Radiological Risk Assessment of ^{232}Th and ^{238}U in Water Leach Purification (WLP) Residue Using Modified SPLP Method

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1. Introduction

Lynas Advanced Material Plant (LAMP) which is the largest rare earth processing plant in the world is located at Gebeng Industrial State (GIE) in Kuantan, Pahang, Malaysia. Lanthanide concentrate (LC) was processed by LAMP in order to extract rare earth elements. Using leaching and purification process, water leach purification (WLP) residue was yielded from the calcined and cracked concentrate of water soluble lanthanide components. The WLP residue contain radioactive elements such as thorium (^{232}Th) and uranium (^{238}U). The aim of this case study is to estimate potential level of ^{232}Th and ^{238}U in WLP residue to enter the human body using modified Synthetic Precipitation Procedure (SPLP) (Method 1312)[1]. In order to determine potential radiation doses hence taking measures to evade radiation exposure to consumers, it is vital to evaluate the radionuclides content of WLP residue. Additionally, knowledge of ^{232}Th and ^{238}U daily intake are crucial for evaluating metabolic parameters of radionuclides uptake and retention in human body.

2. Methods and results

WLP residue samples were collected from LAMP, Kuantan, Malaysia. The initial concentrations of ^{232}Th and ^{238}U in WLP residue are 206.1 mg kg^{-1} and 6.6 mg kg^{-1}, respectively by using X-Ray Fluorescence Spectrometer (XRF, Bruker/S8 Tiger/2009).

2.1 The modified SPLP method

To deduce the concentration of ^{232}Th and ^{238}U in leachate, SPLP method was implemented by modifying pH and reaction time parameters. About 10 g of WLP residue were reacted with 200 mL leaching fluid for about 20:1 solid-to-solution ratio under various pH conditions (4, 5, 7, and 8). All samples were prepared and tested for different reaction times (1, 2, 7, 14 days) at room temperature. The target radionuclides, ^{232}Th and ^{238}U in leachate were analysed using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

2.2 The leaching results

Based on Fig. 1, on the 14th day of reaction, the reading for ^{232}Th and ^{238}U concentrations in leachate were at maximum, which were 8.23 mg kg^{-1} and 0.36 mg kg^{-1}, respectively. These results represent the maximum amount of radionuclides that are potentially available for intestinal absorption and diffusion into bloodstream. 1 to 14 days of contact intervals were applied to simulate average period of flooding in Malaysia. This approach depicted the correlation between leachates and contact time.

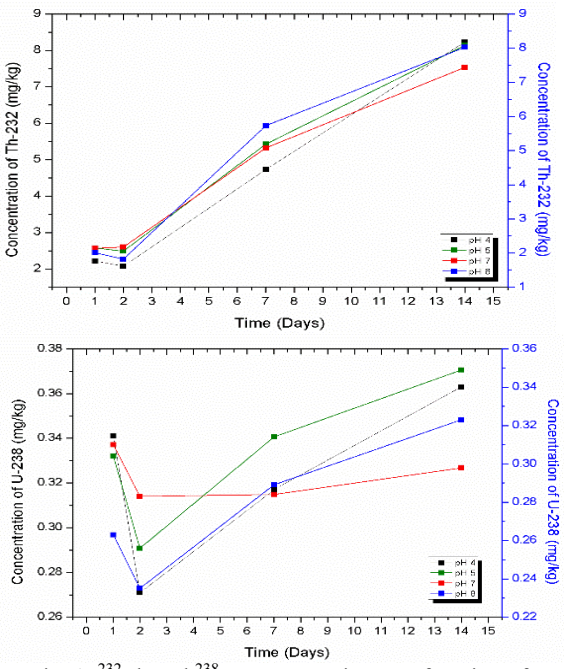

Fig. 1. ^{232}Th and ^{238}U concentration as a function of reaction time and pH by practicing SPLP method.

The leaching fluid pH was prepared for acidic rain and groundwater pHs to simulate the potential remobilization of ^{232}Th and ^{238}U after periods of heavy flooding in LAMP area. The maximum leached concentrations of ^{232}Th and ^{238}U were found at low pH (= 4), while the leached amounts of ^{238}U and ^{232}Th were at minimum which is pH 7 and 8 conditions. The effects of varying pHs prior to ^{232}Th and ^{238}U concentration were studied and the result showed that the rate of concentration value by leaching was very much influenced by pH

value used.

2.3 The committed equivalent and effective dose

To understand better the effects of modified SPLP method on human exposure, ^{232}Th and ^{238}U effective and equivalent dose coefficients were used to estimate committed effective and equivalent dose ingested by public adults and occupational workers [2]. The result for committed equivalent and effective dose of ^{232}Th and ^{238}U are presented in Table 1. The topmost committed equivalent doses of ^{232}Th and ^{238}U were found in red marrow and bone surface, respectively. ^{238}U committed effective dose for workers was higher than ^{232}Th. However, the committed effective dose of ^{232}Th and ^{238}U ingested by public were very low.

Table 1. Committed equivalent and effective dose of ^{232}Th and ^{238}U using modified SPLP method

		pH			
		4	**5**	**7**	**8**
Committed Equivalent dose (mSv)					
Bone surface	^{232}Th	2.340	2.300	2.110	2.280
	^{238}U	0.001	0.001	0.001	0.001
Kidney	^{232}Th	0.030	0.030	0.020	0.030
	^{238}U	0.001	0.001	0.001	0.001
Liver	^{232}Th	0.030	0.020	0.020	0.020
	^{238}U	0.001	0.001	0.001	0.001
Red marrow	^{232}Th	0.670	0.070	0.060	0.070
	^{238}U	0.001	0.001	0.001	0.001
Committed Effective dose (mSv)					
Public	^{232}Th	0.010	0.010	0.010	0.010
	^{238}U	0.001	0.001	0.001	0.001
Workers	^{232}Th	6.680	6.560	6.040	6.520
	^{238}U	8.960	8.620	7.660	7.980

To conduct this research, MONDAL 3 modelling was utilized to analyse the acute intake internal dose of occupational workers' whole body[3]. The data gained from MONDAL 3 are depicted in Figure 2, which shows ^{232}Th and ^{232}U internal dose via ingestion decrease with the reaction time. Indeed, the ingestion dose coefficients are the predominant factor.

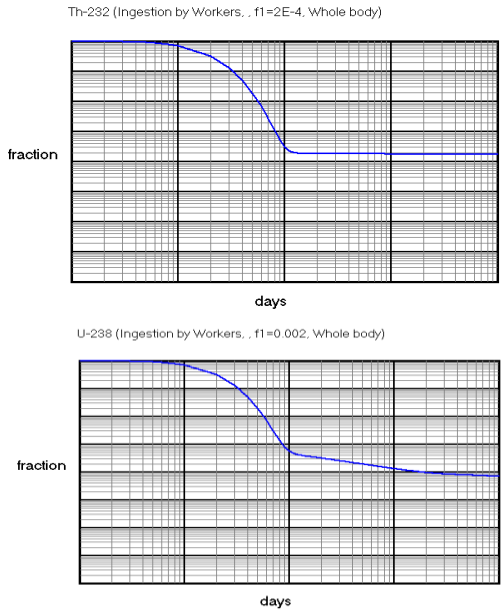

Fig. 2. Internal dose of ^{232}Th and ^{238}U of occupational workers using MONDAL 3.

3. Conclusions

^{232}Th and ^{238}U concentrations have been evaluated by using modified SPLP method. The maximum concentrations of ^{232}Th (8.23 mg kg^{-1}) and ^{238}U (0.363 mg kg^{-1}) in WLP residue were found at low pH (= 4), while the leached amounts of ^{238}U and ^{232}Th were minimum at pH 7 and 8 conditions. The committed equivalent and effective dose from WLP residue of ^{232}Th and ^{238}U by ingestion were affected by the dose coefficient of ^{232}Th and ^{238}U.

References

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