The Impact of the Envıronmental Sıtuatıon on the Landscapes of the Caspıan Sea Coast's Azerbaıjan

Shafiqa Humbatova[1], *Gunay* Abbasova[2*], and *Mahmud* Humbatov[3]

[1]Baku State University, Baku, Azerbaijan
[2]Water and Amelioration Scientific Research Institute, Baku State University, Baku, Azerbaijan
[3]Western Caspian University, Baku, Azerbaijan

Abstract. Coastal transformation as a result of hydrodynamic factors and sea level changes has a significant impact on ecosystems, economic infrastructure and coastal population. [3] Rapid changes in the Caspian Sea level have created unstable conditions for the coastal environment since the 20th century. The aim of this study is to study the impact of pollution on the ecosystem, infrastructure of adjacent areas, natural tourism resources, people, landscape transformations of the Azerbaijani Caspian Sea coast, as well as to assess the magnitude of coastline displacement and morphological changes.

1 Introductıon

In modern times, the rapid development of science and technology and population growth have intensified the use of nature, and new natural area complexes have been used in the production process Natural processes such as erosion, transport and deposition shape and change the coastal environment in different time frames and periods. Sea coasts are changing as a result of natural processes and human impacts. Natural and anthropogenic transformation processes are taking place on the seashores.

Landscapes can help enhance natural conservation and cultural heritage, both of which play an important role in tourism management [1].

One of the most important global environmental problems of the modern era is pollution. Areas and coastal landscapes are contaminated with agricultural, industrial and oil wastes, resulting in pollution that negatively affects water and soil quality. These pollutions are more evident against the background of global climate changes.

Humans have significantly changed the coastal environment, are unable to use the area effectively and efficiently, and effective coastal management is needed.

The most important difference between the Caspian Sea and other open seas lies in their different sea level patterns. It is of great importance to investigate the effect of sea level change on coastal areas [2].

The Caspian Sea has a highly sensitive ecosystem due to its planetary position and the configuration of the earth's crust. In recent years, its ecological status as a closed basin has

*Corresponding author: gunay.abbas@gmail.com

changed under the influence of anthropogenic and biogeochemical factors. it becomes extremely strained as a result of man-made impacts. Oil and petroleum products, which play a major role in general pollution as an anthropogenic factor in destabilising the Caspian Sea ecosystem, have become one of the major pollutants that adversely affect the biocenosis of the sea.

Various climatic zones pass through the Caspian Sea. The northern part of the sea is continental-temperate climate zone; the west coast is temperate-warm climate; the south-west and south coast is subtropical humidity; desert climate passes through the east. All this determines not only the difference in the amount of atmospheric precipitation, but also the nature of the temperature regime and the development of seasonal synoptic processes. The amount of precipitation in different parts of the basin varies quite sharply. Therefore, the highest amount of precipitation in the basin is observed in the north and west.

The results of the conducted research (monitoring and observations) show that the transformation of the coastline has a direct impact on various economic infrastructures, such as commercial harbours, thermal power plants and coastal tourism facilities, which in time affect the hydrodynamic erosion factors of the sea. (coastal currents and waves) and serious damages occur as a result of sea level changes [8, 10]. The coasts of the Caspian Sea are no exception to these trends, and as a result of sea level changes, serious changes occur and are subjected to widespread environmental problems. These environmental changes sometimes occur a hundred times faster than the changes in the oceans and sometimes in the opposite direction [5].

Changes in the geo-ecological status of the Caspian Sea with its natural characteristics over time and space have also shaped the economic activities carried out in the coastal areas. Changes in time and space, instability in the coastal regions have caused changes in the ecological situation.

As a result of the research, it was established that the characteristic indicator of the ecological state of the sea is the degree of its pollution, which can be dangerous for human life, and at the same time can lead to aggravation of ecological conditions by creating a dangerous situation for the life of the living creatures living there.

The degree of pollution of the sea is characterised by the concept of maximum permissible concentration of pollutants (MP). The state and quality of the sea is monitored on the basis of the MPC. The presence of pollutants above the SAC, especially in multiples, means that the state of the sea is unsatisfactory or even critical [5]. It should be noted that the amount of pollutants in seawater varies. This is due to the natural elimination of pollutants as a result of natural, physical, chemical and biological processes occurring there, in other words, self-cleaning of the sea [3-5].

The main factors polluting the sea are river waters, domestic and industrial wastes thrown into the sea, wastes of petroleum products, accidents of tankers and tankers during the transport of oil and petroleum products, loss of petroleum products due to leaks in loading and unloading ports, excavation of the seabed, excavation of sands, testing of nuclear weapons, immersion of containers filled with radioactive and toxic substances into the water, and finally the soil spilled here during atmospheric pollutants. They consider the pollution of the Caspian Sea as the main factor in the change of its ecological status and its periodic rise and fall [5].

It has been established by researches that the change in sea level primarily affects its coasts, sometimes increasing and sometimes decreasing the area of coastal shallows, changing the hydrogeographical network of estuaries, weakening or strengthening the flow of the water mass. It disrupts the water exchange between different parts of the sea, causes changes in the distribution of the solid part of the seabed and many other phenomena. It was determined that general pollution - anthropogenic factors play a major role in changing the stability of the Caspian Sea as an ecosystem.

The structure, formation, dynamics and transformation of the coasts, the hydrometeorological regime of the sea, the nature of the coasts, the lifestyle and life activities of the peoples living there are related to interrelationships. When carrying out scientific research and other research work on the Caspian Sea, complex analyses should be carried out on each of them. Both anthropogenic and natural processes should be taken into account. Natural processes in the landscape lead to the transformation of the coastline. We need to analyse the transformation from two aspects:

- Transformation of coastal areas as a result of natural processes;
- Transformation of coastal areas as a result of anthropogenic impacts.

The main factors affecting the transformation as a result of natural processes are global warming and sea level fluctuations. Global climate change affects coastlines. Climate changes affect the groundwater level and this causes many problems. Reeds are formed in coastal areas. Subasma events occur. In addition, the configuration of the coastline is also changing. As a result of all this, differentiations in landscapes emerge.

The level of the Caspian Sea fluctuates constantly. The level of the Caspian Sea rises and falls from time to time. Accordingly, the depth of the sea and the area covered by it undergo radical changes. The processes of coastal washing and accumulation are subject to both quantitative and dynamic changes. Changes in sea level are mainly related to changes in the mass of water in it (Figure 1). The change in water mass affects the salinity and biological regime of seawater. The depth in coastal waters is also not constant due to the change in level. This has a significant impact on the hydrometeorological processes in the sea, especially on waves, currents, swelling and ebb processes in the shelf zone and determines their main parameters.

Fig. 1. Graph showing multi-year (1952-2022) level fluctuations of the Caspian Sea [15].

For the purpose of a comprehensive geoecological assessment of the state of modern landscapes in the coastal zone of the Caspian Sea, the following interrelated topics were investigated and evaluated:

- Analyses of the modern landscape structure of the study area and the factors influencing its formation at regional and local level;
- Analysis of land use structure and characteristics [1];
- Study of the manifestation of accompanying destructive processes of natural anthropogenic origin;
- Assessment of the types of natural and man-made disasters and the intensity of their development, as well as their impact on the state of natural geosystems:

- Identification of areas of the spread of the main types of pollution (air and water environment, soil and vegetation) [2];
- Impact of population density on the state of modern landscapes in the studied area; impact of settlement, production complexes and infrastructure on transformation;
- The level of providing natural resource potential to the region, the level of utilisation of natural resources, the degree of influence on transformation, the correlation between utilisation and transformation;
- The study of the impact of fluctuations in the level of the Caspian Sea and oil pollution on the geoecological status of coastal areas;
- To determine in which part of the Caspian coastal areas the natural transformation and in which part the anthropogenic transformation is more and its effect on the ecological situation;
- Investigation of the areas where the influence of the Caspian Sea on the landscape is strong, relatively weak and weak;
- Geoecological assessment of modern landscapes in the Caspian coastal regions of Azerbaijan.

The unique ecosystem and landscape of the Caspian Sea is the focus of the world scientific community. The sea coast is steep from the Samur River delta to the south. In the surfacings, alluvial sand-gravel deposits are exposed, forming the coastal depression.

In general the coastline of the western coastal region of the Caspian Sea is smooth, but the Absheron Peninsula region is an exception. There are a series of alternating anticlinal uplifts and synclinal slopes separating them, giving the coastline a fragmented appearance.

The dynamics of the modern coast of the Caspian Sea depends on the geological structure, the lithological composition of the rocks forming the coastal zone, the mechanical and chemical erosion occurring on the scoured coastline, the slope of the underwater slope and sediments. The study area is dominated by erosional and erosional-accumulative coasts. They developed on the Absheron Peninsula in the southeast of Gobustan and in the north of the Absheron Peninsula up to Mount Bashbarmag.

A change of one to two metres in sea level affects the hydrological, biological, physical and chemical regime. The average annual course of surface temperature changes, isotherm lines shift. The main changes occur on the shelf rich in zoobenthos. As the depth changes in shallow areas, the characteristics of surface waves, currents, turbulence and evaporation also change. According to the results of the analysis of the last 15 years, the level of the Caspian Sea has decreased by up to one metre. In recent years, the level of the Caspian Sea has decreased by 10 cm every year, and the amount of evaporation from the sea surface has increased due to climate changes. As the level decreases, the volume of the shelf zone decreases. The area of living organisms living in the shelf zone is shrinking. This negatively affects the biosystem of the basin. The level change in the Caspian Sea changes its volume, water surface area, coastline configuration, bathymetry and in general all morphometric parameters. The Caspian region is characterised by a number of structural and regional features. The development of recreational areas in the coastal areas of the Caspian Sea is mainly determined by the level regime. During 150 years of instrumental observations the fluctuation range was 3.8 m (from 25.2 m in 1837 to -29 m in 1977). In the period 1929-1941 the level decreased by 1.9 m and in the period 1978-1996 by 2.5 m, and these fluctuations caused significant changes in the development of the sea coast. As a result of the sea level drop in 1929-1941, sandy beaches were formed. In Azerbaijan, the level rise of about 600 kilometres, which started in 1978, caused coastal erosion, flooding and subsidence.

Analyses carried out in recent years show that fluctuations in the level of the Caspian Sea off the coast of Azerbaijan have caused major changes in the landscape and landscape-ecological conditions of the region. Therefore, the amplitude of the rise and fall of the Caspian Sea of about 1-1.5 metres should be taken into account when constructing civil

works and sewerage lines in coastal areas. Projections show that the declining level may continue until 2050. If the descents continue like this, the level is likely to drop by 3 metres. The level of the Caspian Sea reached its highest level in 1880, the level fell by 3 metres in the last 200 years from 1930 to 1977, and rose by 2.5 metres between 1977 and 1995. Since 1995, it has decreased by 2.5 metres (1.5 metres according to some scientists). Between 1978 and 1995, when the sea level rose, about 50,000 hectares of land in Azerbaijan were flooded. The damage to the economy is estimated at 2 billion dollars. Falling water level causes salinisation of the soil. If the level continues to fall, it may lead to the extinction of living organisms.

NASA estimates that the level could drop by 5-6 metres. Dutch and German [11]. scientists predict that the level will drop by 9-18 m by the end of this century. The highest level was -25.2 m in 1837, the lowest level was -29 m in 1977, a 15 cm drop of water caused an increase of 60 m^3 of water in the Caspian Sea, while in 1977, with an increase of 3 m, only about 60 m^3 of water increased. 50 thousand hectares of the Azerbaijani coast were covered with water, the landscape of that region is almost degraded, ecologically intact.

On the west coast of the Central Caspian Sea, especially near the Absheron Peninsula, in spring and winter strong winds blow mainly in the north-west-southeast direction. Such winds are relatively rare in the Northern Caspian Sea and its southwestern and southeastern parts [5-7]. The radical change in natural conditions observed in any closed water basin also applies to the Caspian Sea. These changes are caused by climatic, hydrological, geological and other complex processes occurring exclusively in the water region. The main reason for the sharp difference in the physical-geographical and climatic characteristics of the Caspian Sea is that it extends up to 10° in the meridional direction. The length of the Caspian Sea along the meridian and the complexity of the orography of its western and southern coasts determine the diversity of local climatic features. Due to the location of the sea on the borders of temperate and subtropical latitudes, the interaction of various atmospheric circulation systems occurs in the water zone. Therefore, the air masses reaching the sea can be quite diverse in terms of their physical properties and directions. The large water surface of the sea significantly affects the lower layers of these masses.

The largest sea levelling off the coast of Azerbaijan occurred in the northern part of the Absheron peninsula, in the Sumgayit region, when an area of 100 m was flooded. A number of methods are being applied for the restoration of these landscapes and they are being reused for different purposes. It should be noted that the consequences of the conflict will be seriously felt in the southern regions of Azerbaijan, Neftchala and many of our coastal regions and will lead to a number of consequences.

In general, the characteristic signs of pollution of water bodies with oil products are as follows the number of pollution sources, the impact of pollution on all components of the environment, its spread over a large area of the sea, the formation of various pollutants and sediments on the seabed, etc. Water-soluble and heavy fractions of oil adsorb other surfactants, including heavy metals, helping them to rise to the water surface. They deteriorate the quality of water, adversely affect the oxygenation mode, disrupt the balanced interaction of surface waters with the atmosphere.

During the study of the ecological situation of the Azerbaijani coast of the Caspian Sea, it is necessary first of all to determine the number of regions, settlements and villages located on the coastline and the number of people in them. Thus, the number of people in rural settlements in the studied region has decreased, most of the villages belong to the villages of Masalli and Khachmaz districts (table 1). The table was compiled by the author on the basis of the materials of the Statistical Committee of the Republic of Azerbaijan.

As can be seen in Table 1, the Azerbaijani shores of the Caspian Sea are very important for the country. The capital and many important cities are located on the Caspian coast. In addition, a large part of the population has settled in the Caspian coastal regions.

Table 1. Population decrease in rural settlements.

№	Districts	Population	Number of Villages
1.	Khachmaz	178,800 people	more than 210
2.	Shabran	58,300 people	65
3.	Siyazan	39,900 people	30
4.	Khızı	17,000 people	29
5.	Sumgayit	350,000 people	-
6.	Baku	2,6 mln people	-
7.	Absheron	209,000 people	42
9.	Salyan	137,500 people	45
10.	Neftchala	79,000 people	48
11.	Masalli	221,500 people	102
12.	Lankaran	227,500 people	83
13.	Astara	104,000 people	95

One of the main reasons for the change in the ecological status of the Caspian Sea is its pollution by chemical substances. The greatest impact of this pollution on the seas was observed in the years when its level decreased (5) (see).

As a result of the fluctuation of the Caspian Sea level, the composition of the coastal waters has undergone various changes. Therefore, in the research conducted by us, water samples taken from the Hovsan coast of the region were analysed according to the determined indicators. When the composition of sea water is analysed, the amount of pollutants is an important factor in determining the ecological situation. It is important to analyse the hydrochemical composition continuously and consistently and to evaluate the changes in the regime.

Taking all this into account, it was proposed to study the composition and hydrochemical properties of the Caspian Sea water on the beaches of Hovsan, Shikhov and Sumgait and at different distances from the beach.

Complex changes in the Caspian Sea are caused by natural and anthropogenic factors. These changes are more pronounced in places where coastal collector waters are spilled. Therefore, for the study of the Caspian Sea it is necessary to pay attention to the change of chemical properties, water and salt balance in coastal areas.

To clarify the influence of surface water on the Caspian Sea water, samples were taken from Hovsan, Shikhov and Sumgait stations. Ion content, total minerality, total alkalinity, anion and cation ratios, classes and groups, biogenic elements, pH, oxygen, Chemical Oxygen Demand (OKTbixr), OBT (Biochemical Oxygen Demand) and salt content were studied in the samples.

The results obtained are presented in the tables.

Table 2 shows the ion content, total minerality, total cod content, classes and groups according to O.A. Alyokin in water samples taken from Hovsan, Shikhov and Sumgayit stations. (Table 2)

In order to investigate the current hydrochemical properties of the Caspian Sea water, samples were taken from Hovsan, Shikhov and Sumgait stations at certain times and analysed. Meanwhile, ion content, total minerality, total acidity, some chemical properties, pH, Chemical Oxygen Demand (OCTbixr), O2, Biochemical Oxygen Demand (OBT5), suspended particles of seawater were determined by using different methods. As a result of ion content analysis of water taken from Sumgait and Hovsan coasts of the Caspian Sea.

Table 2. Meneral and other element contents in the Caspian Sea water.

№	Sampling location	Date	Total mineralisation mg	Total hardness, Mq-ekv l	A.Alyokin classification	According to A.Alyokin grouping
1	Hovsan station	11.09.20	12973.9	78.9	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca Natrium-kalium-maqnezium
2	Hovsan station 1	23.06.21	12175.9	79.0	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
3	Hovsan station 2 (100m distance)	23.06.21	11957.2	78.5	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
4.	Hovsan station 1	28.10.21	11246.4	82.5	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
5	Hovsan station 2 (100m distance)	28.10.21	11605.0	78.5	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
6	Hovsan station 1	17.01.22	12468.4	77.0	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
7	Hovsan station 2 (100m distance)	17.01.22	12942.0	73.0	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
8	Shikhov station	08.09.20	12200.4	69.0	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca natrium-kalium-maqnezium
9	Shikhov station 1	24.06.21	12257.6	85.0	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca natrium-kalium-maqnezium
10	Shikhov station 2 (100m distance)	24.06.21	12218.6	874.0	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca natrium-kalium-maqnezium
11	Shikhov station 1	27.10.21	11642.2	80.0	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
12	Shikhov station 2 (100m distance)	27.10.21	11380.5	79.09	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium

Continuation of table 2.

№	Sampling location	Date	Total mineralisation mg	Total hardness, Mq-ekv l	A.Alyokin classification	According to A.Alyokin grouping
13	Shikhov station 1	19.08.22	11708.7	79.0	CL>SO>HCO chloride	Na+K>Mg>Ca natrium-kalium-maqnezium
14	Shikhov station 100 m from station 1	19.08.22	11729.5	79.5	CL>SO>HCO xlorid sulfat	Na+K>Mg>Ca natrium-kalium-maqnezium
15	Sumgait 1 beach	16.02.22	11312.8	72.0	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca natrium-kalium-maqnezium
16	Sumgayit 1 (100 m) coast	16.02.22	11500.3	69.5	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca natrium-kalium-maqnezium
17	Sumgayit 2	10.03.22	15405.2	80.5	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca natrium-kalium
18	Sumgayit 2 (100 m distance)	10.03.22	14247.6	77.5	CL>SO>HCO chloride-sulphate	Na+K>Mg>Ca natrium-kalium-maqnezium

As it can be seen from the table, the composition of the water samples taken from Hovsan, Shikhov and Sumgayit stations was analysed and it was found that the total minerality in the samples taken from Hovsan station was 10769,2-13557,2 mg/l and the total minerality was 10769,2-13557,2 mg/l. The hardness was between 67,8-82,5 mg-equl.

At Shikhov station, total minerality ranged between 11347.7-13876.3 mg/l, total cod ranged between 69.0-85.0 mg-equl/l and the presence of sodium-potassium-magnesium group belonging to chloride class was detected at this station. . Also in Sumgait district, where the total minerality is 11144,1-15405,2 mg/l, the total alkalinity varies between 69,5-80,5 mg-eq/l, the water class did not change even once when the total minerality and total alkalinity were high by changing the group to sodium-potassium (table 2).

Fig. 1. Pollution of Hovsan coast by domestic wastes (taken by the author on 02.07.2023).

This difference in the ratios of total minerality and total turbidity of seawater between the localities and in total minerality and total turbidity is due to the composition of the discharged surface and collecting waters, seasonal changes, temperature, general conditions, wind force, mixing of the substrate.

Studies show that hydrocarbon reserves in the Caspian Sea, oil production and transport, population growth in the cities located in the sea basin, intensification of agriculture (chemicalisation) and pollution from industry aggravate the ecological situation of the sea. As a result of all these, the ecological status of the Caspian Sea has been determined, and in some areas it has an acute ecological character.

2 Conclusion

Decline in the level of the Caspian Sea off the coast of Azerbaijan and the problems it may cause:

According to our analyses and observations of recent years, there are practically no unchanged landscape complexes in the area of our research.

In the area of research, sharply changed and radically transformed complexes are widespread. Our research shows that both physical-geographical and economic objects located under water have suffered great damage, the lands have been damaged by flooding, and the vegetation typical of the region has almost disappeared. When the level dropped, a set of measures was taken to restore the landscape in the region. The formation of new agricultural objects has expanded the area of the anthropogenic landscape.

- As a result of the research, it was found that the amount of pollutants in the rivers of the Caspian Sea many times exceeds the standards.
- Sanitary control of river runoff should be carried out as one of the most important measures to restore the sustainability of the Caspian ecosystem.
- Analysis of GFDL and HADGEM data shows that if the expected forecasts are maintained, an increase in air temperature by 2 degrees Celsius is expected. As a result, the expected reduction of the Kura River will be 10 percent in 2020-2040 and 15 percent in 2041-2070.
- The reduction of water resources in the Lankaran-Astara region will be 5% in 2020-2040 and 10% in 2041-2070.
- In the context of global climate change, it is important to use and develop the coastal areas of Azerbaijan in accordance with the climate change adaptation plan.
- Further development of geoecological monitoring is important.
- It is necessary to create marine protected areas, this is important for the protection of biodiversity and sustainable fisheries.

At a distance of 1 m to 20 m from groundwater in the study area

In order to determine the water quality of the Caspian Sea, the hydrophysical, hydrochemical and hydrobiological properties of water samples taken from Khovsan, Shikhov and Sumgait were studied. Water sample analyses show that in some cases the chemical composition and general mineral composition of rivers, collectors and surface waters flowing from them vary significantly depending on their composition and natural conditions.

In the management of environmental and nature conservation issues and problems;

In coastal zone management; Many recommendations are being prepared to help make forecasts for the future; Many recommendations are being prepared to help solve agricultural, environmental and tourism problems.

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