Environmental impact evaluation of a pilot installation for „in situ” processing for uranium ore

Stefan Petrescu, Dan Georgescu, Simona Ciuciu, Dragos Curelea

Research and Development National Institute for Metals and Radioactive Resources, 70, Bd. Carol I, Sector 2, 020917 Bucharest, Romania,
E-mail: icpmrr@icpmrr.ro

Abstract. As a result of the Gamma Geological Research during the 1955-1956 period in the south-west of Romania, there were identified some radioactive anomalies organized in 16 areas. These are placed near Danube River and some of its confluent rivers (Streneac, Ilişova). The exploitation of the Ilisova Uranium Ore started in 1962 and it was partially suspended in 1972. The exploration and exploitation activities restarted in 1976. In the same time it was also started the pilot project consisting in the acid leaching “in situ” of the Uranium Ore extracted from the Ilişova Mines. After 1990 the activity was stopped and all activity abandoned. In 2002, the closing and rehabilitation procedures of the perimeter affected by the exploitation and exploration of the Uranium Ore was started, especially because this perimeter is in the National Park “Portile de Fier” land.

Introduction

The Ilisova Uranium exploitation is located in south-west of Romania, in Banat region at about 50 m from Danube River, on the left side.

The pilot plant for “in situ” leaching of Uranium ore is located inside of Ilisova Exploitation at about 100 meters from G3, G6 and G7 Galleries (Fig. 1).

In order to identify pollution sources that generates by means of their radio elements content and also by different ways, additional effective doses to critical groups, it was need to perform the following investigations:

- Field measurement of gamma rate dose in matrix
- Rock sampling and analyses for U, Ra, Cu, Pb, Zn, Ni, Co.

- Water sampling
- Determination of Radon level
- Preservation of water, soil, sediments and vegetation samples from area around the pilot

Pilot plant for in situ leaching of U ore

In the region of DN 57, at +83 m altitude, a pilot plant for U leaching was built.

This plant consists in an ore deposit having a 6200 sqm surface, a concrete tank for leaching, having a 1000 sqm surface and an U recovery module formed by two columns having 6x3 meters each.

After 1990 year the pilot was set out of order after the suspension of the activities, without developing any closing or ecology project of the area.

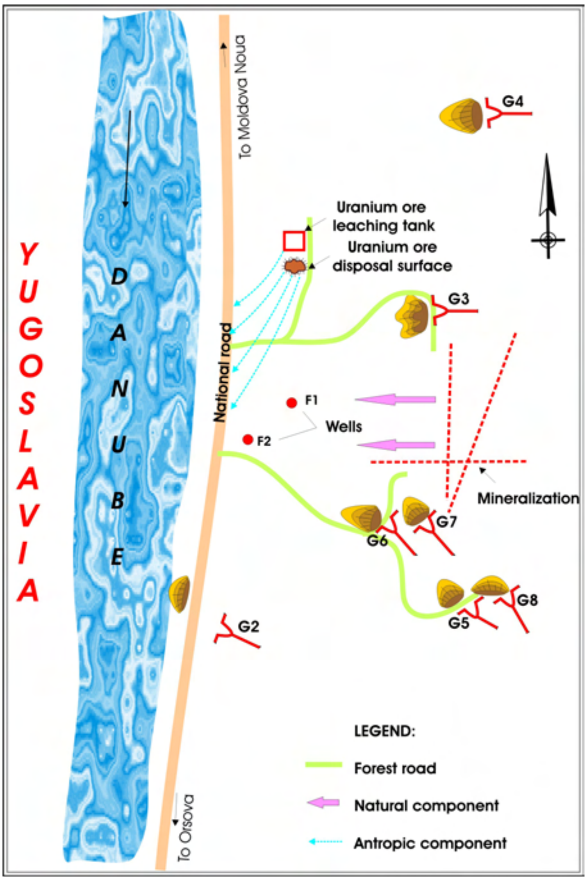

Fig. 1. Ilisova exploitation.

In the concrete tank remained small amounts of materials, in the preserved samples finding the contents: U = 100 ppm, Ra = 2 Bq/g, As = 100 ppm, Cu = 55 ppm, Pb = 60 ppm, Mo = 325 ppm, V = 17 ppm, Ni = 25 ppm, Zn = 36 ppm.

By proceeding measurements in a 5/5 meters matrix in order to determine gamma rate dose on entire tank surface, levels between 0.8 μSv/h – 4.4μSv/h were found.

Close to concrete tank exists a storage surface for U ore used in experiment here, measurements for gamma rate dose performed in a 10/10 meters matrix and about 4.800 sqm surface revealed maximal levels of 2.5μSv/h (Fig.2).

In the preserved samples from this area were found the following maximal element contents: U = 351 ppm; Ra = 2.8 Bq/g; As = 370 ppm; Cu = 310 ppm; Pb = 242 ppm ; Mo = 10 ppm; V = 17 ppm; Ni = 120 ppm; Ag = 250 ppm; Zn = 120 ppm.

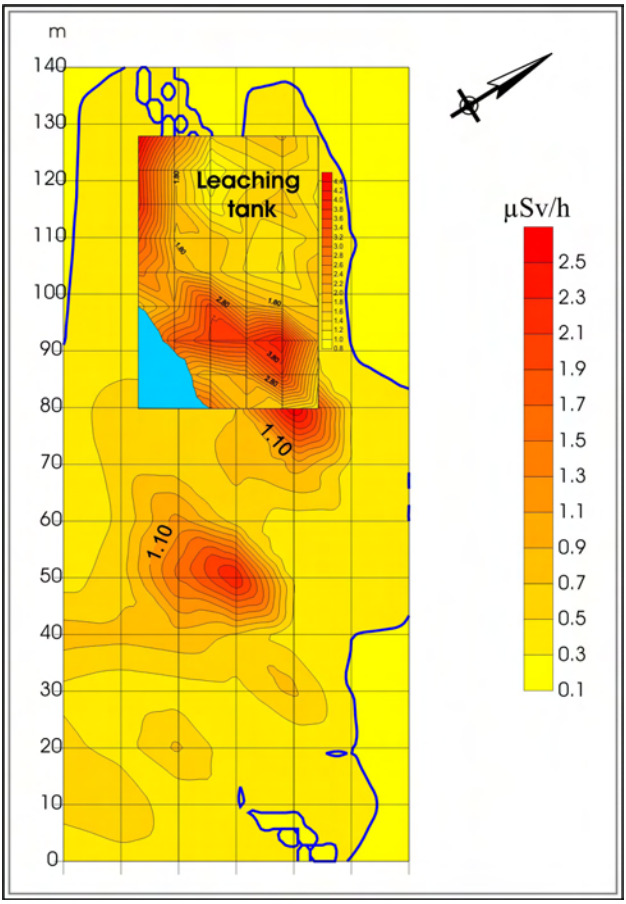

Fig. 2. Gamma debit dose distribution in ore leaching tank and around.

About 80% from surface of ex- ore deposit is now naturally vegetative covered and integrated in the natural landscape of the area. Rn^{222} content inside the concrete tank is 350 Bq/ m^3 on the ex- deposit surface, Rn^{222} content being130 Bq/m^3. Two wells, F1 and F2 are located close to ex- ore deposit and from this water samples were preserved. The levels for radioactive elements were slowly higher than background level: in F1

U = 0.036 mg/ l; in F2, U= 0.09mg/l and Ra = 0.11 Bq/ l.

Higher U levels, mainly in F2 could have the following explanation: ground-water washes the upper size of some uphill mineralization or it is contaminated by waste-waters which run off from leaching tank and from ex- deposit surface (Fig.1).

The annual effective dose evaluation

A main objective regarding radioprotection in exploration and exploitation of nuclear raw materials is to assess the supplemental permissible doses due to internal and external irradiation that could accidentally or permanently exist.

The International and also Romanian Legal Standards (August 2000) provide for each individual person supplemental effective dose by 1 mSv/ year. This level involves all different ways resulting sources from industrial activity in area that person lives.

This supplemental dose (E_{Supl}) by 1 mSv/year overlay background supplemental effective dose ($E_{T\ back}$). Thus, the local effective dose (E_T) is a sum of those two:

$$E_T = E_{supl} + E_{T\ back}$$

So,

$$E_{Supl} = E_T - E_{T\ back}$$

where: E_T- totally effective dose in presence of background;

E_{Tback}- background effective dose;

E_{Supl} – supplemental effective dose caused by all sources from area;

The annual effective dose (E_T), named also effective dose equivalent (EDE) is:

$E_T = E_\gamma + E_i^c + E_i^a + E_{hi} + E_{hRn}$, where

E_γ = external effective dose;

$E_i^c + E_i^a$ = ingestion effective dose;

$E_{hi} + E_{hRn}$ = inhalation effective dose;

$E_{T\ supl} = E_T – E_{T\ back}$

where:

$E_{T\ back}$ = local background dose;

Supplemental effective dose estimation for a person who lives nearby Ilisova exploitation (ex-ore deposit surface and G6 gallery)

Supplemental effective dose estimation will be performed for all the exposure path ways: aquatic way (ingestion), by air (inhalation), ground way (gamma irradiation).

Dose estimation due to ingestion for one person (aquatic way)

We assumed that person uses mine water from G6 gallery and from F2 well, this water having the following contents: U = 0.028 mg/ l, Ra = 0.006 Bq/l for mine water and U= 0.090 mg/l, Ra = 0, 11 Bq/l for F2 water.

In this case supplemental effective dose received by a person is:

$E_{i\ sup}^{a}$ = 0.207 mSv/year

Effective dose estimation due to external irradiation

The highest levels of gamma debit dose were registered on ex- ore deposit surface and inside of leaching tank. It was found a value of 4.4 μSv/year of gamma debit dose which comply with a U content by 419 ppm and Ra content by 10 Bq/g. We assumed that person stays in the area five months, 6 hours/day each (900 hours). There were taken into account only five months, because the nearby houses are not permanent, being used only in summer season.

Thus, annual effective dose due to gamma irradiation is $E_{\gamma T}$= 4.7 mSv/year, $E_{\gamma back}$ being 0.981 mSv/ year. The resulting supplemental effective dose is $E_{\gamma supl}$ =4.7 – 0.981 = 3.710 mSv/year.

Dose estimation due to Radon inhalation and to short lifetime radionuclide

Based on very high Radon content at the gallery entrance, G6 (17.300 Bq/m^3) and on 5 months interval of 6 hours/day each (900 hours), the effective dose will be:

$E_{hRn\ 1}$ = 39.236 mSv.

At this value is added the time spent by person in normal condition (6100 hours).

$E_{hRn\ 2}$ = 0.384 mSv for Rn^{222}= 25 Bq/m^3.

Note: Gallery entrance G6 is extremely close to a house, at about 30 meters.

Thus, the annual effective dose due to inhalation is $E_{hRn\ T}$ = 39,62 mSv/year.

Taking into account the background Rn content $E_{hRn\ back}$ = 0.441mSv/year , the resulting supplemental effective dose will be $E_{hRn\ back}$ = 39.179 mSv/year.

Evaluation of dose due to inhalation of dust containing long time radionuclides

In order to evaluate this dose the following preliminary data were using:

- Stationary time 900 hours
- dust content in atmosphere = 0.0001 g/m^3
- U content = 0.035%
- Ra content = 2.8Bq/g
- U activity level in aerial dust = 0.00087 Bq/m^3
- Ra activity level in the aerial dust = 0.00028Bq/m^3.

$E_{hi\ sup}$ = 0.025mSv/year

The supplemental effective dose is the sum of the entire doses:

$E_{T\ sup} = E_{i\ sup}^{a} + E_{\gamma\ sup} + E_{hRn\ sup} + E_{hi\ sup}$

$E_{T\ sup}$ = 43.130 mSv/year.

The most influence in supplemental effective dose is given by Radon content from gallery entrance G6. Although conditions and data from this scenario are almost impossible to accomplish, over 43 mS/year level represents a very high risk for people around the area.

Conclusions

As a result of pilot plant for “in situ” U leaching processing, about 7000 sqm surface was contaminated and a part of ground water of the ex-ore deposit also. At present the highest risk for population is concrete tank, which still contains amounts of ore and the ex- ore deposit surface that could be any time used for a picnic by the tourists came to visit the“Portile de Fier” National Park.

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