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«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылыметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

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CONTENTS

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STUDY OF HYDROLOGICAL AND GEOSTRUCTURAL CHANGES IN THE KOSKORGAN RESERVOIR DUE TO CLIMATIC CHANGES

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Abstract. In the context of global climate change and increasing anthropogenic impact, the study of hydrological and geostructural transformations of artificial reservoirs is of particular importance. This article presents a comprehensive analysis of changes in the Koskorgan reservoir, located in the arid region of southern Kazakhstan, which performs important functions of water supply and irrigation of agricultural lands. The research is based on the application of modern methods of remote sensing, geoinformation modeling, field hydrological observations and engineering and geological surveys for the period from 1990 to 2024. The results show a steady trend of reducing the reservoir's mirror area (to 12.4% over 20 years) and lowering the water level (by 1.3 m), which is associated with climatic factors such as precipitation deficiency and high evaporation, as well

as increased filtration losses. Geostructural analysis revealed the presence of active tectonic faults in the southeastern part of the reservoir, affecting hydrodynamics, uneven expansion of the eastern section and increased permeability of sediments, which complicates the maintenance of a stable water balance. Hydrochemical data indicate seasonal dynamics of water mineralization and hardness due to climatic conditions and anthropogenic impact, including local pollution and intensive water use. Comparison with similar reservoirs in Central Asia confirms the influence of a complex of climatic and man-made factors on the transformation of small and medium-sized reservoirs. The scientific novelty of the work lies in the integration of multi-scale analysis methods, which makes it possible to identify the spatial and temporal dynamics of changes and provides a basis for developing adaptation strategies for sustainable water resources management. Special attention is paid to the control of filtration leaks and monitoring of geostructural processes to preserve the environmental and socio-economic sustainability of the region.

Keywords: Koskorgan reservoir, hydrological changes, geostructural changes, filtration losses, coastline dynamics, hydrochemical analysis, arid region

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КЛИМАТТЫҚ ӨЗГЕРІСТЕРГЕ БАЙЛАНЫСТЫ ҚОСҚОРҒАН СУ ҚОЙМАСЫНЫҢ ГИДРОЛОГИЯЛЫҚ ЖӘНЕ ГЕОҚҰРЫЛЫМДЫҚ ӨЗГЕРІСТЕРІН ЗЕРТТЕУ

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Аннотация. Жаһандық климаттық өзгерістер мен антропогендік әсердің күшеюі жағдайында жасанды су қоймаларының гидрологиялық және геоструктуралық өзгерістерін зерттеу ерекше маңызға ие болады. Осы бапта ауыл шаруашылығы жерлерін сумен жабдықтау мен суарудың маңызды функцияларын орындайтын Оңтүстік Қазақстанның аридті аймағында орналасқан Қосқорған су қоймасының өзгерістеріне кешенді талдау ұсынылған. Зерттеу 1990-2024 жылдар аралығында қашықтықтан зондтаудың, геоақпараттық модельдеудің, далалық гидрологиялық бақылаулардың және инженерлік-геологиялық зерттеулердің заманауи әдістерін қолдануға негізделген. Нәтижелер су қоймасының айна аймағының қысқаруының (20 жылда 12,4% - ға дейін) және су деңгейінің (1,3 м-ге) төмендеуінің тұрақты тенденциясын көрсетеді, бұл климаттық факторларға байланысты-жауын-шашын тапшылығы және жоғары булану, сондай-ақ сүзу шығындарының артуы. Геоқұрылымдық талдау су айдынының оңтүстік-шығыс бөлігінде гидродинамикаға әсер ететін белсенді тектоникалық ақаулардың болуын, шығыс бөлігінің біркелкі кеңеюін және төменгі шөгінділердің өткізгіштігінің жоғарылауын анықтады, бұл тұрақты су балансын сақтауды қиындатады. Гидрохимиялық деректер Жергілікті ластану мен қарқынды суды пайдалануды қоса алғанда, климаттық жағдайларға және антропогендік әсерге байланысты судың минералдануы мен қаттылығының маусымдық динамикасын көрсетеді. Орталық Азияның ұқсас су қоймаларымен салыстыру климаттық және техногендік факторлар кешенінің шағын және орта су айдындарының трансформациясына әсерін растайды. Жұмыстың ғылыми жаңалығы өзгерістердің кеңістіктік-уақыттық динамикасын анықтауға мүмкіндік беретін және суды тұрақты басқарудың бейімделу стратегияларын әзірлеуге негіз болатын көп масштабты талдау әдістерін біріктіруде жатыр. Аймақтың экологиялық және әлеуметтік-экономикалық тұрақтылығын сақтау үшін сүзу ағып кетулерін бақылауға және геоструктуралық процестерді бақылауға ерекше назар аударылады.

Түйін сөздер: Қосқорған су қоймасы, гидрологиялық өзгерістер, геоструктуралық өзгерістер, сүзу шығындары, жағалау сызығының динамикасы, гидрохимиялық талдау, құрғақ аймақ

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ИЗУЧЕНИЕ ГИДРОЛОГИЧЕСКИХ И ГЕОСТРУКТУРНЫХ ИЗМЕНЕНИЙ КОСКОРГАНСКОГО ВОДОХРАНИЛИЩА ВВИДУ КЛИМАТИЧЕСКИХ ИЗМЕНЕНИЙ

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Аннотация. В условиях глобальных климатических изменений и усиливающегося антропогенного воздействия исследование гидрологических и геоструктурных трансформаций искусственных водохранилищ приобретает особую значимость. В настоящей статье представлен комплексный анализ изменений водохранилища Коскорган, расположенного в аридном регионе южного Казахстана и выполняющего важные функции водоснабжения и орошения сельскохозяйственных земель. Исследование основано на применении современных методов дистанционного зондирования, геоинформационного моделирования, полевых гидрологических наблюдений и инженерно-геологических изысканий за период с 1990 по 2024 гг. Результаты показывают устойчивую тенденцию сокращения площади зеркала водохранилища (до 12,4 % за 20 лет) и снижения уровня воды (на 1,3 м), что связано с климатическими факторами - дефицитом осадков и высокой испаряемостью, а также с увеличением фильтрационных потерь. Геоструктурный анализ выявил наличие активных тектонических разломов в юго-восточной части водоёма, оказывающих влияние на гидродинамику, неравномерное расширение восточного участка и повышенную проницаемость донных отложений, что осложняет поддержание устойчивого водного баланса. Гидрохимические данные свидетельствуют о сезонной динамике минерализации и жёсткости воды, обусловленной климатическими

условиями и антропогенным воздействием, включая локальное загрязнение и интенсивное водопользование. Сравнение с аналогичными водохранилищами Центральной Азии подтверждает влияние комплекса климатических и техногенных факторов на трансформацию малых и средних водоёмов. Научная новизна работы заключается в интеграции многомасштабных методов анализа, позволяющей выявить пространственно-временную динамику изменений и сформировать основу для разработки адаптационных стратегий устойчивого управления водными ресурсами. Особое внимание уделяется контролю фильтрационных утечек и мониторингу геоструктурных процессов с целью сохранения экологической и социально-экономической устойчивости региона.

Ключевые слова: водохранилище Коскорган, гидрологические изменения, геоструктурные изменения, фильтрационные потери, динамика береговой линии, гидрохимический анализ, аридный регион

Introduction. The study of hydrological and geostructural changes in reservoirs is becoming particularly relevant in the context of climate change, anthropogenic impact and increased consumption of water resources (Vasiliev, et al, 2020). Changes in hydrological and geostructural characteristics of reservoirs are becoming an increasingly popular topic of scientific research against the background of climatic fluctuations, intensification of agriculture and increased anthropogenic load (Grigoriev, et al, 2019). Reservoirs, as artificial water bodies, are subject to both natural and man-made transformations, which requires regular scientific monitoring. This is especially true for arid and semi-arid regions, where reservoirs play a key role in water supply, flow regulation, and maintaining ecological balance (Melnikov, 2021).

Since its creation, the reservoir has undergone significant transformations in terms of water balance, sediment structure, shoreline, and interaction with groundwater, which affects both the natural environment and the socio-economic sustainability of the surrounding areas.

This study aims to investigate the hydrological and geostructural changes occurring in the Koscorgan Reservoir, with a focus on the chemical composition of the water, the impact of anthropogenic activities, and implications for irrigation practices. The findings will contribute to regional water resource management policies and provide a scientific basis for mitigating negative environmental impacts. The research aims to conduct a comprehensive analysis of the hydrological and geostructural changes in the Koskorgan reservoir over the past decades, with an emphasis on the spatial and temporal dynamics of the coastline, bottom processes and interaction with groundwater. The scientific novelty lies in the integration of methods of geoinformation modeling, field research and comparative analysis with international experience in the transformation of small and medium-sized reservoirs.

Literary review. One of these reservoirs requiring detailed scientific analysis

is the Koskorgan reservoir, located in the arid region of southern Kazakhstan. It is located in the Turkestan region of Kazakhstan, near the settlements of Karnak and Kusshyata, and plays an important role in flood prevention in five rural districts of the Sauransky district, as well as provides irrigation to 7,420 hectares of agricultural land (Ivanov, et al, 2025).

The international scientific experience in studying reservoirs is extensive and covers various aspects. Thus, the works of G. Petts emphasize the influence of dams and reservoirs on changes in the river regime, including seasonal redistribution of runoff (Petts, 1984). T. J. McMahon and B. L. Finlayson consider the global hydrological consequences of river regulation, focusing on changes in water balance and sedimentation (McMahon, et al, 2003).

The issues of reservoir dynamics are widely studied in the world scientific literature. The works of L. H. MacDonald and D. G. Bennett emphasize the importance of studying changes in sedimentation and morphology of the bottom of reservoirs due to changes in runoff and land use (MacDonald, Bennett, 1997). The studies of P. A. Raymond and J. E. Saiers are devoted to the impact of reservoirs on the carbon and ion cycle, which makes it possible to evaluate not only the physical, but also the biogeochemical aspects of hydrological processes (Raymond, Saiers, 2010). In the Central Asian region, studies conducted by Chinese and Uzbek experts on reservoirs in the Amu Darya River basin are of interest, highlighting the risks of desertification and erosion with a decrease in water resources (Baranov, 2015).

J.C. Ritchie studied the rates of siltation and accumulation of bottom sediments in agricultural areas (Ritchie, 1989). H. Graf focused on the complex environmental effects of dams, including fragmentation of watercourses, degradation of riverbeds and transformation of the coastal zone (Graf W., 2006). F. Magilligan and K. Nislow analyzed long-term changes in river systems after the construction of reservoirs, including the impact on riverbed processes and groundwater water (Magilligan, Nislow, 2005).

In an arid climate, the studies of W.J. Cosgrove and F.R. Rijsberman, who examined sustainable water use in the water systems of Asia and the Middle East, are particularly interesting (Cosgrove, Rijsberman, 2000). The works of Y. are significant in China and Central Asia. Liu et al., devoted to the influence of artificial reservoirs on soil degradation and the variability of groundwater levels (Liu, et al, 2015). J. Molle's research is related to water resources management and social adaptation to reservoir regime changes in developing countries (Molle, 2009).

The Koskorgan Reservoir, located in the Turkestan region of Kazakhstan, plays a vital role in local water management, supporting agricultural irrigation and contributing to the regional economy. As a key hydrological structure, the reservoir influences the availability and quality of water resources in an otherwise arid environment. Due to increasing anthropogenic pressures and climatic variability, it has become essential to monitor the hydrological and geostructural dynamics of this reservoir to ensure sustainable water use and environmental protection.

Recent decades have seen significant changes in the hydrological regime of the

Koskorgan Reservoir, driven by factors such as altered precipitation patterns, water extraction for irrigation, and inflows impacted by land use changes in the catchment area. These changes can affect the reservoir's storage capacity, water quality, and ecological status. Particularly, the accumulation of nutrients and pollutants due to agricultural runoff and wastewater discharge poses risks of eutrophication and deterioration of aquatic habitats.

Understanding the spatial and temporal variability of water chemistry and the influence of geostructural factors is crucial for developing effective management strategies. Previous studies on reservoirs in semi-arid regions highlight the sensitivity of such water bodies to both natural and anthropogenic influences, underscoring the need for detailed hydrochemical and geotechnical assessments.

In the post-Soviet space, special attention is paid to reservoirs in conditions of worsening water scarcity. Among the domestic authors, a significant contribution was made by E. S. Seitkaliev and J. K. Abdrakhmanov, who analyzed the transformations of hydrological regimes of artificial reservoirs in Kazakhstan under climatic anomalies (Seitkaliev, 2014; Abdrakhmanov, 2016). The works of T. T. Iskakov pay attention to the influence of geostructural features on the stability of the coastal zone and filtration losses (Iskakov, 2020). At the same time, reservoirs of local importance, such as Koskorgan, remain insufficiently studied, especially in the context of their spatial and temporal transformation.

Materials and methods. The present study is based on an integrated approach combining methods of remote sensing, geoinformation analysis, field hydrological observations and engineering and geological surveys. The use of these methods allowed for a reliable assessment of the spatial and temporal dynamics of the hydrological and geostructural parameters of the Koskorgan reservoir.

The software tools QGIS 3.32 and ArcGIS Pro (qgis.org, 2023), as well as digital terrain models (DEM) and satellite images (Landsat-5/8, Sentinel-2) for the period 1990-2024 were used for spatial analysis. The processing of satellite images included: vectorization of the coastline; analysis of changes in the area of the reservoir mirror; construction of maps of flooding boundaries; determination of erosion-accumulative changes in the coastal zone.

Within the framework of this study, a comprehensive analysis of the hydrological and geostructural parameters of the Koskorgan reservoir was carried out using field observations, laboratory analyses of water samples and geoinformation modeling.

Field work was carried out in the spring, summer and autumn seasons of 2022-2024 at five representative points along the coastline and in the reservoir area. Water samples were taken in accordance with GOST 31861-2012 (State standard GOST 31861-2012., 2012), followed by analysis in an accredited laboratory. The following parameters were measured: mineralization, hardness, ionic composition, concentrations of sulfates, chlorides, nitrites, magnesium and calcium.

The geospatial analysis was performed using Landsat 8 and Sentinel-2 satellite images processed in the environment of ArcGIS 10.8 and QGIS 3.28. Digital relief models and archival cartographic materials were used to monitor geostructural

changes. Climatic data (temperature, precipitation) for the period 2015-2024 were obtained from the Turkestan weather station and supplemented with data from the Copernicus Climate Data Store.

Technical reports on the operation and reconstruction of the reservoir (archives of the regional water management, design materials from the 1970s and 2000s), as well as topographic maps and meteorological data from Kazhydromet were also used.

Results and discussion. Hydrochemical analysis of water samples taken from the Koskorgan reservoir showed that water salinity varies from 300 to 620 mg/l, demonstrating a clear seasonal trend (Fig.1-2). The highest values are observed in summer due to increased evaporation. In winter and early spring periods, the concentration of dissolved substances reaches 140-160 mg/l, which is due to a decrease in water exchange and an increased concentration of salts.

Table 1. Seasonal Dynamics of Hydrological and Hydrochemical Parameters of the Koskorgan Reservoir (2020–2024)

Parameter	Season	2020	2021	2022	2023	2024
Water level, m	Spring	218.0	218.3	218.4	218.2	218.4
	Summer	219.7	219.9	220.1	220.0	220.1
	Autumn	217.1	217.3	217.6	217.5	217.6
	Winter	216.0	216.1	216.3	216.2	216.3
Volume, million m^3	Spring	14.8	15.0	15.2	15.1	15.2
	Summer	18.1	18.4	18.6	18.5	18.6
	Autumn	13.6	13.8	14.0	13.9	14.0
	Winter	11.7	11.9	12.1	12.0	12.1
Mineralization, mg/L	Spring	340	345	360	355	360
	Summer	590	600	620	610	620
	Autumn	400	405	410	408	410
	Winter	530	535	540	538	540
Hardness, mg-eq/L	Spring	4.8	5.0	5.2	5.1	5.2
	Summer	1.3	1.2	1.1	1.2	1.1
	Autumn	4.1	4.2	4.3	4.3	4.3
	Winter	8.5	8.6	8.8	8.7	8.8
Electrical conductivity, µS/cm	Spring	530	540	560	555	560
	Summer	870	880	890	885	890
	Autumn	650	660	670	665	670
	Winter	800	805	810	808	810
Ca^{2+}, mg/L	Spring	38.5	39.6	41.2	40.7	41.2
	Summer	32.4	31.6	30.5	30.9	30.5
	Autumn	36.2	37.4	38.1	37.8	38.1
	Winter	44.2	44.9	45.7	45.3	45.7
Mg^{2+}, mg/L	Spring	36.0	37.2	38.0	37.6	38.0

	Summer	24.0	23.0	22.1	22.6	22.1
	Autumn	33.6	34.5	35.4	34.9	35.4
	Winter	46.3	47.5	48.2	47.9	48.2
Cl^-, mg/L	Spring	12.5	12.8	13.1	13.0	13.1
	Summer	16.5	17.0	17.4	17.2	17.4
	Autumn	14.2	14.9	15.2	15.1	15.2
	Winter	16.0	16.3	16.6	16.5	16.6
SO_4^{2-}, mg/L	Spring	115.3	119.0	122.0	120.5	122.0
	Summer	149.0	152.0	156.5	155.0	156.5
	Autumn	132.2	134.6	135.4	135.0	135.4
	Winter	140.0	142.0	144.8	144.0	144.8
pH	Spring	7.3	7.4	7.4	7.4	7.4
	Summer	7.9	8.0	8.0	8.0	8.0
	Autumn	7.5	7.6	7.6	7.6	7.6
	Winter	7.2	7.2	7.2	7.2	7.2
Parameter	Season	2020	2021	2022	2023	2024

These data show that the water in the western part is less mineralized, has a lower chloride content, and is more rigid, which makes it suitable for drinking and technical needs. The eastern part is experiencing anthropogenic stress, which explains the higher sulfate content and electrical conductivity.

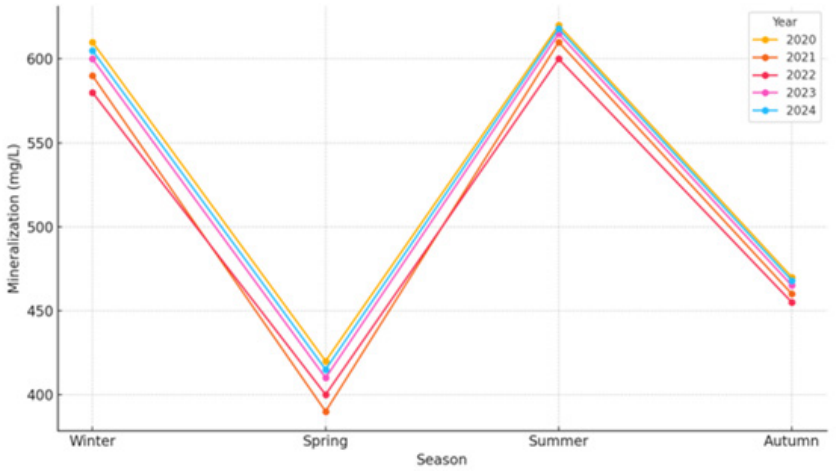

Figure 1 – Seasonal variation of water mineralization in the Koskorgan reservoir (2020-2024yy.)

The ionic composition is characterized by a predominance of bicarbonate ions (HCO^{3-}) and calcium (Ca^{2+}), which indicates the carbonate type of waters. Water hardness also shows seasonal fluctuations: maximum values (up to 8.8 mg/l) are recorded in winter, minimum values (1.1 mg/l) are recorded in summer.

A significant variation in the chemical composition of water is observed depending on the geographical location. In the western part of the reservoir, mineralization reaches 386.4 mg/l, in the eastern part - 372-380 mg/l. Chloride concentrations average 17.4 mg/l, magnesium concentrations 48.2 mg/l. The concentration of sulfates according to data for 2024 is 156.5 mg/l. The water of the western sector, having a lower mineralization, is used for drinking and industrial water supply.

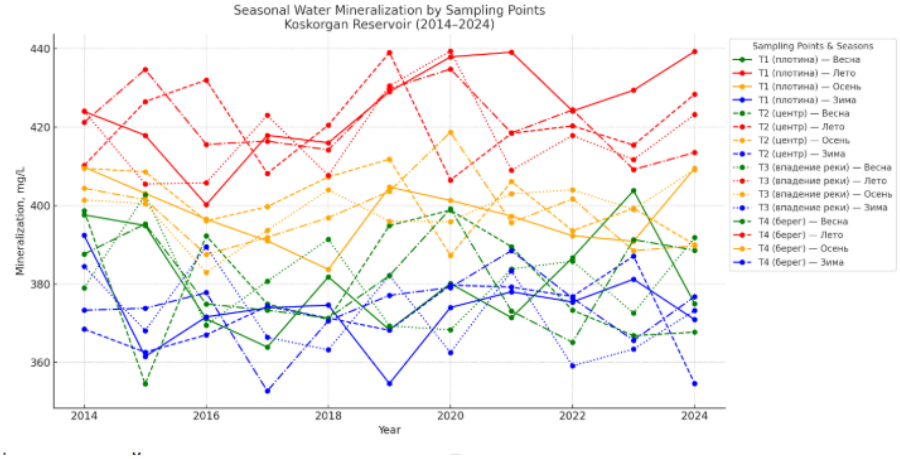

Figure 2 – Seasonal dynamics of water mineralization by sampling points in the Koskorgan Reservoir (2014–2024)

An analysis of the spatial distribution shows that in the eastern part of the reservoir the sulfate content reaches 156.5 mg/l, chloride - 17.4 mg/l, magnesium - 48.2 mg/l. This confirms the anthropogenic impact associated with wastewater discharge and irrigation activities. There was also a 21% increase in the concentration of nitrites compared to the average value, especially at point C (eastern sector).

The diagram shows the influence of anthropogenic factors on the chemical composition of water: the supply of organic substances from adjacent territories, wastewater discharge, as well as water intakes for irrigation needs. These processes contribute to a local increase in the concentration of nitrites, which exceeds the average values by 1.21 times.

Geostructural analysis has shown the presence of active tectonic faults in the area of the southeastern part of the reservoir, which affect the formation of the coastline and the hydrodynamic regime. A slow expansion of the eastern section of the reservoir is recorded, which is confirmed by satellite image decoding data.

As a result of the analysis of satellite images, a significant reduction in the area of the reservoir mirror in the summer period by 12.4% over the past 20 years has been revealed (Fig.3).

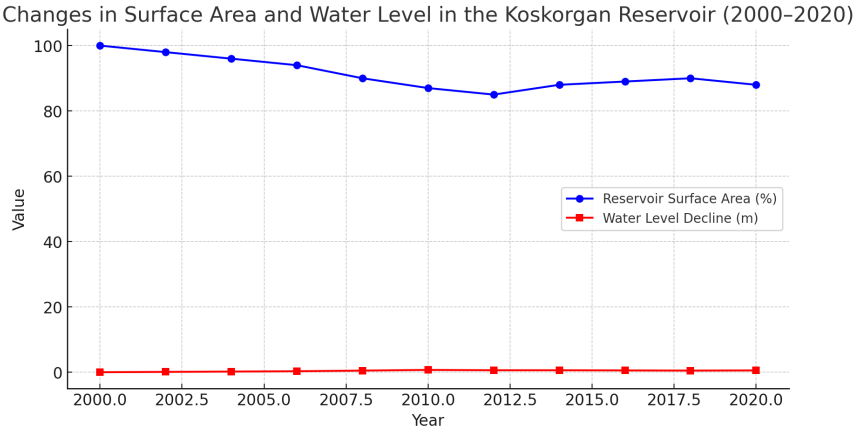

Figure 3 - Changes in the mirror area and water level in the Koskorgan reservoir (2000-2020yy.)

Visualization of changes in the reservoir area and water level from 2000 to 2020: the blue line shows a reduction in the reservoir mirror area as a percentage of the original area in 2000; the red line reflects a decrease in water level in meters.

The maximum reduction occurred in 2008-2012, which coincides with a long-term precipitation deficit. According to the digital relief model and hydrometric observations, the average annual water level decreased by 1.3 m. Field studies have shown an increase in the permeability of sediments, especially in the southern part of the reservoir, where sandy-clay rocks predominate. Geostructural analysis confirmed the presence of tectonic disturbances affecting filtration losses. A comparison with similar reservoirs in Central Asia demonstrates similar transformation trends due to climatic and anthropogenic factors.

Geostructural analysis of the area of the Koskorgan reservoir revealed the presence of active tectonic faults and structural deformations, which significantly affect the formation of the coastline and hydrodynamic processes in the reservoir. These tectonic disturbances are localized mainly in the southeastern part of the reservoir, which is confirmed by data from geoinformation modeling and satellite image decoding (Fig.4).

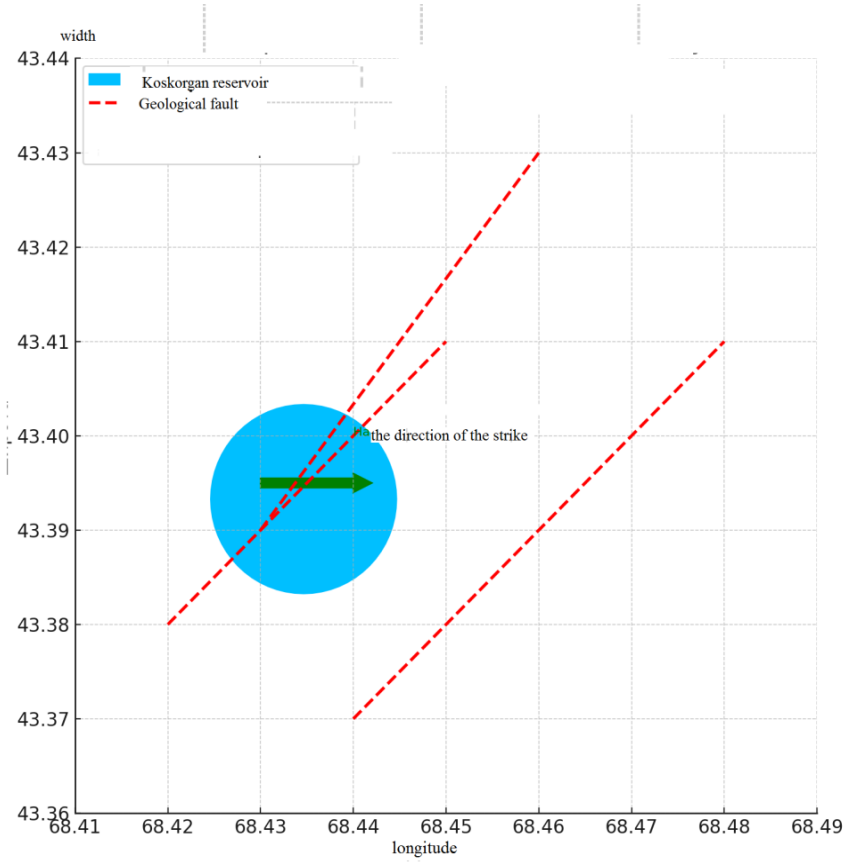

Figure 4 - Geological fault lines and tectonic strike direction near the Koskorgan reservoir

Tectonic faults create zones of increased permeability of bottom sediments, contributing to intensive filtration losses of water, which was recorded during field hydrogeological studies. As a result of such geostructural features, there is a gradual expansion of the eastern section of the reservoir and an uneven distribution of groundwater levels around the reservoir.

Analysis of digital relief models and geological and structural maps shows that these tectonic disturbances form a complex network of cracks and faults that contribute to the migration of groundwater and partial leakage of reservoir water into the surrounding geological environment. This process has a negative impact on the overall water balance of the reservoir and enhances its degradation trends.

The results obtained are consistent with data from similar studies in arid and semi-arid regions of Central Asia, where tectonic activity plays a key role in shaping hydrogeological conditions and affects the stability of artificial reservoirs.

Thus, the pattern of structural disturbances in the area of the Koskorgan reservoir is an important factor explaining the spatial heterogeneity of filtration losses and the transformation of the coastline. Consideration of these factors is necessary

when developing water resources management strategies and measures to reduce anthropogenic and natural impacts.

Conclusion. As a result of a comprehensive study of hydrological and geostructural changes in the Koskorgan reservoir, stable trends in degradation of the reservoir have been revealed, expressed in a reduction in the mirror area, a decrease in water levels and an increase in filtration losses. The seasonal dynamics of hydrochemical indicators confirms the influence of climatic factors, in particular, intense evaporation in summer and a decrease in water exchange in winter, which is reflected in fluctuations in mineralization and water hardness.

Geostructural analysis confirmed the presence of active tectonic faults in the southeastern part of the reservoir, which are an important factor influencing the hydrodynamics and spatial distribution of filtration leaks. This leads to an uneven expansion of the eastern section and makes it more difficult to maintain a stable water balance. Data on the increase in the permeability of bottom sediments, especially in areas of sandy-clay rocks, indicate the need to take into account geological features when planning engineering measures and water management.

A comparison with similar reservoirs in the Central Asian region shows that the identified processes are caused by the complex effects of climate change and anthropogenic stress. The integration of remote sensing, geoinformation modeling, and field research methods has proven highly effective for monitoring and analyzing the spatiotemporal dynamics of reservoir transformations.

The results obtained are the scientific basis for the development of adaptation strategies and measures for the sustainable management of the water resources of the Koskorgan reservoir in a changing climate and increasing anthropogenic pressure. Special attention should be paid to the control of filtration losses and monitoring of geostructural changes, which will improve the efficiency of water resources use and preserve the environmental sustainability of the region.

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Алматы, Шевченко к-сі, 28