Assessment of water quality in the downstream of the Amu Darya basin

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Abstract. Ecosystem vulnerability increases significantly when anthropogenic factors overlap with the effects of adverse climate change, which together negatively affect biodiversity and ecosystem functioning. According to ADB forecasts, the inflow to the lower reaches of the Amu Darya will decrease by 26-35% by 2050. The combined effect of higher water demand and lower inflow will increase the current water shortage - the annual water shortage will increase to 50% of the total demand. In connection with the projected changes, the current state of water resources of the Amu Darya river, as well as the need for the socioeconomic development of the region, the task of assessing the projected impact of climate change on the availability and quality of water resources becomes urgent.

1 Introduction

When we talk about security and stability problems in Central Asia, we cannot ignore such an important issue as the rational use of the region's common water resources. We fully support the position of the Secretary-General of the UN that "water, peace and security issues are inextricably linked. " I am convinced that there is no sensible way to solve the water problem other than taking into account the interests of the countries and peoples of the region. Uzbekistan supports the draft conventions on the use of water resources in the Amu Darya and Syrdarya basins, developed by the UN Regional Center for Preventive Diplomacy. I would like to draw your attention once again to one of the most acute environmental problems of today - the Aral Sea disaster. Here is a map of the Aral Sea tragedy in my hands. I think there is no need to overstate this. Overcoming the consequences of the drying up of the sea requires an active combination of efforts on an international scale. We favor the full implementation of the special program adopted by the UN this year to provide practical assistance to the population affected by the Aral Sea tragedy.

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2 Methods

2.1 The Study area

The Amu Darya is the wettest river of Central Asia is also being affected by global climate change. The Amu Darya River basin is formed by the confluence of the Vakhsh and Panj (Pyandzh) rivers (at which point it becomes known as the Amu Darya) and flows west-north-west. In its upper course, the Amu Darya forms part of Afghanistan's northern border with Tajikistan, Uzbekistan, and Turkmenistan. It then flows across the desert of eastern Turkmenistan and, in its lower course, forms part of the boundary between Uzbekistan to the northeast and Turkmenistan to the southwest. The Amu Darya is 1,415 km long, but its length is 2,540 km if measured from the sources of its headstream, the Panj River, in the Pamirs. In the past, the Amu Darya discharged into the Aral Sea. Still, the diversion of river water for agriculture in the 20th and 21st centuries has contributed to the shrinking of the Aral Sea and ensured that the river no longer reaches its historic terminus [1, 3].

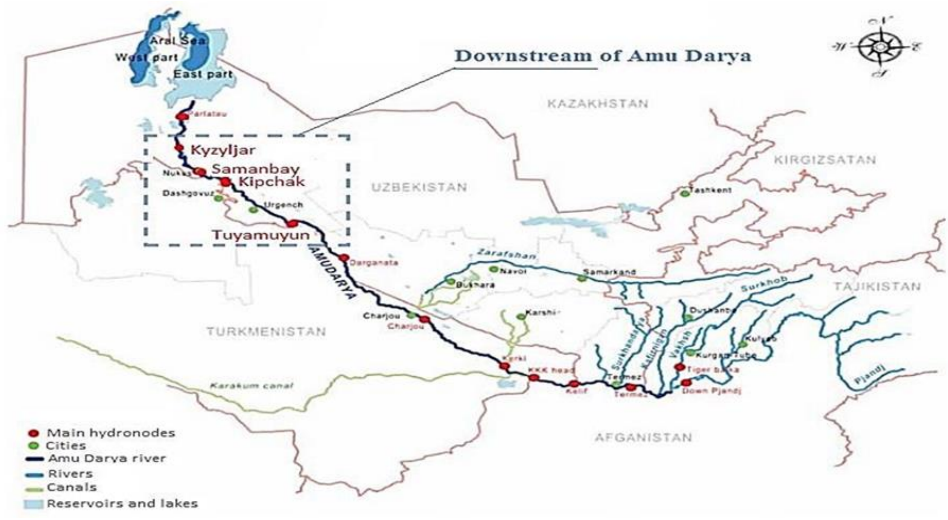

Fig. 1. Schematic representation of gauging stations, drainage channel networks, and hydraulic structures in the lower part of the Amu Darya River Basin [8].

After leaving the highland zone, the river veers to the northwest to cross the arid Turan Plain, where it forms the boundary between the Karakum Desert to the southwest and the Kyzylkum Desert to the northeast. The Amu Darya loses much of its water in this region to irrigation, evaporation, and seepage.

The Amu Darya's basin extends for 950 km from north to south and more than 1,450 km from east to west. It borders the Syr Darya basin to the north, the Tarim Basin to the east, and the Indus and Helmand river basins to the south. Of the basin's total area of 465,500 square km, only half lies within its source region, the mountain ranges of the Pamirs and the Hindu Kush to the east. The Amu Darya system highly dependent on the changes in the glacier mass balances and snowmelt processes as nearly all of the water resources of the Amu Darya River are originating from the high-ranges of the Tian Shan and Pamir mountains.

The downstream of the Amu Darya is situated in the Khorezm region and Karakalpak Republics of Uzbekistan. We selected two hydro posts to study and compare the impact of climate change on water quality. The first of these is the Tuyamoyin hydropost.

Tuyamuyun is located 460 km from the Aral Sea Delta. Tuyamuyun reservoir is located in Khorezm region was constructed for irrigation and energy of year of commissioning 1979. Tuyamuyun reservoir has a total volume of 7800 million m3, in which useful volume 5270 million m3 and dead volume 2550 million m3. The mirror area 790 km2, and the type of dam is earthen with a height of 34m and a length of 900 m. The hydroelectric power station in the Tuyamuyun reservoir has a design capacity of 150 MW. Average annual electricity generation 1000 million kWh with design head 14 m and including 6 number of units [1, 2, 32, 33, 34, 35]. The second one is Kyzyljar, located 102 km from the Aral Sea Delta.

2.2 Retrospective analysis of water quality changes

Assessment of surface water was carried out by comparing the predominant water contaminants for the periods from 1989 to 2017 [29, 30, 31].

Comparison of the prevailing pollutants between the two periods;

Water quality indicators gave the data for each hydro post, indicating only those parameters of pollutants that exceeded the MPC. The results were obtained from calculating the difference between the MPC set by O'zDSt 950:2011 and the available pollutants on each indicator.

One of the existing sources of information on the quality of water bodies is the Hydrometeorological Service of the Republic of Uzbekistan (UZHYDROMET): The UZHYDROMET system has established a stationary network of observation points for the natural composition and contamination of surface waters based on physical, chemical and hydrobiological indicators of water quality [5]. The observations cover major watercourses and reservoirs in the region. Information about the quality of water (water pollution) in the lower reaches of the Amu Darya river includes 17 hhydrochemical parameters. The criteria for assessing surface water pollution set by O'zDSt 950:2011 included various limiting indicators of harm: fisheries, toxicological, sanitary toxicological, organoleptic, and general sanitary [2, 4, 29, 30].

The water quality assessment for reservoirs of use of water from biogenic elements was carried out by the content of nitrogen compounds (ammonium, nitrite, nitrate), and from organic ones - by the content of hard - (chemical oxygen demand) and easily oxidizing (biological oxygen demand) organic substances. The biogenic elements, nitrites, and nitrates are considered toxicological indicators of harm, while chemical oxygen demand and biological oxygen demand are considered general sanitary [16, 17, 18, 19, 20, 28].

In the Tuyamuyun hydropost, the average annual concentration of biological oxygen demand was in the range of 0.51 – 6.23 MPC, and chemical oxygen demand was in the range of 4.4 – 54.4 MPC. The average long-term value (table.1) of biological oxygen was 1.44, and chemical oxygen demand – 17.92 MPC. Throughout the Amu Darya river, the concentration of N-NH4 and N-NO2 did not exceed the MPC norms and amounted to tenths and hundredths of its shares. During the study period, the content of N-NH4 was in the range of 0 - 0.59 mg/l, and - N-NO2 - in the range of 0 - 0.41 mg/l. The concentration of N-NO3 prevailed over other nitrogen compounds and varied from 0.03 to 6.13 mg/l. However, nitrates did not exceed the permissible norms and made up tenths of the MPC. Water-soluble metals in small quantities are necessary for the life of hydrobionts. However, their high concentrations are toxic both for zoocenosis, phytocenosis, and for humans. Iron, copper, and zinc are organoleptic indicators of harm, while hexavalent chromium, lea,d, and mercury are toxicological. The concentration of iron varied from 0.01 to 0.22 mg/l, and copper, zinc, and hexavalent chromium were analyzed from heavy metals. The content of these metals was found in microgram quantities. Although the highest absolute concentrations were for zinc and copper, their MPC values were hundredths and thousandths. (MPC Cu = 1.0 mg / l; Zn = 3 mg/l). During the study period, the average annual concentration of copper in the Tuyamuyun hydropost varied from 0 to 5.6 μg/l; the Maximum concentration of copper in these ranges was 5.6 MPC. The average annual concentration of zinc varied from 0.001 to 20.2 μg/l, with a MAC equal to 1000 μg/l and did not exceed the norm. The concentration of other heavy metals reached tenths of the MPC. The average long-term values of heavy metals were: Cu-0.001 MPC; Zn-0.002; Cr6+ - 0.01 μg/l MPC. Polluting organic substances was investigated phenols, oil products. Phenols, petroleum products, and detergents belong to the organoleptic characteristics of the hazard, and pesticides to the toxicology. The greatest pollution of the river was observed for phenols and petroleum products. (MPC of phenols = 0.001 mg / l, and petroleum products = 0.1 mg/l). The average annual concentration of phenols varied from 0.001 to 0.007 mg/l (17 MPC) and 0.015 mg/l (15 MPC); the average long-term concentration of phenols during the study period was Tuyamuyun-2.2 MPC. The average annual concentration of oil products (fig.9) varied from 0.01 to 0.17 mg/l (0.1 – 1.7 MPC) and 3.3 MPC. The content of other pollutants in the water of the river along its entire length was significantly less. The salinity of water and such of the main ions components as sulfates and chlorides, and he sum of calcium and magnesium ions that make up the total hardness of water, re organoleptic indicators of harm. Water salinity varied from 512.96 mg / l (2002) to 1251 mg/l (2008) [12, 13, 14, 15].

Almost all years, during the winter and spring months, water salinity in this range exceeded 1000 mg/l. The average annual salinity of water was: in low water years 1986, 1989, 1997, 2001-1060, 1110, 1064, 1006 mg/l, respectively; in medium – water years 1985, 1995, 2004 – 1002, 847, 842 mg/l; in high-water years 1988, 1991, 1998, gg-896, 867, 696 mg/l. As water mineralization increases, the concentration of all major ions increases in this range. By chemical composition, water belonged to the sulfate and chloride-sulfate class and three groups: calcium, calcium-sodium, and sodium, the second type [6, 7, 9, 10, 11, 27].

Assessment of the water quality of the Amu Darya river, for reservoirs of economic and drinking water use, by mineralization and the main regulatory ions showed the following. In the Tuyamuyun hydro post, the average annual concentration of water mineralization varied from 0.6 to 1.2 MPC, and the maximum concentration reached 1.7 MPC. In low-water years, the average annual salinity of water exceeded the permissible norms. The average annual values of sulfate ions in this range were within 0.6 – 1.2 MPC, and the maximum values were 0.8 – 1.8 MPC. These values decrease during the flood period and increase during the autumn period. The average annual content of chlorides did not exceed acceptable standards and was 0.4 – 0.9 MPC. However, in some cases, the chlorides exceeded the MPC norms by up to 1.3 times [21, 22, 23, 24, 25, 26].

3 Results and Discussion

In the Kyzyljar hydro post, the average annual content of biochemical oxygen demand varied from 0.008 to 2.50 mgO2/l, and chemical oxygen demand -from 5.6 to 51.53 mgO2/l. At the same time, the average long-term value of BPK5 was 1.44, and COD – 22.28 mgO2/l. The concentration of iron varied in the Kyzyljar hydro post – from 0 to 0.44 mg/l. During the study period, the average annual concentration of copper from 0 to 4.2 μg/l. The average annual concentration of zinc ranged from 0 to 27.9 μg/l. The average long-term values of heavy metals in the Kyzyljar hydro post were: Cu-1.75 μg/l; Zn-5.88 μg/l; Cr6+ - 0.47 mcg /l. The greatest pollution of the river was observed for phenols and oil products. (MPC of phenols = 0.001 mg / l, and petroleum products = 0.1 mg/l). The average annual concentration of phenols varied from 0.001 to 0.005 mg/l (15 MPC) and 0.013 mg / l (13 MPC). The average long-term concentration of phenols during the study period was 2.5 MPC. The average annual concentration of petroleum products varied from 0.01 to 0.09 mg / l (0.1 – 0.9 MPC) and 5.4 MP. Their average long-term values were 0.5 MPC. In the Kyzyljar hydro post, water salinity varied from 488 mg /l (1991) to 3794 mg /

l (2002). in 1986, 1997, 2000, and 2001, in some months, water salinity exceeded 2000 mg/l. The average annual salinity of water in this range was: in low-water years 1986, 1997, 2001 – 1661, 1472, 1380 mg/l, respectively; in medium – water years 1985, 1995, 1999 – 1182, 1257, 959 mg/l; in high-water years 1988, 1991, 1998-957, 781, 936 mg / l. The chemical composition of the water in this range was the same as in the previous range. In the Kyzyljar hydro post, the mineralization of water and the concentration of main ions did not differ much from those in the Samanbay range. The average annual values of water salinity here were in the range of 0.8-2.1 MPC, and the maximum values reached 3.8 MPC (2002). On average, chlorides in high–water years did not exceed the permissible values, and in low-water years-increased to 1.2 MPC. The average annual concentrations of total hardness in all years of research exceeded the permissible norms and were within the range of 1.1-1.7 MPC. In different years of water availability, both during vegetation and no vegetation periods, the irrigation quality of incoming water in this range did not meet the irrigation standards by 20 - 30%.

To reduce the volume of waste water from fields and to improve the efficiency of water distribution, increase the reliability of water accounting, improve the melioration status of irrigated land and save irrigation water and electricity, it is necessary to implement:

- reconstruction of the irrigation network and water distribution nodes with equipping them with cost stabilizers;
- organization of water distribution planning and automated water accounting system;
- construction of new water measuring structures with installation of hydrometric rails and water flow sensors;
- determination of metrological characteristics of water measuring structures and flow stabilizers;
- organizational and campaigning events among WUA members.

In terms of the size of specific irrigation water expenditures, or rather, the irrationality of its use, the countries of Central Asia firmly hold the first place in the world. The main reason for this situation is the low discipline of water use. To save irrigation water, increase the efficiency of irrigation water use, and improve the productivity of water and land use, the following methods should be used:

- hydro technical (water accounting, water circulation, irrigation regime, irrigation technique, washing and water-charging irrigation, reuse of waste water, regulation of runoff, etc.);
- agro technical (structure of irrigated areas, tillage, increase of soil fertility, control of unproductive water losses, afforestation, etc.);
- organizational (organization and discipline of water use, training, etc.).

As a result of global climate change, in conditions of water scarcity and limited water use, rational use of irrigation water is required by improving the principles of soil-melioration and hydro module zoning, developing and implementing science-based irrigation regimes and establishing water consumption of agricultural crops, improving the land melioration status, as well as developing and implementing new, progressive methods of irrigation technology and technology, and optimizing them, this increase in output from an irrigated hectare and the introduction of new irrigated land into circulation is of great national and regional importance.

4 Conclusion

The organic substances in the water of the Amu Darya river, chemical oxygen demand prevailed, the content of which increased from the upper stream to the mouth by 1.5 – 2 times. Water salinity and the content of main ions increased from the river's upper reaches to the mouth, in different water years, by 1.5-3 times. For all the years of observations, dissolved iron content throughout the river did not exceed the permissible MPC standards. General, heavy metals and iron concentration in the river water did not exceed the established norms for reservoirs of economic and drinking water use.

To improve water quality, you must do tighten control of water intake for drinking, household, industrial, and irrigation purposes and strengthen monitoring of the volume and quality of discharged water; also start construction of water treatment facilities, prohibit the discharge of collector and drainage water. Moreover, we have to create sanitary protection zones in places of water intake, catchment, and water protection strips along the banks. The most important continue further cooperation with the main water user countries on the issue of regulating the volume of water intake and spillway.

Currently, the issue of protecting the Amu Darya river from pollution is being resolved at the government level. Thus, on January 16, 1996, in the city of Charjou, signed an agreement between Turkmenistan and the Republic of Uzbekistan on cooperation in water management issues. Article 6 of this Agreement stipulates the issue of dividing the Amu Darya runoff in equal shares (fifty-fifty). The parties also agreed to send a proportion of their shares to the Aral Sea. Another important decision was the agreement to stop the discharge of drainage water into the Amu Darya, starting in 1999. Suppose all the agreed terms of this agreement are implemented. In that case, it will significantly improve the environmental situation of the middle stream and the river as a whole.

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