

ABSTRACT

Doctoral Dissertation for the Degree of Doctor of Philosophy (PhD)
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A water quality monitoring of transboundary rivers in Kazakhstan on the Shu-Talas river basin management

Kazakhstan, located in the heart of Central Asia, is a major industrial and agricultural hub. Approximately half of the country's water resources are formed in neighboring countries (China, Uzbekistan, Kyrgyzstan, and Russia). One of the largest agricultural regions of Kazakhstan lies in the border zone near Kyrgyzstan. The primary source of freshwater in this area is the transboundary water basin formed by the Shu and Talas rivers and several smaller rivers. The waters of these rivers are actively used for agriculture by the local population.

General Characteristics of the Work: This dissertation includes a literature review, a description of the study area, and an analysis of the physical-geographical conditions of the border region, along with anthropogenic and geochemical factors affecting surface runoff and the hydrochemical composition of surface waters. The research analyzes previous studies on the topic based on publications by domestic and foreign researchers. It establishes the methodology for assessing the quality of transboundary waters, describes the study sites, and explains data collection methods. The dissertation presents results of the elemental composition analysis of water (As, B, Ba, U, Li, Mo, Sb, Sr, etc.), bottom sediments, and coastal and riparian soils (As, Sr, Pb, Zn, Mo, Th, U, etc.). The discussion includes mechanisms of pollutant behavior in surface waters, sediments, and soils, as well as identifying direct and potential sources of pollution. A risk-oriented approach for the population using surface waters was also studied and applied.

Relevance of the Research: The waters of the transboundary rivers under study are of critical importance for ensuring Kazakhstan's food security. The border region is renowned for its fertile soils and extensive irrigation networks of canals and ditches. Water from large and small rivers is used for irrigating fields growing staple food crops such as potatoes, carrots, onions, garlic, wheat, oats, as well as orchards, and for livestock farming. Monitoring the quality of water used in agricultural areas is essential for ensuring the quality of agricultural products and public health. Hydrochemical monitoring for toxic elements is conducted only for the main transboundary rivers (Shu, Karabalta, Talas), while small rivers in the basin are largely unexplored.

Research Development: The hydrochemical monitoring of transboundary rivers has attracted considerable attention, with studies identifying significant pollution by toxic elements in rivers of Southern and Southeastern Kazakhstan, particularly Shu and Karabalta rivers. The research by the Kazakh Agency for

Applied Ecology, including studies by M.Zh. Burlibaev and colleagues, has noted episodic extreme concentrations of toxic pollutants and heavy metals at border checkpoints between Kyrgyzstan and Kazakhstan. Studies conducted at Al-Farabi Kazakh National University by Sh.N. Nazarkulova, I.V. Matveeva, M.M. Burkitbaev, B.M. Uralbekov, and others have revealed the influence of uranium ore provinces on the contamination of the Shu River with natural uranium isotopes. Research by T.A. Basova and others identified ecological hazards in the Kyrgyz-Kazakh border region. Studies in Kyrgyzstan by T.V. Tuzova (Institute of Water Problems and Hydroenergetics, National Academy of Sciences of Kyrgyzstan) and B.M. Dzhenbaev (Biological and Soil Institute, National Academy of Sciences of Kyrgyzstan) have focused on the mechanisms of uranium contamination in water. Research on soil pollution due to anthropogenic activity has been carried out by V.A. Alekseenko.

In addition to these studies, the author has reviewed more than 100 scientific works, textbooks, guidelines, and regulatory documents. The dissertation builds on significant works by N.A. Titaeva, V.A. Alekseenko, A.P. Vinogradov, and others to describe geochemical processes and element behavior in river systems. Modern research approaches are adopted based on publications by domestic and foreign researchers.

Research Objective: A water quality monitoring of transboundary rivers in Kazakhstan on the Shu-Talas river basin management.

Research Tasks:

- Conduct fieldwork, collect samples, and perform analytical studies of the elemental composition of water, sediments, and soils in large and small transboundary rivers in the Shu-Talas basin; assess water quality using modern indices, computational, statistical, and cartographic methods.

- Confirm or refute assumptions regarding pollution sources in surface waters.

- Assess individual risks to the population using water from the studied rivers for domestic purposes.

Research Object: The transboundary segments of the Shu-Talas river basin situated along the Kazakhstan-Kyrgyzstan frontier.

Research Subject: Elemental composition of water (As, B, Ba, U, Li, Mo, Sb, Sr, etc.), sediments and soils (As, Sr, Pb, Zn, Mo, Th, U, etc.).

Research Methods: Field expeditions, sampling, and laboratory analysis were conducted, supplemented by statistical and cartographic techniques. The instruments and methods used are certified under the state measurement system of Kazakhstan. Laboratory quality is accredited to ISO/IEC 17025-2019 standards.

Scientific Novelty: For the first time, the elemental composition of minor transboundary rivers in Kazakhstan and Kyrgyzstan has been studied alongside major rivers. Evidence of local contamination in transboundary rivers from industrial facilities in Kyrgyzstan was identified. The role of groundwater in influencing water quality in border areas of transboundary rivers was determined.

The dissertation research corresponds to the basic principles and objectives of the "Concept of development of the water resources management system of the

Republic of Kazakhstan for 2024-2030", approved by the By Decree of the Government of the Republic of Kazakhstan dated February 5, 2024 No. 66 (with changes and updates as of 10/18/2024). The work was carried out within the framework of the scientific and technical program of program-targeted financing "Development of nuclear physical methods and technologies for innovative modernization of the economy of Kazakhstan" (IRN BR23891691, BR09158958).

Scope of application: hydrochemistry, geoecology, ecology, Earth sciences, environment.

Key Results for Defense:

1. Analytical results show contamination in both large and small transboundary rivers with toxic elements in water, sediments, and soils. Uranium concentrations in the Oyrandy River exceed WHO standards (200 µg/L vs. 30 µg/L).

2. Legacy contamination from the collapse of the Ak-Tyuz mine tailings in 1964 persists in the Kichi-Kemin River sediments and soils.

3. Local uranium pollution was identified in the Shu River near the Kamyshtanovskoe uranium deposit.

4. Molybdenum contamination from the Karabalta mining tailings affects nearby small watercourses.

Theoretical and Practical Significance: the obtained research results can be applied to develop and conduct further research in the basin of transboundary rivers of the Shu-Talas water management basin; when planning the expansion of the existing system of hydrochemical monitoring of transboundary rivers of the Shu-Talas basin; when making management decisions to protect the population from adverse factors of surface water pollution.

Personal Contribution: Participation in setting the aim, objectives, and methodological approaches of the dissertation research. Participation in one of the field expeditions for sampling and in the initial stages of analytical investigations. Independent analysis of the literature; processing and interpretation of the obtained results; formulation of conclusions and main statements; construction and analysis of thematic maps; approbation of the main results and publications.

Approbation of the work: the main results of the dissertation and research results were discussed at the following national and international conferences:

Scientific and practical conference "The role of the President of Tajikistan in solving global problems: water is the source of life";

– International Scientific Conference of students and young Scientists "Gylym jane Bilim – 2021";

– 28-th International Seminar on Interactions of Neutron with Nuclei, section «Radiation ecology», Xian, China;

– International conference "Semipalatinsk test site: heritage and prospects of scientific and technical potential" (section "Ecology"), Kurchatov, Kazakhstan;

– III International Scientific Forum "Nuclear Science and Technology", section "Radiation ecology and methods of analysis", Kazakhstan, Almaty;

– International Scientific Conference "Radiobiology and Environmental Safety – 2022", May 26-27, 2022, Gomel, Republic of Belarus;

– IV International Scientific Forum "Nuclear Science and Technology", section "Radiation ecology and methods of analysis".

Publication of the results: 3 articles on the topic of the dissertation have been published in international peer-reviewed scientific journals included in the Scopus and Web of Science database (Water (Special Issue Water Management in Central Asia), Geochemistry International; Environmental Earth Sciences (Springer)); 2 articles in their specialized publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Education and Science of the Republic of Kazakhstan; 1 article in the Conference proceedings (Conference paper) in an international peer-reviewed scientific journal included in the Scopus database (AIP Conference Proceedings), 7 papers in the proceedings of international conferences.

Structure and Volume: The dissertation is structured to include an introduction, five principal chapters, a concluding section, and a comprehensive list of references (comprising 164 sources). The document encompasses 143 pages and features 70 figures, 22 tables, and 4 appendices.

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