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Radon exhalation studies for the remediation of uranium mill tailings ponds in Hungary

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RESUMEN

En 1997 se cerraron en Hungría minas de uranio y plantas de molienda del mineral que habían operado durante más de 35 años. Se usaron anillos de concreto de un metro de diámetro con capas de prueba de distintos materiales para examinar la exhalación de radón in situ. Se estudiaron en total 11 columnas, incluyendo un estanque sin cubrir como punto de referencia. Se midieron las concentraciones de radón de las distintas capas, así como el flujo de radón en la parte superior de cada columna. Basándose en la evaluación de los resultados se diseñaron dos opciones para estudios detallados del área de jales que cubre aproximadamente 2000 m^2. Se midieron las concentraciones de radón en las capas, la emanación de radón de la superficie de la cubierta y la rapidez de dosis gamma a un metro por encima de la cubierta.

PALABRAS CLAVE: Minería y molienda de uranio, estanque de jales, remediación, radón.

ABSTRACT

After more than 35 years operation the uranium mining and milling facilities were shut down in Hungary in 1997. Concrete rings of 1 m diameter filled with test layers of different materials were used for in situ examination of radon exhalation. In total 11 columns were studied, including the uncovered pond as a reference point. Radon concentrations of the layers were measured by radon monitors, and radon flux was measured on the top of each column. On the basis of the evaluation, two covering options have been designed for detailed in-field studies on the tailings area covering about 2000 m^2. Radon concentration in the layers and radon emanation from the surface of the cover were measured, and in situ gamma dose rate at 1 m height over the test cover was measured.

KEY WORDS: Uranium mining and milling, tailings pond, remedial action, radon.

1. INTRODUCTION

The uranium mining and milling activities near Pécs in the south part of Hungary were terminated at the end of 1997. Appropriate strategy and complex plans have been prepared for remedial action. The main principle of the restoration planning is a step-by-step approach taking into account the local conditions of the area to the maximum extent possible. For the sake of achieving a good solution to restoration problems a number of experiments and investigations have been performed on the site.

2. MAIN CHARACTERISTICS OF THE TAILINGS PONDS

By-products of uranium extraction were disposed 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 they contain about 20,3 million tons of solid particles and 9,1 million tons of liquid phase. The radiation levels of the ponds are the following:

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_Gy/h

According to the radiation protection requirements, radon flux from the surface of a restored tailings pond should be less than 0,7 Bq/m^2s, radon activity concentration in the open air shouldn't exceed a background level of 20 Bq/m^3, and external dose rate above the restored site should be less than background + 200 nGy/h.

3. PILOT STUDY WITH COLUMN MEASUREMENTS AND RESULTS

One of the most important tasks of the restoration of tailings ponds is to decrease the radon emanation and exter-

nal 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. The concrete rings with 1m diameter are used for 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 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 At the same time, radon flux was measured on the top of each column.

Measurements of radon concentration in the layers showed that the thicker a layer the higher the radon concentration is in it. It means that the thicker a layer the more radon is retained in it. The multilayer containing 3 or 4 different layers and the flying ash options built up with different thicknesses (30 - 60 cm) show a good radon retention properties. Data of radon exhalation of the top of columns demonstrate a negative correlation between layer thickness and exhalation. Radon exhalation depended on seasonal variation, so the lowest values were measured in winter. On the basis of evaluation of column measurements, two options have been selected for the detailed in-field studies.

4. PILOT STUDY WITH IN-FIELD MEASUREMENTS AND RESULTS

Two test fields have been established for analysing of covering solutions. The area of each in-field territory is about 1000 m^2 (25m x 40m), and these options are close to the final cover version. The first cover option was designed from bottom to top: 30 cm fly ash (radon retention material), 40 cm clay, 20 cm drainage (crushed limestone), 60 cm clayey loess; the second option differ from the first one only that the first and second layer have been built from the same material (70 cm radon retention material). The radon activity concentration was measured with the help of sampling wells on both fields. The 3 x 3 sampling wells were built so that these wells contained flexible, gastight tubes introduced in the cover system at 10 cm height. So the measurement of the radon concentration were carried out from the tailings to the surface. Parallel with, radon exhalation from the surface of the cover was measured nearby the sampling wells. Besides, gamma dose rate measurements were performed, too.

The measurements were performed in different seasons and it's concluded that both experimental cover options can reduce the radon activity concentration from tailings pond to surface layer by 2-3 orders of the magnitude. Similarly the radon exhalation has been reduced by 2-3 orders of the magnitude, so the level of 4-8 Bq/m^2s on the uncovered tailings pond has been decreased to the level of 10-60 mBq/m^2s on the surface of both cover options. The in-field gamma dose rate was measured 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 values of gamma dose rate varied from 250 to 350 nGy/h.

5. CONCLUSIONS

The concrete criteria of the radiation levels for the restored area concerning gamma dose rate, radon concentration (in open air) and radon exhalation are 380 nGy/h, 30 Bq/m^3 and 0,7 Bq/m^2s, respectively. So the final conclusion has been drawn that all data of in-field measurements fulfil the radiation requirements.

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