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SAFETY ASSESSMENT OF RADIOACTIVE WASTES STORAGE "MIRONOVA GORA"

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Abstract

A project of transforming the radioactive wastes storage "Mironova Gora" is under development. A safety assessment of this storage facility was performed to gain assurance on the design decision. The assessment, which was based on the safety assessment methods developed for radioactive wastes repositories, is presented in this paper.

1. INTRODUCTION

The storage facility for low and intermediate level wastes was constructed in the seventies. Radioactive wastes resulting from the maintenance and repair of atomic submarines were disposed off in this storage facility. There are two equal concrete vaults, with numbers 379 and 379a, at the territory of this storage facility. Radioactive contamination of soil, ground and surface water was determined in the nineties. The removal of wastes is considered now. The safety assessment was performed for resolving this problem.

In comparison with near surface radioactive wastes disposal facilities, the considered storage does not have any difference. The wastes are disposed in concrete vaults located in the ground, and the vaults are covered by concrete plates and by an asphalt cover. Because of these features, the conventional methods of safety assessment of radioactive wastes disposal facilities were used in this work. These methods were presented in [1]. Radioactivity transport with ground water was used as the main process of activity distribution in the environment.

2. MODELS OF ACTIVITY TRANSPORT AND INPUT PARAMETERS

The three dimensional numerical model of water flow and activity transport was used for the calculation of the distribution of radionuclides in the environment. The model was developed at the Institute of Biophysics and is described in [2, 3].

The main problem in the calculation of the distribution of contaminants in the environment is the lack of sufficient knowledge of parameters controlling transport processes. Such parameters serve as input parameters in the models. In this work, input parameters used are: hydraulic conductivity, distribution coefficient, diffusion and dispersion coefficients and others. These parameters must be known for all main nuclides and for all considered mediums: for wastes, engineered barriers and soils.

Most important is the source term modeling. In this case, the source term may by *modeled as activity release from wastes into water inside of vaults. Only special experimental* data and realistic empirical models may be used for real cases.

2.1 Wastes consistence and activity source term

Nuclides consistence and their activity was assessed by consideration of the available information about disposed wastes. The used equipment of submarines reactors, spent radiation sources and other wastes are disposed in vaults. According to [4] after 10 years the activities of the main nuclides in corrosion products of one submarine reactor are: ^{55}Fe - 3 Ci (1.1E11 Bq), ^{60}Č9 - 10 Ci (3.7E11 Bq), ^{59}Ni – 0.04 Ci (1.5E9 Bq), ^{63}Ni - 4 Ci (1.5E11 Bq), ^{90}Sr - 2 Ci (7.4E10 Bq), ^{137}Cs - 2 Ci (7.4 E10 Bq). The activity of these nuclides in activated metals is approximately three orders of magnitude higher, except ^{90}Sr and ^{137}Cs. It was assumed, that only nuclides from corrosion products can be transported into water. Nuclides in activated metal, in spent radiation sources and in other wastes were not considered. As the decay constant of ^{55}Fe is high, this nuclide was not considered.

The nuclides inventory was assessed by from the number of reactor equipment units in storage. It was assumed that in each vault the following amounts were present: ^{60}Co - 500 Ci (1.8E13 Bq), ^{59}Ni – 2 Ci (7.4E10 Bq), ^{63}Ni – 200 Ci (7.4E12 Bq), ^{90}Sr and ^{137}Cs – 100 Ci (3.7E12 Bq). The volume of one vault is 778 m^3 , and it was assumed that the volume of wastes is 600 m^3.

The measured total activity of water inside of the vault is 1E-7 Ci/l (3700 Bq/l). Activities of ^{90}Sr and ^{137}Cs in ground water outside of the vault near the walls are approximately some tens Bq/l. It was assumed, that in the vault activities of ^{90}Sr and ^{137}Cs are equal, and equal to total activity – 1E-7 Ci/l (3700 Bq/l). These assumptions are not very conservative, because water samples were taken from the upper part of the vault where dilution may occur.

The activity of ^{60}Co in ground water is 1 – 3 orders of magnitude smaller than the activity of ^{90}Sr. Therefore it was assumed that in water inside the vault, the ^{60}Co activity is 1E-8 Ci/l (370 Bq/l). The same activity in vault water was assumed for ^{63}Ni. For ^{59}Ni it is 100 times less.

The partition coefficient was used for source term modeling (the partition coefficient is the relation of activity in solid wastes to activity in water). Partition coefficients used were: 1400 for ^{90}Sr and ^{137}Cs, 70000 for ^{60}Co, and 28000 for ^{59}Ni and ^{63}Ni.

2.2 Sorption and filtration parameters

The concrete vaults are located in sands and in gravel. Rocks are distributed only near the vaults. The surrounding ground consists of loam and sandy clay. The clay layer is located at a depth of 6 m, the bottom of the vaults is also located at a depth of 6 m.

The distribution coefficient of ^{90}Sr and ^{137}Cs for sand and loam was obtained from measurements of nuclides concentration in ground water and in soil. These measurements were performed in wells [5]. The average ratio of activity in soil and in water (distribution coefficient) for ^{90}Sr is 5, for ^{137}Cs it is 100. The distribution coefficient of cobalt usually is higher in comparison with strontium and smaller than its value for cesium. Therefore the distribution coefficient for ^{60}Co was taken as 15, and the same value was used for nickel. It was assumed, that for clay all distribution coefficients are three times higher.

The hydraulic conductivity according to [5] amounts to 0.001 m/day (1E-8 m/s) for clay, 0.01 m/day (1E-7 m/s) for loam, 2 m/day (2E-5 m/s) for sandy clay, and 10 m/day (1E-4 m/s) for sand. It was assumed that longitudinal and transverse dispersion equals 10 m and 2 m respectively. The active porosity was taken as 0.3.

The previous calculation of ^{90}Sr migration in the time frame of 20 years was performed by using different values of hydraulic conductivity of concrete for obtaining correct conductivity values. Using a concrete conductivity of 1E-4 m/day (1E-9 m/s), the calculated activity in ground water near the vaults is approximately equal to results of measurements (some tens Bq/l) [5].

This value of conductivity was used for the first 50 years. It was assumed that the conductivity of concrete increases with time. Increase of conductivity by ten times is assumed to occur after 50, 150 and 300 years. For the time after 500 years, complete disintegration of the concrete was assumed, i.e. conductivity of concrete is equal to the conductivity of sand.

Characteristic times for changes of concrete properties were taken from [6, 7]. According to [6], 50 years is the lifetime of a concrete cover of "Radon" type concrete vaults, and 150 years is the lifetime of the foundation. The predicted lifetime of concrete vaults is usually 300 – 500 years. The values of fractured concrete conductivity used in this work are in agreement with data given in [7].

The velocity of ground water flow and the distribution of the water level were calculated by applying the three dimensional equation for hydraulic head. It was assumed that in the first 300 years the vaults will be filled by water (present situation).

3. RESULTS OF CALCULATIONS

Two scenarios of activity transport from repository to ground surface (into surface water) were used in this work:

First scenario – discharge of ground water into a small pond near the storage at a distance of 25 m (this is the scenario of the present situation);

Second scenario – discharge in brook at a distance of 500 m. The second scenario assumes performance of certain work for storage safety: filling the nearest pond by soil, providing institutional control and monitoring, establishing sanitary-protective zone with radius 500 m, etc.

The main result of first scenario is: activity of ^{90}Sr in water, discharged in pond, may be higher than the limit of the Russian regulatory document [8] (45 Bq/l); the time of the activity maximum for ^{90}Sr is 75 years. Activities of another nuclides discharged in pond water are less than regulatory limits, but in case of water discharge at ground surface near vaults, activities of other nuclides may be above regulatory limits.

In the second scenario, the activity of ^{59}Ni is the maximum activity of water discharged in brook water at a distance of 500 m, the time of maximum activity in this case is 2500 years. But the maximum activity of ^{59}Ni is three orders of magnitude lower than the regulatory limit. It may be concluded that activity limits will not be exceeded at the boundary of the sanitary-protective zone.

The most important problem of safety prediction is the uncertainty of the results. Comparing calculations with experimental data is the most effective method of uncertainty analysis. The results of calculations performed in this work of ^{90}Sr and ^{137}Cs activities near the vaults are in agreement with results of measurements reported in [5] (some tens Bq/l).

4. CONCLUSIONS

The radioactive wastes storage "Mironova Gora" now is a dangerous object for radioactive contamination of the environment and potential human exposure. The main danger is connected with flooding of concrete vaults and activity transport on ground surface by ground water near storage. Certain works must be done before realization of the wastes removing project. The follwing needs to be done for storage safety: filling the nearest pond with soil, hydro-isolation of vaults, pumping water from vaults, establishing institutional control and monitoring, and a sanitary-protective zone with a radius of 500 m. After completion of the work mentioned above, the storage "Mironova Gora" may be considered as a safe object without negative impact on the environment and the public.

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