Radiological impact assessment for landfill disposal of NORM wastes in Malaysia

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Abstract. In Malaysia, the radiological impact assessment (RIA) report has to be compiled in order to comply with the Atomic Energy Licensing Act 1984, Act 304 and the Guidelines LEM/TEK/30 SEM.2, September 1996 for activity related to the landfill disposal of naturally occurring radioactive material (NORM) wastes. Most of the NORM problems in Malaysia are associated with tin mining, mineral sands processing and oil production activities. The Malaysian Nuclear Agency (Nuclear Malaysia) has experience in conducting the RIAs for the disposal of NORM wastes by landfill. This paper describes an example of RIAs to dispose of tin slag at a specified site in the northern state of Malaysia.

1. Introduction

Tin was at one time the primary export commodity for Malaysia. Nowadays, only a handful of facilities are still operational and in active business owing to a decrease in demand and rising operating costs. Given the current climate, methods and ways are being sought to overcome the problems related to the future disposal of the waste. In Malaysia, any practice that involves the use of radioactive materials is governed by the Atomic Energy Licensing Act 1984 [1] and its subsidiary legislation. Guidelines LEM/TEK/30 SEM.2, September 1996 [2] introduced by the Atomic Energy Licensing Board (AELB) addressing issues and activities involving naturally occurring radioactive materials (NORM) produced by the oil and gas industries. At present, this is the only guideline available for addressing issues related to disposal of NORM wastes. According to the guidelines, for disposal purposes the operator is required to carry out a radiological impact assessment (RIA) for all proposed disposals to demonstrate that no member of public will be exposed to more than 1 mSv/a from all activities/sources. The Malaysian Nuclear Agency (Nuclear Malaysia) has been engaged by a local company to do an RIA study on the use of tin slag as fill material for reclamation works at a specified site in the northern state of Malaysia. Since the land is scarce in this part of the northern state, the company decided to make full use of the land by reclaiming it and converting its status to a light industrial area. The tin slag was chosen because 85 000 t were already available at the site, resulting from approval by the AELB as a temporary storage site. The tin slag was produced by a smelting company and has been found to contain slightly higher amounts of NORM as a result of the direct physical separation process of the tin ores (feed material) during downstream processing. The area of concern was about 27.4 acres of swampy land with fully grown small trees and bushes. Before the reclamation work there were no human activities in the areas around the site [3].

2. Methodology

This study analysed and assessed the possible radiological impact on identified critical groups of the population working on the proposed disposal site. The study was carried out by:

- Determining the source term of the NORM present in the tin slag involved;
- Referring to the radiological criteria set by AELB;
- Identifying the critical group or groups of the population affected directly or indirectly by the radiological exposure from the site; and
- Identifying the critical pathways that allowed the radionuclides identified in the source term to reach the critical group(s) and eventually give rise to the maximum radiation dose.

The expected annual dose results were compared with the permissible levels adopted as a guide i.e. 1mSv/a for individual members of the public and 1 man·Sv in a year for the collective dose of the overall population.

3. Source term

Tin slag is the residue produced during the smelting of tin ores. The concentrations of radionuclides in the tin slag were found to be 0.95 Bq/g ^{238}U, 0.42 Bq/g ^{232}Th, 4.57 Bq/g ^{226}Ra and 1.11 Bq/g ^{228}Ra [3].

4. Exposure scenario and critical group

The exposure scenario considered in this assessment covered only the potential impact on the individuals working on the site (i.e. in the warehouse), in other words an industrial use scenario. In this scenario, the potential exposures considered were those for individuals working in a building (warehouse) constructed over the disposal site. No occurrence of erosion was considered, as a result of assuming that the integrity of the contaminated zone area (tin slag thickness of 0.5 m) and the building foundation would be maintained. Various depths of clean soil cover were analysed and a soil cover of 1.2 m was chosen for the optimum estimated dose and viability of the reclamation project. The warehouse workers were assumed to be the critical group in this assessment. The workers were assumed to work on site for 8 h per day, 5 days per week. The exposure time was assumed to consist of 8 h indoors and 1 h outdoors on site. The exposure pathways evaluated included external, inhalation and radon. The water supply was assumed to come from an unaffected off-site source. Four hundred and sixty four individuals were assumed to work on site corresponding to the affected area considered in the assessment.

5. Modelling and analysis

Dosimetric models were established based on the public and exposure scenarios identified. The radiological impact on the critical group working on site as a result of slag disposal was analysed using models using the RESRAD 6.3 computer code [4]. Inputs to the code were mostly based on the site-specific data. They were obtained from the measurements made by Nuclear Malaysia and from the reports made available to Nuclear Malaysia by other relevant government agencies. Any unavailable local data were adopted from default figures recommended by RESRAD, which in most cases were found to be very conservative [5]. Default or estimated values were used in cases where no site-specific input parameter values were available. Uncertainty in the values of these parameters introduces an uncertainty in the overall dose estimates. Therefore, in order to evaluate the potential effects of such uncertainty in the critical parameters, a limited sensitivity analysis was performed. These default values were assessed and chosen to be the most realistic for the conditions on site. However, as a normal practice in any impact assessment, the values were chosen in such a way that use of these values in any situation would not result in underestimation of the dose (slightly conservative).

6. Results of analysis

The results of the analysis and the graphic presentation for the industrial scenario are shown in Table 1 and Fig. 1, respectively. It is clear from these results that the maximum total dose expected to be received by members of the critical group working on the proposed site (in warehouses) as a result of disposing the tin slag is 0.45 mSv/a. The estimated annual doses are found to be below the dose limit of 1 mSv/a. From Fig. 1, it can be seen that the radionuclide which gives the most significant contribution to the total dose is ^{226}Ra. The dose decreases with time due to the leaching process taking place. Due to close proximity of the site to the sea, dilution of radionuclides was expected. Based on the projected number of the public working on the site i.e. assuming 464 individuals (industrial use scenario), the collective dose received by this group was estimated to be 0.21 man·Sv. As with the individual doses, this estimated doses also falls within the acceptable collective dose limit criterion, namely 1 man·Sv.

TABLE 1. TOTAL DOSE FOR THE INDUSTRIAL USE SCENARIO

Elapsed time (years)	Total annual effective dose (mSv)
1	4.44×10^{-1}
3	2.27×10^{-1}
10	2.15×10^{-2}
30	2.78×10^{-5}
100	2.39×10^{-6}
300	4.54×10^{-6}
1000	5.53×10^{-5}
100 000	2.22×10^{-11}

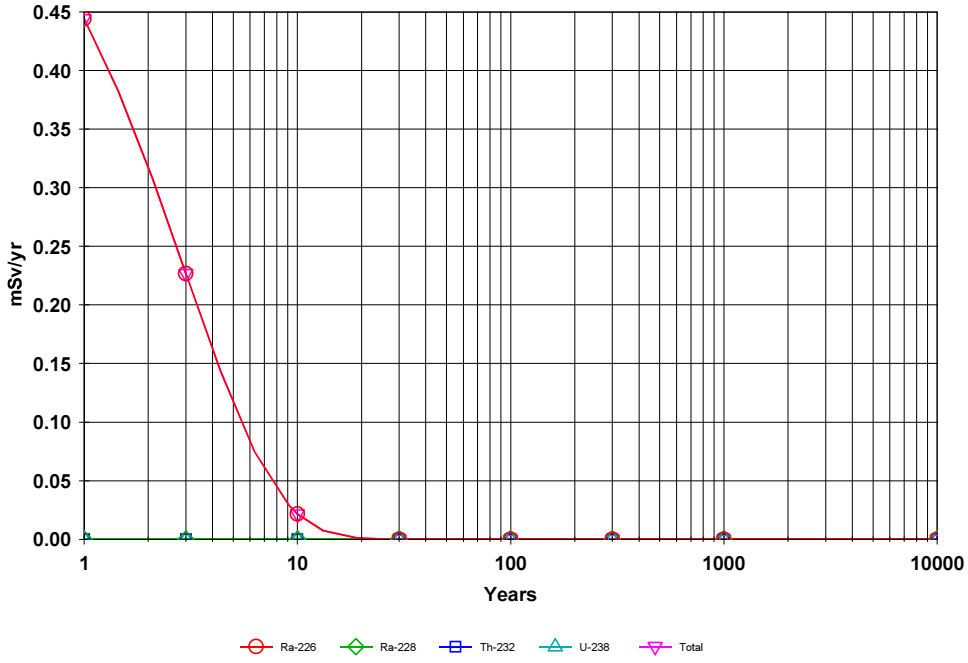

FIG. 1. Total dose for the industrial use scenario

7. Conclusions

Based on the RIA study conducted, the site chosen was approved by the AELB for disposal of tin slag and for reclamation of the land for construction of warehouses (i.e. industrial use). All future developments and new projects (if they exist) other than those described above for the reclaimed land should be subject to the submission of a new RIA report.

REFERENCES

[1] Atomic Energy Licensing Act of Malaysia, Act 304 (1984).

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[4] Argonne National Laboratory, A manual for implementing residual radioactive material guidelines using RESRAD, ANL/EAD/20-2, September 1993.

[5] Argonne National Laboratory, Data collection handbook to support modelling the impacts of radioactive material in soil ANL/EAIS-8, April 1993.