SOIL TO RICE TRANSFER FACTOR OF THE NATURAL RADIONUCLIDES IN MALAYSIA

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Study on environmental radiation protection and determination of contamination of natural radionuclides such as Uranium, Thorium and Potassium in soil and crops samples are very important as part of environmental health surveillance programs projects to develop a subject of interest in the environmental sciences. In the present study, we have detected natural radioactivity elements U, Th and K in soil and paddy crops. The samples were collected from two places at Kedah in Malaysia. The transfer factor (TF) of uranium for five rural areas was measured by the Gamma ray spectroscopy and high-purity Ge (HPGe) detector as 0.20, 0.16, 0.17, 0.14 and 0.11 respectively. Whereas the TF values of thorium were found to be 0.15, 0.05, 0.04, 0.02 and 0.05, respectively. On the other hand for potassium the TFs values were 1.43, 1.20, 0.11, 0.52 and 0.53 respectively. Similarly, the transfer factors for five selected urban areas were measured 0.05, 0.06, 0.08, 0.04 and 0.09 for uranium, 0.01, 0.05, 0.11 and 0.03 for thorium and 0.24, 1.05, 0.09, 0.14 and 4.12 for potassium respectively. The outcomes satisfied the standards of *IAEA*.

Key words: Malaysia, potassium, rice, thorium, transfer factor, uranium.

1. INTRODUCTION

A large amount of the radiations soaked up by the human are coming from the natural sources. Natural radionuclides incorporate cosmogenic radionuclides such as ^{14}C and ^{3}H, primordial radionuclides, including affiliate nuclides of ^{238}U, ^{235}U, ^{232}Th-series and some independent nuclides such as ^{40}K and ^{87}Rb. Internal dose from these radionuclides depends on environmental conditions, lifestyle and so on. The contamination level of the natural radioactivity in our environment has been under intensive investigation because of public concern of radiation- induced health hazard [1-7]. The transfer of radionuclides (uranium, thorium, radium and potassium) from soil to plant and their distribution among different sections of plant depends on the soil nature. The level of accrual of natural radioactive elements is affected by the metal-selective function of plants during uptake of elements to sustain the mechanism of homeostasis in typical environments [8]. Food consumption is the foremost cause of human exposure to radioactive elements that escorts to internal radiation doses [9-10]. The annual effectual dose (estimated by Santos *et al.*) incarcerated by the adult inhabitants of Rio de Janeiro City with the long-lived natural radionuclide (^{232}Th, ^{238}U, ^{210}Pb, ^{226}Ra and ^{228}Ra), reached 14.5 μSv due to the ingestion of vegetables and their derived products [11]. The transfer factors (TFs) of the radionuclide in soil to the crops are gazed at as one of the most significant parameters in environmental safety estimation needed for nuclear facilities [12-14]. Resettlement and amassing of radionuclide in the soil–plant system is complex, and assessment models commonly make use of a soil–plant concentration ratio, referred to as a transfer factor (TF). This ratio depicts the quantity of radionuclide expected to enter a plant from soil [15]. The transfer factors of different radionuclides in the tropical environment of Bangladesh have been investigated by A.S Mollah and Aleya Begum [16]. They investigated the transfer factor of pot grown plants. J.Solecki and S.Chibowski determined the transfer factor of vegetables such as carrot, potato, sugar beet as well as grass and soil in the arable areas of Roztoczan′ ski National Park Poland [17]. They found the mean values of ^{137}Cs and ^{90}Sr transfer factors from soil to grass are equal to 0.26±0.23 and 0.18±0.15, respectively. Shigeo UCHIDA *et al.* calculated the TFs of 36 and 34 elements for brown rice and white rice on the dry weight basis. They found that the critical paths of radionuclide and the critical foods in Japan are different from those in European and North American countries because agricultural products and food customs are different [18]. Ibrahim and Whicker (as cited by Vera Tome *et al.*) measured the TF values for between 0.04 and 0.07 for ^{232}Th, and 0.01 to 2.88 for ^{230}Th which were found in a uranium mine for native plants in a Mediterranean area (Spain) [19, 20]. The TF value for ^{232}Th was from 0.000021 to 0.0023 for different vegetable crops grown on a contaminated lake bed. In grass TF value was between 0.0011 and 0.11. Their results showed that the transfer factors for both the natural radionuclides and the stable elements are independent of the substrate types involved and also of the areas [19]. In the south west India regions, G. Shanthi *et al.* calculated the soil to rice TF values for the radionuclides; ^{226}Ra, ^{232}Th, ^{238}U and ^{40}K are 8.8×10^{-2}, 14.2×10^{-2}, 5.8×10^{-2} and 6.3×10^{-2}, respectively [21]. They concluded that in the majority of the crops the non-edible parts amass more radionuclides than the edible parts.

Rice is the staple food of Asia, including Malaysian community. An average quantity of rice taken by an adult is about 100 gram per day. The quantity is seen to be very small, but without realizing there are radionuclides present in the rice that can affect the body. Amount of radionuclides accumulated in the body can be known by measuring the concentration of radionuclide contained in the rice. Present study was conducted to measure and compare the concentration of uranium, thorium and potassium in the different samples of rice. We have weighed up the transfer factor as well as concentration level of these radionuclides both in soil and crops belonging to rural and urban areas.

2. MATERIAL AND METHOD

2.1. SAMPLING

The samples used in this experiment were soil and its associated rice. Rice is the seed of the paddy plant or in scientific name is *Oryza Sativa.* The samples were collected from 2 different areas in Kedah (Malaysia). Five samples (A1 to A5) from the rural and the other 5 (B1 to B5) from urban area were chosen as a prod.

One kg of each soil has been taken from area of 5 cm in depth with 10 cm in diameter from surface level. The mass of each sample of paddy was 100 g. Soil samples were dried for 24 hours by the Jovan oven with the temperature 100°C. Panasonic blender was used to grind the soil sample to turn into a powder form. Afterword, paddy powder was diluted with the HCl acid and distilled water. In order to obtain equilibrium state for gamma ray spectroscopy; the samples were kept in Marinellin beaker for a month to complete dryness.

2.2. INSTRUMENTATION

The experiments were carried out using gamma ray spectroscopy system with high purity germanium detector (HPGe) of efficiency 20% which connected to a multi-channel analyzer (MCA). To avoid the effect of radiation from cosmic ray HPGe detectors were placed in the lead shield 4.7 cm thick. The energy calibrations of the gamma ray spectra were done using standard radioactive source of ^{137}Cs, ^{60}Co, ^{152}Eu.

3. RESULTS AND DISCUSSION

3.1. CONCENTRATION OF THE ELEMENT IN SOIL AND CROP

In order to obtain the concentration C of an element; the following equation was used [16].

$$\mathrm{C} = \frac{\text{mass of standard}\left(\text{UTH or K–40}\right)}{\text{mass sample}} \times \frac{\text{sample activity}}{\text{standard activity}} \tag{1}$$

Besides that, the equation for uncertainty of concentration as below is used

$$\Delta \mathrm{Q} = \left(\frac{\Delta S}{S} + \frac{\Delta P}{P} + \frac{\Delta MP}{MP} + \frac{\Delta MS}{MS} \right) \mathrm{C} \tag{2}$$

where, ΔQ is uncertainty for concentration, S stands for sample activity, ΔS for uncertainty for sample activity, P for standard activity, ΔP for uncertainty for standard activity, MP is the mass standard, ΔMP is uncertainty mass standard, MS is mass sample and ΔMS is the uncertainty mass sample.

The concentration of uranium was calculated and plotted as a function of sample number. Figure 1 and 2 represent the concentration of uranium in soil and rice at the rural and urban area respectively. In the rural areas, among the samples the highest concentration of U in soil was 3.49 ppm for sample A4, whereas, the highest concentration of uranium in crop was found to be 0.52 ppm for that sample. The result depicted that for the urban areas, the concentration was higher than rural area. The highest concentration for uranium in soil in urban area was 3.67 ppm and for rice it was 0.25 ppm.

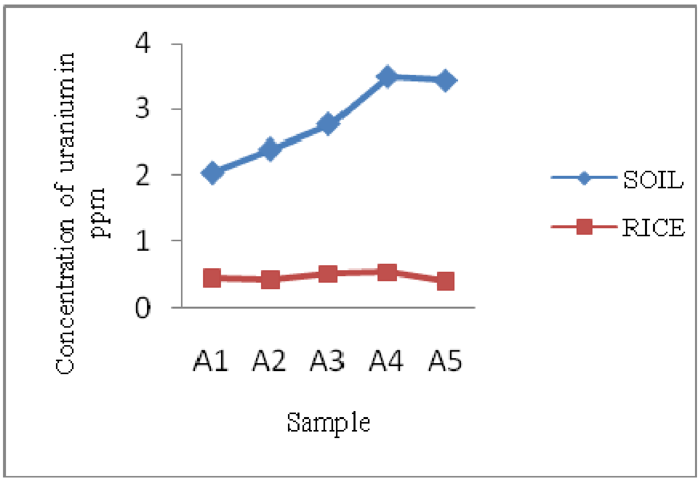

Fig. 1 – Concentration of uranium in sample at rural area.

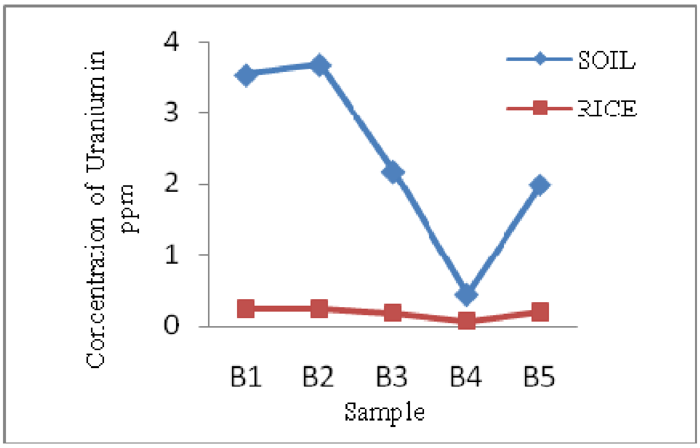

Fig. 2 – Concentration of uranium in sample at urban area.

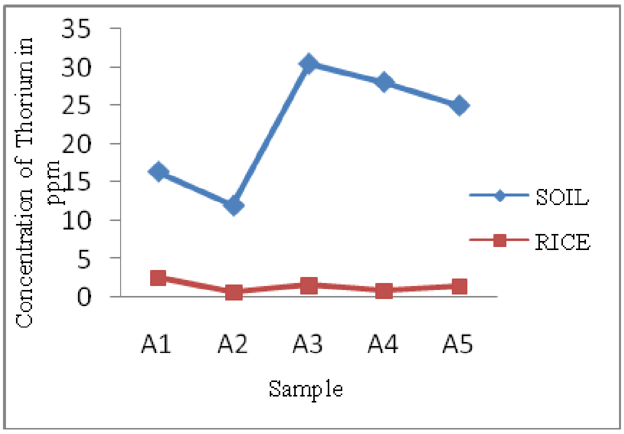

Fig. 3 – Concentration of thorium in sample at rural area.

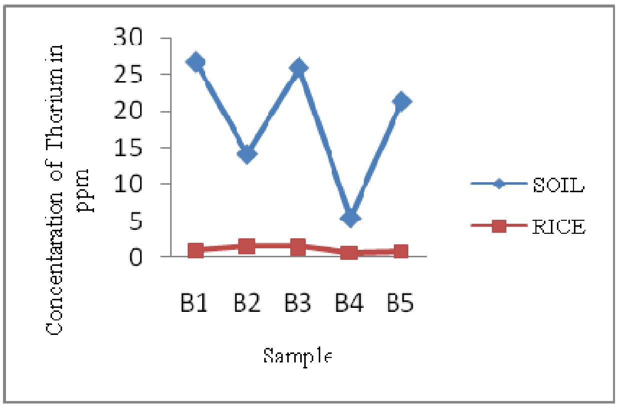

Fig. 4 – Concentration of thorium in sample at urban area.

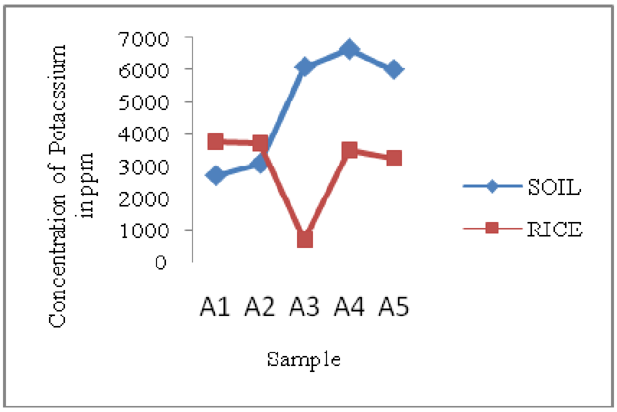

Fig. 5 – Concentration of potassium in sample at rural area.

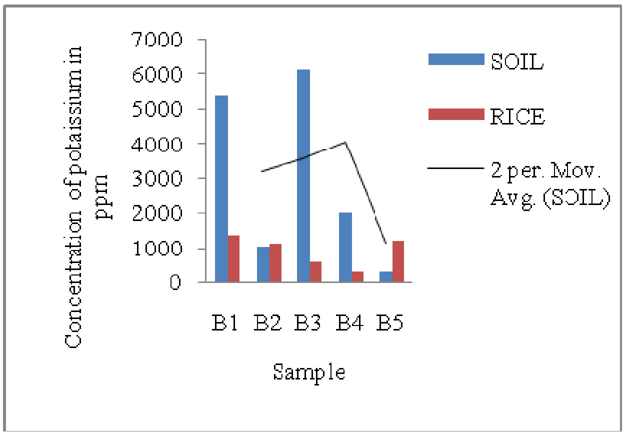

Fig. 6 – Concentration of potassium in sample at urban area.

In sequence the concentration of thorium is shown in Figure 3 and 4; which envisaged that the highest concentration of thorium in soil in rural area was 30.43 ppm and at same time the lowest concentration was 12.05 ppm. In case of rice crops, the highest value of concentration was 2.58 ppm, whereas the lowest value was 0.68 ppm. For the urban area the highest concentration was calculated as 26.71 ppm in soil and 1.60 for the crop. At this area the lowest concentration in soil was found to be 5.46 ppm and for the crops this value was 0.73 ppm. Results foreseen that for thorium, the concentration at rural area was higher than the urban area.

The results in the Figure 5 and 6, envisage that the highest concentration of potassium in soil at rural area was 6646.95 ppm and the lowest concentration was 2693.54 ppm. At the same vicinity, the rice crops had a highest concentration 3751.22 ppm. At the urban area the highest concentration for soil was found to be 6095.04 ppm and the lowest concentration was near to 299.88 ppm. In case of crops, the highest concentration was 1333.12 ppm and the lowest was 291.44 ppm.

The above statistics show that different areas have different amount of concentration. This may be due to dissimilarity in locations and the physical properties of the soil and the crop. Furthermore, amount of fertilizers or other elements in that soil and crops also can make the difference among all of concentrations.

3.2. CALCULATION OF TRANSFER FACTOR FROM SOIL TO CROP

To evaluate the soil to crop transfer factor following equation was used [18]

$$\text{TF}=\frac{\text{concentration element in crop}\left(\text{Bq/Kg}\right)}{\text{concentration of element in soil}\left(\text{Bq/Kg}\right)} \tag{3}$$

The result gives us an idea that, uranium has higher number of transfer factor than thorium. That was may be due to the amount of soil pH and its texture. The transfer factor data is shown in the Table 1. The tabulated data shows that in the rural area, the values of transfer factor for the uranium, thorium and potassium were poles apart to each other. In case of uranium the highest value of TF was 0.20. Whereas for thorium and potassium the highest values of transfer factor were 0.15 and 1.43 respectively. In the urban area the highest TF for uranium, thorium and potassium were 0.09, 0.11 and 4.12.

Result predicted that for both areas, potassium has highest TF. This was due to the fact that potassium is an important element to fertile the crop. Even though potassium is the radioactive element but it does not harm in aquatic system. Potassium is important to grow plant to adapt the environmental stresses. Therefore as compare to the uranium and thorium, the potassium had the highest number of transfer factor. The higher transfer factor of potassium at that time was not at risk streak because that value was not at staid position to harm the body.

Table 1

Transfer factor at rural area and urban area

sample	Transfer factor from soil to crop		
	Uranium	Thorium	Potassium
A1	0.20	0.15	1.43
A2	0.16	0.05	1.20
A3	0.17	0.04	0.11
A4	0.14	0.02	0.52
A5	0.105	0.05	0.53
B1	0.05	0.03	0.24
B2	0.06	0.11	1.05
B3	0.08	0.05	0.09
B4	0.04	0.11	0.14
B5	0.09	0.03	4.12

4. CONCLUSION

The concentration and transfer factors of soil to crop in Kedah (Malaysia) were experimentally estimated. Among the different outcomes of the research; we focused over the concentration for uranium, thorium and potassium in soil and crop at rural and urban area. The result predicted that the values of concentration of uranium, thorium and potassium at the safe level at Kedah. The calculated dose was found to be still lower than the dose limit (1 mSv/year) from *International Atomic Energy Agency* standards. In rural areas the highest transfer factor of uranium, thorium and potassium in soil were found to be 0.20, 0.15, and 1.43 respectively. While in the urban area the highest transfer factor of uranium, thorium and potassium were 0.09, 0.11 and 4.12 respectively.

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