



The study of migration of radionuclides in radioactive waste repository surroundings

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State policy on radioactive waste

- ⊙ Poland is one of the few European countries without nuclear power.
- ⊙ In Poland, there are only low and intermediate level waste
- ⊙ Radioactive waste in Poland originates from research reactors, scientific, educational institutions, industry and hospitals.
- ⊙ The spent fuel from the research reactors was returned to Russian Federation
- ⊙ In 28.01.2014, the Council of Ministers adopted a program of Polish nuclear power





National Radioactive Waste Repository in Poland (NRWR)

- National Radioactive Waste Repository in Rózan is the only place of disposal of radioactive waste in Poland.
- NRWR is located at the former military fort (covering an area 3.045 ha)
- According to the classification of IAEA, it is a surface landfill for final disposal of short-lived, low and intermediate level waste and sealed radioactive sources.



- It is also used for temporary storage of long-lived waste, mainly alpha-radioactive, waiting to dispose them in a deep geological repository.
- Solid and solidified waste are placed in concrete buildings of the fort or in the moat and flooded with concrete with the addition of bentonite, which, due to the sorption properties, improves the effectiveness of insulation





To ensure the maximum objectivity of radiological studies of the environment, they are carried out additionally by:

- ◉ The Radiation Measurements Laboratory
- ◉ The Central Laboratory for Radiological Protection
- ◉ The Institute of Nuclear Physics on behalf of the National Atomic Energy Agency
- ◉ The Polish Geological Institute – The National Research Institute

Effectiveness of applied protection (barriers) are systematically checked by inspection:

- The radiological exposure of employees based on individual measurements,
- The radioactivity of the basic elements of the environment (air, water, soil, vegetation),
- The radiation levels in and around the repository.



Due to the fact that the landfill in Rózan will be closed in 2020 because of exhausted storage capacity, in Poland started work on finding new location for the landfill of low-and intermediate-waste.

- IPPA Project (Implementing Public Participation Approaches in Radioactive Waste Disposal) was a project within the Seventh Euratom Research and Training Framework Programme (FP7) on Nuclear Energy of the European Commission. The project, developed in 2011-2013, was coordinated by Karita Research, Sweden
 - "Development of methodology to evaluate the safety and identify the optimal location of shallow disposal of low and intermediate level radioactive waste", started in 8th of May 2013
-

Additionally, there is a Polish Underground Storage Program (PURL) initiative, which is a common idea of research institutions responding to the needs of the national economy and sustainable development. It is intended to continue the research and development of deep repository undertaken in Poland in the late 90s of last century.



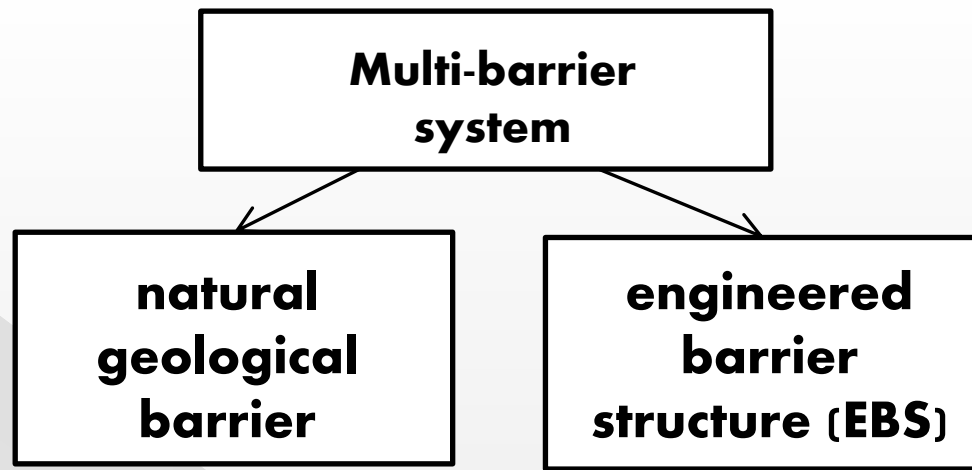
The migration of radionuclides

Migration of radionuclides into the aquatic environment can be a result of natural evolution of the environment and slow degradation of barriers. The danger of radionuclide release depends on the type and activity of the waste (radionuclides) disposed and their release rate.

Properly defined quantitative assessment of the mechanisms, which affects the migration of radionuclides is essential to carry out accurate calculations and estimates for long-term safety of the repository. Therefore :

- ⊙ The studies of migration of selected radionuclides in the established system of protective barriers and the created scenario of leaks are performed;
- ⊙ The sorption of radionuclides on the materials used as protective barriers, artificial and natural should be determined,
- ⊙ There are many computational codes for simulations of pollutants movement in the geosphere and transport modeling, which allow forecasting repository behavior during long-time operation.





Sorbents: bentonite, clay, zeolites

Artificial barriers: metal and concrete tanks, stainless steel, asphalt seals

Barrier systems require continuous improvement based on progress in the field of materials in science and new engineering solutions.

The environmental research and monitoring of pollutants should be conducted at all phases : during design of the facility, during operation of the repository, and after closing-up.

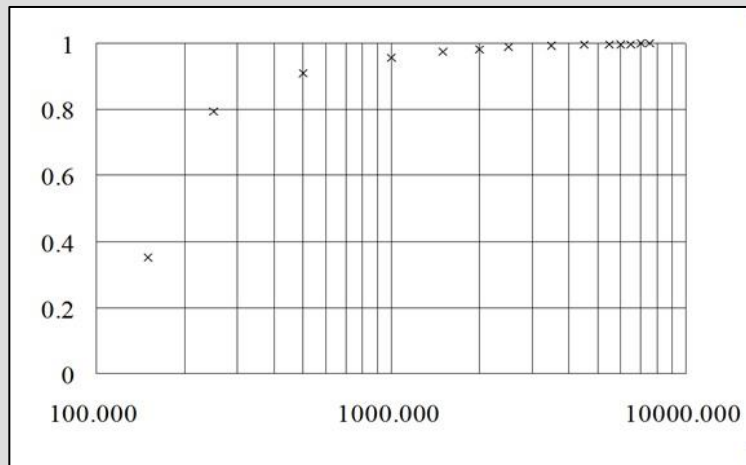
They allow verification of previous laboratory studies on the migration of radionuclides and durability of designed protective barriers.



Sorption of radionuclides on the materials used as protective barriers

Effect of the sorbent concentration on sorption efficiency of cobalt ions

adsorption efficiency [%]

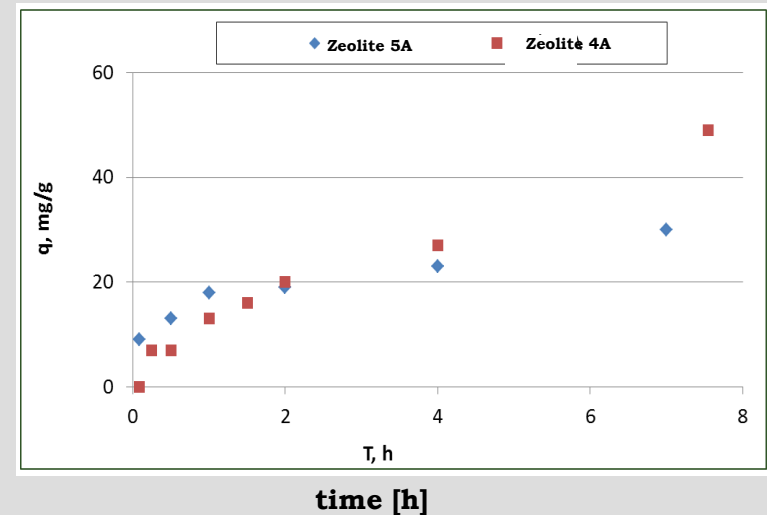


ratio between the bentonite and the cobalt [g / g]

$[\text{Co}^{2+}]_0 = 0,02 \text{ g/l}$, $T = 25^\circ\text{C}$, $t = 3\text{h}$

The kinetics of sorption of Co^{2+} on zeolites 4Å i 5Å

sorption capacity [mg/g]



$[\text{Co}^{2+}]_0 = 100\text{mg/l}$, $[\text{Co}^{2+}]/[\text{sorb.}] = 1/10$,
 $\text{pH} = 6,5$

Adsorption efficiency of cobalt on bentonite increases with increasing ratio between bentonite and cobalt ions and it reaches 100% at bentonite to cobalt ratio of 2000



Numerical tools and codes

Single phase flow (+Richardson)

- Modflow
- Feflow
- Porflow

Solute Transport

- MT3D
- Feflow
- Porflow

Two phase flow

- Tough2

Richards' equation

$$\nabla [k_r k_s (\nabla h + \nabla z)] + q = F \frac{\partial h}{\partial t}$$

k_r -relative hydraulic conductivity

k_s -hydraulic conductivity tensor in saturation zone

h -height of pressure

z -height of position

q -function expressing the power or water consumption

The evaluation of the multi-barrier system is carried out after detailed tests to determine its parameters and after analysis, including mathematical modeling of contaminant migration.



Conclusions

In connection with further activities concerning the development of new repositories for low, intermediate and high level waste in Poland, it is necessary to put greater emphasis on safety.

Therefore, the following methods are being implemented:

- ⊙ The barriers used at present are still improved;
- ⊙ Computer simulations are being carried out to avoid black scenarios such as gaping of protective barriers
- ⊙ There are more accurate geological and geophysical researches in potential localizations for siting the repositories.

