

УДК 504.45:551.46
DOI 10.56525/LVCN2323

ASSESSMENT OF THE GEOLOGICAL CONDITION OF THE COASTAL ZONA OF THE CASPIAN SEA IN AKTAU REGION

¹N. Sh. Janaliyeva, ¹A.A. Zhakanova, ²M.A. Dzhabykbayeva

¹Yessenov University, Kazakhstan, Aktau

²KazNIPImunaigas Branch of KMG Engineering LLP

e-mail:nurgul.janaliyeva@yu.edu.kz, Aimira2.zhakanova@yu.edu.kz,

M.Dzhabykbayeva@kmge.kz

Annotation. The article analyzes the aspects of monitoring the coastal and marine zones of the Caspian Sea. The key task is to analyze the impact of human activity on the marine part and the coastal zone of the Caspian Sea, which is an important ecosystem. Aktau city, located on the shore of the Caspian Sea, is a unique object for geoecological research. As part of the research, the content of humus, heavy metals and other soil parameters was determined. Humus and other chemical characteristics of the soil were analyzed in the laboratory. Studies have shown that the content of heavy metals in the upper layers of the soil most clearly reflects intense anthropogenic activity. Special attention is paid to the importance of the Caspian Sea for transport, tourism, fishing and industry. Solutions are also proposed to preserve the environmental sustainability of the region and ensure the rational and balanced use of natural resources.

Keywords: monitoring, marine environment, coastal zone, heavy metals, soil, sea water.

Introduction

The Caspian Sea is currently attracting considerable attention from both economic and political circles in many countries. It occupies a unique position due to its rich biological and mineral resources. In this regard, the task of preserving its environmental sustainability and ensuring the rational and balanced use of natural resources is particularly relevant. The successful resolution of these issues directly affects the sustainable development of the countries and peoples living in this region [1]. Particular attention is drawn to the Kazakh part of the Caspian Sea, where large oil fields such as Tengiz and Kashagan are concentrated. Kazakhstan is one of the key players in the Caspian region due to its rich oil and gas reserves [2]. The country holds high positions in terms of oil production among the CIS countries. A significant part of the production is concentrated in the Kazakh sector of the Caspian Sea. Important projects such as the Kashagan field are international and attract large investments from all over the world, contributing to the development of the energy sector and the country's economy as a whole [3].

Materials and methods

Samples of the marine environment and coastal zone from the village of Akshukur and the village of Shapagatov in the Caspian Sea. Hydrological stations (HS) are designated as 14, 15, 16 and 17, research sites (RS) of the coastal zone are designated as 1, 2, 3, 4. As well as water and soil samples from the facilities of Seaport-1, Seaport-2, Dostar-1, Dostar-2, Yacht Club-1, Yacht Club-2, Koshkar-Ata-1, Koshkar-Ata-2, table 1 [3].

Table 1 - Location of hydrological stations and sampling points at research sites.

Station №	Location	Width	Longitude	Distance from shore, m
HS-14	The area of the village Akshukur	43°48'04.00"	51°00'35.00"	1153,85
HS-15	The area of the village Akshukur	43°46'58.00"	51°00'00.00"	3627,17

Station №	Location	Width	Longitude	Distance from shore, m
HS-16	The area of the village of S. Shapagatova	43°46'00.00"	50°59'02.00"	6406,71
HS-17	The area of the village of S. Shapagatova	43°45'00.00"	50°58'00.00"	8745,93
HS-18	№1 SeaPort	43°37'56.00"	51°10'1.00"	563
HS-19	№2 SeaPort	43°36'51.00"	51°12'47.00"	842
HS-20	№1 Dostar	43°35'40.00"	51°14'19.00"	374
HS-21	№2 Dostar	43°35'40.00"	51°14'15.00"	685
HS-22	№1 Yacht Club	43°62'90.04 "	51°16'84.99 "	201,25
HS-23	№2 Yacht Club	43°62'96.86 "	51°17'13.18 "	135
RS -1	The area of the village Akshukur	43°48'1"	51°1'59"	303,65
RS-2	The area of the village Akshukur	43°49'5"	51°2'14"	1635,1
RS-3	The area of the village of S. Shapagatova	43°49'0"	51°1'29"	2135
RS-4	The area of the village of S. Shapagatova	43°55'19"	51°2'0"	9578
RS-5	Dostar Beach	43°36'53"	51°12'48"	94
RS-6	Temporary storage warehouse	43°36'47"	51°13'44"	2000
RS-7	Move	43°35'28"	51°14'5"	300
RS-8	1.3 t from the seashore near Kaztransoil	43°36'20"	51°13'41"	130
RS-9	№1 Yacht Club	43°62'90.04"	51°16'84.99"	350
RS-10	№2 Yacht Club	43°62'96.86"	51°17'13.18"	300
RS-11	№1 Koshkar-Ata	43°70'93.28"	51°19'09.03"	Closer to the airport
RS-12	№2 Koshkar Ata	43°73'33.83"	51°18'57.25"	Closer to the airport

Samples of seawater and soil of the research object. Seawater samples were taken using a Hydro Bios bathometer (1.7 liters) in accordance with GOST 17.1.5.05-85 and GOST 17.1.5.04-81.

Measurements of water parameters (pH, phosphates, nitrite and nitrate nitrogen, ammonium nitrogen, total nitrogen and dissolved oxygen) were carried out at hydrological stations using modern equipment, including a photocolorimeter and a gas chromatograph.

Soil samples were taken from the coastal territory of the Caspian Sea. Soil samples were taken from a depth of 0-20 cm using the envelope method. The samples were taken at 12 research sites, with 20 sampling points. Tools and methods of analysis. A photocolorimeter, a liquid analyzer, a pH meter-ionomer and a gas chromatograph were used to analyze the composition of water and soil in accordance with established standards.

Determination of heavy metals in the soil. To determine the content of heavy metals in the soil, the method of atomic absorption spectrometry with plasma atomization was applied using a high-precision AAS MGA-915M device (manufactured by Lumex, Russia).

Studies of the marine environment were conducted in a shallow water area near the city of Aktau, located in the Mangystau region of the Republic of Kazakhstan, and adjacent territories. These studies were carried out jointly by the Department of Ecology and Geology of the Yessenov University (YU) and the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences (RAS) under the leadership of Doctor of Technical Sciences, Professor G.J. Kenzhetaev and Doctor

of Geographical Sciences, Corresponding Member of the Russian Academy of Sciences P.O. Zavyalov [4].

Research results and their discussion. The results of analyses of heavy metals in water were also carried out in 2019 and 2023 for comparative analysis. Based on changes in the content of heavy metals, it is possible to conclude whether the environmental situation has improved or worsened, and assess the possible consequences for health and the ecosystem. This approach will provide a systematic and detailed comparison of data, which will help identify long-term trends and understand how the state of the environment has changed over this period.

In the spring of 2019, an analysis of the content of heavy metals in seawater was carried out in an ecological laboratory accredited by the Department of Natural Resources and Environmental Management of the Mangystau region. The study covered the measurement of concentrations of metalloids (e.g., arsenic) and metals, including barium, cadmium, chromium, copper, iron, mercury, nickel, lead, vanadium, aluminum, and zinc.

The results showed that the levels of arsenic, iron, mercury, vanadium, and aluminum were below the detection limit. However, exceedances of the maximum permissible concentrations (MPC) for cadmium (2.1 times), chromium (4 times), copper (3.7 times), nickel (5.2 times) and lead (4.6 times) were recorded. At the same time, the content of barium and zinc remained within the normal range. The concentrations of heavy metals and arsenic are shown in Table 2.

Table 2 – Concentration of heavy metals and metalloid in water 2019, Akshukur

Station s	mg/l											
	As	Ba	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn	V	Al
HS-14	< 0.005	0.008	0,017	0,11	1,9	< 0.1	< 0.0002	0,37	0,092	0.03	<0.00 1	< 0.04
HS-15	< 0.005	0.007	0,015	0,20	2,3	< 0.1	< 0.0002	0,51	0,097	0.03	<0.00 1	< 0.04
HS-16	< 0.005	0.008	0,021	0,13	3,7	< 0.1	< 0.0002	0,45	0,138	0.02	<0.00 1	< 0.04
HS-17	< 0.005	0.007	0,019	0,18	1,85	< 0.1	< 0.0002	0,39	0,117	0.03	<0.00 1	< 0.04
max.	-	0,008	0,021	0,20	3,7	-	-	0,45	0,078	0.03	-	-
min.	-	0,007	0,015	0,11	1,85	-	-	0,29	0,028	0,02	-	-
Average	-	0,0075	0,018	0,155	2,775	-	-	0,37	0,053	0,02 5	-	-
MPC fish farm*	0.01	2.0	0.01	0.001	0.005	0.05	0.0001	0.01	0.01	0.05	0.001	0.04
MPC of water **	0.05	0.1	0.01	0.05	1.0	0.3	0.0005	0.1	0.03	5.0	0.1	0.1
Mean± SD	-	-	0,02± 0,022 3	0,16± 0,001 7	2,44± 0,748	-	-	0,43± 0,004	0,11± 0,020	-	-	-

Note: *Consolidated list of MPC and approximate permissible exposure levels (APEL) of hazardous substances for waters of fishery reservoirs. 1990.

**Sanitary requirements for the safety of drinking water (Order № 147. 229.506).

The chromium content shows an uneven distribution. The minimum values, about 2.1 MPC, were recorded in the coastal part of the sea, while the maximum values, about 4 MPC, were recorded on HS-15 at a distance of 3627 m from the shore.

The copper concentration at a distance of 8.74 km from the coast turned out to be lower, about 2 MPC, compared with HS-16, located closer to the coastline of the Caspian Sea. As for nickel, its high concentration (5.1 MPC) is observed on HS-15, while on HS-14 and HS-17 concentrations decrease to 3.7 and 3.8 MPC, respectively.

The maximum concentration of lead exceeding 4.6 MPC was recorded on HS-16 in the shipping lanes area, while lower values (about 3 MPC) were noted on HS-14 at a distance of 1.15 km from the coast.

The minimum concentration of cadmium (1.07 MPC) was detected at HS-15 (at a distance of 3627 m from the shore, depth 17.8 m), while the maximum concentration exceeding 2 MPC was observed at HS-16 (distance 6407 m from the shore, depth 18.5 m), also in the shipping lanes area.

The toxicity of heavy metals mainly stems from their ability to form complex compounds in organisms, establish covalent bonds with carbon atoms, and participate in redox processes that alter the valence of the metal. As a result of these processes, the normal activity of biologically active substances in the tissues of aquatic organisms is disrupted. This leads to an increase in the ability of trace elements to overcome biological barriers, a violation of the balance of microflora and various phenomena that worsen their viability. Thus, all heavy metals have a common property - biological activity. When they enter the natural environment as a result of human activity, they begin to circulate, becoming involved in the biological cycle. Under certain biogeochemical conditions and concentrations, they exhibit toxic effects on living organisms. In this regard, there is a need to control the level of their concentration in natural environments [5].

The results of studies conducted in 2019 show that the soil is polluted with heavy metals such as copper in these areas. High concentrations of copper at some observation points may be associated with industrial processes or other sources of pollution specific to the region.

Excess copper content was found in soils at three research sites: RS-1 (3.2 MPC), RS-2 (4.7 MPC) and RS-3 (3.6 MPC) (Figure 1). However, at the background site (RS-4), a value is observed that is lower than the maximum permissible concentration (2.1 MPC), and the copper content at RS-11 and RS-12 located in the Koshkar-Ata region does not exceed the MPC and amounted to 2.23 mg/kg at RS-11, as for RS-12 there The value is lower and amounted to 2.04 mg/kg, but compared with other heavy metals, the value of copper is higher. This fact may be due to natural processes associated with the accumulation and migration of copper in the soil cover [6].

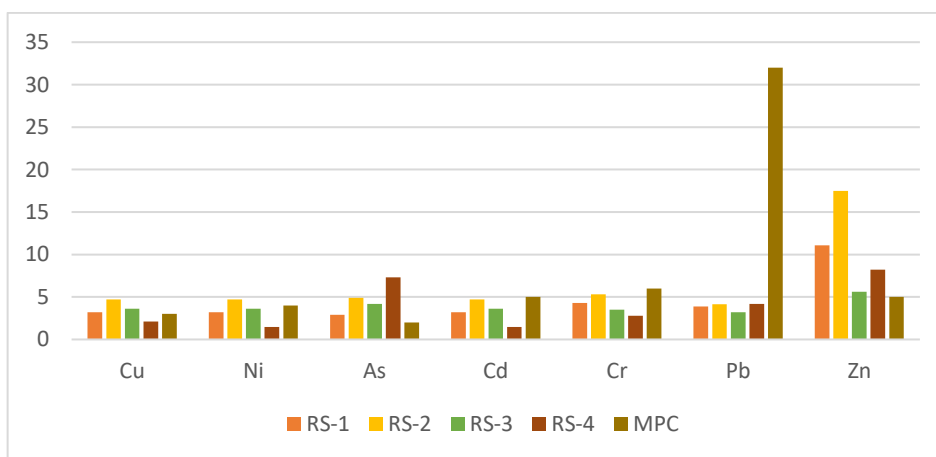


Figure 1 – The content of heavy metals in the soils of the study site for 2019

Possible causes of excess copper content on RS-1, RS-2, and RS-3 may include anthropogenic influences such as industrial activity, runoff from transportation, or the use of fertilizers with a high copper content. It is also worth considering the geological features and natural processes that affect the distribution of elements in the soil environment [7].

In contrast, the lower copper content on RS-4 may be due to a lower impact of anthropogenic factors on this territory or its remoteness from sources of pollution. Also, natural processes such as phytoremediation or physico-chemical processes in the soil can contribute to reducing the concentration of copper at this site [8].

Thus, excess copper content at certain sites may be the result of various impacts, both anthropogenic and natural, and requires additional research to identify the specific causes of this phenomenon.

The level of heavy metals and arsenic metalloid in the soil at the RS-2 research site, located in the area of an open warehouse of road construction materials near the highway, indicates a high degree of soil contamination. A comparative analysis with other sites shows that the highest content of copper, nickel, zinc, arsenic, cadmium, chromium and lead is observed here. At the same time, the least soil contamination was recorded at the RS-4 background site.

Conclusion

A comprehensive analysis of the water and soil resources of the coastal zone of the Caspian Sea near Aktau showed the presence of significant concentrations of heavy metals such as copper, nickel, and lead, exceeding the maximum permissible concentrations at a number of observation points. These results indicate the negative impact of anthropogenic factors, primarily industrial activity and maritime transport, on the environmental condition of the studied area. A comparative analysis with the results of 2019 reveals a slight improvement in certain environmental indicators, which may be associated with the implementation of environmental protection measures and partial modernization of industrial facilities. However, zones with persistently high levels of pollution remain, especially in areas adjacent to industrial sites and port infrastructure.

The identified spatial heterogeneity of contamination emphasizes the necessity of continuous geocological monitoring and the application of an integrated approach to environmental management in the coastal zone. Further studies should focus on identifying the main sources of heavy metal input, assessing their long-term ecological and health risks, and developing effective mitigation strategies aimed at reducing anthropogenic pressure and ensuring the sustainable use of the natural resources of the Caspian Sea coastal region.

REFERENCES

1. Джаналиева Н., Серикбаева А., Кенжетаев Г., Сейдалиева Л. Экологический мониторинг прибрежных и офшорных зон Каспийского моря в пределах пригородов города Актау // *Environmental Engineering and Management Journal*. – 2020. – Т. 19, № 8. – С. 1419-1426. – URL: <http://www.eemj.icpm.tuiasi.ro/>; <http://www.eemj.eu/>;
2. Эткин Д.С., Недвед Т. Управление рисками разливов нефти в Каспийском море // *International Oil Spill Conference Proceedings*. – 2021. – URL: <https://www.ioscproceedings.org/>;
3. Baumann M., Ozdogan M., Wolter P.T., Krylov A.M., Vladimirova N.A., Radeloff V.C. Landsat remote sensing of forest windfall disturbance // *Remote Sensing of Environment*. – 2014. – Т. 143. – С. 171–179;
4. Fedotov P.S., Ermolin M.S., Karandashev V.K., Ladonin D.V. Characterization of size morphology and elemental composition of nano-, submicron- and micron particles of street dust separated using field-flow fractionation in a rotating coiled column // *Talanta*. – 2014. – Т. 130. – С. 1-7;
5. Ольшанская Л.Н., Халиева А.С., Титоренко О.В., Ефремова Н.А. Влияние меди и свинца на развитие высших растений и фиторемедиацию почвы // *Журнал "Экология и природопользование"*. — 2023. — Т. 15, № 2. — С. 45-55;
6. Fedotov P. S., Ermolin M. S., Karandashev V. K., Ladonin D. V. Characterization of size, morphology and elemental composition of nano-, submicron, and micron particles of street dust separated using field-flow fractionation in a rotating coiled column. *Talanta*, 2014, v. 130, p. 1-21
7. Bhattacharjee, S.; Dutta, T. Chapter 1—An Overview of Oil Pollution and Oil-Spilling Incidents; Das, P., Manna, S., Pandey, J.K., Eds.; Elsevier: Amsterdam, The Netherlands, 2022; pp. 3–15. ISBN 978-0-323-89978-9;

8. Yang, G.G.; Bae, K.B.; Chung, W.H. Socio-ecological resilience of Oil spill: Focusing on the hebei spirit oil spill on the west coast of Korea. *Int. J. Appl. Bus. Econ. Res.* 2016,14, 10793–10808;
9. Исаев А.С., Козлов М.В. Геоэкологический мониторинг прибрежных территорий морей и океанов. — М.: Наука, 2018. — 312 с.
10. Курбанов А.А., Абдуллаев А.К. Экологическое состояние прибрежной зоны Каспийского моря и проблемы устойчивого развития // Вестник Каспийского университета. — 2019. — № 2. — С. 45–53.
11. Zonn I.S., Kostianoy A.G., Kosarev A.N., Glantz M.H. *The Caspian Sea Encyclopedia*. — Berlin: Springer, 2010. — 525 p. DOI: 10.1007/978-3-642-11524-0
12. Kosarev A.N., Yablonskaya E.A. *The Caspian Sea*. — The Hague: SPB Academic Publishing, 1994. — 259 p.
13. Karbassi A.R., Monavari S.M., Nabi Bidhendi G.R., Nouri J., Nematpour K. Metal pollution assessment of sediment and water in the Caspian Sea // *Environmental Monitoring and Assessment*. — 2008. — Vol. 137. — P. 451–462, DOI: 10.1007/s10661-007-9785-7
14. Abdollahi M., Pejman A., Bidhendi G.N. Heavy metal contamination of coastal sediments of the Caspian Sea // *Environmental Earth Sciences*. — 2013. — Vol. 69. — P. 2385–2394. DOI: 10.1007/s12665-012-2068-6
15. Förstner U., Wittmann G.T.W. *Metal Pollution in the Aquatic Environment*. — Berlin: Springer-Verlag, 2012. — 486 p.
16. Kabata-Pendias A., Pendias H. *Trace Elements in Soils and Plants*. — 4th ed. — Boca Raton: CRC Press, 2011. — 548 p.
17. Alloway B.J. *Heavy Metals in Soils: Trace Metals and Metalloids in Soils and their Bioavailability*. — Dordrecht: Springer, 2013. — 613 p.
18. Ansari A.A., Gill S.S. *Heavy Metals in Water: Presence, Removal and Safety*. — London: Royal Society of Chemistry, 2015. — 371 p.

ОЦЕНКА ГЕОЛОГИЧЕСКОГО СОСТОЯНИЯ ПРИБРЕЖНОЙ ЗОНЫ КАСПИЙСКОГО МОРЯ В РЕГИОНЕ АКТАУ

¹Джаналиева Н.Ш., ¹Жаканова А.А., ²Джабыкпаева М.А.

¹Yessenov University, Казахстан, Актау

²Филиал ТОО «КМГ Инжиниринг» «КазНИПИМунайгаз»

e-mail: nurgul.janaliyeva@yu.edu.kz, Aimira2.zhakanova@yu.edu.kz,

M.Dzhabykbayeva@kmge.kz

Аннотация. В статье анализируются аспекты мониторинга прибрежной и морской зон Каспийского моря. Ключевой задачей является анализ воздействия деятельности человека на морскую часть и прибрежную зону Каспийского моря, которые являются важной экосистемой. Город Актау, расположенный на берегу Каспийского моря, является уникальным объектом для геоэкологических исследований. В рамках исследований было определено содержание гумуса, тяжелых металлов и других параметров почвы. Гумус и другие химические характеристики почвы были проанализированы в лаборатории. Исследования показали, что содержание тяжелых металлов в верхних слоях почвы наиболее четко отражает интенсивную антропогенную деятельность. Особое внимание уделяется важности Каспийского моря для транспорта, туризма, рыболовства и промышленности. Также предлагаются решения для сохранения экологической устойчивости региона и обеспечения рационального и сбалансированного использования природных ресурсов.

Ключевые слова: мониторинг, морская среда, прибрежная зона, тяжелые металлы, почва, морская вода.

АҚТАУ АЙМАҒЫНДАҒЫ КАСПИЙ ТЕҢІЗІНІҢ ЖАҒАЛАУ АЙМАҒЫНЫҢ ГЕОЛОГИЯЛЫҚ ЖАҒДАЙЫН БАҒАЛАУ

¹Джаналиева Н.Ш., ¹Жаканова А.А., ²Джабыкпаева М.А.

¹Yessenov University, Қазақстан, Ақтау

²«ҚМГ Инжиниринг» ЖШС «ҚазҒЗЖИмұнайгаз» филиалы
e-mail:nurgul.janaliyeva@yu.edu.kz, Aimira2.zhakanova@yu.edu.kz,
M.Dzhabykbayeva@kmge.kz

Андатпа. Мақалада Каспий теңізінің жағалау және теңіз аймақтарын бақылау аспектілері талданады. Маңызды экожүйе болып табылатын Каспий теңізінің теңіз бөлігі мен жағалау аймағына адам қызметінің әсерін талдау негізгі міндет болып табылады. Каспий теңізінің жағасында орналасқан Ақтау қаласы геоэкологиялық зерттеулер үшін бірегей объект болып табылады. Зерттеулер гумустың, ауыр металдардың және басқа топырақ параметрлерінің мазмұнын анықтады. Зертханада Гумус және топырақтың басқа химиялық сипаттамалары талданды. Зерттеулер көрсеткендей, топырақтың жоғарғы қабаттарындағы ауыр металдардың мөлшері қарқынды антропогендік белсенділікті айқын көрсетеді. Каспий теңізінің көлік, туризм, балық аулау және өнеркәсіп үшін маңыздылығына ерекше назар аударылады. Сондай-ақ, аймақтың экологиялық тұрақтылығын сақтау және табиғи ресурстарды ұтымды және теңгерімді пайдалануды қамтамасыз ету үшін шешімдер ұсынылады.

Түйін сөздер: Мониторинг, теңіз ортасы, жағалау аймағы, ауыр металдар, топырақ, теңіз суы.