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BIOSPHERE CONCEPTUAL MODEL DEVELOPMENT IN THE FRAME OF BAITA BIHOR REPOSITORY SAFETY PROJECT

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Abstract

The topic of this paper is the development of the biosphere model in the frame of the preliminary performance assessment of the Romanian National L&ILW repository, Baita-Bihor. The work presents the actual understanding of the radionuclide pathways through the repository adjacent area and their conceptualization, collection of required data, implementation of model and preliminary calculation results. The model takes into consideration a leaching scenario from the near field and the transport of radionuclides by river water. The critical group is a small community of inhabitants relying on the local resources, which constitutes an agriculture community "small farm system". On the basis of the defined specifications (biosphere equations and data), application of model and dose rate estimates were performed by the ABRICOT code.

1. Introduction

The Romanian national L&ILW repository Baita Bihor is placed into former Uranium mine at 840 m above sea level. Even though, since 1985 the repository is under operation, up to now a safety analysis was not achieved. During the last 16 years, the environmental radioactivity of the repository impact area was monitored by dose rate measurements and sampling. Low values of the artificial radioactivity were measured in soil, vegetation and river water samples. No evidence of transfer of radionuclides from repository emplacement wastes was found.

2. Biosphere model

2.1. Description of transport pathways

In the absence of a Romanian standard for environmental transport of the radioactive material through the environment and human exposure pathways, the German radiation protection ordinance [2] and the Canadian standard [3], with proper modifications and site specific available data, were considered. According to the geographical and hydrographical features of the site, the hypothetical critical group consists of a small resident community of two villages (Baita Plai, 94 inhabitants and Baita Sat 940 inhabitants) living immediately downstream the repository. This small group of inhabitants relying on the local resources constitutes an agriculture community, "small farm system" [6]. After discharge of the radioactivity into the river, the contaminated water is assumed to provide part of the water drunk by men and animals or used to irrigate gardens. Possibility of soil contamination after river flooding is considered. Exposure consists of the combination of exposure by ingestion of contaminated water and contaminated food products and external exposure due to soil contamination.

Biosphere receptors	River Soil Crops (pasture, root and green vegetable) Animals (cows and fish) Water (irrigation, drinking)
Biosphere transport media	River, irrigation and drinking water Soil Pasture
Biosphere transport mechanisms	Water abstraction for irrigation and drinking water Foliar interception Root uptake Adsorption Ingestion of water, pasture and soil by cows and ships Leaching Erosion River flow
Human exposure mechanism	Inhalation Ingestion of water, crops, beef, milk and fish External exposure

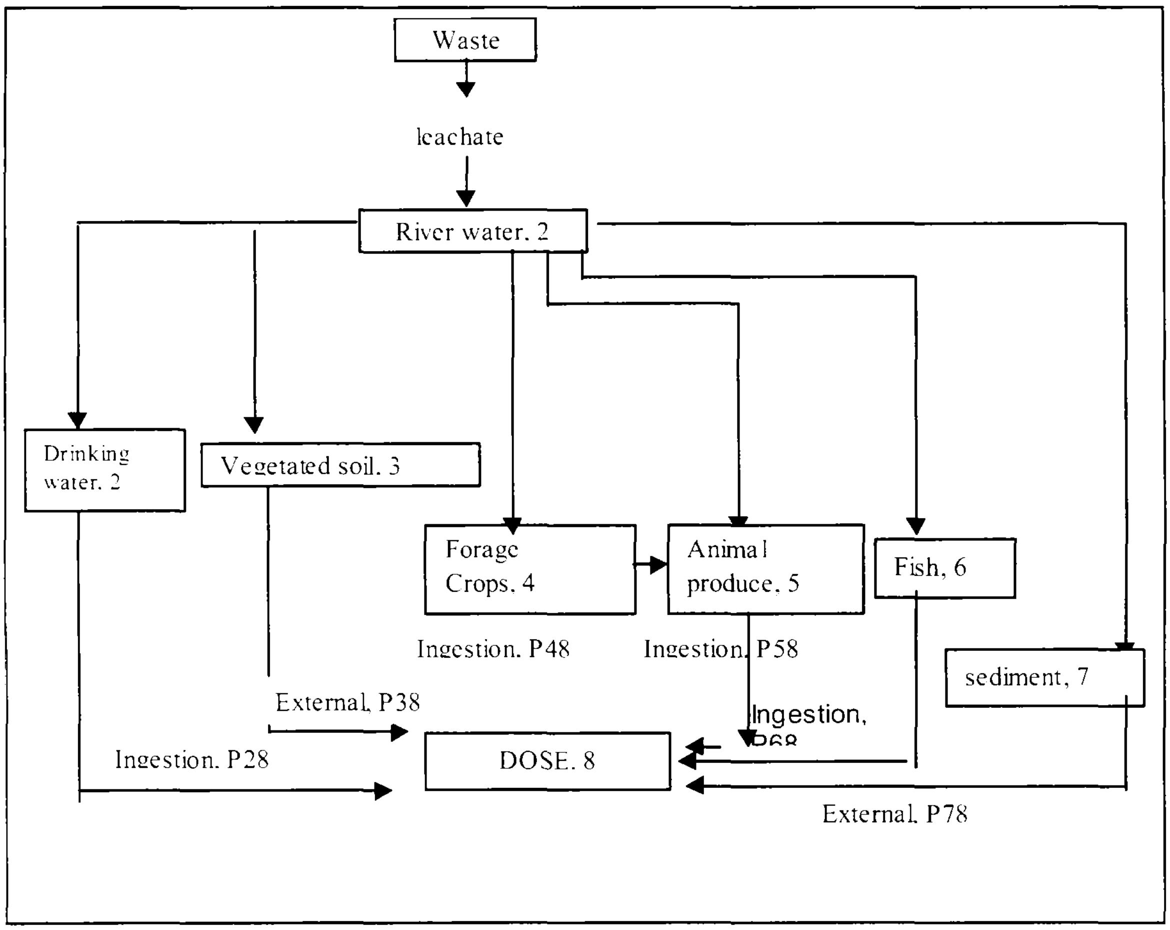

Figure 1. The simplified representation of the transport paths.

The local habits and diet are similar to the rest of country. The simplified model of transport of radioactive material through the environment and human exposure pathways, via river water, is shown in Figure 1. Steady-state condition for the transfer of radioactive material from one compartment to another was supposed. In the frame of the base case scenario of the Baita-Bihor repository performance assessment, the most suitable biosphere scenario [1], was defined by the following biosphere receptors, transport media and mechanisms:

Each block or compartment in the diagram is numbered, and the concentration in compartment i is denoted by C_i. Transfer from compartment i to compartment j is characterized by a pathway transfer parameter P_{ij}, such the amount in compartment j arising from compartment i under steady-state conditions is $P_{ij} C_i$ [6].

2.2. *The annual effective dose*

The annual dose is a sum of external and internal exposure. External exposure is caused by the gamma radiation of radioactive material present on the soil. Internal exposure is due to ingestion of contaminated drinking water and foodstuff (vegetal and animal produces). The contamination of drinking water, vegetal and animal products are due to contamination of river water.

2.2.1. External exposure

From all the external pathways, only the ground shine is considered, due to contaminated soil. The exposure from radioactive cloud could be considered only on a severe accident caused by an strong explosion inside of the repository. The equation for annual external dose for tissue T, due to contaminated soil with radionuclide r, ($H_{T,r}$) is [2]:

$$H_{T,r} = C_{soil}\, g_{T,r}\, t_{soil}$$

where:

C_{soil} = radionuclide r concentration in soil, in Bq/kg;
$g_{T,r}$ = dose conversion factor, Sv h^{-1} Bq^{-1} kg
t_{soil} = time, h/year

2.2.2. Internal exposure

Generally, inhalation and ingestion of water and food give the internal annual dose. In DNDR-Baita normal status, the inhalation pathway can be neglected. Therefore, the annual dose on tissue T due to ingestion of radionuclide r via foodstuff, in Sv, is:

$$H_{T,g,r} = (U^{Pf} C_r^{Pf} + U^{Bl} C_r^{Bl} + U^{Mi} C_r^{Mi} + U^{Fl} C_r^{Fl})\, g_{g,r,T}$$

where: U^{Pf} annual intake of vegetables, in kg
U^{Bl} annual intake of leafy vegetables, in kg
U^{Mi} annual milk and diary intake, in kg
U^{Fl} meat and animal produces, in kg
C_r^{Pf}, C_r^{Bl}, C_r^{Mi}, C_r^{Fl}, concentration of radionuclide r in vegetable, leafy vegetable, milk and diary and meat, in Bq/kg
$g_{g,r,T}$ dose conversion factor for tissue T by ingestion of radionuclide r in Sv/Bq.

The concentration of radionuclide r in each foodstuff could be evaluated using default parameters or site specific parameters.

2.2.3. Aquatic pathway

The annual dose due to contaminated river water is given by the following pathways:

- drinking water;
- water to fish transfer;
- water intake for animals to milk and meat;
- irrigation - pasture - animal - meat;
- irrigation - crop.

Under the hypothesis that all drinking water is contaminated, the biological dose (per organ) is obtain from:

$$H_{o,g,x}=g_{o,g,x}\int c_{w,x}(t)U_w(t)dt$$

where:

$g_{o,g,x}$ = dose conversion factor for ingestion, for radionuclide x, per organ o [Sv/Bq]

$c_{w,x}$ = the activity of the radioisotope x in the drinking water [Bq/L]

U_w =the drinking water consumption [L/day].

For the time being, there is no fish in Crisul Baita River because of its chemical pollution caused by mining activities. Because the mining activity is diminishing, the return of fish in the river, in the near future, is very probable. The amount of precipitation in the area is about 1100 mm/year. Because of this high amount of precipitation, the irrigation of land is used in small extend, mainly in dry years. During the springtime, the area could experience floods, especially during the snow melting. The floods could be considered in some extent as irrigation of pastures, although the dilution of radionuclides in water body during flood period can be higher than the rest of the year.

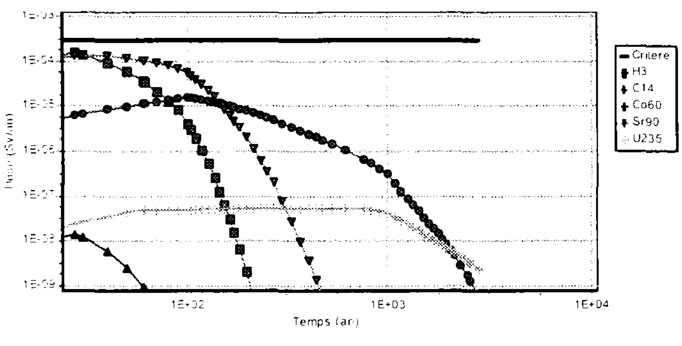

Figure 2. Time variation of the annual dose

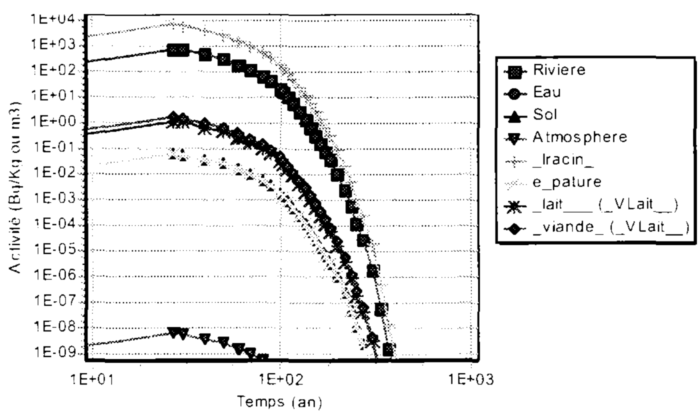

Figure 3 Time variation of the activity by pathway

3. Implementation of model. Preliminary results.

The most conservative established base case scenario (1) "*Drained system*" assumes that the release of water, and radionuclides is through the repository access gallery. The contaminated water is supposed to flow directly into the nearest creek Crisul Baita.

Dilution in the river is taken into account. The contaminated river water is assumed to be used for drinking water, irrigation, etc., which finally results in a dose rate man. For assessing this scenario two computer computer codes were used: REPOS6 [4] for the source-term and ABRICOT [5] for the biosphere modeling. Doses and associated concentrations for the relevant pathways defined in Figure 1 were calculated by the biosphere expressions given above, based on available specific and selected generic data. The derived dose rates and activities by pathways are shown in Figures 2 and 3. Even though these results are preliminary (the purpose of the calculations was the model validation), it can be concluded that the assessed doses complied with a constraint of 0.3 mSv/y (ICRP 81) and that a picture of the time behavior of the activity distribution in repository environment was obtained.

4. Conclusions

The biosphere model for Baita Bihor repository performance assessment was achieved in this work. Calculations performed with ABRICOT code have tested the consistency (completeness and existence of any errors) of the model developed in the paper. Confidence exists that the model is appropriate and adequate for the intended purpose. The preliminary obtained results are used to define the necessary follow-up works to complete site characterisation, produce site-specific data, validate or modify parameter values.

References

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