RESULTS OF PILOT STUDIES OF ENVIRONMENTAL RESTORATION OF URANIUM MINING TAILINGS PONDS IN HUNGARY

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After more than 35 years operation the uranium mining and milling facilities near Pécs city in Hungary were finally shut down in 1997. One of the most important and most complicated tasks is the remediation of tailings ponds because of the complexity of chemical, radiological and geotechnical requirements of the restoration. Tailings ponds are potential sources of radioactive contaminants through both aerial and terrestrial pathways. The potential risk of environmental contamination from the latter route has been substantially decreased by pretreatment of the soil (liming) before construction. The main task of the restoration now is to decrease radon emanation and wind erosion of the ponds, to give geotechnical stability and environmental friendly shape to the resulting pile and to prevent soil erosion from the slopes.

In the first pilot study concrete rings of 1 m diameter filled with test layers of different materials were used for in situ examination of radon infiltration. In total 11 columns were studied, including the uncovered pond as a reference point. Radon concentrations of the layers were measured by monitors equipped with scintillation soil probe, and in parallel radon flux was measured on the top of each column.

On the basis of the evaluation of the results two covering options have been designed for detailed studies on in-field on territories cover about 2000 m². Radon concentration in the layers, radon emanation from the surface of the cover were measured, and in situ gamma dose rate at 1 m height over the cover has been done.

Key words: remedial action, uranium mining and milling, tailings pond, radon emanation

INTRODUCTION

After more than 35 years of operation the uranium mining and milling activities near Pécs city in the south part of Hungary were terminated at the end of 1997. Appropriate strategy and complex plans have been prepared for the remedial action. The main principle of the restoration planning is the applying of step by step approach taking into account the local conditions of the area to the maximum extent possible. Because, every site being undertaken for restoration has a particular specifications, so in effect different solution is needed for each mining and milling site. For the sake of achieving a good solution to restoration problems a number of experiments and investigations have been performed on the given site.
MAIN SITE CHARACTERISTICS

By-products of the uranium milling have been disposed of in two tailings ponds. The ponds have been built with ring dike and drainage system. The area of each pond is 1 million m\(^2\), and these contain about 20.3 million tons of solid particles and 9.1 million tons of liquid phase.

Material in the tailings ponds contains the residuary isotopes of the uranium decay series after the ore processing. The radiation levels of the ponds are the following:

- Uranium content of solid phase: 55-75 g/t
- Uranium content of liquid phase: < 0.1 mg/l
- Average Ra-226 activity concentration of solid phase: 12.6 Bq/g
- Average Ra-226 activity concentration of liquid phase: 5.2 Bq/l
- Radon activity concentration inside ponds: 40-1100 Bq/m\(^3\)
- Radon flux inside ponds: 4-8 Bq/m\(^2\) s
- Dose rate inside ponds: 1.4-10.0 µGy/h

BASIC PLANNING REQUIREMENTS

According to the radiation protection requirements of planning, radon flux from the surface of the restored tailings pond should be less than 0.7 Bq/m\(^2\) s, radon activity concentration in the open air shouldn't exceed background + 20 Bq/m\(^3\), external dose rate above the restored site should be less than background + 200 nGy/h.

PILOT STUDY WITH COLUMN MEASUREMENTS

One of the most important tasks of the restoration of tailings pond is to decrease the radon emanation and external gamma dose rate. A programme has been launched to test different solutions for cover layers including type of cover materials and its thickness under in-situ conditions.

In the first step, 1 meter diameter concrete rings are used for building test layer series and different arrangements of materials. Out of 11 options being studied, the first option is the uncovered tailings taken as a reference option. The concrete rings are constructed in a leak tight mode and in the middle part of each layer a sampling tube is introduced in order to measure the changes of radon concentration Radon concentrations of the layers were measured by radon meters equipped with Lucas cell (AB-5, Pylon Electronics Inc.), sampling was performed by soil probe (Pylon Electronics Inc.). At the same time, radon flux was measured on the top of each column (Alphaguard, Genitron Instruments, RGM-3).
RESULTS OF COLUMN MEASUREMENTS

It's concluded that heap leaching materials to be planned to use as mechanical support layer contain a lot of radionuclides, so this material shouldn't give the best solution owing to the expected high radon emanation. Other materials have acceptable level of radioactivity.

Measurements of radon concentration in the layers showed that the thicker the layer the higher the radon concentration in it. It means that the thicker the layer the more radon is retained in it (Fig 1. ). The multilayer and the flying ash options show a good radon retention properties. Data of radon exhalation of the top of columns demonstrate a negative correlation between layer thickness and exhalation (Fig 2.). Radon exhalation depended on seasonal variation, so the lowest values were measured in winter, and this situation was caused by freezing through the column material.

On the basis of evaluation of column measurements, two options have been selected for the detailed in-field studies.

PILOT STUDY WITH IN-FIELD MEASUREMENTS

In the second step, two test fields have been established for analysing of covering solutions. The area of each in-field territory is about 1000 m² (20m x 40m), and these options are close to the final cover version. The first cover option was designed from bottom to top: 30cm radon retention material, 40cm clay, 20cm drainage (crushed limestone), 60cm clayey loess; the second option differ from the first one only that the first and second layer have been built from the same material (70cm radon retention material).

The radon activity concentration were measured with the help of 3-3 sampling wells on both fields. The sampling well comprises 15 flexible and leak tight tube introduced in each 10 cm of height of cover system. So the measurement of the radon concentration were carried out by 10 cm in the cover layers. Parallel, radon exhalation from the surface of the cover were measured nearby the sampling wells. Besides, gamma dose rate measurements were performed, too.

RESULTS OF IN-FIELD MEASUREMENTS

The measurements of radon gas was achieved by using equipment having scintillation chamber and real time mode apparatus equipped with different detectors (AB-5, Pylon Electronics Inc.; PRASSI, Silena Ltd.) These instruments can measure radon gas in soil after sampling, continuously radon activity concentration in air together with radon daughter activity concentration. The radon flux was measured by 4 channel instrument which can simultaneously collect the meteorological parameter, too (Alphaguard, Genitron Instruments Ltd., RGM-3). The measurements were performed in different seasonal time and it's concluded that both experimental cover options can reduce the radon activity concentration from tailings pond to surface layer by order of the magnitude of 2-3 (Fig 3.).
Similarly the radon emanation has reduced by order of the magnitude of 2-3, so the level of 2-4 Bq/m²s on the uncovered tailings pond has been decreased to the level of 10-60 mBq/m²s on the surface of both cover options.

The in-field gamma dose rate was measured by large scintillation detector (Automess, Berthold Ltd.) at 1m above the cover in 3 x 6 mesh points. The measurements were carried out at the beginning state of cover system and at that time when the layers have got into steady state.

The final conclusion has been drawn that all data of in-field measurements fulfil the radiation requirements.

REFERENCES


Figure 1: Radon retention in the columns
Figure 2: Radon exhalation rate from the surface of the columns
Figure 3: Radon activity concentration of the test field I and II