The Modern Problems of Monitoring, Pollution and Management of the Transboundary Rivers of Aral Sea basin

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Abstract: The problems of pollution and protection of an environment of transboundary rivers of Aral Sea basin is discussed in this study. The main sources of pollution of transboundary rivers water is estimated. It is recommended that based on this paper:
-Rational use of water resources of transboundary rivers by implementing design engineering of irrigated areas, introduction of the advanced water save technologies to the irrigated farming (overhead irrigation, drip irrigation, etc.)
-Development and use of the modern technologies combining various kinds of cleaning that will allow, on the one hand, cleaning return waters, on the other hand, to refine their quality up to the quality of clean waters.
-Introduction of the modern methods of monitoring of quality and quantity of transboundary rivers waters.
-According to the globally adopted international norms, the projects of transboundary character should be agreed with downstream countries that potentially will have influence from the development and operation of the project.
-Increase of ecological culture, knowledge of the officials and the population of the region on protection and rational use of water resources of the transboundary rivers.

Keywords: Climate change, Monitoring, Pollution, Return waters, trans-boundary rivers,

1. Introduction

The economic development of the Aral Sea basin region in many respects is connected to presence of water resources and their rational use. Consequently the most attention should be paid to use of resources of the transboundary rivers, which were at all times the source of the vital needs of inhabitants and countries within the basin of these rivers. Today this is under the interest of more than 55 million people, living in the 5 countries of the Aral Sea basin.

2. Results and discussion

2.1. Amydarya and Syrdarya rivers basin

The main transboundary rivers of Aral Sea basin are rivers Amudarya and Syrdarya. In the table1. date on water resources of Amudraya and Syrdarya rivers are given. The main runoff of Syrdarya river is formed in Tienshan mountain area in territory of Kyrgyzstan and runoff of Amudaya river is formed in Pamir-Alai mountain area in Tajikistan. Also, some part runoff of Amudarya river is formed in mountain area of Afghanistan and Iran. The total mean annual flow of the transboundary rivers in the Aral Sea Basin is estimated as about 116 km^3.

During the board of Soviet Union the agricultural sector was developed extensively. In the Aral Sea basin irrigated area increased from 2.0 to 7.9 million ha basically for cotton production during 1925-2000. And the irrigation and water facilities have turned to the basis that guarantees agriculture. Intensification and expansion of agricultural manufacture become the powerful factor of influence on environment. On the other hand, strengthened rates of growth of number of the population in the Aral Sea basin, the occurrence of large territorial - industrial complexes on base of urbanized territories - large and average cities without the sufficient account of the ecological requirements to utilization of industrial and municipal-household wastes has resulted in pollution of natural environment also [1].

In Soviet period management huge and extensive network of irrigation and drainage canals has been created. Total length of irrigation network: inter-farm – 47.75 th. km , on-farm – 268.6 th. km, total amount of drainage wells – 965, total length of collector-drainage network–191.9 th. km, including subsurface – 47.9 th. km. Due to poor conditions of the irrigation network and ineffective water resources management, the losses in the irrigation network are estimated 40% . However, namely the cotton-monoculture was the main reason for the ecological problems in the region. Uzbekistan is the main water resources consumer in the region, as its agricultural production almost entirely depends on irrigation for which about 90% of the water withdrawal from the surface sources is used. The main reason of lost water resources of region irrigated agriculture. At the moment all countries of Aral Sea basin are used irrational irrigation method-furrow irrigation. Using this method leads to a lost of a great volume of water through evaporation and filtration (Fig.1).

Tab.1 Surface water resources in the Aral Sea basin (mean annual runoff, km^3/year)

	River Basin		Total Aral Sea Basin	
	Syrdarya	Amudarya	km^3	%
Kazakhstan	2.516	—	2.516	2.2
Kyrgyzstan	27.542	1.654	29.196	25.2
Tajikistan	1.005	58.732	59.737	51.5
Turkmenistan	—	1.405	1.405	1.2
Uzbekistan	5.562	6.791	12.353	10.6
Afghanistan and Iran	—	10.814	10.814	9.3
Total Aral Sea basin	36.625	79.396	116.021	100

About 50% water resources of Amudarya and Syrdarya river used by Uzbekistan (Fig.2). Second main consumer is Turkmenistan (21%). Uzbekistan, with a population over 28 million people and 447,400 square km of territory is at the centre of Central Asia. About 60% of Uzbekistan's land area is desert steppe broken by irrigated, fertile oases along the Amudarya and Syrdarya rivers. Around 25-30% of Uzbekistan's GDP is derived from agriculture with about 45% of the population employed in the sector [2]. Mostly covered by desert only partially mountainous, Uzbekistan contributes 4.7 km3 of the flow to the Amudarya river basin.

Fig.1 Cotton watering

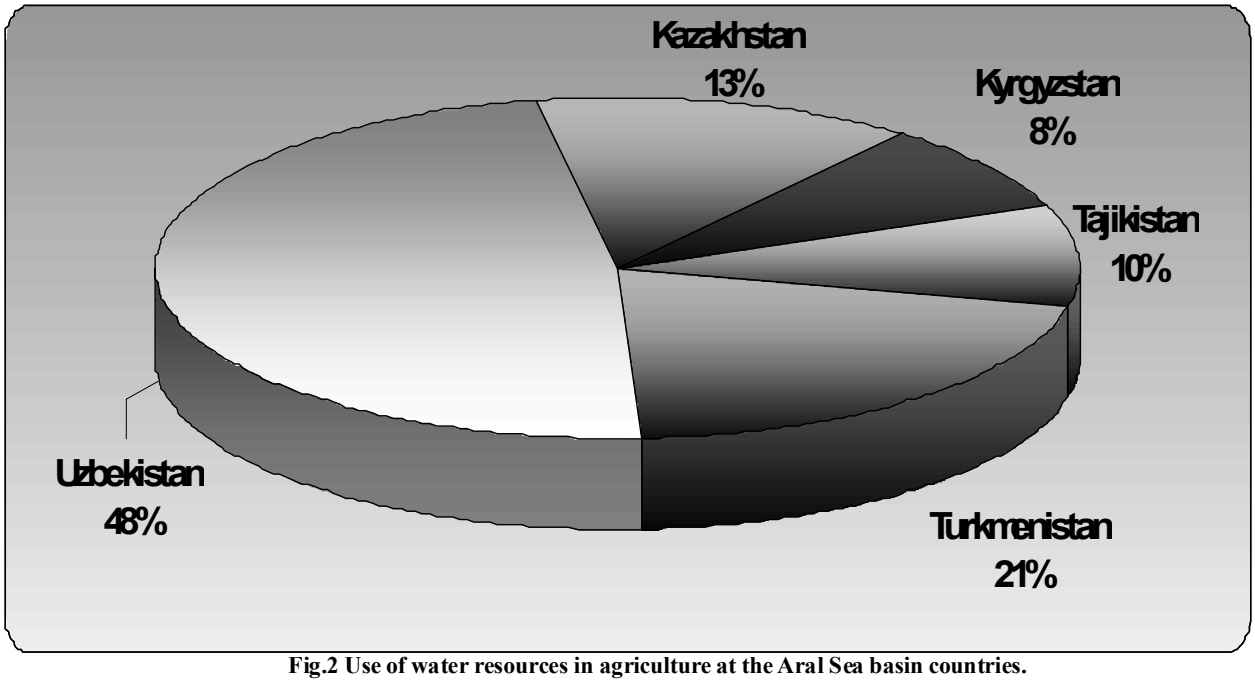

Fig.2 Use of water resources in agriculture at the Aral Sea basin countries.

The average interstate allocation of water to Uzbekistan from the river is 33.9 km3, whereas, for example, in 2000, 2.39 million ha were irrigated in the Uzbek portion of the Amudarya basin requiring 35.3 km3 of water. The large amounts of water necessary for Uzbekistan to maintain the agricultural sector of its economy require that it negotiates with its upstream neighbors on continual basis [3].

The main sources of the pollution of the transboundary rivers Aral Sea basin are return waters from the agricultural sector, municipal and industrial waste waters (Fig.3). Return waters constitute a high proportion of water resources in the basin which is also a major source of pollution. The annual mean values of return flows, consisting of drainage and wastewater from irrigation, industry, and municipal users have varied between 28.0 km3 and 33.5 km3. The total amount is comprised of about 95% of agricultural drainage water and about five percent of untreated domestic and industrial wastewater [1,3].

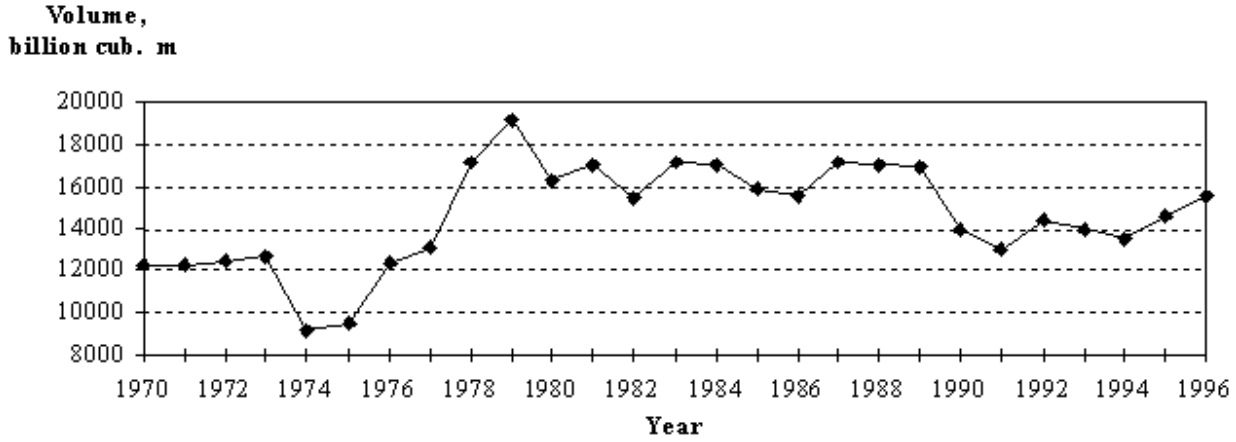

Fig.3 Drainage and wastewater variations in the Syrdarya river basin.

The quality of the drainage effluent depends on the location of the irrigation scheme within the river basin (upper, middle, or lower reaches) and the leaching requirements of the irrigated area. It also depends on the use of agro-chemicals. The local salt mobilization is determined in part by the type of the drainage system (open, subsurface or vertical), seepage, drain spacing, and drain depth. The poor quality creates limitations for the re-use of drainage water, especially for irrigation. Only about 15% of total return flows are re-used and more than 55% returns to rivers. About 30% end up in natural depressions, from which the water evaporates [4].

2.2 Influence of climate change

It is expected that the water flow will potentially decrease by 2-5% in the Syrdarya river basin and by 10-15% in the Amudarya river basin by 2050 [5]. During the years of acute water scarcity (assessment for extremely warm and dry years), irrigation water use in the Syrdarya and Amudarya rivers basins might decrease by 25-50%. Increase of evaporation coupled with warming will lead to water loss in the irrigation zones. It is expected that irrigation norms will increase in average by 5% by 2030, 7-10% by 2050, and 12-16% by 2080 in Uzbekistan. Expected decrease of river water resources will lead to worsening of the water scarcity situation, which will be especially acute during low-flow years [6]. The situation with water supply in Uzbekistan might worsen due to expected reduction of existing water resources with the most acute consequences occurring in the Aral Sea area. Scarcity of water resources, especially in the years of extreme water deficit, requires review of water use principles and applying water deficit mitigation measures. The main adaptation measures that are most necessary include development of regional principles and rational solutions that meet interests of all transboundary rivers users, implementation of the integrated water resource management system, establishment of the system of early drought prevention, strengthening legal basis in water use, water saving, improvement of irrigation-drainage system infrastructure, improvement of irrigation techniques and shaping careful attitude towards water. Climate Change impact assessment was conducted for cotton, winter wheat, rice, alfalfa, and vegetables. Crops losses were estimated in relation to productivity of modern breeds with optimal irrigation regime and with water deficit by the scenarios with the use of irrigation model ISAREG [7]. Just due to evaporation, the loss in cotton crops could achieve from 4% by 2030 to 10% by 2050. With this, maximum loss rate in extreme years could achieve 14%.

The main crop losses in the future will be determined by water security of irrigated farming. By 2050, cotton crop losses could achieve 11-13% in the Syrdarya river basin and 13-23% in the Amudarya river basin only due to Climate Change (increased evaporation and reduced flow). Decrease in grains and vegetables productivity is also possible [5].

2.3. Sources of pollution of the of Syrdarya river.

In the basin of of the Syrdarya river is irrigated about 2 millions of hectares. The channels with total volume of water fence of 23, 12 km3 per one year are constructed for irrigation. On needs of irrigation of water fence from the river has increased from 70 % in 1960 up to 89 % in 2007. Extent of main and inter-economic collectors makes 13690 km. In the basin of Syrdarya river is located in area of accommodation of large industrial objects, which waste water renders influence on quality of water resources of the basin, to which concern: ON "Electrokhimprom", Alti-Aryk oil refining factory, lime factories, urban clearing structures. In territory of the Syrdarya river basin there are 6 regions of Uzbekistan: Andizhan, Namangan, Fergana, Tashkent, Dzhizak and Syrdarya, which return and waste water is damped in Syrdarya and its inflows (Fig.4.). Water recuorces of Syrdarya river also used by Kyrgystan (upstream) and Kazakhstan(downstream). The oxygen mode in 2007 was satisfactory, concentration of the dissolved oxygen at a level 11.35 mgO/dm3 that corresponds to a level of the last year [8]. On current of the river the contents of organic substances (on COD) varied within the limits of 10.1-16. 8 mgO/dm3. Water is most polluted by organic substances in ranges below hudrostvor Bekabad city and Nadejdinsky settlement (middlestream), where the maximal value of COD have made 28.1 mgO/dm3 and 33. 3 mgO/dm3 accordingly. The pollution of water by nitrogen nitrate and nitride has increased in 1.5-1.6 times, on the contrary, has decreased in as much time and has made – 1.97 mg/dm3 Maximum Allowable Concentration (0.2 MAC), 0.046 mg/dm3 (2.3 MAC), 0. 05 mg/dm3 (0.1 MAC) accordingly. The contents of phenols on current of the river varied a little and has made on the average 0.001 mg/dm3 (1 MAC) that corresponds to a level of the last year. Pollution of Syrdarya river water by petroleum insignificantly has increased, but did not exceed MAC - 0.04 mg/dm3 (0. 8 MAC). The content of copper has not changed, and the content of zinc and chrome in comparison with previous year has increased in 1.4-1.6 times and has made 0.8 mkg/dm3 (0.8 MAC), 5.6 mkg/dm3 (0.6 MAC) and 1.4 mkg/dm3 (1.4 MAC) accordingly. The presence of HCH isomers was marked at a level of 0.002 mkg/dm3 (0.2 MAC), DDT and its metabolites are not found out. Water of the river has increased mineralization-1227.8 mg/dm3 (1.2 MAC), that on 66.2 mg/dm3 is higher than in previous year. On chemical structure in all phases of hydrological mode, water concerns to chloride class (seldom sulphate), group of sodium or calcium.

Concentrations of heavy metals in Amydarya and Syrdarya river weater also were studied. The basic quantity

(more than 50 %) of heavy metals, such as mercury, chrome, antimony, zinc and cadmium in the rivers of the region migrates in the dissolved form, which is necessary to take into account at estimation of pollution and migration of metals in these rivers. On the other hand, less toxic heavy metals- iron, europium, lanthanum and cobalt migrates, basically, as an impurity, that is in the not dissolved form. In river water of arid zone the contents of the majority of heavy metals (Hg, Cr, Sb, Co, Fe, Zn) in 3-5 times is higher in comparison with the global data. The rather high content of heavy metals in water of arid zone caused by landscape-, geo - and biochemical features, and also lythology-mineralogical structure of breed of ground in the top ranges. The conditions of arid climate, and also alkaline reaction of ground and breeds, which are characteristic for all the basin, advance rather high mobility of Hg, Zn, Cd, Sb, Cr, Co and other elements in river water of arid zone [8].

The level of a mineralization is constantly increasing, especially in the middle and the downstream of Syrdarya and Amudarya. In the end of 1960s the level of mineralization did not exceed 1.0 g/l even in the downstream current. Now it changes from 0.4-0.5 g/l in the upstream and up to 1.7-2.3 g/l in the downstream current. The quality of river water in the downstream current of Amudarya and Syrdarya rivers has worsened. There is an intensive drainage and salting of grounds in deltas of these rivers, deep degradation of ecological systems, flora and fauna.

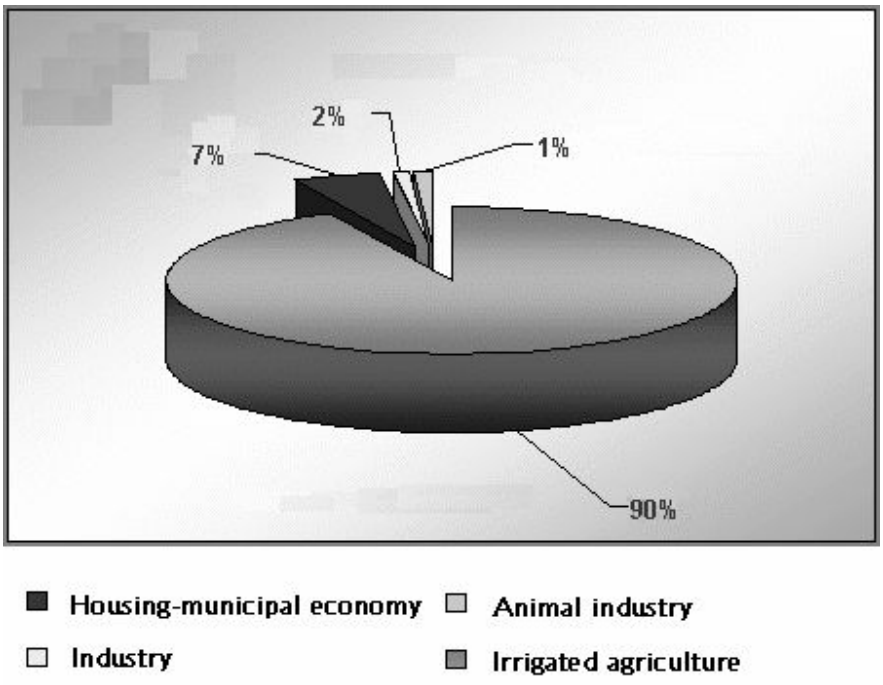

Fig.4 Dumps of waste water in Syrdarya river on branches of national economy

2.4. Water resources management of the Aral Sea basin rivers

After disintegration of Soviet Union there were certain difficulties in water resources management of the Aral basin. The basic quantity of drain of the rivers of the Aral basin is formed in Tajikistan, Kyrgyzstan and Afghanistan. However main consumer of water of the basin is Uzbekistan , Turkmenistan and Kazakhstan. Therefore now there are some disagreements in sharing and management of water resources of the Aral basin. It is necessary also to take into account in the future water fence from Afghanistan. The Amudarya and Syrdarya river basins are rich of complex transboundary environmental challenges. Most notable features that characterize the Amudarya and Syrdarya are its transboundary nature and its division into upstream hydropower use and downstream irrigation use. At the moment Tajikistan and Kyrgyzstan have problems connecting energy deficiency. Given the huge downstream demand for water and upstream demand for energy, these characteristics result in economic, social and environmental instability within the basin, eventually, influencing the quality of life of the basin population. Primarily, water-energy conflicts occur because upstream water release does not coincide with seasonal irrigation

needs of the downstream riparian. Namely for two riparian countries: Tajikistan and Kyrgyzstan (upstream) and Uzbekistan, Turkmenistan and Kazakhstan (downstream). If on example of Tajikistan this problem will be analyses. During the Soviet period, the republics sharing the Amudarya were involved in water-energy transfers directed from Moscow. Tajikistan received Turkmen and Uzbek gas in return for electricity produced mainly for irrigation pumps in summer. Tajikistan also received electricity from Uzbekistan during winter. After independence, bilateral trade replaced this arrangement. For example, Tajikistan, unable to satisfy internal energy demand through hydropower production, continues to import electricity and gas from Uzbekistan. Nevertheless, bilateral trade has its problems, too. It is almost usual that Uzbekistan stops gas supplies to Tajikistan due to the latter's failure to pay, in addition, gas supplies from Uzbekistan are often unreliable due to low pipeline pressure as a result of old non-modernized energy systems. Particularly, given Tajikistan's scarcity in fossil fuels, low socio-economic development of the country, it is understandable that the country is pursuing to develop its large hydropower capacity. Central Asia has huge energy potential, development of which needs high level of both proper management and regional cooperation. However, while solving the energy security problems with expansion and construction of hydropower plants on transboundary rivers, the following important points should be taken into consideration: Further construction works of the Rogun Dam should be based on the results of the evaluation by the World Bank, which will be available by the end of 2010. Ecological consequences, especially, those related to the Aral Sea along with possible socio-economic impacts on the basin population (around 55 million people) of the project should be discussed among riparian and integrated to the evaluation plan.

3. Suggestions and recommendations

The following suggestions and recommendation can be given from this study:

1. Rational use of water resources of Transboundary Rivers by implementing design engineering of irrigated areas, introduction of the advanced water save technologies to the irrigated farming (overhead irrigation, drip irrigation, etc.)
2. Development and use of the modern technologies combining various kinds of cleaning that will allow, on the one hand, cleaning return waters, on the other hand, to refine their quality up to the quality of clean waters.
3. Introduction of the modern methods of monitoring of quality and quantity of transboundary rivers waters
4. According to the globally adopted international norms, the projects of transboundary character should be agreed with downstream countries that potentially will have influence from the development and operation of the project.
5. Increase of ecological culture, knowledge of the officials and the population of the region on protection and rational use of water resources of the transboundary rivers.

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