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Results of Studying the Chemical Composition of Water in Different Types of Reservoirs

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Abstract: The purpose of the study was to comparatively characterize and assess the seasonal dynamics of organoleptic indicators, the degree of mineralization and the chemical composition of water in some reservoirs in Uzbekistan. It was established that the organoleptic indicators and mineralization parameters of the water of the Kattakurgan reservoir in spring and summer were practically within the limits of the maximum permissible concentration, and the indicators of the chemical composition of the water were below the upper limit of the maximum permissible concentration. In water samples from the Tuyamuyun hydroelectric complex, organoleptic indicators and parameters of water mineralization in the summer were higher than the maximum permissible concentration. Indicators of the chemical composition of water in the summer were below the upper limits of the permissible level; significant interseasonal differences were noted in the content of chlorides and sulfates. Organoleptic indicators and the degree of mineralization of water samples from the Charvak reservoir were within the MPC, all parameters of the chemical composition of the water were lower in relation to the upper limit of the MPC, regardless of the place of sampling and the time of year.

Keywords: reservoirs, reservoir water, chemical composition, water mineralization, organoleptic characteristics.

Currently, in different countries of the world, the attitude of specialists and the population towards the construction of reservoirs is ambiguous: on the one hand, they are needed for the socio-economic development of society, meeting its needs for water, food, energy, and recreation; on the other hand, they can have a harmful effect on the nature and conditions of use of river valleys above and below the dam site [3, 9, 10, 11].

The distribution of chemical elements in surface waters is determined by their abundance in the earth's crust and solubility in water. The complexity of the chemical composition of surface water bodies is determined not only by the presence in them of a large number of chemical elements and the variety of their compounds, but also by the different content of each of them, which varies in different types of water, which is associated with the peculiarities of the conditions of their formation. The complexity of the chemical composition of surface water bodies is determined not only by the presence in them of a large number of chemical elements and their compounds, but also by the different content of each of them, which varies due to the peculiarities of the conditions of their formation [6, 8].

In this regard, an urgent task is to analyze the variability of river waters in the bowls of reservoirs and assess their quality based on their chemical composition [2]. The chemical composition of water in reservoirs is determined, to a greater extent , by natural factors, and in lowland reservoirs - by anthropogenic factors [4, 5].

In this regard, the purpose of the study was to comparatively characterize and assess the dynamics of organoleptic indicators, the degree of mineralization and the chemical composition of water from different types of reservoirs in Uzbekistan.

Materials and methods of research. The objects of study were the Charvak (run-of-river), Kattakurgan (fill-water) reservoirs, and the Tuyamuyun hydroelectric complex, which includes the Ruslovoe, Kaparas and Sulton Sanzhar reservoirs (mixed - run-of-river-fill) of the Republic of Uzbekistan.

Kattakurgan reservoir (Kattakurgan district of Samarkand region) is a valley irrigation reservoir, in operation since 1941. Located in the left bank part of the Zeravshan Valley, 6 km south of the city of Kattakurgan. It is intended for seasonal regulation of the flow of the Zarafshan River. A natural basin in the foothills of Zerabulak, formed at the junction of the ancient logs of Shursai and Uzunduksay, was used for the bowl. Filling is carried out through a supply canal from the Zarafshan tributary - Karadarya. The length of the coastline is more than 200 km, the maximum length is 15 km, the maximum width is 10 km, the maximum depth is 25 m. The surface area is 80.5 km ^{2}, the reservoir volume is more than 662 million m ^{3}, the dead volume is 24 million m ^{3}. Water accumulation occurs in the winter-spring period; it is supplied from the reservoir during the growing season of plants. Externally _ water exchange is accumulative-transit type 1 [2].

Tuyamun reservoir (Tuyamuyun hydroelectric complex), flooding began in 1984 . It owes its location to the Tuyamuyun Gorge, located on the border of the middle and lower reaches of the Amu Darya River, 450 km from the Aral Sea. The total capacity of the reservoir is 7.8 km 3 ' the useful capacity is 5.28 km ^{3}. One surface is more than 250 km ^{2}, the area of the water surface is 780 km ^{2}, the flow regulation is seasonal. The length is 80 km, the water level at the dam is 13 m, the morphological type is complex-basin-valley [2].

Charvak reservoir (Bostanlyk district of Tashkent region, 85 km from the city of Tashkent) - a channel, valley reservoir, built in 1978, formed by blocking the Chirchik River at the exit of the latter from the Charvak basin, flooding the valleys of the two main tributaries that make up the Chirchik River - Pskem and Chatkal . The reservoir has a total volume of 2.006 km ^{3}, a useful volume of 1.58 km ^{3}, and a surface area at a normally backed level of 40.1 km ^{3}. The reservoir dam closes the Charvak gorge 5 km below the confluence of the Pskem and Chatkal rivers . The area of the reservoir when completely flooded is more than 41 km ^{2}, the maximum depth at the dam is 150 m, the volume of water is about 2 billion m ^{3}. Filling with water occurs mainly in the spring due to melting snow, drainage occurs in the summer during the growing season of plants. About external _ In terms of water exchange, it is accumulative-transit type 1 - seasonal regulation of flow [2].

Sampling of water to determine the chemical composition and mineralization, water of reservoirs was taken from the following points: the inlet channel, the outlet channel, directly at the dam and several intakes from the reservoir bowl using generally accepted methods widely used in practice. Transportation of samples was carried out traditionally.

We used traditional organoleptic methods for determining smell, taste and flavor, as well as photometric methods for determining color and turbidity, methods for determining total hardness, dry residue content, sulfates, chlorides (chlorine ion), nitrates, nitrites, total iron with thiocyanate.

To confirm the results obtained using traditional methods, express methods for studying these indicators using test strips from Macherey - Nagel (Germany) were also used. All studies were carried out in 2012-2014, samples were taken from each sampling point three times, a total of 9 series of studies were carried out.

The main principle for selecting priority indicators - organoleptic parameters, data on the chemical composition and mineralization of water for a comparative assessment of selected research objects was their mandatory determination in various studies, which are prescribed by regulatory and methodological documents of the Republic of Uzbekistan [7, 13].

The scientific and practical significance of the research lies in the fact that for the first time a comparative description of the seasonal dynamics of organoleptic indicators, the degree of mineralization and the chemical composition of water in some reservoirs of Uzbekistan is given. Recommendations on the medical, social and economic efficiency of water use in this region are given on the use of reservoir water (household, drinking and recreational). In addition, medium- and long-term forecasts of the degree of pollution of these water bodies are given for a preventive response to the regulation of their runoff. The data obtained made it possible to save money on a preliminary study of water bodies filling reservoirs planned for construction in this region.

Statistical processing of research materials was carried out using traditional methods of variation statistics. All calculations were carried out on a personal computer based on Pentium 4 processors using a package of application programs for medical and biological research. When organizing and conducting research, the principles of evidence-based medicine were used.

Results and its discussion. Research has established that water samples from the Kattakurgan reservoir in terms of organoleptic indicators (in spring and summer) are close to the standards [7, 12], with which the results were compared. The results of the study of odor, color and pH were within the maximum permissible concentration (MPC), only the color in the afferent canal in the summer was slightly higher - respectively 25.5 ^{o} versus 20-25 ^{o}. In terms of dry residue in all water samples, the indicators were up to 346.1 mg/dm ^{3} (0.3 MPC), in the inlet channel up to 415.0 mg/dm ^{3} (0.4 MPC), in the outlet channel 0.4 MPC (MPC - up to 1000 mg/dm ^{3}). In the spring, the indicators were slightly higher than in the summer - 375.0-452.5 mg/dm ^{3} (0.4-0.5 MPC).

The total water hardness in this reservoir was within acceptable limits (7-10 eq / dm ^{3}), except for the indicator of the outlet channel, which was 14.3 eq / dm ^{3} (1.4 MPC). It was revealed that spring indicators were 1.8-1.9 times higher than summer ones (6.0-7.0 eq / dm ^{3} versus 3.3-3.6 eq / dm ^{3}) - (P <0. 05).

For permanganate oxidation, the values were within the acceptable range, but all indicators in the spring were lower than the summer data (P <0.05).

The results obtained for the Tuyamuyun hydroelectric complex for these parameters differed from the data for the Kattakurgan reservoir in that some indicators were significantly higher in the summer (P <0.05). If the smell, general hardness and permanganate oxidation were within the MPC, then different indicators were obtained for color, general hardness and dry residue. In water samples obtained above and below the dam, as well as in the outlet channel (Amu Darya River), the color of the water turned out to be higher than permissible - 32.5 ^{o} , 27.1 ^{o} and 33.0 ^{o}, respectively , against 20-25 ^{o} (1.3 ; 1.1 and 1.3 MPC).

The indicators of the spring season differed sharply from the summer in terms of color: all indicators were at the level of the maximum permissible concentration; the indicators of all water sample points were significantly 3.2 times lower than the data obtained in the summer (P <0.001). An increase in dry residue in relation to the MPC (up to 1000 mg / gm ^{3}) was noted in water samples taken in the summer in the outlet channel (1323.8 mg / gm ^{3} - 1.3 MPC), above the dam of the Ruslovoe reservoir (up to 1267. 9 mg / gm ^{3} - 1.3 MPC), in the Sulton Sanzhar reservoir (1232.2 mg / gm ^{3} - 1.2 MPC). Only in the water of the Caparas reservoir the dry residue was within the permissible limits (874.3 mg / gm ^{3} - 0.8 MAC). The spring indicators differed in that all parameters (except for the Amu Darya River) were within acceptable limits and they were significantly lower than the data obtained in the summer (P <0.05).

A distinctive feature of the Tuyamuyun hydroelectric complex from the Kattakurgan reservoir was the following:

firstly, the dry residue in the water samples was increased;

secondly, the spring indicators differed in that the organoleptic indicators and parameters of water mineralization (except for data from the Amu Darya River) were within acceptable standards;

thirdly, the above indicators were significantly lower than the data obtained in the summer ($P < 0.05$).

This is explained by the fact that the Kattakurgan reservoir is a bulk type and the water is mainly in a stagnant position, and the deposition of chemical substances occurs more intensely. This situation is confirmed by the fact that the performance of the Caparas reservoir , where water movement was also limited, was close to acceptable values.

In contrast to the Kattakurgan reservoir and the Tuyamuyun hydroelectric complex, almost all indicators of water samples from the Charvak reservoir were within the acceptable standard. With a pH value of up to 9.0, in water samples from the Charvak reservoir , pH values in summer ranged from 7.3 (in the recreational area and above the dam - 300 meters from the shore) to 7.5 (in the middle of the reservoir, above the dam - 1 km from the dam and below the dam). The spring parameters did not differ from the summer season data ($P > 0.05$).

Noteworthy is the fact that the indicators of color, solids, total hardness and permanganate oxidation were: firstly, practically similar, regardless of the location of sampling; secondly , they were at the MPC level; thirdly, the studied indicators differed from the data from the Kattakurgan and Tuyamuyun reservoirs; fourthly , inter-seasonal differences were determined (in the spring they were higher than in the summer), which is a distinctive feature of the Charvak reservoir. Apparently, this is explained by the peculiarities of the location, filling and composition of the water. There are no areas enriched with chemicals along the path of the mountain rivers feeding the reservoir. In addition, the high location and mountainous terrain also protects the reservoir from the effects of climatic and anthropogenic factors.

Further research was devoted to studying the chemical composition of the water in the reservoirs selected for study.

The results obtained show that the content of chemical substances in water samples from the Kattakurgan reservoir, regardless of the sampling location and time of year, was within the MPC, except for sulfates, the values of which were higher than permissible in the spring season (Table 1).

Table 1. Indicators of the chemical composition of water in the Kattakurgan reservoir

Objects	Season	The name of indicators					
		Iron, mg / dm^3	Chlorides, mg/dm^3	Sulfates mg/dm^3	Nitrates, mg/dm^3	Nitrites, mg/dm^3	PF, mg P /dm^3
Standard		<0.3	<250	<400	<45	<3.0	<3.5
Middle body of water	spring	0.015	18.5	574.6	<4	0.019	0.03
	summer	0.015	15.6	121.4	3.7	0.009	0.04
Recreational area	spring	0.019	18.0	546.7	<4	0.019	0.02
	summer	0.010	15.7	126.2	3.7	0.007	0.04
Higher dams	spring	0.038	19.0	574.6	<4	0.024	0.03
	summer	0.006	15.3	129.0	3.6	0.009	0.04
Below dams	spring	0.015	19.0	580.2	<4	0.021	0.03
	summer	0.020	15.6	120.1	3.6	0.013	0.04
Leading channel	spring	0.038	11.5	522.7	<4	0.011	0.03
	summer	0.049	12.1	135.6	3.6	0.018	0.08
Abductor channel	spring	0.015	19.0	580.2	<4	0.021	0.03
	summer	0.073	14.3	92.2	3.6	0.033	0.06

Note: The error of the methods used is ±20%;

PF - polyphosphates.

The iron content in the studied water samples was low regardless of the time of year. The lowest indicator in summer was found in water samples taken above the dam, and the highest in the outlet canal. The same results were obtained in the spring.

The same trend persisted in the detection of chlorides in the studied water samples, with the difference that the spring indicators were slightly higher than the summer ones (except for the leading channel).

Sulfates in summer were 3-5 times lower than the MPC. The highest level of sulfates was determined in the water of the afferent canal (135.6 mg / gm ^{3} - 0.3 MAC), the lowest in the outlet canal (92.2 mg / gm ^{3} - 0.2 MAC). A different picture was observed in water samples taken in the spring - all indicators, regardless of the sampling site was higher than permissible (1.1-1.2 maximum permissible concentrations).

In water samples taken in the summer, nitrates were detected in low quantities (from 3.6 mg / dm ^{3} to 3.7 mg / dm ^{3} - 0.1 MAC), interseasonal differences in nitrate content were not detected. Nitrites in water samples from the Kattakurgan reservoir were determined to be several tens of times below the MPC, regardless of the location of sampling and the time of year. There were only minor seasonal differences depending on sampling location. This trend continued in terms of polyphosphate content.

Similar studies were carried out with water samples from the Tuyamuyun hydroelectric complex (Table 2).

Table 2. Indicators of the chemical composition of water samples from the Tuyamuyun hydroelectric complex

Objects	Season	The name of indicators					
		Iron, mg / dm ^{3}	Chlorides mg/dm ^{3}	Sulfates, mg/dm ^{3}	Nitrates, mg/dm ^{3}	Nitrites, mg/dm ^{3}	PF, mg P /dm ^{3}
Standard		< 0.3	<250	<400	< 45	< 3.0	< 3.5
Vdhr Caparas	spring	0.03	142.0	648.0	<4	footprints	footprints
	summer	0.02	211.6	261.1	<4	0.02	footprints
Vdhr Sulton Sanzhar	spring	0.03	148.0	702.2	<4	footprints	footprints
	summer	0.02	200.2	262.9	<4	0.01	footprints
Vdhr Ruslovoe (above the dam)	spring	0.14	137.8	628.8	<4	0.02	footprints
	summer	0.05	248.9	275.8	<4	0.06	0.06
Vdhr Ruslovoe (below the dam)	spring	0.56	138.0	619.2	<4	0.04	footprints
	summer	0.10	201.3	283.8	<4	0.05	0.07
Outflow channel	spring	0.86	109.6	336.0	<4	0.04	footprints
	summer	0.04	188.2	237.2	<4	0.08	0.08

Note: The error of the methods used is ±20%;

PF - polyphosphates; Vdhr - reservoir.

The results obtained differed from the parameters for the Kattakurgan reservoir. In summer, the iron content in water samples from all sampling points was below its maximum permissible concentration. The highest indicators were determined in water samples obtained below the dam of the Ruslovoe reservoir; the indicators were 2-5 times higher than in water samples taken from other points ($P < 0.05$).

The chloride content was within the MPC, regardless of the sampling location and time of year. Spring chloride values were significantly lower than summer data ($P < 0.05$). The same trend was observed in the content of sulfates as with water samples from the Kattakurgan reservoir.

The content of nitrates and nitrites was several tens of times lower than the MPC values, regardless of the place of sampling and the time of year. Similar results were obtained when studying the quantitative content of polyphosphates. In all cases there were no interseasonal differences.

A distinctive feature of the Tuyamuyun hydroelectric complex from the Kattakurgan reservoir is a higher level of dry residue; all spring indicators of the chemical composition of water (except for the Amu Darya River) are within acceptable limits; all indicators are significantly lower than summer time data.

The results obtained show that the composition of the water in the Charvak reservoir was characterized by low chemical composition, regardless of the sampling location (Table 3).

Chloride levels in the summer were below the permissible level by an average of 200 times, sulfate levels were lower by an average of 17-18 times. The same picture was observed for the nitrite content, but the opposite picture was obtained for the quantitative content of polyphosphates, i.e. their content, on the contrary, was increased several times compared to the content in other studied reservoirs (P <0.05). The same trend continues in spring indicators of the chemical composition of water.

Table 3. Indicators of the chemical composition of water samples from the Charvak reservoir

Objects	Season	The name of indicators					
		Iron, mg/dm 3	Chlorides mg /dm 3	Sulfates, mg/dm 3	Nitrates, mg/dm 3	Nitrites mg/dm 3	PF, mg P /dm 3
Standard		<0.3	<250	<400	<45	<3.0	<3.5
Middle body of water	spring	0.010	1.4	56.9	<4	0.0035	0.02
	summer	0.008	1.1	14.5	<4	0.0002	1.01
Recreational area	spring	0.075	2.1	59.2	<4	0.0078	0.02
	summer	0.005	1.4	16.7	<4	footprints	0.02
Above the dam (300 m from the shore)	spring	0.010	1.4	59.2	<4	0.0018	0.02
	summer	0.005	1.4	16.7	<4	footprints	1.01
Above the dam (1 km from the shore)	spring	0.200	1.9	58.6	<4	0.0093	0.01
	summer	0.014	1.3	15.7	<4	0.0001	1.02
Below the dam (2 km from the dam)	spring	0.050	1.5	58.1	<4	0.0048	0.01
	summer	0.007	1.1	12.7	<4	0.0004	1.03

Note: The error of the methods used is ±20%;

PF - polyphosphates.

A comparative analysis of organoleptic indicators, mineralization parameters and chemical composition of the water of the compared reservoirs revealed the following patterns:

firstly, all the studied indicators in the summer, regardless of the place where the water sample was taken, were within the limits of the maximum permissible concentration;

secondly, in all respects, the best water quality was in the Charvak reservoir, the worst in the Tuyamuyun hydroelectric complex;

thirdly, sulfate levels in spring were higher than permissible in the Kattakurgan reservoir and Tuyamuyun hydroelectric complex, lower in the Charvak reservoir, regardless of the sampling location;

fourthly, the worst parameters of organoleptic properties and chemical composition were found in water samples above and below reservoir dams or in the outflow channel;

fifthly, the interseasonal difference was significant in the content of chlorides in water samples of the studied water bodies;

sixth, interseasonal differences between organoleptic indicators and parameters of the chemical composition of water were most pronounced in water samples from the Tuyamuyun hydroelectric complex, then the Kattakurgan reservoir;

seventh, the greatest influence of anthropogenic factors was noted at the Tuyamuyun hydroelectric complex.

Conclusions.

Organoleptic indicators and parameters of water mineralization of the Kattakurgan reservoir in the summer were within the maximum permissible concentration, and in the spring the indicators were also within the acceptable level. The chemical composition of water in the Kattakurgan reservoir was significantly below the MPC.

In water samples from the Tuyamuyun hydroelectric complex, organoleptic indicators and parameters of water mineralization in the summer were higher than the maximum permissible concentration. The highest rates were above and below the dam of the Ruslovoe reservoir, the outlet channel and the Sulton Sanzhar reservoir. Indicators of the chemical composition of water at the Tuyamuyun hydroelectric complex in the summer were below the MPC for all indicators.

Organoleptic indicators, degree of mineralization and parameters of the chemical composition of water samples from the Charvak reservoir were within the MPC, regardless of the sampling location and time of year.

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