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Results of Research on the Study of the Chemical Composition of the Amu Darya River's Water in the Dynamics

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Abstract The goal was to study and assess the chemical composition and the content of pesticides in water samples from the Amu Darya River in the Bukhara region of Uzbekistan. It has been established that organoleptic parameters, indicators of water salinity, ammonia nitrogen, nitrites, nitrates, sulfates, chlorides in water samples of the Amu Darya river at the point of water sampling were mostly within the standard values. The absence of nitrites indicated the absence of fresh pollution of the reservoir, as well as the total content of radionuclides or total β-activity of the river water samples showed no deviations from the norm.

Keywords Amudarya river, Organoleptic characteristics, Pesticides, Radionuclides

1. Introduction

The Amu Darya River originates at the confluence of the Pyanj and Vakhsh rivers located in Tajikistan. In addition to the Panj and the Vakhsh, the main tributaries include the Surkhan Darya and the Kafirnigan. The former tributary of the Zeravshan no longer flows into the Amu Darya. The average annual flow of the Amudarya basin is 78 km^3. About 80% of the total flow is generated in the territory of Tajikistan, irrigated agriculture accounts for 90% of the total water consumption [7,8].

The factors adversely affecting the water quality of the Amu Darya include: landfills for household waste; return water from irrigation systems, equipment used in irrigation systems; insufficient capacity of sewer networks; floods, mudflows, earthquakes (Afghanistan, Tajikistan); floods and landslides (Afghanistan, Tajikistan), coastal erosion and soil degradation (Afghanistan); regulation of the flow of the river, which change its regime (Tajikistan, Uzbekistan) and others [1,6].

The Amudarya Delta suffers from reduced runoff and poor water quality, which have a negative impact on ecosystems. The return waters of irrigation systems have a negative impact on the quality of water resources, causing a gradual increase in salinity and concentration of major ions in the section from the headwaters to the plains. Drainage waters contain sulphates, chlorides, sodium, pesticides, nitrogenous, phosphoric compounds. Equipment used in irrigation systems leads to additional water losses. Lack of sewage collection systems, outdated equipment, insufficient capacity of sewage networks lead to pollution of water resources with urban sewage.

Additional impact factors are landfills for household waste, soil degradation of the river bank. The reduction in the flow of the Amu Darya, caused by the withdrawal and diversion of river water, exacerbates the problems associated with the quality of water resources [1].

The projected increase in aridity and total evaporation in the region will lead to an increase in demand for irrigation water, which, in turn, will affect the amount of water resources in the Amu Darya [1,5].

It is known that the distribution of chemical elements in surface waters is determined by their prevalence in the earth's crust, and its solubility in water [3,4,6]. The complexity of the chemical composition of surface water bodies is determined not only by the presence of a large number of chemical elements and the diversity 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 [2].

2. Main Body

2.1. The Purpose of Our Research

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Based on the above, the goal was to study the chemical composition, the content of pesticides, the total activity of natural and radionuclides in water samples from the Amu Darya River.

2.2. Material and Methods of Study

The Alat region of the Bukhara region of Uzbekistan, which is located 110 km from the city of Bukhara, on the bank of the Amu Darya River, was chosen as the water sampling point for research.

To determine the chemical composition of water, water sampling was carried out using generally accepted methods, observing all the requirements of the UzSSt (SSt - State Standard) 950-2011. "Drinking water. Hygienic requirements and quality control UzSSt 951-2011. “Sources of centralized drinking water supply. Hygienic, technical requirements and selection rules. Transportation of samples was carried out by road transport, while paying attention to the protection of samples from the influence of physical factors (direct sunlight, temperature, mechanical effects), chemical factors (natural and artificial pollutants) and biological factors (pathogenic, conditionally pathogenic and saprophytic microflora).

The following parameters of the chemical composition of water were studied: determination of the organoleptic parameters of water (taste, smell, color and turbidity), total hardness, total mineralization (dry residue), sulfates, chlorides, nitrates, nitrites, total iron, ammonium salts (quaternary ammonium), polyphosphates. Toxic chemical elements were determined using an Optima 2100 DV optical emission spectrometer with an inductively coupled Perkin Elmer argon plasma (Germany). The determination of the total activity of natural and radionuclides was performed by the gamma-beta spectrometry method using an MKS-AT1315 spectrometer (Russia).

Statistical processing of the research material was carried out using variation statistics on a personal computer, based on Pentium 4 processors using a software package for biomedical research.

3. Results of the Study

The results show that some organoleptic indicators of the water of the Amu Darya River are close to drinking water (the standard chosen is UzSSt 950-2011). Results by smell, pH (pH), chromaticity and turbidity were within the standard (Table 1).

Nitrogen ammonia (quaternary ammonium) in the water samples were not detected, which corresponds to the standard. The presence of large amounts of nitrogen in the water of nitrites or nitrites may indicate relatively fresh pollution of its nitrogen-containing organic substances. In our studies, nitrites from water samples were not detected (the norm is up to 3.0 mg/dm^3), which indicates the absence of fresh contamination of the studied reservoir.

Table 1. Organoleptic and mineralization parameters waters of the Amu Darya River

Compare parameters	The name of indicators	
	UzSSt 950-2011	Water under study
Smell, points	2	1
Turbidity, mg/dm^3	1,5	1,3
Chromaticity, º	20	15
Hydrogen indicator (pH)	6-9	8,1
Ammonia nitrogen, mg/dm^3	absence	0
Alkyl nitrites, mg/dm^3	absence	0
Alkyl nitrates, mg/dm^3	not more than 45,0	2,0 (0,04 MPC)
Total mineralization, mg/dm^3	not more than 1000	662 (0,7 MPC)
Total hardness, mg-eq/dm^3	not more than 7,0	7,0 (1,0 MPC)
Sulfates, mg-eq/dm^3	not more than 400	197 (0,5 MPC)
Chlorides, mg-eq/dm^3	not more than 250	90 (0,4 MPC)
PO, mgO_2/dm^3	not more than 5,0	0,44 (0,1 MPC)
Suspended substances, mg/dm^3	absence	1,1 (1,1 MPC)

Note: The accuracy of the methods used is ± 10%; PO-permanganate oxidability.

Water containing maximum permissible concentrations for nitrates (nitrate nitrogen) is considered unsuitable for drinking mainly because it can be toxic. Nitrate nitrate in drinking water can be harmful to children, adolescents and adults, since nitro compounds (carcinogens) can be formed from them in the stomach. Nitrate nitrate in drinking water is allowed up to 45 mg/dm^3. In our studies, they stood out in low quantities (an average of 2.0 mg/dm^3 - 0.04 MPC).

The total mineralization is the amount of dissolved salts in milligrams contained in 1 liter of water and gives an idea of the degree of mineralization of water. Water with a dry residue up to 1000 mg/dm^3 is called fresh, and more than 1000 mg/dm^3 is mineralized. The total mineralization in our studies was at the border of the normal level, making 662 mg/dm^3 (0.7 MPC) versus 1000 mg/dm^3 in the chosen standard.

Currently, there are common, carbonate, permanent, and removable stiffness. Total hardness is a natural property of water, due to the presence of hardness salts, that is, all calcium and magnesium salts in raw water. Carbonate hardness - due to the presence of bicarbonates and calcium and magnesium carbonates dissolved in raw water. Disposable hardness - the one that can be eliminated by boiling water.

Transition from soft water to hard, and sometimes vice versa, can cause dyspeptic phenomena in people. For drinking purposes, they prefer medium hard water, for economic and industrial purposes - soft water. The total hardness of the water studied by us (7.0 mg eq/dm^3 - 1.0 MAC) was within the upper limits of normal values (up to 7 mg eq/dm^3).

Sulphates are normal in drinking water up to 400 mg/dm^3. In water samples, the sulfate content averaged 197 mg/dm^3 (0.5 MPC), which is 2.0 times lower than the upper limits of the standard.

High solubility of chlorides explains their wide distribution in all natural waters. The value of chlorides is that they in a concentration above 350 mg/dm^3 limit water consumption, are an indicator of contamination of surface water sources. The content of chlorides in drinking water is normalized to no more than 250 mg/dm^3. The detectability of chlorides in the water samples we studied was 90 mg/dm^3 (0.4 MPC), which is 2.8 times lower than the permissible concentration.

For permanganate oxidizability, the values were also within the normal range - 0.44 mgO_2/dm^3 (0.1 MPC) in the test water against 5.0 mgO_2/dm^3 in UzSSt 950-2011. Suspended substances are not rated according to UzSSt 950-2011 and UzSSt 951-2011, but their absence in drinking water is considered expedient.

The same studies were conducted in August-September 2015. Comparative results show that during that period of the study, the parameters of color and turbidity, respectively, were 2.0 and 4.3 times higher than the standard, while the remaining indicators were within the standard. The current parameters differed from the previous ones in that almost all of the indicators were within normal limits of the MPC.

Thus, the results show that the organoleptic indicators we studied, some indicators of water salinity, as well as ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, sulfates, and chlorides in the Amu Darya water samples were mostly within the standard. The absence of nitrites indicated the absence of fresh pollution in water samples from the Amu Darya River.

Further studies were devoted to the study of the chemical composition of water. The results show that the content of chemicals in the water samples was within the normal range (Table 2).

It is known that in the surface waters iron (II) is contained in the form of a fairly stable humic iron. High iron content affects the organoleptic properties of water. According to the standard, the iron content in water samples should not exceed 0.3 mg/dm^3. In the samples we studied, the iron content was set at the upper limit of the norm (0.3 mg/gm^3), amounting to 1.0 MAC.

Determination of the content of manganese, copper and zinc showed that they were not detected in the water under study, although according to the standard, up to 0.1 mg/dm^3, 1.0 mg/dm^3 and 3.0 mg/dm^3 are allowed, respectively. The results obtained allow us to conclude that the parameters of these chemical elements in the studied water samples were normal.

It was established that the fluorine content according to the given standard is allowed up to 0.7 mg/dm^3, and in our studies the content of this chemical element in the water samples of the studied water body was 0.3 mg/dm^3, which is within the selected standard.

Table 2. Components (chemical composition) affecting the organoleptic properties of the water of the Amu Darya River

Compare parameters	The name of indicators	
	UzSSt 950-2011	Water under study
Iron, mg/dm^3	0,3	0,3
Manganese, mg/dm^3	0,1	not detected
Copper, mg/dm^3	1,0	not detected
Fluorine, mg/dm^3	0,7	0,3
Zinc, mg/dm^3	3,0	not detected
Oil products, mg/dm^3	0,1	1,77
SSAS anionic, mg/dm^3	0,5	0,11
Polyphosphates, mgP/dm^3	3,5	2,7
Phenol, mg/dm^3	0,001	not detected
BOD_5, mgO_2/dm^3	3,0	4,0

Note: The accuracy of the methods used is ± 10%.

The content of petroleum products and anionic synthetic surface-active substances (SSAS) are also important parameters of the quality of the water studied, so they are normalized in UzSSt 950-2011. The results of our research show that the synthetic detergents in the samples of the water we studied amounted to 0.11 mg/dm^3 (0.6 MPC), which are within the standard (up to 0.5 mg/dm^3). But the parameters of oil products in the studied water samples were increased to 1.77 mg/dm^3 (17.7 MPC), although the norm to 0.1 mg/dm^3. It should be emphasized that the analysis of water samples from the same sampling point after 7 days showed the opposite result, that is, the repeated result was 0.1 mg/dm^3, which is within the normal range. The increased parameter in the study of the first sample, apparently, is associated with a single pollution of the water of the investigated reservoir and the accidental ingress of oil products in the water areas of the reservoir.

Polyphosphates - one, two and three substituted phosphoric acid compounds, in water according to the standard up to 3.5 mg/dm^3 are allowed. In the water samples, the amount of polyphosphates was relatively low (2.7 mgP/dm^3 - 0.8 MPC). Phenols were not detected in all samples.

In addition, the biochemical oxygen consumption (BOD) of water for 5 days (BOD_5) was slightly increased to 4.0 mgO_2/dm^3 (1.3 MPC), at a rate of 3.0 mgO_2/dm^3. Apparently, this is due to the place of sampling of water, which is characterized by a high degree of sedimentation, a large amount of vegetation and marshy shores. We are convinced that if the sampling site (water intake) meets modern requirements, the described parameter will be at the level of the standard. Our beliefs are supported by the results of earlier (2014–2017) studies of BOD_5 and BOD_{20} carried out by us in the water of the Amudarya River and some reservoirs of Uzbekistan.

These parameters, except for petroleum products, detergents, BOD_5 were studied in previous studies (August-September 2015) from the same water sampling

point. In those studies, all the results were also within the standard. This means that during this past time, there were no natural or artificial factors that adversely affect these indicators.

Thus, all components (chemical composition) affecting the organoleptic properties of the Amu Darya river water — iron, manganese, copper, zinc, fluorine, surfactant, polyphosphates were within the standard, except for the content of oil products and the BOD5 indicator, which were above the upper limits of the standard. But this increase in the standard is random and does not reflect the true state of the water quality of the Amu Darya River.

We also studied the content of inorganic components of toxicological indicators of river water samples. The results are shown in Table 3. In this table 3, we found it appropriate to present the results of the determination of inorganic components, the definition of which is prescribed in UzSSt 950-2011.

Table 3. Parameters of inorganic components in water samples of the Amu Darya River, the definition of which is prescribed by UzSSt 950-2011

Indicators	UzSSt 950-2011	Results
Aluminum, mg/dm^3	0,2	0,00226
Beryllium, mg/dm^3	0,0002	0,00013
Boron, mg/dm^3	0,5	not detected
Cadmium, mg/dm^3	0,001	not detected
Molybdenum, mg/dm^3	0,25	not detected
Arsenic, mg/dm^3	0,05	not detected
Nickel, mg/dm^3	0,1	not detected
Mercury, mg/dm^3	0,0005	not detected
Lead, mg/dm^3	0,003	not detected
Selenium, mg/dm^3	0,01	0,0037
Strontium, mg/dm^3	7,0	0,1787
Chromium, mg/dm^3	0,05	not detected

Note: The accuracy of the methods used is ± 10%.

The results show that the content of all the above inorganic components (chemical elements) were within the limits of the standard or were not detected at all. The data indicate that according to the content of these parameters, the quality of water meets the standards adopted in the Republic of Uzbekistan (UzSSt 950-2011 and UzSSt 951-2011).

The same results corresponding to the standards of water quality were obtained as a result of research in 2015 (August-September), which indicates the absence of changes in these indicators in the dynamics of research for several years.

At the same time, studies were also carried out to study the content of toxic chemical elements, the determination of which is not obligatory according to O'zDSt 950-2011 (Table 4), but are of great importance for determining the quality of the water samples from various sources, including surface water bodies. Amu Darya River.

A comparative analysis shows that a high calcium content (67.2187 mg/dm^3) was found in the water samples studied, the remaining toxic elements were detected in small quantities or were not detected at all. Such a high content of calcium in the studied water, apparently, is due to the constant high salinity of water in water bodies of Uzbekistan, including the Amu Darya River.

Table 4. Indicators of toxic chemical elements in water samples of the Amu Darya River

Indicators	Results
Calcium, mg/dm^3	67,2187
Lithium, mg/dm^3	0,00087
Magnesium, mg/dm^3	not detected
Potassium, mg/dm^3	0,00153
Silver, mg/dm^3	0,00011
Sodium, mg/dm^3	not detected
Rubidium, mg/dm^3	0,00014
Vanadium, mg/dm^3	not detected
Gallium, mg/dm^3	0,00041
Indium, mg/dm^3	0,00031
Bariium, mg/dm^3	not detected
Uranium, mg/dm^3	0,00712

Note: The accuracy of the methods used is ± 10%.

In our previous studies (August-September 2015), close to these indicators were obtained, and then an elevated content of calcium (2.456 mg/dm^3) and sodium (3.2056 mg/dm^3) in the water under study was noted. If over time the sodium content dropped to the standard level ("not detected" in June-July 2017), then the calcium content remained at a high level until recent studies.

Thus, no increase in the concentrations of inorganic components in relation to normal values was detected in the water samples of the Amu Darya River, but some parameters of toxic chemical elements (calcium) remain consistently high. It has been established that according to these studied parameters, the studied water is suitable for use by the population for household, drinking, cultural and domestic purposes, but when providing the population with drinking water, one must keep in mind the constant high content of water salinity (calcium).

The next stage of research was the study of the content of pesticides in the studied water. The determination was carried out by traditional methods (MG.№ 012-3/0010 and MG №. 012-3/0012) on the basis of sanitary rules and regulations of RepUz (SanR&R of Rep.Uz) "Hygienic standards of pesticides in environmental objects and foodstuffs". The residual levels of α-, β-, and γ-isomers of hexachlorocyclohexane (HCCH), dichlorodimethyltetramethane (DDT) and its metabolites (DDD, DDE) were determined.

Next, we carried out the determination of the total content of radionuclides (the content of the specific activity of natural and artificial radionuclides) in samples of the studied water using the method specified in MG No. 012-3/0058 approved by the Ministry of Health of the Republic of

Uzbekistan.

The results indicate that the total content of radionuclides (^{137}Cr, ^{90}Sr, ^{40}K, ^{226}Ra, ^{232}Th, ^{238}U) or the total β-activity of water samples correspond to the standard parameters given (SanR&R of Rep.Uz) №. 0196-06. I would like to remind that, according to clause 1.3 of NRB - 2006 (SanR&R of Rep.Uz) №. 0196-06, the requirements of the rules and regulations do not apply to cosmic radiation from the Earth's surface and internal human exposure to natural potassium (40K), which is almost impossible to influence. The results were almost identical with the previous studies (August-September 2015).

Thus, the determination of the parameters of the total content of radionuclides (137Cr, 90Sr, 40K, 226Ra, 232Th, 238U) or the total β-activity of water samples at the point of sampling water from the Amu Darya showed no deviations from the norm.

4. Conclusions

1. For the first time over the course of two years, monitoring of the organoleptic indicators, parameters of water salinity, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, sulfates, chlorides in samples of the water of the Amu Darya river was conducted in a comparative aspect, where it was found that they were limits of standard values. The absence of nitrites indicated the absence of fresh pollution of the studied reservoir.

2. Conducted independent research on the study and evaluation of components affecting the water quality of the Amu Darya River - iron, manganese, copper, zinc, fluorine, synthetic surfactants, polyphosphates were within the standard adopted in the Republic of Uzbekistan, except for the content of petroleum products and the BOD5 indicator, which were above the upper limit of normal. But in the dynamics of research it was revealed that this increase is random and does not reflect the true state of the water quality of the Amu Darya River.

3. It was established for the first time that no increase in concentrations of inorganic components — aluminum, beryllium, arsenic, mercury, lead, and others — was observed in the water of the Amu Darya river relative to normal values accepted for open reservoirs of Uzbekistan, but the calcium content remained consistently high, which was not was established by previous researchers.

4. The α-, β- and γ-isomers of hexachlorocyclohexane (HCH), dichlorodimethyltetramethane (DDT) and its metabolites (DDD, DDE) were not detected in water samples at the point of water withdrawal from the Amu Darya River, which confirms the results obtained by other researchers.

5. For the first time, we have determined in dynamics the parameters of the total content of radionuclides or total β-activity in samples of the water of the Amudarya River, where it has been established that there are no deviations from the norm adopted in the Republic of Uzbekistan.

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