

## **ABSTRACT**

of dissertation for the doctor of philosophy degree (PhD)  
6D060800 - Ecology

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Assessment of the boron pollution dynamics of the groundwater and surface water  
of Ilek river valley

### **General description of work.**

The dissertation is devoted to the study of hydrodynamic and hydrogeochemical features of the movement processes of groundwater contaminated with boron, wedging out into the surface water of the Ilek river valley.

Calculations were carried out on a tasks series of component analysis models based on actual groundwater monitoring data of the Ilek river valley for the specifics of transport from different pollution sources.

For determining, the current situation of boron pollution of the Ilek River and the Aktobe reservoir have been carried out experimental studies of the chemical composition of surface water. In addition, the insufficiency of the ecological capacity of the Ilek river valley with a minimum runoff based on the modeling of turbulent dilution of wedged contaminated groundwater by the surface water of the Ilek river is substantiated.

In this PhD thesis given analyzes the effectiveness of various environmental measures and proposes the best option for improving the water quality of the Aktobe reservoir, which receives the polluted Ilek river. Periodic pumping out of sludge followed by their use as fertilizers is recommended.

### **Relevance of the research topic.**

Water supply is one of the strategic state tasks. The state of water resources largely determines the level of economic development. In Kazakhstan, water is one of the determining factors in the development and distribution of productive forces. The republic is rich in land resources, which are the main reserve for the growth of arable land in the country. The scarcity of water due to its uneven distribution across the territory affects the development of agricultural production and industry. Water resource of the republic are used in various sectors of the economy, but the most significant consumer of fresh water both at the present level and in the future is agriculture – irrigation, provision of water to the rural population and livestock. It accounts for about 85% of the total water consumption; the remaining 15% goes to industry and water supply to the urban population.

The most acute water problems of the Republic of Kazakhstan are the growing deficit and irrational use of water resources, pollution of surface and underground waters. The quality of surface water, in almost all water bodies, does not meet

established standards. Deterioration in the quality of surface and groundwater comes from so-called historical pollution, as well as from wastewater discharges from chemical, oil refining, machine building and non-ferrous metallurgy enterprises. There is an imbalance between the ability of the natural environment to restore and anthropogenic stress.

Pollution of surface water by industrial waste is the cause of increased siltation of rivers, which has a harmful effect on the composition of bottom sediments, which form an integral part of the aquatic environment, the ecological system.

Aktobe region is rich in many types of minerals, which make up a significant part of the mineral resource complex of Kazakhstan. In the Aktobe region, all republican reserves of chromite ores are concentrated, 46.2% - nickel, 28.3% - titanium, 12% - cobalt, 5.9% - zinc, 5.6% - copper, gold - 3.6% bauxite - 1.8%. The river basin in this territory is saturated with industrial enterprises of the industrial zone of Aktobe. These are Aktobe Chrome compound Factory, its ponds and sludge collectors; the Aktobe TPS and its ash removal bowl, the Aktobe KazChrome ferroalloy Factory, its slag dump and old filtration fields.

However, major sources of pollution in the Aktobe region are historical. This problem arose as early as 1941, when a Chemical Factory was launched at the Alga district center. For 23 years in a row, the factory dumped polluted water into Ilek. After built sludge collectors, but without a special screen. As a result, the boron still seeps into groundwater and ends up in Ilek. So on the banks of the groundwater Ilek River there is a high level of boron pollution.

In this situation, the region constantly recorded an excess of boron concentration in the vicinity of the Bestamak village by 50 times in 2018, the MPC of boron in a reservoir in the area closest to sludge collectors was exceeded by 143 times, in 2017.

It should be noted, that Ilek river is trans boundary, it flows into the Ural River and eventually the polluted water enter the Caspian Sea, to the spawning grounds of sturgeon. Pollution of groundwater and surface water by boron in the Ilek river valley and Aktobe reservoir – the sources of water supply in Aktobe region - has an impact on the socio-economic development of the region and the formation of an ecological situation in the territory.

The boron element plays a significant role in the life of plants; moreover, it is one of the five most important trace elements. However, in humans and animals, long-term consumption of water and foods with a high content of boron leads to violations of the basic life-support systems of the body.

The problem of pollution of the Ilek river with boron is very acute for the Aktobe region, since boron is transported along the Ilek river and stored in the silts of the Aktobe reservoir, which is a recreational resource and a source of water supply for the city of Aktobe. The great dynamism of boron leads to the fact that during the stirring during releases from the reservoir, boron enters the lower reaches of the Ilek river, harming river organisms (teratogenic effect) and the population, adversely affecting heredity.

Based on the severity of the problem, the study of the dynamics of the progress of contaminated groundwater with boron has a high degree of relevance.

### **The purpose of work.**

The purpose of this dissertation is to analyze the dynamics of the pollution processes of ground and surface water of the Ilek River valley with boron.

### **Tasks of work:**

To achieve purpose it was necessary to solve the following tasks:

1. Analysis of the results of many years of previous studies of boron pollution of groundwater and surface water of the Ilek river valley;
2. Give a general geographical characteristic of the studying region and its affiliation to the biogeochemical provinces;
3. Studying the dynamics of changes in the hydrogeochemical situation based on a system analysis of regime observations and developing a multidimensional statistical model (component analysis);
4. The formation of a model of the flat task of the turbulent diffusion for numerical experiments of various options for providing flow and boron content in wedged groundwater;
5. Development of proposals and a system of measures to reduce the level of pollution of the Ilek river valley based on the proposed models.

### **The main provisions to be defended:**

- In the filtration conditions of groundwater contaminated with boron changed from the initial acidic medium to filtration in a modern alkaline medium was established based on a series of tasks of a multidimensional statistical model of component analysis;
- The conditions for the dilution of pollution by groundwater are determined under different wedging conditions and different background concentrations of boron in the surface water of the Ilek river based on the turbulent diffusion model;
- The main measure for prevent pollution of the Ilek river below the dam of the Aktobe reservoir is to extract sludge and then use it as fertilizer and change the bottom outlet to the overflow method.

### **Object and subject of research.**

**The object of the research** is the Ilek River valley.

**The subject of the research** is dynamic of boron pollution processes of ground and surface water of the Ilek river valley.

In solving the problems necessary to achieve the goal, the following **research methods** were used: collection and systematization of available information on studies performed in this territory; field and analytical studies; mathematical and multidimensional statistical modeling (component analysis and a flat model of turbulent diffusion); comparative analysis of environmental objects; substantiation of a set of environmental measures.

### **The scientific novelty of the work.**

The following results were obtained in the work:

- the changing was established in the hydrogeochemical environment from acidic to alkaline on the basis of a series of tasks of a multidimensional statistical model of component analysis;
- the insufficiency of the ecological capacity of the Ilek river for diluting contaminated groundwater that squeezed into the Ilek river was established for the first time (with water coming frequency 95% flow rate);
- The expediency of removing sludge with their subsequent use as fertilizers and replacing the bottom outlet with the overflow method has been proved.

### **The theoretical and practical significance of the work.**

**The theoretical significance** of the study lies in the substantiation of a set of methods and approaches in solving the complex theoretical problem of combining motion models of groundwater and surface water in a changing environment of the pollution source for the development of environmental measures.

### **The Practical significance.**

To provide sustainable economic development of the region, a set of measures for the rational use and protection of water resources is necessary.

The application of existing recommendations to improve the water quality of the Ilek river by intercepting contaminated groundwater before it wedges out into the river, cleaning it from boron element at sewage treatment plants, and also reclaiming sludge collectors are expensive. At the present, these activities are practically not feasible.

Of particular relevance is the removal of bottom sediments, silt from the Aktobe reservoir, thereby eliminating the migration of boron with surface and ground runoff.

In the work, the change in the role of the main sources of groundwater and surface water pollution in the Ilek river valley was revealed. It allows construction objectively of a system of environmental protection measures to prevent pollution of the Ilek river valley, Aktobe reservoir and the underlying territories.

### **Work approbation.**

The materials of the dissertation were reported and discussed at various international symposia and foreign conferences:

- 17<sup>th</sup> International Multidisciplinary Scientific GeoConference (SGEM) on Ecology, Economics, Education and Legislation, Albena, BULGARIA, 29.06.2017-05.07.2017;
- VI International Student Forum "Green Bridge through Generations", Almaty, Kazakhstan, April 11-12, 2017;
- III International Congress of Young Scientists on Sustainable Development, Moscow, Russian Federation, May 17-27, 2017;
- VII International Student Forum "Green Bridge through Generations", Almaty, Kazakhstan, April 9-10, 2018.

**The author's personal contribution** is the formulation and conduct of experiments, the construction of multidimensional statistical models and the interpretation of their results, the calculation of parameters and modeling of a series

of problems of the plane problem of a turbulent diffusion model, and the generalization of the results by writing articles.

### **Publications.**

The main results of the dissertation were published in 9 publications:

- 1 article was published in the Journal, which included in the Scopus database (39 percentile),
- 5 articles were published in publications recommended by the Committee for Monitoring in the field of education and science of the Republic of Kazakhstan,
- 3 papers in collections of international symposia and foreign conferences.

### **Relationship with research and government programs.**

The theme of the dissertation submitted to the defense, “Assessment of the boron pollution dynamics of the groundwater and surface water of Ilek river valley”, was carried out as part of solving one of the priority environmental problems of the Aktobe region (Ilek river pollution with hexavalent chromium and boron).

### **The scope and structure of the work.**

The thesis is presented on 140 pages and includes 26 figures and 25 tables, 2 graphical appendix. The work consists of introduction, literature review, description of objects and research methods, results and their discussion, conclusion and list of used sources from 180 literatures.