GPS 5800 (TSC 3)								
Name		Northeren latitude		Eastern longotide		H		
Geophysic 1		40° 21' 28,56345"		49° 56' 30,44430"		-39,85		
Geophysic 2		40° 21' 27,28908"		49° 56' 30,11465"		-39,94		
DGPS C-NAV 2050								
Name		Northeren latitude		Eastern longitude		H		
Geophysic 1		40° 21' 28,56401"		49° 56' 30,48440"		-40,21		
Geophysic 2		40° 21' 27,43310"		49° 56' 30,11346"		-40,11		
Mean square error (MSE)								
Northeren latitude		Eastern longitude		Δh				
"		"		m				
-0,00056		-0,04010		0,360				
-0,14402		0,00120		0,170				
Δx²		Δy²		Δh²				
0,000000		0,001608		0,1296				
0,020742		0,000001		0,0289				
Σ Δx²		Σ Δy²		Σ Δh²				
0,020742		0,001609		0,158500				

$$m_{xy} = \pm \sqrt{\frac{\Sigma \Delta x^2 + \Sigma \Delta y^2}{n}} = \pm \sqrt{\frac{0,020742 + 0,001609}{4}} = 0,075 \text{ metr}$$

$$m_h = \pm \sqrt{\frac{\Sigma \Delta h^2}{n}} = \pm \sqrt{\frac{0,158500}{4}} = 0,20 \text{ metr}$$

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Tsunami risk assessment in the Caspian Sea

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Keywords: Tsunami, earthquakes, geotectonics, numerical model, tsunami risk assessment

Introduction

Severe consequences of ecological disasters of recent years demonstrated the necessity of raising standards for construction of sea oil and gas producing facilities, nuclear power generating plants and other elements of the coastal zone industrial infrastructure. It would be enough to mention disasters like the one of the Deepwater Horizon oil rig in the Gulf of Mexico in 2010 and tsunami caused reactor disaster at the Fukushima nuclear plant in 2011. The Caspian Sea is the region of intense industrial use including oil extraction, fishing and transportation. Taking into consideration high density of population in the shore zone as well as sensitivity of biota of the Caspian region it seems very important to reconsider current risk assessments for natural disasters bearing in mind the lessons of recent events.

According to the archived historic records of anomalous sea level deviations were repeatedly observed in the Caspian Sea. It is assumed that they were related to the submarine earthquakes. For example, on July 8, 1895 extremely powerful Krasnovodsk earthquake (M=8.2) caused the shore flooding at the Uzun Ada peninsular.

Modern methods of tsunami risk assessment include two main approaches, namely the 'deterministic' and 'probabilistic'. Deterministic method is based on numeric modeling of tsunami events of seismic origin in order to determine 'the worst' scenario which could result in extremely dangerous consequences. Probabilistic method allows to study relative contribution of large and small events to the general assessment of tsunami risk. It also allows to determine the probability of occurrence of a given magnitude event at a given time period.

Basing on the experience of Shirshov Institute of Oceanology (kulikov et al., 2014) it is planned to perform tsunami risk assessment for the Caspian Sea shore zone using both deterministic and probabilistic methods. This combined approach to assessment will allow us to better determine the level of tsunami risk.

It is assumed that this study will result in obtaining the objective assessment of tsunami risk in the Caspian Sea region which can be used in the planning of industrial infrastructure construction in the coastal zone, laying pipelines and oil and gas extraction rigs construction.

This paper presents new results of tsunami risk assessment based on deterministic method.

Materials and methods

The Caspian Sea region and its environment belong to seismically active zones. Knowledge about the strong near coastal earthquakes in the Caucasian region ($M \geq 5.6$) has been known since the VII century and from the end of XIX century for the Turkmen coast (New Catalogue, 1977).

According to the available instrumental data, the earthquake sources of the Central Caspian occur at depths ranging from 0 to 80 km (New Catalogue, 1977). The most numerous earthquakes occur at the depths of 10–15 km, and some increase in the number of tremors takes place at depths of 30–35 km. Ulomov (2003) gives average calculated periods of the earthquakes for the Caspian Sea (Table 1).

Magnitude	Average recurrence period T in years	
	Whole region	Caspian Sea
6.0 ± 0.2	2.6	24 (~15)
6.5 ± 0.2	7.8	68 (~30)
7.0 ± 0.2	24 (~15)	195
7.5 ± 0.2	72 (~55)	560
8.0 ± 0.2	216 (~330)	1620
8.5 ± 0.2	655	-

Table 1. Average recurrence periods of the earthquakes of different amplitudes in the Caspian Sea and the surrounding regions calculated using recurrence diagrams in (Ulomov, 2001). In parentheses are the observed values of the average recurrence period for the magnitude ranges where the observational data markedly deviate from the linear dependence $\log N = 4.135 - 0.918 M_s$.

It is natural to relate the Caspian Sea areas and coastal regions, where the level of seismic activity is the highest, to the potential tsunami generation areas. According to the earthquake data for the period of 1931–1982 taken from the work of Panahi and Kasparov (2008), there was carried out the zoning of the Caspian Sea based on the level of seismic activity. Seven local zones of high seismic activity have been found in the Caspian Sea (see (Solov'eva et al., 2004)); they are given in Fig. 1. The largest of them S6 (the seaward edge of the area) coincides with the extreme eastern section of the Terek–Caspian deep fault and is characterized by a high recurrence of strong earthquakes. A smaller zone is located within the Apsheron Threshold on the underwater part of the said fault (S5). A high recurrence of strong earthquakes is characteristic for the whole area of the threshold. It is here, in the vicinity of this area of high seismicity, the epicenters of the two most powerful undersea earthquakes occurring on March 6, 1986, and September 16, 1989, were located. In the western part of the Caspian Sea, it is possible to distinguish four zones of high seismic activity, two of which (S1 and S2) are located near the western edge of the Scythian–Turan platform, while the other two zones (S3 and S4) occupy the sea area north of the Apsheron Peninsula (Fig. 1).

The numerical simulation of the tsunami dynamics has become a standard technique in the study of tsunamis and assessment of tsunami risks for certain parts of coast. Modern numerical methods in hydrodynamics constitute a powerful computer technology, which has proven its ability to create accurate models of historical tsunamis provided they are able to assimilate the field observations and instrumental data. The simulation of a possible tsunami with a source located in the Caspian Sea was performed on the basis of a numerical model with an explicit difference scheme.

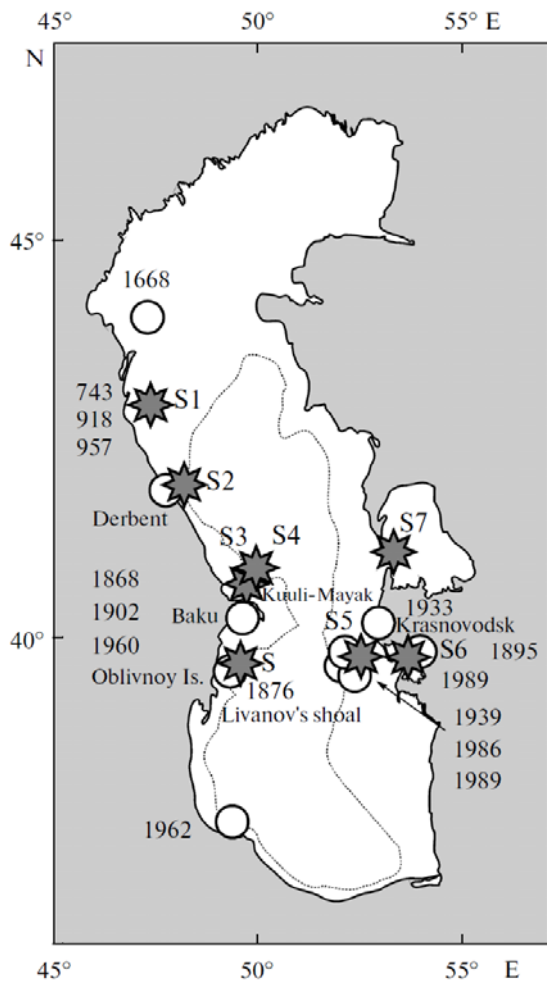


Fig. 1. Caspian Sea regions where historical tsunamis or abnormal variations of the sea (open circles) have been observed and zones of higher seismic activity of the Caspian Sea (S1 to S7) according to (Panakhi, Kasparov, 1988) (asterisks); (S) is the South Apsheron zone of high seismic activity. The numbers in the figure indicate the years of relevant events

Results

The analysis of the observational data and the numerical simulation results show that the Caspian Sea belongs to the areas of moderate tsunami hazard. The most likely area of wave generation threatening the CIS settlements is the Apsheron region with the highest level of seismicity. According to the sketchy historical evidence, waves up to 2 m high were observed on the Caspian coast. Unfortunately, the incompleteness of the data prevents us from performing an adequate statistical analysis and assessing the probabilistic characteristics of the tsunami manifestation on the coast. Given the nature of the seismicity and numerical simulation results, we infer that a relatively high level of tsunami risk is characteristic for the Caspian coasts. According to our estimates, the maximum wave height can be as high as 10 m at some sites of the coast, while 3 m high tsunami waves may occur in the Caspian Sea with a recurrence of about 200 years. It should be noted that possible sources located in the southern part of the Caspian Sea and directly threatening the coast of Iran were not considered in our

The numerical calculations performed in this study were used to calculate the tsunami height values at several coastal sites. These heights represent the absolute maxima of all the possible maximum values of the wave heights calculated for different sources. Use was made of 20 testing sources located in the zone of the maximum seismicity (the Apsheron Threshold).

study. In turn, the northern part of the Caspian Sea is well protected by a vast shallow water area preventing the propagation of long waves of the tsunami type. We restrained ourselves from calculating the heights in this zone. Thus, these results relate to the tsunami hazard for the central part of the Caspian coast: Russia, Azerbaijan, Kazakhstan, and Turkmenistan.

Discussion

The foregoing conclusions concerning the tsunami hazard are based on the numerical modeling performed for grids with a resolution of 30 arc seconds. It's provide only a qualitative estimate of the distribution of tsunami heights along the coast. Calculations are based on a linear hydrodynamic model of the tsunami propagation, which cannot adequately describe the processes of wave propagation in specific shallow water regions and its runup onto the shore. In fact, the above calculated values of the tsunami wave height refer only to the 5 m isobath. Thus, the simulation results can be considered as a rough estimate of the level of the tsunami hazard. Obviously, more accurate local tsunami zoning must be performed using nonlinear hydrodynamic models based on detailed information about the bottom relief of the coastal areas with due account of the bottom roughness parameters, the possible wave breaking, etc.

Acknowledgements

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THEME VII

The Application Of Remote Sensing
And GIS On Investigation Of Modern
Climatic Trends

Creation of thematic layers of different satellite data of the Shabran-Siyazan region based on GIS technology

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Keywords: rivers, classification, thematic layers, Straxler and Schreve.

Introduction. Rivers are fed by surface and underground waters. In general, food sources are four types: rain, snow, glaciers and groundwater. The first three are related to surface water.

One of the main factors of feeding rivers is the climate and as the well-known meteorologist A.I.Voikov said - rivers are the product of climate.

The superiority of these and other nutrient sources in river basins depends on local conditions. Sometimes it is impossible to determine which foods are superior to basins. In this case, the concept of mixed feed is used.

The flow of rivers is influenced by climate, as well as other vegetation, soil, relief and anthropogenic factors. Depending on the geological structure of river basins, the role of groundwater in feeding can be determined. Feeding with rain is mainly due to mostly rainfall and long-term rains. Heavy rains continue in the short term, this time increasing the level of rivers and rain, then gradually declines sharply. Long-term rainfall is largely a large area and river is fed by precipitation for a long time. The rivers of the equatorial and climatic zone, the Lankaran natural region are mainly fed by rainwater.

Snow accumulated during the winter, begins to melt in the spring and feeds rivers for alloys. Snow water depends on snow melting water and the it depends on the weather conditions in the period. More than 50% of the flow of flat rivers in Eastern Europe is snow. Nutrition with glacial water characteristic of rivers of high mountainous regions. In the rivers that feed on glacial waters, during the summer, water wealth rises (Amu-Darya, Syr-Darya). After snowfall and precipitation part of the water flows into the soil layer and increases the supply of groundwater. Then, over the years, it regularly feeds river. The role of groundwater in the feeding of rivers from north to north is increasing. In constantly frozen spreaded areas feeding by underground water is very little.

About 30% of an annual drain of Volga are underground waters. Generally, 2-3 sources of a forage are involved in feeding of the rivers. Such mixed feeding is characteristic of the majority of the rivers.

When determining the flow of rivers and determining the distribution of flow during the year, it is important to study their nutritional sources.

In moderate valleys the majority of the rivers eats snow water. In addition to snow waters the share of underground and rain waters increases in the north. From the Dneprin downstream to in the area of the Azov Sea, Lower Volga Region and Northern Kazakhstan, the rivers are almost completely snow-smearred with snow. Underground waters are very deep in these regions, and rain water is mainly used for evaporation. Most rivers with small basins are dry completely in summer. In the desert and forest-desert zones, underground waters are not deeply involved in the feeding of rivers. However in these areas the main source of the rivers is snow water and the most part of their stream coincides with an era of spring.

Mountain rivers is often consumed by snow and glacial water. In the winter months, glacier rivers are fed only in underground waters. It should be noted that the nutritional properties of the mountain rivers vary depending on the altitude.

The feeding of large rivers is complicated by the different physical and geographical conditions of their flows. In these rivers the feed is usually mixed. The basis of the food of the East Asian rivers is the monsoon rains. Monsoon rains fall during the warm season of the year.

Materials and methods. It should be noted that the feeding of rivers passing through frozen areas is unfounded and that the sources of rivers in the region are snow and rain water.

A group of hydrological instruments is used to form a river network on the north-eastern slope of the Greater Caucasus and Lankaran natural areas. The ArcGIS software is used to model water flows using these tools.

Multispectra Landsat -5 2010 and Sentinel-2 2017 were purchased in the Shabran-Siyazan

section of the study area (Fig. 1a, b).

Information on the shape of the Earth's surface can be used in various fields, for example, in the regional planning of agriculture and forestry.

The main purpose of these areas is to understand the principles of water movement on the surface and the effects of changes in the flow in a particular area.

This set of tools consists of several tools, and the processing was performed in the following sequence.

At first, the filling phase begins at the local level. Local level drops (and pixels) are actually minor faults which occur when the data is resolved or altitudes are rounded to the nearest whole number.

Low-level descent at the local level uses the basins to get more water outflows. If the drop is not executed at the local level, drainage can destroy network.

The filling tool is used for descent and descent at the local level with several equivalents, such as The Stream Of Focus , Local Stroke, Water Basins And Filling Areas. When the Z (height) value given by this tool is considered, all of the local level continues until it is filled. As you perform this operation, you may experience lower local landing levels at the boundaries of the filled zones, which will be eliminated at the next stage.

This tool can also be used to remove local upgrades.

One of the following operations is to determine the direction of the flow. It is possible to determine the flow direction from each raster column to obtain the hydrological property of the surface. The direction of the flow is accomplished by means of the tool.

The surface of the instrument recognizes the input as input and the raster allows each cell to show the flow direction.

The direction of the flow is determined by a sharp decrease or the maximum decrease from each cell. The distance is determined by the center of the cells.

Another tool used is the flow collection. The flow calculator calculates the flow rate as the total weight of all cells entering the raster's descent. Concentrated areas of haulage streams with high flow. ; they can be used to determine the flow of water flows.

After using the aforementioned tools, they use consistently water flow sequences and water flows in the space object.

Water flow sequence tool is the method of mastering the sequence in the network. This consistency is a method based on the classification of the number of goals in the stream. The water flow sequence tool works in two ways: Straxler (1957) and Schreve (1966). In both of these two methods, sequence "1" is taken in the upstream or outward flow.

The algorithm used by the water flow instrument in the space object is a vectorization program and the flow direction is specifically intended for vectorization of the known linear networks or water flow networks. The tool has been optimized for intersection and use of routing raster in vectorization of neighboring cells. All the aforementioned instruments have been taken consistently in taking the images depicted in Figures 2 c and d.

Finally, a basin tool is created to reflect the contours of all drainage basins. Figure 2 e and f show all the basins of the Shabran-Siyazan region for different years and the area of research chosen on it.

The drainage basin and the river water collector are different. The river water collector (or drainage basin) is a dry surface and a layer of subsoil where river is fed. Because the river is fed both underground and surface water, underground and surface water collectors are separated and their borders may not coincide.

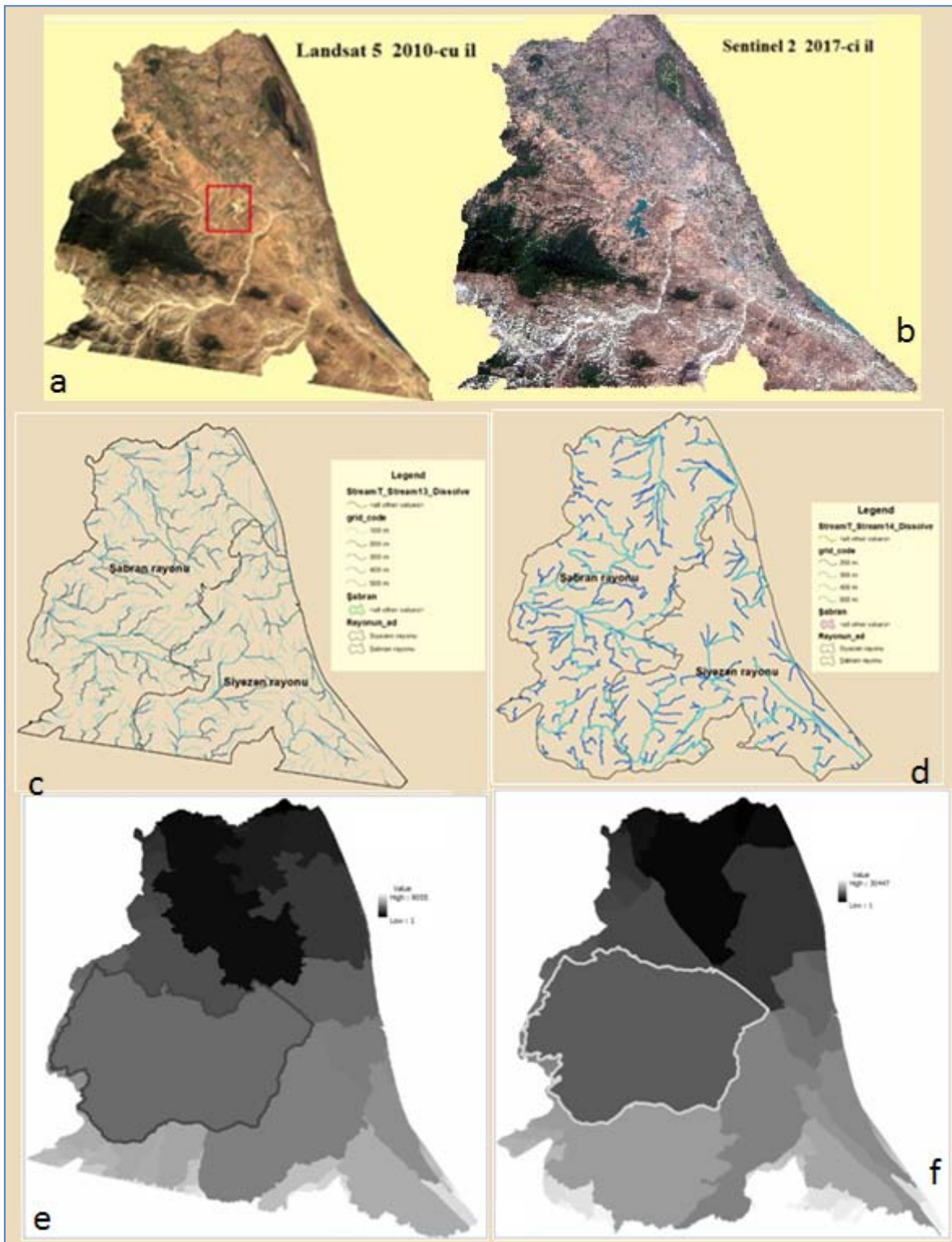


Figure 1 - Multispectral images Landsat -5 2010 (a) and Sentinel-2 2017 (b) Shabran-Siyazan region, water flow (river network) (c, d) and basins of this region (e, f)

After the classification of natural factors and the above-mentioned anthropogenic factors at the beginning of the study, we must classify the multispectral descriptions of the Shabran-Siyazan region of the northeastern slope of the Greater Caucasus. The classification is performed in ArcMap by an uncontrolled classification method. Received results are shown in Figure 2 *a* and *b*.

The purpose of the classification is to incorporate all the cells into the appropriate class or chapter in the studied area. This classification was conducted with 10 classes. In addition, a descriptive river network is depicted in each image. The intensity of the river network is observed when the

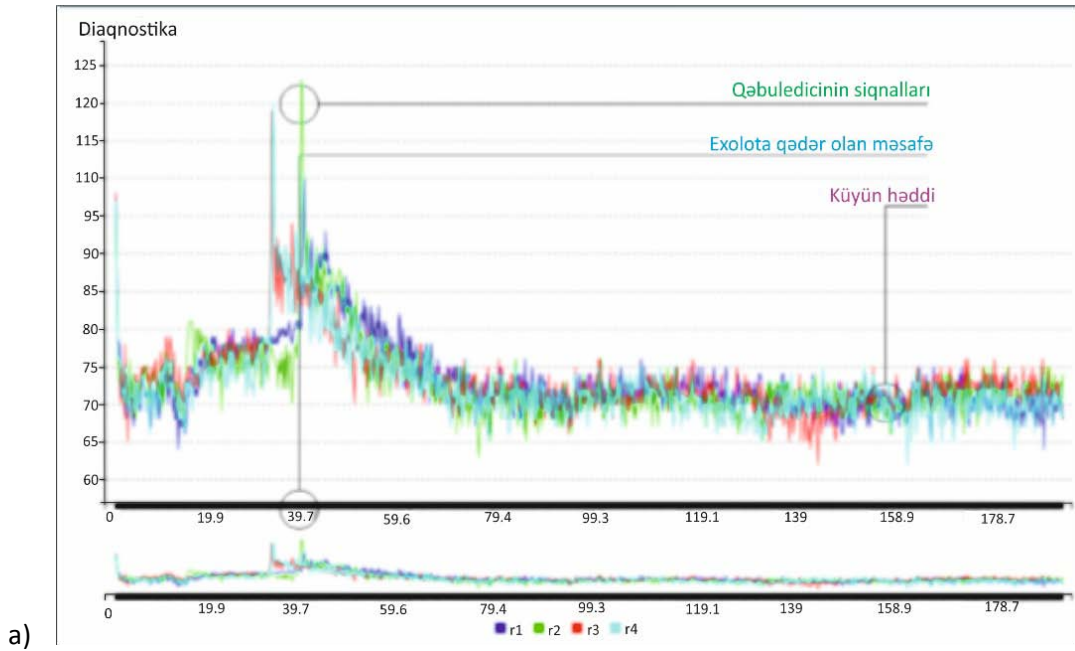


Figure3. C-NAV 2050 Graph of diagnostics of receivers bathymetry and noise(all measurements are given in mm).

As seen from table 1, even though there is 1 (one) difference in the number of satellites receiving the signals in both ships, the results of position (PDOP), horizontal (HDOP) and vertical (VDOP) quality indicators are identical. The calibration results of C-NAV 2050 GPS receivers are within the above mentioned tolerances (SP 11-111,-2004). If the minor deviations identified in the observation interval/range during the diagnostics of bathymetry and noise are not considered then, we can express that the results have sufficient quality and meet the accuracy requirements set for geophysical investigations (SOCAR, 2012).

Results and proposals

The following results and proposals can be made based on investigations and analyzes carried out:

1. One of the important components of complex scientific-research and industrial works at sea (offshore) is their geodetic provision.
2. The measurement tools and methods for geodetic provision requires specific approach in each individual case and are chosen considering the specific characteristics of works.
3. Even though the modern methods and procedures of offshore geodetic provision have some obvious advantages compared to the classic methods and technologies in terms of accuracy and automatization, there exists some theoretical-methodological and normative problems in their industrial application. Resolving these problems is one of the important questions that modern sea (offshore) geodesy faces.
4. It is proposed to install the dynamic positioning equipment in scientific-research ships operating in the Caspian Sea. This equipment creates opportunity to accurate and sustainable maneuvering of ship at a any given point of object or on profile lines.

classification in these drawings is compared to the hydrological river network where the forest area is dense.

Areas of all images of which are described above and shown in Figure 2 (c, d) in the form of layers called ArcSene basins. After we did the most recent operations in the ArcMap program, these results were called ArcSene and a clear distance between the layers was obtained and each layer was vibrated.

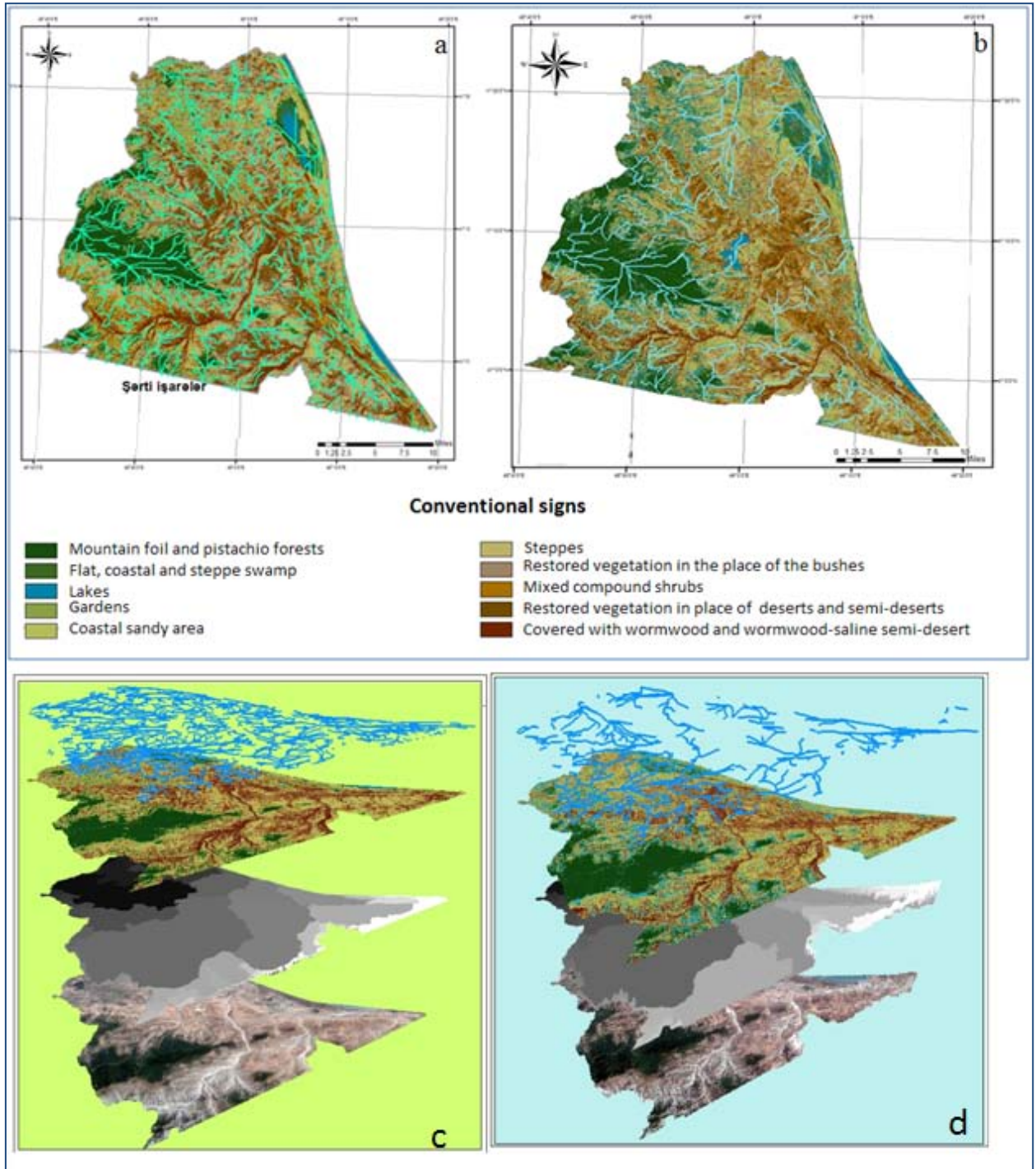


Figure 2 - Landsat -5 2010 (a) and Sentinel-2 2017 (b) classification of multispectral and thematic layers of the Shabran-Siyazan region on ArcSene for 2010 (c) and 2017 (d)

Results. The result of the study was Landsat-5 2010 and Sentinel-2 2017 multispectral images of the Shabran-Siyazan region reflecting the flow of water (river network) and the classification of multispectral and obtaining thematic layers

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Modelling of Oil Spills and Coastal Pollution Probability and Validation using Multi-Temporal Remote Sensing Data

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Keywords: SAR, ENVISAT, Oil Rocks

Introduction

This research focused on the following objectives: (1) using satellite data to characterize the spatiotemporal distribution of anthropogenic oil spills from Oil Rocks Settlement, Chilov and Pirallahi Islands (2) stochastic modelling of the oil spill risk pose to water quality and shoreline ecosystems, and (3) validating model predictions using satellite images. 165 satellite images acquired between 1996 and 2015 were used for the detection of oil spills using object-based classification and visual interpretation. Anthropogenic hotspots were observed at Oil Rocks Settlement, Chilov and Pirallhi Islands, three oldest oil production sites with estimated oil spilling up to 1264 m³ per day. They had different degrees of temporal repetition of oil spills. The largest area (5639 km²) experienced 1-10 detected oil spills, while 993 km² experienced 11-20 oil spills, 775 km² experienced 21-50 oil spills, 208 km² experienced 51-100 oil spills, and 36 km² experienced 101-150 oil spills. The majority (83% or 6157 km²) of sea surface area within the combined boundary of detected oil spills (7422 km²) had a 50% or greater chance of oil spill contamination, indicating good agreement between predictions and data. Additionally, exponential regression analysis revealed positive correlation between pixel values for contamination probability and calculated oil spill frequency. Approximately 6% (44 km of 751 km) of Azerbaijan's shoreline had a 50% or greater probability of contamination from oil spills over the period of 2006 -2009 with land use classes sensitive to pollution. This research demonstrates how remote sensing data can be used to identify oil pollution hotspots quantitatively assess the risk to shoreline areas with high environmental value.

Materials and methods

This research used both passive optical and active microwave satellite images to detect oil spills and natural seepage slicks. The use of both types of satellite data for this purpose is well-established (Bentz *et al.* 2005; Zhao *et al.* 2014). The principle of oil spill detection is based on the decreasing radar backscattering level with slick and appears as a dark patch with lower backscatter from the sea surface (Girard-Ardhuin *et al.* 2003). 165 satellite images were acquired in accordance to the suitable wind speed on the day of imagery acquisition and visual inspection of image content for detection of oil spills and natural seepage slicks. The semi-

automatic detection of oil spills and seepage slicks, visual discrimination of oil slicks from look-alikes, computation of oil spill frequencies, approximation of leak sources and contamination probability modelling were used for this research.

The risk of pollution and shoreline contamination from oil spills was modelled using deterministic and stochastic modelling of oil releases from platforms, rigs, vessels, wells, pipelines and other infrastructure and predict consequences for the water surface, water column, shoreline and coastal habitats (Ranjbar *et al.* 2014). Stochastic modelling was used to provide insight about the overall oil contamination probability under a wide range of weather conditions extrapolated from the multi-year data set of Caspian Sea winds and currents. The overall oil contamination probability covered the period of 2006-2009, because the hydrodynamic data of winds and currents were only available for this period. Model predictions were validated by comparing them to oil spills detected from multi-year 1996-2015 satellite images using spatial overlay and regression analysis. Potential environmental consequences to the shoreline were assessed quantitatively using shoreline contamination probability. Shoreline contamination probability is the predicted likelihood that a particular segment of shoreline will be contaminated under different oil spill modelling scenarios.

Results

Computations of the temporal repetition or reoccurrence frequency of man-made oil spills and approximated leak sources are presented in Figure 1a. Areas around Oil Rocks Settlement, Pirallahi and Chilov Islands had different degrees of temporal repetition of oil spills (Figure 1a). The largest area (5639 km²) experienced 1-10 detected oil spills, while 993 km² experienced 11-20 oil spills, 775 km² experienced 21-50 oil spills, 208 km² experienced 51-100 oil spills, and 36 km² experienced 101-150 oil spills (Figure 1a). The approximated location of leak sources based on the computed temporal repetition of detected oil spills are presented in Figure 1a and it is possible to observe that the highest frequency of leak sources is located at Oil Rocks Settlement.

The majority (83% or 6157 km²) of sea surface area within the combined boundary of detected oil spills (7422 km²) had a 50% or greater chance of oil spill contamination (Figure 1b), indicating good agreement between predictions and data. Additionally, exponential regression analysis revealed positive correlation between pixel values for contamination probability and calculated oil spill frequency with $R^2 = 0.34$ (Figure 1b).

The threat that oil spills pose to Azerbaijan's shoreline was assessed using the predicted probability of shoreline contamination (Figure 1c). Shoreline contamination probability is a prediction of the likelihood that a given segment of shoreline will be contaminated under different oil spill modelling scenarios. Shoreline contamination probability was predicted for the period of 2006-2009 since it is based on the stochastic oil spill modelling results. Approximately 6% (44 km of 751 km) of Azerbaijan's shoreline had a 50% or greater probability of contamination from oil spills over 2006-2009 period. The most threatened sections of shoreline were located on the northern part of Absheron Peninsula.

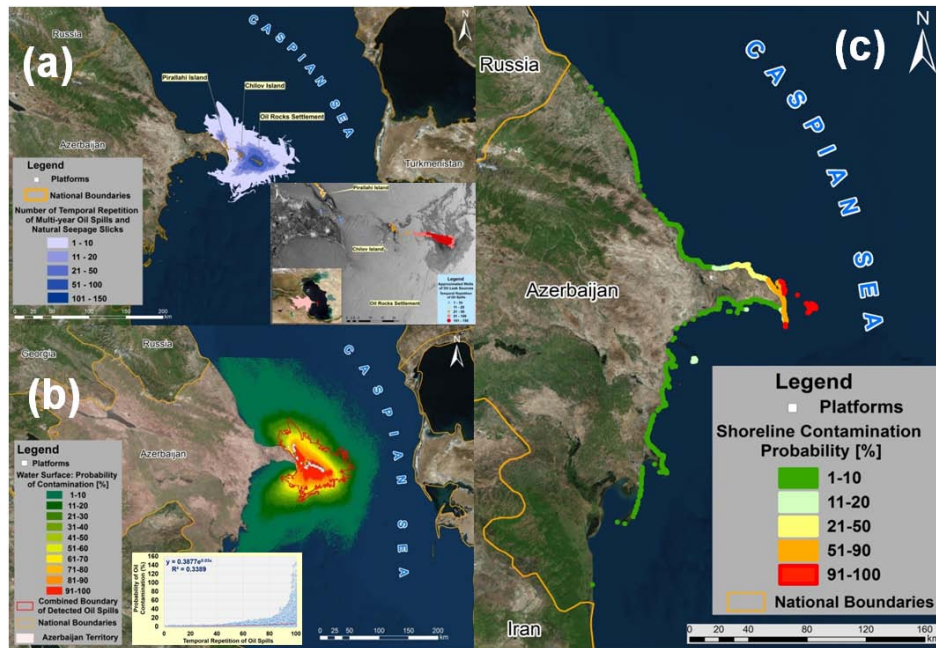


Fig. 1 (a) Temporal Repetition (Frequency of Reoccurrence) of Oil Spills and of Oil Leak Sources Associated with Wells of Oil Rocks Settlement, Pirallahi and Chilov Islands; (b) Water Surface Contamination Probability (c) Shoreline Contamination Probability

Discussion

1. The spatial and temporal occurrence of oil spills and natural seepage slicks in the Azerbaijani portion of the Caspian Sea was assessed using 411 SAR and optical satellite images from 1996-2015. The anthropogenic oil spills with the largest spatial extent and most frequent occurrence were located around Oil Rocks Settlement, Pirallahi and Chilov Islands, while natural seepage slicks were most prevalent in the southern part of the Caspian Sea. The biggest hotspot of oil spills and leak sources were observed at Oil Rocks Settlement with computed temporal repetition of oil spills equal to 51-100 (208 km²), 101-150 (36 km²) and oil leak frequencies of wells equal to 51-100 (39), 101-150 (127). The average daily oil spill rate at the Oil Rocks Settlement, Pirallahi and Chilov Islands was estimated to be 1264 m³.

2. A triangular area (7566 km²) characterized by high risk of oil contamination was identified immediately offshore of the Absheron Peninsula, where the Azerbaijani capital, Baku, is located. The size, shape and location of this area result from the interaction of natural and anthropogenic factors, including wind and current speed and direction, bathymetry, and primary leak sources on the sea floor. Eighty-three percent (6157 of 7422 km²) of the entire study area had a 50% or greater chance of contamination over 2006-2009 period. Pixel values for the modelled risk of contamination were positively correlated with the observed frequency of oil spills during the study period, supporting the reliability of the modelling approach.

3. Approximately 6% (44 km of 751 km) of Azerbaijan's shoreline had a 50% or greater probability of contamination from oil spills over 2006-2009 period with land use classes sensitive to pollution. The most threatened sections of shoreline were located on the northern part of Absheron Peninsula.

Acknowledgements

We would like to acknowledge European space agency (ESA) for the provision of access to ENVISAT images under the project ID: 15837.

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Satellite Observations of Oil Spill and Approximation of Leak Sources from Old Petroleum and Gas Infrastructure in the Caspian Sea

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Keywords: SAR, ENVISAT, Oil Rocks

Introduction

The Oil Rocks Settlement, Chilov and Pirallahi Islands in the Caspian Sea were selected as the study areas because of their long-term oil exploration history. The main goal of this research was to study oil pollution, determine oil spill frequencies and approximate oil leak sources around the Oil Rocks Settlement, the Chilov and Pirallahi Islands in the Caspian Sea using 136 time-series ENVISAT radar images acquired during 2006-2010. The detailed research goals are following: (1) Detection of oil spills around the Oil Rocks Settlement, Chilov and Pirallahi Islands in the Caspian Sea using 136 multi-temporal ENVISAT SAR images acquired for the period of 2006-2010; (2) Computation of oil spill frequencies based on detected oil spills from 136 multi-temporal ENVISAT SAR images for the determination of spatiotemporal distribution trends of oil spills and hot spots with persistence and temporal repetition of regular oil pollution in marine environment; (3) Approximation of probable oil leak sources at the Oil Rocks Settlement and around Chilov and Pirallahi Islands based on the frequencies of detected oil pollution; (4) Determination of spatial relationships among areas of detected oil spills and wind speeds in the Caspian Sea.

Materials and methods

ENVISAT ASAR Wide Swath Medium Resolution radar satellite images were used for the purpose of oil slick detection, computation of oil spill frequencies and approximation of oil leak sources using 136 multi-temporal ENVISAT SAR images acquired during 2006-2010. The VV polarisation mode was used for the present research because of the technical suitability for the oil spill detection. The appearance of oil slicks in SAR imagery depends on the Caspian Sea conditions during the acquisition in particular the wind speeds, currents and also on the oil parameters as spill age and oil type (Akar *et al.* 2011; Espedal *et al.* 1999; Karantzalos *et al.* 2008; Topouzelis K. N. 2008; Ivanov *et al.* 2012). If the wind speed is low, then the surface might be very smooth with low level of the backscatter causing difficulties in the detection of oil spill. In case of high wind speed, advantage is that thick slicks can be detected whereas it can be difficult to detect thin slicks. The workflow used for the semi-automatic oil spill detection, visual discrimination of oil slicks from look-alikes, computation of oil spill frequencies and approximation of leak sources is presented in Figure 1a. The exponential regression analysis was performed between detected oil spill areas from 136 multi-temporal ENVISAT images and wind speeds to understand the role of winds in the spatiotemporal distribution of observed oil pollution during 2006-2010.

Results

The map of oil spill frequencies computed based on the 136 multi-temporal ENVISAT images suitable for oil spill detection during 2006-2010 is presented in Figure 1b. The achieved oil spill frequencies and areas don't obviously cover the whole range of frequencies because these computations are explicitly based on the acquired and selected number of useful 136 multi-temporal ENVISAT images for oil spill detection around Oil Rocks Settlement, Chilov and Pirallahi Islands to make the general persistence and temporal repetition assessment of regular environmental oil pollution. This approach allowed to detect hot spots with high frequencies of oil spills and their spatial distribution (Figure 1b). The detection of oil spills from 136 multi-temporal ENVISAT ASAR Wide Swath Medium Resolution images and geospatial multi-temporal overlay analysis contributed to the increase of the accuracy and reliability of detected oil spills, to computation of oil spill frequencies by criticality level and determination of the hotspots of regular oil spills (Figure 1b). The approximated leak sources based on the count of oil spill frequencies assigned to rationally distributed points at Oil Rocks Settlement and around Chilov and Pirallahi Islands are presented in Figure 1c. It is possible to observe that the most critical classes of oil leaks are located around the Oil Rocks Settlement. The exponential regression analysis between wind speeds and detected oil slick areas from 136 multi-temporal ENVISAT images acquired during 2006-2010 revealed R^2 equal to 63% (Figure 1d). This means that wind speed is one of the key factors controlling spatiotemporal changes of oil slick areas around the Oil Rocks Settlement, Chilov and Pirallahi Islands.

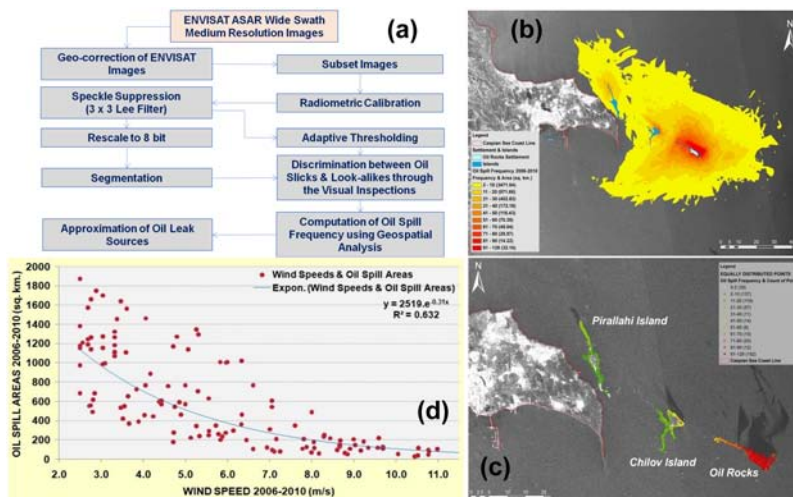


Fig. 1
 (a) Workflow for the Detection of Oil Spills, Computation of Frequencies & Approximation of Oil Leak Sources;
 (b) Map of Oil Spill Frequency around the Oil Rocks, Chilov and Pirallahi Islands in 2006-2010;
 (c) Map of Oil Leak Sources at Oil Rocks, Chilov and Pirallahi Islands based on the Oil Spill Frequency 2006-2010;
 (d) Exponential Regression Analysis between Wind Speeds & Detected Oil Slick Areas from ENVISAT Images Acquired During 2006-2010

Discussion

Oil slicks were mainly detected on 136 multi-temporal ENVISAT Wide Swath Medium Resolution images acquired under the Caspian Sea wind speed range of 2.5 - 12.4 m/s. The following oil spill frequencies computed based on 136 multi-temporal ENVISAT images were observed around the Oil Rocks Settlement, the Chilov and Pirallahi Islands during 2006-2010: 2-10 (3471.04 sq. km.), 11-20 (971.66 sq. km.), 21-50 (692.44 sq. km.), 51-128 (191.38 sq. km.). The persistence and temporal repetition of oil spills prove the continuous environmental pollution around the Oil Rocks Industrial Settlement, Chilov and Pirallahi Islands and provide the hot spots of oil concentration for planning of cleaning activities. The most critical oil leak sources with the frequency range of 41-128 were observed at the Oil Rocks Settlement. The frequency ranges of 0-30 and 11-60 were observed at Pirallahi and Chilov Islands, respectively. The exponential regression analysis between wind speeds and oil slick areas detected from 136 multi-temporal ENVISAT images revealed the regression coefficient equal to 63%. The

regression model showed that larger oil spill areas were observed with decreasing wind speeds.

Acknowledgements

We would like to acknowledge European space agency (ESA) for the provision of access to ENVISAT images under the project ID: 15837.

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Study of the influence of floods of the Kura River on populated and industrial sites with application of modern technologies

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KEY WORDS: fluctuates, space information, satellite, analysis

Introduction The possibility to timely forecast emergencies from remote sensing data and in particular from AZERSKY images is an important precondition for taking precaution measures and effectively planning the work to eliminate consequences of floods.

The processing of satellite imagery data for the purpose of rapid monitoring of large areas is the most relevant and optimal in terms of resources and time.

Materials and methods:

The practical value of this work is the development of methods for monitoring hydrological hazards on space- based technologies that increase the importance of satellite information for flood prevention and risk management programs. The developed technology will allow to monitor hydrological dangerous situations and to use, at the same time, satellite information of medium and high resolution together with ground data. Mapping a potential flooding area can help in future when planning settlement of given region, effectively forecast and take appropriate measures to reduce the consequences of a natural disaster.

The inconstancy of the level, which fluctuates in large amplitudes, is the most characteristic feature of the Kura River and the Caspian Sea. In the past, unexpected changes in transgressions and regressions influenced the fate of entire ethnic group. According to L.N.Gumilev (1980), one of the factors that undermined the power of the ancient Khazar state, was in the 10th century AD flooded a significant part of the pastures in the northern Caspian region.

The Azerbaijani coastal zone is characterized by considerable natural-resource and economic potential, the rational use of which is of vital importance for coastal countries. However, the socio-economic development of the entire Caspian region largely depends on changes in natural conditions, and, first of all, on fluctuations in the level of the Kura and the Caspian Sea. For today, dependence on fluctuations

in the level is the main problematic issue of the Caspian territories. Recently, the interest of international organizations in the problem of fluctuating of the level of the delta of Kura and the Caspian Sea has increased. This is connected in some way with the increased importance of the region and its resources for the leading countries of the world, since Neftchala and Salyan administrative districts are of interest in terms of economic benefits. Therefore, modern methods of solving the problems of flooding are a priority for specialists in this field. Since the region is unstable in natural phenomena, constant monitoring and analysis are required. We can provide more accurate information from space images. In this scientific work, the images from satellite "AZERSKY" were used.

Brief economic-geographical information about Neftchala and Salyan districts

Information on the main economic activities of Neftchala administrative districts

The basis of economic activity of the region is production of oil, gas, black caviar (oil is produced in the amount of 43-45 thousand t per year, gas 22-23 million m³, fish 15-16 t, caviar 1,5-1,6 t); in agriculture cotton growing (7-8 thousand t/year), cultivation of grain crops (80-85 thousand t/year), livestock. Along with this, other agricultural products are produced.

Joint oil gas producing enterprise "Anshad-Petrol" operating in the region, fish factories of Khyilly, Kuragza, and Kura Sturgeon breeding plant are state enterprises. In addition, there are LTD "Neftchala Balyq combine", LTD Neftchala pambiq, LTD Neftchala Yodobrom.

This region is a coastal part of the Kura-Araz lowland with a specialization based on the cultivation of cereals and melons, cotton, as well as fisheries, the oil and chemical industry, and transport infrastructure. The region accounts for about 80% of the total flooding area. Significant changes occurred in the estuary of the Kura, which is approximately 4000 hectares. To the south of the Kura river delta there is a plain with a gulf and a unique Gizilagach reserve. The bay is separated from the sea from the east by the Kura spit, which is flooded and blurred (15-20 cm per year). As a result of erosion, as early as in 1980 a strait was formed, which led to a change in the hydrological regime and the salinity of the bay.

The flooding area on the shores of the bay is 8000 hectares. With an increase in the level in this area, 10 settlements, 23 industrial enterprises will be flooded; the loss of land will amount to qqq800 ha. Dilution of the coastal strip complicated the medical and environmental conditions.

A critical situation has arisen in Azerbaijan- the increase in the water level in the Kura River caused the breakthrough of dams in various regions of the country. According to preliminary information, as a result of continuous torrential rains in recent years and the flood of the Kura River in rural areas, 40 districts- about 20,000 houses and more than 50,000 hectares of sown areas and pastures- appeared in

the flood zone, over 300 houses have collapsed, up to two thousand have come to emergency conditions, numerous infrastructure objects and other social facilities have failed.

In 2010, Kura broke through the first protective dam in the direction of Talish village of Hajigabul in Azerbaijan. As a result of the breakthrough of the dam, about 150 houses in the village Azad in Sabirabad were under water, more than 60 houses collapsed. Victims among the population were avoided due to preliminary evacuation of residents. Streams of water from the destroyed dam rushed towards Lake Hajigabul. The repeated increase in the water level in the Kura River again aggravated the situation in Imishli, Saatli, Shirvan, Salyan and Neftchala regions.

In addition to natural phenomena, flooding is also affected by the anthropogenic factor. Illegal construction of water canals by residents of the region for agricultural purposes is carried out. The construction of illegal canals leads to the destruction of dams of Kura River, which creates real risks of flooding settlements.

The considered regions are of economic interest from the point of view of further development, since it has a natural resource potential for the development of the branches of the chemical, oil industry and agriculture. The emergency flooding situation in the areas of the Kura delta forces specialists such as economists, geographers, emergency workers to solve a number of problems using the latest information on problem-depressive territories, received from space satellites and for processing such technologies as geo-information and space images processing.

Flood monitoring tools can be divided into two groups: contact and remote. Contact facilities include ground observations of a network of hydrological posts, instrumental surveys of flooded areas. Remote facilities include aerial photography, aero-hygrometry and remote sensing of the Earth from space.

However, none of the listed facilities is able to separately provide data reflecting a rapidly changing picture of a river spill. Therefore, given the vastness of river flood plains and the speed of the changing process, an integrated approach based on ground and remote research methods is needed.

An urgent task of the scientific and technical justification and research is the possibility of using high and medium resolution for assessing the risk of flooding in the modeling of river level, as well as the construction of a geo-information system for monitoring floods and prompt notification of relevant organization. The study uses methods and algorithms for processing satellite information with reference to the tasks of flood monitoring using the example of a particular area in the floodplain. The practical value of the work is the development of methods for monitoring hydrological hazards that increase the importance of satellite information for flood prevention and risk management programs.

The developed technology will allow to monitor hydrological dangerous situations and to use at the same time satellite information of medium and high resolution together with ground data.

Mapping a potential flooding area can help in the future when planning the settlement of a given region, effectively forecast and take appropriate measures to reduce the consequences of a natural disaster.

The assessment of the consequences of flooding is, first of all, in indication of consequences of mechanical influence (destroyed bridges, breakthrough of dams, erosion processes and activation of landslides), hydrological (flooding of land, channel changes). The definitions of such consequences can be accompanied by both visual observations, and the application of remote methods-space imagery. It permits significant savings in research resources. Most of the settlements are traditionally located near water bodies. In recent years there has been a tendency to accelerate the development of coastal areas- flood plains and riverine terraces.

The final and important feature of space monitoring is the ability to combine operational information about the state of the terrain (photographic portrait of the terrain) and digital cartographic layers of GIS containing data on urban planning and the design of protective structures.



Fig . 1 Simulation of the risk of flooding from time-varying space information. Black contours of the forecast on the information of 2010 are superimposed on a picture of 2016.

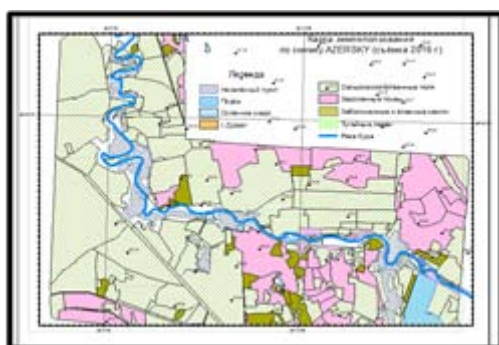


Fig.2 Map

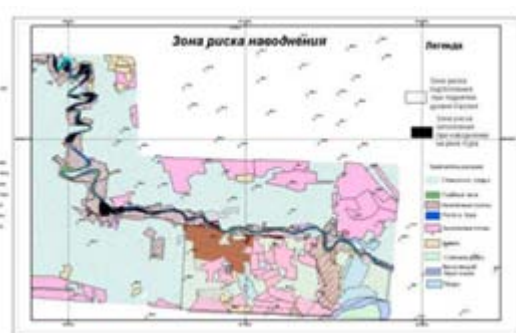


Fig.3 Map of the risk area

Thus, the ability to timely forecast emergences from remote sensing data and in particular from AZERSKY images is an important precondition for taking precautionary measures and effective planning for flood management. The processing of satellite imagery data for the purpose of rapid monitoring of large areas is the most actual and optimal in terms of resources and time.

ESTIMATION OF THE AMOUNT OF SPILLED OIL

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Keywords: oil spill, oil thicknesses ,sea surface, SAR image.

Introduction

Accurately measuring oil-on-water slick thicknesses significantly increase understanding of the dynamics of oil spreading and behavior. Knowledge of slick thickness makes it possible to determine the effectiveness of certain oil spill countermeasures including dispersant application and in situ burning. At present time optical and SAR images obtained by satellites widely used for oil detection. The determination by remote sensing methods of oil thicknesses allow us to estimate the amount of spilled oil. In present work we give a certain method how from SAR images the thicknesses information may be derived. This method is developed using the "Prestige" accident SAR images.

Materials and methods

Oil-water SAR contrast may be defined as the difference of back scattered radiation intensity from an oil-covered sea surface and from a clean sea surface. The intensity of backscattered radiation is proportional to *radar cross section* σ , which can be presented as a sum of components:

$$\sigma = \sigma_{br} + \sigma_{sp} + \sigma_{wb} \quad (1)$$

where, σ_{br} - Bragg scattering, σ_{sp} - specular reflection, σ_{wb} - scattering by waves breaking. The Bragg component σ_{br} is formed due to resonance mechanism of scattering. Let the sea surface radiolocation is performed under the angle θ , by electromagnetic wave with wave vector, \vec{k} (Fig 1A). Then from whole specter of sea wave harmonics only harmonic with wave vector $\vec{k}_{b\perp} = 2\vec{k} \sin \theta$ contributes to back scattering (the resonance scattering) F.G. Bass, and I.M. Fuks (1978):

$$\sigma_{br} \sim S(\vec{k}_{b\perp}) \quad (2)$$

where $S(\vec{k}_{b\perp})$ - sea wave specter, $\vec{k}_{b\perp}$ is the projection of vector $2\vec{k}$ to horizontal plane. Thus the Bragg component σ_{br} is proportional to square of amplitude of sea wave harmonic with wavelength $\Lambda = \frac{2\pi}{k_{b\perp}} = \frac{\lambda}{2 \sin \theta}$, where $\lambda = \frac{2\pi}{k}$ is the wavelength of incident electromagnetic wave. For the angle of illumination-observation $\theta = 53^\circ$ and frequencies of electromagnetic waves, usually applying in SAR, we have following :

f, GHz	19.35	22.2	85.5
λ, cm	1.55	1.35	0.35
Λ, cm	0,97	0.85	0.22

As we see the resonance wavelengths, Λ , of sea wave harmonics fall into capillary and gravitational- capillary part of sea wave spectrum.

The specular reflection σ_{sp} is governed by surface facets which are perpendicular to vector, \vec{k} , and it is proportional to probability density $W(\vec{\gamma})$ of this facet gradients, $\vec{\gamma} = -\frac{\vec{k}_{\perp}}{k_z}$, and Fresnel reflection coefficient $R(\chi)$ at local incident angle $\chi = 0$:

$$\sigma_{sp} \sim R(0)W(\vec{\gamma} = -\frac{\vec{k}_\perp}{k_z}) \quad (3)$$

where, k_z is the vertical component of vector \vec{k} .

The component, σ_{wb} - scattering by waves breaking, is determined phenomenally: it suggested to be proportional to ratio of a foam occupied sea surface area A_f to located area A :

$$\sigma_{wb} \sim \frac{A_f}{A} \quad (4)$$

Because of the SAR radiation incident to the sea surface oblique the backscattered radiance is formed due to resonance mechanism of scattering.

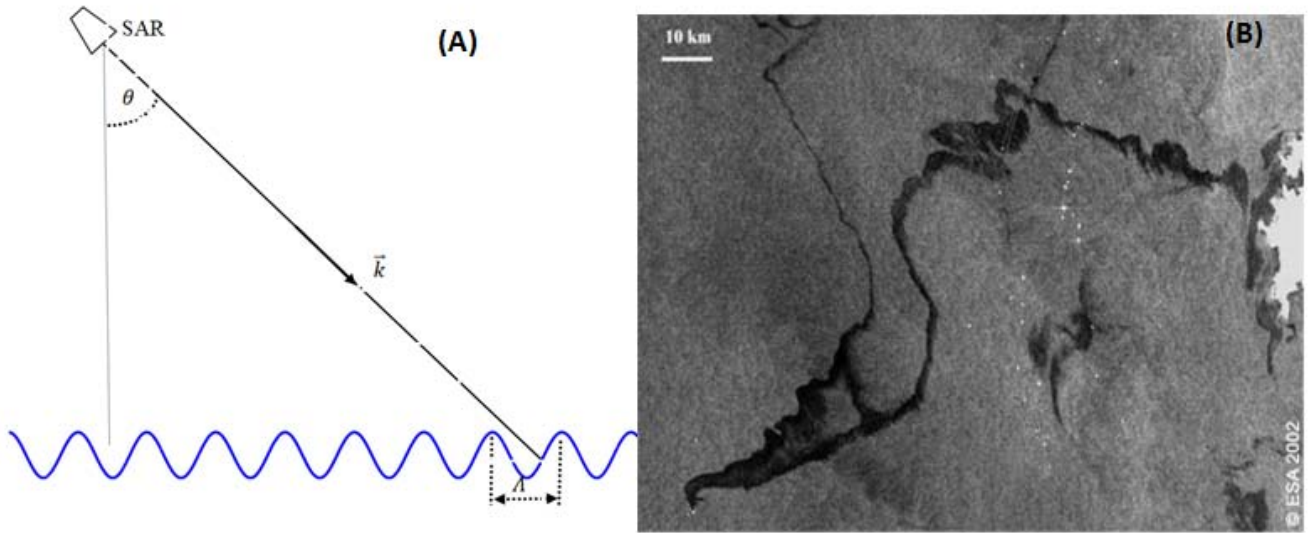


Fig. 1. (A) Geometry of SAR remotely sensed radiance ; (B) satellite image of the same 20 November, 2004 event. This SAR image shows tanker, Prestige, 100 km off the Spanish coast. Photo by European Space Agency.

The ratio between components of radar cross section σ in equation (1) has a complicated behavior and depend on incident angle θ and wind speed v . This fact is a very important for interpretation of SAR images obtained by satellites in wide interval of angles θ . In interval of angles $0^\circ \leq \theta < 25^\circ$ main contribution to radar cross section σ , gives the component σ_{sp} - specular reflection; in interval $25^\circ \leq \theta \leq 35^\circ$ prevalence σ_{br} - Bragg scattering; at $\theta > 35^\circ$ the component σ_{wb} - scattering by waves breaking is a important. The differences in contribution to cross section σ of components are governed by nature of waved surface. The appearance of internal waves effects mainly to characteristics of wave breaking. The presence of oil films on the waved sea surface damps only ripples, whereas the long waves and characteristics of wave breaking are not changed.

Results

The closely inspection of SAR images of “Prestige” accident show that the thick oil spelled the darker. Consequently, we can conclude that the backscattered radiation intensity decrease when oil thickness increase for some observation conditions and oil spilled cases. This dependence we assume to be linearly. To derive this dependence, we use image of Prestige accident (Fig. 1B). As we see from Fig 1B the coastal area of land which has highest brightness may be used as a reference point.

Let the volume of the oil spilled on the sea surface at the time $t = 0$ is V_0 . Let also at the time t the area of the occupied by oil is $S = S(t)$ and average thicknesses is $\bar{l} = \bar{l}(t)$. If the volume of spilled oil is $V(t)$ then the following relationship takes place,

$$\bar{l}(t) = \frac{V(t)}{S(t)} \quad (5)$$

the dependence of volume V on time t appears due to effects of evaporation and dispersion.

As we can see from equation (5) the average thicknesses \bar{l} can be determined from known spilled oil volume $V(t)$ and area $S(t)$. The area $S(t)$ can be derived from plane or satellite images of region including oil spilled. We develop the FORTRAN program for determination oil spilled area S , from images. This program based on the distinction of oil spilled and pure sea surface brightness's.

The thicknesses l of oil in the oil spilled area is not constant, it changes from point to point. Accordingly the brightness's of oil at the image are changed from pixel to pixel. In the first approximation it is reasonable to assume that the more thicknesses l the more damping of ripples, consequently, is small the backscattering signal (in other words the brightness of corresponding pixel). So, we can put

$$B = B_0 - ql \quad (6)$$

where B_0 is a brightness of a clear part of sea. The coefficient k must be determined as :

$$q = \frac{B_0 S}{2V} \quad (7)$$

from (6) and (7) we obtain,

$$B = B_0 \left(1 - \frac{S}{2V} l\right) \quad (8)$$

The inverse dependence are also linear and given by:

$$l = l_{max} \left(1 - \frac{B}{B_0}\right) \quad (9)$$

Where the maximum thickness l_{max} and average thickness, \bar{l} , under the assumption that the oil surface is a linear function, are connected by relationships.

$$l_{max} = 2\bar{l} \text{ and } l_{max} = \frac{2V}{S} \quad (10)$$

A satellite image of "Prestige" tanker accident at 20 November 2004 is used for case study (Fig 2.). The image in Fig 2 has been taken after four days of accident and the quantity of spilled oil was approximately 12000 tons.

In this image zero brightness (relatively) $B = 0$ has the oil films with maximal thickness, l_{max} and the brightness approximately ≥ 55 has pure water. Thus the calculated oil covered area was $822.4km^2$, which is 6.42% of total image area $12810km^2$, and the mean thickness, was $\bar{l} = 0.0147mm$.

Assuming that the equation (6) takes place, we find for $l_m = 0.0294mm$ and the following five gradation of thickness which corresponds to five gradation of brightness. This gradation on the image "Prestige" is shown in a Table 1.

Brightness (B)	Thickness l (mm)	Area of oil (%)	Area of oil (km^2)	Volume (km^3)	Mass (ton)
$44 < B < 55$	$0 < l < 0.0058$	0.5419	64.58	0.000204	202
$33 < B < 44$	$0.0058 < l < 0.0118$	1.1780	150.9	0.001329	1320
$22 < B < 33$	$0.0118 < l < 0.0176$	1.3220	169.3	0.002488	2470
$11 < B < 22$	$0.0176 < l < 0.0234$	1.2500	160.1	0.003292	3269
$0 < B < 11$	$0.0234 < l < 0.0294$	1.6910	216.6	0.005726	5685

Table 1. The values of oil characteristics for different oil thicknesses.

For each thickness gradation corresponding processed images are shown in Fig 2.

The calculated total mass is 12946 tons. This quantity is different from real spilled oil mass about 10 %. The small divergence verifies the assumption of linearity (5) at sufficient level for practical application.

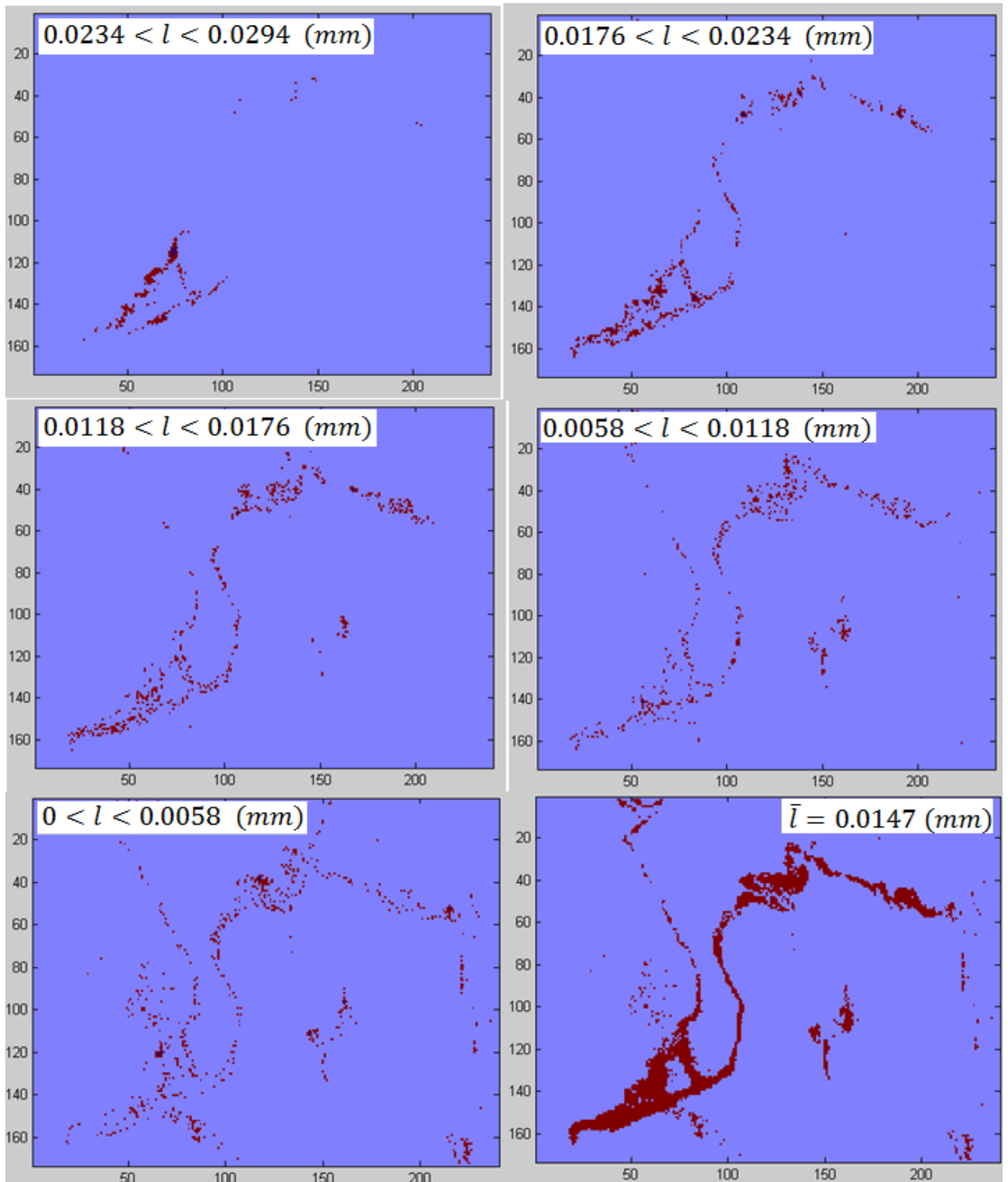


Fig. 2. The oil spilled area with thickness from different intervals and overall area with average thicknesses $\bar{l} = 0.0147$ (mm) .

Having the time series of oil spilled images obtained from satellites or airplanes and using above described method the parameters required for monitoring of oil spilled may be defined. Classification of the set of oil spilled images, obtained in different meteorological and illumination- observation conditions on

relationship between brightness of oil and its thicknesses will be useful for improving the methods of monitoring. As we see the assumption of linearity (5) gives good results for considered "Prestige" image. Probably, for each class of images own relationship (in polynomial, exponential or other form) can be identified. Then the offered method with data base of classified images may be used for leaning new oil spelled cases.

Acknowledgements

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Assessment of the snow resources on the southern slope of the Greater Caucasus belonging to the Kish River basin in 2003-2015

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Keywords: climate change, accumulated snow resources, snow measurement routes, Greater Caucasus, Kish river basin.

Changes in climate and global warming are actual subject in the 21st century. As an example of effects of global warming on Azerbaijan can be illustrated by Caspian Sea level rising, melting of glaciers, overflowing rivers, destructive effects of floods, unusual temperature anomalies, increasing temperatures in the hottest month.

Research on the topic climate change vulnerability analysis indicate a decrease in water resources in the major rivers of the country. In particular, decrease is observed in winter precipitation and snow water resources, as well as in spring precipitation. This also led to a decrease in both surface and ground water. According to the analyses after the First and Second National data Communication to the United Nations Framework Convention on Climate Change decreases in river water resources continued.

Obviously increasing of heat resources and extending the number of days with high temperature causes melting of all glaciers in Azerbaijan. Glaciers of the Tufan mountain (the second highest peak of Azerbaijan) and the snow cover around the Tufan lake (the highest mountain lake in the country) significantly reduced, almost completely melted in the last 40 years. Azerbaijan is a country where water resources are less and unequally distributed where agriculture can grow mainly under irrigation. Thus, water resources formed during spring-summer period are gathering in water reservoirs located on different rivers of our country and are used during intensive vegetation period. The snow accumulation in the basins continues from the beginning of November to the end of March and intensively melts due to sharp temperature rise during spring. Therefore, the study of accumulated snow resources in the basin during the winter and the calculation of gathered water resources in the snow are of great importance in calculating the flow in high water period.

The Greater Caucasus Range enters the territory of Azerbaijan at the western Tinov Rosso peak (3374 m), located on the border with the Republic of Georgia. Only the southern slope(northern slope is located in Dagestan MR) of the range belongs to Azerbaijan which located between the peaks of Tinov-Rosso and Bazarduzu(4466 m), but both slopes of the south-eastern part of the range belongs to the territory of the Republic.

The southern slope of the main Caucasian range descends to Alazan-Ayrichay lowland (in some literature Alazan-Haftaran valley), which extends in parallel to many places (in some literature Alazan-Ayrichay is part of the Kura lowland). Length of this lowland in the territory of the Republic of Azerbaijan which begins from territory of the Republic of Georgia is 210 km and 30 km width.

The present climate of the area is generated under different influenced factors. Geographical location plays an important role in these factors. The amount of radiation from the Sun

depends on the direct geographical location on the Earth's surface. The accumulation of this radiation in the atmosphere, as well as on the surface of the earth, quantitative indicators of heat balance and generally the type of the climate depends on this passive factor. One of the factors affecting the climate is the relief of the area. The parallel position of the Greater Caucasus Mountains prevents cold air flow from the north and significantly affects the atmospheric circulation.

As all meteorological factors, atmospheric precipitation is subject to vertical zonality law. Changing gradient of precipitation depending on the altitude is very complicated for the entire area. The amount of precipitation is increasing by ascending altitudes slopes of the Great Caucasus Mountains, but from certain altitudes begins to decreasing again. The maximum amount of precipitation was 1400-1450 mm which observed at a height of 2400-2800 m on the southern slopes of the Greater Caucasus. The total amount of precipitation considerable decreases from the specified elevation zone to the watershed of the mountains and at a height of 3700-4000 m, a total of precipitation is just 1200-900 mm.

Snow cover is formed in the lowland and foothills of the Republic on December and January, in the middle hill at the beginning of November and in the highland from October 1st. The period of snow melting and the disappearance of snow cover is vice versa. Snow melting and disappearing of snow cover in the lowlands usually is in middle of winter, rising to the highlands disappearing of snow cover is delaying and in the highlands this date is June 1st or 10.

The snow accumulation process in the basin begins when the temperature changes from positive to negative during the year. The accumulation of snow begins from this time. At the earliest times, this process goes in the high mountain regions; in the later periods, the downward movement of the snow line begins in relatively low areas as a result of air cooling and the flow in the rivers decreases. The distribution of snow resources on vertical zonality depending on the altitude of the basin occurs. Accumulation of snow-water resources in the basin begins from in September - October continues till May - June. In low areas, this interval is short.

The number of days with snow cover is 20 in the foothills of the Greater Caucasus is 20, 80-120 in the Middle zone and 160-250 in high mountainous. Snow cover remains permanent in the area of the highest peaks of the Greater Caucasus in the mountains higher than 3900 m.

The wind often blows the snow from convex part of the slope to the pit zone in the highlands. Usually, snow in 2-3 m depth is accumulated at the expense of blown snow from smaller erosion slopes. These snow valleys are remains in the form of white spots of various shapes on the background of alpine meadows up to mid-summer, even though, sometimes it can not melt even at the end of the summer. These snow spots form specific microrelief forms at high altitudes.

Spot observations on snow cover in meteorological stations (posts) don't reflect fully the diversity of distribution of snow cover. Requirement additional information about snow cover characteristic in snow route measurement observations is related to providing reliable hydrological forecasts, assessment of snow-slip situation and importance of identification climate characteristics.

Snow measurement in the river basins of the Republic are observed by the National Hydrometeorology Department of the Ministry of Ecology and Natural Resources on 23 routes and by the Nakhchivan Hydrometeorology Department on 5 routes. Snow route measurement

in the Caucasus are observed once a year - in March when snow accumulation is maximal in major parts of mountain basins.

Snow route measurements on the southern slope of the Greater Caucasus cover highlands from 580 to 2800 m and all spring-summer snow melting zone.

Snow cover melts in March up to altitude 1500 m in foothill, in May at 2500-3000 m and in June-July at higher altitudes. Depending on the altitude, the melting of the snow cover increases from 50 to 180 days.

The biggest average-decade depth in the foothills of the Greater Caucasus is 10 cm, in the middle hill 20-50 cm and in the highland - more than 70 cm (average depth of snowfall only perennial observation data).

River	Flows to	Name of snow route (start and finish points)	№	Altitude	Max depth of snow
Kish	-Ayrichay -Qanix -Kur -Caspian sea	Shaki city –	1	885	14
		Chukhadurmas	2	980	19
		Mountain	3	1250	32
			4	1400	46
			5	1600	56
			6	1900	65
			7	2100	73
			8	2300	94
			9	2500	83
			10	2800	78
	Chukhadurmas river outfall – Koshan Mountain	1	1200	20	
		2	1300	33	
		3	1400	56	
		4	1450	60	
		5	1560	131	
		6	1600	111	
		7	1750	89	
		8	2100	90	
9		2500	95		

Table 1. Information on the maximal depth of the snow which observed on the selected altitudes at the 2003-2015

To analyze the snow resources of the southern slope of the Greater Caucasus were selected snow routes belonging to the Kish River basin and Table 1 was developed according to survey results of snow route measurements in Shaki city-Chukhadurmas mountain and Chuxodurmas river outfall-Koshan Mountain (2003-2015).

The analysis of the results in Shaki city-Chukhadurmas mountain shows that the maximum depth of the snow is increasing by ascending altitudes and this process continues to 2300 m altitude and then again decreasing. However, the maximum depth of the snow cover is beginning to decline from the 1560 m altitude on the Chukhadurmas river outfall-Koshan Mountain

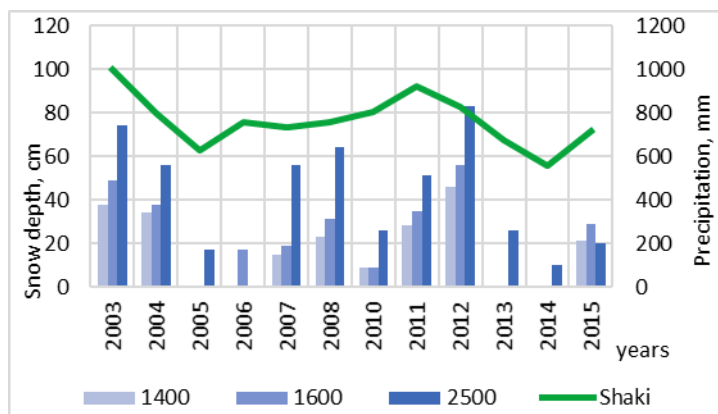


Figure 1. Variation of observation total precipitation in Shaki Meteorological Station with the snow depth at various altitudes on the snow field of "Shaki city - Chukhadurmas Mountain" for 2003-2015

However, in order to explore the impact of the total precipitation on the southern slope of the Greater Caucasus, the depth of the snow in snow fields and the total precipitation data in Shaki meteorological station are collected and all data were evaluated and analyzed (Figure 1, 2)

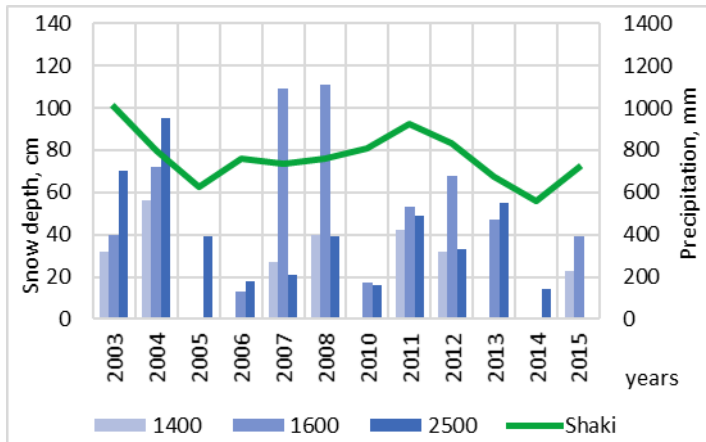


Figure 2. Variation of observation total precipitation in Shaki Meteorological Station with the snow depth at various altitudes on the snow field of "Chukhadurmas river outfall - Koshan Mountain" for 2003-2015

If we analyze Figure 1.2, we can see the closely relationship between snow accumulation in the snow fields in 2003, 2011 and 2012 which was rich for total precipitation, so that during the same period was observed abundant of accumulated snow.

According to the data of meteorological station and the data of snow route measurements on snow field in march, we can say that 2005 and 2014 was dry year for Kishchay.

However, despite the high value of total precipitation in 2010 in

both snow field, reduction of snow resources was observed. This is related to most of precipitation was when the air temperature has been positive in the same year and snow resources could not accumulated. Snow resources could not accumulated due to the fall of most of the precipitation was at the positive temperature of the weather

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Application of remote sensing methods for prevention of oil spill risk in the Azerbaijani sector of the Caspian Sea

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Keywords: Oil spill, remote sensing methods, Caspian Sea

Introduction

The Caspian basin is very rich with hydrocarbon deposits and several energy projects are realized by the countries around the Caspian Sea. Obviously, oil and gas production, oil tankers accidents, oil spillage from the oil tankers, transportation, and oil and gas processing operations impact the physicochemical parameters of the seawater adversely and create a significant oil pollution problem for all countries around the Caspian Sea. According to monitoring and tests conducted by the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan (MENR), hydrocarbon compositions were identified in the samples taken from ground waters of the sea bottom. This pollution in bottom ground waters caused reduction of organisms in predominantly Baku inlet and consequently affected the food chain in the water environment (MENR). Consequently, this contamination spreads and creates environmental crises in several coastal areas. As it impacts the physicochemical parameters of the sea, it creates difficulty for fish and other aquatic creatures to live in the water. Considering food chain of nature, nourishing with the fish which contaminated by hydrocarbons also impacts human organism as well.

Moreover, cleaning oil pollution is also one of the expensive processes and additionally an effective cleaning and rapid oil response operation in case of Tier,1,2 or 3 oil spill disasters require up-to-date and useful technologies. These technologies include skimmers, vessels, booms, dispersants, remote sensing methods, etc. But in this article, will be focused on only the effectiveness of remote sensing according to the hydro-meteorological condition in the Azerbaijani sector of the Caspian Sea.

In practice, there are several remote sensing methods that are used in oil spill detection such as radar systems, laser fluorosensor, passive microwave, ultraviolet, near infrared, and thermal infrared sensors, etc. (Jha et al., 2008).

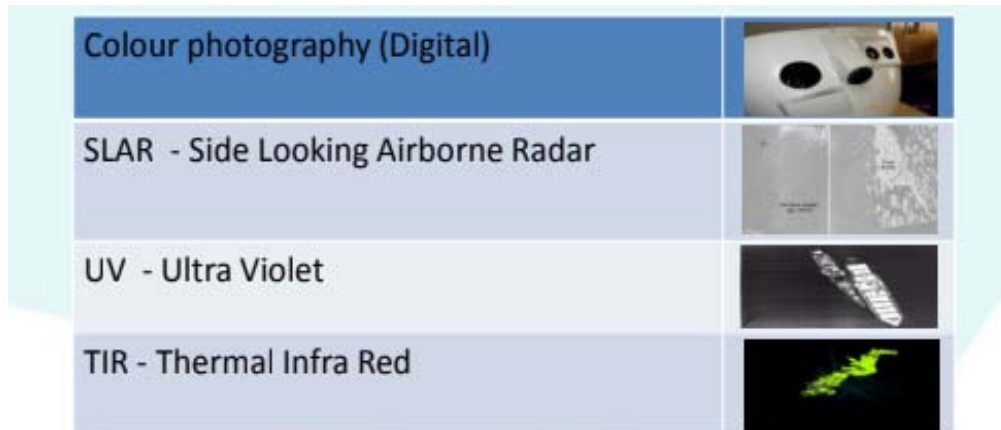


Fig.1.Remote sensing methods in oil spill response operation (Oil Spill Response Limited training course)

Of course, all of them have advantages and limitations. Their operation also depends on certain factors such as daytime, wind speed, the intensity of rain, the concentration of oil, etc. Therefore, obtaining information and processing late can cause a delay in oil spill response operations. This is why selecting the most appropriate and fast working methods by considering the hydro-meteorological condition of the area is important in order to implement the tactical and strategic oil response plans more operatively.

Materials and methods

To analyze the effectiveness of remote sensing methods in oil pollution several articles, reports and oil spill response plan of SOCAR, BP and other oil and gas producing companies have been reviewed and analyzed (SOCAR and BP’s Oil Spill Response Plan). At the same time, statistical hydro-meteorological information in the Azerbaijani region of the Caspian Sea collected in order to consider impact of wind, wave, temperature and other factors in the oil response plan (Aliyev et al., 20014). Different maps have been also studied to determine the sensitive points in order to protect living and recreational areas.

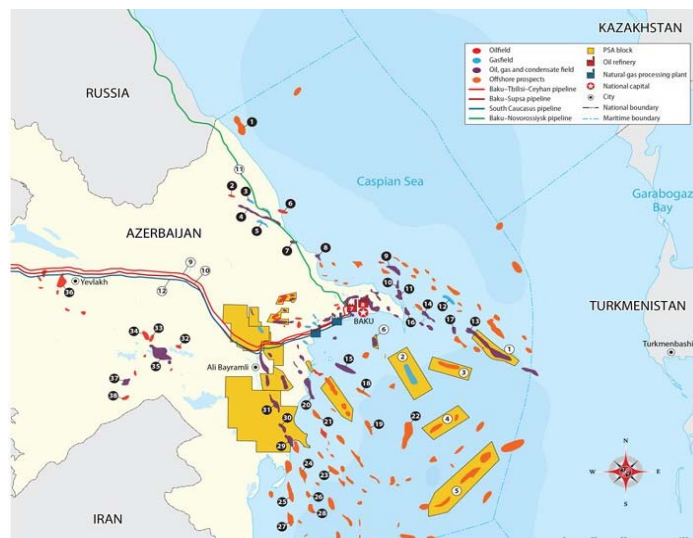


Fig. 2. Oil and gas production area of Azerbaijan (The Oil and Gas Year)

Considering that software is an inseparable part of the effective oil spill response operation the role of ArcGIS and three-dimensional oil spill model the Oil Spill

Contingency and Response model (OSCAR) developed by Sintef have been analyzed (SIntef).

Results

Looking at the close past, different remote sensing methods depending on the situation were applied in oil spill response operations. Different projects like, the “Studying the variation from the impact of oil products in the Azerbaijani sector of the Caspian Sea by radars systems” implemented by A.Sh. Mehdiyev, B.M.Azizov and others; and SOCAR and Azercosmos cooperation during the accident in Guneshli Oil field in 2015 can be shown as an example (Mehdiyev et al., 2014).

The first project was implemented in around Oil Rocks and used RADARSAT-2 radar system which belongs to Canada. The effective usage quality of Synthetic Aperture Radar systems allowed to study a huge area and it was identified that the ideal condition for detecting oil spot was time when the speed of the wind was between 3-9-11 m/s. It is worth noting that, the analyzed photos covered different seasons in 2012, 2013 and 2014. This study showed that radar system is very useful for oil spill detection.

When it comes to the second case, both optical and radars systems were applied in an accident which happened in Gunashli oil field on 4 December 2015. After the claims of other countries about serious oil pollution at the Caspian Sea “Azercosmos” OJSCO took new aerospace photos through RADARSAT-2 satellite of Canadian company MDA. According to the result, any serious oil pollution was not detected and the little spillage of oil was cleaned in a short period.

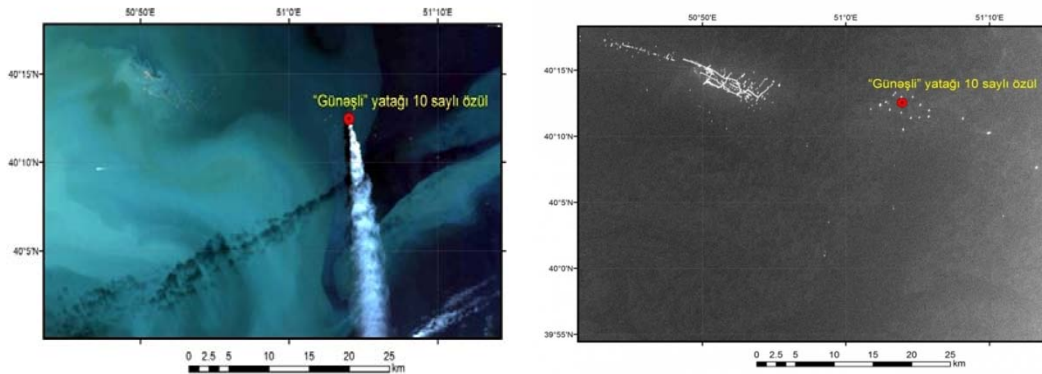


Fig.3. and 4. The photos taken by Azercosmos during accident in Gunashli oilfield (APA news)

Considering effective operation, several factors such as daytime and darkness, fog, cloud, algae, thin oil such as from ship discharges in a small amount, wind shadows, sun glitter coastlines, seaweed, ice and debris can create a serious problem for positive oil spill detection (Azizov et al., 2017). Normally, those factors have also affected the process and created problems in terms of processing information and differencing of oil from different factors such as algae, sun glint, and wind sheens. The result of the operations shows that in order to eliminate any shortcomings and errors the software

and up-to-date methods (polarizations) should be used. This will help to save time and process information much quickly and effectively.

To run models, it is required to know:

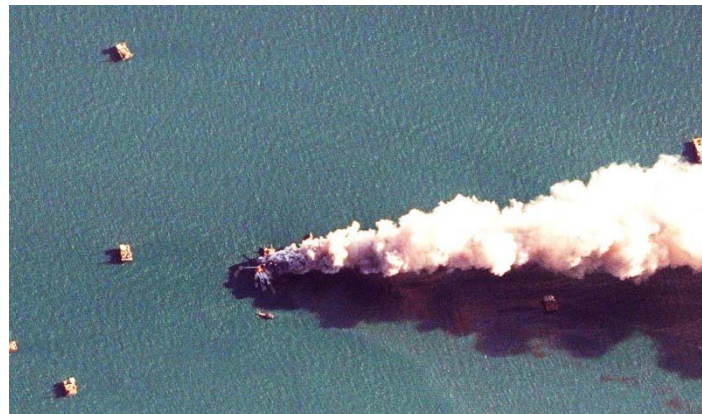
Position of Release: Latitude / longitude and depth

Spill Details: Date, start time, volume, release duration, model duration, oil type, (oil temperature on release, diameter of release hole, gas/liquid ratio, gas density, suspended sediment load of water)

Metoccean Data: Winds and currents (Oil Spill Response Limited)

Discussion

As Azerbaijan is an oil and gas producing country, it should prepare and develop a very strong strategic and tactical oil spill response plan against Tier 1,2 or 3 oil spill accidents. Although, the Ministry of Emergency Situations, the Ministry of Ecology and Natural Resources, SOCAR and BP conduct training and develop oil response plan there are still a lot of things to do. In order to improve Azercosmos's experience in oil spill response operations and prepare competent specialists in oil spill modeling, Azercosmos should also be involved in trainings. The photo below is taken by Azercosmos's satellite.








Guneshli Oilfield Accident, Azerbaijan



Fig.5. Azercosmos's operation in oil and gas field (Azercosmos)

Apart from theoretical training, practical training should be also conducted to create a real oil spill situation and prepare the local specialists for Tier 1, 2 and 3 accidents.

One of the advantages of remote sensing application is that it is possible to estimate layer thickness interval and calculate the area of oil in m^3/km^2 according to Bonn agreement Oil appearance code by using aerospace photos. Below information and example can be shown as the importance of remote sensing methods:

Code Description	Appearance	Layer Thickness-Interval (μm)	M^3 per km^2
Sheen (silvery/grey)		0.04 to 0.30	0.04 – 0.3
Rainbow		0.30 to 5.0	0.3 – 5
Metallic		5.0 to 50	5 – 50
Discontinuous True Oil Colour		50 to 200	50 – 200
Continuous True Oil Colour		200 to More than 200,000	More than 200



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Fig.6. Bonn agreement Oil appearance code (Oil Spill Repsonse)

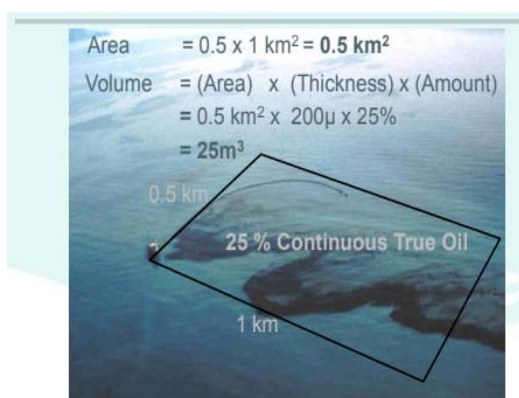


Fig.6. Volume of oil estimation

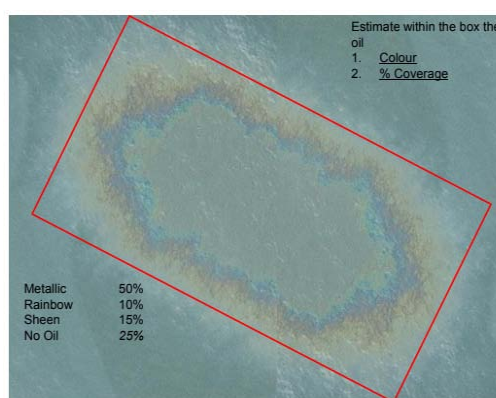


Fig.7. Estimation of oil according to the color

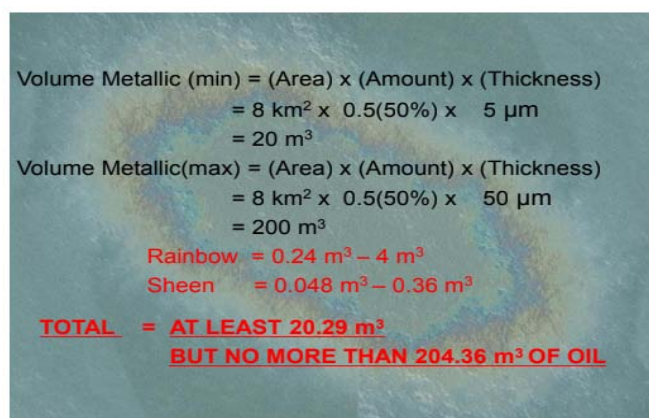


Fig.8. Calculation of minimum and maximum volume of spilled oil code (Oil Spill Response)

Above information shows the necessity of modeling software using remote sensing methods in oil spill prevention. But as mentioned in the article, all of them have limitations. For example: It is difficult to prevent an oil disaster which happens at night and under hard weather conditions. The consequence of this can be a serious environmental damage and loss of a big amount of money for the cleaning process. Therefore, it is suggested that multifunctional airplanes such as Maritime surveillance aircraft Dornier 228 of the Central Command for Maritime Emergencies (CCME) can be used in Azerbaijan as well. This airplane

has FLAR and SLAR: Forward-looking and side-looking radar, MWR: Microwave radiometer, LFS: Laserfluorosensor. COC and Central operator console and it is operated by the Naval Air Wing 3 (MFG 3) of the German Navy. The usage of this method can minimize any possible errors during operations and eliminate a big scale of oil pollution at the Caspian Sea.

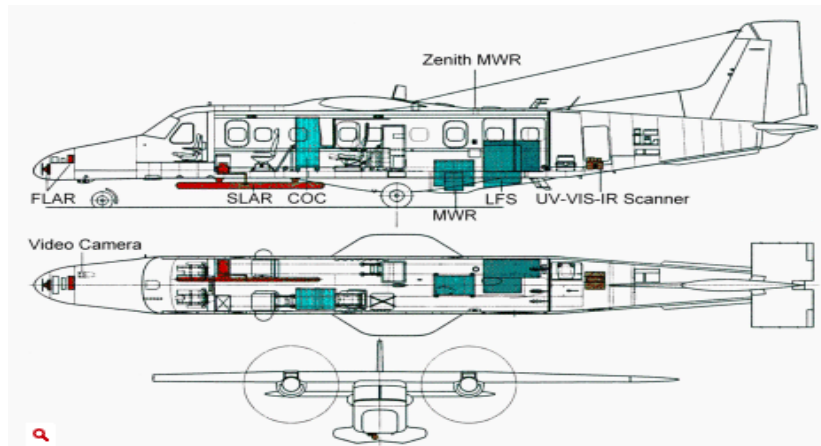


Fig.9. Dornier 228 (SEOS Project)

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Oil spill pollution detection along the Baku coastline using satellite monitoring

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Keywords: Oil spill; Satellite monitoring; Caspian Sea; Baku coastline

1 Introduction

The amount of daily shipped oil in the world's oceans has decreased to more than 100 million tons (Liu & Wirtz, 2009). Discharges/spills of oil and its derivatives that resulted from marine transportation, offshore platforms and oil terminals are very serious threats to marine ecosystems with the contamination of seawater, bottom sediments, shores and beaches persisting for several months and even years (Kostianoy & Lavrova, 2014). Because of these impacts, detection of oil pollution is among the most important goals of monitoring of a coastal zone (Kostianoy et al., 2006).

Since the Caspian Sea belongs to the world's largest oil-bearing and production regions, the main sources of oil pollution are considered to be offshore oil production, as well as, natural oil seepages at the sea bottom (Mityagina & Lavrova, 2016). According to some estimates (Aliyev, 2003), there are approximately one million tons of oil leaks annually into the Caspian Sea. Since aerial surveys over large areas of the Caspian Sea are inefficient and expensive, using satellite imagery is a much more suitable way to identify probable spills.

The Synthetic Aperture Radar (SAR) instrument, which can collect data independently of weather and light conditions, is an excellent tool to monitor and detect oil on water surface. In this study, oil pollution along the coastline of Baku, Azerbaijan was monitored using multiple satellite observation SAR images obtained from European Space Agency's (ESA) Sentinel-1 A and Sentinel-2 and also Landsat-8 satellite images and recommendations have been prepared to combat this harmful effect of the oil industry.

2 Materials and methods

A multi-source approach integrating satellite (Sentinel-1, Sentinel-2 and Landsat-8) is recommended in order to reach the full potential for cost-effective oil spill pollution detection along the Baku coastline, by minimizing most constraints. All of the images were dated January 1, 2018. By using Sentinel-1A-B SAR images, which can be obtained by free and open access from ESA's Sentinels scientific data hub (2018), Caspian Sea oil spill and natural seepages were detected. The Caspian Sea is an area with frequent and massive oil spills easily visible with optical sensors like Pan-sharpened Landsat-8 or Sentinel-2 Natural Color. Landsat-8 or Sentinel-2 optical images, which can be obtained by free and open access from U.S. Geological Survey's EarthExplorer (2018), the oil slicks exhibit dark and bright contrasts with respect to the pollution level of the water.

3 Results

Sentinel-1 is the most commonly used tool to detect oil spills and natural seepages. Oil slicks exhibited dark/bright contrasts with respect to oil-free waters at Landsat-8 visible band scene. Also, thermal bands of Landsat-8 showed higher temperatures than the surrounding SST. The ratio of B2/B11 showed best results for oil spills.

4 Discussion

Sea-based sources of pollution and discharge of industrial waste have been considered as the serious environmental problems encountered in the Caspian Sea's coastal areas (Pak & Farajzadeh, 2007). Among the problems, oil pollution has been continuously growing during the decades. This pollution in the Caspian Sea were detected using SAR and optical images, in this study. One of the major advantages of this kind of monitoring is the ability to extract oil spill parameters such as location, linear size and spill areas. Spatial and temporal information (i.e. oil spill distribution at sea and its evolution in time) allows the users and decision makers to establish the major cause and source of oil spills, and then outline the risk areas. The main findings and ideas resulting from this study can be summarized as follows:

1. Satellite monitoring is an efficient tool for the collection, visualization and analysis of information on oil spills in the marine environment. Use of the this approach as a core of the oil spill monitoring system is foreseen.
2. With this tool the problems/tasks of the analysis, modelling and forecasting natural processes influencing the drift and spreading of emergency oil spills can also be solved successfully.
3. Satellite monitoring can qualitatively and quantitatively characterize not only spatial and temporal distribution of oil spills but also the environmental conditions of the sea basins as a whole.
4. Imaginery modinoting providing resources and information for pollution authorities are considered to be very useful for managers and technical personnel to support management and decision making. Application of the achievements of satellite technologies to monitoring oil spills in the marine environment will not only allow spill distribution to be obtained but also track the environmental consequences and lead to prevention measures being undertaken.
5. Taking into account the modern tendencies in oil production and transportation on the Russian shelves, there is an obvious need to create an monitoring system based on satellite imagery. Completely integration of all kinds of information, systems and resources on a Caspian level, within a single monitoring system, is also foreseen.

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AUTOMATIC OIL SLICKS DETECTION USING MULTI-TEMPORAL SENTINEL SAR DATA

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Key words: Marine pollution, Oil spill detection, Probability map, Sentinel SAR

INTRODUCTION

Since the oil spills cause extensive ecological and economical damages and affect the marine and wildlife habitats, marine oil spills are a common threat to all sea bordering countries. In most cases it is critical to respond to spills in a timely manner, and therefore it is important to determine its areal extent, and most recent position of the contaminated area in near real time. In this context, satellite based oil pollution monitoring systems, mainly space borne Synthetic Aperture Radar (SAR) systems are being used for monitoring and in hazard response efforts due to their high accuracy, frequent acquisitions, large area coverage and day-and-night observations.

As a result of a strong storm on 4 December 2015, a damaged high-pressure underwater gas pipeline has caused a fire at platform #10 in the Guneshli field of the State Oil Company of Azerbaijan in the Caspian Sea. Although any signs of oil spills were not reported by the authorities, however a Sentinel 1A satellite image collected by the European Space Agency on December 7th has shown some features which contradicts that report. As reported in the SkyTruth website, besides many other smaller oil slicks that routinely seen, a dark slick had areal extent as 192 square kilometres, and originated from the same coordinates as the fire and smoke plume seen on these MODIS satellite images. If it has a high possibility to be an oil, then it translates to over 50,000 gallons of contaminant (with a rough estimate if this slick is only one micron thick). In this paper, it is aimed to test a new automatic algorithm developed for determining the extent of the oil spill from SAR imagery acquired in the Caspian Sea and evaluate our findings with the reported results.

MATERIALS and METHODS

SAR imagery is sensitive to surface roughness which is altered in case of an oil spill (Alpers and Hühnerfuss, 1988). Although the amount of damping is affected by wind and wave conditions the oil slicks change the smoothness of ocean surface and appear darker compared to surrounding oil free ocean. In the literature, there are many methods developed to detect oil spills from SAR intensity images (Del Frate et al., 2000; Solberg et al., 2007); however, in this study, it is aimed to develop a practical framework where results from different methods and sources can be combined to provide a joint solution, which is likely to have less uncertainty. This proposed framework has also been tested and validated successively in the Deepwater Horizon oil spill occurred in the Gulf of Mexico in April 2010 (Osmanoğlu et al., 2012).

The algorithm is composed of three calculation steps: (1) Pixel (point) probability, (2) Spatial probability, and (3) Spatio-temporal probability. Point probability is calculated based on normalized radar cross section, where darker pixels get higher probabilities for oil contamination (Barni et al., 1995). Spatial probability is based on the damping ratio given the current wind conditions and imaging parameters (Gade et al., 1998, Kim et al., 2010). Point and spatial analysis results are then combined to provide a joint probability for oil slick at each acquisition. The spatio-temporal probability is estimated from multiple SAR acquisitions separated shortly in time, resulting in a time varying probability of oil slick over target area.

The first and second steps of the algorithm are run iteratively at five different spatial resolutions, in a pyramid structure with five different stages. At each stage the image is multi-looked to the power of two, such that at the first stage the image is multi-looked to 2, and to 4 at the second stage.

The study area is shown in Figure 1, and is about 125 km × 65 km, centred around the area where oil spill has occurred. Observations from Sentinel-1A before and after the explosion were used to show the beginning and end of the spill.

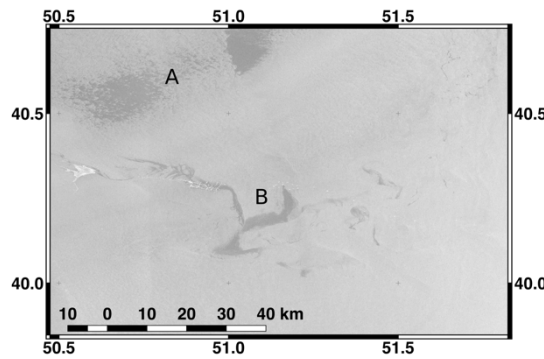


Fig. 1. December 7th, 2015 Sentinel image of the study area. A and B denote low wind speed area and suspected oil spill respectively.

RESULTS

Multi-temporal SAR images were acquired and processed using the proposed method. Some of the imaging parameters and environmental conditions are summarized in Table 1. The wind speed and direction were measured at the Baku International Airport (Wunderground, 2015). Despite the low damping factors calculated according to the airport wind-speeds, the algorithm was able to map the spills, most likely because the wind speeds off-shore were slightly higher.

Date/Time(GMT)	Sensor	Wind Speed [m/s]	Wind Direction	Orbit Direction	Damping Factor [dB]
2015-12-02 02:35	Sentinel-1A	4.1	WNW	Descending	0.9
2015-12-07 02:43	Sentinel-1A	3.0	S	Descending	0.5
2015-12-13 14:36	Sentinel-1A	2.6	W	Ascending	0.3
2015-12-20 14:28	Sentinel-1A	2.1	W	Ascending	0.2

Table 1. The imaging parameters and environmental conditions used in this study.

The result of oil spill detection algorithm applied to the December 7th image is shown in Figure 2. The probability maps were calculated for the five iterative steps using point and spatial probability methods and later combined. There is a likely low-wind area in the north-east corner of the study area (shown with red circle), which is the algorithm assigns a high oil probability. The spatial-probability is assigned wrong in this case, as the low-wind area is at the corner of the study site. Furthermore, the point-probability can also be skewed in this analysis, as the wind information is coming from a station on land, instead of a buoy close to the study area. With better wind estimation and enlarged study area, these false-positives should diminish.

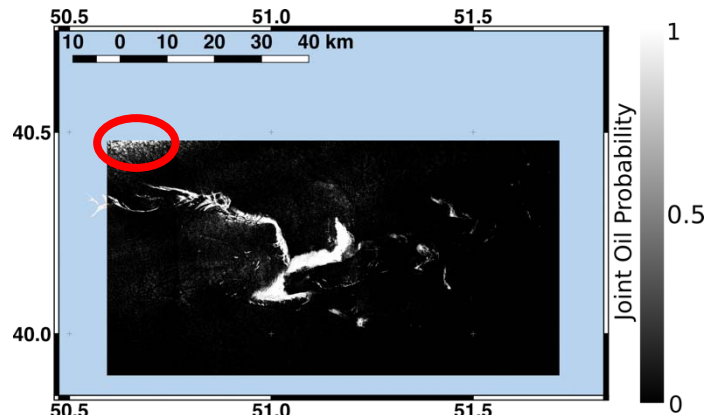


Fig. 2. The joint oil slick probability map in the area. Background is from Wikimedia map layer.

DISCUSSION

In this paper, we presented a method to combine SAR data from multiple observations, acquired at different times from different geometries, to obtain a combined oil slick probability map for the oil spill in the Caspian Sea. Furthermore, it is also possible to combine results from different algorithms applied to the same data set, to increase accuracy as presented in this paper.

Our analysis showed that the oil covered area is about 170 km², similar to but slightly less than what was reported by Skytruth. Using the same assumption of 1-micron thick oil, would be roughly equal to 45,000 gallons. In order to further validate our results, we also turned to MODIS imagery acquired on the same date, though acquired about 5 hours after the Sentinel-1A imagery. In Figure 3, a true colour MODIS imagery is shown at 500m resolution. There are minor gaps in the image due to masking of cloudy pixels. In the MODIS imagery dark blue is clear water and lighter colours indicate sediments or oil slick. Even though the sediment/oil spill in MODIS imagery covers a much larger area, the same shape outlined in SAR imagery, as shown in red in Figure 3, can be seen slightly to the south, and almost double the area. This is likely due to the wind spreading the oil over the sea surface, as the prevailing wind direction is South at 3 m/s on this day.

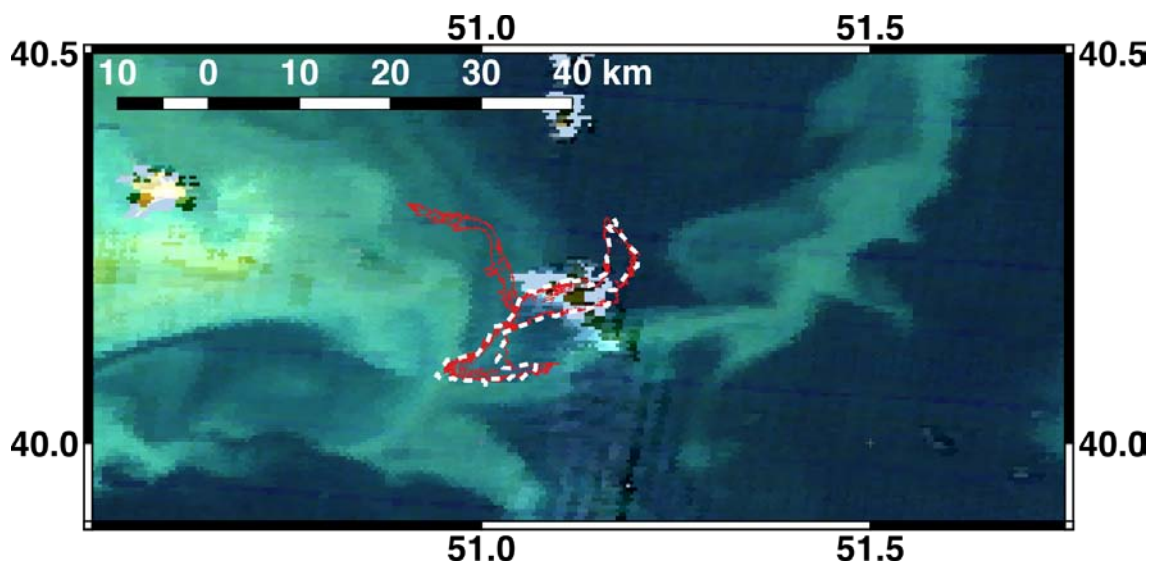


Fig. 3. True colour MODIS imagery from December 7th, 2015. The red outline shows the oil spill extent detected using Sentinel-1A data. The dashed line denotes the approximate area defined by Skytruth.

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SKYTRUTH; <https://www.skytruth.org/2015/12/socar-10/>

Wunderground; <https://www.wunderground.com/history/airport/UBBB/>

Biological Hotspots in the Caspian Sea Revealed from Satellite Ocean Color Observations

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Over the past two decades, satellite ocean color (OC) observations have proven a great asset in understanding large scale (i.e., ~ 1km) physical and biological phenomena in coastal and oceanic waters. Satellite sensors measure water-leaving radiances, which give clues on the optical properties of upper water column. NASA's ocean color images, however, have not been extensively explored over the Caspian Sea, whose ecosystem has been under pressure due to major human interventions since late 90's. In this study, we analyze historic ocean color observations made by the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Terra and Aqua platforms from 1999. More specifically, we evaluate time-series of chlorophyll-a products and create a 1km-grid Caspian Sea anomaly map, which allude to biological hotspots where potentially algal blooms have occurred. This map will provide insights into how various exploration activities have influenced the Caspian Seas' ecosystem over the past two decades. In addition, it will assist different stakeholders involved in oil/gas or fishery industries with planning for effective uses of resources or risk mitigation activities in the future.

Study of the seasonal distribution of the Caspian Sea level amplitude by satellite altimetry

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Keywords: *The Caspian Sea, Volga River, satellite altimetry, track, Jason 1-2, ENVISAT, amplitude, phase*

Introduction

One of the main factors affecting to seasonal fluctuations of the Caspian Sea level is river water input (Volga, Ural, Kura, Terek, etc.). The Volga provides 78-82% of the total river input to the Caspian Sea (Hydrometeorology and Hydrochemistry of seas, 1992).

In order to analyze the spatial and temporal distribution of seasonal sea water level fluctuations and the influence of the river flow of the Volga on this distribution, it is necessary to create spatial and temporal distribution maps of sea level amplitude and phases of its occurrence for the whole surface of the Caspian Sea. However, it is impossible to solve this problem according to the in-situ observation, because they cover only coastal regions. Relatedly, for this purpose it is more expedient to use remote sensing data, which are much attractive in situations when contact measuring cannot be conducted because of geographic, political or economic reasons (Troitskaya et al., 2011).

The main advantages of this remote sensing method is global coverage and high penetrating ability of radio waves through the atmosphere and clouds. This allows to perform investigation practically in all weather conditions, as well as in condition of the presence of sufficiently high aerosol concentrations in the air (Troitskaya et al., 2011). For the Caspian Sea satellite radar altimetry data were successfully used since Topex/Poseidon launch in 1993 (Kouraev et al., 2011). However, taking into account the temporal variability of the water regime of the Caspian Sea, it is of great interest to study sea level amplitude and phase distribution using recent data of Jason 2. It should be taken into consideration that the satellites of the Jason series have an advantage in the frequency of repetition of data, and the ENVISAT satellite is preferable in regard to the density of track distribution over the sea's water area. The accuracy of measuring by Jason satellites over the oceans is 2 cm (Fu et al., 2001), but the error in calculating the altitude of the sea surface in relation to the reference ellipsoid reaches 4.2 cm (Chelton et al., 2001). The accuracy of measuring by ENVISAT vary depending target size (Arsen et al. 2015) and is generally 4-5 cm for big open water bodies (Crétau et al., 2011; Lebedev et al., 2005).

Used material and research methodology

The satellite altimetry observation data of Envisat (2002-2009) GDR v2, Jason 1 (2002-2009) GDR-C and Jason-2 (2008-2013) GDR-D data used in this work were obtained from Centre of Topography

of the Oceans and the Hydrosphere (ctoh.legos.obs-mip.fr) and processed in collaboration with LEGOS/ECHOS research group (www.legos.obs-mip.fr).

The Caspian Sea boundary intersects with 8 Jason 1-2-3 tracks (016, 031, 057, 092, 107, 133, 168, 209 and 244). Four of them are ascending, and 4 descending (Fig. 2a). The revisit time for each of these tracks is about 10 (9.9156) days. The Caspian Sea intersects with 25 tracks of the ENVISAT satellite as well. Of these, 14 are ascending, and 11 are descending. The revisit time for each of these tracks was about 35 days.

To identify the annual maximum amplitudes and their phases of occurrence in the entire water area of the Caspian Sea, a complex research along the corresponding tracks, consisting of three stages was carried out.

In the first stage, for each track for each satellite the sea level was calculated using LEGOS processing chain which was described in Cretaux et al. 2011. The sea level is calculated as follows:

$$SSH = \text{altitude} - \text{corrected range},$$

where SSH is the sea surface height, altitude is the satellite orbit, and corrected range is the measured range with atmospheric path delay and geophysical corrections. The expression for the sea level anomaly is as follows:

$$SLA = SSH - MSS,$$

where SLA is the sea level anomaly, and MSS is the mean sea level.

The averaging of the sea level was carried out over 10 km strips. Outliers inside each patch were filtered using a 3-sigma test.

At the second stage of the study the spatial and temporal distribution of sea level is analyzed. For each satellite for each track, the 10 km averaged sea level time series are used to determine annual mean, annual maximum and minimum values of the sea level anomalies and phase (the day of the year of their occurrence). For each 10 km patch the average multi-annual amplitudes and the phases were also calculated.

Finally, after the completion of the first and second stages of the studies the distribution of the mean annual maximum amplitudes and the phases of their occurrence throughout the all water area were created using ArcGIS 10.3 (Fig. 2).

Results

Fig. 1 reflects monthly distribution of the Volga River water flow based on in-situ observation data, conducted from measurement point Verhnee Labejye for 2002-2013 years. Despite the fact that the maximum water discharge in Volga is observed in May, the spatial variability of the amplitude and phases of sea level observations indicate the complexity of these changes (Fig. 2).

According to the data taken from Jason 1 and Jason 2 satellites for the 2002-2013 period of observations, the largest amplitudes (43-48 cm) of seasonal sea level changes (Fig. 2a) were observed in the eastern part of the North Caspian (133th track) from June 25 to July 5 (Fig. 2b). In the Northern Caspian, south to the delta of the Volga (tracks 57 and 168), relatively high values (33-38 cm) of amplitude in the sea level were also observed (Fig. 2a) from mid-May to early June (Fig. 2b). The relatively bigger values of the seasonal sea level fluctuations amplitude, can be explained by the enormous influence of the flow from the Volga and Ural rivers, as well as such factors as the shallow sea depth, the nature of surface currents and, in part, the effect of relatively light fresh water that enters the sea at the expense of the mentioned rivers.

Discussion. The comparison with the data of ground in-situ stations (Abuzyarov, 2011) shows that the values of amplitudes and phases of observation, obtained in this study are much closer to the real values.

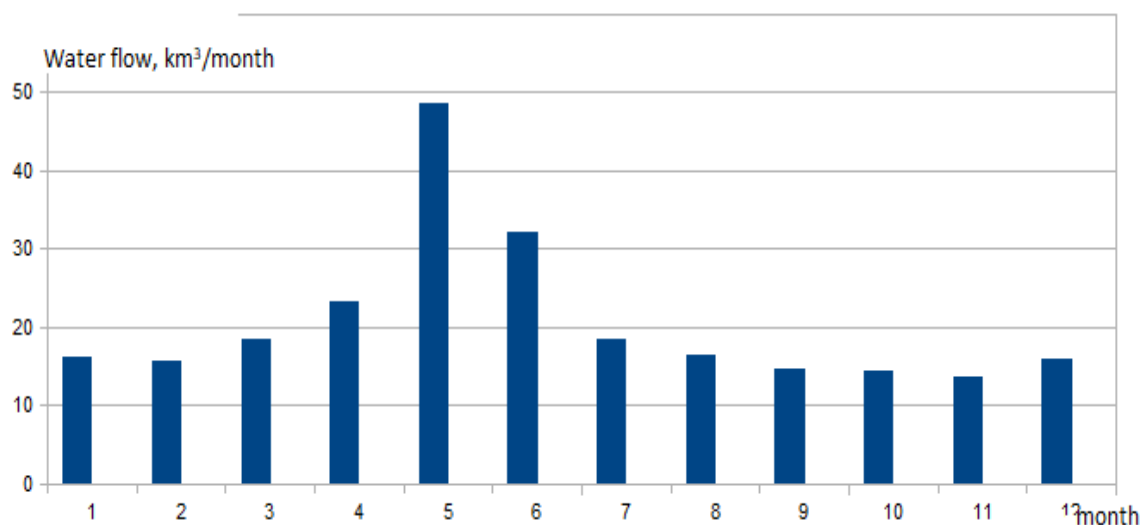


Fig. 1. The histogram of intra-annual water flow of the Volga River based on the observation data for 2002-2013 years.

In the Middle Caspian, the sea level amplitude is relatively lower than in the Northern Caspian. Along the track 92 in the deep-water areas, it varies around 28-33 cm (Fig. 2a). This result has a good agreement with the observation data from the coastal region stations (Abuzyarov, 2011). In the relatively northern part of the deep-water area, the phases of occurrence of the sea level amplitudes are observed from June 25 to July 5, and in the southern part in July 5-15 (Fig. 2b). The amplitude phases to the east of track number 92 are related to an earlier period, whereas to the west – on the opposite (tracks 133 and 209). If compare with the depth map, it can be concluded that in the shallow water areas of the Middle Caspian, seasonal amplitudes of the level are observed at an earlier time than in the deep waters. The reason is apparently because of heating of the sea water which causes the evaporation to increase, which prevents a further rise in sea level due to the flows of the Volga and other rivers.

In the Southern Caspian (tracks 31, 92, 209), the values of the sea level amplitude are generally getting lower values (23-28 cm). In the western part of the South Caspian, the water level and the amplitude of its fluctuation is slightly bigger compared with to the eastern part (Fig. 2a). The phases of the occurrence of sea level amplitudes in the eastern territories are observed earlier than in the western areas (Fig. 2b). This can be explained with relatively huge river flow and with huge amount of atmospheric precipitation in the western part. The phases of the occurrence of sea level amplitudes in the eastern territories are observed earlier than in the western areas (Fig. 2b). The reason for that is probably lies on fact that, in South Caspian region the impact of river Volga decreases, and unlike western territories the amount of precipitation here not high, whereas evaporation is opposite, conversely is larger. In other words, rapid evaporation in the eastern part of the sea leads to an earlier formation of the amplitude.

Maps of distributions of seasonal amplitudes and phases of their occurrence, obtained through the altimetry observation data from the ENVISAT satellite, have shown that the nature of these distributions is generally similar with those obtained from the Jason 1-2 series satellites (Fig. 2).

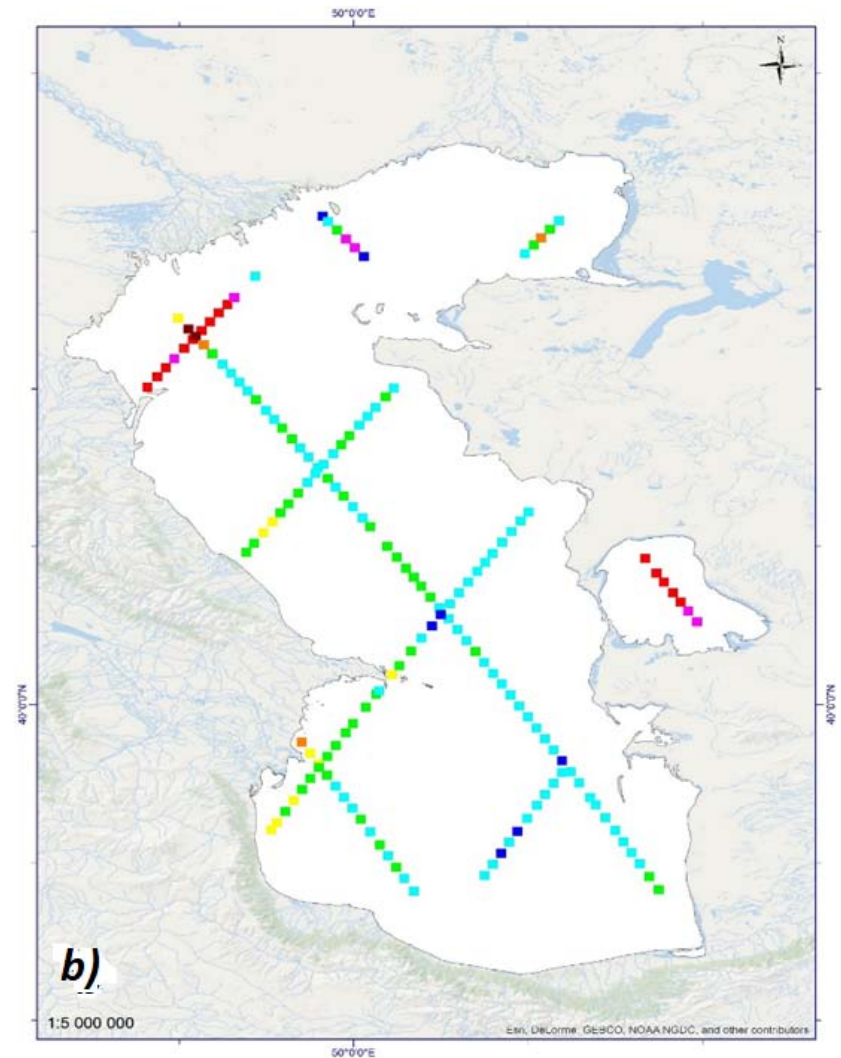
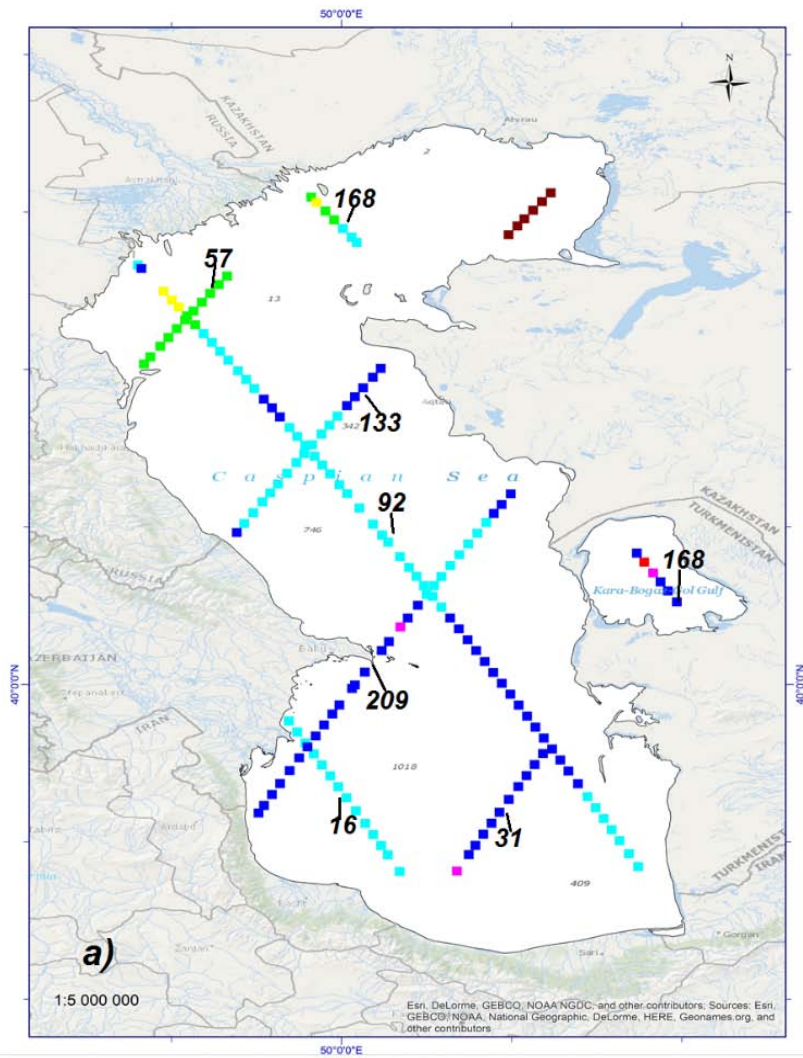


Fig. 2. Distribution maps for tracks of annual level amplitudes in the Caspian Sea and the phases of their occurrence (b) based on the data of the altimetric observations of the Jason 1-2 satellites for 2002-2013 year

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THEME VIII

Archeology And Paleoarcheology Of The Caspian Region

ARCHEOLOGICAL RESEARCHES IN THE CASPIAN LITTORAL TERRITORIES OF AZERBAIJAN

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Keywords: Caspian Sea, Azerbaijan, archaeology, Gobustan, Mesopotamia

Introduction

The Caspian littoral regions have been in the centre of attention from ancient times for favourable natural conditions and resources. Numerous monuments were discovered and studied in this territory with archaeological excavations.

Subsequent to the Turkmenchay peace treaty of 1828, Russian and European scholars-travellers focused on Azerbaijan and its ancient monuments. In 1829, the Russian Imperial Archaeological Committee delegated research in Azerbaijan to A.Yanovskini.

After Jacques De Morgan excavated and investigated more than 230 stone-box graves, dolmen monuments in the 90s of 19th century, archaeological excavations in Lenkaran were suspended for a long time [Bünyatov, 1960, p.9].

Materials and methods

The main methods of studying the Caspian littoral regions are archaeological excavations and exploration works. This study of the ancient history and culture of the area is divided into two conditional interims:

- The Soviet era – 1920-1991
- The years of independence – from 1991 up to now.

Archaeological study of Shabran city started in 1935, under the guidance of E.A.Pakhomov. As a result of 80-year-long (intermittently) archaeological excavations, the city's medieval castle walls, farm wells, stoves and ample material and cultural remains were discovered [Göyüşov, 1986, pp.142-150].

In 1939-1940, the Gobustan rock paintings were discovered on the Caspian coast, in 60-70 km from Baku. I.M.Jafarzadeh explored in Gobustan more than 6,000 petroglyphs of diverse content during 1947-1966 [Azərbaycan maddi mədəniyyəti, 1949, 1951, 1953].

During the soil-related works in Syrt-Chichi village of Guba district in 1962, clay vessels, bronze ornaments and weapons were obtained around the Galagyah hill in the Caspian basin. These specimens verify that the North and North-East Azerbaijan was inhabited by ancient tribes.

In 1963-1965, archaeological excavations and researches were carried out in Absheron peninsula under the leadership of M.Q.Aslanov. The obtained archaeological materials enabled the scholars to inspect the occupation of the Bronze Age people, especially the way craft developed independently.

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In 1964-1967, in South-East Azerbaijan – in Shuvi village of Astara – the Bronze Age maces were found as material and cultural remains. In other villages (Telmankend, Pensar, Tengerued, Mashehan, Alasha, etc.), mounds were detected. The abundant archaeological material, i.e. weapon specimen were obtained from Telmankend mounds. These weapons are similar to those of Western Asia. Telmankend mound is dated to the second half of the 4th - the first half of the 3rd millennia BC [Mahmudov, 1967, pp.2-3].

Since 1965, J.N.Rustamov and F.M.Muradova carry out research excavations in the monuments of "Ana Zagha", "Chardag zagha", "Feeruz", "Daire", "Boeyukdash" in Gobustan. The alongside settlements mounds are also researched [Rüstəmov, Muradova, 2003].

In 1967, at the foot of Billebur mount in Lankaran, scholars F.R.Makhmudov and H.R.Kesemenli discovered metal ware belonging to the Late Bronze and Early Iron ages.

From 1968 to the beginning of the 21st century, an underwater expedition operates in the Caspian Sea nearby the Absheron peninsula. Interesting finds from different periods are obtained near Pirallahy, Guergan, Baliq, Dash Adasy [Квачидзе, 2003, pp.143-147].

Since 1969, Q.M.Aslanov leads the archaeological research almost all over the Absheron area, including Shuvalan (Bandustu), Turkan settlements.

In 1970, the Mil-Mughan expedition led by H.R.Kesemenli unearthed Bronze Age material and cultural remains in Gyz-tepe (Ilanly-tepe) settlement of Jalilabad district [Kəsəmənli, 1971, pp. 1-18].

In 1973, F.R.Mahmudov found stone tools from the Khudabakhish Yurdu Bronze Age settlement near Hishkadere village of Masally district. The stone-covered mounds of ancient sedentary agricultural tribes were dated to the 3rd millennium BC. Simultaneously, at the foot of the Talysh mountains, the Divalona monument consisting of stone cists and tombs, surrounded by cromlech, was studied. The monuments belong to the 2nd-1st millennia BC.

In 1974-1975, research in the Absheron peninsula was continued by Q.M.Aslanov. The historical monuments of the Mesolithic up to the Late Middle Ages, e.g. Bronze Age settlements, mounds, stone cists and soil graves were discovered. The art samples of Bronze and Early Iron ages, like cave paintings, are of special significance amongst the material and cultural monuments of Absheron.

In 1976-1977, the Mughan archaeological group unearthed Middle Bronze Age farm wells and soil graves in Misharchay basin (Jalilabad). The finds were dated to the 3rd-2nd millennia BC.

The Late Bronze Age pottery vessels found during an exploration drilling carried out near the Yukhari Seki part of Boeyukdash mountain in Gobustan in 1977. More abundant materials (pottery specimens, stone labour tools, etc.) were revealed in the so-called "Ana zagha" field. In 1979, ancient art samples were discovered in Gobustan on the stone #110. On the southern surface of the stone two goats facing each other, and a mankind holding a daf-like musical instrument "Gaval", a bow and arrow in his hands are depicted. These Bronze Age paintings are of realistic style [Rüstəmov, Muradova, 2003].

Starting from 1982, the Guba-Khachmaz archaeological group conducted researches in Sarkar-tepe settlement and investigated the Bronze Age layer of the monument. Pottery, stone, bone and metal tools were obtained from the six unearthed constructional layers of the monument. In 1986, in the Seyidli village of Khachmaz region, traces of cremation burial tradition were determined, bronze spearhead and clay containers found in a Middle Bronze Age tomb.

In 1985, the "Archaeological Research of South-East Azerbaijan Monuments" expedition was established for research in the Caspian basin, Astara, Lankaran, Masalli, Lerik, Yardimli and Jalilabad. Heretofore, I.Narimanov, F.Mahmudov (Alikomek-tepe) and H.Kasamanli conducted archaeological works there. Archaeological maps of the regions were prepared during this period. In 2011, the Azerbaijan-France international archaeological expedition was established to study the heritage of Jacques de Morgan. A.Alekberov from Azerbaijan and Michel Kazanova from France led this expedition. As a result of joint activities Kravaladi, Juji Tuk, Mundigah, Amarat and other archaeological monuments were explored in Lankaran and Lerik [Alekberov, Kazanova, 2015, pp.370-378].

The Bronze Age monuments of North-East Azerbaijan were scientifically analyzed in the candidate's thesis of D.L.Musaev in 1991. A classification of the archaeological material (pottery, stone, bone, metal wares) collected from the settlements of Akhty-tepe and Hasangala (Khachmaz district, to the North of Serker-tepe and Akhtigazmalar villages), Mollaburkhan-tepe (on the left bank of Gudyalchay river), Filter I (within the Shollar water reservoir), Tepeyataghy (to the North-East from Khudat), Chaqqally-tepe I and Chaqqally-tepe II (near Aygunlu village of Shabran district), Gefle-tepe I, Govdeshan-tepe II (Gusar district), Boeyuk-tepe I and Boeyuk-tepe II (near Kijan village), Kuchumkhan-tepe (near Gueller village), Dashly-tepe (near Nughadi II village of Guba district) is given in the thesis [Musayev, 1991].

In the 2000s, archaeologist A.M.Mammadov studied the ancient and medieval monuments of Salyan region.

As of 2004, the "Mugan Neolith-Eneolithic Expedition" in Jalilabad district investigates the ancient settlements and graves of the 5th-4th millennia BC, like Polu-tepe and Alkhan-tepe.

As of 2009, I.N.Aliyev accomplishes archaeological excavations and research in Dubendi cave, Damba cemetery, Kelazagh, Gurgan-Damba in Absheron peninsula, vast archaeological materials obtained [Əliyev I, Əliyev C, 2015, pp.189-193].

Prosperous material and cultural remains are found as the result of D.L.Musaev's investigations in Sarkar-tepe monument (Khachmaz region) in 2011, and in Mollaburkhan-tepe in 2012-2014. Part of the archaeological material of the 4th-3rd millennia BC proves the economic and cultural relations of the local population with the Mesopotamian tribes.

In 2013, the Guba-Khachmaz archaeological expedition extensively studied the complex of Sandiq-tepe monuments in Guba district, and in the Gara Dundur fortress in Siyazan district [Xəlilov, 2015, pp.261-267].

Archaeological excavations and research in Shabran district were endured by Q.O.Goshgarly in 2013-2014, and by S.H.Ashurov in 2015-2016.

In 2015-2017, archaeological excavations were continued in Polu-tepe settlement of Jalilabad district, Mollaburkhan-tepe settlement between Gimil Gyshlaq and Mollaburkhan villages of Khachmaz district, Chaggaly-tepe monument in Aygunlu village of Shabran district. Meanwhile, in Guerdeser village of Lerik district, 24 soil tombs were revealed in Piboz-tepe necropolis of 5th-2nd centuries BC.

The Late Middle Ages Christian temples in Kilvar village of Shabran district and Kohne Khachmaz village of Khachmaz district are investigated and measured.

Results

Studies reveal that the Caspian region was initially settled 100-120 thousand years ago. Nearly 5-6 thousand years ago, the Caspian basin became an abode of tribal culture and ideology. Today, the archaeological excavations and explorations of the Caspian littoral regions are successfully continued. Undoubtedly, the history of the region will gain updates with the further studies.

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The problems of the historiography of the Khojaly-Gedebey culture

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Keywords: Problems of historiography of Caucasian Archaeology; European research on Caucasian archaeology; Khojaly-Gedebey-culture; Caucasus Collections

Introduction

This paper points out the research problems concerning the Khojaly-Gedebey culture which was prevalent in the South Caucasus during the Late Bronze and Early Iron ages. The author has been studying this culture for more than ten years; she has been carrying out research in museums, archives and stack-rooms in Azerbaijan, Russia, Germany, and Austria. In this paper she presents the problems she has found, and she brings them up to international discussion.

The first problem: the name of the culture.

In prior archaeological research, the cultural sites from the Late Bronze and Early Iron Ages in the central and southern Caucasus are known under the following names: "Central South Caucasian culture," "Ganja-Karabagh culture" and "Khojaly-Gedebey culture."¹ European scientists did not yet dedicate comprehensive studies to that culture - with the exception of Hanchar who subsumed all finds known at that time belonging to that culture,² and Schachner who, at least, compiled the available information,³ and also G. Kossack who pioneered contributions to the chronology in the Caucasus. They only occasionally mentioned it under all of the three names "Khojaly-Gedebey," "Ganja-Karabakh" and "Central South Caucasian culture."⁴

Based on the geographic range and the peculiarities of this culture with its distinct original characteristics, "Khojaly-Gedebey culture" is the most accurate designation for this culture.

The second problem: its geographic range should be redefined.

The Khojaly-Gedebey culture was widespread over the western regions of today's Azerbaijan, southern Georgia, the northern regions of today's Armenia and the north-west of Iran. Research carried out in recent years, especially by V. B. Bakhshaliyev, confirms that the Khojaly-Gedebey culture was also spread across southern regions of Azerbaijan. Research led by the Iranian archaeologist R. Hejberi shows that this culture was also spread to regions south of the Araz River. Therefore, further research in the South Caucasus and southern regions of Azerbaijan as well as in north western Iran is urgently needed to determine the role of this culture in history, which needs to be verified by recent analyses.

N. V. Minkevich-Mustafayeva classifies monuments of the Khojaly-Gedebey culture in the territory of Azerbaijan in the following three categories: Karabakh Mountain Group, Ganja-Goygol Group and Gedebey Group⁵.

¹ Goeyüshov and Martinov 1990, p.114

² Hanchar 1934; 1937.

³ Schachner 2002.

⁴ Kohlmeyer and Saherwala, 1983, p.53.

⁵ Minkevich- Mustafayeva 1956, p. 5.

Dealing with the **sources of the Khojaly-Gedebey culture** (conservation, statistics, research methods) brings us to another important problem.

Previously it was impossible to study the Khojaly-Gedebey culture systematically because many artifacts belonging to it were scattered across museums in Azerbaijan, Georgia, Russia, Germany, Austria, and France.

The chronology of the Khojaly-Gedebey culture should also be reviewed.

According to the latest research, the following chronology of monuments belonging to the Khojaly-Gedebey culture is proposed:⁶

MBA-LBA (Transitional period)	15 th century BCE
LBA I (Early stage)	14 th -13 th centuries BCE
LBA II (Development stage)	12 th -11 th centuries BCE
LBA III (Final stage, initial use of iron)	10 th -9 th centuries BCE
Iron Age (Widespread use of iron)	8 th -7 th centuries BCE

But the most important problem is historiography.

The historiography of the Khojaly-Gedebey Culture: ideological approaches, distortions, and research problems.

The research history of the Khojaly-Gedebey Culture can be tentatively divided into three chronological periods:

- 1.) the middle of the 19th century until the 1920s;
- 2.) the 1920s-1980s (Soviet Period)
- 3.) the 1990s until the 2010s (Post-Soviet Period).

This historiography covers the geographic regions of Europe, Russia (or the USSR) and the southern Caucasus (mainly in the Post-Soviet Period).

When looking at the historiography of the Late Bronze and Early Iron Ages in the Southern Caucasus written in the last 185 years in German, Russian and Azerbaijani it becomes quite obvious that there are several historiographies of the same period.

Until today many German scientists consider Virchow's, Bayern's and Belck's publications a basis for their own work. Without scrutinizing the erroneous information given by them is used for statements and publications. This becomes quite obvious when we have a close look at some catalogues of museums and exhibitions. Here are four examples from Germany:

1. **"Early hill tribes in Armenia and the Caucasus - Berlin investigations of the 19th century"** by K. Kohlmeyer and G. Saherwal⁷

2. **Kalakent.** In 1985 W. Nagel and E. Strommenger published a catalogue "Kalakent" which is listing the finds and the majority of the original letters written by Belck to Virchow⁸.

This book, however, was translated into Azerbaijani in 1999 thus multiplying the errors. The Azerbaijani version is not only incorrect in substance, it is also filled with coarse

⁶Hüseynova 2011,p. 20.

⁷Kohlmeyer and Saherwal,1983.

⁸ Nagel and Strommenger 1985.

grammatical and transcription errors; whereas other parts were not translated correctly, a great deal had been changed, distorted, twisted and fabricated⁹.

3. The most recent exhibition with exhibits from the Caucasus opened in 2008 in the Berlin Museum of Ethnology with the title "**Azerbaijan - Land of Fire. History and Culture in the Caucasus**"¹⁰.

4. Another example is the exhibition "**The Silver Horse - Archaeological Treasures between the Black Sea and The Caucasus**"¹¹, in which the Berlin Museum of Prehistory and early History once again presented investigations of the Caucasus collection.

Unfortunately in this catalogue the authors preferred to rely upon the old outdated interpretations without critical analyses or corrective notes. So it is full of historical, archaeological, and geographical errors.

Many German colleagues referred to these outdated interpretations until 2011. German and Azerbaijani colleagues reproduced the "facts" stated therein and created a scientific "truth" by repeating them time and again. After the publication of the catalogue on Kalakent these hypotheses and assertions have been reiterated in new dissertations.

Results

Since its beginning in 1829, the Caucasian archaeology has gathered a lot of problems. The Khojaly-Gedebey culture in particular is a research gap in the investigations of the Late Bronze and Early Iron Ages. Its geographic range, its genesis and its chronology are not sufficiently investigated yet. The conservation of the monuments, statistics, and research methods must be reviewed. When analyzing the original reports of archaeological excavations, it became known that a lot of artifacts discovered in the region of the southern Caucasus are not available in any local museum. It was noted that these materials are being held in museums in Europe, especially in Russia, France, and Germany. Most collections belonging to this culture are held in museums outside Azerbaijan as well and could not be completely investigated to date. Mainly we find these materials in the following museums: State Historical Museum and Pushkin State Museum of Fine Arts in Moscow, Hermitage Museum in St Petersburg, Georgian National Museum in Tbilisi, Museum of Natural History in Vienna, Museum of Prehistory and Early History in Berlin, National Museum of Archaeology in Saint Germain-en-Laye near Paris.

Discussion

All the above mentioned problems should be discussed in an open atmosphere by an international team of scientists who could find well founded answers to these questions. Since 2009, the author has been investigating the collections and finds belonging to the Khojaly-Gedebey culture in many museums in Baku, Tbilisi, Moscow, St Petersburg, Berlin, and Vienna. She has pointed out specific problems and made concrete proposals to solve them. Now she brings up the investigations of the Khojaly-Gedebey culture made so far for international discussion and invites the scientific community to co-operate with her.

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¹⁰ Schindelbeck 2008.

¹¹ Wemhoff and Kokowski 2011.

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Spiral-end belts in Iran:

Cultural Transformation with the Southern Caucasus

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Abstract:

The archaeological studies in the southern and western Caspian Sea region attest vast cultural and social transformation with the southern Caucasus region during the Late Bronze and Early Iron Ages. The archaeological finds from these studies are the basis our main understandings of this cultural contact. In this regard analysis of these material within a vast geographical and cultural area would shed light on the image of the ancient history of the region. One group of these material culture are metal belts which appeared by the first millennium BC in western Iran, Caucasus and Anatolia. This region had a great part in the emergence and development of different types of belt groups in the Middle East. The belt groups recovered from this region demonstrate various manufacturing techniques, decorative and wearing styles, each representing different geographical and social groups. A group of these belts have peculiar forms, ending to a double opposing spiral, and forming a quadruple-spiral while fastened at the front. These belts are mainly recovered from tombs, associated to warriors regarding the abundance of metal weaponry. It is while the identity of the group which were using these belt style is not known yet. This article aims to study these belts from a typo-chronological perspective, regarding the iconographical features on them and their manufacturing techniques. The results demonstrate that the belts could be associated to a specific group of warriors in southern and western Caspian Sea region and the Caucasus as well.

Key Words: *Spiral-end Belts, First Millennium B.C., Spiral-end/Part Culture, Southern Caspian Sea, southern Caucasus*

Introduction

Our knowledge of belts' history in Iran is mainly restricted to two articles by Moorey and Ryder (Moorey and Rydner 1967) and Calmeyer (Calmeyer 1989) who have provided an overall history of their development and distribution in Iran. Their work included early depictions of belts on artworks as well as introducing various complete and fragmented examples, either from controlled excavations or from unknown provenances. These belts are scattered in various museums and collections all over the world (Amiet 1984; Pittman 1984). However our information on metal belts, their development and evolution are rather restricted and a comprehensive study on them is still lacking. It is while according to archaeological findings metal belts were widespread during Iron Ages, late second millennium to mid-first millennium B.C. in western half of Iranian Plateau.

Among archaeological findings, metal belts are generally broad and long strips with various decorations rendered horizontally on them. These decorations are executed in different techniques. It must be noted that these findings could be confused by some other strips such as chariot strips or furniture decorations.

However, in some cases, the most prominent characteristic which distinguishes belts with other metal strips is their pierced borders to be sewn on a leather back or textile lining.

Regarding the archaeological findings the very early examples of metal belts in Iran have been introduced during early Iron Ages (Calmeyer 1989). As most of existing metal belts are coming from uncontrolled excavations it is somehow impossible to propose a chronological framework for them. While the late second and early first millennium seem to be the time span they were widely in use in Iran. Apparently, the process of production and use of metal belts was abolished completely by the middle of first millennium B.C. subsequent to the introduction of Achaemenid new costume style (Ibid). Although the period was rather short, during this time various metal strips have been recovered from archaeological excavations and there are many belts in the market which are attributed to Iran.

The belts are produced in different forms and techniques. An overall look at the existing belts would demonstrate various morphological, technical, decoration as well as wearing style groups among them. The Present study is going to date with a specific group among them, the belts with a totally different appearance, the belts ends in a double opposing spiral at both ends in the front. Regarding their terminals, this group would be referred to as "*spiral-end belts*" in this article. The questions addressed in this study are, whether there is a relation between these belts' morphological changes and their geographical distributions in Iran? Whether these belts are the characteristic of a specific geographical region in Iran or are imported objects from adjacent regions? In particular, this article aims to explore whether there is a relation between the emergence of these belts in southern and western Caspian Sea and the existence of the women warriors in the southern Caucasus? To do this the general characteristic of these belts has been presented and then the examples have been introduced according to their decorating techniques and geographical distributions based on existing examples. Then these belts have been studied within the vast group of double/quadruple-spiral style objects. It is while for a better understanding and interpretation of this research questions, more stratified samples and reliable data are needed.

General Characteristics

The belts are rectangular metal strips with their endings cut into a double opposing spiral. The small pierced holes at the base of the spirals are representing their wearing style. The material used to produce these belts is mainly bronze. Although it's rather difficult to determine their exact manufacturing techniques without comprehensive studies, it's more likely that at the very first the metal was hammered flat into the shape of a continuous strip and then the ends were cut into the shape of a double spiral with their tips turning their backs.

Attribution of these metal strips to metal belts is evidenced in two forms, the complete belts or in fragments found in situ on skeletal remains from archaeological excavations and their probable artistic representations on status's waist from Marlik.

Unlike highly decorated belts from Iran during Iron Ages (Moorey & Rydner 1967: 86), these belts are less decorated. Decorations on them have mainly included geometric and floral patterns and in some cases human and animal figures. These designs are executed in various techniques. The most current technique used to decorate these belts is in dotted technique, which is composed of an accumulation of small projections or big/ middle size blobs. There are some others decorated with incised lines by a chisel and in one case the belt is decorated by small stud projections.

The first known example of these belts, was a complete belt from Khurvin which was introduced by Ghirshman (Ghirshman, 1964). Within the next years Moorey introduced some other examples from clandestine excavations and attribute them to Luristan based on their decorations (Moorey and Ryder 1967: 86; Moorey 1971: 241- 245). Kleiss excavations at Bisutun yielded another belt with double spiral-end (Kleiss, 1989: 28, fig. 6). Neghaban excavations in Marlik yielded more spiral-end belts in situ in graves (Neghaban 1995; 1996). The last belt with double spiral-end has been recovered from Hasanlu warrior graves. This belt was first published by Muscarella (Muscarell 1988) and then by Danti and Cifarelli in the Hasanlu publication project (Danti & Cifarelli 2013).

Based on decorating techniques and motifs on them these belts could be studied in three types and sub-types. The “spiral end belts with decorations in dotted techniques, repoussé/ stud”, spiral end belts decorated in “linear technique”, and the “plain” examples.

The Belts:

Up to now 17 examples of belts, ended in double spirals, complete or in the fragment, are known. Among them, 11 have been reported during archaeological excavations. One belt from Khurvin (Ghirshman, 1964), one belt from Bisutun (Kleiss, 1989, fig. 6), 8 belts from Marlik (Negahban 1964: pl. II, IV, V, VIII; fig. 103-5, 107-115, 136-142; 1995: 98- 102, figs. 86- 91; 1996: figs, 876, 878, 881, 887), and a belt terminal fragment ended in a double spiral also, had been recovered from Hasanlu (Muscarella 1988: 49, fig. 58). The last 6 specimen and fragments, without exact provenance, are now scattered in various museums and private collections in the world. Prior to Marlik examples most of these belts were attributed to Luristan by Moorey and Calmeyer by comparing their terminals with some parallel endings in some bracelets and pin heads said to come from Luristan (Moorey 1967: 87; 1971: 243; Calmeyer 1971: 692; Zahlhaas 2002, figs.91, 161, 162, 64).

These belts are rectangular metal strips¹ with dimensions varying from 6 to 8.6 cm in height² and from 46 cm reaching to 60 cm. in length, but all of them end in “double spiral terminals” which is their prominent characteristics.

An overall look at these belts would demonstrate that, other than their peculiar endings, what is making them different from other contemporary metal belts, is their plainness or simple decorations. According to Moorey and Rydner this is a rare characteristic among the metal belts in the western half of Iran during Iron Ages (Moorey & Rydner 1967: 86). In contrast to the belts from northwestern Iran, Ziwiye, Ardebil and Hasanlu, and western Iran, Luristan which are elaborately decorated, there exist plain examples among spiral-end belts. Whether this is because of their practical functions or their mass production or whether it is their local characteristics in a specific region requires much more examples from controlled excavations.

Eight spiral-end belts have been recovered from 4 tombs at Marlik, which included eight fragmented examples made of a thin bronze sheet. Among them there are 4 plain belts, with no decoration (Figure. 2), three from tomb 47 and one from Tomb 52 (Negahban 1995: 98, figs. 87-88, 90- 91). There is a parallel example to these belts in Ashmolean Museum. This belt has been attributed to Luristan by Moorey (Moorey 1971: 241, fig. 460). He also attributes the British Museum plain spiral-end belt to Luristan

¹ . In some examples this heights are varying, as in the middle are broader and tapering gently to the both ends.

² . It's except Marlik examples because Negahban has not mentioned their heights.

although he points out the absence of “highly decorative features” in these belts in contrast to Luristan and northwestern Iran examples (Moorey & Rydner 1967: 86).

Decorated spiral-end belts have simple decorations executed in three techniques- dotted, chased or repoussé linear and a mixture of them. The excavated decorated belts from Marlik (Negahban 1995: 97-98, figs. 86, 89; 1996: Pl. XVI, 185) are all decorated in dotted techniques (Figure. 3). Their designs are composed of a set of blobs of various sizes in various orders such as rosettes or geometrical patterns. These three belts are coming from two tombs, the most elaborately decorated belt is the belt at Marlik comes from tomb 26, a band of rosettes, composed of a small projecting blob at the center which is surrounded by four or five blobs covers its middle and a band of parallel vertical lines consist of three tiny dots decorates the borders while the whole surface of this belt is filled with small dots (Negahban 1995: 98, fig. 86). Another belt fragment, 31.0 cm, is decorated with a single row of repoussé dots along its edges (Negahban 1995: 97, Pl. XVI. 185).

The next belt, from tomb 52, is a rectangular shaped strip and seems to be the broadest belt among Marlik spiral-end belts. It is decorated with a band of short vertical lines composed of three tiny dots in upper and lower edges and four dots at the both ends while the whole surface of the belt is filled with tiny dots (Negahban 1995: 98, fig. 89). Moreover there are some broken pieces of bronze sheets, presumably, belts, have been recovered from Marlik tombs which are decorated in dotted technique (Negahban 1995: figs. 94- 96). The belt recovered from Bisutun excavations also is decorated in the same technique as the Marlik decorated belts, the borders of the belt is decorated by big blobs with four smaller blobs in their intervals (Kleiss, 1989: fig. 6)

The next comparable belt to these examples is a complete belt without exact provenance. This belt is now in a private collection possession in Oxford³. Moorey attributes this belt to Luristan with “no doubt” (Moorey 1971: 243). Like Marlik belts, this belt, has been decorated in dotted techniques. Dots on this border are ordered in 4 parallel rows along the belt length (Moorey & Rydner 1967: Pl. Ic; 1971: 243), this belt doesn't have the pierced holes at the base of its spiral ends instead it has two holes in both upper and lower edges.

Among the spiral-end belts decorated in dotted techniques, there are two belts in Ashmolean Museum with decorations executed in somehow different techniques than the previous ones. On these belts along dots and blobs, there can be seen some rather stylized human figures rendered in repoussé lines. On one of them, there appear two stylized naked male figures with arms raised on both sides (Figure 4). One of these figures is rendered standing on an animal. The remaining part of the belt's surface is decorated with blobs in various orders -two blobs standing vertically and three other making a triangle at one end and two standing vertically on the other. On the opposed sides, there are three rows of vertical lines of 6 blobs and the borders are decorated with a band of chased crossed motifs. In one end there remains a rivet (Moorey 1971: 241- 2). The different characteristic of this belt is the technique in which these designs have been rendered. The human figures and the circles have been executed in repoussé linear technique. The periphery in both figures and blobs have been margined by tiny dots. It seems that the smith first rendered the figures then surrounded them by tiny dots. According to its decoration this belt may belong to a later time than previous examples.

The next Ashmolean belt contains three naked male figures with the same gesture –raised hands on both sides -two at both ends set vertically and the third parallel to the ends between two panels of four blobs.

³ . This belt is in the possession of Mrs. R. Maxwell-Hyslop.

The whole surface of this belt is decorated by small pressed holes (Moorey and Ryder 1967: 86, Pl. 1a fig. 2; Moorey 1971: 242, fig. 462).

The last belt in Ashmolean Museum is totally different in both design and execution techniques from the all above parallel belts. The belt is framed by a band of dots arranged in triple lines. Within this frame, there are chased grazing gazelles on both sides of a central tree (floral motif) (Figure.5). Moorey, compares its morphological characteristics such as hair style, ribcages, ringed horns, and the gazelle's short tuft ending tails and the tree with the figures rendered on Ziwiye ivories and Neo-Assyrian artworks (Moorey & Ryder 1967: 86, Pl. 1b, fig.1; Moorey 1971: 241 fig. 461). Furthermore, the emphasized ribcage is comparable to the Uartian morphological characteristics.

The last example, according to its manufacture and decoration techniques, falls in a more recent group. This belt is a fragment recovered from archaeological excavations from Hasanlu in northwestern Iran. This belt terminal, a fragment of which only 7.01 x 7.01 cm is remaining is technologically and morphologically different from the belts described above. In Hasanlu belt the metal sheet is not cut into the shape of a double spiral but the spiral is made of a wire coiled to the shape of a double spiral and attached to the belt's end by a stud. The surface of the belt is covered by studs in various sizes (Muscarella 1988: 48- 49, figs. 55- 57; Rubinson 2012a, 107- 109, fig. 9; Danti and Cifarelli 2013: Pl. 5a) (Figure 6). This decorating technique had been discussed by Rubinson as a "*local style of the belt at Hasanlu*" (Rubinson 2012a: 110).

Other Double-Spiral Metal Objects from Iran and other regions

Studying these belts from just a morphological perspective can only provide a typological changes and somehow technological or executing techniques of these objects. It is while a wide spacio-temporal analysis of them would provide more information on the cultural contacts and exchange within the Middle East and even a vast geographical region in the ancient world. As well as to propose a distribution and the significance of existence of such objects among the archaeological findings.

Although this kind of belts have not been reported from other sites except Marlik and Bistoun and Hasanlu in Iran, but their prominent spiral end terminals, which are not easy to execute compared to the simple rectangular belts, relates them to a broader group of the objects, the double spiral tradition of the metal objects which have been in use since the third millennium B.C. from sites in Aegean lands, Anatolia, Iran, Central Asia, and the Indus Valley, suggesting that the transmission of artistic motifs (both their forms and their meaning) occurred along the trade routes that linked the regions (Reade, 2003: 129, cat. 77).

The objects of this group could be classified in four main groups:

- **Quadruple-spiral beads:**

These beads are made of two pieces of gold wire twisted around each other to form a vertical center. The ends of the wire are coiled into four separate cones, and the resulting quadrant spiral is fixed into a circle of gold.

In Marlik graves about 13 of these beads have been recovered complete or in fragment (Negahban, 1996: 20, 143, Pl. 50, Pl. XXVI B, 21,164, fig. 15, Pl. 78). A number of these beads have been recovered in Royal Cemetery of Ur IIIA tombs in Mesopotamia (Reade, 2003: 129- 130, cat. 78), and Troy III, dating to the third millennium BC (Schaefer, 1948: fig. 168, nos. 20, 132, p. 292; Matthiae, 2003: 185; Reinholdt, 2003: 266, 170a- 170b). Three quadruple-spiral and one half-quadruple-spiral bead have been recovered from a temple at Tell Brak. Two of the quadruple beads have spiral forms made from heavy round wire; the other is made of a flat sheet (Hasen,

2003: 233, cat. 159). Another bead of this type have been recovered from Tomb 20 at Ashur and attributed to the Gut-Gudes period (ca. 2250- 2100 BC) by Mawell- Hyslope (Maxwell-Hyslop, 1971, fig. 460, p.71).

- **Double Spiral pendants:**

These objects are made of a coiled wire to the shape of a double opposing spiral. These pendants are lacking among the Marlik grave goods. Double spiral pendants have been reported from Tepe Hissar III (Schaefer, 1948b, fig. 239, nos. 16, 193, p. 448) another example which is dated to a later period, ninth to seventh period, recovered from a hoard from Tepe Nush-i-Jan (Maxwell-Hyslop, 1971: Pl. 252, p. 267, Stronch, 1969, Pl. VIIIa, p. 15), which possibly might be a heirlooms from the third millennium BC (Arzu, 2003: 244). Another double spiral pendant from the Cemetery at Ur from a very young child's grave (Reade, 2003: 129, cat. 77). Double-spiral pendants are common at the Early Bronze Age site of Eskiypapar in central Anatolia, where in one grave a necklace of 24 gold beads of various sizes was discovered (Tosi & Lamberg-Karlovsky: 2003: 352, fig. cat. 246). It is while parallel examples have been reported from Causacuc regions such as Maral Deresi and dated by Schaefer to 1200 BC. (Schaefer, 1948, fig. 275, nos. 1, 9, 214, p. 448). The very similar example recovered from Kizilburun necropolis dating to the Middle Bronze Age (Veli Bakhsheliov: 2007:165, fig 26. 22) another example from Kolani necropolis (Veli Bekhsheliov, 2007: 222, fig. 95. 3) and the last one from Veri in Russian Talysh (Morgan, 1896).

- **Double Spiral Headed pins:**

Objects of this group was not recovered from Marlik tombs. Spiral-heads pins have also been recovered in third-millennium contexts in Central Asia at Anau, Mundigak and Parkhai II, and in the Insud Valley at Chanhudaro and Mohenjoradro. Tepe Hissar a site in north-central Iran just south of the Caspian Sea sharply pointed pins and wands both with a double-spiral motifs occur as early as Hissar II (ca. 3000- 2500 BC) but are more frequent in Hissar III (ca. 2500- 2000 BC). (Tosi & Lamberg-Karlovsky: 2003: 352, fig. cat. 246). Pins with similarly decorated double-spiral heads have been recovered at Shahr-I Sokhta and at Tepe Giyan in southeastern and western Iran, respectively (Tosi & Lamberg-Karlovsky: 2003: 352, fig. cat. 246). The next pin of this type have been recovered from Vaske necropol in Iranain Talish (???) The next examples are attributed to Luristan (Zahlhaas 2002: figs.91, 161, 162, 64).

Open-Loop flat bracelets with double-spiral ends:

These flat bracelets are very similar in the shape to the bronze belts. Until now two of this objects have been published. One from Marlik excavations (Negahban, 1996: 170, 5.8 cm in diameter, Pl. 83. Fig. 359). The next similar example coming from calndstine excavations is attributed to Luristan. This bronze open-loop band had a plain surface with no decorations. (Zahlhaas, 2002, fig. 64)

Moreover these objects there are some others which cannot be placed within these categories. The bracelet from Troy is one of these objects, the bracelet is embellished with more than 50 double spirals attached to the band (Tosi & Lamberg-Karlovsky: 2003: 352, fig. cat. 246; Reinholdt, 2003: 255, fig. 76), this could be dated to Early Bronze Age, ca. 2500- 2300 BC (Reinholdt, 2003: 255, fig. 76)

Discussion and Conclusion:

The significance and application of these double spiral style objects is not easy to determine. It is while they could be classified as personal ornaments which characteristics has made them appropriated for gifts exchange or tribute which are now mainly recovered from contexts such as elite burials, temples and palace treasuries.

The artistic representations of these objects too represent a ceremonial or religious function for them in the ancient world. A female terracotta seated figurine from Altyn-depe in western Central Asia, belonging to the Namazga V (ca. 3rd millennium BC), has two tresses in front form a double opposing spiral form resembling the pendants of this type (Tosi & Lamberg-Karlovsky: 2003:357, fig. cat. 250a). The abstract iconography of a female figure incised on a slab is recalling the double spiral pendants. This slab which was found under an altar dedicated to the goddess Ninhursanga, one of whose functions was to preside over child birth, dating to about 2300 BC might have been used in the cults (Tosi & Lamberg-Karlovsky: 2003: 352, fig. cat. 246). Similar schematic representations of the female form are found only on stone figurines from the Levant, the Aegean area, and western Anatolia (Marqueron, 2003: 163, cat. 106). On a cylinder-seal from Syria, made of arsenical copper for a burial in Anatolia, a quadruple spiral has been depicted before a deity, which has been interpreted as the symbol of flowing water and possibly associated with the goddess Nanshe, daughter of god Enki (Arzu, 2003: 243- 244).

The appearance of double/quadruple-spiral motifs in association to female deities as well as female iconography in the Middles East, is representative of their ritual significance for the women. As moreover their artistic representation, the recovered double/quadruple-spiral objects are generally coming from graves attributed to female. The double/quadruple-spiral bead from Royal Cemetery at Ur is from queen Paupi (Woolley, 1934, 574). The double/quadruple-spiral style beads and pendants from Marlik are attributed to the women graves by Negahban, although the skeletons are so badly preserved that their sex could not be determined and so the graves with much jewelry and a few weapons are taken to be for women and the ones with more weapons and a few jewelry as men's (Negahban, 1996: 14- 20). Interestingly no double/quadruple-spiral style bead or pendant have been recovered from the graves which contained double-spiral end belts.

Among all the spiral-end/part objects the spiral-end belts were most probably northwestern Iranian objects (Figure 1). Despite Moorey who attributes these belts, based on their iconographical features, to Luristan traditions, the existing data from archaeological excavations in Marlik, Khurvin and Bisutun demonstrate a geographical distribution in the southwestern Caspian Sea and its nearby regions in Iran for them. In these objects, the repoussé dots/blobs have been arranged in geometric order or rosette forms. Moreover the waistbands of the naked male figurines from Marlik have been decorated by a set of "repoussé" blobs/dots. Negahban believes the belts depicted on the waist of some of the naked male figurines found in Marlik tombs, also represents a set of blobs/dots on their whole surface, although their ends are not represented. On the other hand, Negahban believes, the depicted males and females on some vessels from Marlik also are wearing belts with the same decorations (Negahban 1995: 97). Regarding these data the belts with parallel decorations which Moorey attributed them to Luristan (Moorey 1971: 243) more probably might have been produced and imported from a region at the southwestern or western Caspian Sea, such as Marlik.

In the case of the Spiral-end belts it must be mentioned that the iconographical and decorating techniques on them could provide a key to their attribution to a geographical region or a cultural group.

In general despite the simplicity of the decorations on these belts, the existing examples could be classified in three different groups:

- Spiral end belts without decorations.
- Spiral end belts with decorations in “dotted techniques: repoussé bosses/ studs”
- Spiral end belts decorated in “linear technique”,

Most of these rather simple belts had been recovered from Marlik, Bisutun and Hasanlu warrior's tombs, or in tombs which contained other objects of arms and armors.

Apparently using dots or blobs, or "*repoussé bosses*", in decorating metal objects was a specific characteristic of the period. This technique, not only used on belts but also could be seen on other objects of personal ornaments or jewelry. Objects with this decorations found not only in Marlik (Negahban 1964: Pls. 54, 55) but also from Hasanlu (Rubinson 2012b: fig. 27.02), Amlash (Culican 1964: Pl. VIII. b, Pl. IX.) and in western Iran and even more widely in southern Caucasus (Rubinson 2012a: 110) and in Urartian sites⁴ dating to 1000-800 B.C. (Iron Age II period).

Based on archaeological findings the early examples of these belts have been produced in a region at the southern borders of the Caspian Sea in centers such as Marlik. While the belts with unknown province which had been attributed by Moorey to Luristan may, chronologically, are the next examples of these belts.

Even though Muscarella believes the three decorated belts in Ashmolean Museum with spiral ends are forgeries regarding their decorations. Or even in some cases, as the belt with incised gazelles, the belt is ancient while the decoration is done in modern times. He just considered the plain examples as the ancient belts and the decorated ones as the modern forgeries⁵ (Muscarella, 2000: 92). It is while among the spiral-end belts which are recovered from archaeological excavations from Marlik (Negahban 1995: 97-98, figs. 86, 89; 1996: Pl. Pl. XVI, 185), or Bisutun (Kleiss, 1989: fig. 6), the belts are decorated by panels of repoussé dots or blobs or rosettes. In the case of the two belts in Ashmolean Museum with male repoussé figures it must be noted that although the gesture is not known in Luristan, they recall the Khurvin naked bronze figurine wearing a belt, with the same gesture, the hands raised on his sides. On the other hand the surface of these belts is covered with small repoussé dots or blobs as the belts from Marlik or Bisutun. The decorating technique on these belts may be the predecessor of the technique used in decorating the belt in the Louvre Museum. The various scene have been depicted on this belt in dotted technique (Figure 7). The belt is said to be from Amlash (Figure 1) in the Gilan province, a region located in the southern Caspian Sea. While Amiet attributes the origin of the scene and the technique to Caucasian cultures (Amiet 1968: 257, figs. 4-6).

The last example of belts in this group in Iran had been recovered from Hasanlu IV (Iron Age II (1050- 800 B.C.)) warrior's tombs. This belt is totally different from other belts in Hasanlu which are decorated by repoussé blobs/bosses. This belt had been placed in the objects of local style at Hasanlu because of its

⁴ . On some Urartian belts there are “repoussé” blobs composing rosettes or the surface is filled by blobs see for (Tasyurek, O., A., T., 1975, *The Urartian Belts in the Adana Museum*, Ankara).

⁵ . such statements require much more detailed studies.

stud decorations, is more likely, as its spiral-end relates it to the northern/northwestern Iranian belts during Iron Age II.

As no spiral-end belt has been reported from any other region yet it is more likely that they are the characteristic of the Iron Age II belts in northern and northwestern Iran. Although their forms and decorations show some Caucasian and Urartian ties, they are north/northwestern Iranian objects of Iron Age II period, which first appeared in Southern Caspian Sea regions such as Marlik. The belts probably moved westward to the regions such as Ziwiye and Bisutun. Although Moorey attributes the belts to Luristan as he mentions the details are recalling the animals and the floral motifs represented on Ziwiye ivory objects (Moorey & Ryder 1967: 86, Pl. Ib, fig.1; Moorey 1971: 241 fig. 461, 241 fig. 461). Apparently the last examples had been produced at Hasanlu which according to Rubinson appear to have their origin in the southern Caucasus (Rubinson, 2012a).

At the end it must be mentioned that double spiral end belts could provide some clues about the existence and the distribution of the women warrior groups in the southern and western Caspian Sea as well as the southern Caucasus in the case they would be the subject of a more detailed and comprehensive studies.

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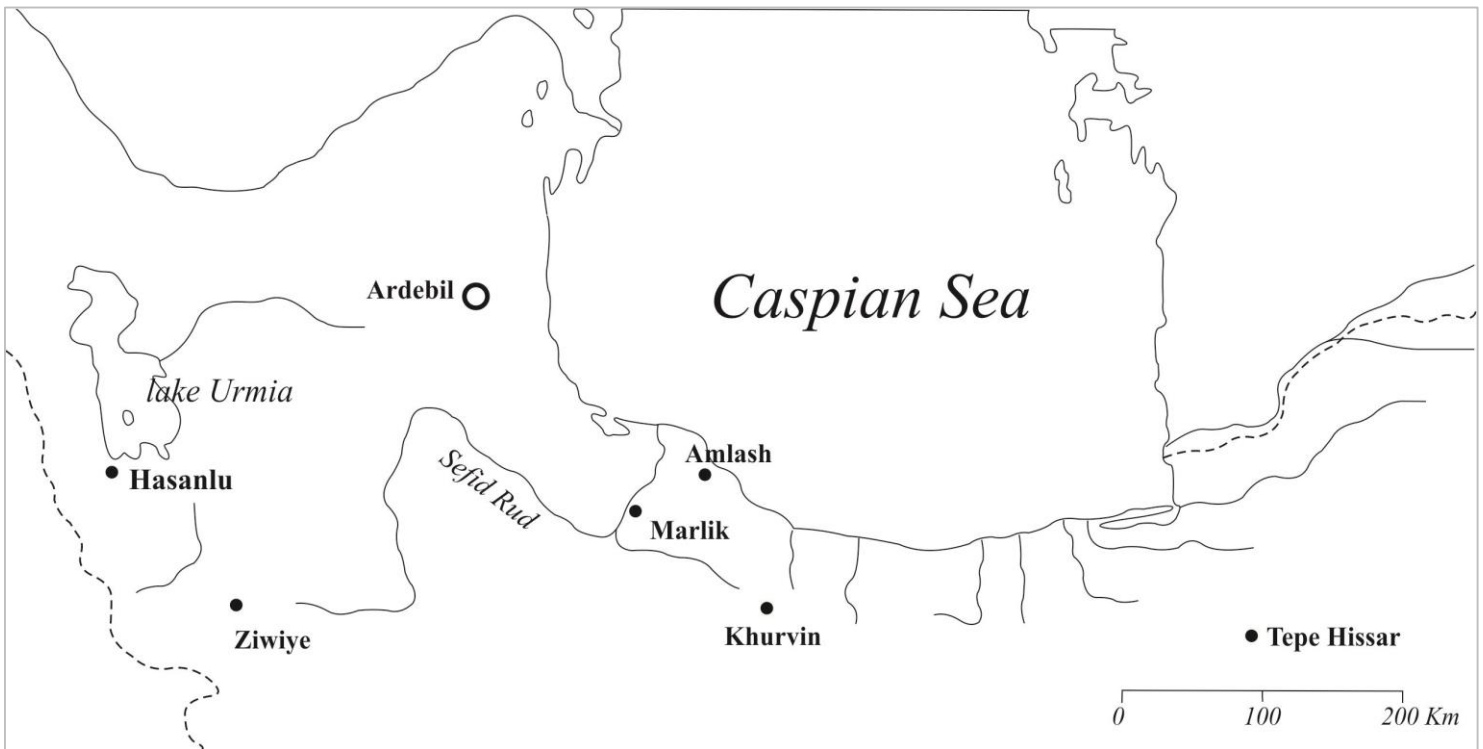


Figure 1: Geographical Distribution of Spiral-end Belts and dotted technique objects in Iran

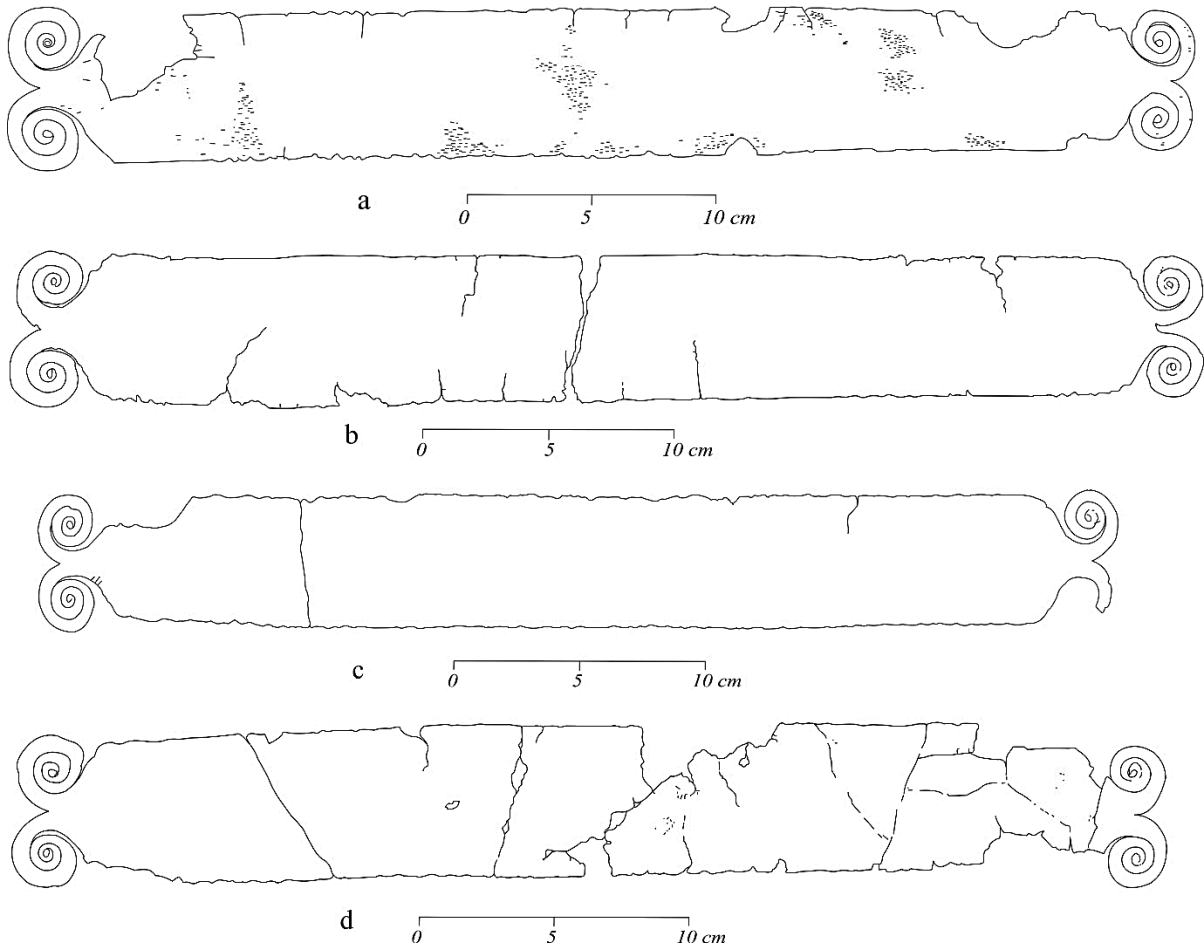


Figure 2: Plain spiral-end belts, Marlik (Negahban 1995, figs. 87, 88, 90, 91);
the sketches has been redrawn

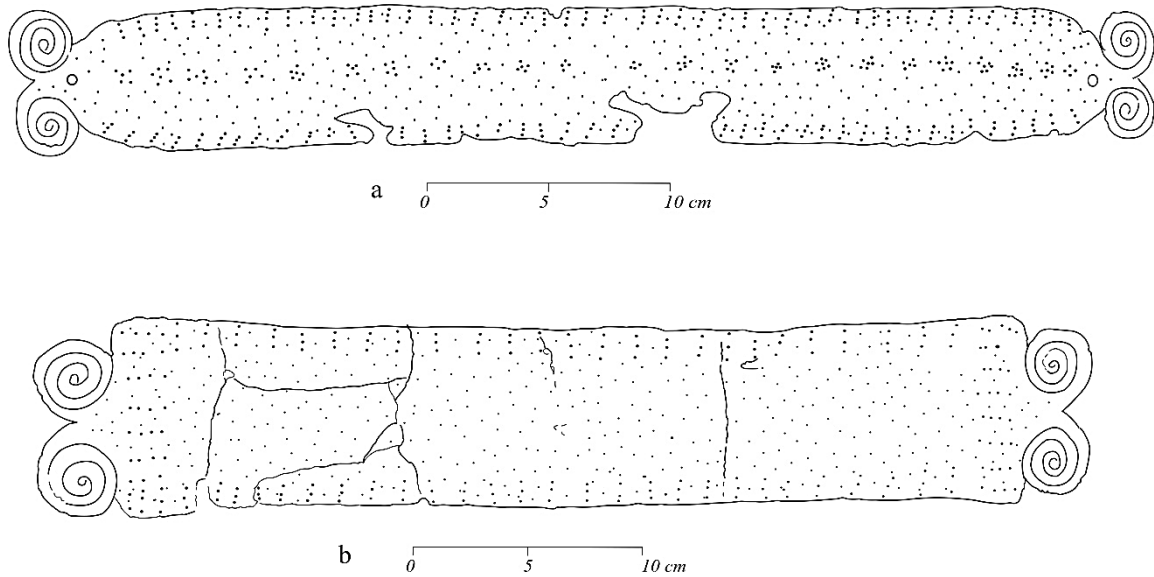


Figure 3: Spiral-end belts with repossé bosses decorations, Marlik, (Negahban 1995: figs. 86, 89)
the sketches has been redrawn

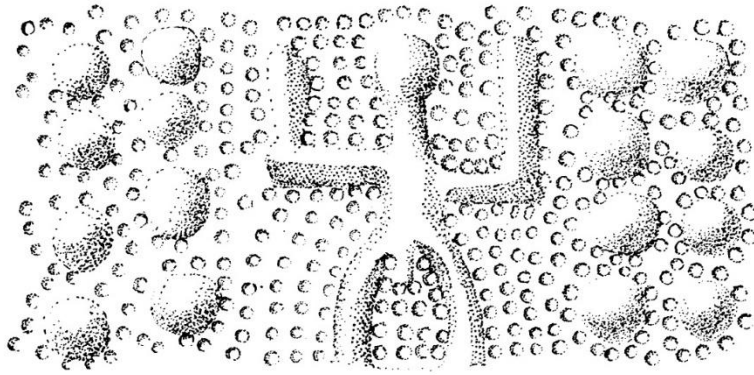


Figure 4: a male figure with raised hands on a belt with unknown province (Moorey 1967: fig. 2).

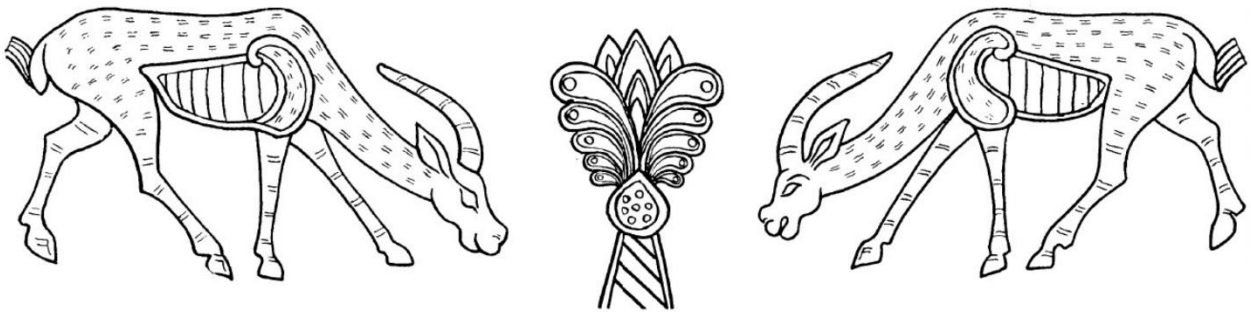


Figure 5: animal and floral motifs rendered on a belt with unknown province in Ashmolean Museum (Moorey 1971: fig. f).



Figure 6: a spiral-end fragment decorated with studs, Hasanlu (Muscarella 1988: fig. 58)

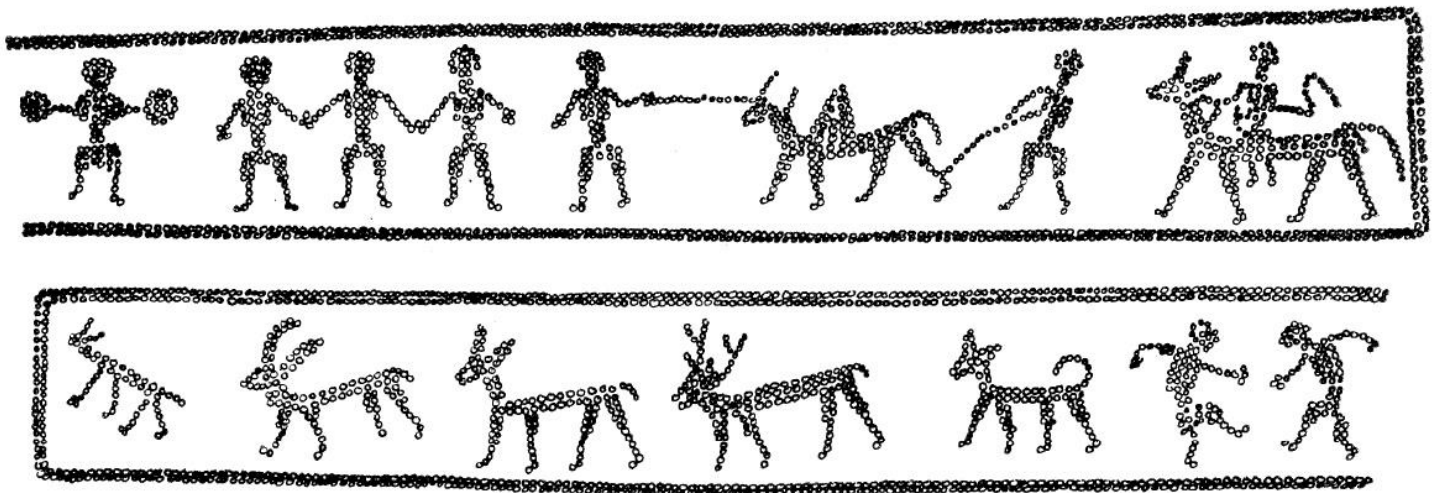


Figure 7: scenes depicted in dotted technique on a belt from Amlash, (Amiet 1968: fig. 6).

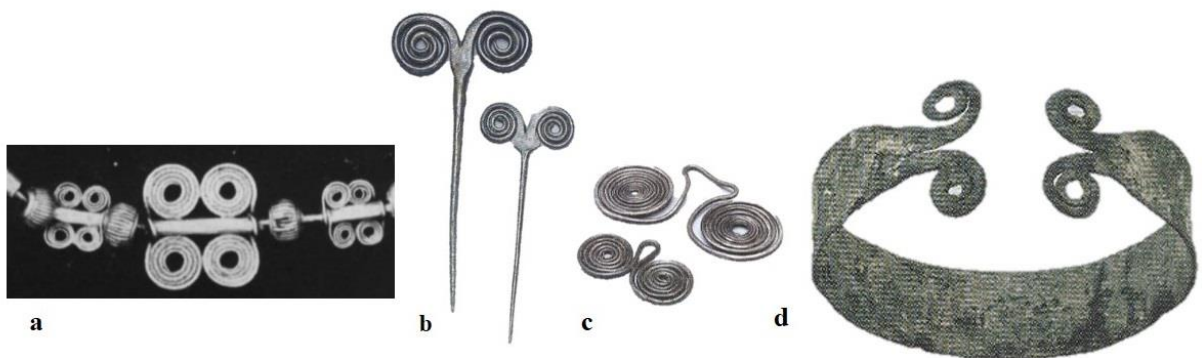


Figure 8: Spiral-end/part objects: a. spiral-end beads Ziwiye (Culian 1964: Pl. VIII. a), b. pin, c. hair bead, d. bracelet: Luristan (Zahlhaas 2002: figs.91, 161, 162, 64).

Current status of archaeological research in Eastern Caspian region

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Keywords: Eastern Caspian, Final Pleistocene, Early Holocene, Mesolithic, knapping technology, geometric microlith

Introduction

Caspian Sea is situated in the Centre of Eurasia; it is surrounded by Zagros, Caucasus, Turan – regions of important routs of human migrations in the past. And Caspian Sea was a natural barrier which determined a likely migration route for Paleolithic-Neolithic human populations. Because of its central geographic location, the area also channeled culture, technology, and other forms of exchange between adjoining regions Europe, Near East, Central Asia from the first modern human occupation into Eurasia up to the present day.

Unfortunately not all areas of Caspian region are studied evenly; the territory of Eastern Caspian is very poorly understood. Previous investigations of prehistory in the Eastern Caspian were conducted in the middle of 20th century by A.P. Okladnikov (Okladnikov, 1954; 1966) and later by G.E. Markov (Markov, 1966) and also these studies greatly suffer from the absence of absolute radiocarbon dates. The researchers studied (Djebel, Dam-Dam-Cheshme-1, 2, Kaylui, Kuba-Sengir). They suggested that this industries belong to Mesolithic industries with geometric microliths were usually suggested to represent direct migrations from the Zagros and South Caspian. Later S.K. Kozłowski (Kozłowski, 1996) proposed to include these materials in Trialetian culture, characterized by massive geometric microliths (length 30–60 mm), which vary in the chronological sequence: trapezoid / asymmetrical triangle / lunate.

A re-studying of the materials from Okladnikov's excavations and Late Quaternary sections of the region has recently been carried out by our team. This presentation focuses on the new preliminary results about the role of Eastern Caspian region in ancient human history.

Materials and methods

We analyzed archaeological collections from the Dam-Dam-Cheshme-2, Kaylui and Kuba-Sengir sites. For each site, we aggregated information concerning geological context and stratigraphy from published materials.

For each collection, we conducted lithic attribute analysis (after Monigal, 2002) with special attention to technologically and typologically significant attributes, including typology of the dorsal surface, ventral surface, proximal edge, striking platform parameters, lateral profile, cross sectional morphology, and metric characteristics. To estimate the age of undated tool assemblages, we conducted detailed typological comparisons with other well-dated Central Asian and Zagrosian archaeological assemblages and produced a hypothesized chronology for the considered materials.

Results

Based on technological attributes we identified a few techno-typological stages of lithic industries development. Flint was the most commonly utilized raw material During the Final Pleistocene – Early Holocene transition time. The predominant primary reduction strategy was aimed at blade and small blade production. The tool kits from this period contain mostly geometric microliths. The lunates and triangles are characteristic for early complexes, the triangles and trapezoids – for late complexes. The length of the lunates is 20–50 mm, triangles and trapezoids 15–25 mm.

Discussion

The preliminary results of the research demonstrated that the shape of geometric microliths varies in the sequence: lunate / triangle / trapezoid. The obtained data do not correspond to the Trialetian variability of geometric microliths. At the same time the southern Caspian (Komishan, Ali Tepeh) sites show the same trend as in Trialetian of change in type of geometric microliths. Also the similar kind of the trapezoids are presented in the late Mesolithic-early Neolithic materials in Mangishlak peninsula (Astaf'ev, 2014). Consequently, the obtained results actualizes the general revision of the archaeological materials of the Southeast Caspian and in particular Trialetian. General distribution of the currently described sites suggests clear influence of Late Quaternary Caspian sea transgressions on migration patterns of ancient humans in Central Eurasia. Thus, in Western Turkmenistan all known sites are located close to the maximum position of Late Khvalynian transgression the Caspian Sea (Yanina, 2016). Further research of connections of ancient human migrations with Caspian Sea region environmental change is of high demand with focus on highstands of transgressions and formation of the Uzboi and Manych spillways as barriers for the main routes.

Acknowledgements

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FEATURES OF HABITAT OF NEOLITHIC SETTLEMENTS OF AZERBAIJAN IN ACCORDANCE WITH PALYNOLOGICAL DATA

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Keywords: Neolithic, Holocene, palynology, natural conditions, climate

Introduction

Habitat – the landscape and climatic conditions, as well as flora and fauna has played an important role in the life of ancient man. This condition has been a key factor, defining the boundaries of settlement of a human and having a strong impact on the properties of the economy and life of that period.

Relatively cold and very dry conditions at the end of the last glacial period 20-18 thousand years ago (Valdai, Wurm) (Velichko, 2009) led to the fact that almost all the plains and foothills in Azerbaijan were covered with desert vegetation (Taghiyeva, 2012). The rivers of this region were shallow, while the pastures were unproductive, and relatedly, there were no conditions for the existence of big animals, on which the ancient man used to hunt. Therefore, at that period the Caspian regions were less attractive for humans.

In the period of about 16-15 thousand years ago, warming and melting of the cover- and mountain glaciers began, and the amount of precipitation increased. Waters in rivers dramatically became larger (Belyaev & Georgiadi, 2009.), and during floods riverbeds were fertilized with silt, and relatedly, foundations for future river civilizations were laid.

Shomutepe, an ancient settlement in the Caucasus associated with plant-growing- and cattle-breeding which originated 7510±70 years ago, for the first time was discovered by I.G.Narimanov in the vicinity of Akstafa city (Narimanov, 1987). Later, a lot of settlements related to Shomutepe as well as other ancient plant-growing- and cattle-breeding cultures were discovered, which date back to the 6th-4th millennia BC. These settlements were emptied and “disappeared” even before the end of the 5th millennium BC, and later, at the turn of the 5th and 4th millennia BC, no humans settled here for several centuries (Ahundov, 2000). Plant-growing- and cattle-breeding cultures appeared again in Azerbaijan in the second quarter of the 4th millennium BC (Narimanov et al, 2007).

Materials and methods

In the emergence and disappearance of material cultures, the main role is played by natural factors, mainly by climate change, and also anthropogenic factors, namely economic activity of humans. The object of the study is the deposition of the cultural layers of the Neolithic settlements – Chalagantepe, Leilatepe, Farmantepa, Alkhantepa, Uchoglan, and also the Soyug-Bulag mound that had been in Azerbaijan since the second half of the 5th millennium BC up to the 3rd millennium BC. Settlements date back to the time of the Leilatepe and Kura-Aras cultures. The Leilatepe culture existed until the end of the 4th millennium BC (Ahundov, 2000), after which it “disappeared”. In the second half of the 4th millennium BC, carriers of the Kura-Aras culture came to Azerbaijan. For several centuries they coexisted with the humans of Leilatepe (Ahundov & Almamedov,2009), and then lived here for another thousand years – until the end of the 3rd millennium BC. (Munchaev, 1975).

The studied sections of Neolithic settlements are located on the plains (Karabakh, Mil and Garayazi) of 0–400 m of height, in the zone of modern semi-desert landscapes. These territories concentrated the bulk of the population during its settlement, and the landscapes here were subjected to the greatest changes. At present, it is a zone of modern wormwood-

saltwater and ephemeral semi-deserts on gray and light-chestnut soils. The annual precipitation is 200-500 mm, while the average temperatures of July and January are 25-27° and 0-3° respectively.

The palynological method is the most effective for the reconstruction of the human habitat. Sampling for analysis was carried out by each 5 cm in the cultural layer of each settlement. Cameral studies and chemical treatment of spore, as well as pollen samples were carried out in accordance with the method of maceration of V.P.Grichuk. Pollen and spores were viewed using temporary preparations through the “Carl Zeiss” microscope while the enlargement was x400 and x600 with simultaneous photographing.

The definition of spores and pollen was based on the use of pollen atlases (Kuprijanova & Aleshina, 1978) and electronic atlases of modern pollen and spores (<https://www.polba.ru>; <https://oldweb.geog.berkeley.edu/ProjectsResources/pollenKey/byType.html>; <https://www.paldat.org/>). Statistical processing of the results of the determination and registration of microfossils was carried out by the method of counting of Karevskaja (1999).

Results

The settlement of Chalagantepe (middle of the 5th millennium BC (6560±60 years ago [22] is located on the Karabakh plain. The spore-pollen diagram is characterized by the predominance of grass pollen (60-100%), at the beginning – *Gramineae*, then – *Polygonaceae*. Pollen of *Chenopodiaceae*, *Artemisia*, and *Ephedra* are rare. As for woody plants, domination belongs to pollen of *Pinus s/g*, *Diploxylon* (70-90%) and *Carpinus* (up to 20-25%), while *Juglans* and *Fagus* are rare. No spore is available.

The settlement of Alikemektepesi (the last quarter of the 5th millennium BC) is located on the Mugan plain. The pollen of grasses of *Compositae* and *Chenopodiaceae* prevail. The rarely found pollen includes *Fabaceae*, *Cyperaceae*, *Ranunculaceae* and *Quercus* prevail.

The settlement of Leilatepe (second quarter to the middle of the 4th millennium BC) [23] is on the Karabakh plain. Pollen grasses predominate up to 100%. The pollen of woody plants of *Pinus*, *Carpinus caucasica* and *Ulmus* is rare. The spores are represented by mosses. There are two palynozones. In the lower palynozone, pollen of *Malvaceae* (60-70%) and *Gramineae* (20%) prevail, whereas the upper palynozone is dominated by pollen of *Chenopodium botris* L., *Convolvulus* and *Polygonaceae*.

The settlement of Farmantepe (second half of the 4th millennium BC – 6-5.9 thousand years ago) is located on the Karabakh plain. The spore and pollen spectrum is dominated by the pollen of herbaceous plants (67 to 96%) with prevalence of *Chenopodiaceae*. Pollen of tree species is lesser (4-29%) and represented by *Pinus eldarica*, *Salix*, *Tamarix*, *Juniperus*, *Pistacia*, and *Morus*. Three spore-pollen zones are distinguished.

The settlement of Alkhantepe (second half of the 4th millennium BC) [7] is located in the southern part of the Mugan plain and the foothills of the Talysh Mountains. Pollen grasses, including *Compositae*, *Chenopodiaceae*, *Artemisia*, and *Gramineae*, as well as motley grass are spread much (50-95%). Pollen of woody plants (1-38%) is represented by *Pinus eldarica*, *Populus*, *Ulmus*, *Carpinus*, and *Salix*. Spores of *Equisetum*, *Polypodiaceae*, and *Osmunda* are rare. There are 4 palynozones here.

Soyug-Bulag Mound (the last quarter of the 4th millennium BC) is located on the Garayaz Plain with the prevalence of grass pollen (68 to 95%): *Compositae*, *Chenopodiaceae*, *Artemisia*, and *Fabaceae*. Among the pollen of wood (from 5 to 29%) *Pinus eldarica* is the most found. *Pinus kochiana*, and *Abies*, as well as *Quercus*, *Ulmus*, *Carpinus*, *Salix*, *Acer*, *Alnus*, and *Pterocarya* found, too. Spores are rare. There are 3 palynozones.

The settlement of Uchoglan (3rd millennium BC) is located on the Karabakh plain. With prevalence of pollen of herbs of *Chenopodiaceae*, *Fabaceae*, *Compositae*, and *Polygonaceae*,

pollen of woody plants (up to 10%) is represented by *Ulmus* (up to 50%), *Alnus* (up to 40%), *Pinus eldarica* (up to 40%), as well as by *Carpinus caucasica* (up to 25%), *Corylus* (up to 25%) and *Fagus* (up to 10%). Spores are represented by mosses.

Discussion

According to the classification of climatic rhythms of Holocene A.Blitt-R.Sernander, in the territory of Azerbaijan, three periods of changes in natural conditions are distinguished for the palynological spectra of the Neolithic settlements.

The first period. The first half of the Atlantic period, 6th-5th millenniums BC (8-6 thousand years ago). The settlements of Chalagantepe and Alikemektepesi. At this stage, desiccation of climate happened, as evidenced by an increase in the pollen of xerophilic grasses and a decrease in pollen of tree species. The vegetation cover of the steppes changed due to natural (climate aridization) and anthropogenic (occurrence of plant-growing) factors. At the same time, aridization contributed to the emergence of plant-growing, which mainly developed in the floodplain of the Kura and its tributaries, in the flood lands, which led to the "flowering" of crops and weeds.

The second period. The second half of the Atlantic period, 4th millennium BC. (6-5 thousand hp). The spectra of the settlements of Leylatepe, Alkhantepe, Soyug-Bulag and Farmantepe correspond to this period. At this stage, the humidity of the climate increased. This is evidenced by an increase in the pollen of motley grasses mesophilic grasses, and an increase in pollen of tree species – up to 38% in the Alkhantepa section. The presence of pollen of *Fagus orientalis*, *Picea orientalis* and *Abies* in the spectrum is fixed. Pollen of these trees, most likely, was introduced from neighboring areas (they did not grow on the plain), however, this drift occurred not very long ago. The presence of beech pollen in the Alkhantepe section shows that at that time the beech descended below 600 m on the Mugan plain, and the climate was accordingly more humid than now, with an average annual rainfall of at least 420 mm per year. A decrease in *Pinus eldarica* pollen in the spectra is fixed, which is related to the anthropogenic impact – cutting of trees. The invention of the potter's wheel and the manufacture of ceramics in this period led to the use of pine wood for ceramic firing. This stage ended with a strong aridization, which put an end to the Leilatepe culture as it is fixed in the sections of Alkhantepe, Leilatepe and Soyug-Bulag.

The third period. The first half of the subboreal period, 3rd millennium BC (5-4 thousand years ago). The spectra of the Uchoglan settlement corresponds to this period. The composition of the pollen, namely, a large amount of beech pollen (up to 10%) is an evidence of a more humid climate. Higher humidity is evidenced also by the fact of settlement of the elevations and high river terraces by the inhabitants of the Kura-Aras culture, unlike what did their predecessors. This indicates the high water content of the rivers and the greater amount of precipitation. Long-term (more than 1000 years) existence of settlements of this culture (it has accumulated powerful cultural layers) was responsible for the the depletion of soils. On the other hand, the increase in river flow and the flooding of the most fertile flood lands led, at the end, to the weakening of the inhabitants of the Kura-Aras culture.

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THEME IX

Sustainable Development, Disaster
And Risks Of The Caspian Sea
Region

Sustainable development, disaster and risks of the Caspian Sea Region.

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Keywords: Caspian sea, pollution, degradation, extraction, ecological situation, inland waters

The Caspian Sea is the largest world's inland water reservoir and comprises 44 % of world lake water. Although the surface area varies depending on the level deviation (10-20 %), the average surface area is 370,000 square kilometers, which is more than the size of other lakes. The geo-strategic position of the Caspian Sea is of great importance for Azerbaijan and the region as a whole. Caspian oil plays a special role in the economic recovery of the countries in the region, with large oil and gas deposits. In the intensive development of hydrocarbon reserves, the protection of the biodiversity of the sea and the improvement of its ecological situation are in the center of attention.

It should be noted that the problems of the Caspian Sea environment are one of the main factors affecting the sustainable development of the region. In this regard, Azerbaijan attaches great importance to the expansion of mutual cooperation based on the principles of common approach for a broader settlement of these problems, taking into account the seriousness of environmental problems in the Caspian region and their impact on socio-economic development. Among these problems , the damage caused by contamination, marine transport and oil and gas extraction are serious problems. In addition, the level of the Caspian Sea level, as well as the serious problems, causes the destruction of flora and fauna and other facilities.

Pollution by rivers.

In addition to the level of devastation in the Caspian Sea problem, the pollution of seawater pollution and associated environmental degradation are the most important problems of the recent period. The rich natural resources and the importance of treatment have historically caused a large number of people around it. Up to 130 rivers in the Caspian Sea carry 300 cubic kilometers of water per year. Twelve billion cubic meters of waste water flows into the Volga River annually. All ecological problems of Russia's major industrial region are brought to the Caspian through Volga. 95% of hazardous substances are transported to Volga. There are 145,000 tons of oil, 1353 tons of phenol, 1,160 tons of zinc and other substances. The Kur and Araz rivers bring to the Caspian all the flows of the South Caucasus, though 70% of Azerbaijan's population uses it for drinking water. .m and Kur bring 522 million cubic meters of water to the Caspian. As a result of emissions of pollutants, flowing rivers, 80% of the Caspian Sea water flows through the Volga River in Russia, as a result of industrial and communal flows. Anthropogenic activity by Russia and Kazakhstan also increases the amount of radioactive waste in the Caspian Sea. To prevent this, the monitoring of the sea situation, the information structure of the observation system, identification and assessment of environmental changes, and most importantly, are the creation of structures to calculate the anthropogenic factors in the background of natural processes.

Contamination by sea transport

At the same time, exploitation of offshore oil fields and transportation of oil products, and sea transport also pollute the Caspian waters.

Samples taken from offshore bottoms have been identified as oil products, phenols, and mercury in some regions. The most polluted bay of Baku, where pollution of the groundwater sediments leads to the reduction of organisms and benthos and in some cases, dip fauna. The pollution of seawater has caused great tension in the ecological conditions of the Caspian Sea and has created an ecological crisis in some coastal areas. The ecological conditions of the sea also had a negative impact on the creation of a number of water reservoirs in the Volga and Kura basins. This led to a sharp decrease in the amount of water, and on the other hand deprived a number of precious species of traditional caviar.

Pollution caused by oil and gas extraction.

The most polluted areas in the sea are at the same time environmental crisis areas. Such areas include Aktau, Baku, Sumgayit, Makhachkala, Turkmenbashi, and offshore oilfields.

When discussing the pollution of the Caspian Sea, the following features should be taken into account: Firstly, uneven distribution of wastewater leads to serious pollution of separate seas. Secondly, the coastal pollution is carried from one zone to another and polluted. Taking into consideration that the waste is accumulated on the top of the water - when it comes to the "water-atmospheric" zone, it is necessary to note that more polluted areas of the sea have been polluted.

The most dangerous contamination for the Caspian Sea is pollution with hazardous chemicals. These include oil hydrocarbons, hydrocarbons, carbohydrates, chlorine organic compounds, and heavy metals. Oil hydrocarbons play a major role in sea pollution. The conversation is about the sea oil industry and subsea oil pipes covering the Absheron peninsula and half of Manchislau. Although the appearance of oil spills in the sea at times was considered as a science and technique, some scholars have given full coverage to the possibility that it will cause harmful consequences in the near future. Though over half a century has passed, these ideas are justified and we are witnesses that the Caspian has become a global problem. Its ecological situation now bother the whole world. Baku is the dirtiest part of the Caspian Sea. It is no coincidence that he has gained the status of "dead biscuit" biologically.

Compared to the eastern and western parts of the sea, the level of contamination in the north is relatively small. The role of Volga and other river-water reservoirs in the protection of the Caspian lake environment, especially in the wastes, is great. At the same time, the sediments of the Caspian Sea and its physical, chemical and biological treatment processes are also important. In the middle and southern regions, the temperature (normality) increases the speed of chemical reactions in the water, and ultimately, the sea water is self-sufficient.

Anthropogenic pollution in the coastal strip of the Caspian Sea

One of the other reasons for the oil pollution of the Caspian Sea comes from poor hydrocarbon control in existing streams (natural streams, municipal streets, etc.). As a result of the unmanaged waste management at the enterprises or facilities operating near these streams or coastal areas, the Caspian Sea is affected by anthropogenic impact and, therefore, leads to the destruction of living organisms in the water environment.

The problem of changing the level of Caspian sea.

The change in the level of the Caspian Sea has always caused socio-economic and environmental problems in the coastal zone. For example, in the event of a decline, all hydropower facilities, including ports, need to be rebuilt. The area of the shelf zone where the fauna of the Caspian fauna is settled and the area decreases, hindering the passage of fish to the river to spawn.

The hydrometeorological regime of this zone also has negative changes. In the event of a rise in the level of socio-economic life of the coastal zone, there is a great deal of damage, environmental degradation, swamps, homes and lands remain under water. For example, in the coastal zone of Azerbaijan in the 1978-1995 level 2.5m above sea level "ecological refugees" The damage caused directly to Azerbaijan is \$ 2 billion. For example, many settlements and farms located in the southern part of our country 10-15 years ago faced that catastrophic disaster, causing serious damage to the population and the state.

As can be seen from Table 1, during the 20th century, the level of the Caspian Sea increased and diminished respectively over the years.

Years	Level (compared Baltic sea)	Area (1000 km²)
1910	-26,30	405,5
1920	-27,80	389,0
1930	-27,10	398,5
1940	-28,09	379,0
1950	-27,93	376,5
1960	-27,81	374,1
1970	-27,73	374,0
1980	-27,57	371,6
1990	-27,44	386,0

Table 1. The change of the Caspian Sea level during XX century

Watering of equipment, flooding of oil products, dismantling of facilities, etc. In the southern and central areas, the Caspian Sea is exposed to more hydrodynamic hazards. In addition, the bottom of the Caspian Sea is susceptible to mud volcanoes. Areas with sulfur content are more dangerous. If there is a strong earthquake, it can take up to 1 million tons of sulfur-containing hydrocarbons at 1000 atmospheres, which is a global disaster.

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Disaster Risk Reduction for Waterfront Urban Areas: The case of Water Level Rise Adaptation Methods in Baku, Geneva and San Francisco

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Keywords: *Urban planning, disaster risk reduction, waterfront urban areas, water level rise adaptation methods, Baku*

Introduction

The effects of climate change are impacting the cities and the concerns about the cities future in terms of resilience are increasing. Increasing complexity of disasters impacts the coastal zones of cities, which are predominantly characterized by high density of land use and population. Almost 65 percent of cities with populations above 2.5 million today are located along the world coasts and sixty percent of the world's population already lives in coastal areas (Xalxo, 2007).

In addition to the risks associated to coastal cities (irregularities of precipitation, cyclic changing of water level) the Caspian Sea has its particular risks related to the patterns of urban development and industrial development (e.g. oil exploration) on the Sea. The rapid rise of Caspian Sea water level (about 2.25 meters since 1978) has caused much concern to all five littoral countries, primarily because flooding has destroyed or damaged buildings and other engineering structures, roads, beaches and farm lands in the coastal zone (Roshan *et al.*, 2012).

Today, the Caspian Sea water level (attitude -28) can possibly rise to a maximum of -25/-26 level (if continuous humid years occur), which means Sea level can possible rise up to 2.5 meters or drop off 1.5 meters within the natural variation cycle (EIA report, Baku Shipyard Project, 2011). Perennial fluctuations in sea level are due to changes in its water balance elements under influences of climate changes and use of water resources in catchment area of the Sea (Mansimov M.R. *et al.*, 1999).

These fluctuation changes can impact negatively on the built environment and human security. In case of increase of water level, it may cause social and economic disruption, environmental degradation, chemical pollution of the waterfront areas related to the oil industry, erosion, landslide etc. Whereas, in case of decrease, it may cause the dust and sand winds, storms, salinization of the land, as well as it can impact agriculture. In another word, it can impact human security.

The natural disasters which impact the human security and the cities infrastructure - have shown the importance of disaster risk reduction (DRR) and climate adaptation program in cities. The measures of the program shouldn't be only construction project as an "afterthought" (Bosher *et al.*, 2007a). Indeed, it should be seen as a continuous process, with resilience being methodically built into the design, construction and operation processes (DCOP).

The different methods of urban planning have their role to play in reducing and managing the range of hazards and uncertainties. The inquiries highlight the importance of physical/protective interventions which should be integrated into the built environment. Throughout the presentation, the possible vulnerabilities scenarios for waterfront urban area of the city of Baku will be shown and different methods towards DRR and adaptation that have been implemented in Geneva and San Francisco will be shared.

Materials and methods

The above-mentioned challenges faced by the cities highlights the importance of interdisciplinary approach in research methods and practices. The interdisciplinary approach: the relationship between urbanism and social sciences shows that, the spatial planning is becoming more than more an attractive and a necessary tool for DRR and adaptation, as it presents an opportunity to regulate

the long-term use of space through which exposure to natural hazards and human-induced threats can be minimized (Sutanta *et al.* 2010). The methods to meet the presented challenges are the historical analysis, observation, and field investigation.

Results

The above described problematic raises the multifunctional urban space development for improving the resilience and reducing the risks. Today, the design and/or retrofitting of urban spaces should have multiple functions compared to previous practices. For example, the site can be dedicated to the public as leisure space (for walking and cycling) – in case of low level of water and it can be flooded – in case of high level of water.

The designed urban spaces should also contribute to promote the biodiversity and the natural environment. Yet relatively few cities have full inventories of their biological diversity or of the precise distribution of that diversity and as mentioned by Given (2000, p. 22) “*the biological diversity is a global, regional and urban matter of importance*”.

The biodiversity is a very important issue also for resilience and the loss of biodiversity provides one of the greatest challenges currently faced by the world community (Given, 1998). It improves the quality of the ecosystem, gives life to the city and plays important role in environmental and human safety. All this posits a mandatory intersectoral exchange of data and information towards informed strategies of development.

Discussion

There are coastal cities which are turned dominantly to the economic development of their waterfront areas with a little understanding and including the DRR and adaptation programs in the development process. The coastal cities in Middle East region are ignoring above mentioned elements and primarily focusing on the urban marketing, economic development rather than the resilience.

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Modern aspects of environmental legislation of Azerbaijan (on examples of sustainable development and climate changes)

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Keywords: climate changes, economic growth, natural resources, pollution, sustainable development

Introduction

World Commission on Environment and Development defined in 1987 'Sustainable Development' as trend of significant meets of demands of present generation without compromising the ability of future generations to meet their own needs.

Constitution of Azerbaijan declares general principles for the development of national environmental policy. First National Environmental Action Plan of Azerbaijan (NEAP) was developed in late 90th and supported by the World Bank; has had positive effect on development of environmental protection and natural resource sufficiency, thus proving the value of NEAP as the policy instrument. The NEAP stresses importance of policy reforms and integration of environmental policy to economic areas.

One of main legal docs of modern Azerbaijan is National Programme on Environmentally Sustainable Social and Economic Development (Presidential Decree 612), includes environmental aspects as the part of Country's overall development strategy. Institutional and administrative capacities require strengthening as regards of implementation and enforcement. Civil society is open for necessity of becoming valuable partner to government for the development and implementation of environmental policy.

Azerbaijan's economic growth relies on comprehensive part of the successful development of oil and natural gas resources; crude oil and oil product exports made up ≈70% of exports, and oil-related revenue made up to 50% of budget.

Key areas of environmental issues and problems in terms of significant challenges - identification of quality air and water resources, limited inland water resources, nature protection, including conservation of forestry and biodiversity, as well as aquatic diversity and sturgeon stocks, management of the environmentally unsound waste and industrial pollution (by oil production, energy sector and transport), oil-contaminated sites, the Caspian Sea water level fluctuation, coastal and marine pollution, degradation of soil resources and land use, in particular desertification; protection of natural and cultural heritage is the special block, contenting conventional aspects.

Methods and materials

The Law on Environmental Protection (June 1999, latest amendments - March 2001) - main document of national environmental legislation, defines

environmental expertise as “the identification of conformity of the environmental conditions with qualitative standards and ecological requirements in order to identify, prevent and forecast the possible negative impact of an economic activity on the environment and related consequences”.

One of the substantive legal rules in Azerbaijan is the Law on Air Protection establishes the legal basis for the protection of air and impact to the ecosystems, including Caspian Sea basin; thus implementing the constitutional rights of inhabitants to live in healthy environment, stipulates the rights and obligations of the authorities, legal entities and individuals also NGOs in this respect, sets general requirements for air protection in economic activities, establishes rules for the State inventory of harmful emissions and their sources, introduces general categories of breaches of the Law that triggers punitive measures.

Researches concerning of protection of atmosphere and prevention of climate changes, reflect that ending up activities of some numbers of substantive sources of heavily polluting industrial enterprises (since 1991) has led to substantial reduction of pollutants. If in 1990 the volume of pollutants was \approx 2.1 million tons, in 1998 it had declined as 352,000 tons. Some numbers of problems still remain: most air filters in active enterprises have bad conditions.

On the way to resolve worldwide pollution problems, Azerbaijan ratified the United Nations Framework Convention on Climate Change and the Vienna Convention for the Protection of the Ozone Layer. In 2000, Azerbaijan ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change, and as a Party to the Convention Azerbaijan has undertaken to develop, implement and disseminate programmes to reduce expected impacts on climate change.

Drawing up a national action’s plan of minimizing negative impact of climate changes on the country’s economy and health of population, as well as informing the international community Azerbaijan has proceeded to:

- prepare a national inventory of greenhouse gases;
- assess opportunities for reducing the use of greenhouse gases and implementation of national policy;
- evaluate of impact of climate changes to ecosystems and major sectors of economy, prepare for adaptive measures to minimize loss from pollutants.

The key principles based on the Law on Environmental Protection (1992) and Resolution 122 of the CM on the Payments for Nature Use IAW the Application of Charges for Natural Resources, Discharge of Pollutants to the Natural Environment and Rates of Charges for Environmental Pollution. The Law on Environmental Protection reconfirms the legal validity and basics for economic instrument, emphasizes using economic incentives for environmental protection by means of charges for use of natural resources and pollution. Monitoring system based on several possibilities of remote sensing by various satellites (NOAA, Nimbus, LandSat etc).

Reducing environmental pollution and damages of human health cost-effectively requires an integrated approach for urban air quality management

important step in development of an urban air quality management strategy is monitoring and evaluating air quality.

Results

Modern monitoring and modeling systems are essential for policy-making suited to the primary objectives of human health protection; there are several key tasks for understanding of nature of technogen character of air and water pollution, above all collecting data on ambient pollutant concentrations and developing an emissions inventory. Most of monitoring stations in Azerbaijan are regularly indicating CO₂, SO₂, NO_x and total suspended particles, but still not available data for fine particulates (PM10 and PM2.5), although these are far more damaging public health than suspended particulates. Ground-level ozone isn't monitored in big cities with high ozone levels. Ground-level ozone originates from transport emissions and can cause summer smog.

In 2000 were thrown 908 000 tons of pollutants to the atmosphere, 43% - by mobile units; by stationary sources – 515 000 tons among them - 430 000 tons extremely hazardous waste. Emission by gaseous and liquid substances counted 96% of total volume, particularly sulfate anhydride – 35000 tons, carbon monoxide – 26 000 tons, nitric oxide – 24 000 tons. Main hazardous organic substances are most dangerous with the level of significant decreases to 14% (compare to indicators of 1999). Thus total value of pollution decreased to 59 000 tons or to 10% (comparable to 1999).

According to implementation of multilateral environmental agreements (UN Framework Convention on Climate Change and Kyoto Protocol, UNECE conventions and other international legal documents), Azerbaijan develops and establishes necessary regulatory and legal framework to control the trade and use of ozone-depleting substances (ODS), to enable fulfill obligations under the Montreal Protocol.

The National Ozone Centre was established to support the ODS, the initial national programme for the phase-out of ODS was compiled in 1997, several projects have been implemented in cooperation to GEF. The total consumption of ODS in Azerbaijan decreased from 966 metric tons of ozone-depleting potential (ODP) before the ratification of the Protocol to 13.6 metric tons ODP in 2002, this drop of almost 99% has been achieved through significant changes in industrial development and valuable decrease of production of refrigeration equipment. ODS consumption continues of reduction.

Discussion

Azerbaijan has been Party to the UNECE Convention on Long-range Transboundary Air Pollution since 2002, but not ratified protocols. The Government intends to ratify the Protocol on Persistent Organic Pollutants (POPs), the Protocol on Heavy Metals, and the Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP).

Modern world is the rough arena of economic growth, but industrial development shouldn't decrease a quality of natural surround of humanity. Nature protection aspects are secured broad consensus among stakeholders (government,

civil society, international partners) concerning emergency of measures to protect the national environment, thus setting a common basis for further actions. In 2007 Azerbaijan signed Memorandum of Understanding (MoU) on the "Clean Development Mechanism" projects. As following European countries in decrease of atmospheric emissions by 2020 in 30%, Azerbaijan will reduce greenhouse gas emissions contributing to climate change. Partner country Germany (in this agreement) uses modern technologies to reduce greenhouse gas emissions, contributing to energy efficiency. The purpose of signing the MoU is in order that Azerbaijan may apply German experience.

State Programme on Poverty Reduction and Economic Development approved by Presidential Decree (2004-2008, 2009-2013 and up to 2020) is envisaged to play significant role; as a comprehensive strategy with multi-sector approach, it influences now and will develop the environmental sector within the context of entire national priorities.

The Programme provides long-term period and will be revised annually as the envisaged policy measures are implemented and yield results, addressed the role of environmental conditions as a cause of poverty as well as a tool to reduce it. Assumption of "economic development which upsets the environmental balance cannot be sustainable" obliges the Government of Azerbaijan to promote balanced growth and improve some of key sectors of national economy: increase of:

- investment sums to the climatic aspects,
- access to credit among businesses and entrepreneurs,
- development of infrastructure,
- encouragement of small and medium enterprises,
- development of industry and agriculture in different regions,
- improvement of environmental protection,
- reforms of energy generation and distribution,
- promotion of tourism, including rural tourism and ecotourism.

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TRANSFORMATION OF ECOGEOCOMPLEXES FORMED IN THE COASTAL ZONE OF THE CASPIAN SEA

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Key words: groundwater, proluvial, geocomplex, salt-marsh, transformation

Introduction

The features of groundwater, present in the foothill and plain areas of the coastal part of Azerbaijan play a role of landscape-forming factor, conditioned by the complexity of altitudinal and spatial differentiation of the relief, the climate features, lithology of the constituent rocks, the drainage, and the proximity to large enclosed water basin.

The geocomplexes of the Kura-Aras (21631 km²), Samur-Davachi (2900 km²) and Lankaran (1840 km²) plains are formed mainly due to alluvial and proluvial removals of mountain rivers, shown as extended conic forms of transformed mass, which typically pass to flat marine and alluvial-marine deluvial plains of middle- and upper Quaternary age in the Caspian costs. The relief of these plains in almost all areas is represented by accumulative forms, with rare exceptions.

Desertification and degradation of semi-desert and dry steppe landscapes of the Kura-Aras plain and foothill areas, characterized by high heat capacity and arid climate, occurs both under the influence of natural and anthropogenic factors. This happens when ground waters in underground layers are mixed with washed rocks and salts found on their way, and mineralized. Under the influence of capillary force along narrow vertical channels, water columns rise up to the surface of the Earth. Eventually, hot air dries up the soil, and water evaporates, leaving white accumulations of salt on the ground – the poison for vegetation, which causes the widespread development of salt-marshes (“solonchaks”) and other halophytic geosystems.

Beside with this, in the Kura-Aras lowland, the irrigated plant-growing has been widely developed since ancient times. The population of this zone, which suffers from the harmful effects of growing salinization, is forced to seek measures to combat this phenomenon. Relatedly, at present there are large areas occupied by salt-marshes in the Kura-Aras lowland, which is the reason for the strong transformation and degradation of the natural-technogenic landscapes.

Materials and methods

This research was carried out based on the data available from the past scientific literature, as well as through using results of related fieldworks led by the author in the study area. The main emphasis is made on the transformation trends observed by the ecogeosystems of the Caspian region. To define this tendency, the comparison of the materials of the past with data of recent observation was carried out.

Results

The modern ecosystems is formed considerably due to lithocomplexes of the Gusar foothill inclined plain, composed mainly of the Upper Pliocene–Quaternary complex of alluvial-proluvial, as well as alluvial and alluvial-marine sediments of high infiltration capacity. Groundwater in this zone is spread up to a depth of 150 m, and the thickness of the rocks reaches 113.8 m, whereas in the lower part, due to the pressure of present water in the bottoms, it decreases to 60 m. A large number of available springs are associated with this condition, the areals of outlets of which extend from north to south across the entire Samur-Davachi lowland, entailing the formation of intrazonal hydromorphic ecosystems. In the vast part of the Shollar Plain, the groundwater is fresh, total mineralization of which varies from 0.2 to 1 g/l. The presence here of a number of buried uplifts along with an abundance of fresh groundwaters causes the development of plain forest-shrub landscape complexes (Mikhailov, 1970). In the southeastern part of the lower parts of the rivers of Garachay and Velvelechay, the total mineralization of groundwater increases, and the pressure waters become slightly saline (up to 3 g/l), whereas ground waters are saline and in some areas salty (38.6 g/l). Relatedly, landscape complexes become halophytes while semi-desert salt-marsh and semi-salt-marsh geocomplexes predominate. In the country, there are two largest water intakes (Shollar and Khachmaz) located in the plain areas, receiving freshwater and the groundwater. They meet the needs of the population of the cities of Baku and Sumgait.

The general direction of the discharge of the groundwaters of the Pre-Talysh plain, which are formed within the Lankaran foothill alluvial, alluvial-proluvial and deluvial-proluvial plains, are everywhere in the direction of the Caspian Sea. The level of groundwater lies from 0 m to 26 m below the surface of the Earth, decreasing from the foothills to the shore of the Caspian. Absolute height of their level ranges from 63 m to –27 or –28m. Waters of soil and Khvalin-Khazar aquifers in the contact strip zone of the plains and foothills are mostly fresh or slightly saline, while their mineralization ranges from 2 to 1 g/l. Toward downstream these waters become brackish and saline with a dry residue up to 25-32 g/l. Water supply of many cities and other settlements is carried out due to wells where these waters are accumulated. It can be noted that the change in the level of salinity of groundwater is reflected also in the nature of the natural-technogenic landscapes. Contemporary landscape complexes from the foothills of the Talysh Mountains towards the Caspian Sea are gradually changing and becoming more halophytic, as clearly observed in the north-eastern part of the Lankaran lowland, to the north of the Villashchay river valley.

Unlike other regions, the groundwater in the territory of Absheron peninsula is not widely spread. Thus, the groundwater table is fixed along its northern and eastern coasts as well as in the territory of Baku, while in the western part of the peninsula they are developed in forms of ruptured areals, and their influence on modern geosystems is less stable. Mineralization extent of them is different: fresh – with a dry residue up to 1 g/l, slightly saline – 1-3 g/l, strongly saline – from 3-10 g/l, saline – from 10-50 g/l and brines over 50 g/l. In western Absheron, groundwater salinity varies from 6.4 to 88.6 g/l. In the waterless valleys occupied by drying strongly salty lakes, salt-marsh semi-desert landscapes are developed. An active role the formation of these landscapes is played by mud volcanoes that are the sources of migration of various toxic salts.

A significant role in the desertification of landscapes of coastal territories is played by relief and lithological complexes of sediments that form it. The relief of the pre-Caspian areas of Azerbaijan as a result of multidirectional new tectonic movements is characterized by a complex altitudinal-spatial differentiation, and is represented by wide intermountain (Kura-Aras) and foothill (Samur-Davachi and Lankaran) plains altitudes of which range from –27 to 500-600 m (Budagov et al., 1993).

The Kura-Aras plain in a structural sense corresponds to the eastern part of the Transcaucasian depression, which within the study area is represented by slightly inclined, weakly split and flat accumulative plains. The process of accumulation of the sediments of continental and marine genesis and the formation of the modern relief in the Kura-Aras plain have occurred on the background of a general differentiated absolute deflection in the latest tectonic stage (Shirinov, 1975).

The Samur-Davachi lowland stretches along the foot of the northeastern slope of the Greater Caucasus (to the south of the Samur River) along the Caspian coast, extends, the height of which ranges from –26 to 200 m (in some places to 500 m). Its northwestern sector (to the north of the Velvele River), called the Shollar Plain, is mainly composed of alluvial and alluvial-proluvial sand and pebble sediments, and is represented by cones of removals of such mountain rivers as Samur, Gusarchay, Gudialchay, etc. Due to favorable tectonic-lithological and hydrogeological conditions, there are flatland forest landscapes, developed within the Shollar Plain on the background of arid climate and semi-desert landscape. In most part of the territory, various transformed agro landscapes, more resistant to the process of desertification may predominate as well. To the southeast of the Velvele River, a narrow and slightly inclined plain is stretched along the sea. The plain is characterized by an arid climate and the presence of toxic clayey sandy loamy deposits of toxic salts (Mikailov, 1970; Guliyeva, Kuchinskaya, 2005).

The Lankaran lowland is composed mainly of alluvial and alluvial-proluvial materials, brought by the rivers of the Talish Mountains. Here, in conditions of a humid subtropical climate, intense anthropogenization of landscapes occurs (Ismailov, 1990).

Discussion

The analysis of actual materials shows that in recent years, as a result of the rise of the Caspian and the intensification of anthropogenic impact, the influence of the geomorphologic-hydrogeological factor on the geosystems of the coastal territories increases. The areas of halophytic and hydromorphic landscape complexes are expanding, and desertification processes are activated. This means that there is a replacement of the relatively productive natural-technogenic landscapes by less-fertile ones. Eventually, this sharply worsens the landscape and environmental conditions, destroying the natural and resource potential in the coastal zone.

The intensive uplift of the Caspian Sea (up to 2 m) in 1977–1998 caused a strong swamping of its coasts. The rise in the level of the Caspian Sea (with the flooded territories at about 800 km² in total) caused intensive reformation of the relief of the coastal strip, and facilitated abrasion processes on steep banks. The sharp rise in the groundwater level due to the rise of the absolute basis of the erosion of the Caspian contributed to the formation of marshes and salt-marshes, and also salinization of soil in the Caspian lowland region and the Kura-Aras lowland, which in turn leads to degradation and desertification of the dominant semi-arid landscape. The length of the flooded areas is more widespread in the Gyzylagach Bay and the Sarah Peninsula.

With the rise in the sea level and the groundwater waters table in the coastal areas of the Southeastern Shirvan Plain and Gyzylagach bay, the area of development of the "old" meadow-marsh, salt-marsh and meadow-salt-marsh landscapes has expanded considerably. New meadow-marsh and salt-marsh complexes were formed as well. While the level of the Caspian Sea is currently high, and the formation of new salt-marshes in the coastal strip of the Kura-Aras lowland continues, the areas of deserted landscapes will increase, since salinity is the main property of the soils of the Kura-Aras lowland.

To restore the biopotential and maintain the ecological balance, it is necessary to organize detailed landscape and reclamation studies. This would enable conducting of engineering and landscape planning that may allow specifying the measures for optimizing the landscape-ecological situation.

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Sustainable development: the interrelation of the natural and socio-economic issues in Caspian Sea

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Key words: sustainable development, Caspian Sea, sea level, fisheries, environmental management.

Introduction

Sustainable development is the organizing principle for meeting human development goals while at the same time sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend. The desired result is a state of society where living conditions and resource use continue to meet human needs without undermining the integrity and stability of the natural system. Sustainable development can be classified as development that meet the needs of the present without compromising the ability of future generations.

As the concept developed, it has shifted to focus more on economic development, social development and environmental protection for future generations. Today Caspian Sea is one of the main issues of the world.

The Caspian Sea, called the jewel of two continents, Asia and Europe, is the world's largest inland body of water, encompassing some 44 percent of the volume of all inland lakes and seas. Five countries share the immense natural heritage of the Caspian Sea. The Caspian Sea is exceptional by many standards. Moreover it is a closed lake with very large variations in its water level because of natural oscillations of the components that make up the water balance. The variations in the water level have had a strong influence on most aspects of economic life. This has been particularly so during the past few decades.

The largest river of Europe, the Volga, plays the principal role in the hydrological regime of the Sea. In addition to water, it also brings, as do other rivers that flow into the Caspian, a considerable amount of pollutants, which influence the aquatic ecosystems including the unique population of the few species of sturgeon. The Sea and its shores are rich with mineral resources, including oil, but prospecting and extraction also require effective environmental management.

The objective of this article is to analyse the interrelation of the natural and socio-economic issues for the sake of regional sustainable development in a very special region of the world.

Environmental Challenges

The biodiversity of the Caspian aquatic environment is derived from the long history of the existence of the sea and its isolation, allowing ample conditions for speciation. The number of endemic aquatic taxa, over 400, is very impressive. There are 115 species of fish, of which a number are anadromous and migrate from the Caspian up the rivers to spawn. The best known of these is the sturgeon, which has provided a valuable economic resource for over a century. There is also a Caspian freshwater seal, one of only two species that occur worldwide.

A conventional idea of a sustainable fishery is that it is one that is harvested at a sustainable rate, where the fish population does not decline over time because of fishing practices. Sustainability in fisheries combines theoretical disciplines, such as the population dynamics of fisheries, with practical strategies, such as avoiding overfishing through techniques such as individual fisheries quota curtailing destructive and illegal fishing practices by lobbying for appropriate law and policy, setting up protected areas, restoring collapsed fisheries, incorporating all externalities involved in harvesting marine ecosystems into fishery economics, educating stakeholders and the wider public, and developing independent certification programs.

Fisheries and aquaculture are, directly or indirectly, a source of livelihood for over 500 million people, mostly in developing countries. (2)

Social sustainability can conflict with biodiversity. A fishery is socially sustainable if the fishery ecosystem maintains the ability to deliver products the society can use. Major species shifts within the ecosystem could be acceptable as long as the flow of such products continues.(1) Humans have been operating such regimes for thousands of years, transforming many ecosystems, depleting or driving to extinction many species.(3) "To a great extent, sustainability is like good art, it is hard to describe but we know it when we see it."(1)

According to Hilborn, the "loss of some species, and indeed transformation of the ecosystem is not incompatible with sustainable harvests."(1) For example, in recent years, barndoor skates have been caught as bycatch in the western Atlantic. Their numbers have severely declined and they will probably go extinct if these catch rates continue.(13) Even if

the barndoor skate goes extinct, changing the ecosystem, there could still be sustainable fishing of other commercial species.(1)

Overfishing can be sustainable. According to Hilborn, overfishing can be "a misallocation of societies' resources", but it does not necessarily threaten conservation or sustainability".(1) Overfishing is traditionally defined as harvesting so many fish that the yield is less than it would be if fishing were reduced.(1) On the other hand, overfishing can precede severe stock depletion and fishery collapse. Hilborn points out that continuing to exert fishing pressure while production decreases, stock collapses and the fishery fails, is largely "the product of institutional failure."(1)

Today over 70% of fish species are either fully exploited, overexploited, depleted, or recovering from depletion. If overfishing does not decrease, it is predicted that stocks of all species currently commercially fished for will collapse by 2048.(4)

Rising ocean temperatures and ocean acidification are radically altering aquatic ecosystems. Climate change is modifying fish distribution and the productivity of marine and freshwater species. This reduces sustainable catch levels across many habitats, puts pressure on resources needed for aquaculture, on the communities that depend on fisheries, and on the oceans' ability to capture and store carbon. Sea level rise puts coastal fishing communities at risk, while changing rainfall patterns and water use impact on inland (freshwater) fisheries and aquaculture.

The situation of oscillations in the level of the Caspian Sea is typical of closed lakes. It is typical not only from the hydrometeorological point of view, but from the point of view of economic impacts as well. The variations in sealevel cause uncertainty over time in economic activities. The interest groups involved, including governments, have to develop a long-term strategy for the management of the region. Thus, it is important to determine the expected upper and lower extremes with a reasonable probability of occurrence.

Owing to the relatively rapid rise in sealevel, the Caspian coastline is currently in a state of transition. In general, the change from the retreating phase of the Caspian to the advancing phase has led to a transition from predominantly accumulating processes along the shore to a prevalence of abrasion processes. On formerly accumulating shores, erosion processes have begun and continue in many places.

This brief review of the damage associated with the rise in the level of the Caspian Sea brings us to a very important conclusion: stabilization of the level of the Caspian Sea is in the interests of all countries surrounding the sea. This might provide a basis for international

cooperation with regard to a lot of give-and-take issues. Obviously, a total or partial stabilization of the sealevel is beyond human means, but some modest degree of control is possible, as the Kara-Bogaz-Gol experience has demonstrated. Another possibility would be to use the flat territories of the north-eastern Caspian as evaporation pans; they had in fact been working that way before the sealevel dropped in the 1930s.

Theoretically, it is also possible to control the sealevel by regulating water consumption in the basin, mainly in the Volga River basin. However, this would involve a very complex political problem: the Volga and its basin belong to one country, the Russian Federation, while the Caspian Sea belongs to five. Moreover, the portion of the shoreline belonging to Russia is modest. Management of an international lake (or sea) by means of action in a large but national river would not be a trivial diplomatic issue.

Another option would be large water transfers from neighbouring northern basins. About 10 years ago such proposals were sharply (and justly) criticized by the environmental movement. Neither the present political climate nor current levels of science and technology are yet good enough to reconsider such projects.

Cooperative Policies for Stabilizing the Environment

Developing a common strategy for sustainable economic activity on the Caspian Sea (and its shores) under conditions of drastic changes in the sealevel is a very good subject for negotiation and cooperation. It is not, however, a trivial subject; international cooperation is not just desirable but absolutely necessary.

Other important development issues for the Caspian Sea require international cooperation. Two are briefly mentioned here: the management of marine biological resources and the management of mineral resources in the seabed, primarily oil and gas.

Conclusion

As a result we can state that nature must be respected. This is particularly true of the Caspian Sea region. It is a special case of closely integrated natural, political, environmental, social, and economic issues. It is in the interests of all branches of the economy to learn how to move on along the road of sustainable development, given the very large variations in the sealevel. This will be impossible, however, without effective international cooperation. Broadly speaking, effective management of the Caspian Sea and its resources cannot be achieved without concerted action by all five riparian countries. Only a holistic approach at the international level can make economic development of the region truly sustainable.

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SUSTAINABLE DEVELOPMENT OF AGRICULTURE IN THE CASPIAN REGIONS OF AZERBAIJAN

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Key words: Caspian regions, crop, opportunity, agro-industrial, cultivation

Introduction

Azerbaijan reestablished its economy and reached considerable achievements since the beginning of 2000es. Significant economic reforms conducted in regard to distribution and use of land resources, as well as the use of mechanisms of market economy in agrarian sector opened big opportunities for the increase in agricultural production and growth in farm businesses.

Agriculture is a significant area of Azerbaijan's non-oil economy. The analysis of recent situation in agriculture shows that sharp differences between the regions currently are much less in terms of diversification of agricultural production rather than volume of production in this economic sector. Wheat, fruits, vegetables and potato as the more-produced and necessary products are grown almost in all regions. As for livestock, it is represented mainly with cattle- and sheep-breeding activities, and also poultry industry and other smaller businesses. Animal industries shared 51.0% of all agricultural products by 2015 in opposite to 44.5% observed in 2000. They meet considerable part of requirements of Azerbaijan's population for livestock products. The agricultural output of Azerbaijan continues to grow. In 2005-2015, agricultural products have grown by 3.1 times while the share of agriculture, forestry and fishery in GDP has risen from 9% to 10.7% during the same period.

Significant contribution to the agrarian sector of the country is made by the four Caspian economic regions – Aran, Guba-Khachmaz, and Lankaran-Astara. Contribution of another Caspian region – Absheron to the agriculture of Azerbaijan is small, since this economic region is highly industrialized, and its rural population number is lower in number as well.

Methods and materials

In this research, the territorial organization and development of agricultural areas by different regions of the country is studied using methods of comparative analysis and statistical review. Geographical conditions, the factor of labor force provision and governmental priorities on the studied economic area were taken into consideration in studying and evaluating of the opportunities for prospective development of agrarian sector.

As the Figure 1 below shows, the three Caspian regions – Aran, Guba-Khachmaz, Lankaran-Astara and Absheron together account for 53% of the GDP of agriculture of Azerbaijan (Agriculture in Azerbaijan, 2016).

Analysis of the territorial distribution of the agriculture shows that the Aran region contributes 32% of GDP of agriculture mainly due to its larger territory compared to other regions of the country along with its favorable climate and relief allowing development of various areas of cultivation and livestock (Figure 1). Its territory encompasses low plains which are suitable for land use and irrigation. The region has more developed irrigation system due to existence of channel system and collector-drainage network. The main produced agricultural crops are cereals, mainly wheat, vegetable, fruit, grape, sugar-beet, watermelon, melon, soybeans, cotton, etc. Guba-Khachmaz and Lankaran-Astara specialize in production of fruits and also vegetables. Situated in the southern part of Azerbaijan, Lankaran-Astara traditionally was known a territory of subtropical fruits, such as lemon and orange as well as tea, while other crops such as potato, vegetables and different fruits were widely cultivated in recent decades.

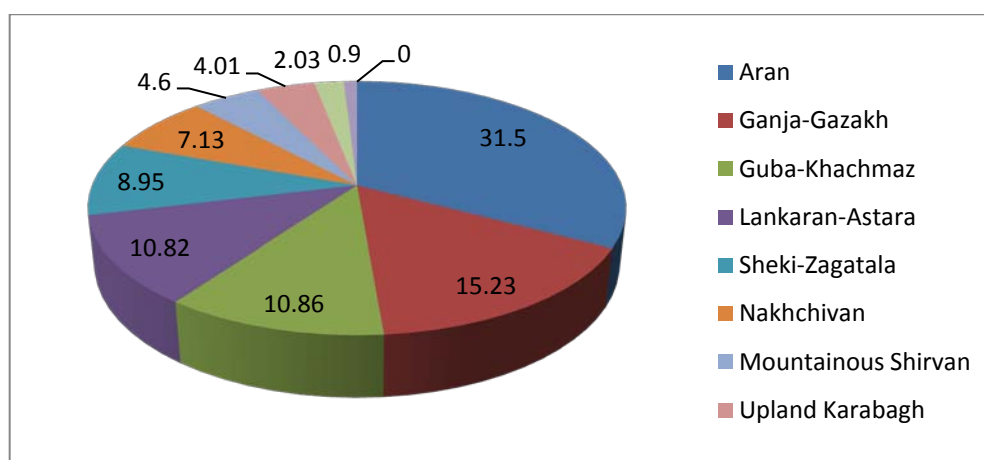


Figure 1. Percentage of GDP of agriculture in the economic regions of Azerbaijan

Territorial and branch structure of the country's agrarian sector saw positive changes due to the efforts made by the government. The analysis of the dynamics of development of Azerbaijan's agriculture shows that considerable advancement in agrarian sector happened after the implementation of the first State Program on socioeconomic regions.

Under the *first State Program* on socioeconomic development of regions (2004-2008), a plant of sugar production has been commissioned in the Aran economic region which currently is the largest one in the Caucasus region. The new milk- and butter mills in Salyan, pomegranate producing enterprise in Goychay can be mentioned as well. A plant of tinned production and a plant of dairy products were built in Lankaran-Astara region.

The technical and financial support toward farmers and agribusinesses as a part of the first State Program found its reflection also in agricultural statistics. In 2003-2008, the production of agriculture and food industry were considerably grown, including 21,4% by wheat, 40,1% by potato, 17,4% by vegetable, 78,1% by grape, 30,6% by meat of cattle, 18,3% by milk, 47,9% by egg and 22,3% by wool.

The works implemented in accordance with the first Program were continued under the *second State Program* (2009-2013). Factories of tea and ice cream in Lankaran, a wine-mill and the Goytapa water reservoir in Jalilabad district, a cannery in Bilasuvar, a refrigerating storehouse in Salyan, a storehouse for fruits and vegetables, etc. have been established. In 2011, the commissioned facilities included a juice- and wine-producing enterprise in Agshu, two large factories of milk and dairy products in Aghjabadi, a lemonade mill, a factory of mixed forage in Imishli.

Results

Currently, achieving of desirable results in agrarian sector of Azerbaijan, including its Caspian regions, considerably depends on the motivation of activities of local businesses through subsidies, the provision of favorable economic condition and security, the elimination of bureaucratic impediments, and the expansion of foreign investment in agricultural regions. Non-oil sector is represented mainly by products of farms and agro-industrial facilities in the country. Growth in this sector happens due to investments, change of domestic demand, and also ongoing structural and institutional changes. Meanwhile, the typical feature of regional development in Azerbaijan is that it still considerably depends on governmental support and allocations.

One of the main factors negatively affecting the agriculture in the Caspian regions is availability of poor and insufficient material resources and lack of access to necessary technical provision in rural areas. Weakness of the material and technical bases of the agriculture is observed in most of administrative districts, whereas subsidies allocated and provided through relevant entities are limited.

Moreover, as observations led by us in the Caspian regions (especially in Guba-Khachmaz and Lankaran-Astara regions) show, in some cases delays in providing with agricultural machinery can be faced during harvest season as well. On the other hand, the weak use of pesticides by farms should be noted in particular. Farmers do not have sufficient means of protection to lead pest control. This is related to relatively poor material and technical base of farming.

While most of arable lands in the country require irrigation, proper land use and appropriate irrigation are not conducted efficiently. Rules of sowing and cultivating typically are not followed by the farmers who are not aware of the needed requirements. The shown factors do not allow reach high productivity and harvesting larger amount of crop in sown areas.

Consequently, the volume of harvested crop does not change considerably through time, though much higher production growth in farming must be targeted. Similar problem concerns the livestock (cattle breeding) where breeding and keeping of animal species of high agricultural importance is managed at less level. Volume of products per unit of area of farmlands continues to be at low level. The above mentioned processes are observed in conditions of high influence made on the lands as a result of continuous farming activity and overgrazing. As observations show, sometimes the same arable lands are used for different purposes in different years, since farmers may hesitate in making choice in regard to the sort of crop to be cultivated. Such situation relates to lack of priorities in their activities as well as the unstable income gained.

Apart from these, effects of climate change (seasonal variations in regime of temperature and precipitation) are also responsible for the low efficiency seen in the agriculture. Degradation of lands, erosion and land salinization are reducing the efficiency in farming. Beside with these, lack of awareness of proper land use at whole, poor infrastructure as well as less environmental concern performed by farmers lead to additional efforts to be made.

Discussions

The Caspian regions of Azerbaijan have a great potential for the development of agrarian sector based on its natural resources. These regions are rich in natural potential, necessary for the development of agriculture. As we think, the establishment of agrarian-industrial complexes should be regarded as the main means for improving level of living of rural population. Increasing cultivation output of rural areas can be achieved in the condition of real high offers to be made by small and medium agro-industrial businesses in sales market.

In the economic regions of Lankaran-Astara and also Guba-Khachmaz with relatively higher population density, area of fertile lands per capita decreases year by year. Under this circumstance land resources of the country should be used to develop much profitable branches of agriculture only. Transition to intensive ways and methods in land use as well as the application of advanced technology in this area must mitigate the negative impact on the environment. Particularly, in regard to Lankaran-Astara, the priority in the territorial organization of farming must include intensification of agricultural production rather than extending the area of plantations. Much productive sorts must be purchased and used in sowing.

The considerable growth in agrarian sector can be available in the future if financing of processing industry will be efficiently managed. Agricultural businesses should be increased in the regions, and supply of the local businesses with modern appliances and technology should be carried more efficiently. Competitiveness of local businesses and producers in the market enterprises must be promoted and strengthened. Import of GMO products is not welcomed.

The role of livestock products also must be increased in GDP of agriculture through the improvement of situation with forage base as well as transition to breeding much productive species of cattle. Since development of farming business in the regions significantly depends on state funding, the creation of strong private sector in country's economic regions must be promoted further. Meantime, creating of strong regional budgets of local administrations and preventing of their complete dependency on state funding must be regulated. Regulating, crediting and strong state

support of the agriculture will have a positive effect on the overall development of the Caspian regions, promoting employment rate and reduction of portion of the population with less income.

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Environmental consequence of Caspian rapid sea level changing in Gorgan Bay

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Keywords: Gorgan Bay, Caspian Sea, environment, fluctuation, morphology

Introduction:

The global warming issue is an absolutely accepted concept of the Anthropocene stage. Moreover it has been predicted that due to 3 degrees increment of globe temperature by 2100, the vast parts of crowded coastal cities with their all social and economic infrastructures will be disappeared and inundated (Feng, 2014). This is despite the overall hydrologic response of inland seas, lakes, ponds, side bays in northern parts of Africa, Middle East and some other parts of the globe, which act differently from free ocean water bodies (Khoshravan & Vafaie, 2016). As global temperature increment leads to the growth of evaporation rate and precipitation reduction and finally causes the drought trend development, through mentioned regions. Namely, it can be pointed to the drought of vast parts of the inner lakes of Iran plateau as Urmia Lake, Parishan, Maharloo and Hamoon. The Caspian Sea basin as the biggest closed watershed in the world also has followed the similar destiny and illustrates the impacts of global warming with various ranges during the 20th century Kroonenberg & et al (2000). Nowadays the Gorgan bay as one of the Caspian Sea dependent water resources has lost vast parts of its water supplies due to drought procedure. Therefore the main objective of the current study is the evaluation of morphological of Gorgan bay due to water level fluctuations Caspian Sea, because of global warming, and illustration of effective and practical solutions in order to get rid of current situation of the bay. The Gorgan bay watershed is one of the most important southern catchments of Caspian Sea basin with an area about 15000 Km² which consists of mountainous, sub mountain regions, and coastal plains (Alizadeh, 2010). According to the wetlands classification conducted in Ramsar convention (1975), the Miankaleh wetland and Gorgan bay were classified as type A, the permanent shallow sea water bodies. The precipitation range is decreasing along west-east direction (from 800 mm up to 450 mm). The Gorgan bay is located at the southeastern part of Caspian Sea and lies in west-east direction parallel with shoreline (fig1). At the moment, the length of the bay is 44 Km and it's width at the widest section is about 12 Km. the area of Gorgan bay is 360 Km² and its maximum water depth is evaluated about 4 m.

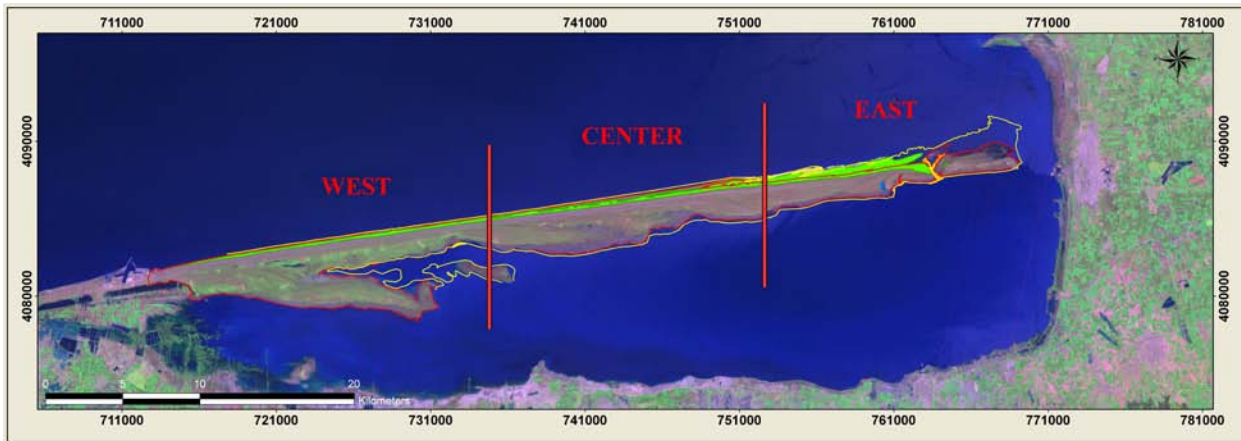


Fig 1- Gorgan Bay and Miankaleh Lagoon location map

Materials and methods:

The current study has been conducted on the base of scientific documentations, field studies, evaluation of coastal sediments and satellite images interpretation. At the first step, the creation of the bay and the most important factors of its morphological evolution have been rebuilt due to geological evidences. The deformation rate of Gorgan bay coastal line during various fluctuations of Caspian Sea has been evaluated by comparing the satellite pictures of 1966, 2004, and 2016 years. The energy level and important flows in sedimentation process in main inlets, as important factors of depository environment evaluation, have been evaluated by the help of sedimentology studies. The adaption ways with natural circumstances and global warming phenomenon have been finally presented.

Results:

The classification of sedimentary environments of Gorgan bay

The field studies have shown the various sedimentary environments in Gorgan bay and Miankaleh peninsula. The most important regions are as follows: wetlands, muddy zones, salty marshes, deltas, communication channels, and the sandy coast of sea, the intermediate zones between sea and wetlands, and sand dunes. As a general point of view, the Gorgan bay sedimentary environments are classified as follows:

- Paludal sediments, including dark clays with high organic materials, full of Mollusks lime shells (gastropods and bivalves)
- Sandy spit sediments, including well sorted brown reddish sands, with bivalve shells)

- Marine sediments, fine well sorted sandy materials along with microorganisms and marine mollusks lime crusts
- Sand dunes and Aeolians, including fine light brown well sorted sands and iron oxide without marine shells

The effect of rapid fluctuations of Caspian sea on the Gorgan bay

The Caspian Sea water level has experienced about 3 m shrinkage between 1930-1978 and has reached to -28 m water level (fig 2), and as a result the huge parts of Gorgan bay have been dried out. The maximum drought vulnerability has been observed in western areas of Gorgan bay and the complete obstruction of Ashooradeh, Chopoghli and Khoozini channels inlets have caused the blockage of water to the Gorgan bay. But due to sequential Caspian sea water level increment during 1978-1995, about 2.5 meters, up to -25.5 m, the Gorgan bay has been again completely full of water during a 22 year period. But the above condition hasn't last so much and due to the Caspian Sea second shrinkage from 1995 up to now, and 1.5 meter water level reduction up to -27 m, the Gorgan bay has been dried out and the capacity of communicative channels inlets have been seriously diminished.

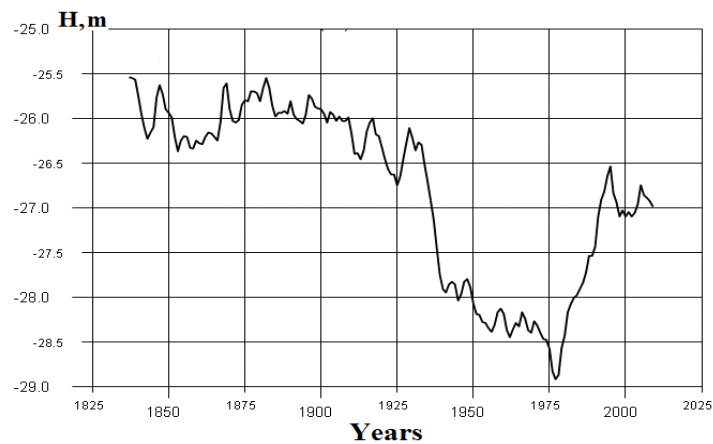


Fig 2- The Caspian Sea level changing according to the data of Baku sea gauge (1835- 2014)

Discussion:

According to the obtained results from previous studies on Gorgan bay, due to balance the stable hydrologic structure of Gorgan bay and Miankaleh wetland, we should use such methods which are compatible with global warming rate and rapid pendulous scenarios of Caspian Sea. Therefore some of the most important deterrent proceedings against Gorgan bay drought are as follows:

- **Construction of artificial channel for water exchange with Caspian sea**

As a result in order to relate the sea and bay, it is needed to find a new location with better situation in this respects: the less distance between sea and bay, the Caspian sea bed slope at low depth areas, the distance to the Amir Abad port.

- **The dredging of old channels**

The dredging of old channels is the last, costly and more economically risky way to save the bay. if the reduction rate of Caspian Sea is considered to be stopped, the dredging of channels in future won't be an unexpected task, just as the project at 1976. But the main question is that: will the Caspian Sea reducing trend be paused? If the answer is yes, we should expect the new development phase and then take decisions on dredging the channels on the base of macro-economic politics.

Conclusion

The overall results of current study shows that considering the rapid fluctuations of Caspian Sea water level, the best choice to save the Gorgan bay is the environmental compatibility solution. It means that the reduction and increment phases of Caspian Sea during last 500 years from -28 up to -25 meters water level should be considered.

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THE SPATIAL DISTRIBUTION OF TOXIGENIC FUNGI IN ANTHROPOGENIC AREAS OF BAKU CITY AND TOXIGENICITY OF THEIR SPECIES

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Keywords: *ecosystem, toxigenic fungi, mycotoxins, mycobiota, anthropogenic impact*

Introduction

Strains of toxigenic fungi produce toxins, which are toxic to all living life forms and these toxic compounds are called mycotoxins. The most common toxigenic molds are *Alternaria*, *Aspergillus*, *Botrytis*, *Candida*, *Cladosporium*, *Chaetomium*, *Fusarium*, *Mucor*, *Stachybotrys*, *Paecilomyces*, *Penicillium*, *Rhizopus*, *Trichoderma*, *Ulocladium* and *Verticillium*. The distribution of these fungi is cosmopolitan in nature, they exist virtually everywhere and so, the air we breathe carries a wide variety of them. Some of their mycotoxins be present within their spores and that airborne fungal spores can pose major health risks to humans, animal and even plants. Also, they are capable of causing allergic responses in susceptible individuals. Mycotoxins are chemical toxins present within or on the surface of the mold spore, which can be inhaled, ingested, or touched and are nearly all cytotoxic, disrupting various cellular structures such as membranes, and interfering with vital cellular processes such as protein, RNA and DNA synthesis. Major groups of mycotoxins are aflatoxins, alternariol, gliotoxin, ochratoxin, citrinin, ergot alkaloids, patulin, fumonisin, zearalenone and trichothecenes. They can affect vascular, digestive, respiratory, nervous, cutaneous, reproductive and immune systems. One nanogram of mycotoxin is enough to cause an adverse health effect in people. For example, aflatoxin is a potent human carcinogen, ochratoxins carcinogenic and nephrotoxic, patulin can damage the immune system, fumonisins can affect to nervous system. This information clearly shows their negative health effects in humans[1,2]. Therefore, there is need to be aware of the composition, spatial distribution of them to better control them. For this reason the presented work discusses the issues of the negative impact of toxigenic fungi on anthropogenic ecosystems. The aim of this work, was to determine and to explore the toxigenic species of fungi which distributed in anthropogenic areas and which are important in our life.

MATERIALS AND METHODS

In this study, chiefly Baku city was selected as research object and about 30 soil and air samples were taken from the city and were examined. Fungi were isolated by plating the soil and air samples on a Petri dish containing the potato dextrose agar (PDA), SDA (Sabouraud dextrose agar), Czapeks agar (CZA). For the soil samples ; Inoculation of the treated samples was carried out by Waksman soil dilution method applying the following dilutions: 1/10; 1/100; 1/1000; 1/1000. For this, from each soil sample, 10 g of soil was suspended in 90 mL of sterilized water in a 250 mL flask and was shaken for 30 min at 200 rpm. Microscopic fungi isolated from soil were grown in thermostat at 26 -27 °C. The plates were incubated for 2~4 days for the screening of species and then these species were transferred into a new pure cultures and incubated for 7-21 days, after which their genera were determined on the basis of macromorphology. The identification was performed based on cultural-morphological properties via determination of physiological and biochemical properties.

For the air samples, sedimentation method was used in this experiment. For this, an open petri dishes with nutrient agar is placed on the surface of the soil in some areas of the city during a certain period of time and at the same time to inhabit bacteria in the culture media was used cephalosporium solution. Based on information found in mold characterisation literature, obtained species were studied their potential toxicological health effects[5].

RESULTS

As a result of conducted work a total of 49 cultures of microscopic fungi were isolated and 24 species of toxigenic fungi isolated from those 49 cultures. Based on the results analyses of cultured micromycetes identified that, microscopic fungi mainly confer to the classes of *Zygomycetes*, *Ascomycetes*, *Deuteromycetes*. Among them from the toxigenic fungi - *Alternaria*,

Aspergillus, Candida, Cladosporium, Chaetomium, Fusarium, Mucor, Rhizopus, Penicillium, Trichoderma, and Stachybotrys were widely distributed genera. The dominant genus was Aspergillus. On the basis of the identification of the fungal colonies obtained from the soil and air samples which were taken from the studied areas it was found that, toxigenic fungi species were widely distributed in polluted areas than the others. Thus, in our investigation we have found that in samples which were taken from the non polluted areas occurrence only 9 genus of toxigenic fungi, but in polluted soil samples we have found that it was 14 genus. So this allows us to say that the oil contaminated sites may be play as an indicator role for the development of toxigenic fungi.

As the quantitative analysis of the microscopic fungi cultures isolated from the different areas of Baku city has shown that the moderately and fast growing toxigenic species of *Aspergillus nidulans*, *A.ruber*, *A.solani*, *A.ustus*, *A. Versicolor*, *Candida alpicans*, *C.lipolytica*, *Chaetomium celluloliticum*, *Fuzarium oxysporium*, *F.semitechum*, *F. Sporotrichiella*, *Gliocladium album*, *Penicillium granulatum*, *P.citreonigrum*, *P.islandicum*, *P.variabile*, *Trichoderma viride*, *Trichoderma harzianum*, *T.lignorum*, *Stachybotrys atra* represent the more in these studied anthropogenic areas than the relatively unpolluted areas.

Finally, 49 selected species studied for their toxigenicity and according to the literature information it was found that, 24 species of them are toxigenic[2,3]. For example, some *Aspergillus* species, such as – *A. fumigatus* and *A. flavus* can cause serious disease(especially allergic diseases) in humans and animals. Inhalation of *Aspergillus fumigatus* conidia can cause severe aspergillosis in immunosuppressed people because the potential toxicity of a large number of secondary metabolites are present in these airborne conidia.

Cladosporium can cause allergies and asthma in some people and in very rare cases, it can cause infections. Penicillium species make potent toxins, such as Ochratoxins that this toxin can causes a major toxicosis in living things. They mostly known as a carcinogen and nephrotoxin and have been linked to tumors in the human urinary tract. In addition, they inhibit mitochondrial ATP production; And it was cleared that, from those species *P.citreonigrum* and *P.islandicum* were widely distributed in studied areas.

Alternaria consists of numerous toxigenic species and are known as major plant pathogens. Many species of Alternaria are pathogen, opportunist-pathogen and toxigen. In addition all of these, the mold *Alternaria* is a well recognized allergy causing fungus. They can cause certain allergies and opportunistic infections in immunocompromised people such as AIDS patients and can cause alternariosis and alternariatoxicosis in humans and animals. This paper shows that, toxigenic *A.alternata*, *A.arborescens* spread in anthropogenic areas.

According to the samples were taken from the soil and air layer of the city were determined that toxigenic *Stachybotrys atra*(also called *S.chartarum*) was also spread in studied areas. And mycotoxins produced by them known as satratoxins. Inhalation of *Stachybotrys* toxic spores may result in trichothecene absorbtion. Due to their low molecular weight, spores are easily transported through the air and in most cases cause different toxicological health impacts. Exposure to *Stachybotrys* toxins has been reported to cause human neurotoxicity. All spores are allergenic, can become harmful at some dose, and even extremely potent compounds become harmless at low enough concentrations. The members of this genus also can cause many allergological problems in some asthmatic individuals[3,4].

DISCUSSION

The results obtained in this study have provided that the anthropogenic impact on the ecosystem play a dominant role in the distribution of toxigenic fungi. This research has shown that some toxigenic species, such as *Aspergillus nidulans*, *A.ustus*, *Chaetomium celluloliticum*, *Fuzarium oxysporium*, *F.semitechum*, *Penicillium granulatum*, *P.citreonigrum*, *P.islandicum*, *P.variabile*, *Trichoderma viride*, *Trichoderma harzianum*, *T.lignorum*, *Stachybotrys atra* exhibit an extremely wide metabolic diversity in these areas. The increase in toxic species populations following pollution impact can also be used as an indicator that pollution is occurring. And the production of toxins by these fungi in mostly depends on the environmental conditions

This demonstrated that toxigenic species of fungi have the pathogenic and toxicological health impacts to humans live in these area. Also they have many toxic effects for plants and animals. At last all the members of these toxigenic fungi study of their morphological, physiological and biochemical poperties and thus based on their literature information determined that they can demonstrate toxicity, pathogenicity, opportunistic-patogenicity properties in plants, animals, especially in humans. In conclusion

in our experiments indicate that to study of the members, composition, biology and ecology of that toxigenic fungi species and their toxigenic properties is important topic in the assessment of risk factor on human health.

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Sustainable use of the Caspian Sea in the context of climatic, environmental and technogenic challenges.

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Keywords: The Caspian Sea, sustainable development, climate change, technogenic challenges, Marine Spatial Planning.

Introduction

Development of the port infrastructure, intensification of gas and oil production and transportation, development of tourism along with natural and climatic factors have a strong impact on the ecosystem of the Caspian Sea. All of this complicates sustainable development of the region and sustainable use of marine resources. This research examines climatic, ecological and technogenic challenges associated with sustainable use of the Caspian Sea. Effective solving of such problems requires an integrated approach, interaction between scientists, representatives of authorities, environmental organizations, business representatives, port and marine services in the framework of Integrated Coastal Zone Management and Marine Spatial Planning.

Materials and methods

The aim of this research is to develop recommendations for the fulfillment of the main targets of Sustainable Development Goal #14 (SDG14) on the Russian coast of the Caspian Sea. This is one of the 17 Goals set in Resolution 70/1 “Transforming our world: the 2030 Agenda for Sustainable Development” adopted by the UN General Assembly on September 25, 2015.

The method for this research will be collection and analysis of various types of work related to SDG14, carried out by organizations in the coastal zone and water areas of the Russian coast of the Caspian Sea. Then, assessment of the effectiveness of such activities will be made. Similar work carried out in foreign countries for the Caspian Sea and in other seas will be studied and their expertise and experience will be used for analysis and elaboration of recommendations for achieving SDG14 in the Russian coastal region of the Caspian Sea (Shapovalov & Kostianaia 2018).

Results

The Caspian Sea has an important economic value, directly related to shipping, fishing, oil and gas extraction and transportation, ports and resort areas. Current climatic, anthropogenic and ecological processes have a strong impact on sustainable use of the Caspian Sea. A predicted trend towards an increase in the air and sea surface temperature should lead to an increase in the duration of the holiday season on the Caspian Sea coast and to a decrease of ice cover in the Northern Caspian. Sharp climate changes causing disturbances and sometimes destruction in the coastal zone, as well as an increasing anthropogenic impact, influence development of

the port infrastructure, gas and oil production and transportation, development of tourism, etc.

Since the Caspian Sea is a drainless water body, the process of renewal of the water of the Caspian Sea is very slow compared to other seas. This causes a much higher degree of negative impact of pollutants that cause irreversible effects in the marine ecosystem. Additional adverse factors in the Caspian Sea include storm winds and extreme waves, ice conditions (in the Northern Caspian), significant interannual sea level changes, dangerous geological and geomorphological conditions (earthquakes, gas-saturated zones, etc.). In addition, these parameters are very difficult to predict as to the time of occurrence and severity of the consequences (Kostianoy et al. 2016; Lavrova et al. 2011; Lavrova et al. 2016).

Exploration and exploitation of oil fields in the Caspian Sea, as well as natural oil seeps to the sea surface from the seabed are the most considerable sources of pollution of the sea surface. Industrial development of Caspian oil and gas resources due to the development of large oil fields, as well as its transportation to world markets, becomes the main source of anthropogenic impact on the environment of the Caspian Sea (Korshenko & Gul 2005; Zonn 2005).

Discussion

The increasingly intensive use of the marine environment inevitably leads to conflicts of interest: for example, development of the oil and gas industry, strengthening the economy can simultaneously cause significant harm to the environment. In order to eliminate such contradictions and ensure sustainable use and protection of the marine environment, in addition to Integrated Coastal Zone Management (Mikhaylichenko 2006), Marine Spatial Planning (MSP) is used. MSP is considered to be the main tool for resolving conflicts arising from the growing use of seas and oceans. The MSP process analyzes existing and planned activities related to the marine environment for the balanced achievement of economic, social and environmental objectives (Schubert 2018). In Russia, MSP has not yet been developed enough (Mikhailova 2017), partly because of the lack of a legislative framework regulating MSP.

The Russian coast of the Caspian Sea is of great importance for the development of the economy, infrastructure, shipping, tourism in the Russian Federation. Climatic, ecological and technogenic challenges complicate sustainable development and sustainable use of marine resources. To effectively solve such problems, an integrated approach is required, as well as interaction between scientists, government officials, environmental organizations, business representatives, port and marine services.

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Impact of natural hazards to economy in Azerbaijan

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Keywords: drought , extreme floods, storm, heavy rains , lightning

Introduction

A natural hazard is a threat of a naturally occurring event will have a negative effect on humans. This negative effect is what we call a natural disaster. In other words when the hazardous threat actually happens and harms humans, we call the event a natural disaster.

Nowadays the impacts of natural conditions on economic life are very important. Therefore, geographical research service level must be in full compliance with the international requirements.

In Azerbaijan, investment in infrastructure since the mid-20th century has provided significant opportunities for economic growth and poverty alleviation.

The dangerous geographical hazards are - . storms, extreme temperature events, forest fires, water scarcity and droughts, floods, snow avalanches, landslides, earthquakes, volcanoes etc.

One of the most common natural disasters is extreme floods in the world. The extreme floods gives serious damage to economy and human life. Floods is destroyed the residential areas, industrial and agricultural enterprises, roads, irrigation systems, ditches, sluices. The daily maximum precipitation and maximum water flow of rain floods are the most pressing and complex categories for geographical researches and generalizations. Nowadays risk assessment of heavy rains have particular importance for the economy. There are serious side effects of heavy rains for sewerage network, agriculture and to the formation of rivers flood. Intensive rains create devastating floods during short time at small areas. The floods have more devastating effect in mountainous areas. Analysis of relationship between the intensity and the duration of rain is very important for the research of heavy rains.

Materials and methods

- All of these processes have been operating throughout Earth history, but the processes have become hazardous only because they negatively affect us as human beings. Important Point - There would be no natural disasters if it were not for humans. Without humans these are only natural events.

- Risk is characteristic of the relationship between humans and geologic processes. We all take risks everyday. The risk from natural hazards, while it cannot be eliminated, can, in some cases be understood in a such a way that we can minimize the hazard to humans, and thus minimize the risk. To do this, we need to understand something about the processes that operate, and understand the energy required for the process. Then, we can develop an action to take to minimize the risk. Such minimization of risk is called hazard mitigation.

- Although humans can sometimes influence natural disasters (for example when poor levee design results in a flood), other disasters that are directly generated by humans, such as oil and toxic material spills, pollution, massive automobile or train wrecks, airplane crashes, and human induced explosions, are considered technological disasters, and will not be considered in this course, except when they occur as a secondary result of a natural disaster.

Some of the questions we hope to answer for each possible natural disaster are:

Where is each type of hazard likely to be present and why?

What scientific principles govern the processes responsible for the disasters?

How often do these hazards develop into disasters?

How can each type of disaster be predicted and/or mitigated?

- As discussed before, natural disasters are produced by processes that have been operating since the Earth formed. Such processes are beneficial to us as humans because they are responsible for things that make the Earth a habitable planet for life. For example:

- Throughout Earth history, volcanism has been responsible for producing much of the water present on the Earth's surface, and for producing the atmosphere.

- Earthquakes are one of the processes responsible for the formation of mountain ranges which

which direct water to flow downhill to form rivers and lakes.

- Erosional processes, including flooding, landslides, and windstorms replenishes soil and helps sustain life.

Floods don't distribute often large area but extending more discrete form. All of these make difficult to observe floods and their maximum, as a result it is possible only after floods to determine the maximum water flow according to their traces. The formation of rainfall floods is different from the formation flood flow. At that time the main role is duration and character of rainfalls. Firstly determined the rainfall area, its duration, quantity, average and maximum intensity and then on the basis of these determined the scale of the floods. Depending on all of them rainfall flood is the most dangerous for forming flooding in river.

Results

Research of floods and droughts event from a scientific point are very important for their early warning and prevention of damage. That time this is an important challenge for world scientists. The past 20 years exposed to flood at the banks of the lake and largest river and suffered damage from this incident cases was significantly increased. This is very seriously problem for the farms of in the area and people which living here.

Flooding can cause a range of health impacts and risks, including: death and injury, contaminated drinking water, hazardous material spills, increased populations of disease-carrying insects and rodents, moldy houses, and community disruption and displacement.

As rains become heavier, streams, rivers, and lakes can overflow, increasing the risk of water-borne pathogens flowing into drinking water sources. Downpours can also damage critical infrastructure like sewer and solid waste systems, triggering sewage overflows that can spread into local waters.

In addition to extreme floods, other dangerous geographical events for agriculture is drought. Drought is an insidious hazard of nature. It is often referred to as a "creeping phenomenon" and its impacts vary from region to region. Drought can therefore be difficult for people to understand.

Heavy rains also make some difficulty for aviation activities, even can be caused aviation disasters. Incessant rainfall weakens the appearance, causing the electricity and icing of aircraft during the flight. Torrential rains significantly affects landing of the aircraft.

Lightning is the most dangerous atmospheric events for economy. Especially it has a serious impact for transport. At aeronavigation lightning was caused very serious losses and many human deaths.

Lightning is a sudden electrostatic discharge during an electrical storm between electrically charged regions of a cloud, between that cloud and another cloud (CC lightning), or between a cloud and the ground (CG lightning). As a rule lightning occurs on ball-rain (CC) clouds and it is accompanied with downpour and hard rain.

At Earth's surface at the same time nearly 1,500 lightning are observed. Their average speeds are registered for 46/1 second. Lightning are unevenly distributed on the surface of our planet. There are ten times more lightning over the ocean than on the mainland. The maximum lightning activity on Earth is observed in Central Africa. Over the Arctic and Antarctic polar regions are almost never observed the lightning.

Watch closely and you will see the step leaders heading down from the cloud. These are rarely visible and last only a few thousandths of a second. Note that one reaches the ground and this is the path that the much brighter lightning bolt follows.

The intensity of the lightning depends on the sun's rays, therefore the maximum of the afternoon hours in the summer, but the minimum is taken into account at the time of the sinking sun.

Discussion

This paper addresses natural disasters whose origin and scale are not limited to natural causes, in other words where the causes and the effects are also closely related to demographic and industrial growth, something inherent to the socio-economic growth of contemporary societies.

The natural hazards are - related to the activities of the wind - strong winds, wind shear, wind side, crosswind, which caused to limited visibility distance - blizzard, fog, dust and dust storms, heavy rains

and low clouds, related to convective processes - lightning, turbulence, extreme temperatures and besides hail.

Likewise, the analysing of dangerous atmospheric events is very important for agrometeorology which is the main field of the country's economy. Particularly, hail, extreme temperatures and shower is very important for agriculture and livestock. These events have a very negative impact on agricultural economy.

The dangerous meteorological events affect transport system, especially aviation transport. Nowadays, many traffic accidents have occurred because of limited visibility distance. According to flight experience, 60% of aircraft accidents due to limitation of meteorological visibility occurred by fog effect. In recent years, it was clear by the world flight experience, 78% of aviation events happened by meteorological conditions during take-off and landing of aircraft is caused by wind drifts.

Global statistics on the economic impact of disasters are collected and reported as a total sum for all sectors, and do not capture the impact on individual sectors. National and international disaster loss databases typically report populations affected and damage to housing and other infrastructure, but seldom report damage or losses in the agriculture sector. As a result, there is no clear understanding of the extent to which natural hazards and disasters impact the agriculture sector and subsectors in developing countries.

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Importance of studying of inland water resources in sustainable development of the country and protection of ecosystems

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Keywords: inland water resources, Land-use, synthesis of methods

Introduction

One of global world problems is the water supply of population and various sectors of economy. At present, there is no such branch of economy, the development of which is possible without the availability of sufficient water resources. Therefore, from the point of view of sustainable economic development and protection of ecosystem the assessment of inland water resources should be under the constant attention of business executives and scientific researchers. This is especially important for countries located in arid regions and suffering from water shortage. The Republic of Azerbaijan refers to these categories areas. Total river water resources of Azerbaijan is estimated at 30.9 km³. Most of these resources flow through to republic in transit way (20.6 km³). 10.3 km³ consist of inland river water resources, and in a natural way they don't satisfy all demands of republic economy (12-14 km³). Another problem related to water is the change in climatic conditions and intensification of changes in other natural-anthropogenic factors. Spatio-temporal changes occurring in water resources and proportion of individual components in water balance require their continuous study and put on forefront the exploration and application of more modern and sensitive to changes in methods. Effectiveness of these methods is that in spite of many flow-forming factors have been taken into estimating in the context of methods, but calculations are carried out in the presence of one or some factors. The late changing factors were not known within the estimation content in fact, but their roles are considered. On the other hand, studies are fulfilled quickly and more sensitive to changes. In recent years, by the support of UNESCO and FAO organizations the inland water resources of several countries have been determined specifically by these methods. We have proposed innovative, high reliable and simple methodology to calculate water resources and water balance components by the way synthesis of advantages of some hydrologic methods using GIS-technology.

Materials and methods

New methodology was developed based on well-known methods in the world and innovations proposed in our studies. Some these methods are useful to calculate surface runoff, but other methods to assessment infiltration or evaporation rates of territory. Modified rational method for calculating surface runoff, USDA methods for estimating infiltration and soil moisture; Lvovich method for studying their theoretical foundations are more effectively (Lvovich M.I., 1969; Thompson. D.B., 1986; USDA..., 1986; Application of..., 2010). Although major runoff-forming factors are covering in context this methodology, but calculations are fulfilled only LULC (Land-use & Land-cover) and precipitation data.

The rivers and lakes are main natural sources of inland water resources of Azerbaijan. The estimations of Lenkoran river water resources and Hocasan lake water balance components based on new synthesis methods are shown in presented article (figure 1). It is not accidental that

selection of these water bodies as a research object. Both of them reflect most important issues of inland water bodies of Azerbaijan. The most serious problem of rivers is their water resources decrease. It should be noted with regret that, the Lenkoran river is also beyond the frame of this process. Simultaneously, Lankaran is largest river (1096.1 km²) among directly flow into Caspian Sea rivers that are formed inland of Azerbaijan. Lake Hochasan is distinguished by a combination of common specific features of republican lakes (salinization, sewage pollution and treatment needs, drying, etc.). Area of lake basin is 32.2 km², but its water surface area is about 1.85 km².



Figure 1. View of location of studies areas over Azerbaijan Republic

Hydro-meteorological data are taken from Ministry of Ecology and Natural Resources manuals. Data of ungauged areas were obtained with GIS-technology taking into account DEM features and interpolating of climate data.

LULC data were determined by satellite images (2017) of studies areas.

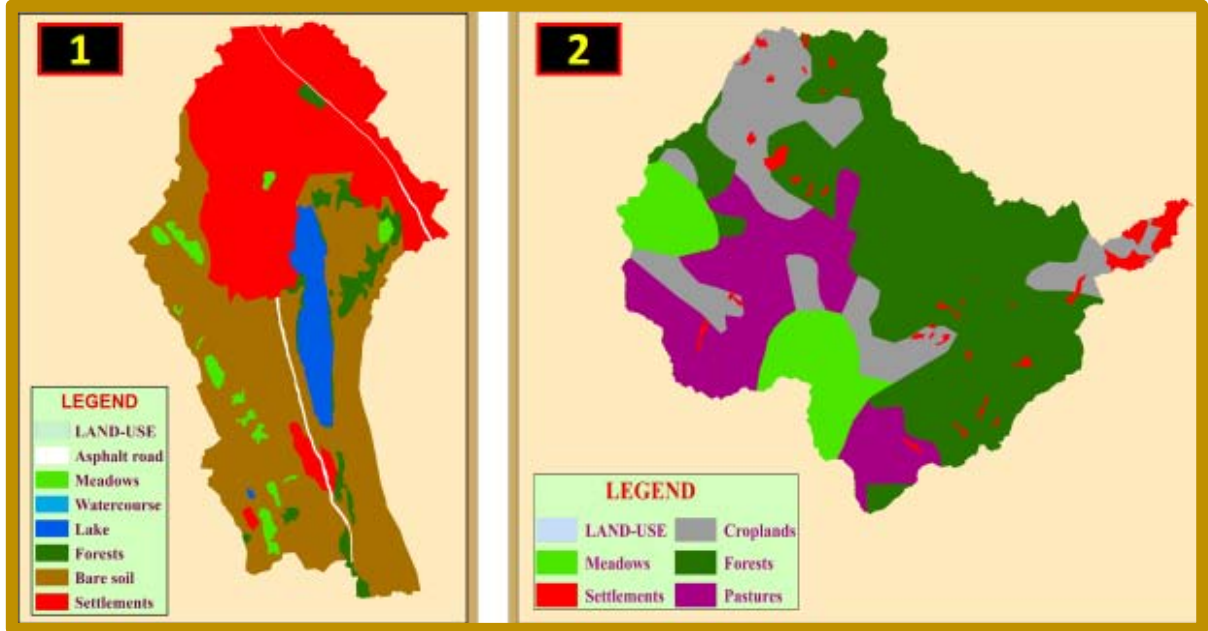


Figure 2. Land-use data of Lake Hocasahan(1) and Lankaran river(2) basins

Studies were carried out in following sequence:

- 1) Using GIS-Hydrology program, flow directions and accumulations have been identified, basins of water bodies are divided.
- 2) Were determined main indicators at assessment of rational (surface) runoff coefficient-LULC, HSG (hydrological soil groups) and DEM (elevation & slope) data.
- 3) Was defined correctional rational coefficient. Rational coefficients (c) characterize the level of surface runoff in event of rainfall. For estimation coefficient “c” in multi-annual period is necessary to correct its. Correctional coefficients depend on humidity condition of territory.
- 4) Were calculated USDA methods water balance elements (hydrologic losses, initial abstraction, maximum and actual soil moisture) (Ponce V.M., et al., 2016).
- 5) For estimation of infiltration a semi-empirical formula was offered by us based on USDA water balance components (Teymurov M.A., et al., 2018).
- 6) Total runoff is found summing surface runoff and base-flow.
- 7) Evapotranspiration is obtained with difference subtract total surface runoff from precipitation.
- 8) Surface runoff and its underground feeding fraction together represent the yield of the water balance from fallen precipitation, but other elements as water losses. Therefore, the water resources are considered as the sum of surface runoff and base-flow.

Results

Multy-annual water balance components of Lake Hocasahan were estimated in following quantities: precipitation-287.6 mm, potential evaporation-1141.4 mm, actual evaporation-165.7 mm, humidity coefficient-0.2519, rational coefficient-0.7267, correctional coefficient-0.3257, infiltration coefficient-0.2331, initial abstraction-123.8 mm, hydrological losses-219.6 mm, soil moisture-95.7 mm. The natural multy-annual income part of lake water balance (3.959 mln.m³) is 1.403 mln.m³ more than losses share (2.556 mln.m³) (table 1). However, it does not have enough to fill total volume of lake (3.50 mln.m³) and is less than 2.5 times. As can be seen from table,

wastewater that flows to the lake constitutes the main part of its water balance (69.8 %). Although very dirty, waste-water (9.153 mln.m³) is a major source of non-drying and protection of lake ecosystem. Filling and turning into a overflow lake, even increase of area in recent years (5.41%) are also explained by wastewater.

Lake water balance components	Water volume, mln.m³
Total water volume of lake	3.500
Precipitation fallen over lake surface	0.528
Surface runoff into lake	1.963
Underground water flowing into lake	1.468
Wastewater discharge into lake	9.153
Total income part of water balance	13.112
Evaporation from lake surface	2.096
Outflows from lake	7.056
Infiltration from lake bottom	0.460
Total losses part of water balance	9.612

Table 1. Water balance of Lake Hocasasan

Estimated average annual water balance elements of Lankaran river for 2017 are expressed in following values: precipitation-874.2 mm, actual evaporation-486.6 mm, humidity coefficient-1.27, rational coefficient-0.2565, infiltration coefficient-0.2513, hydrological losses-649.9 mm, initial abstraction-353.7 mm, soil moisture-296.2 mm. Study results show that current water resources of river (420.23 mln.m³) are decreased with comporation 12.9% (482.62 mln.m³) after last assessment in 1978, or 4.8% (441.61 mln.m³) in 1989 (Rustamov S.G. & Kashkay R.M., 1989).

Discussion

New methodology is very important from the point of view of solving many problems of hydrological science, such as estimating of water resources, determining role of water balance components separately, predicting of water losses risks, protecting available ecosystem and forecasting more efficient land-use management, assessing climatic and anthropogenic factors, etc.

The conceptual advantages of proposed methodology are:

- To eliminate shortcomings in existing methods.
- To alleviate investigation dependence on observation data.
- To insure efficiency, accuracy and interactivity in calculating water resources.
- All scientific results in studies are based only on GIS-technologies.
- There is not spatio-temporal constraint in study.

Investigations over water resources and water balance elements of 29 water bodies show that errors are very little when comparing of actual gauged values and estimates obtained as a result of research. The error percentages of 22 water bodies from 29 has been under 10%, only 7 rivers around ±10-15%. The results may be used also for assessment of the water resources at un-gaged sites of any territory.

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THEME X

Changing Ecosystem Health Of
Caspian Sea Under Multiple
Stressors

The environmental problems of the Caspian Sea and the reasons for its occurrence.

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Keywords: Pollution, degradation, extraction, ecological situation, inland waters

Introduction

The Caspian Sea is the largest world's inland water reservoir and comprises 44 % of world lake water. Although the surface area varies depending on the level deviation (10-20 %), the average surface area is 370,000 square kilometers, which is more than the size of other lakes. The geo-strategic position of the Caspian Sea is of great importance for Azerbaijan and the region as a whole. Caspian oil plays a special role in the economic recovery of the countries in the region, with large oil and gas deposits. In the intensive development of hydrocarbon reserves, the protection of the biodiversity of the sea and the improvement of its ecological situation are in the center of attention.

It should be noted that the problems of the Caspian Sea environment are one of the main factors affecting the sustainable development of the region. In this regard, Azerbaijan attaches great importance to the expansion of mutual cooperation based on the principles of common approach for a broader settlement of these problems, taking into account the seriousness of environmental problems in the Caspian region and their impact on socio-economic development. Among these problems, the damage caused by contamination, marine transport and oil and gas extraction are serious problems. In addition, the level of the Caspian Sea level, as well as the serious problems, causes the destruction of flora and fauna and other facilities.

Materials and methods

Pollution by the rivers.

In addition to the level of devastation in the Caspian Sea problem, the pollution of seawater pollution and associated environmental degradation are the most important problems of the recent period. The rich natural resources and the importance of treatment have historically caused a large number of people around it. Up to 130 rivers in the Caspian Sea carry 300 cubic kilometers of water per year. Twelve billion cubic meters of waste water flows into the Volga River annually. All ecological problems of Russia's major industrial region are brought to the Caspian through Volga. 95% of hazardous substances are transported to Volga. There are 145,000 tons of oil, 1353 tons of phenol, 1,160 tons of zinc and other substances. The Kur and Araz rivers bring to the Caspian all the flows of the South Caucasus, though 70% of Azerbaijan's population uses it for drinking water. .m and Kur bring 522 million cubic meters of water to the Caspian.

As a result of emissions of pollutants, flowing rivers, 80% of the Caspian Sea water flows through the Volga River in Russia, as a result of industrial and communal flows. Anthropogenic activity by Russia and Kazakhstan also increases the amount of radioactive waste in the Caspian Sea. To prevent this, the monitoring of the sea situation, the information structure of the observation system, identification and assessment of

environmental changes, and most importantly, are the creation of structures to calculate the anthropogenic factors in the background of natural processes.

Contamination by sea transport

At the same time, exploitation of offshore oil fields and transportation of oil products, and sea transport also pollute the Caspian waters.

Samples taken from offshore bottoms have been identified as oil products, phenols, and mercury in some regions. The most polluted bay of Baku, where pollution of the groundwater sediments leads to the reduction of organisms and benthos and in some cases, dip fauna. The pollution of seawater has caused great tension in the ecological conditions of the Caspian Sea and has created an ecological crisis in some coastal areas. The ecological conditions of the sea also had a negative impact on the creation of a number of water reservoirs in the Volga and Kura basins. This led to a sharp decrease in the amount of water, and on the other hand deprived a number of precious species of traditional caviar.

Pollution caused by oil and gas extraction.

The most polluted areas in the sea are at the same time environmental crisis areas. Such areas include Aktau, Baku, Sumgayit, Makhachkala, Turkmenbashi, and offshore oilfields.

When discussing the pollution of the Caspian Sea, the following features should be taken into account: Firstly, uneven distribution of wastewater leads to serious pollution of separate seas. Secondly, the coastal pollution is carried from one zone to another and polluted. Taking into consideration that the waste is accumulated on the top of the water - when it comes to the "water-atmospheric" zone, it is necessary to note that more polluted areas of the sea have been polluted.

The most dangerous contamination for the Caspian Sea is pollution with hazardous chemicals. These include oil hydrocarbons, hydrocarbons, carbohydrates, chlorine organic compounds, and heavy metals. Oil hydrocarbons play a major role in sea pollution. The conversation is about the sea oil industry and subsea oil pipes covering the Absheron peninsula and half of Manchislau. Although the appearance of oil spills in the sea at times was considered as a science and technique, some scholars have given full coverage to the possibility that it will cause harmful consequences in the near future.

Compared to the eastern and western parts of the sea, the level of contamination in the north is relatively small. The role of Volga and other river-water reservoirs in the protection of the Caspian lake environment, especially in the wastes, is great. At the same time, the sediments of the Caspian Sea and its physical, chemical and biological treatment processes are also important. In the middle and southern regions, the temperature (normality) increases the speed of chemical reactions in the water, and ultimately, the sea water is self-sufficient.

Anthropogenic pollution in the coastal strip of the Caspian Sea

One of the other reasons for the oil pollution of the Caspian Sea comes from poor hydrocarbon control in existing streams (natural streams, municipal streets, etc.). As a result of the unmanaged waste management at the enterprises or facilities operating near these streams or coastal areas, the Caspian Sea is affected by anthropogenic impact and, therefore, leads to the destruction of living organisms in the water environment.

Results

Among the Caspian Sea problems contamination of the sea water and related deterioration of environmental condition is the main issue of the latest period alongside the sea level oscillations. The rich natural resources of the sea and its therapeutic significance caused many people inhabit around the sea. The basic pollution sources of the Caspian Sea are the slopes of the cities and industrial objects situated in its basin, coasts, and water areas, as well as various contaminants discharging from maritime transportation and oilfields. Currently 15 ml people live in Caspian coastal zones, whose life activity is directly connected with the sea (mostly fishery).

The Caspian Sea which is the most fecund water basin of the world is considered the unique sea for containing great numbers of sturgeon (roughly 95%). As it is known, sturgeon produces black caviar that is considered very valuable product in the world market. Therefore genetic pool of these fish in the Caspian Sea is strictly preserved. It must be mentioned that the main exporter of black caviar is due to inhabitants of this lake on Earth. But riches of the Caspian Sea do not deplete with this. Caspian Sea is also one of the largest hydrocarbon raw centers for oil-gas reserve potential. Caspian Sea is mostly studied like other endorheic basins for its ecological characteristics.

The problem of changing the level of Caspian sea.

The change in the level of the Caspian Sea has always caused socio-economic and environmental problems in the coastal zone. For example, in the event of a decline, all hydropower facilities, including ports, need to be rebuilt. The area of the shelf zone where the fauna of the Caspian fauna is settled and the area decreases, hindering the passage of fish to the river to spawn.

Discussion

The hydrometeorological regime of this zone also has negative changes. In the event of a rise in the level of socio-economic life of the coastal zone, there is a great deal of damage, environmental degradation, swamps, homes and lands remain under water. For example, in the coastal zone of Azerbaijan in the 1978-1995 level 2.5m above sea level "ecological refugees" The damage caused directly to Azerbaijan is \$ 2 billion. For example, many settlements and farms located in the southern part of our country 10-15 years ago faced that catastrophic disaster, causing serious damage to the population and the state.

Watering of equipment, flooding of oil products, dismantling of facilities, etc. As can be seen from Table 1, during the 20th century, the level of the Caspian Sea increased and diminished respectively over the years. In the southern and central areas, the Caspian Sea is exposed to more hydrodynamic hazards. In addition, the bottom of the Caspian Sea is susceptible to mud volcanoes. Areas with sulfur content are more dangerous. If there is a strong earthquake, it can take up to 1 million tons of sulfur-containing hydrocarbons at 1000 atmospheres, which is a global disaster.

Years	Level (compared Baltic sea)	Area (1000 km²)
1910	-26,30	405,5
1920	-27,80	389,0
1930	-27,10	398,5
1940	-28,09	379,0
1950	-27,93	376,5
1960	-27,81	374,1
1970	-27,73	374,0
1980	-27,57	371,6
1990	-27,44	386,0

Table 1. The change of the Caspian Sea level during XX century

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Historical profile of selected metals in the core sediments of southeastern part of Caspian Sea (Gorgan Bay)

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Keywords:Gorgan Bay, sediment, selected metals,Cores

Introduction

Core sediments are very useful instrument for reconstruction and detecting different process as paleoclimate, effects of anthropogenic activities and natural events on sedimentary environments (Harikumar and Nasir, 2010), also investigation on Geochemical and geo-statistical assessment of aquatic ecosystems (Karbassi et al., 2005; Mohamed et al., 2005; Sun et al., 2012; Vallius, 2014; Veerasingam et al., 2015). coastal zones with their variable physical and chemical properties are suitable environment for accumulation of pollutants (such as heavy metals), and may activity cases sinks or sources of heavy metals in bottom sediments (Harbison,1986; Szefer et al., 1995). Trace metals concentrations from natural and anthropogenic sources in coastal area can be increase due to high input and urbanization (Harikumar and Nasir, 2010). In fact, increase of metal contamination in aquatic environments because of industrial or human activities have directly influence on coastal ecosystems (Alessandro et al., 2006). Thus, core sediments obtained from these coastal areas provide a good chronological record of contamination (Morelli et al., 2012). Understanding trace metal emissions in coastal environments is an important task for researchers and policy makers, and regulatory actions can be implemented to reduce potential health risks.

Materials and methods

In this research for Historical profile of selected metals in the core sediments of southeastern part of Caspian Sea (Gorgan Bay), 5 sedimentary cores (K1, K3, K5,K7,N1) and 15 superficial samples were collected from different parts of Gorgan Bay using a Gravity Corer and Van Veen grab. The grain size analysis was carried out with a laser particle size analyzer major and trace elements were measured by the ICP-OES method.

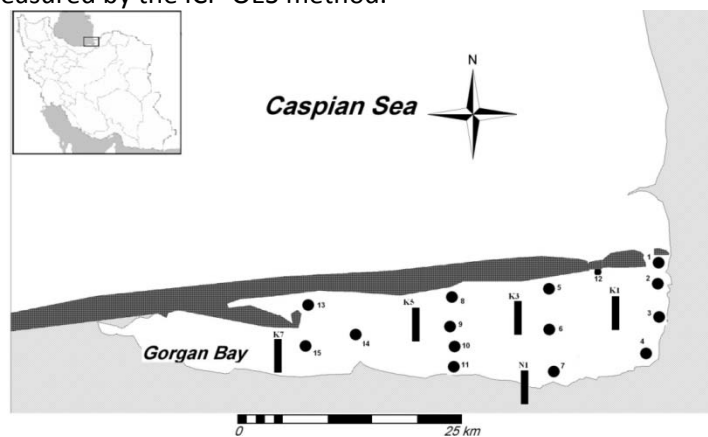


Fig.1. sampling map

Result and Discussion

Grain size analysis showed most of the surface samples from eastern part of the Grogan Bay are generally in the range of sandy silt or sandy mud and in the central and western parts are in the range of muddy sand and silty sand, while in the core sediments, grain size was very variable from sand to clay due to sea level fluctuations in different periods. In the geochemical study, it was determined that the concentration of the major elements (including aluminum, iron, calcium, magnesium, potassium, sodium and sulfur), and trace elements (including arsenic, copper, chromium, cobalt, lead, zinc, molybdenum and nickel) are comparable to the natural grade in the earth crust (less than or equal) except the chrome because of specific gravity in coastal area and arsenic due to the high solubility in seawater and the desire for enrichment in evaporative minerals showed a higher concentration than the mean earth crust. Geochemical maps showed that concentrations of major elements in most samples were more concentrated in the eastern parts, and the concentration of all trace elements (Co, Zn Cr, Ni, As, Pb), except molybdenum decreased, from east to west of the Bay. These changes are probably related to the finer content of bed sediments in these sectors, as well as higher sediment inputs and more traffic on fishing boats. Also, the results of heavy metal concentration changes in cores indicate that the highest concentration of heavy metals is generally in the depths of 0-50 cm and the lowest concentrations of these elements are at a depth of 70 cm and more. (Figure.2)The high correlation between trace elements shows the same geochemical properties and the potential source of contamination. Also, the positive correlation of these elements with aluminum and iron is probably due to the absorption of these elements by clay minerals and iron hydroxides, while the negative correlation of calcium with these metals is probably owing to the non propensity of trace elements to presence in calcium carbonate (Generally, biological origin).

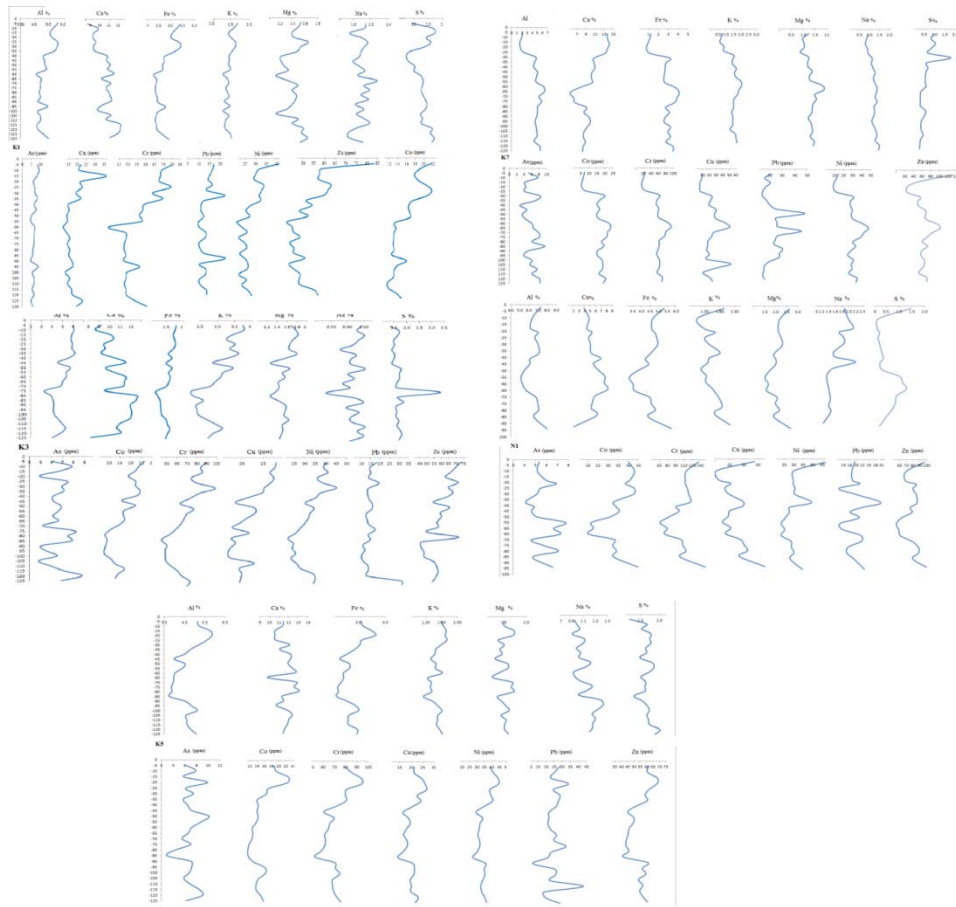


Fig.2. trend of major and trace metals in 5 cores

The value of the enrichment factor (EF) for the main elements in the surface samples is 1 and lower because of less human activities and natural entrance. While enrichment factor for chromium, lead and zinc in the eastern part of study area (stations 1 to 5) is more than 2 to 4 times higher. Also, the molybdenum with a different trend is mostly enriched in the western parts, and its highest value is related to samples from stations 11, 12 and 13 in the west of the Gorgan Bay, that concentration is more than 3 times over the concentration of the element in natural samples. Nickel, cobalt, copper and arsenic are also contaminated in most samples, upstream sediments of the region and erosion of formations in the south and southeastern part of the region by seasonal and permanent rivers is probably the main factor for their enrichment in the environment, another factor is that local contaminants are probably due to repair of the fishing boats that have been poured into the sediments. The values of the enrichment factor for the main and trace elements in the core samples K1, K3, K5, N1 are generally in the range of 1, which indicates the natural source of the elements in the sediment, while in the core K7 for zinc, lead, and arsenic, moderate to high enrichment suggests that with regard to the Behshahr industrial town and entry of wastewater into this environment could cause contamination and pollution (Figure.3).

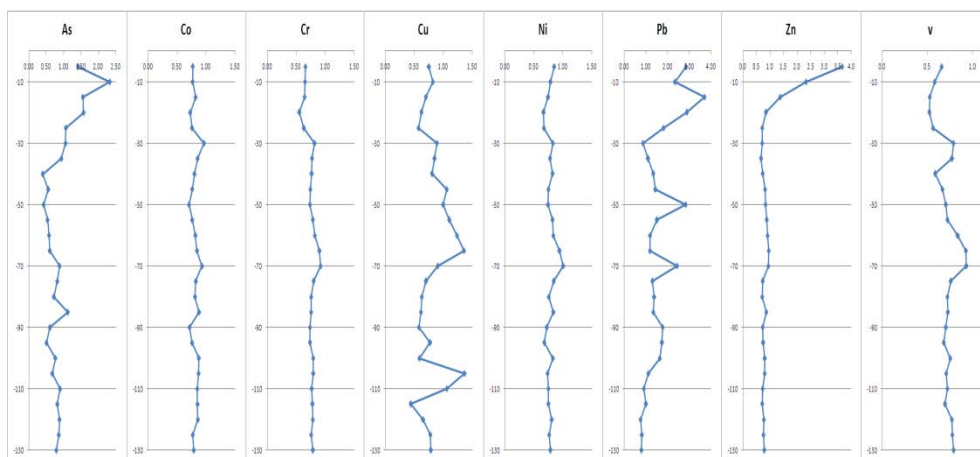


Fig 3. Trend of enrichment factor in K7

Finally, the comparison of variations in the concentration of selected elements in the study area (surface and core sediments) with the American and Canadian sediment quality guidelines showed that the amount of these elements in the sediments of this region is less than dangerous and harmful and is in the range between the two guideline but because of ecosystem condition, tourism and aquatic resources, this area, must be prevented, managed and monitored properly before they constitute a serious threat to the health of the environment and the organisms .

Table 2. Comparison of this study (surface and core sediments) with other studies and quality guidelines

Region	Pb (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)	Ni(ppm)	V(ppm)	Co(ppm)	Cr(ppm)	Reference
GORGAN BAY(surface)	4.1-18.3	3.8-31.2	13-75	4.4-11.8	10.3-50.4	38.66-80.2	3.5-20.8	13-52	This study
GORGAN BAY(Cores)	9.88-43.8	6.01-45.2	23.86-106.18	2.89-10.15	8.78-105.4	13.07-116.50	5.37-44.79	15.32-149.6	This study
Southern part of Caspian Sea	12.48±3.22 (7.20-19.03)	18.91±4.48 (10.83-25.50)	66.85±10.11 (44.68-78.09)	9.94±1.71 (7.17-13.52)	32.87±5.25 (20.80-39.46)	86.07±20.71 (52.96-112.90)	14.85±2.80 (11.41-19.57)	72.29±19.48 (45.62-110.88)	Bastami et al. (2016)
Caspian Sea (Iran)	15.98±3.29 (10-23)	21.87±8.97 (14-42)	73.22±18.91 (51-112)	10.37±2.71 (7-17)	47.71±11.3 (2-34-65)	149.48±63.44 (89-329)	30.21±7.34 (22-33)	127.38±49.85 (75-275)	Bastami et al. (2015)
Caspian Sea (Iran)	18.0±4.17 (11.3-24.6)	34.7±11.9 (13.2-50.9)	85.3±17.9 (55.9-146)	12.5±3.04 (6.97-20.1)	51.6±11.8 (29.4-67.8)	116±20.5 (76.5-145)	15.9±4 (6.9-24.2)	85.2±15.3 (59.6-128)	De Mora et al. (2004)
Persian Gulf	3-10	5-33	4-79	4-21	20-192	47.47-57.94	3-22	92.37-104.18	Agah et al. (2012)
Algeciras Bay, Spain	2.0-39.0	5.0-25.0	33.0-117.0	-	19.0-144.0	-	5.0-22.0	30.0-251.0	Díaz-de et al., (2011)
Musandum peninsula, Ganga, India	0.91-9.5	2.4-5.4	7.7	29.3	9.9-15.4	10.2-18.1	1.98	66	Fowler et al. (1993)
Sungai Buloh, Malaysia	148.8-211.4	12.7-84.0	137.3-201.2	-	14.6-82.5	-	30.0-102.2	126.8-196.1	Pandey et al., (2014)
ERL ^a	43.4-32.0	27.4-55.5	65.2-152.7	-	9.4-22.4	-	1.6-5.6	32.3-54.4	Nemati et al., (2011)
SEL ^b	31	16	120	6	16	-	-	26	Long et al., (1995)
TEL ^c	250	110	820	33	75	-	--	110	Long et al., (1995)
PEL ^d	30.2	18.7	124	7.24	15.9	-	-	52.3	ISQG (1995)
	112	108	271	41.6	42.8	-	-	160	ISQG (1995)

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Heavy Metal Pollution in Water and Heavy Metal Poisoning

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Keywords: *Toxic metal , Heavy metals, Pollution*

INTRODUCTION

Water pollution is contamination of water by foreign matter that deteriorates the quality of the water. Water pollution covers pollutions in liquid forms like ocean pollution and river pollution. As the term applies, liquid pollution occurs in the oceans, lakes, streams, rivers, underground water and bays, in short liquid-containing areas.

It involves the release of toxic substances, pathogenic germs, substances that require much oxygen to decompose, easy-soluble substances, radioactivity, etc. that becomes deposited upon the bottom and their accumulations will interfere with the condition of aquatic ecosystems. For example, the eutrophication: lack of oxygen in a water body caused by excessive algae growths because of enrichment of pollutants. According to the water cycle, naturally, water around us will be absorbed to the land (soil) and rivers will stream from the upstream to the downstream and released to the sea. In normal situation organic pollutants are biodegraded by microbes and converted to a form that brings benefits to the aquatic life. And for the inorganic pollutants, in the same situation, don't bring to much hazards because they are widely dispersed and have almost no effect to the environment which they are released to.

Some of the pollutants like lead (Pb), arsenic (As), mercury (Hg), chromium (Cr) specially hexavalent chromium, nickel (Ni), barium (Ba), cadmium (Cd), cobalt (Co), selenium (Se), vanadium (V), oils and grease, pesticides, etc are very harmful, toxic and poisonous even in ppb (parts per billion) range. There are some minerals which are useful for human and animal health in small doses beyond which these are toxic. Zinc (Zn), copper (Cu), iron (Fe), etc fall into this category. For agriculture, some elements like zinc, copper, manganese (Mn), sulphur (S), iron, boron (B), together with phosphates, nitrates, urea, potassium, etc are useful in prescribed quantities. There are some compounds like cyanides, thiocyanides, phenolic compounds, fluorides, radioactive substances, etc which are harmful for humans as well as animals.

Methods and materials

Atomic Absorption Spectrometry (AAS) is a technique for measuring quantities of chemical elements present in environmental samples by measuring the absorbed radiation by the chemical element of interest. This is done by reading the spectra produced when the sample is excited by radiation. The atoms absorb ultraviolet or visible light and make transitions to higher energy levels. Atomic absorption methods measure the amount of energy in the form of photons of light that are absorbed by the sample.

Flame atomic absorption methods are referred to as direct aspiration determinations. They are normally completed as single element analyses and are relatively free of interelement spectral interferences. For some elements, the temperature or type of flame used is critical. If flame and analytical conditions are not properly used, chemical and ionization interferences can occur. Different

flames can be achieved using different mixtures of gases, depending on the desired temperature and burning velocity. Some elements can only be converted to atoms at high temperatures. Even at high temperatures, if excess oxygen is present, some metals form oxides that do not redissociate into atoms.

The GFAA and flame AAS measurement principle is the same. The difference between these two techniques is the way the sample is introduced into the instrument. In GFAA analysis, an electrothermal graphite furnace is used instead. The sample is heated stepwise (up to 3000°C) to dry. The advantage of the graphite furnace is that the detection limit is about two orders of magnitude better than that of AAS. The analysis of different species of a given element is important because different oxidation states of the same element may present different toxicities and, consequently, different risks. Therefore, sequential extraction procedures for the separation and further analysis of a species have been developed for several metals.

Results

SOURCES OF HEAVY METAL - Environmental pollution from hazardous metals and minerals can arise from natural as well as anthropogenic sources. Natural sources are: seepage from rocks into water, volcanic activity, forest fires etc. Pollution also arises from partitioning of polluting elements (which are concentrated in clay minerals with high absorption capacities), between sedimentary rocks and their precursor sediments and water. With rapid industrialization and consumerist life style, sources of environmental pollution have increased. The pollution occurs both at the level of industrial production as well as end use of the products and run-off. These toxic elements enter the human body mostly through food and water and to a lesser extent through inhalation of polluted air, use of

cosmetics, drugs, poor quality herbal formulations' (herbo-mineral preparations) and 'Unani' formulations, and even items like toys which have paints containing lead.

Sources of heavy metals - Chromium (Cr)-Mining, industrial coolants, chromium salts manufacturing, leather tanning

- Lead (Pb) lead acid batteries, paints, E-waste, Smelting operations, coal-based thermal power plants, ceramics,

- bangle industry

- Mercury (Hg) Chlor-alkali plants, thermal power plants, fluorescent lamps, hospital waste (damaged thermometers, barometers, sphygmomanometers), electrical appliances etc.

- Arsenic (As) Geogenic/natural processes, smelting operations, thermal power plants, fuel

- Copper (Cu) Mining, electroplating, smelting operations

- Vanadium (Va) Spent catalyst, sulphuric acid plant

- Nickel (Ni) Smelting operations, thermal power plants, battery industry

Cadmium (Cd) Zinc smelting, waste batteries, e-waste, paint sludge, incinerations & fuel combustion

- Molybdenum (Mo) Spent catalyst

- Zinc (Zn) Smelting, electroplating

One group of factors that may be detrimental to all organisms within urban ecosystems is metal contaminants, such as lead, zinc, copper, cadmium, mercury, nickel, and iron, that get deposited in soil. Metal contaminants are introduced into food webs at the bottom of the food chain and reach earthworms and other invertebrates that live in the soil. When consumed by organisms such as birds and snakes, the contaminants and their potential toxic effects accumulate within sensitive organs and tissues.

HUMAN EXPOSURE THROUGH FOOD, AIR AND WATER

Heavy metal pollution of surface and underground water sources results in considerable soil pollution and pollution increases when mined ores are dumped on the ground surface for manual dressing. Surface dumping exposes the metals to air and rain thereby generating much AMD. When agricultural soils are polluted, these metals are taken up by plants and consequently accumulate in their tissues. Animals that graze on such contaminated plants and drink from polluted waters, as well as marine lives that breed in heavy metal polluted waters also accumulate such metals in their tissues, and milk, if lactating. In summary, all living organisms within a given ecosystem are variously contaminated along their cycles of food chain.

Discussions

HEAVY METAL POISONING AND BIOTOXICITY- The biotoxic effects of heavy metals refer to the harmful effects of heavy metals to the body when consumed above the biorecommended limits. Although individual metals exhibit specific signs of their toxicity, the following have been reported as general signs associated with cadmium, lead, arsenic, mercury, zinc, copper and aluminium poisoning: gastrointestinal (GI) disorders, diarrhea stomatitis, tremor, hemoglobinuria causing a rust-red colour to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia when volatile vapours and fumes are inhaled. The nature of effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic. Cadmium is toxic at extremely low levels. In humans, long term exposure results in renal dysfunction, characterized by tubular proteinuria. High exposure can lead to obstructive lung disease, cadmium pneumonitis, resulting from inhaled dusts and fumes. It is characterized by chest pain, cough with foamy and bloody sputum, and death of the lining of the lung tissues because of excessive accumulation of watery fluids. Cadmium is also associated with bone defects, viz; osteomalacia, osteoporosis and spontaneous fractures, increased blood pressure and myocardic dysfunctions. Lead is the most significant toxin of the heavy metals, and the inorganic forms are absorbed through ingestion by food and water, and inhalation (Ferner, 2001). A notably serious effect of lead toxicity is its teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin; dysfunctions in the kidneys, joints by food and water, and inhalation. A notably serious effect of lead toxicity is its teratogenic effect. Lead poisoning also causes inhibition of the synthesis of haemoglobin; dysfunctions in the kidneys, joints and reproductive systems, cardiovascular system and acute and chronic damage to the central nervous system. Zinc has been reported to cause the same signs of illness as does lead, and can easily be mistakenly diagnosed as lead poisoning. Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction. The clinical signs of zinc toxicosis have been reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, kidney failure and anemia. Mercury is toxic and has no known function in human biochemistry and physiology. Inorganic forms of mercury cause spontaneous abortion, congenital malformation and GI disorders (like corrosive esophagitis and hematochezia). Poisoning by its organic forms, which include monomethyl and dimethylmercury presents with erethism (an abnormal irritation or sensitivity of an organ or body).

Acknowledgement

The toxic elements enter the body mainly through water, food and air. Cosmetics, dental products, some drugs, particularly Ayurvedic and Unani drugs also contribute. More research is needed to assess the extent to which these products affect human health. Public awareness should be created. There should be monitoring and control over the concentration of heavy metals in cosmetics. Heavy metals are important in many respects to man, especially in the manufacturing of certain important products of human use, such as accumulators (Pb), mercury-arc lamps and thermometers (Hg), utensils (Al) and a wide range of other products. But the biotoxic effects, when unduly exposed to them could be potentially life threatening hence, cannot be neglected. While these metals are in many ways indispensable, good precaution and adequate occupational hygiene should be taken in handling them. Although heavy metal poisoning could be clinically diagnosed and medically treated, the best option is to prevent heavy metal pollution and the subsequent human poisoning.

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Identification and prevention of sources polluting the Caspian Sea during drilling, completion and exploitation of oil and gas wells in Azerbaijan's aquatorium.

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Keywords: oil and gas wells, open fountain, griffins, exploitation of wells, Caspian Sea, contamination sources.

Introduction.

The oil, which flows into the sea during drilling, completion and operation of oil and gas wells in the Caspian Sea, besides, various chemical compositions are used to maintain the wells of the wells, all of these causes sea pollution. Our goal is to provide environmental safety while using natural resources. When oil and gas wells are drilled, oil, gas, water manifestations, open flood and griffin can occur in the well, and it can result leakage of large amounts of oil products in the Caspian Sea. This will cause formation of oil membrane on the surface of the sea which leads to the pollution of the Caspian Sea and the destruction of living things there.

Materials and methods.

The open fountain is the flow of water, gas and oil from well that can not be controlled. When complex open fountain happens gas more than 1 mln. m³ of, and oil more than 200 tons can spill and can be observed with fire. At the same time, in the process of drilling of oil and gas wells, oil, gas, water or mixtures thereof are observed on the ground at or below the bore. This event is called griffin. Griffins cause large quantities of oil and gas degradation, layer energy loss, and environmental pollution. Griffins are natural and artificial. Artificial griffins are associated with drilling oil and gas wells. One of the main reasons for artificial griffins is non cementation of protective belts in the construction of wells. Prevention of griffins requires considerable funding, and sometimes it is impossible to prevent it. One of the main factors influencing the quality cementing of wells is the fact that the drilling fluid in the cementing process is not removed from the back of the belt. As a result of experts research, it was proved that, the specific weight, viscosity and sliding tension of the cement solution must be greater than the drilling solution to effectively remove the drilling fluid from the back of the belt.

Oil, surface active substances, mine waste water, waste water containing chemicals, and paraffins can be illustrated mainly environmental pollutants as during the operation of wells. Operation of wells in the sea environment is conducted with fountain, compressor and depth pump method. In order to maintain the technological regime in the wells, amount of mechanical composition of well product, percentage of irrigation, bottom of well, corner of well, layer pressure are constantly measured. Violation of the regime of the wells operating

under fountain and compressor method, change of worker pressure determined with the decline of the well production. Environmental pollution occurs while controlling the well operation and rehabilitation of the damaged operation regime. As you can see, there are several steps to prevent these processes.

Result.

The main source of pollution of the Caspian Sea, except for accidents, is the drilling cuttings, drilling rig, layer water and layered sand with oil in its composition that is accumulated during the drilling of the well. Large volume of drilling sludge generated during drilling require pre-treatment of oil products and chemical reagents. drilling sludge is rock particles that emerge from the well when digging wells. Disposal of these into the sea without treatment leads to the destruction of the ecological balance. Studies show that, limit concentration of drilling cuttings for water bodies living in the Caspian Sea is 2.0-2.3%, and thickness which results with death is 1.5-2.9%. Concentration of harmless drilling cuttings prepared in Azerbaijan for the fauna of the Caspian Sea is 0.3-0.4g / l.

Organic and inorganic chemicals are used to regulate the mechanical properties of the drilling fluid and as examples of oxygen, sunil, sulfanol, graphite, caustic soda, barite can be shown. Barite is used to aggravate drilling fluid.

The amount of barite depends on the necessary density of the drilling fluid and sometimes reaches up to 35%. It should be noted that, chemically processed and heavy drill muds, as well as barite and chemical reagents included in their composition have a disastrous effect on fishes and their invertebrates.

Thus, the following measures should be taken to reduce the risk of pollution of the Caspian Sea during drilling operations:

1. Choose less toxic reagents when conducting drilling works;
2. Reduce waste toxicity in various ways (chemical, technical and mechanical) in drilling and oil production;
3. To create waste-free technology by completely neutralizing wastes and use them in various industries;
4. Constantly to improve environmental standards and apply them to the Caspian Sea.

In the process of exploitation of wells by means of fontan-compressor in sea conditions, the stationary equipment on the stationary platform is deployed on a new scheme that eliminates environmental pollution as a result of this scheme. All fountain wells in this scheme are equipped with packer and "cut-off valves". "Cutting-valve" should be placed on the lines of the fountain armature. These valves begin to work when the pressure in the system is lower than

the specified value. When the pressure is low in the well, when the temperature increases, the machine runs. Technological collection levels are provided by level indicator, protective valve, level and pressure regulators. The system is also designed with arrangement in order to prevent beatings. Improper application of these valves during well exploitation may lead to environmental pollution. In any well, the well-protective "cut-off valve" is switched on, the light and sound signals enter into the operator room, and as a result, the cause of failure in the well is investigated and measures are taken.

Discussion .

Thus, we can minimize environmental damage by using methods to ensure the safety of oil and gas wells extracted from the aquatic environment, throwing of rocks into the sea extracted from the well after cleaning and cleaning composition of the drilling fluids. However, it is not possible to completely eliminate it, as there are accidents in the well drilling process. The reason for these accidents is due to the carelessness of the drilling brigade.



Picture 1. Oil membrane on the surface of the Caspian Sea.

In the event of accidents, oil, petrol and diesel fuel in most cases, and burning products during fires spread to the environment. When oil products flow into the sea, the oil membrane forms on the surface of the sea. Depending on the initial thickness of the oil membrane, up to 15-50% of oil products remain in the oil membrane spread after the fire (picture 1).

As a result of the laboratory research it was determined that, drilled rocks contain up to 8% of the chemical reagents, the concentration of these reagents in normal drilling condition may be as follows:

clayey solution , q/l	0,5-1,0
Drilling cuttings, q/l	<0,5
barite, q/l	0,5
Lime , q/l	≤0,005

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The threat of plastic pollution to marine fauna of Caspian Sea

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Keywords: Marine pollution, Microplastic, Plastic ingestion

Introduction

The Caspian Sea (CS) is the largest inland body of water on Earth without outflows, shared coastlines between five countries. The entire extension of the southern coast belongs to Iran and is rimmed by the Alborz Mountain Ridge (Zonn and Kosarev, 2010). Today, the southern coast of the CS is home to thousands of people and attracts millions of tourists each year. At the beginning of this century, the major environmental issues of CS were the impact of sea level fluctuations on coastal inhabitants, the drastic decline in sturgeon populations, and water pollution (Jafari, 2010). Oil and gas offshore and onshore operations, industrial, municipal and agricultural wastes, in addition to unregulated transport and equipment traffic, were the main sources of pollution. Now, plastic pollution is a rising problem.

Plastics have become crucial to many areas of modern life, used for manufacture to the transportation of almost all products (Isensee and Valdes, 2015). Along with an extreme increase in plastic production, plastics are the fastest growing component of waste. Every year, more than 2 million tons of plastics use in Iran that much of them litter the landscapes. Only in Iranian rim of CS, around 7% of 6600 tons of daily produced trashes are plastics, 90% of them are polluting the river banks, wetlands, beaches, and forests. Plastics enter the sea by wind blowing, directly through the poor waste management, shipping, fishing and illegal dumping. Furthermore, over 130 rivers, including enormous Volga River, provide inflow and debris to the Sea from the drained lands. Globally, almost 10% of the annual production ends up into the oceans, and plastic debris accumulation has been reported as a global scale phenomenon (Avio *et al.*, 2015).

Adverse effects of macro-size plastics have been documented in terms of the decrease of aesthetic values of coastal areas, entanglement and physical damages to locomotory, respiratory or digestive appendages lead to death in marine mammals, turtles, seabirds, fish, and invertebrates (Wilcox *et al.*, 2015; Isensee and Valdes, 2015). In 2009 approximately 10% of 312 stranded carcasses of Caspian Seal showed direct evidence of entanglement in large mesh nets (Dmitrieva *et al.*, 2013). Wilcox *et al.*, 2015 predicted plastics ingestion increases in seabirds, and it will reach 99% of all species by 2050. Large floating pieces may act as habitat, or promote rafting by alien species representing an additional risk to local biodiversity or spread diseases (Browne *et al.*, 2015; Avio *et al.*, 2015).

Microplastic

As a result of their durability, plastic particles might persist in their initial condition for up to 50 years in the marine environment (Wegner *et al.*, 2012). Then, under the influence of wave action and UV, large plastics gradually degrade into smaller fractions, thus giving rise to fragments generally categorized as microplastics (<5 mm) (Lusher *et al.*, 2013). Considerable amounts of micro-sized plastic particles are also directly introduced into the water systems. Particles in the form of granules and resin pellets (2- 6 mm), the raw material of plastic manufacture, are released during transport and handling. Many of them can easily found in trash lines of Southern CS especially near busy Anzali and Amirabad ports. Other sources of them are consumer products like facial cleansers and toothpaste (median size, 196- 375mm) as well as industrial abrasives (Wegner *et al.*, 2012). Decreasing size, the plastic fragments are potentially available to an increasing number of marine species and the problems change

when animals start to inhale or ingest it (Browne *et al.*, 2015). They have been ingested by invertebrates such as zooplankton, polychaetes, bivalves, crustaceans, echinoderms, salps, etc. of different trophic levels and by marine vertebrates (Lusher *et al.*, 2013; Nobre *et al.*, 2015). There is also evidence of take-up microplastics via trophic transfer (Naji *et al.*, 2018).

It is also known that plastic polymers tend to accumulate persistent and toxic hydrophobic pollutants (POPs) such as PAHs, PCBs, and DDT at higher concentrations than seawater or sediments according to the time of exposure, type of resin and its characteristics (Nobre *et al.*, 2015). A recent study carried on sediment and plastic wastes of Miankaleh (Eastern part of Southern CS) showed a much higher concentration of PAH compounds on the plastics than sediment (Rajabi and Riyahi, 2018). This might increase the risk of exposure to marine organisms, by which bioaccumulation and biomagnification could occur through the food chain (Naji *et al.*, 2018).

Plastics are also made with several chemical pollutants known to be toxic and disrupt the functioning of the endocrine system (Rochman *et al.*, 2014). These chemical compounds such as emollients, colorants, antioxidants, and UV-stabilizers are usually added in order to enhance their performance. Studies carried on the surface water and sediment of Anzali wetland (west of Southern CS) to determine the concentration of two plasticizers showed their amounts were higher than the environmental risk limit (Hassanzadeh *et al.*, 2014a, b). The additives can leach from ingested microplastics into the body of organisms and their biological effects can be severe (Rochman *et al.*, 2014).

Conclusion

A recent review of the United Nations Convention on Biological Diversity documented over 600 species, ranging from microorganisms to whales, affected by marine plastic waste (Wilcox *et al.*, 2015). Microplastics can accumulate in high numbers in the intestines, resulting in physical harm, promote a false sense of satiation, transfer plastic additive toxins and POPs causing carcinogenesis and endocrine disorders, and leave cellular alterations (Lusher *et al.*, 2013; Avio *et al.*, 2015). The Caspian's ecosystem has already suffered from extensive pollution. A huge number of macroplastics and microplastics of different shape, color, size, and types are found on the shorelines and sea surface. Considering the other chemical pollutants of Caspian Sea, and absorbing behavior of microplastics, they can act as a vector of chemicals and microbes to fragile marine food chains and human. This additional stress is a real threat to Caspian Sea Fauna and needs a regional monitoring program and strong acts to decrease the ecological and biological effects of plastic pollution.

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