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RADIOACTIVE CONTAMINATION IN TAP, RAIN AND MINE WATER IN MALAYSIA BY GAMMA-RAY SPECTROSCOPY

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Natural radio-nuclides; ^{238}U, ^{232}Th and ^{40}K in rain, mine and tap water in Johor Bahru, Malaysia were measured by gamma-ray spectroscopy. Mean activity concentration of ^{238}U, ^{232}Th and ^{40}K were found in rain water 2.34 ± 0.11, 15.06 ± 0.10, 4183.52 ± 0.06 ppm, in mine water 3.32 ± 0.10, 27.30 ± 0.08, 6528 ± 0.05 ppm and in tap water 2.18 ± 0.11, 13.74 ± 0.11 and 4435.97 ± 0.06 ppm respectively. The mean estimated dose of ^{238}U, ^{232}Th and ^{40}K in (μSv yr^{-1}) to an adult from the rain, mine and tap water intake was 0.002 ± 0.0001, 0.019 ± 0.0001, 0.584 ± 0.00004 ; 0.003 ± 0.0001 , 0.035 ± 0.0001 , 0.911 ± 0.00004 and 0.002 ± 0.0001, 0.017 ± 0.0001, 0.619 ± 0.00004 respectively.

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1. Introduction

The substance like uranium, thorium, polonium and radium shows natural radioactivity. Radiations have destructive effect on living tissues. Ionizing radiation is powerful enough to change chemical bonds of their composition. Radioisotopes have destructive effect on living tissues, lung and may enter the body by inhalation, drinking, eating injection, or through broken skin [1].

Enhanced levels of radioactivity present in water and natural radio-nuclide’s in drinking water and risk of leukaemia were investigated [2]. Natural radioactivity of drinking water depends on the geological properties of the soils. The tap waters in black sea region of Turkey were studied natural radioactivity [3]. The concentrations of radioactivity of bottles water in Pakistan were measured [4].

In this paper the determination of uranium, thorium and ^{40}K isotopes for radiochemical properties in the rain, tap and mine waters suggest the information of radiological implications in waters in Malaysia.

2. Materials and methods

The mine’s water samples are collected from Taiping, Perak, and tap and rain water samples are taken from Johor Bahru area, Malaysia. The samples under several stages or processes are explained as follow: One liters of water needed for each sample and stored in bottles. One liters of water for each sample was added to nitric acid (HNO_3) but before that the original pH value of water is measured. The addition of nitric acid is dependent on the pH of the water. Water pH was measured and nitric acid added until the pH reading indicates between pH 1-3. Nitric acid was used in this sampling method is to retain the element in the water from missing or deficient. Then the water will going through the evaporation process until 0.5 liters. Evaporation method was

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used to compress the elements in the water. The samples then stored for a month or about 28 days in the marinelli container in order to obtain equilibrium state for gamma spectroscopy.

3. Experiments

A gamma ray spectroscopy consists of HPGE detector and 8192 channels computerized multi-channel analyzer were used to measure water samples. The resolutions of spectrum were found 1.8 keV at 1332.5 keV energy peak. The detector efficiency was 20%. HPGe detectors were placed in the lead shield 47 cm thick, 10 cm coated with tin and copper, respectively and the thickness of 1 mm and 1.6 mm in order to reduce the effects of radiation emanating from the building and the cosmic. In the detection of gamma-rays, germanium was chosen because it has a high cross section value.

4. Results and discussion

In order to obtain the concentration, C of an element; the following equation was used,

$$C_s = \frac{N_s C_p}{N_p} \tag{1}$$

N_S = Counts of sample, N_p = Counts of standard

C_p = Concentration of standard and C_s = Concentration of sample

Besides that, the equation for uncertainty of concentration as below

$$\Delta Cs = \frac{\Delta N_s}{N_s} + \frac{\Delta C_p}{C_p} + \frac{\Delta N_p}{N_p} \tag{2}$$

Where, ΔC_s is uncertainty for concentration, N_s stands for sample counts, ΔN_s for uncertainty for sample counts, N_p for standard accounts, ΔN_p for uncertainty for standard counts, N_p is the mass standard, ΔN_p is uncertainty mass standard.

On the basis of calculation; the standard concentration for different radionuclide's and concentrations of ^{238}U, ^{232}Th, and ^{40}K in rain, mine and tap water samples was tabulated in table 1. Specific activity and annual effective dose of ^{238}U, ^{232}Th, and ^{40}K in rain, mine and tap water samples are presented in table 2 and 3.

Table 1. ^{238}U, ^{232}Th and ^{40}K in ppm for rain, mine and tap water samples

Samples	Mass of the sample (± 0.01g)	Radionuclides	Type	Sample Count (N_s)	Standard Count (N_p)	Concentration (ppm)	Average Concentration (ppm)
Rain	500.00	^{238}U	^{214}Pb	118±11	666±26	0.84±0.13	2.34±0.11
			^{214}Bi	498±26	606±25	3.88±0.09	
		^{232}Th	^{208}Tl	256±16	1740±42	14.60±0.09	15.06±0.10
			^{228}Ac	197±14	1260±36	15.51±0.10	
		^{40}K		1160±34	1080±33	4183.52±0.06	4183.52±0.06
Mine	500.00	^{238}U	^{214}Pb	201±14	666±26	1.43±0.11	3.32±0.10
			^{214}Bi	670±26	606±25	5.22±0.08	
		^{232}Th	^{208}Tl	289±17	1740±42	16.48±0.08	27.30±0.08
			^{228}Ac	484±22	1260±36	38.11±0.07	
		^{40}K		1810±43	1080±33	6528±0.05	6528.00±0.05
Tap	500.00	^{238}U	^{214}Pb	104±10	666±26	0.74±0.14	2.18±0.11
			^{214}Bi	465±22	606±25	3.62±0.09	
		^{232}Th	^{208}Tl	109±10	1740±42	6.22±0.12	13.74±0.11
			^{228}Ac	270±16	1260±36	21.26±0.09	
		^{40}K		1230±35	1080±33	4435.97±0.06	4435.97±0.06

Table 2. Specific activity of ^{238}U, ^{232}Th and ^{40}K for rain, mine and tap water samples.

Samples	^{238}U (Bq kg^{-1})	^{232}Th (Bq kg^{-1})	^{40}K (Bq kg^{-1})
Rain	28.78±1.35	60.74±0.40	128.85±0.01
Mine	40.83±1.23	110.10±0.32	201.06±0.01
Tap	26.81±1.35	55.41±0.44	136.63±0.01

Table 3. Annual effective dose of ^{238}U, ^{232}Th and ^{40}K for rain, mine and tap water samples

Samples	Annual Effective dose (μSv yr $^{-1}$)		
	^{238}U	^{232}Th	^{40}K
Rain	0.002 ± 0.0001	0.019 ± 0.0001	0.584 ± 0.00004
Mine	0.003 ± 0.0001	0.035 ± 0.0001	0.911 ± 0.00004
Tap	0.002 ± 0.0001	0.017 ± 0.0001	0.619 ± 0.00004

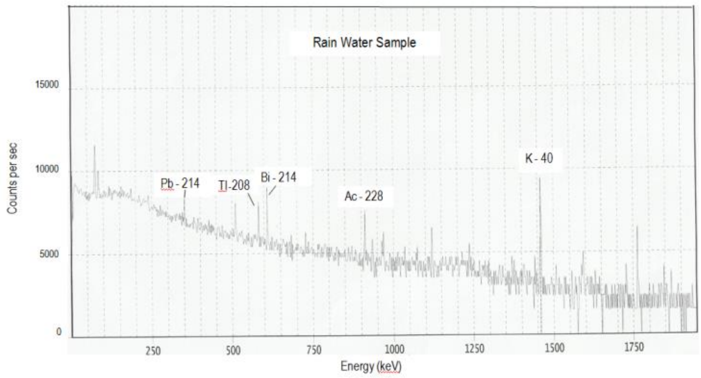

Fig .1 Gamma ray spectrum for rain water in Johor Bahru, Malaysia.

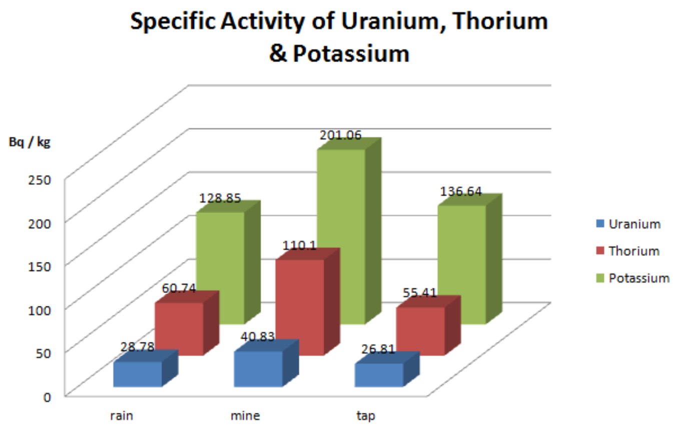

Fig. 2 Specific activity of Uranium, Thorium and Potassium for rain, mine and tap water.

Fig. 1 shows the typical spectrum of rain water sample. The energy peaks for the various radio-nuclides are indicated. The activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in the rain water sample were 2.34 ± 0.11, 15.06 ± 0.10, 4183.52 ± 0.06 ppm, which is equivalent to specific activity 28.78 ± 1.35, 60.74 ± 0.40 Bq kg^{-1} and 128.85 ± 0.01 Bq kg^{-1} respectively. The value of ^{238}U, ^{232}Th, and ^{40}K in the mine water sample were 3.32 ± 0.10, 27.30 ± 0.08, 6528.00 ± 0.05 ppm respectively, which is equivalent to specific activity 40.83 ± 1.23, 110.10 ± 0.32, 201.06 ± 0.01 Bq kg^{-1}. The value of ^{238}U, ^{232}Th, and ^{40}K in tap water sample were 2.18 ± 0.11, 13.74 ± 0.11, 4435.97 ± 0.06 ppm respectively, which is equivalent to specific activity 26.81 ± 1.35, 55.41 ± 0.44, 136.63 ± 0.01 Bq kg^{-1}. Figure 2 shows the specific activity of Uranium, Thorium and Potassium in rain, mine and tap water. It is shown that activity concentration of potassium is larger than thorium and the concentration of thorium is greater than uranium in all of the 3 samples. The value of ^{238}U, ^{232}Th, and ^{40}K in the mine water was greater than rain and tap water.

The annual effective dose of ^{238}U, ^{232}Th, and ^{40}K for rain, mine and tap water are 0.002, 0.019, 0.584 µSv yr^{-1}, 0.003, 0.035, 0.911 µSv yr^{-1} and 0.002, 0.017, 0.619 µSv yr^{-1} respectively. This study shows that radiologically water sample is safe that have been investigated since it gave much lower internal exposures than the Sources and effects of ionizing radiation(UNSCEAR) [5] reported world average value of 0.12 mSv yr^{-1} and the World Health Organisation(WHO) [6] and International Commission on Radiological Protection (ICPR) [7] preference limit of 0.1 mSv yr^{-1} and 1.0 mSv yr^{-1} respectively. The UNSCEAR has reported that the average worldwide exposure to natural sources in foods and drinking water (ingestion exposure) is 0.29 mSv yr^{-1} (about 0.17 mSv yr^{-1} from ^{40}K and about o.12 mSv yr^{-1} from Uranium and Thorium). From the water samples that have been investigated in this study the annual effective dose for ^{238}U, ^{232}Th, and ^{40}K in rain was 0.002 ± 0.0001 μSv yr^{-1}, 0.019 ± 0.0001 μSv yr^{-1} and 0.584 ± 0.00004 μSv yr^{-1} while for mine was 0.003 ± 0.0001 μSv yr^{-1} , 0.035 ± 0.0001 μSv yr^{-1} and 0.911 ± 0.00004 μSv yr^{-1} respectively and tap 0.002 ± 0.0001 μSv yr^{-1} , 0.017 ± 0.0001 μSv yr^{-1} and 0.619 ± 0.00004 μSv yr^{-1} which means all of the 3 samples contributed much lower effective dose compared to the UNSCEAR report.

5. Conclusion

Radioactivity characterization of rain, mine and tap water sample were performed. The activity concentrations of ^{238}U, ^{232}Th, and ^{40}K radionuclide's in the three water sample of Johor Bahru region were measured using gamma-ray spectroscopy. This study showed that ^{40}K contributed the largest activity concentration while ^{238}U contributed least activity in those three water sample. The use of water samples that have been investigated in this study since they gave much lower internal exposures than the UNSCEAR reported world average value of 0.12 mSv yr^{-1} and the WHO and ICRP reference limits of 0.1 mSv yr^{-1} and 1.0 $mSvyr^{-1}$ respectively. The radioactive concentration of ^{238}U, ^{232}Th, and ^{40}K in tap and rain are lesser than mine water. Moreover, all of the water samples are safe to be used by human either as drinking water or daily routine activity.

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