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LANDSCAPE TRANSFORMATİON AND İTS GEOECOLOGİCAL ASSESMENT ON THE HOVSAN COAST OF THE BAKU SECTOR OF THE CASPİAN SEA

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Annotation

The Caspian Sea represents a critical ecosystem not only for Azerbaijan but also for all littoral states. Fluctuations in sea level, transformations of coastal landscapes, and marine pollution significantly affect the population living along the coast. The investigation and prevention of pollution in the Caspian Sea coastal zone-especially considering the dynamic fluctuations in sea level-remain among the top environmental priorities for each Caspian state.

Keywords: Geoecological assessment criteria, landscape transformation, hydrochemical analysis, landscape monitoring, anthropogenic impact

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1.Geoecological Changes on the Hovsan–Turkan Coastline of the Azerbaijani Caspian Sea

Long-term observations have been conducted to monitor changes in the natural environment caused by both natural and anthropogenic factors. In recent decades, human impact on ecosystems has intensified significantly on a global scale. Uncontrolled exploitation of natural resources has led to serious ecological consequences, resulting in substantial alterations to ecosystems. Within this global context, there is a growing need for geoecological monitoring, particularly focused on the changes in coastal landscapes under the influence of human activity.

The sustainable use and planning of coastal landscapes are closely aligned with several Sustainable Development Goals (SDGs). Proper coastal zone management is essential for mitigating environmental, economic, and social issues. Many developed nations adopt integrated coastal zone management strategies to address these challenges. Ignoring such principles may result in the degradation of vital infrastructure, economic losses, and environmental instability.

Coastal zones, particularly their landscapes, are susceptible to changes driven by geomorphological and climatic factors. Understanding and assessing the scale of these transformations are critical for informed

decision-making. The Azerbaijani coastline of the Caspian Sea is home to significant infrastructure, including oil industry facilities, transport and tourism infrastructure, fishing enterprises, and agricultural sites. Thus, the impact of sea level fluctuations on these installations, along with a scientific and geoecological evaluation of landscape transformations, is of utmost importance.

Object of Study:

The Hovsan–Turkyan sector of the Baku coastline, located within the Azerbaijani section of the Caspian Sea.

Research Methods:

In the course of this study, various research methods were employed, including field expeditions, landscape-geomorphological analysis, historical geology, paleogeographical and paleoecological approaches, analogical comparisons, mathematical-statistical methods, and cartographic techniques. Visual observations and ground-based measurements were conducted. Fieldwork was carried out, and water samples collected from the shores of the Caspian Sea were analyzed in the laboratory. The water quality of the Caspian Sea in the relevant area, including its hydrochemical properties, ionic-salt composition, total hardness, total mineralization, classification according to O.A. Alyokhin, pH levels, microelements, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and suspended particles were examined. [3]

Anthropogenic Landscape Transformations

The Need for Forecasting and Managing Human Impact on Coastal Landscapes

From constructive point of view it is important to determine not only the level of anthropogenic transformation of landscapes, but also those tendencies that can be developed in landscapes under different anthropogenic impact. At the same time this is inevitable preconditions for landscape prognosis and recommendations and working out of future strategies. Also, it is necessary to take all possible measures to avoid negative anthropogenic landscape changes. Importance of studying of this issue is just determined by it. [1]

In recent decades, the regional manifestations of global climate change have been observed along the Azerbaijani coast of the Caspian Sea.

In modern research, one of the most important methods for studying the dynamics and transformation of landscapes is geoecological assessment. Among the fundamental methods applicable to solving geoecological problems, the principle of actualism holds a central role. The essence of this method lies in comparing the current natural conditions of the Earth's surface, atmosphere, and world oceans with paleogeographical conditions that existed in historical geological periods. The methodological approach based on the principles of actualism involves the use of paleogeographic and paleoecological data to address contemporary geoecological problems. [2]

Multilayered Structure and Formation Factors of Coastal Landscapes

Unlike other natural systems, coastlines develop at the intersection of multiple layers of the geographical environment (lithosphere, hydrosphere, biosphere, atmosphere), each with distinct properties. Their formation under diverse climatic and tectonic conditions contributes to the complexity of their geomorphological structure. The variation in lithological and morphological characteristics of these structures—or morphostructures formed upon them—along with the orientation of coastlines, development of mud volcanoes, and differential tectonic movements, all play significant roles in shaping and evolving the coastline.

The interaction of relief-forming factors along Azerbaijan's Caspian Sea coast enables the identification of various zones with distinct geomorphological characteristics, forming the basis of geomorphological regionalization.

In the Absheron Peninsula, the impact of geological and tectonic settings on the development of the coastal relief is particularly evident. The coastline is highly indented, corresponding to folds; bays generally align with synclines, while headlands form along anticlines. This alternation of structural forms directly influences the distribution and succession of accumulation and abrasion processes along the coast.

The most prominent protruding relief form on the northern coast of the Absheron Peninsula is the Sarygayabashi headland, which corresponds tectonically to the anticlinal uplift of the same name. Offshore, this headland continues as abrasion ridges composed of layered, diatom-rich rock formations.

The southern coastline of the Absheron Peninsula is also characterized by alternating headlands and bays. These include the Hovsan, Sultan, and Shikh headlands formed along the Kala, Central Absheron, and Bibiheybat folds, and the intervening bays developed along corresponding synclines.

2. Hovsan–Baku Coastal Zone

The Hovsan-Baku area encompasses the southern coast of the peninsula (Shirinov). The Hovsan syncline, located between the Kala and Zigh anticlines and opening broadly to the sea, contains primarily accumulative shores forming part of the district. Further west lies the Baku port, with Bayil Cape, Bibiheybat Bay, and the Shikhov beach located to the south. [5]

These shores begin near the village of Turkan and extend westward toward the outskirts of Baku city. They are primarily accumulative in nature. However, near the village of Hovsan, where solid rock outcrops occur, localized abrasion is observed. As a result, the coastline forms two recessed curves—essentially broad, shallow bays—east and west of the Hovsan headland. [5]

Abrasion and Sedimentation at Hovsan Port

The coastal zone near the village of Turkan starts with a broad accumulative Yeni-Kaspi terrace and beach. Moving westward, the accumulation terrace narrows near the closure of the Kala brachianticlinal uplift, which consists of fragile limestone formations from the Caspian and Baku stages. However, abrasion is minimal due to the low inclination of rock layers and the shallow depth of the water, resulting in weak wave action and sediment deposition along the underwater slope. The Yeni-Kaspi terrace reappears and widens further towards Hovsan. Coastal ridges from 1929–1940 and from the present day are observable, but due to limited material availability, the ridges are not very high. The beach also widens in this direction, reaching 200–300 meters near the Hovsan port.

Abrasion near Hovsan port is caused by the emergence of older, more resistant rocks from beneath recent loose sediments through tectonic faults. These rocks indicate the proximity of a buried structural uplift. Although an abrasion cliff is observed at the Hovsan headland, erosion proceeds very slowly, causing the cliff to protrude compared to surrounding accumulative areas. Due to the shallowness of the water, waves often fail to reach the shore, resulting in minimal sand accumulation. Most material settles on the underwater slope. Ongoing sediment accumulation on the seabed has led to the formation of sand islands and banks, the largest of which is Qum (Sand) Island. In some cases, these islands form atop submerged structural uplifts or fragments thereof. These islands and banks block the shallow coasts, and sediment is mainly transported shoreward during stormy weather conditions.

Figure 1. *Photographed by the author on July 2, 2023, on the shores of the Caspian Sea near Hovsan*

Fig. 2. *Photographed by the author on July 2, 2023, on the shores of the Caspian Sea near Turkan*

As can be seen from the images above, residential areas and tourism facilities have been constructed in close proximity to the coastlines of Hovsan and Turkan without accounting for fluctuations in the sea level. This can potentially lead to significant economic losses during periods of sea-level change. Field investigations have revealed that parts of these coastal areas are polluted with household and plastic waste.

Hydrogeological mapping is essential for analyzing the current characteristic state of specific geo-ecological problems in a given region. The study of the natural environment and forecasting its changes under anthropogenic impact has become a crucial task in landscape geo-ecology.

Stages of Geo-ecological Assessment

Geo-ecological assessment is generally conducted in three stages:

1. Ecological-geological mapping (cartography and map preparation);
2. Ecological-geological exploration (research of specific sites);
3. Continuous monitoring (environmental observation). [2]

Each of these research components has been systematically utilized in the scientific study. Geo-ecological investigations were conducted along the Azerbaijani coast of the Caspian Sea—particularly in Baku city, and the Hovsan and Turkan coastlines—using visual observation and field research methods across multiple years. The dynamics of coastal landscapes were studied, and water samples from the Caspian Sea were analyzed in the laboratory. The results were compared using comparative analysis methods across different years. The impact of pollutants found in the water on marine life and coastal landscapes was identified.

Over the long term, the main task of existing geophysical-geological, geographical-geomorphological research services operating in the coastal areas of the Caspian has been to create a data bank within a monitoring system. This system does not represent a new conceptual framework requiring the creation of new observation stations, lines, telecommunications, or data processing centers. Rather, it integrates with the already existing universal environmental observation and control system. The monitoring conducted in this research includes the following main directions:

- Monitoring of factors affecting the natural environment and its current condition;
- Assessment of the actual state of the natural environment;
- Forecasting the environmental condition and evaluating the projected state.

3. Ecological condition of the coastline

In Baku, biological treatment facilities have been constructed and commissioned in Buzovna (10,000 m^3 capacity) and Shuvalan (18,000 m^3 capacity). The Hovsan Aeration Station was reconstructed, and new biological treatment facilities with a capacity of 200,000 m^3/day were built, increasing the total design capacity from 600,000 m^3/day to 800,000 m^3/day. In Sumgait, new biological treatment facilities with a capacity of 200,000 m^3/day were also built and commissioned. [6]

The Caspian Sea is exposed to greater pollution from areas with concentrated industrial enterprises. Examples include the Sumgayitchay River, Acidere stream, Hövsan canal, the 32nd canal, and others. These sources contribute to the degradation of the ecological condition and the emergence of

unsanitary conditions in recreational and other areas of the coastal zone. This, in turn, negatively impacts the development of ecotourism. [6]

Field research was conducted in 2022–2024 along the coastal landscapes of the Hovsan–Turkan region. Water samples were collected from the Caspian Sea and analyzed in the laboratory. The total mineralization and hardness of seawater samples from Hovsan and Turkan were measured. The natural and anthropogenic factors influencing the hydro-chemical regime of water bodies, depending on time and space, help assess water quality.

Understanding the hydro-chemical characteristics of the Caspian Sea water-across different periods and distances-is crucial for evaluating its composition and hydro-chemical dynamics. [3]

Fig. 3: *Hovsan coastline, where water samples were collected*

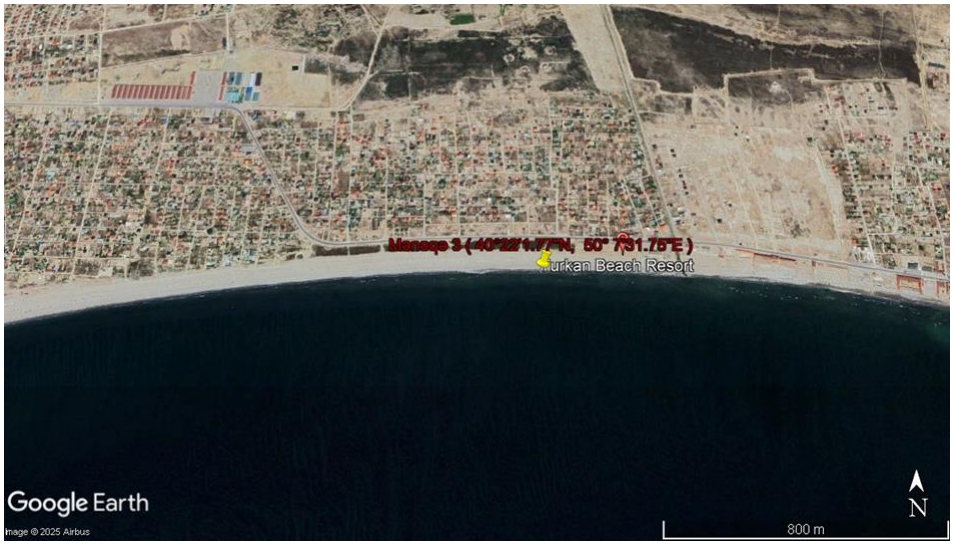

Fig. 4: *Turkan coastline, where water samples were collected*

Results of Seawater Analysis from the Hovsan and Turkan Coastline

Table 1 – Ion Composition of Seawater

№	**No.**	**Sampling Location**	**Date**	**Total Mineralization (mg)**	**Total Hardness (meq/l)**	**O.A. Alyokhin Classification**
1	Hovsan station	11.09.2022	12973,9	78,9	CL>SO>HCO chloride-sulfate	Cl > SO > HCO; Na+K > Mg > Ca (chloride-sulfate; sodium-potassium-magnesium)
2	Hovsan station 1	23.06.2023	12175.9	79.0	CL>SO>HCO chloride	Na+K>Mg>Ca Sodium-potassium-magnesium
3	Hovsan station 2(100m apart)	23.06.2023	11957.2	78.5	CL>SO>HCO chloride	Na+K>Mg>Ca Sodium-potassium-magnesium
4	Hovsan station 1	28.10.2023	11246.4	82,5	CL>SO>HCO chloride	Na+K>Mg>Ca Sodium-potassium-magnesium

5	Hovsan station 2(100m apart)	28.10.2023	11605.0	78.5	CL>SO>HCO chloride	Na+K>Mg>Ca Sodium-potassium-magnesium
6	Hovsan station 1	17.01.24	12468.4	77.0	CL>SO>HCO chloride	Na+K>Mg>Ca Sodium-potassium-magnesium
7	Hovsan station 2(100m apart)	17.01.24	12942.0	73.0	CL>SO>HCO chloride	Na+K>Mg>Ca Sodium-potassium-magnesium
8	Turkan station	08.09.2022	12200,4	69,0	CL>SO>HCO chloride-sulfate	Na+K>Mg>Ca Sodium-potassium-magnesium
9	Turkan station 1	24.06.2023	12257.6	85.0	CL>SO>HCO chloride-sulfate	Na+K>Mg>Ca Sodium-potassium-magnesium
10	Turkan station 1	27.10.2023	11642.2	80.0	CL>SO>HCO chloride	Na+K>Mg>Ca sodium-potassium-magnesium
11	Turkan station 1	19.08.2024	11708,7	79,0	CL>SO>HCO chloride	Na+K>Mg>Ca Sodium-potassium-magnesium

Factors Influencing Water Quality

Variations in total mineralization and hardness between and within sampling points are influenced by the content of runoff and collector waters, seasonal changes, temperature, general conditions, wind intensity, and mixing of bottom layers. [4]

4. Conclusion and Recommendations

Based on recent analyses and observations in the study area, landscape complexes have been significantly transformed by both anthropogenic and natural influences. Practically no unaltered landscape complexes remain along these coastlines. The formation of new industrial facilities has expanded anthropogenic landscapes. Water sample analyses show that chemical composition and total mineralization vary significantly, depending on the composition of incoming river, collector, and runoff waters, as well as the natural conditions of the area.

Changes in the hydrogeological conditions of Hovsan coastal aquatorium have altered the water content of rocks during hydrogeological drilling aimed at collecting water samples. If groundwater is located near these rocks, hydrogeological-chemical processes may be disrupted. In addition, dry drilling operations can cause alterations in rock masses—not only due to fragmentation but also due to the impact

of drilling fluids and chemical reagents—which represents a technogenic factor affecting coastal landscape transformation.

Based on the study, the following actions are recommended for modern application:

- To improve the methodology for regional geo-ecological assessment by identifying coastal ecological problems through analysis of landscape-ecological deformation and determining direct indicators for anthropogenic load;
- To analyze the spatial-temporal geo-ecological conditions by identifying high and moderate anthropogenic pressures in urban areas and their surrounding zones, particularly in agricultural regions, and determining maximum environmental impact indicators of industrial, demographic, and agricultural loads;
- To designate a boundary considering sea-level fluctuations along the Caspian coast, and prohibit construction within these zones;
- To implement sanitary monitoring of river flows entering the Caspian, as part of a critical measure to restore ecosystem stability;
- To ensure the use and development of Azerbaijan's coastal areas in accordance with an adaptation plan addressing the regional impacts of global climate change;
- To enhance and refine geo-ecological monitoring systems;
- To establish marine protected areas, which is crucial for biodiversity conservation and the sustainable development of fisheries;
- To develop a comprehensive set of recommendations for solving environmental problems, particularly those related to environmental management and sustainable tourism;
- To prepare a coastal zone management plan aligned with sustainable development principles;
- To conduct collaborative research among Caspian littoral states to identify and prevent regional
- manifestations of global climate change and transformations within the Caspian Sea.

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