UDC: 614.777:628.1

HYGIENIC ANALYSIS OF THE POPULATION'S DRINKING WATER SUPPLY

Nizom J. Ermatov – D.M.Sc., professor
Feruza L. Azizova – D.M.Sc., professor
Dilshod Sh. Alimukhamedov – D.M.Sc., professor
Tashkent State Medical University (Tashkent, Uzbekistan)
Murodbek A. Niyazmetov
Urgench RANCH Technological University (Urgench, Uzbekistan)
Dulta Kenjaboev – Ph.D., associate professor
Tashkent State Medical University (Tashkent, Uzbekistan)
muradbek9547@gmail.com

Abstract. *This article presents a territorial analysis of the provision of high-quality drinking water to the population of Bagat District. The findings indicate that access to drinking water in the district center is very high, with nearly the entire population covered by centralized water supply services. However, across the district as a whole, the coverage rate is 67.7%, reflecting significant disparities between the central area and remote rural settlements. This situation is associated with insufficient development of water supply infrastructure in rural communities, limited coverage of water distribution networks, and the continued use of alternative water sources, including wells and local water intake facilities. From a scientific perspective, these indicators demonstrate the persistence of territorial inequalities in access to drinking water within Bagat District. The difference between the district center and the district-wide coverage rate amounts to 29.8 percentage points (97.5% versus 67.7%), highlighting the need to modernize rural water supply systems, construct new distribution networks, and expand access to centralized drinking water services. The analysis further revealed a steady upward trend in this indicator during 2005–2026. While it stood at 11 units in 2005, it reached 25 units by 2020, representing an approximately 2.3-fold increase over 15 years. The most pronounced growth occurred during 2020–2025, when the indicator rose from 25 to 35 units, an increase of 40%. The data also show that per capita daily water consumption remained stable at 140 liters per day during 2005–2015. By 2020, this figure had increased to 180 liters per day, representing a 28.6% rise compared with 2015. The projected value for 2026 is 200 liters per day, which is 60 liters, or 42.9%, higher than in 2005, indicating a continuous increase in household water consumption. According to the available data, only 12% of the urban population was covered by centralized water supply services in 2005. This figure increased to 14% in 2010, 17% in 2015, 20% in 2020, 26% in 2025, and is projected to reach 30% in 2026, reflecting the ongoing implementation of infrastructure development projects in this sector. The study examined the condition of water supply infrastructure, the level of population coverage by centralized drinking water systems, the territorial distribution of water supply networks, and the existing challenges within the water supply system.*

Keywords: *drinking water, water supply, territorial analysis, infrastructure, centralized water supply, population coverage, water resources, public utility services.*

Relevance of the topic.

The failure of hygienic and microbiological parameters of drinking water to meet established sanitary norms constitutes one of the primary factors in the occurrence and spread of waterborne diseases. According to data from the World Health Organization, a significant proportion of diarrheal diseases is attributable to the consumption of contaminated drinking water and to inadequate sanitation conditions [16]. This problem is particularly acute in the Aral Sea region, where specific natural and climatic conditions, combined with the high degree of mineralization characteristic of local water sources, exert an adverse effect on drinking water quality [4, 7, 13].

In Bagat District as well, the issue of providing the population with safe, high-quality drinking water is of paramount importance from the perspectives of sanitary-hygienic compliance and public health protection. Accordingly, the scientific substantiation of safe and efficient water source utilization, along with the improvement of systematic microbiological monitoring of water quality, is currently regarded as one of the priority directions in the field of public health [5].

A considerable body of scientific research is being conducted at the global level on the rational and safe use of water resources and on the improvement of microbiological monitoring systems. Of particular importance are studies focused on the seasonal analysis of the microbiological status of water bodies, the identification of seasonal variations in the chemical composition of water, and the assessment of the relationship between chemical parameters and the distribution of microorganisms [3, 6, 7].

At the same time, scientific research aimed at establishing an effective monitoring system through the integrated year-round study of the microbiological, hydrobiological, parasitological, and chemical properties of water under the specific conditions of Bagat District remains insufficient. In particular, determining the prevalence of pathogenic and conditionally pathogenic microorganisms, analyzing their association with water mineralization, and evaluating the factors affecting water quality represent pressing scientific challenges. Therefore, the scientifically grounded development of preventive measures aimed at ensuring the provision of high-quality drinking water, preventing waterborne diseases, and improving sanitary-hygienic conditions is of substantial theoretical and practical significance [9].

Bagat District (see Figure 1) is one of the administrative units of Khorezm Region of the Republic of Uzbekistan. As of January 1, 2025, the district's population amounted to 179,558 persons. According to official statistical data, approximately 95% of the urban population and 86% of the rural population are covered by the centralized drinking water supply system.



Fig. 1. Map of Khorezm Region

Notwithstanding the above, the reliability and sustainability of the water supply system remain insufficient. While urban residents receive drinking water for an average of 12–24 hours per day, water supply in rural areas is largely carried out on a scheduled basis. This indicates that despite relatively high centralized water supply coverage rates, ensuring continuous provision of safe and high-quality drinking water to the population remains an ongoing challenge.

The total length of drinking water pipelines in the district is approximately 238 km. In recent years, certain measures have been undertaken to expand and modernize the centralized water supply

system. However, infrastructure development has not always been accompanied by commensurate improvements in water quality indicators. In particular, the elevated hardness level of groundwater, the primary source for domestic and drinking purposes, remains one of the key environmental and sanitary concerns in the area [3, 11].

The development and improvement of projects related to the advancement of the drinking water supply system and the protection of water sources are today inconceivable without the involvement of sanitary-hygienic specialists. Ecological-hygienic research that considers the natural-climatic characteristics, socioeconomic conditions, and sanitary-epidemiological situation of the region plays a crucial role in both project decision-making and in the determination of environmental protection measures [10].

These challenges are especially relevant for the communities of the Aral Sea region. Bagat District is no exception, as a number of difficulties related to the provision of high-quality drinking water persist. The elevated mineralization of local water sources and the unstable epidemiological situation with respect to intestinal infections further intensify the urgency of addressing this issue [15, 17, 18].

Materials and methods.

For assessing the sanitary-hygienic condition of the drinking water supply system in Bagat District, official statistical data, information bulletins on hygiene and environmental science, and reporting materials of the Sanitary-Epidemiological Welfare and Public Health Department of Khorezm Region were analyzed.

During the study, data on the quality of water from both centralized and decentralized water supply sources were utilized. Specifically, the chemical composition of water, total hardness, degree of mineralization, and microbiological parameters were examined. Additionally, comparative analyses were conducted on the proportion of drinking water samples failing to meet sanitary-hygienic requirements, the level of population coverage by centralized water supply, the water delivery schedule, and the technical condition of the water distribution networks.

The objects of study were centralized domestic and drinking water supply systems, groundwater sources, and piped water delivered to the population. During the study, the level of drinking water provision to the population, the condition of water networks, and the sanitary characteristics of the water were comparatively assessed.

Drinking water quality was evaluated against the requirements of the national standard UzSt 133:2024 "Drinking Water. Hygienic Requirements and Quality Control" of the Republic of Uzbekistan, as well as the international recommendations of the World Health Organization on drinking water quality [17, 18].

Statistical processing of the data was carried out through comparative analysis of recent-year indicators from official sources. This approach made it possible to identify the development dynamics of the water supply system in Bagat District, prevailing trends, and the principal sanitary-hygienic challenges.

The analytical findings indicate that in Khorezm Region, the level of centralized drinking water provision to the population has been gradually increasing in recent years. Nevertheless, particularly in rural areas, this indicator continues to lag behind the national average. This situation is explained by the specific natural-climatic conditions of the region, the elevated degree of groundwater mineralization, and the physical deterioration of certain sections of the water distribution infrastructure [8, 14, 15].

In the Bogat district, the indicators of centralized drinking water supply to the population have been showing positive growth dynamics in recent years. In particular, in 2020, the coverage of the urban population with centralized water supply was approximately 78 percent, and in rural areas - 60 percent, while by 2025 these indicators reached 95 and 86 percent, respectively. This indicates the effectiveness of the work carried out to expand the water supply infrastructure in the district and implement new projects.

At the same time, despite the increase in the level of water supply to the population, some problems related to the stability and quality of water supply remain. While water supply is carried out on a schedule in some settlements, fluctuations in water pressure are observed in rural areas. In addition, the high hardness of groundwater used in the district is one of the main factors negatively affecting the quality of drinking water [1,2,3].

The results of the comparative analysis show that the level of coverage of centralized water supply in the Bogat district is approaching the average indicators of the republic. However, sanitary and hygienic problems associated with water quality and its uninterrupted supply to the population remain relevant. This indicates the need to improve water treatment technologies, modernize water treatment facilities, and further develop water supply infrastructure [14,15].

Although the level of centralized water supply to the population in the Khorezm region has been increasing in recent years, its overall indicators have not yet reached a sufficient level. As of 2024, the level of water supply to the urban population was 92.5 percent, while in rural areas this indicator is much lower, remaining almost two times less (see Figure 2).

During 2023–2024, the water supply indicator in urban areas increased by approximately 11 percent, while in rural areas the growth rate reached 35 percent. This indicates that the development of water supply infrastructure in rural areas has intensified in recent years.

According to the analysis, if the current development rates are maintained, the full coverage of the urban population with centralized water supply can be achieved in approximately 6–7 years, and in rural areas - in 10–12 years. This should also take into account the natural growth of the population.

The results of the comparative assessment show that the indicators of centralized water supply in urban areas are approaching the average level of the republic, but in rural areas these indicators are still significantly lower (see Figure 2).

Although some problems remain in the field of providing the population with high-quality drinking water in the Khorezm region, in recent years, certain work has been carried out in the Bogat district to expand the volume of centralized water supply. According to local utilities, the main part of the water consumed by the population is spent on household needs and irrigation of household plots. This situation is one of the characteristics of the agriculturally specialized areas of the Khorezm region.



Fig. 2. Data on the level of drinking water supply of the population of the Bogat district of the Khorezm region as of January 1, 2026

The analysis of the structure of water consumption shows that water used for household needs and irrigation of households occupies a large share in total consumption, while water consumption in other directions is relatively small. This situation indicates a high dependence of the population, especially the population living in rural areas, on individual and multi-purpose use of water resources.

In recent years, several centralized water supply systems have been operating in the Bogat district, which provide drinking water to settlements. The total length of water pipeline networks in the district is approximately 238 km, which indicates the consistent development of water supply infrastructure.

In general, the development of centralized water supply systems in the Bogat district is in line with the general trends observed in the Khorezm region. At the same time, problems related to the physical obsolescence of some parts of the existing infrastructure, interruptions in water supply, and the high hardness of groundwater, which is used as the main source of drinking water for the population, remain relevant [1,2,11].

Results and discussion.

On the basis of the research findings, a comparative analysis was conducted of the principal water supply indicators for 2020 and 2025 across three levels: Khorezm Region as a whole, the center of Bagat District, and Bagat District overall.

Table 1 presents data on the number of water supply networks, their total length, the level of population coverage by drinking water supply and sewerage systems, and the capacity of water facilities.

Table 1

Key Water Supply Indicators for Khorezm Region, the Center of Bagat District, and Bagat District (as of 2020 and 2025)

Indicator	Khorezm Region	Bagat District Center	Bagat District
Number of water supply networks			
2020	39	1	4
2025	40	1	4
Total length of water supply networks (km)			
2020	1,715.4	134.0	179.0
2025	3,281.9	156.3	248.6
Population coverage by centralized drinking water supply (%)			
2020	45.1	84.0	37.8
2025	65.6	97.5	67.7
Population coverage by sewerage system (%)			
2020	8.4	20.0	0
2025	8.8	26.4	0

The analyzed data demonstrate that sanitary conditions regarding water use across Khorezm Region are broadly similar. However, certain inter-district variations exist with respect to drinking water coverage levels, water quality, and the reliability of water supply. Although centralized water supply coverage indicators in Bagat District are comparatively high, sanitary-hygienic concerns related to water quality and continuity of supply persist.

Within the district, the population's use of water for domestic, drinking, and cultural-household needs is primarily based on groundwater delivered through centralized water supply systems, with some residents additionally using wells and well-type structures. At the same time, water samples from both urban and rural settlements are occasionally found to be non-compliant with sanitary-hygienic norms with respect to chemical parameters—a situation primarily attributable to the elevated hardness and mineralization of groundwater.

One of the main focuses of this study was the sanitary-hygienic assessment of the water use conditions in Bagat District and the identification of existing problems.

In contrast to the tourism-oriented districts of Khorezm Region, Bagat District is predominantly an agricultural area. This characteristic directly influences both the composition of water consumption and the nature of utilization of water supply systems. In Uzbekistan, both surface and groundwater sources are widely used for domestic and drinking water supply.

At present, approximately 95% of the urban population and 86% of the rural population of Bagat District have access to centralized water supply services. One of the important positive features of the district's water supply system is that groundwater constitutes the principal water source.

At the same time, in accordance with the requirements of the national standard UzSt 133:2024 "Drinking Water. Hygienic Requirements and Quality Control" of the Republic of Uzbekistan, water quality in certain chemical parameters does not fully comply with established norms. In particular, the total hardness of water is observed to exceed the established sanitary-hygienic requirements in some instances (see Figure 3).



Fig. 3. Drinking water coverage levels in the center and throughout Bagat District, %

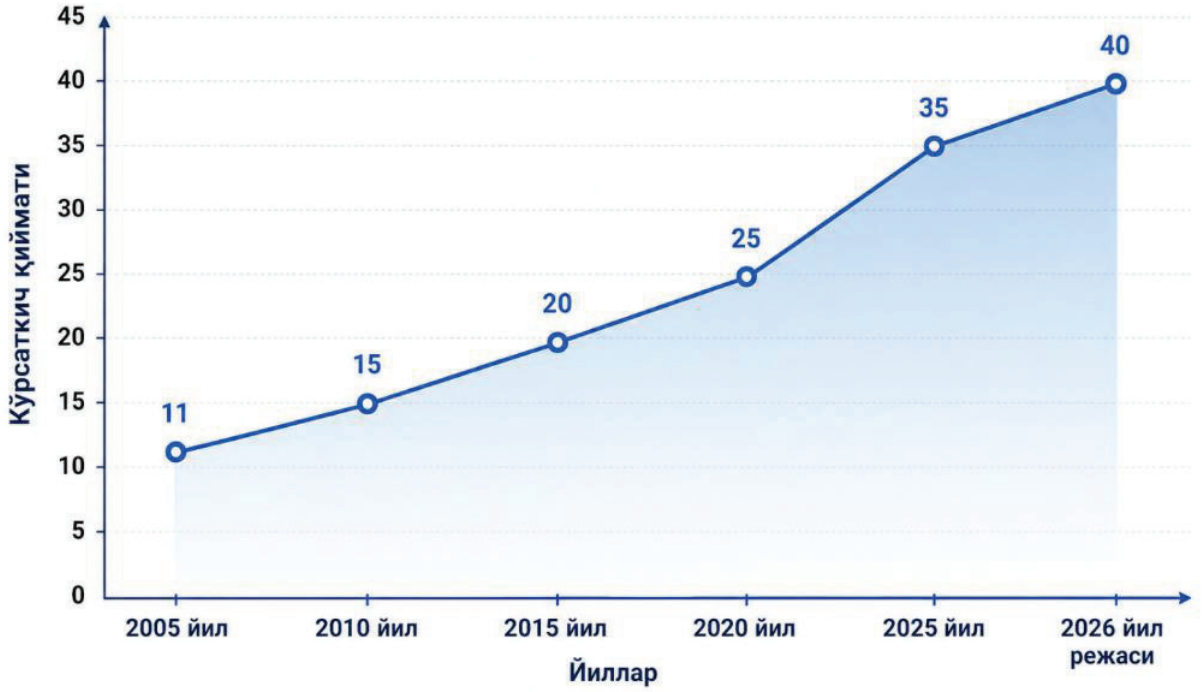


Fig. 4. Water supply capacity, thousand m³/day (2025–2026)

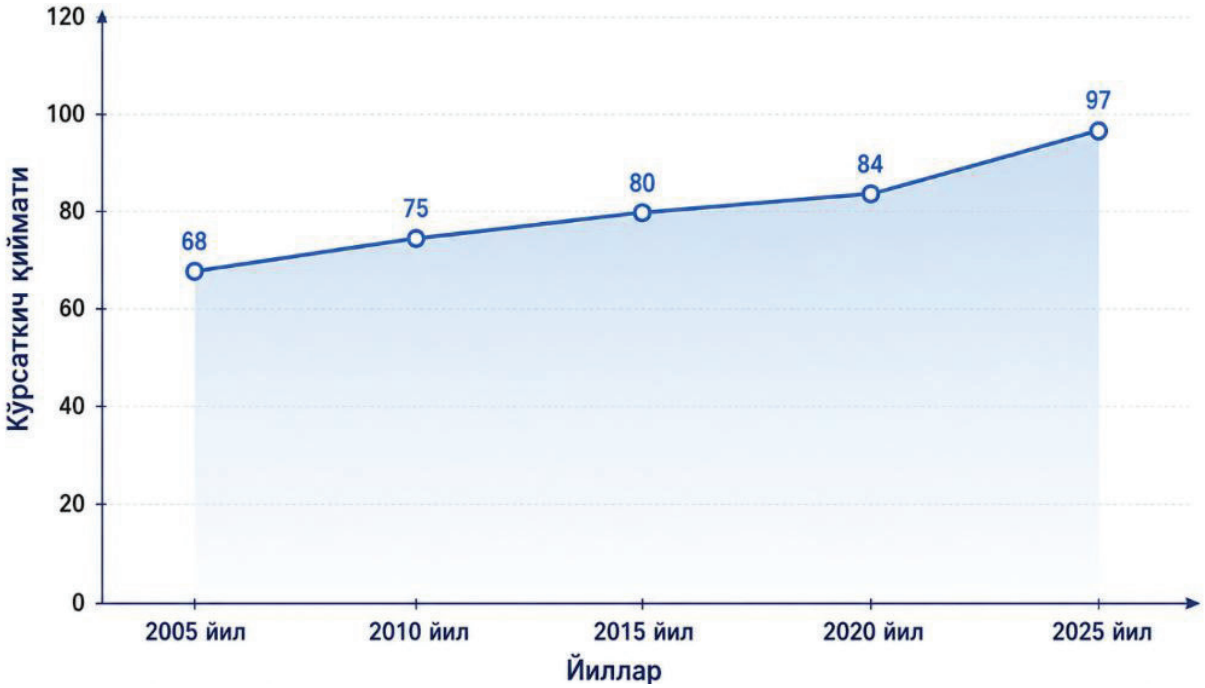


Fig. 5. Drinking water provision levels for the population of Bagat District center (2025–2026, %)

The water use of the population of Bagat District for domestic, drinking, and cultural-household purposes is primarily supplied from groundwater sources delivered through centralized water supply networks. In certain areas, residents also use individual wells and well-type structures. In some settlements, surface water sources treated through appropriate purification and disinfection processes are also utilized for drinking and domestic purposes.

However, some water samples collected from distribution networks and water sources in both urban and rural areas of the district do not fully comply with sanitary-hygienic norms in terms of chemical parameters.



Fig. 6. Per capita daily water consumption in urban settings (2025–2026, liters/day)



Fig. 7. Urban population coverage by sewerage system (2025–2026, %)

The primary cause of this situation is related to the natural-geographical characteristics of the region: namely, the elevated hardness and mineralization of groundwater (see Figures 7 and 8).

In recent years, the proportion of tap water samples failing to meet bacteriological sanitary requirements in Khorezm Region has remained higher than the national average. Although these

indicators in Bagat District are broadly close to the regional average, deviations from sanitary-hygienic norms have been recorded in certain rural settlements. This is particularly evident in indicators related to the chemical composition of water, including those reflecting the elevated hardness and mineralization characteristics of local groundwater sources.

As a result of the modernization of water supply facilities, renovation of water treatment plants, and strengthened sanitary oversight in recent years, a gradual decrease in the proportion of non-compliant water samples has been observed.

The epidemiological safety of drinking water is assessed primarily through the compliance of its microbiological and parasitological parameters with established sanitary norms. Total microbial count reflects the degree of bacterial contamination of water, accounting for saprophytic microflora, and typically increases as a result of the influence of surface water, rainwater, or domestic wastewater. For this reason, it serves as an important indicator for monitoring the efficiency of water treatment processes at treatment facilities and for detecting technological failures.

The detection of bacteria belonging to the Enterobacteriaceae family indicates fecal contamination of water. The presence of thermotolerant coliform bacteria, including Escherichia coli, is recognized as the primary marker of "fresh" fecal contamination. Accordingly, a large number of sanitary and regulatory documents establish the complete absence of coliform bacteria as the principal criterion for assessing the epidemiological safety of drinking water.

Furthermore, the detection of coliphages in water indicates the possibility of viral contamination, while the presence of sulfite-reducing Clostridium spores signals an epidemiological risk associated with long-term fecal contamination [17, 18].

Drinking water quality is assessed against international standards, WHO guidelines for drinking water quality, and the sanitary-hygienic norms in force in the Republic of Uzbekistan. In accordance with these requirements, drinking water must be epidemiologically and radiologically safe, chemically harmless to human health, and organoleptically acceptable for consumption.

The analytical results demonstrate that the sanitary conditions of water use by the population of Bagat District are broadly consistent with the average situation observed across Khorezm Region. However, the predominance of groundwater sources and the variability in drinking water quality indicators among different settlements within the district are notable.

In this regard, the necessity of strengthening sanitary-hygienic oversight of centralized water supply systems, improving water treatment and disinfection technologies, and broadly implementing comprehensive sanitary-preventive measures aimed at protecting public health has been substantiated.

The analytical findings further indicate that groundwater sources in Bagat District generally meet the sanitary requirements established for Category I water sources with respect to turbidity, oxidizability, iron content, and fluoride levels. At the same time, deviations from normative standards are observed with respect to total water hardness and certain chemical components.

This underscores the necessity of employing water softening and disinfection technologies when utilizing groundwater within the centralized domestic and drinking water supply system.

Dug wells and tube wells remain important sources of water supply in Bagat District, particularly in rural areas. The hygienic evaluation of such water sources requires consideration of the hydrogeological characteristics of the area, potential contamination sources, and the effectiveness of the applied water treatment and disinfection technologies.

During the summer season, the sharp increase in water consumption in certain settlements of the district results in water supply being conducted on a scheduled basis. This is explained by the limited water resource availability and the insufficient technical capacity of the distribution networks.

The water supply system of Bagat District is primarily reliant on groundwater sources. At the same time, the need to modernize certain water facilities and to technically upgrade technological equipment persists.

According to data from the sanitary-epidemiological service, some water samples have been found to contain total hardness levels exceeding established norms. This condition may have an adverse effect on public health, in particular by increasing the risk of developing diseases of the urinary and digestive systems.

At the same time, the majority of water samples were found to comply with sanitary requirements in terms of microbiological parameters. Specifically, total microbial counts remained within permissible limits, and pathogenic bacteria responsible for intestinal infections were generally not detected in the samples examined.

Analysis of the quality of piped water supplied to the population of Bagat District indicates that water does not fully comply with the requirements of the national standard UzSt 133:2024 with respect to certain chemical parameters. Elevated total hardness, characteristic of local groundwater sources, remains one of the principal concerns.

Overall, the sanitary conditions of water use in Bagat District are broadly comparable to those observed in other districts of Khorezm Region. However, the predominance of groundwater sources, the instability of water quality indicators, and disparities in water supply levels between individual settlements persist as challenges requiring attention.

Conclusions.

1. An analysis of the drinking water supply situation in Bagat District, Khorezm Region, revealed a consistent increase in the level of centralized drinking water coverage over recent years. As of 2025, approximately 95% of the urban population and 86% of the rural population are supplied with piped water through centralized systems. This indicates that ongoing efforts to develop water supply infrastructure in the district are yielding tangible positive results.

2. Certain challenges persist with regard to the reliability of the water supply system and water quality. Among the principal sanitary-hygienic concerns identified in the district is the elevated hardness of groundwater used for domestic and drinking purposes. The implementation of scheduled water supply in some settlements reflects the limited technical capacity of existing networks and the physical deterioration of certain facilities.

3. Microbiological analyses indicate that drinking water parameters generally comply with sanitary requirements. However, deviations from normative standards were observed with respect to chemical parameters—most notably total hardness levels.

4. The sanitary conditions of water use by the population of Bagat District are broadly comparable to the average indicators recorded across Khorezm Region. Nevertheless, continued implementation of measures to improve water treatment technologies, modernize water supply infrastructure, and strengthen sanitary-hygienic oversight remains essential.

REFERENCES

1. Almatov, B. I., & Ermatov, N. Zh. (2018). Analysis of the effectiveness of reservoir water use based on the study of their microbial and chemical composition. European Science, (8(40)), 35–37. [In Russian]

2. Almatov, B. I., & Ermatov, N. Zh. (2018). Efficiency of reservoir water use in Uzbekistan. In International Scientific Review of the Problems and Prospects of Modern Science and Education (pp. 80–82). [In Russian]

3. Balliev, A. I., Chembarisov, E. I., Ballieva, R., et al. (2024). Contemporary mineralization and chemical composition of small local water bodies in the Southern Aral Sea region. [In Russian]

4. Duschanov, B. A., Abdullayev, R. B., Mustafayev, Kh. M., et al. (2022). The Aral Sea: Problems of ecology and health. Tashkent. [In Russian]

5. Kosimov, S. K., & Makhmudov, I. R. (2022). Problems of drinking water quality in rural regions of Uzbekistan. Bulletin of the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, (4), 25–30. [In Russian]

6. Nuraliev, N. A. (2022). Reservoirs: features of the chemical composition of water, microbiological and hydrobiological aspects. [In Russian]
7. Nuraliev, N. A. (2023). Microbiological and hygienic safety of Amu Darya river water. 18, 21. [In Russian]
8. Rakhimov, B. Kh., & Tursunov, Sh. A. (2023). Modern methods of water treatment for elevated hardness. Water and Ecology, (1), 12–18. [In Russian]
9. Siddikov, Z. A. (2024). Hygienic assessment of the water supply of the population in an ecologically unfavorable zone. Medical Journal of Uzbekistan, 6(3), 45–51. [In Russian]
10. Usmanov, I. A. (2025). Assessment of financial flows for the optimization of water supply in Uzbekistan in the context of climate change. [In Russian]
11. Chembarisov, E. I., & Balliev, A. I. (2024). Contamination of watercourses and water bodies of the Republic of Karakalpakstan and practical recommendations for its reduction. [In Russian]
12. Ermatov, Z., et al. (2022). Modelling the chemical composition process concerning formation of metals from manual arc surface on the basis of the electrode coating charge components classification. International Journal of Mechatronics and Applied Mechanics, (12), 170–176.
13. Khalilov, B., & Mamarasulov, A. (2021). Health risks associated with high mineralization of drinking water in the Aral Sea region. Environmental Health and Preventive Medicine, 26, 45.
14. UNDP Uzbekistan. (2020). Water Governance in the Republic of Uzbekistan: Challenges and Opportunities. Tashkent.
15. UNICEF & WHO. (2023). Progress on Household Drinking Water, Sanitation and Hygiene 2000–2022: Special Focus on Inequalities. New York: UNICEF.
16. WHO. (2024, March 7). Fact sheet: Diarrhoeal disease. Retrieved from https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease
17. World Health Organization (WHO). (2022). Guidelines for Drinking-water Quality (4th ed., incorporating the 1st and 2nd addenda). Geneva: WHO Press.
18. World Health Organization / UNICEF. (2024). Diarrhoea: Why children are still dying and what can be done. WHO/UNICEF Report.