ENVIRONMENTAL ASPECTS AND SAFETY CONSIDERATIONS - # 10373 AT URANIUM -MANAGEMENT FACILITIES IN ROMANIA

Gheorghe VIERU*, Ioan Muntean**
** Institute for Nuclear Research*
0300 Pitesti, P.O. Box 78, ROMANIA
*** Uranium National Company (CNU)–*
Bucharest, Romania

ABSTRACT

This work contains the main aspects during the transport and disposal of NORM (uranium ore, tailings, uranium waste) in Romania and, where appropriate, assessments are made of radiological impacts of these transport and disposal operations.
Specific problems related to the safety, environmental monitoring aspects of such activities-transport and disposal of tailings, there are also analyzed. The study express a significant part of the research carried out by the main author and, is concluded, that the level of the estimated doses for transport and disposal are within acceptable limits

INTRODUCTION

This paper is a part of the research activities carried out by the main author to assess environmental aspects, radiological consequences, risk and safety of NORM materials disposal and transportation in Romania and is a result of the work within the IAEA CRP (Co-coordinated Research Programme) on NORM entitled**:** *The appropriate level of regulatory control for the safe transport of naturally radioactive material (NORM)* **where the main author, is** Chief Scientific Investigator for the Romanian Scientific Research Contract concluded with the IAEA Vienna [1].

Safety and security during mining operation of very low radioactive material (NORM) such as uranium ore, tailings and uranium waste, transport are matters of international importance [1, 3].

The objective: is to protect persons, property and the environment from the effects of radiation during these operations of radioactive material [3].
The Management of Radioactive Material (RAM) including NORM-Naturally Occurring Radioactive Material is an essential activity and, consequently, the IAEA will continue to preserve an important role in the international approach for a safe management of these materials;

Safety and Security in the transport of NORM is a national responsibility while international standards and approaches to safety promote consistency, help to provide assurance that nuclear materials and radiation related technologies are used safely and facilitate international technical cooperation and trade [1,3];

In Romania, the Uranium National Company (CNU) is responsible, for [2]:

- exploitation of the uranium ore;
- transport and processing of the uranium ore;
- concentrates processing and delivering of the final products, e.g. U_3O_8 and UO_2.
- Safety disposal and transportation of the processing waste.

The company has several subsidiaries in Romania, among them are: Bihor (Baita), Suceava (Crucea), Banat (Oravita) and Feldioara (Brasov).
In Figure 1 are presented the routes of RAM Transportation in Romania including NORM:

Figure 1 Routes of RAM transportation in Romania including NORM transport

TRANSPORT OF URANIUM ORE

As indicated on the map, the uranium ore is transported from Bihor (Baita), Suceava (Crucea), Banat (Oravita) subsidiaries, by railway, to the CNU Feldioara for processing. Every special wagon used for transport has approximately 50 t of uranium ore.
From uranium ore mine, Crucea to the Vatra Dornei railway station (Suceava subsidiary), approx. 42 km, and the ore is transported by road, by means of the special licensed trucks.
Every truck is loaded with 13 tones of uranium ore. From uranium ore mine Baita to the Stei railway station (Bihor subsidiary), approx 26 km, the ore is transported by road, by means of special licensed trucks also [1, 2].
The uranium dioxide concentrate, processed at CNU Feldioara (Brasov) is transported, by road, to the Nuclear Fuel Plant, Pitesti.

DISPOSAL OF THE URANIUM MILL TAILINGS AT CNU FELDIOARA BRASOV

The disposal option in mud-setting ponds sites was chosen for very low-level waste resulting from handling or the transformation of Naturally Occurring Radioactive Material (uranium ore).
Whatever the waste level of activity to be considered, the intrinsic safety of the selected option is assessed through an approach without exemption or clearance levels, which is only based on radiological impact studies demonstrating the special care and respect for human beings of the limit of exposure of the public of 1 mSv.person. y^{-1}.
The mill tailings present a low to very low activity which decreases very slowly. They owe their radiological characteristics to the natural radioactive elements initially present in the ore (mainly radium 226). Approximately the total sum of the daughters of uranium are present in mill tailing and the specific activity accounted is about 10^5Bq/kg.
The mail tailings are disposed (at Feldioara CNU Subsidiary) near the place of production, in natural basins (mud-setting pond), valley closed by dam. These entire disposal are managed by CNU Bucharest. The disposal site was subjected to remediation
On arrival, at CNU Feldioara processing facility, the uranium ore is processed in order to obtain uranium concentrate (yellow cake).
After processing within Feldioara nuclear facilities, the resulted uranium mill tailings, is transported by means of an Ø 219 mm pipe, approx. 2 km, to a mud-setting pond.
In this sludge bed pond take place the gravity settling decantation.
The solid uranium mill tailings fall at the bottom of the pond and the liquid part is transferred, through a pumping system in the Mittelzop sludge bed. The uranium waste has an uranium content of about 6mg/l and the activity of about 152.1 Bq.
Again, from this liquid part, the uranium is recovered, through a special procedure, and the remained liquid is transferred to the OLT River. The maximum uranium content of the waste transferred into the waters of OLT River will not exceed 0.6 mg/l. The restriction (pass criteria) for uranium content of the waters of OLT River is less than 0.021 mg U/l.
The CNU have written a detailed procedure related to ***the remediation of the disposal site***, among them are the followings:

- disposal in conventional landfill sites is the best solution of the efficient management of the mill tailings;
- Radiological impact is of prime importance but should not be neglected other concerns including the potential damages of the dam (earthquake, erosion, rupture of dam, etc.);
- the change of the use of underground waters may be checked by means of constraints;
- radiological consequences within the long term must be assessed through the study of standard scenarios corresponding to possible hazards situations;
- the procedure have to be done taking into consideration the concern of ensuring the diversity of the expertise and the correct and prompt information of the public;
- Protection of the health of population against the danger of ionizing radiations in accordance with the Euratom Directive no. 96/29. The dose limits applicable to the population have to be estimated in the most realistic way.

DISPOSAL OF THE STERILE URANIUM ORE AT CNU SUBSIDIARIES URANIUM MINES AND ITS MANAGEMENT

The uranium ore extracted from the uranium mine CRUCEA, BAITA and Oravita is radiometric sorted and if the quantity of the ore has less than 0.004% uranium content this is considered sterile and is deposited on a special conventional landfill sites.

These places are strictly delimitated as “controlled zone” which is checked regularly by the Nuclear Regulatory Body from Romania–CNCAN (National Commission for Nuclear Activities Control).

The ore, with more than 0,02% uranium content is transferred in special tanks and from here the uranium ore is transferred into the trucks and transported to the respectively railway stations.
In the followings figures 2 and 3 these activities are shown:

Figure 2 Disposal of uranium sterile

A specific study has to be performed for each types of waste of each producer e.g. all CNU’s subsidiaries. The results have to be addressed to the administration of disposal sites along with the request for elimination as a basis for the definition of the source term to consider the impact study and to assess the acceptability of the wastes.
When the dose is higher than 1mSv, the producer has to search an appropriate way to dispose of its waste taking into consideration the providing of the radiation protection programme.

Figure 3 Truck loading with uranium ore

ENVIRONMENTAL ASPECTS

Potential release of radionuclides from NORM–uranium ore-as air dispersion or to water pathway have been assessed taking into account site-specific geological and hydro-geological conditions and based on to normal scenario.

This scenario describes expected evolution of the disposal system including natural degradation of engineered barriers in long term perspective such as: minimal intrusion time through the repository 150 years, advection flow through repository for 250 years is 0.1x Inf (Inf = natural infiltration rate of 0.015m/y), for 250-650 years is 0.5 x Inf, for 650 Years - 1x Inf.

Based on the results obtained, the maximum activity concentration of radionuclides in the water through environment, in the last 5 years is, for Baita uranium mine location, presented in the next two figures, 4 and 5, as follows:

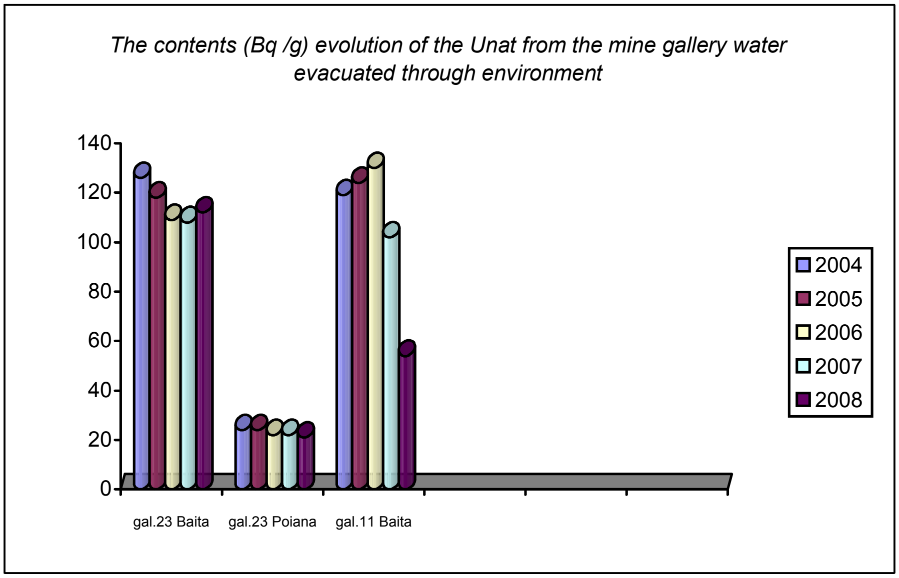

Figure 4 the contents (Bq/g) evolution of U nat from the mine gallery Baita

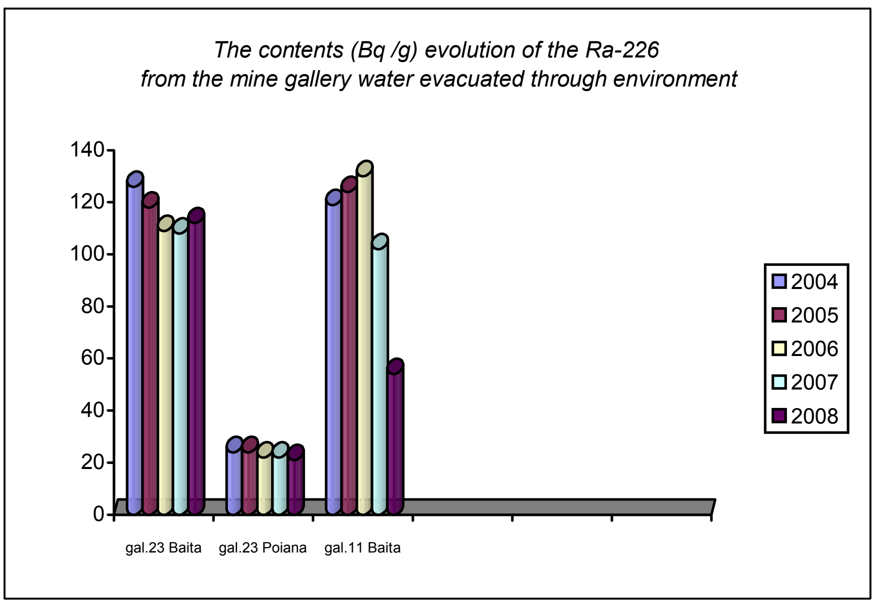

Figure 5 the contents (Bq/g) evolution of the Ra-226

It is to be considered that the activity concentration of other radionuclides in groundwater is considerably lower. If we referring to the Uranium mine Baita also [1], it was determined that the effective dose for workers to be no more than 20 mSv/y; The equivalent dose for the population around the mine (about 3km radius) it was determined to be 0.3 mSv/y; The collective dose determined was to be 0.2 mSv/y within the same area [1]. These doses were estimated using the IAEA’s computer code INTERTRAN II and the SANDIA’s RADTRAN 5 computer code.

THE DISPERSION FACTORS

Around mining area (about 1km), where the mining rocks formation taken place in a zone with the higher background, the problem of the correct interpretation of data as there were estimated by computer codes is a sensitive target [1].

The following results were obtained:

- External irradiation: (0.5 ÷ 5 μSv/h);

Average contents of U nat and Ra 226, in soil:

- U nat = (8.72 ± 0.97) g / t
- Ra 226 = (40.14 ± 2.07) g / kg

Average contents of U nat and Ra 226, in vegetal area:

- U nat = (7.72 ± 0.65) g / t
- Ra 226 = (110,0 ± 12.0) g / kg

With referring to the Radon 222, it is to be noted that the values of concentration are smaller than the sensitive limit of 1589 Bq/m3. The Radon Concentration (RC) was determined [1] by using a specific formula in two zones: *the witness and the impact* zones.

In the *Witness* zone we determined:

- Total effective dose (mSv) = 5.88

And in the *Impact* zone we determined:

- Total effective dose (mSv) =15.50

In case of the normal evolution scenario the annual effective dose for all radionuclides transferred to the environment it was estimated not to exceed 1.4 x 10xE-6 Sv/y;

The estimated annual effective dose is lower than dose constraint of 0.2 mSv/y

IDENTIFICATION AND THE EVALUATION OF THE POTENTIAL RISKS DUE TO THE TRANSPORT AND DISPOSAL OF THE VERY LOW LEVEL RADIOACTIVE WASTE

TRANSPORT BY ROAD

As shown in Figure 1 the routes for transport of the uranium ore and uranium concentrate are both by road and by rail modes.

In order to evaluate the dose resulting from possible road accidents involving these radioactive shipments [4, 5, 6], based on the frequency of occurrence of accidents of specified severities the IAEA computer code INTERTRAN II has been used. On the other hand for rail transport a probabilistic risk assessment method (PRA) has been adopted for this work aimed at quantifying the potential radiological consequences and the expected probability of occurrence of such accident sequences [7].

Data to be used as input data to the computer code INTERTRAN II has been provided by postulate possible accidents scenarios [2, 4, 6] such as: transport hazards (fixed impact hazard, mobile impact hazard), accident frequencies by road. Based on these there were calculated road accident probabilities such as

- probability of impact only: 0.421×10^{-5} per journey;
- probability of impact and fire: 1.50×10^{-10} per journey;

It is also assumed that, following an impact, the content may become available for dispersion.

The collective dose assessed areas follows:

- dose to public along route: $0.25x10^{-5}$ person.Sv.y^{-1};
- dose to public during stops: $0.37x10^{-8}$ person.Sv.y^{-1} ;
- dose to truck crew: $0.47x10^{-5}$ person.Sv.y^{-1}

The total annual collective dose is: $0.72037x10^{-5}$ person.Sv.y^{-1}
The associated latent cancer fatality risk is estimated at $0.77x10^{-10}$ y^{-1}.

TRANSPORT BY RAIL

There are different kinds of operation contributing to the overall risk, such as: rail transport, rail road transfer activities (from Crucea to Vatra Dornei and from Baita to Stei), handling and misoperation activities, etc. Transport and handling possible accidents may occur and pose a potential risk for the public and the environment [1, 2].
Because the occurrence of such accidents is statistical in nature, the probability risk assessment (PRA) has been adopted in order to quantify the potential radiological consequences and the expected probability of occurrence of such accidental sequences.
The potential radiological consequences have been calculated by using INTERTRAN II computer code. The calculated radiological risks include [1, 6]:

- radwaste exposure of the public and transport personnel from routine (incident free) transport of the very low level radioactive material (uranium ore);
- transport accident resulting in radiation exposure of the population and contamination of the environment

The accidental sequences include steps such as:

- characterization and the type and quantity of shipment;
- determination, selection and description of the type, severity and probability of occurrence of transport and handling accidents;
- assessment of potential radiological consequences for the spectrum of wealth condition encountered along the rail route;

The IAEA computer code INTERTRAN II has been used to determine the collective dose to population and transport personnel and the preliminary risk assessment results are [2, 4, 5]:

- crew: $1.34x10^{-5}$ person.Sv/y;
- members of the public: $1.78x10^{-5}$ person Sv/y;

TOTAL**:** 3.12×10^{-5} person Sv/y
Radioactivity releases are not expected to occur in close proximity to a possible accident site at a probability level as low as 10^{-7}, i.e. a chance of 1 in 10 million for the total volume of the uranium ore to be transported.

CONCLUSIONS

The disposal of the mining processing waste (uranium ore) as well as the disposal of sterile in Romania is a very complex problem taking into consideration the importance and the need of the safety for such activities.
The Romanian Nuclear Regulatory Body-CNCAN set up strictly regulation and procedures according to the Recommendation of the IAEA Vienna and other international organizations. The National Uranium Company (CNU) has adopted and implemented the adequate regulation and procedures in order to keep the environmental impacts and the radiological consequences at the lower possible level and to assure the safety in carrying out these activities including

transport and the disposal site at the acceptable international levels. The levels of the estimated doses for transport and disposal are within the acceptable limits provided by national and international regulations and recommendations.

ACKNOWLEDGEMENTS

The author wants to express deeply thanks to the IAEA Secretariat for the strong support, both technically and financially, under contract. in order to carry out the scientific research for the peaceful goals of the use of nuclear energy for progress of the mankind.

REFERENCES:

1. G. Vieru, "Final Report on NORM, the IAEA CRP-Appropriate Level of Regulatory Control for the Safe Transport of Naturally Occurring Radioactive Material (NORM)", IAEA Vienna, 2009;
2. G. Vieru et al, "Consideration on the safety disposal and transportation of the mining processing waste (uranium ore) in Romania", paper accepted for presentation at ALTA 2006 Conference, Australia;
3. IAEA Nuclear Security Series Guide-Security of Radioactive Material during Transport, (2007);
4. G. Vieru, "Risk and Safety Evaluation in Radioactive Waste Transport in Romania", RAMTRANS, Vol. 10, No. 2, pp. 105-112, London, UK, (1999);
5. G. Vieru, "The Identification and the approach of the risk and safety problems associated with the transport of radioactive materials in Romania", Romanian Nuclear Program, Internal Report, INR Pitesti, Romania, (2002);
6. G. Vieru, "Safety criteria for the transport and storage of the Radioactive Materials, in Romania", Romanian Nuclear Program, Internal Report, INR Pitesti, Romania, (2001);
7. G. Vieru, "The Safety of Transport of Radioactive Materials in Romania", RAMTRANS, Vol. 14, No. 1, pp. 15-27, London, UK, (2003);