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ASSESSMENT OF THE IMPACT OF URANIUM PRODUCTION WASTE STORAGE FACILITIES ON THE ENVIRONMENT BASED ON THE RESULTS OF HYDROGEOLOGICAL MONITORING AND NUMERICAL MODELING

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INTRODUCTION

The largest uranium mining enterprise in Russia, Public Joint-Stock Company Priargunsky Industrial Mining and Chemical Union (PJSC PIMCU) was established in 1968. Uranium mining is carried out by underground mining on the basis of operating mines, and ore processing is carried out at a hydrometallurgical plant[1]], which began operating since 1976. Simultaneously with the commissioning of the GMZ, a sulfuric acid plant was started. The sulfuric acid was produced from pyrite cinders. Since 2009, the sulfuric acid plant has been switched to block sulfur.

The wastes with a residual radioactivity caused by processing uranium ore are deposited in a ravine in two tailing dumps, neutralized with calcareous water. A cinder storage facility for the wastes produced by pyrite roasting process at the sulfuric acid plant is located in the same ravine. These wastes are characterized by high sulfate ion concentration and a lack of radioactivity. All these storages are a wet type, in the landscape its represents as cascade of three lakes.

Leaks through earthen dams within the limits of normative losses are intercepted by a system of drainage wells in the lower tail of the storage facility dam and are returned into the technological process. Monitoring of leakages from them is carried out by 196 observation wells.

To inform the public about the state of the environment in the area where the enterprise is located, summarized results are published in annual environmental reports [2].

Wells field situated near a river is located within the study area provide water for a city with a population of 45 thousand people. Water is obtained from first aquifer of the intermountain artesian basin. The exploration wells are located in 12 kilometers from storages.

For over 40 years of the storages existence a contamination plume in the aquifer has formed by the filtration through earth dams. The plume does not exceed area of the sanitary protection zone of these three storages. As practice shows, the leaks through earth dams are very common for the wet type of tailings in old mines of hydrometallurgical plants (in Germany, USA, Canada, Niger, Australia, etc.) [3].

The main objective of this study was a conservative forecast of the spread of contamination plume towards the water intake. The forecast was carried out with two assumptions that from now on (from 2015), the collection of waste into the storage facilities is stopped and the interception of contaminated water by drainage wells in the lower tail of the cinder storage dam is stopped. Conservative approach means maintaining the concentration of pollutants in the sources at a constant level for the entire forecast period.

DESCRIPTION

The geological structure of the territory involves two structural floors. The lower floor is represented by Proterozoic and Early Paleozoic metamorphic rocks, Riphean, Vendian and Paleozoic granitoids.

The upper floor contains Mesozoic (J-K) terrigenous strata of sedimentary and sedimentary-volcanic rocks that fill up depressions and calderas, Upper Jurassic small intrusions of the Kukulbei complex and subvolcanic rocks genetically related to the Late Jurassic and Cretaceous volcanism.

The research area is located within an intermountain depression. The intermountain artesian basin is associated with this depression. This basin consists of a few aquifers which are hydraulically connected and formed an aquifer system. The upper part of a cross-section consists of conglomerates, sandstones, siltstones (Lower Cretaceous rocks) that overlap with Quaternary sediments of alluvial, limnetic and proluvial genesis, which are the main collector of fresh groundwater used for the city's water supply.

For generalize purpose once considered all types of groundwater in this basin as parts of unite aquifer system, but conditionally divided by the types of water-bearing rocks and their filtration properties.

Systematic observations of the state of the environment on the territory of PJSC PIMCU began in 1973. Hydrogeological monitoring is currently carried out in 196 observation wells.

Data analysis of groundwater level dynamic shows, that the longest observed steady period was the last 14 years. The groundwater average depth for this period is no deeper than 5 m on the most of the research area, which leads to a high rate of the evapotranspiration. The well field situated nearby the river doesn't make a significant impact on groundwater level, because pumping wells obtain water what before was discharging by evapotranspiration and the river.

Also, it is important to mention that near the location of tailings dumps are stand out a mine drainage, that cause a local groundwater depression and prevents the spread of contaminated water.

METHODS

Based on the created GIS project, digital elevation model, digitized geological maps, engineering geological well logs and hydrogeological monitoring data, a three-dimensional geological model (GM) was created in the GMS software package. The GM was used as the basis for filtration and solute transport models. In the transport solute model, sulfate ion is selected as an indicator of groundwater contamination, since it has the greatest migration capacity compared to other contaminants in storages.

Based on the analysis of the data of the geological site structure model was performed with a 4-layer. The area of the model is 4283 sq. km; the boundaries of the model are determined by the boundaries of the catchment basins.

To verify hydrodynamic and transport solute model, ground water levels and concentration of sulfate ion from observation wells located in the ravine were used. Once obtained a good convergence of field and model data. The deviations of the model and measured concentrations of the sulfate ion are within the limits of the determination errors.

RESULTS AND DISCUSSION

The simulation results indicate that the contamination plume from the first tailing dump is stable and partially discharged in the mine drainage. The contamination plume from the second tailings dump is less influenced by the mine drainage and its slowly spreading along the ravine toward the river. The cinder storage facility, which closes the cascade of simulated lakes, has the main role in the groundwater contamination process. As it was mentioned above the cinder storage facility is a main source of sulfate ion contamination that is the reason why sulfate ion is a very suitable indicator for this particular model.

The prediction modeling of remediation actions showed that in the case of complete elimination of the cascade of man-made lakes the currently existing plume of pollution will migrate at a significantly lower rate and gradually degrade due to hydrodynamic dispersion. Reduction of the sulfate ions concentration to the values of MPC for drinking water (500 mg / l) will take about 300 years

CONCLUSION

Conducting facility-focused monitoring allows implementing the concept of controlled pollution. This concept includes an information analysis system for facilities of the nuclear power industry based on facility-focused monitoring system of subsurface state, hydrodynamic and solute transport modeling and as a result an informational geo-ecological report.

Conclusions:

1. The current state of groundwater in the area of waste storages shows that the groundwater contamination does not exceed the boundaries of the sanitary protection zone for all kind of manmade pollutants;
2. The primary manmade contamination of groundwater is the sulfate ion coming from the cinder storage facility; uranium pollution mainly is intercepted by the mine drainage. Therefore sulfate ion was used in the solute transport model as an indicator of contamination spread;

3. Conservative forecast shows the spread of contamination in the groundwater from the tailing dumps does not reach the water supply wells even at the horizon of the forecast of 300 years.

REFERENCES

[1] www.priargunsky.amz.ru
[2] Environmental Safety Report PJSC PIMCU 2015 (www.rosatom.ru)
[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Technologies for the treatment of effluents from uranium mines, mills and tailings. IAEA-TECDOC-1296, IAEA, Vienna (1996).

Country or International Organization

Russian Federation

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