

ANNOTATION

Dissertation for the degree of Doctor of Philosophy (PhD) in
the specialty 6D060800 – «Ecology»

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«Changes in the resources and hydrochemical regime of rivers of the Aral-Syrdarya water economic basin under the influence of anthropogenic activities»

Relevance of the research. Transboundary river basin Syrdarya is a densely populated region of Central Asia where irrigation is developed. Of the total volume of water resources in the basin, 94% of river flow is regulated. Violation of the natural regime led to a quantitative reduction and qualitative deterioration of water resources, disruption of the ecological balance of natural complexes, especially in the lower part. It is also worth noting that the issues of fair water distribution between neighboring states in the basin have not yet been resolved. The processes of degradation of the river system of the river basin that have occurred and are ongoing. The Syrdarya River, given the existing principles of water resource management, makes it particularly relevant and necessary to develop an assessment of the impact of anthropogenic activities on river flow and hydrochemical regime for targeted management of water resources and the basin's ecosystem based on equitable water distribution between neighboring states.

The purpose of the research is to develop a new methodological and information-analytical basis for assessing the anthropogenic impact on water resources and river systems of the transboundary Aral-Syrdarya water basin based on the principles of sustainable development of nature.

In the context of the formulated goal, the following tasks were solved:

- study of the natural and climatic conditions of the formation of river flow and hydrochemical regime for further analysis of the current ecological state of the Kazakh part of the Syrdarya river basin;
- analysis and selection of methods for studying the quantitative and qualitative characteristics of river flow and hydrochemical regime of the Kazakh part of the Syrdarya river basin;
- assessment of the variability of river flow, elements of the water balance and hydrochemical regime of the Kazakh part of the Syrdarya River basin, taking into account anthropogenic loads and climate changes;
- long-term forecasting of the use of water resources, transboundary inflows and elements of the water balance in the Syrdarya River basin, which is innovative;
- development of methodological foundations of ecological flow as the basis for the stable development of river systems in the Syrdarya River basin (Kazakh part).

The scientific novelty of the research consists of the following points:

- based on a comprehensive analysis of hydrometeorological information, the assessment of

modern river flow resources in the Syrdarya River basin (Kazakhstan part) was clarified;

- based on a comprehensive analysis of information on the hydrochemical regime of the Syrdarya River (Kazakh part), patterns of its spatiotemporal changes were identified, and for the first time a complete and objective picture of the current ecological and hydrochemical state of the river was obtained;

- as a result of generalization of water management information on the territorial division of water use, a scenario forecast of the future state of the water balance of the Syrdarya River basin (Kazakh part) was carried out, which was implemented for the first time for this region;

- for the first time, a scientific and methodological approach was presented to substantiate the ecological flow for the river systems of the Syrdarya River basin (Kazakh part).

The object of the research is the rivers of the Aral-Syrdarya water basin.

The subject of the research is the dynamics of changes in river flow and hydrochemical regime, clarification of water resources, and regulation of flow.

The main provisions to be defended:

- 1 Quantitative assessment of river flow and clarification of the methodology for assessing anthropogenic changes in the hydrological regime of rivers in the Syrdarya River basin (Kazakh part);

- 2 Quantitative assessments of the anthropogenic transformation of the hydrochemical regime in the Syrdarya River basin (Kazakh part);

- 3 Prospective scenario assessment of river flow resources and clarification of the methodology for long-term scenario forecasts of the future state of the water balance (prospective water consumption) of the Syrdarya River basin (Kazakh part);

- 4 Determination of the volume of environmental flow, ensuring the stability of the river ecosystem, taking into account the elements of the riverbed balance in the form of a linear-correlation model and water management processes in the Syrdarya River basin (Kazakh part).

The practical significance of the research lies in increasing the reliability of water resource assessments by applying the methodology of comprehensive accounting of formation factors; in obtaining updated estimates of the elements of the riverbed water balance and their anthropogenic transformations; in a differentiated assessment of the role of individual types of economic activity on river flow. Flow normalization was carried out for years of different water content, which makes it possible to determine the volume of environmental flow that ensures the stability of the river ecosystem. The results of the work can be used by authorized bodies, design and research organizations involved in planning the development of the water sector of the country's economy.

Approbation of the study. The main results and provisions of this dissertation research were reported and discussed:

- at the International Conference “Desertification of Central Asia: Assessment, Forecast, Management” (2014, Astana, Republic of Kazakhstan);

- at the International scientific and practical conference “Hydrology and Innovative Technologies in Water Management” (2015, Astana, RK);

- at the International Scientific-Practical Conference “Water Resources of Central Asia and

Their Use” devoted to the summing-up results of the “Water for Life” decade declared by the United Nations (2016, Almaty, RK);

- at the International Scientific and Practical Conference “Environment and Sustainable Development of Regions. Environmental challenges of the 21st century” (2017, Kazan, Republic of Tatarstan, Russian Federation);

- at the International scientific and practical conference “Water Resources Management in the context of globalization”, dedicated to the 105th anniversary of the birth of Professor L.E. Tazhibayev” (2021, Almaty, RK).

The personal contribution of the author to the solution of the tasks of the dissertation research is:

- in the choice of problems, ways and means of solving them, formulations and justifications of scientific propositions;

- to clarify the assessment of changes in river flow resources of the transboundary Syrdarya river basin in connection with climate change and under the influence of anthropogenic activities;

- in assessing anthropogenic changes in the hydrochemical regime (by the group of main ions, organic substances, nutrients, heavy metals and organochlorine pesticides) of the transboundary Syrdarya river;

- in assessing the current water balance, as well as long-term forecasting of changes in its components; - in the development of methodological foundations for regulating the environmental flow of rivers in the Syrdarya River basin (Kazakh part).

Based on the materials of the dissertation research, 20 papers were published, including 6 in publications indexed by Web of Science and Scopus, 4 in publications recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan, 10 – in materials of International scientific and practical conferences and in other scientific journals and publications.

Dissertation structure. The dissertation is presented on 195 pages and consists of normative references, definitions, symbols and abbreviations, introduction, 4 sections, conclusion and a list of sources used from 233 titles, 7 of them in foreign languages; contains 8 tables, 23 figures and 12 appendices.

Assessment of the natural water resources of the river flow. Surface water resources were assessed within water management areas. For each WMA and for the basin as a whole, local emerging resources, inflows entering a given area from other areas, and total resources were determined. Natural river flow resources of the Kazakhstan part of the river basin of Syrdarya amounted to 30.5 km³, of which: local - 3.29 km³ (of which 0.39 km³ outflow abroad along the Ogem and Maydantal rivers); transboundary inflow along the Syrdarya river – 27.6 km³. Local resources are concentrated in the upper watersheds of the Arys, Keles, Shayan, and Bogen rivers.

Under the influence of anthropogenic activities, the river flow of the Kazakhstan part of the basin decreased by 5.33 km³, include by 4.39 km³ due to irrecoverable water consumption and by 0.94 km³ due to additional losses from reservoirs. In the upstream countries, the total withdrawals from the

rivers of the Syrdarya basin, according to official data of the Interstate Coordination Water Commission (ICWC), on average over the past decades amounted to 34.1 km³. Under these conditions, the inflow to Kazakhstan decreased from the conditionally natural value by 11.8 km³ and amounted to 17.7 km³. As a result, the total runoff of the Aral-Syrdarya WMB decreased by 2 times (48%, 17.1 km³) compared to the conditionally natural period. Inflow along the river The Syrdarya decreased by 40% (11.8 km³), in Kazakhstan - by 5.33 km³.

The available river flow resources of the Aral-Syrdarya WMB for the modern period amounted to 22.9 km³, incl. natural local resources 3.56 km³, actual inflow along the river Syrdarya 17.7 km³, inflow through transfer canals 1.99 km³, natural outflow along the Ogem and Maydantal rivers into the territory of Uzbekistan 0.42 km³. An assessment of the natural water resources of the river flow was carried out. Surface water resources were assessed within water management areas. For each WCU and for the basin as a whole, local emerging resources, inflows entering a given area from other areas, and total resources were determined. Natural river flow resources of the Kazakhstan part of the river basin. Syrdarya amounted to 30.5 km³, of which: local - 3.29 km³ (of which 0.39 km³ outflow abroad along the Ogem and Maydantal rivers); transboundary inflow along the river. Syrdarya – 27.6 km³. Local resources are concentrated in the upper watersheds of the Arys, Keles, Shayan, and Bogen rivers.

Assessments of the impact of anthropogenic activities on the hydrochemical regime of rivers were based on the differentiation of pollutants into groups of pollutants: main ions, organic substances, nutrients, heavy metals, organochlorine substances. Research to determine changes in the hydrochemical regime of a river is based on probabilistic characteristics of water content. For assessment, 4 characteristic availabilities were selected: P = 25% (high-water year), P = 50% (average water year); P=75% (low-water year); P=95% (extremely low-water year).

A forecast assessment of transboundary water inflow along the river was carried out Syrdarya in conditions of climate change with the increasing impact of anthropogenic influence in 2030, 2040 and 2050. According to the forecasts received, a reduction in the total available resources of the Aral-Syrdarya WMB (at a rate of 22.9 km³ for the modern period) according to the base scenario of transboundary inflow is expected to decrease to 17% (will amount to 19.0-19.4 km³), with the implementation of a positive scenario of transboundary The inflow will remain almost at the level of the modern period within 10% (will be 21.0-23.8 km³), in accordance with the negative scenario of transboundary inflow, a reduction of up to 37% is expected (will be 14.3-17.6 km³). Taking into account the forecast demand for water by economic sectors (with the expectation of an increase in irrevocable water intake from 170 to 250%, according to subscenarios), a water shortage is expected, a violation of the equilibrium state delta of the river Syrdarya, up to the cessation of water flow into the Northern Aral Sea, which will lead to its drying out and threaten an environmental disaster.

The international legal framework must ensure a fair, reasonable, environmentally sustainable and binding regime for water use and water allocation for all parties. At the same time, it is necessary to take into account the needs of nature itself for water in order to preserve and increase bioproductivity and biodiversity. In other words, preserving the natural character of the river flow as

a natural object. Only the environmentally permissible volume of water resources is subject to withdrawal, taking into account the mandatory losses of runoff and the environmental requirements of the delta. This work should be combined with activities to establish the river's operating regimes and water distribution, an issue that is of particular relevance in light of the increasing frequency of extreme events in the region (floods, low water). It is necessary to specify in the Agreement the main provisions for managing basins in extreme situations: the passage of floods of more than or close to 1% of the supply and water flows during low water with a supply of less than 75% (the order of water distribution, the application of measures, the involvement of other waters in low-water conditions, etc.). To preserve river ecosystems, the most important task is to scientifically substantiate the permissible volumes of withdrawal and environmental flow of rivers. The process of assessing environmental flow is very complex, resource-intensive, and to determine environmental flow indicators in the region, in a specific country and in transboundary basins covering several countries, the selection of methods is important.

Releases for sanitary and environmental needs must provide a flow regime that is sufficient in quality, quantity and distributed over time to maintain the sustainability of the healthy state of the river and other aquatic ecosystems. In this regard, it seems that the supply of water for "sanitary and environmental needs, including the needs of the Aral Sea" should be recorded, just like all other releases, in the operating mode of the cascades and the entire river for years of different water content and different regimes. Thus, we are talking about the need to jointly develop a mechanism that would allow planning the operation of all reservoirs in the basin in order to ensure a water use regime that would ensure minimal damage to ecosystems.

The study addresses issues and provides an overview of the definition of environmental flow. A review of the methodology for regulating environmental flow has been carried out. A general calculation algorithm is presented for different flow rates. The values of environmental flow and the volume of maximum permissible withdrawal of river flow of various levels of supply for the Aral-Syrarya water basin were obtained. It should be noted that these environmental flow values were calculated for modern realities, taking into account that in neighboring republics there is a huge water intake from this river and in the near future the volume of water intake will not decrease.

In conclusion, we can say that the expected threats to reduce river flow in the river basin. The Syrdarya, caused by climate change and increased demand for water, can lead to an even greater shortage of surface water, deterioration of the environmental situation, especially in the lower reaches, and increased tension in relations between the countries of the region.

In this situation, it is necessary to reduce the load on the water resources of the Syrdarya River through the introduction of effective water-saving technologies. The negotiation process needs to be strengthened.