Environmental Risk Assessment for Long Term Storage Facility in Bukit Kledang, Perak, Malaysia

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1. Introduction

Naturally Occurring Radioactive Materials (NORM) in Malaysia are largely found in thorium hydroxide from the processing of monazite and xenotime, oil and gas industries such as sludge and scale,s and the processing of ilmenite (red gypsum and iron oxide). Other than that, NORM such as monazite produced from the processing of tin tailing (in Malaysia commonly called amang), tin slag made from the smelting of tin, ilmenite and zircon can be found [1].

After completion of Decontamination and Decommissioning (D&D) process, the Long Term Storage Facility (LTSF) in Bukit Kledang, Perak, Malaysia, has been promoted to become a repository facility, recently. Contaminated material and Thorium waste that possibly contain some minor volumes of thorium hydroxide were disposed in the repository facility [2]. All these unwanted materials having NORM have subsequently been termed NORM wastes and every activity are regulated and controlled by the Atomic Energy Licensing Act, 1984 (Act 304). Atomic Energy Licensing Board (AELB) is responsible for this as the licensing authority of the Act 304. AELB imposes the NORM activities including milling activity related to minerals containing NORM, oil and gas businesses, and its waste management through conditions and regulations of license issued to the licensees and licensing procedure [1].

Waste management is the main issues occurred from NORM activities and large amount of wastes generated from mining industries and mineral processing plants commonly holding low level of naturally occurring radionuclides. As stipulated in the Atomic Energy Licensing Radioactive Waste Management Regulations 2011 Decommissioning and Decontamination (D&D) of the monazite cracking plant to extract rare earth minerals operating since 1982 situated in the northern part of Malaysia, implementation of 1 Bq/g was set as the clearance limit for naturally occurring radionuclides from series of uranium and thorium.

The activity of extracting rare earth minerals had ceased its process in January 1994 and the waste materials were stored in drums and packages and classified as LILW-LL (Low and Intermediate Level Waste–Low Level) in the LTSF. The purpose of this study is to measure the radiological impact assessment of these radioactive minerals to the environment and the target elements to be focused on are thorium and radium sludge, thorium contaminated equipment and potassium. RESRAD software code was used to investigate areas surrounding the repository facility in Bukit Kledang, Perak to compare with the limits prescribed by Atomic Energy Licensing Board of Malaysia (AELB), which is 1 mSv y^{-1} for public and 20 mSv y^{-1} for working personnel. The parameter input was based on the research location specific value, existing value in RESRAD and suitable estimation values based on analysis.

2. Methods and Results

Several important parameters were set up to simulate the radiological impact assessment of radioactive nuclides to the environment using RESRAD software code.

2.1 Sampling Area

From [4], a total of 4 soil samples from area near the repository facility in Bukit Kledang, Perak were collected. This area is the storage site for the Asian Rare Earth Factory (ARE) radioactive waste. The sampling sites are shown in Fig. 1. Sampling area around repository facility were named A1, A2, A3 and A4. These 4 sample point locations covered the secluded area.

Fig. 1. Sampling area around repository facility.

2.2 Radionuclides activity concentration

According to [4], results of measurement and data collected at different positions nearby the repository

facility for the 4 soil samples is summarized in Table 1 below. ^{226}Ra, ^{232}Th and ^{40}K are the three most common elements of radionuclides determined in this research areas. Through uranium and thorium series decay products, the natural activity of ^{226}Ra and ^{232}Th of radionuclides data is obtained, while the concentration of ^{40}K natural activity is a single peak decision [4].

Table I: Specific activity of radionuclides

Sample locations	Specific activity of radionuclides (Bq/kg)		
	^{226}Ra	^{232}Th	^{40}K
A1	17.87	34.96	7.59
A2	29.92	38.71	59.40
A3	20.63	30.14	27.95
A4	25.49	35.48	26.96

2.3 Pathways

The pathways being measured in the study was inhalation, external gamma radiation, plant and meat ingestion, intake of water and milk, aquatic foods and soil ingestion. Dispersion of radionuclide in passing through the environment and critical pathways for the assessment of dose to the specific groups by various relocation patterns have been identified. The exposure pathways evaluated including external radiation, inhalation of airborne particulate (inhalation rate of 8400 m^3/y), ingestion of plant (44 kg/y), milk (92 L/y), meat (63 kg/y), aquatic foods (6.3 kg/y), soil and drinking water (510 L/y) assumed grown and taken on site. Default data were used since there were no available site specific or generic data for Malaysia [3].

2.4 Dose

After calculating the dose affecting the environment, the results can be seen for each sampling area of A1, A2, A3, A3 and A4.

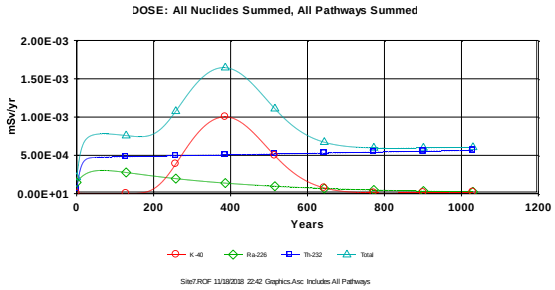

Fig. 2. Calculated dose for site A1.

From Fig. 2, maximum value of dose calculated is around 1.6 μSv/yr at approximately 400 years considering all radionuclides and pathways summed. The highest recorded value of dose at sampling site A1 is coming from ^{40}K with a reading of 1.0 μSv/yr at approximately 400 years.

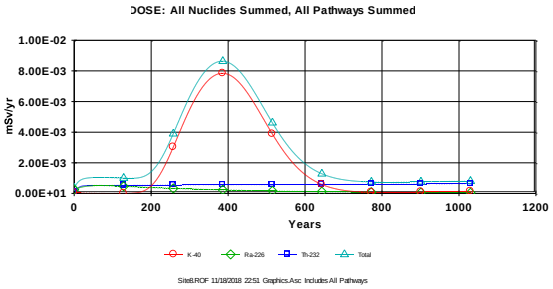

Fig. 3. Calculated dose for site A2.

From Fig. 3, maximum value of dose calculated is around 8.5 μSv/yr at approximately 400 years considering all radionuclides and pathways summed. The highest recorded value of dose at sampling site A2 is coming from ^{40}K with a dominant reading of 7.9 μSv/yr at approximately 400 years.

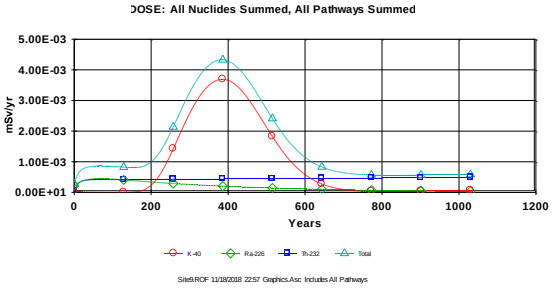

Fig. 4. Calculated dose for site A3.

From Fig. 4, maximum value of dose calculated is around 4.4 μSv/yr at approximately 400 years considering all radionuclides and pathways summed. The highest recorded value of dose at sampling site A3 is coming from ^{40}K with a reading of 3.8 μSv/yr at approximately 400 years.

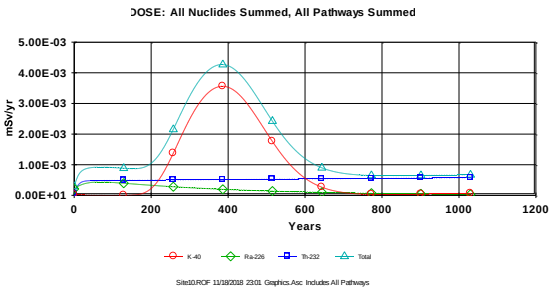

Fig. 5. Calculated dose for site A4.

From Fig. 5, maximum value of dose calculated is around 4.3 μSv/yr at approximately 400 years considering all radionuclides and pathways summed.

The highest recorded value of dose at sampling site A4 is coming from ^{40}K with a reading of 3.6 μSv/yr at approximately 400 years.

From the data collected, the highest concentration of ^{40}K radionuclide were recorded at sampling site A2 with a value of 59.40 Bq/kg which brings a value of 8.5 μSv/yr dose. Several factors such as specific condition of area, soil type and pH, existence of underground rock, soil texture and organic matter affect the specific activity concentrations causing different values according to sites.

Even though the highest value of assessment is coming from sampling site A2 which is 8.5 μSv, but it is still lower than the world average of 0.48 mSv [4]. This approves that all of these sampling areas are in a good and safe condition for the public.

2.5 Excess cancer risk

As clarified earlier, this research concentrates on the surrounding area near repository facility. Results obtained for cancer risk from this research only represent at specific site sampling area.

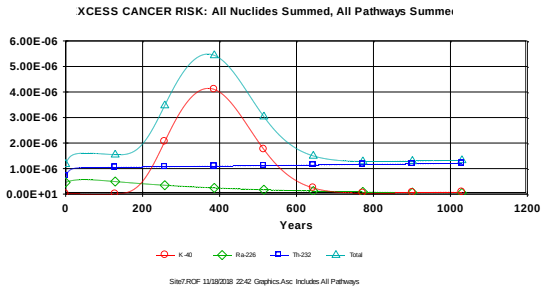

Fig. 6. Calculated cancer risk for site A1.

From Fig. 6, maximum value of cancer risk calculated is around 5.5 x 10^{-6} at approximately 400 years considering all radionuclides and pathways summed. The highest recorded value of cancer risk at sampling site A1 is coming from ^{40}K with a reading of 4.2 x 10^{-6} at approximately 400 years.

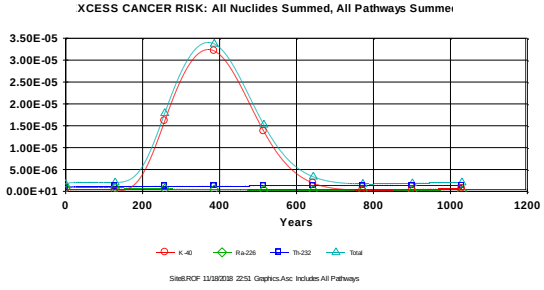

Fig. 7. Calculated cancer risk for site A2.

From Fig. 7, maximum value of cancer risk calculated is around 3.4 x 10^{-5} at approximately 400 years considering all radionuclides and pathways summed. The highest recorded value of cancer risk at sampling site A2 is coming from ^{40}K with a reading of 3.3 x 10^{-5} at approximately 400 years.

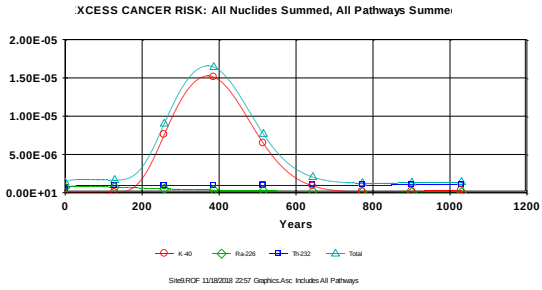

Fig. 8. Calculated cancer risk for site A3.

From Fig. 8, maximum value of cancer risk calculated is around 1.6 x 10^{-5} at approximately 400 years considering all radionuclides and pathways summed. The highest recorded value of cancer risk at sampling site A3 is coming from ^{40}K with a reading of 1.5 x 10^{-6} at approximately 400 years.

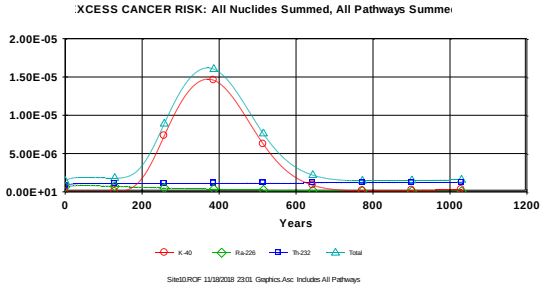

Fig. 9. Calculated cancer risk for site A4.

From Fig. 9, maximum value of cancer risk calculated is around 1.6 x 10^{-5} at approximately 400 years considering all radionuclides and pathways summed. The highest recorded value of cancer risk at sampling site A4 is coming from ^{40}K with a reading of 1.48 x 10^{-6} at approximately 400 years.

3. Conclusions

Results were analysed for each of the sampling sites A1, A2, A3 and A4 and it is found that sampling site A2 poses the highest calculated dose around 8.5 μSv/yr and calculated cancer risk around 3.4 x 10^{-5} at approximately 400 years considering all radionuclides and pathways summed for total amount of 128.03 Bq/kg specific activity of radionuclides ^{226}Ra, ^{232}Th and ^{40}K. From this information, the higher the activity concentration, the higher the dose calculated and thus pose the higher cancer risk. However, the highest dose calculated in this study is still way below than the world average of 0.48 mSv. Moreover, some factors such as specific condition of area, soil type and pH, existence of underground rock, soil texture and organic matter affect the specific activity concentrations causing different

values according to sites are taken into considerations for further research. These results can be used as an extra data to be compared with other research study to improve terrestrial radioactivity model data for Malaysia background and future interrelated activities of radioactive contamination particularly nearby the repository facility area.

ACKNOWLEDGEMENT

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REFERENCES

[1] Lin. T, Decommissioning of Mineral Processing Plant And Remediation Of Norm Contaminated Sites.
[2] Adziz. M, Siong. K, Determination of Gross Alpha and Gross Beta in Soil Around Repository Facility at Bukit Kledang, Perak, Malaysia, 2010.
[3] Kontol. K, Sulaiman. I, Razalim. F, Radiological Impact Assessment in Disposal of Treated Sludge, 2012.
[4] Adziz. M, Siong. K, An Assessment of Absorbed Dose and Radiation Hazard Index from Soil Around Repository Facility at Bukit Kledang, Perak, Malaysia, 2013.
[5] B.A. Almayahi, A.A.Tajuddin, M.S.Jaafar, Radiation Hazard Indices Of Soil And Water Samples In Northern Malaysian, 2015.