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# ASSESSMENT OF NATURAL RADIONUCLIDE LEVELS FOR TEA SAMPLES IN NAJAF, IRAQ

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***Abstract.*** *In this paper, twenty tea samples that are available in Najaf markets were tested for their radioactivity contents using gamma-ray spectroscopic measurements NaI(Tl) "3× 3". The specific activity of $^{238}U$, $^{232}Th$ and $^{40}K$ from tea samples ranged from 2.87±1.75 to 22.03±1.95 Bq/kg, 5.80±3.45 to 64.74±5.12 Bq/kg and 630.00±13.08 to 1354.67±25.82 Bq/kg respectively. Hazard indices were also calculated to assess the radiation hazard. All calculated values for hazard indices were less than unity.*

***Keywords:*** *Radioactivity, radionuclides, tea, hazard index and Iraqi food*

## 1. INTRODUCTION

$^{238}U$, $^{232}Th$ and $^{40}K$ are three long-lived naturally occurring radionuclides present in the Earth's crust. Generally, there are two sources of environmental radionuclides, natural (mainly from the $^{238}U$, $^{232}Th$ series) and artificial ($^{137}Cs$) sources [1]. The recent technological activities, industrialization and associated technological endeavors have resulted in increased encroachment and pollution of nature. In addition to the naturally occurring radionuclides, essential and heavy elements artificially produced and technologically enhanced concentrations of these elements will be also taking place due to the activities listed above. All these activities may cause certain contamination of radionuclides, toxic elements and other polluting agents on vegetation [2]. Studies on transfer of natural radionuclides from soil to plants have been carried out in various regions of the world to understand the nature of absorption and accumulation of radioactive and non-radioactive elements [3-9] usually transferred to plant tissues by direct transfer via the root system, or by absorption of fallout radionuclides and resuspension of contaminated soil followed by deposition on plant leaves [3,10,11].

In addition to the well-known 16 essential elements for the growth and reproduction of plants, a number of other natural radioactive elements like uranium, thorium and their progeny, cosmogonic radionuclide $^{7}Be$ and artificial radionuclides such as $^{137}Cs$ and $^{90}Sr$ are found to be present in plants to different extents [12,13].

The knowledge of radiation levels and radionuclides in the foodstuff is important for assessing the effects of radiation exposure due to both natural and artificial radioactivity. The radiological importance of these radionuclides is due to the gamma-ray exposure of the body via digestion. Radioactivity in the food comes from naturally occurring radionuclides and artificial radionuclides [14]. Radionuclides pass to the human body through the food chain. Root uptake is the initial and significant step of radionuclide transfer from soil to the plant in the food chain (IAEA 2009). In the past, translocation and percent distribution of $^{137}Cs$ in different parts of the tea plants were investigated based on the foliar absorption and root uptake [15]. Radiation hazard indices may be calculated in soil, building material, and food, in order to measure the radiation hazards when inhalation from the human. The radiological hazard indices are a widely used radiation index to assess the radiological hazard of food samples (may be used in tea). The aim of this study is to assess the levels of natural radioactivity in tea leafs and hazard to human health.

## 2. EXPERIMENTAL

### *2.1 Sampling and preparations*

A total of twenty tea samples were collected from different local markets of Najaf province with different origins. All samples were prepared for the measurement of specific activity, the samples were grinded into a fine powder with the particle size less than 1 mm and then dried in a temperature-controlled oven at 100 C° for 24 hours to remove moisture. Each sample is stored in a sealed polyethylene Marinelli beaker for 4 weeks to achieve the secular equilibrium. This Marinelli beaker was used as sampling and measuring container. Before use, the containers were washed with hydrochloric acid and rinsed with distilled water. The specific activities were measured using NaI(TI) detector with 3"×3" crystal dimensions (Alpha Spectra, Inc.-12I12/3) coupled with a multi-channel

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analyzer 1496 channel (ORTEC-Digi Base) with a range of 0–3000 keV accompanied by the computer software (MAESTRO-32). The detector was enclosed in a graded lead shield. The resolution of detector was 6.8 keV for 662 keV and counting efficiency is 0.8% for 1332 keV. The $^{238}U$, $^{232}Th$ and $^{40}K$ radionuclides were identified by detection of the 1765, 2614 and 1460 keV respectively [16]. In order to subtract the background from each measurement, an empty Marinelli beaker (with the same geometry) was measured. The counting time was pre-set at 18,000 s just to obtain the gamma spectrum with good statistics.

### *2.2 Specific activity measurement*

The specific activity of each radionuclide was calculated by the following equation [17, 18].

$$A_s(Bq/kg) = \frac{C}{\varepsilon \times p_\gamma \times M_s} \quad (1)$$

where $C$ is the count rate of gamma rays (counts per second), $\varepsilon$ is the counting detector efficiency, $p_\gamma$ is the absolute transition probability of γ-decay and $M_s$ is the mass of the sample (kg).

### *2.3 Hazard indexes*

Widely used quantities such as the external ($H_{ex}$) and internal ($H_{in}$) hazard indices and the level of gamma radiation hazard ($I_\gamma$) are used to reflect the external exposure and are defined as following [19]:

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (2)$$

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (3)$$

$$I_\gamma = \frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000} \quad (4)$$

## 3. Results and discussion

The spectra of twenty tea samples of different origin were analyzed. The specific activity of $^{238}U$, $^{232}Th$ and $^{40}K$ is given in Table 1. The specific activity of Uranium-238 in (Bq/kg) unit varied from 2.87±1.75 to 22.03±1.95 with an average 09.08, whereas for the minimum value recorded in sample (T9), which represents Royal Stallion manufactured in London, and for the maximum value recorded in sample (T17), which represents Yaqoot from Sri Lanka, we can notice that all values of uranium specific activity are under the worldwide average (30 Bq/kg) [20]. Specific activity values of Thorium-232 ranged from 5.80±3.45 Bq/kg to 64.74±5.12 Bq/kg with the average of 21.81 Bq/kg, and the minimum value was found in Shah Savand sample (T1) from IRAN, while the maximum value was found in Naturavita Kamilica sample (T2) from Croatia.

Table 1. Specific activity and radium equivalent in (Bq/kg) of tea samples

| Sample code | Sample Name | origin | Specific activity (Bq/kg) | | |
|---|---|---|---|---|---|
| | | | $^{238}U$ | $^{232}Th$ | $^{40}K$ |
| $T_1$ | Shah Savand | Iran | 6.45±1.69 | **5.80±3.45** | 0993.41±14.96 |
| $T_2$ | Naturavita Kamilica | Croatia | 14.74±2.34 | **64.74±5.12** | 1286.11±27.90 |
| $T_3$ | Shah Saman | Iran | 10.46±3.78 | 26.02±6.21 | 1088.50±19.85 |
| $T_4$ | Yellow Label | London | 5.89±1.84 | 11.58±2.98 | 0874.59±15.32 |
| $T_5$ | Mahmood | Sri Lanka | 3.70±2.34 | 11.74±4.73 | 1127.40±17.38 |
| $T_6$ | Alghazaleen | Sri Lanka | 9.53±5.12 | 21.43±4.29 | 1053.48±18.02 |
| $T_7$ | Ahmed | England | 7.02±2.14 | 27.35±4.03 | 1050.78±17.84 |
| $T_8$ | Alwazah | Sri Lanka | 17.57±4.24 | 24.34±2.91 | 1143.91±17.77 |
| $T_9$ | Royal Stallion | London | **2.87±1.75** | 20.77±2.72 | **0630.00±13.08** |
| $T_{10}$ | Budgerigar | Sri Lanka | 4.22±2.61 | 21.14±3.43 | 1137.10±17.92 |
| $T_{11}$ | Loyd | Boland | 8.60±3.29 | 27.28±2.27 | 0990.68±18.39 |
| $T_{12}$ | MIR | Sri Lanka | 5.34±1.78 | 21.53±2.67 | 1073.90±18.11 |
| $T_{13}$ | Alokozay | U.A.E | 11.13±2.57 | 12.51±3.85 | 0774.78±17.84 |
| $T_{14}$ | Das gesunde plus | Germany | 6.07±3.13 | 17.62±3.70 | 0786.85±14.71 |
| $T_{15}$ | Lavanda | Croatia | 10.01±4.69 | 15.51±3.26 | 0928.23±18.99 |
| $T_{16}$ | Dilmah | New Zealand | 16.49±5.14 | 25.03±4.43 | 1005.66±19.60 |
| $T_{17}$ | Yaqoot | Sri Lanka | **22.03±1.95** | 19.28±4.03 | 1333.49±20.81 |
| $T_{18}$ | Green | Kenya & Indonesia | 8.86±5.64 | 22.93±7.24 | **1354.67±25.82** |
| $T_{19}$ | Alalam | Iraq | 3.49±2.13 | 15.57±3.96 | 0645.42±12.83 |
| $T_{20}$ | Kamy | Tunis | 7.15±2.11 | 24.12±4.09 | 0979.01±17.17 |
| Min. | | | 2.87±1.75 | 5.80±3.45 | 0630.00±13.08 |
| Max. | | | 22.03±1.95 | 64.74±5.12 | 1354.67±25.82 |
| Average | | | 9.08±3.01 | 21.81±3.97 | 1012.90±18.22 |

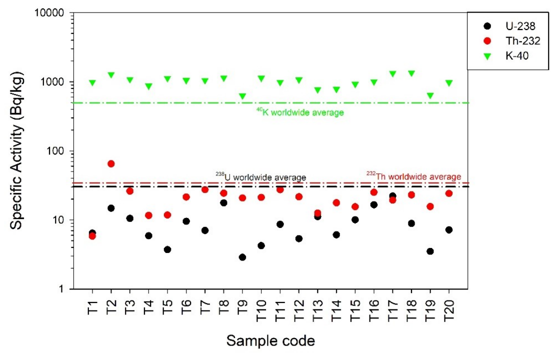


Figure 1. Specific activity of tea samples

Table 2. Absorbed dose rate, External and Internal hazard indices and activity concentration Index ($I_\gamma$) of tea samples.

| Sample code | $H_{ex.}$ | $H_{in.}$ | $I_\gamma$ |
|---|---|---|---|
| $T_1$ | 0.25 | 0.26 | 0.38 |
| $T_2$ | 0.56 | 0.60 | 0.80 |
| $T_3$ | 0.36 | 0.38 | 0.53 |
| $T_4$ | 0.24 | 0.26 | 0.37 |
| $T_5$ | 0.29 | 0.30 | 0.45 |
| $T_6$ | 0.33 | 0.35 | 0.49 |
| $T_7$ | 0.34 | 0.36 | 0.51 |
| $T_8$ | 0.38 | 0.43 | 0.56 |
| $T_9$ | 0.22 | 0.23 | 0.32 |
| $T_{10}$ | 0.33 | 0.34 | 0.50 |
| $T_{11}$ | 0.33 | 0.36 | 0.50 |
| $T_{12}$ | 0.32 | 0.34 | 0.48 |
| $T_{13}$ | 0.24 | 0.27 | 0.36 |
| $T_{14}$ | 0.25 | 0.26 | 0.37 |
| $T_{15}$ | 0.28 | 0.31 | 0.42 |
| $T_{16}$ | 0.35 | 0.39 | 0.52 |
| $T_{17}$ | 0.41 | 0.47 | 0.61 |
| $T_{18}$ | 0.39 | 0.42 | 0.60 |
| $T_{19}$ | 0.20 | 0.21 | 0.30 |
| $T_{20}$ | 0.32 | 0.34 | 0.47 |
| Min. | 0.20 | 0.21 | 0.30 |
| Max. | 0.56 | 0.60 | 0.80 |
| Average | 0.32 | 0.34 | 0.48 |

All specific activity values are lower than the worldwide average (30 Bq/kg) [20] except for the one value for the sample (T2), this value was higher than the worldwide average, maybe because of the leafy fertilizers used or the higher content of thorium in agricultural soil. The Potassium-40 specific activity values range from 630.00±13.08 Bq/kg to 1354.67±25.82 Bq/kg with average 1012.90±18.22 Bq/kg. The minimum value is found in a London tea named Royal Stallion (sample T9), but the maximum value is recorded in Green Tea from Kenya and Indonesia (sample T18). In Table 1, all values of specific activity for Potassium-40 are higher than the worldwide average (400 Bq/kg) [204]. The large variation between the specific activities obtained for $^{40}K$ and other two radionuclides can be easily ascribed to the high content of Potassium in fertilizers used in leafy nutrition. The calculated $Ra_{eq}$ values for all samples are also presented in Table 1.

The comparison of specific activity values of tea samples with the worldwide average is plotted in Figure 1. The calculated radiation hazard index of tea samples is listed in Table 2. The values ranged from 0.20 to 0.56 with an average value of 0.32 and from 0.21 to 0.60 with an average value of 0.34 for external ($H_{ex}$) and internal ($H_{in}$) respectively as mentioned in Table 2. For radiation hazard index, the values varied from 0.30 to 0.80 with an average value of 0.48. For all tea samples the values of hazard indices were less than unity [20].

## 4. Conclusion

All tea samples have uranium activity less than the worldwide average; one sample has thorium activity greater than the worldwide average. All samples have high potassium activity greater than worldwide average. All calculated values of hazard indices were less than unity.

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