River water quality Amudarya in territory of Karakalpakstan

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Abstract. The object of the study is the Amudarya River, which is the only source of water supply and domestic water use of the population of the Republic of Karakalpakstan. The studies were carried out because the Republic of Karakalpakstan belongs to the regions of ecological disaster. Therefore, work to reduce anthropogenic pollution's adverse impact on the environment is necessary. The research methods included the sampling of water from the Amudarya River in the established sections of the reservoir according to the seasons of the year for five years, 2016-2020, and the conduct of water analysis following the standard O'zDSt 951:2011 "Sources of centralized domestic and drinking water supply. Hygienic, technical requirements, and selection rules. The indicators of taste, smell, and water color in the studied sections of the Amudarya River correspond to the established hygienic standards. The concentrations of ammonium, nitrates, nitrites, sulfates, chlorides, and total iron in water do not exceed their maximum allowable concentrations. However, the concentrations of turbidity, total hardness, and mineralization of water exceed the permissible values set on them. The maximum turbidity concentrations in water are 39.0 mg/l, total hardness 10.8 mg-eq/l, and salinity 1182.0 mg/l. Based on the work results, monitoring of water quality in the Amudarya River in Karakalpakstan has been improved.
This research aimed to study the long-term quality and assessment of water in the Amudarya River in the territory of Karakalpakstan.

1 Introduction

Karakalpakstan is located on the territory of the Turan lowland. The Karakum Desert adjoins it in the southwest, the Ustyurt Plateau in the northwest, and the Kyzylkum Desert in the northeast. The territory of Karakalpakstan also includes the southern half of the former Aral Sea, on the dried bottom of which the new Aralkum saline desert and the drying lower reaches of the Amudarya River are now being formed [1-3].

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In the Amudarya River basin, 16–19 km3 of return water is formed annually, of which 95% of the total runoff is drainage water, and 5% is untreated industrial and household wastewater [4].

Surface waters within the Republic of Karakalpakstan in the lower reaches of the Amu Darya River are polluted due to return waters with increased salinity, contaminated with mineral fertilizers and pesticides, as well as due to discharges of untreated industrial and domestic wastewater from settlements located in the upper and middle flow of the Amudarya River basin [5-7].

In recent years, isolated studies have been conducted in Karakalpakstan to assess the quality of drinking water and its possible adverse impact on the population's health [8,9,10,11,12]. These works show that many indicators of the quality of drinking water of the population of Karakalpakstan do not meet the requirements of the republican standard O'zDSt 950:2011 "Drinking Water".

A few studies have been conducted on the ecological state of surface waters within the Republic of Karakalpakstan [13-16].

The quality of groundwater in Karakalpakstan, in recent years, due to an increase in the concentration of mineralization and general hardness, also does not meet the requirements of the standard for sources of domestic and drinking water supply [17, 18].

Studies have been carried out to study the hydroecological state of water resources in the Aral Sea region on the example of the Amudarya River basin and the modern chemical composition of surface waters [19, 20].

The purpose and objectives of these studies were to study the dynamics of long-term changes in the quality of river water and develop recommendations for improving monitoring of the ecological state of the Amudarya River in areas where water is used by the population of the Republic of Karakalpakstan.

2 Methods

Research methods included laboratory and expeditionary studies. Expedition trips were carried out quarterly according to the year 2016-2020 seasons. With water sampling in 4 sections of the Amudarya River: 1. Tuyamuyun hydropost, 2. Samanbay hydropost, 3. Kyzylzhar, 4. Mezhdurechenskoe reservoir.

Selected water samples from the established sections of the Amudarya River were subjected to laboratory analyses following O'zDSt 951:2011 "Sources of centralized domestic and drinking water supply. Hygienic, technical requirements, and selection rules.

3 Results and discussion

The research results showed that, according to organoleptic indicators - smell, taste, and color- water quality in surface reservoirs fully complies with hygienic requirements.

A similar situation is noted for the concentrations of ammonia, nitrites, and nitrates in the water, the chlorides and sulfates content in reservoirs, oxidizability, and total iron. However, the water quality in terms of turbidity, general hardness, and mineralization in the studied sections of the Amudarya River does not meet the requirements of O'zDSt 951:2011 (Figures 1-6).

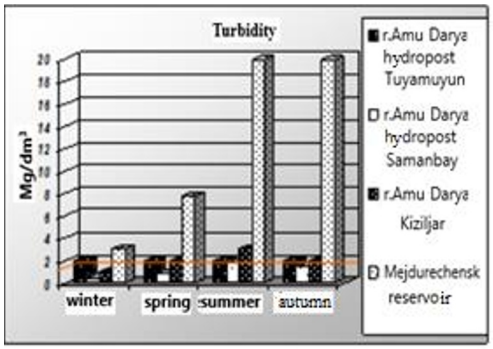

Fig.1. Turbidity of water in reservoirs for 2016

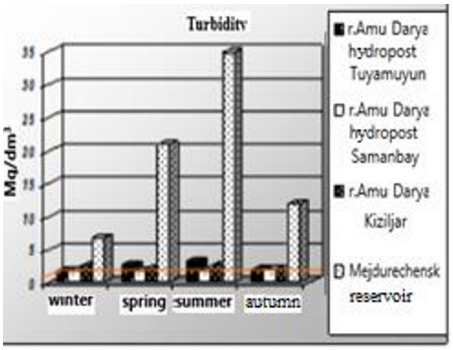

Fig. 2. Turbidity of water in reservoirs for 2020

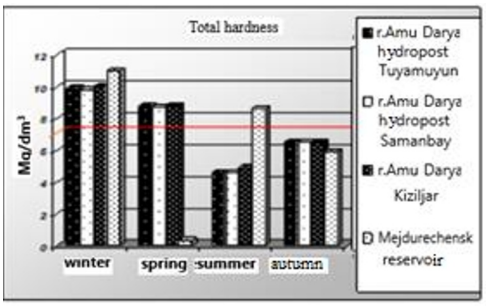

Fig. 3. Total hardness of water in reservoirs for 2016

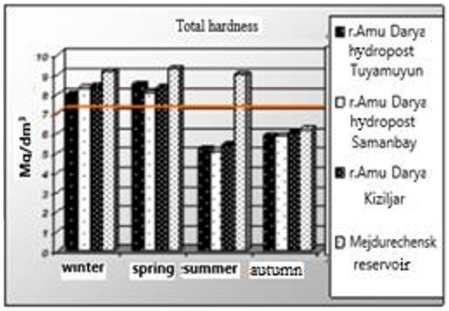

Fig. 4. Total water hardness in reservoirs for 2020.

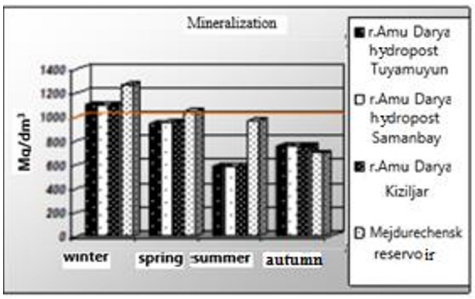

Fig. 5. Mineralization of water in reservoirs for 2016

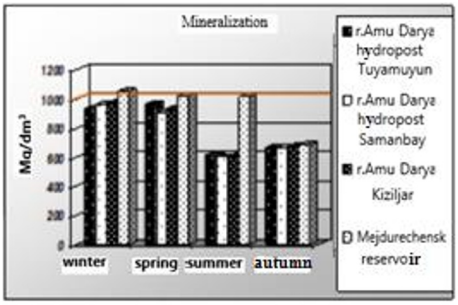

Fig. 6. Mineralization of water in reservoirs for 2020

The indicators of general hardness in the water reservoirs in the alignment of the Tuyamuyun gauging station in 2016 were set at the level of 4.6 mg-eq/l - 9.9 mg-eq/l (MPC 7.0 mg-eq/l); in 2017, they were set at 5.3 - 9.9 mg-eq/l; in 2018, they were set at 4.8 mg-eq/l - 10.4 mg-eq/l; in 2019, they were set at 5.5-10.0 mg-eq/l and in 2020, they were set at 5.2-8.5 mg-eq/l. The value dependence of this indicator on the research season has not been established.

The highest concentrations of total water hardness of the Amudarya River at the Tuyamuyun gauging station in 2016 were set at 9.9 mg-eq/l; in 2017, they were set at 9.9 mg-eq/l; in 2018, they were set at 10.4 mg-eq/l; in 2019, they were set at 10.0 meq/l and in 2020, they were set at the level of 8.5 meq/l. The highest concentrations of total water hardness of the Amu Darya River at the Tuyamuyun hydropost site in 2016 were set at 9.9

mg-eq/l; in 2017, they were set at 9.9 mg-eq/l; in 2018, they were set at 10.4 mg-eq/l; in 2019, they were set at 10.0 mg-eq/l and in 2020 they were set at the level of 8.5 mg-eq/l.

The maximum numbers of water salinity at the Tuyamuyun gauging station section of the Amudarya River in 2016 were at the level of 1101.0 mg/l (MPC 1000 mg/l), in 2017, they were at the level of 1057.0 mg/l, in 2018, they were at the level of 1030 mg/l, in 2019, they were at the level of 1182.0 mg/l and in 2020, they were at the level of 965.0 mg/l.

Studies have shown that water quality in water objects at the Samanbay hydropost site generally meets the requirements for the studied indicators, except for general hardness and mineralization. The indicators of the general water hardness in the specified section of the Amudarya River in almost all seasons for the studied period of 2016-2020 exceed the standard values.

In 2016, the highest concentrations of total hardness were set at 9.8 mg-eq/l (MPC 7.0 mg-eq/l); in 2017, they were set at 9.5 mg-eq/l, and in 2018, 2019, and 2020, this figure was 10.4; 10.7 and 8.3 meq/l. The results indicate that the highest concentrations of total hardness in water in the studied section of the Amudarya River were determined in 2017.

Indicators of the general hardness of the water in the Kyzylzhar site are determined by the year's seasons in concentrations exceeding the maximum permissible concentrations established for them. In 2016, the total hardness of water was determined at the level of 10.0 mg-eq/l; in 2017, it was 9.7 mg-eq/l; in 2018, it was 10.6 mg-eq/l; in 2019, it was 10.7 mg-eq /l, and in 2020, it was 8.4 meq/l.

An analysis of the data obtained for 2016-2020 indicates that the mineralization of water in the Kyzylzhar site only in 2020 does not go beyond the limits of hygiene standards and amounts to 601.0-972.0 mg/l, depending on the year's season.

In the water of the Mezhdurechensk reservoir, the water quality does not meet the requirements of turbidity, total hardness, and salinity. In the winter of 2016, water turbidity was determined at concentrations of 3.0 mg/l; in spring, this figure increased to 7.8 mg/l, and in summer and autumn, to 20.0 mg/l (MPC 1.5 mg/l). In 2017, the turbidity of water in the reservoir in winter was 12.0 mg/l. In spring, the turbidity of water decreases to 7.0 mg/l, rises to maximum values (33.0 mg/l) in summer, and decreases again in autumn to 22.0 mg/l.

A similar dynamic of changes in the concentration of turbidity in the water of the Mezhdurechensky reservoir by seasons of the year was established in 2018. Thus, in the winter and spring periods of the year, the turbidity of water is 10.0 mg/l; it rises to maximum values (35 mg/l) in summer and decreases to 21.0 mg/l in autumn.

In 2020, the concentrations of turbidity in the water of the Mezhdurechensky reservoir went beyond the normative values. In winter, it is 17.0 mg/l; in spring, it is 13.0 mg/l; in summer, it is 39.0 mg/l; and in autumn, it is 35.0 mg/l. In 2020, the turbidity values in the reservoir's water also exceeded the MPCs established for them. In winter, indicators are determined at 6.9 mg/l, in spring 21.0 mg/l, in summer 35 mg/l, and in autumn 12.0 mg/l.

The total water hardness of the Mezhdurechensk reservoir is determined in the autumn of 2016 at the level of 5.9 mg-eq/l, which corresponds to hygienic standards (MPC 7 mg-eq/l). However, there is an excess of the established norms for overall hardness in winter, spring, and summer periods. In particular, the total water hardness of the reservoir in winter is determined at a concentration of 11.0 mg-eq/l; in spring, it is at 9.3 mg-eq/l, and in summer, it is 8.6 mg-eq/l.

In 2017, there was an excess of the normative of the total hardness in the water of the Mezhdurechensky reservoir throughout the year. The maximum of its values is noted in the autumn period when the concentrations of total water hardness are determined at the level of 9.9 mg-eq/l. In winter, the indicators of total water hardness are set at 7.8 mg-eq/l; in the spring, they are set at 8.5 mg-eq/l; and in summer, they are set at 7.9 mg-eq/l.

In 2018, there was a correspondence in the indicator of total hardness in the water of the Mezhdurechensky reservoir during the summer and autumn seasons. The maximum of its values is noted in spring when the concentrations of total water hardness are determined at the level of 10.5 mg-eq/l. In winter, the indicator of the total water hardness in the reservoir is set at 10.0 mg-eq/l.

A similar dynamic of changes in the indicator of total hardness in the water of the Mezhdurechensk reservoir was observed in 2019. Correspondence of the indicator of total hardness in the reservoir's water during the summer and autumn seasons of the year was established: 6.3 and 6.5 mg-eq/l, respectively. The maximum of its values is noted in the winter period of the year when the concentrations of total water hardness are determined at the level of 9.3 mg-eq/l. In the spring of the year, the indicator of the total water hardness in the reservoir is set at 7.6 mg-eq/l.

In 2020, only in the autumn period of the year, the values of the total hardness of the water in the reservoir did not go beyond the limits of hygiene standards. During this period, the total hardness of water averages 6.2 mg-eq/l. In winter, spring, and summer, the total water hardness in the reservoir exceeds the standard values and averages 9.2 mg-eq/l, 9.3 mg-eq/l, and 9.0 mg-eq/l, respectively.

The dynamics of changes in the indicator of water salinity in the Mezhdurechensk reservoir for 2016-2020 indicate that there has been a deterioration in the quality of the reservoir's water over the retrospective period. In 2016, the water salinity indicators did not meet the requirements in winter and spring - 1265.0 mg/l and 1041.0 mg/l, respectively. In 2017, the mineralization of water in the reservoir exceeded the standard values only in the autumn period of the year - 1084.0 mg/l. In other periods of the year, the mineralization of water in the reservoir was at the level of 880.0-970.0 mg/l.

In the winter and spring periods of 2018, this indicator in the reservoir's water averages 1193 mg/l and 1186 mg/l, respectively (MAC 1000 mg/l). In the summer and autumn periods of the year, mineralization indicators did not go beyond the normative values, with an amount of 758.0-812.0 mg/l.

In 2019, the water salinity indicators in the Mezhdurechensk reservoir went beyond the hygiene standards only in the winter period - 1063 mg/l. In other periods of the year, mineralization indicators were in the range of 747-862 mg/l.

In 2020, the mineralization of water in the Mezhdurechensk reservoir only in the autumn period of the year met the standard's requirements and, on average, was determined at 685 mg/l. In the winter of 2020, water mineralization is 1052 mg/l, in the spring period - 1022 mg/l, and in the autumn period - 1015 mg/l, respectively.

4 Conclusions

Thus, the results showed that water quality in the studied sections of the Amudarya River in terms of organoleptic indicators - smell, taste, and color correspond to the regulatory requirements. A similar situation is noted for the concentrations of ammonia, nitrites, and nitrates in water, the content of chlorides and sulfates in river water, oxidizability, and the total amount of iron. At the same time, it was found that the quality of water in terms of turbidity, total hardness, and salinity does not meet the requirements of the standard for sources used for drinking and domestic water supply.

Based on the results obtained from the assessment of the water quality of the Amudarya River over a long period, the following conclusions can be drawn:

1. Organoleptic indicators: taste, smell, and color of the water of the Amudarya River correspond to the established hygienic standards. The concentrations of ammonium, nitrates, nitrites, sulfates, chlorides, and total iron in water are determined at the level of standard values.

2. The highest turbidity rates - from 20.0 to 39.0 mg/l, depending on the study period, are detected in the water of the Amudarya River at the Mezhdurechenskoye Reservoir section.

3. The maximum values of the total water hardness are set at the Samanbay and Kyzylzhar sites: 10.7 mg-eq / l and 10.8 mg-eq / l, respectively.

4. The highest concentrations of water mineralization at 1265.0 mg/l are detected at the site "Mezhdurechenskoe reservoir" and "Tuyamuyun hydropost" - 1182.0 mg/l.

5. Recommendations have been developed to improve the monitoring of water quality in the Amudarya River, introduced into the practice of the work of the bodies of sanitary supervision over the ecological state of the environment in the Republic of Karakalpakstan.

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