

ABSTRACT

to dissertation work of Abdibay Assel on the topic «Research of the water-salt regime of irrigation water in the lower reaches of the Syrdarya river» submitted for the degree of Doctor of Philosophy (PhD) in the educational program: 8D08603 - Water resources management using IT-technologies

Relevance of the Research Topic

At present, the salinity level in arable lands is high, which undoubtedly affects both the quality and quantity of agricultural products. In particular, the water-salt regimes of irrigated lands in the Kyzylorda region do not meet the required standards. One of the main reasons for this is the disruption of the hydrochemical regime of the Syrdarya River, which makes a significant contribution to the problem. The increase in the volume of drainage-collector and polluted wastewater entering the Syrdarya leads to ecological difficulties and a deterioration of the sanitary condition of the river's lower reaches, which, in turn, has a serious impact on the health of the population in nearby settlements and worsens living conditions.

The hydrological and hydrochemical regimes of the river flow are closely interconnected. Moreover, they allow the identification of years with high water availability and the forecasting of future water quality conditions. The volume of water consumed from the river is of such importance that it ensures the stability of hydrobiological and hydrochemical processes, the maintenance of normal water quality, the improvement of the sanitary state of the riverbed, and contributes to the health of the population living along the lower reaches of the river.

The improvement and formation of water quality in the riverbed are determined by the process of self-purification (including hydrochemical, biological, chemical, and physical processes). The river's self-purification capacity is also influenced by the timing of wastewater inflow. The self-purification capacity of the Syrdarya River has not been practically studied.

Therefore, the scientific study and formation of water-salt regimes in the Tugisken, Zhanakorgan-Shieli, Kyzylorda, and Kazaly irrigation areas, located in the lower reaches of the Syrdarya River, taking into account all factors affecting their formation, ways to maintain balance, and the natural-climatic conditions of the region, is a relevant and urgent task. In this regard, the study of the current state of the water-salt balance in irrigated lands, determination of soil salt inflow and outflow processes, monitoring the quality of Syrdarya River water, and development of

recommendations for maintaining the water-salt regime at a level that does not negatively affect crop yields will play an important role in addressing this problem.

Aim of the Dissertation Research

The aim of the dissertation is to study the water-salt regime of irrigation waters in the lower reaches of the Syrdarya River.

Research Objectives:

- To create a research database based on factual data for analyzing and assessing changes in the water-salt regime of water and irrigated areas in the lower reaches of the Syrdarya River;
- To develop a methodological system for analyzing and assessing changes in the water-salt regime of water and irrigated areas in the lower reaches of the Syrdarya River;
- To study the patterns of formation of the water-salt balance in the lower reaches of the Syrdarya River;
- To assess the ecological state of the lower basin of the Syrdarya River;
- To evaluate the water-salt regime of irrigated areas in the lower reaches of the Syrdarya River;
- To ensure effective management of the cultivated areas of irrigated lands in the lower reaches of the Syrdarya River.

Research Methods

During the study, the climatic conditions, relief, and landscape features of the investigated region were first preliminarily examined. The research was conducted in the following sequence: analysis of the water quality in the lower reaches of the Syrdarya River, study of the water supply process for irrigated lands, determination of the volume and quality of discharge waters, investigation of water-salt regimes, selection of technological methods for analysis and research, and obtaining and summarizing the final results.

To improve the quality of water supplied to irrigated agricultural lands and enhance the quality of river water used for irrigation in the Y. Zhakhaev village of the Shieli district, a hydrobotanical method based on the cultivation of reeds was applied. In this context, relying on the works of foreign scientists, their proposed methods were reviewed and applied, specifically considering the scientific studies of A.N. Kostyakov, S.F. Averyanov, N.M. Reshetnik, Kh.E. Yakubov, I.P. Aidarov, and L.V. Kireicheva.

Key Findings Submitted for Defense (Proven Scientific Hypotheses and Other Conclusions Representing New Knowledge)

- A scientific data repository based on concrete hydrological and field materials was established for the analysis and assessment of changes in the water-salt regime of river waters and irrigated areas in the lower reaches of the Syrdarya River.

- A scientifically grounded methodological system was developed for the comprehensive analysis and assessment of changes in the water-salt regime of irrigation water and irrigated areas in the lower reaches of the Syrdarya River.

- The ecological state of the lower basin of the river and the irrigated areas was assessed in spatial and temporal dimensions. According to data for the period 2000–2020, it was shown that the majority of the territory falls into the “very poor” category.

- In the irrigated areas named after Y. Zhakhaev in the Shieli district, it was experimentally proven that the use of reeds can improve the quality of river water by up to 20%. This method is recommended as an effective tool for regulating the water-salt balance and reducing salinization processes in the region’s water-soil system.

Description of the Main Research Results

The results of the analysis conducted in the Kyzylorda region, located in the lower reaches of the Syrdarya River, showed that the formation of the water-salt balance in the river basin and irrigated areas depends on a number of factors. In particular, the formation of the water-salt balance is directly determined by the following factors:

- Irreversible water losses due to evaporation from the riverbed surface and irrigated agricultural lands;

- The volume and mineralization (salinity) level of discharge waters entering the river channel;

- The dynamics of river flow changes and the degree of salinization in the delta region.

Moreover, the development rate of irrigated areas is also an important component of the water-salt balance. In this regard, the equation characterizing the water-salt balance of irrigated lands in spatial and temporal dimensions is proposed as a scientifically grounded methodology that can be used to assess changes in the quality of the region’s water resources.

Based on fundamental works on modeling the water balance of river catchment basins and the law of mass conservation, mathematical equations were developed for calculating, assessing, and predicting the water-salt balance of the lower reaches of the Syrdarya River and irrigated areas. In developing these equations, it was taken into account that the processes of evaporation from the riverbed and agricultural

lands, as well as atmospheric precipitation, exhibit the greatest variability and stochastic nature. While the other components of the water-salt balance are formed under deterministic conditions, a linear trend method was applied to assess the rates and directions of their changes.

It was found that the mineralization level of the river flow entering the irrigated zone of the Kyzylorda region, located in the lower reaches of the Syrdarya River, exceeds the permissible limit for the use of irrigation water in agriculture. In this regard, to improve the quality of water supplied to the river basin and irrigated agricultural lands, a hydrobotanical method based on the use of reeds was tested in the Y. Zhakhaev agricultural area of the Shieli district. The research results showed that this method can improve the quality of river water by up to 20%. Furthermore, it was demonstrated that this approach helps reduce salinization processes in the region's water-soil system and can be considered an effective tool for regulating the water-salt balance.

Overall, the research results obtained in the Kyzylorda region, located in the lower reaches of the Syrdarya River, are based on the developed equations characterizing the water-salt balance of the basin and irrigated lands, the methodology for calculating test indicators to assess their ecological state, as well as the results of experiments with hydrobotanical fields applied for river water purification. The formed scientific conclusions can serve as a scientific basis for the comprehensive implementation of measures aimed at improving the ecological and water management conditions of the region.

Justification of the Novelty and Significance of the Obtained Results

During the study, changes in the water-salt regime of irrigated lands in the lower reaches of the Syrdarya River were comprehensively analyzed based on actual field and hydrological data. The obtained results make it possible to assess the hydrogeological condition of the region, identify the dynamics of salinization processes in the irrigated agricultural system, and propose effective measures to mitigate them. The scientific novelty lies in the identification of spatial and temporal changes in the water-salt exchange and the substantiated assessment of their impact on the productivity of agricultural lands. The scientific conclusions have practical significance for the effective management of water resources and the improvement of land reclamation conditions in the lower reaches of the Syrdarya River.

Compliance with Scientific Development Directions or State Programs

The research results fully correspond to the directions of sustainable development of the agro-industrial complex of the Republic of Kazakhstan, the

efficient use of water resources, and the improvement of land reclamation. The work aligns with the objectives of rational natural resource management set forth in the “Kazakhstan–2050” Strategy, as well as with the goals of the national project “Green Kazakhstan” and state programs for the development of the agro-industrial complex. The obtained scientific results contribute to the stabilization of irrigated agriculture, the reduction of soil salinization processes, and the enhancement of food security.

Description of the Doctoral Candidate’s contribution to the preparation of each Publication

In preparing each publication, the doctoral candidate was directly involved in selecting the research topic, collecting materials and data, analyzing and processing them, systematizing and formulating the scientific results. In addition, the candidate wrote the main sections of the articles, conducted the literature review, formulated conclusions, and prepared the manuscripts for publication.

A total of 12 articles have been published on the dissertation topic. Among them, 2 articles were published in international peer-reviewed scientific journals indexed in Web of Science and Scopus: the first article in the *Caspian Journal of Environmental Sciences* (Scopus, Q2, percentile 59), and the second article in *News of the Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences* (Q3, percentile 42). In addition, 5 articles were published in the proceedings of international scientific conferences, and another 5 articles appeared in scientific 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.

Volume and Structure of the Dissertation

The dissertation consists of an introduction, 4 chapters, a conclusion, 101 references, and appendices. The total volume of the dissertation is 117 computer-typed pages, including 34 figures and 49 tables.