
Contribution ID: **217**

Type: **ORAL**

# Development of mine water quality, subsequent sediments contamination and passive 226Ra treatment in Zadní Chodov, Czech Republic –case study

*Tuesday 26 June 2018 17:20 (20 minutes)*

INTRODUCTION

The uranium deposit Zadní Chodov was discovered using a car-borne gamma survey in the year 1952. In 1958, the uranium mining area Zadní Chodov was established, covering 7.16 km2. During operation, 5 mining shafts were constructed on the deposit [2]. Shaft No. 1 with a total depth of 401.6 m was closed in 1963, the shaft No. 2, reaching depth 761.8 m was closed in 1989. Shaft No. 3 was excavated to 28th floor level in depth of 1263.2 m. Furthermore, there were shafts No. 12 (780.4 m depth) and No. 13 (1083.8 m depth). As with many other ore deposits in the Czech Massif, local uranium ores were exploited by using method of cut-and-fill stopping and gradual top-slicing stoping under a man-made ceiling.

MINING HISTORY

Uranium ore was mined at the site for 40 years and the total production exceeded 4,000 t U (the 6th largest deposit in the Czech Republic). The exploration activities were completed in 1988, and mining operation ceased in 1992, concurrently with many other mines during the first wave of ordered mining activities reduction. The mine was closed, the surface area mitigated, while waste dumps material was processed into crushed aggregates. In February 1993, the underground water pumping was discontinued and spontaneous flooding of mine was allowed.

MINE WATER TREATMENT

Due to the mine flooding, in March 1995 the water streamed to the surface, yielding 15 L/s. To resolve these circumstances, a Hydrogeological Study of the Region was performed aimed to asses a final management system for the water outflow and subsequent treatment [5]. A drainage system was built in the area of concern, connected to an accumulation pond followed by a decontamination station (water treatment plant). The captured mining waters were continuously sampled prior to entry, while the dissolved contaminants, especially Uranium and Radium, were monitored.

The initial high Uranium and Radium concentrations associated with the first flush effect had in first five years (1995 –2000) a declining trend.
In November 2001, a borehole HVM-1 was drilled from the surface to the second mine level, from the area with the lowest surface elevation (from the "melioration ditch") and thus was created a new pathway, allowing efficient, spontaneous runoff of the mine water to the surface, while reducing the water level inside the mine. This was done to eliminate any previous outflows and enable the deposit to be gravitationally drained.

In 2010, the mine water reached quality which allowed its release into the watershed, without pumping and cleaning. Since then, the mine water has been experimentally discharged without cleaning into the melioration ditch that leads to the Hamer Creek, however the mine water treatment plant (decontamination station) is still on standby and ready to be activated if necessary.

MINE WATER, SEDIMENTS AND LEGISLATION FRAME

The initial high Uranium and Radium concentrations associated with the first flush effect had in first five years (1995 –2000) declining trend. Nowadays mining water has a low content of dissolved solids (ca 300-350 mg/L) and hydrochemistry has greatly stabilized. Unat. (less than 0.1 mg/L on average) and 226Ra (1,600 mBq/L on average) concentrations do not show significant anomalous variations since 2010.

In accordance with valid Czech legislation in the field of radiation protection, the quality of the discharged mine water is continuously monitored and concentration of 226Ra is also monitored in the sediments along the melioration ditch up to the Hamer Creek estuary. Currently along approximately 900 m of the stream there are 11 monitoring locations. Measured concentration values are compared with reference levels. Particular attention is paid to the accumulation of 226Ra in the sediments along the upper segment of the melioration ditch. If the values of the Radium concentrations in the sediments would consistently exceed the reference levels, and the contamination would spread towards the Hamer Creek, the situation would have to be addressed. One possible solution would be reactivation of the decontamination station. Therefore, a preliminary exploration of the area was launched in 2017 to test other potentially useful methods of "cleaning" mine water on the site.

## ENVIRONMENTAL IMPACT ASSESSMENT

Through the year 2017, an in-situ gamma spectrometric survey of the area, surrounding the mine water outflow, was conducted to determine the background values of natural radionuclides and localized possible anomalies of 226Ra or Unat mass activities. This was carried out mainly in locations of the previous water exhausts and in the area of the melioration ditch. The monitored locality is minimally populated and presently used as a grazing pasture for cattle. The gamma spectrometry method did not show exemption levels of radionuclides in the soil, the only possible source of cattle contamination could be the pasture watering system. Based on known concentrations of radionuclides in water, a commitment effective dose was estimated for a representative person, resulting from the meat consumption of cattle, grazing on the site under observation, in the usual pasture regime. At the recommended consumption of 20 kg of beef from Zadní Chodov area, the estimated commitment effective dose was calculated at less than 1 μSv.

## WATER VOLUME-LIMITED TREATMENT EXPERIMENTS

Experimental treatment of the outflowing mine water using adsorbents was started in May 2017, based on studies documented in [1, 3, 4, 6, 7]. Two different adsorbents –peat and zeolites (grain size 1-1.25 mm, 2.5-5 mm and 4-8 mm), was placed at the bottom of the 200 L volume barrels. A part of the borehole whole volume of water entered the barrels bottom and passed through the adsorbent layers and finally overflown the barrels. The water flow rate was measured continuously. The peat had low effectiveness from beginning of the experiment and was washed out due to its low specific weight. The treatment using zeolites grain size 4 –8 mm resulted in very low efficiency and thus both experiments were terminated.

Next step was the use of smaller adsorbent pellets (grain size 1-2.5 mm and 2.5-5 mm) starting in June 2017. The testing continued for 4 months and the water samples for radionuclides concentration measurement (before and after treatment) were taken 5 times per week and later 3 times per week. The relative effectiveness of 226Ra treatment was calculated.

## DISCUSSION

The water flow rate in barrels was approximately 0.25 L/s, effective height of barrels was 80 cm and the thickness of the zeolite layer was 20 cm. Taking into account that zeolite layer decrease effective flow volume by about 50 percent, the time interval for contact between water and zeolite is estimated to be 1 minute 40 seconds. In case of zeolite with grain size 1.0-2.5 mm the average initial adsorption ability reached 70%, which after 3 month of experiment duration decreased to level of 40%. In comparison the zeolite of grain size 2.5-5 mm had average initial adsorption ability approx. 80%. The linear trend describing radionuclides concentration decrease indicates adsorption ability about 50% after 4.5 months of operation.

The average water flow rate from the drilling well HVM-1 was from October 2016 to September 2017 14.92 L/s. It could be expected that with increasing of the adsorbed radioactive contaminants (and minerals) the adsorption ability of the zeolites will decrease. In case of desired higher water flow rate the amount of required adsorbent must increase proportionally, to maintain the same treatment effectiveness. So far performed introductory experiments do not enable correct estimation of direct dependence between amounts of zeolite used, water throughput and treatment efficiency. Given the above mentioned parameters interdependence, for cleaning mine water using throughput of 15 L/s would require 60 times higher volume of adsorbent to achieve 50% capture effectiveness for 226Ra. That corresponds to 3 tons of zeolite utilization during each 4 month period.

## COST BENEFIT ANALYSIS

In the years 2008 - 2010, the average annual cost of running the mine water treatment plant (using the conventional barium chloride active treatment process) was on the order of millions CZK. Searching for less expensive alternative, a zeolite-based cleaning technology could be passive, greatly reducing the operating costs. If we will consider the use of common "pool mixes"and the adequate amount of approximately 10 ton, the cost of adsorbents consumption can be at the level of hundred thousand CZK per year. In that case it is necessary to add the cost of maintenance, control, monitoring, removal of contaminated materials and landfill. All these operations are expected to be one order less expensive than water treatment plant in operation.

CONCLUSIONS

On the basis of the available data, the passive method of mine water treatment at the site of Zadní Chodov, using zeolite adsorbents, appears to be potentially applicable. Mining water at the site has low mineralization with a low proportion of suspended matter, which has a positive effect on the life of the sorbent [4]. For the first experiments, commonly available "pool mixes"of adsorbent based on clinoptilolite were utilized. However, it would be desirable to utilize adsorbents based on synthetic zeolites which could have much higher efficiency for adsorption of 226Ra. Higher efficiency and capacity of the adsorbent would, of course, mean overall cost saving, lower consumption, simplification of the loading, unloading and transport process, while reducing the amount of "waste" to be deposited at the tailings pond. Assembling a technological unit utilizing the zeolite technology will be the subject of further deliberation. The main issues will be:

- Choice between settling tank and closed piping system
- Ensuring a uniform flow through the adsorbent - avoiding preferential path formation
- Testing the effectiveness of different types of adsorbents
- Adsorbent recycling options
- Use of a wetland system - the natural way of the mine water cleaning

These and other tasks are planned for the next stages of testing the mine water treatment process in Zadní Chodov and assumes that the findings will also be used at other localities, where the deposition of mine water can cause ecological load.

REFERENCES

[1] BARESCUT, J., CHAŁUPNIK, S., WYSOCKA, M. Radium balance in discharge waters from coal mines in Poland the ecological impact of underground water treatment. Radioprotection, 44-5 (2009), 813-820.
[2] DIAMO, s. p.. Závěrečná zpráva o ložisku Zadní Chodov. DIAMO, státní podnik –správa uranových ložisek, o. z. Příbram (1996).
[3] CHAŁUPNIK, S. Impact of radium-bearing mine waters on the natural environment. In Radioactivity in the environment (Vol. 7, pp. 985-995). Elsevier (2005).
[4] CHAŁUPNIK, S., FRANUS, W., WYSOCKA, M., GZYL, G. Application of zeolites for radium removal from mine water. Environmental Science and Pollution Research, 20-11 (2013), 7900-7906.
[5] ŠTROUF, R. Hydrogeologická studie podchycení plošného výronu důlních vod na lokalitě Zadní Chodov. MS, AQUATEST –Stavební geologie a.s., (1999).
[6] WANG, S., PENG, Y. Natural zeolites as effective adsorbents in water and wastewater treatment. Chemical Engineering Journal, 156-1 (2010),11-24.
[7] WENDLE, G. Radioactivity in mines and mine water-sources and mechanisms. Journal of the Southern African Institute of Mining and Metallurgy, 98-2 (1998), 87-92.

## Country or International Organization

Czech Republic

**Primary author:** Mr WLOSOK, Jirí (DIAMO, state enterprise)

**Co-authors:** Mrs THINOVÁ, Lenka (DIAMO, state enterprise); Mr ČERMÁK, Martin (DIAMO, state enterprise); Mr BICAN, Radek (DIAMO, state enterprise)

**Presenter:** Mr WLOSOK, Jirí (DIAMO, state enterprise)

**Session Classification:** Health, Safety, Environment and Social Responsibility

**Track Classification:** Track 10. Health, safety, environment and social responsibility