ABSTRACT

thesis for the degree of doctor of philosophy (PhD) for

specialty 6D075500 – «Hydrogeology and engineering geology»

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Theme: «Hydrogeological and hydrogeochemical aspects of groundwater treatment from hexavalent chromium»

The relevance of the work. Growing technogenic impact on the environment seriously affect on a groundwater quality state, nowadays technogenic components are found not only in the upper, poorly protected unconfined aquifers, but also in deep artesian systems. Anthropogenic impact on groundwater has become particularly noticeable in the current century, due to the development and intensification of industry and agriculture, large cities growth and the expansion of urbanized areas. It causes depletion of groundwater resources and deterioration of their quality; there is a certain tendency for increase, not natural groundwater characteristic components (chlorides, sulphates, iron, etc.), but elements that are exclusively related to human activities - such as surface-active substances, pesticides, synthetic organic matter, etc.

To the class of "dangerous" ecotoxicants, refers primarily heavy metals whose circulation features in the environment are determined by their resistance, bioavailability and probability of causing negative effects at very low concentrations. In this aspect, chromium and its compounds, capable of long circulating in the environment, have a very negative effect on the natural environment. Along with Pb, Ni, As, Cd, Hg and a number of others, chromium as toxic element, which is alien to the biosphere, is produced in the amount of thousands of tons per year, enter the environment and pollute it locally and regionally.

The scale and intensity of anthropogenic impact on the state of groundwater in the mining complex is threatening. In this connection, urgent issues of timely detection, assessment of the degree of distribution and formation of hexavalent chromium contamination areas, analytical study of the state and impact of pollution on the water-rock system, development of scientific foundations for reducing the technogenic impact on the environment through improved pollution cleaning technology are extremely relevant.

One of the most promising technologies for groundwater treatment on a modern state is the in-situ technology of Cr VI, based on the creation of reaction zones directly in the aquifer, by injecting a reagent and reducing the hexavalent toxic form of chromium to a more stable trivalent one.

Among the main advantages of the in-situ treatment included the following:

- capital and operating costs for the construction of an injection units' network, usually lower than the costs for the performance of ground-based deposition stations;

- absence of ground facilities, turnover of washing water and disposal of sludge allows to save considerable funds, time for cleaning and the area of land plots treatment facilities;

- due to the fact that the products of sedimentation reactions remain in the subsurface space, directly in the aquifer, the injection reagent purification method from Cr VI is a non-waste technology.

The choice and justification of parameters for the effective treatment from Cr VI using in-situ technology requires consideration a number of basic hydrogeological and hydrogeochemical aspects: flow dynamics, the injectivity degree of the formation, dissolution and precipitation of mineral phases with a change in oxidation-reduction and acid-base conditions, adsorption-desorption processes, cations on the surfaces of solid phases, decrease in the number of active sorption sites, changes in activity and concentration of substances in solution et al.

Until recently, the creation of hydrogeochemical models, allowing to perform a quantitative description of these processes, was constrained by the lack of appropriate software. The absence of models adequately describing the behavior of chromium when interacting with other reactive-active substances in a complex hydrogeochemical water-rock system significantly complicated the selection and justification of the work on groundwater purification, requiring additional volumes of experimental and field studies and lowering the reliability of forecasts.

The **objectives** of the work were to improve the process of groundwater cleaning, by optimizing in-situ treatment method by constructing a hydrodynamic model taking into account the basic hydrogeochemical processes, selecting the optimum reagent concentrations, the location of the injection units, and conducting injection / pumping operations.

The main **research tasks:**

- scientific substantiation of the in-situ treatment for the purification of groundwater from hexavalent chromium;

- mathematical model development for convective and diffusion mass transfer, taking into account the processes that determine the geochemical behavior of chromium in porous media, including dissolution / precipitation processes, changes in activity and concentration of substances, ion exchange, adsorption / desorption, complexation, changes in acid-base properties of the medium, homogeneous and heterogeneous oxidation / reduction processes;

- development a methodology for the implementation and adaptation of database structures for the implementation of hydrogeochemical modeling;

- development of a system for operative control over the results of the injections carried out, on the basis of the constructed mathematical model, which allows conducting a controlled process of groundwater purification at the contamination site;

- recommendations on approbation and introduction of the developed methods and models in the practice of solving problems of groundwater purification from hexavalent chromium.

Scientific novelty of the results. By the results of experimental works performed the following statements have been obtained, which have scientific novelty:

- developed a system for the operational control of the process of groundwater purification from hexavalent chromium, based on the constructed mathematical model of the purification section;
- improved the method of injection units location, due to the construction of hydrodynamic flow charts;
- recommendations on optimization of the process of groundwater purification were compiled based on the pilot tests experimental studies.

Practical significance. Developed system of the operational process control for the groundwater purification has following practical significance:

- studied behavior of Cr VI during interaction with the reagent (iron sulphate heparahydrate) in complex hydrogeochemical systems;
- optimized process of operating hydrocycles, the location of injection units due to the constructed mathematical model;
- carried out a scientific justification of the volume and composition of the required experimental and full-scale studies to carry out in-situ treatment;
- increased the reliability of forecasts when selecting and justifying the parameters of in-situ groundwater treatment systems.

Work approbation. As a result of research on the topic of the thesis published 14 articles in co-authorship, including 3 in the international journal included in the SCOPUS database, 4 articles in the republican specialized publications recommended by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, and materials and theses of 7 reports at republican and international conferences, forums and congresses.