Natural Radioactivity Measurements in different regions in Najaf city, Iraq

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***Abstract*— This study measures the activity of ^{238}U, ^{232}Th, and ^{40}K. The soil samples collected from different sites in Najaf city, Iraq. The studied samples were analyzed and the concentrations of radionuclides were determined using γ-ray spectrometry (NaI (Tl) detector). The mean values specific activity of radionuclides were agreement with those of the international values (IAEA) except sample S1 (Kufa) and sample S2 (Najaf Sea).**

***Keywords*— Natural radioactivity, soil, Najaf Sea, γ-ray**

I. Introduction

One of the scientific subjects that attract public attention is human exposure to ionizing radiation. Since radiation of natural origin is responsible for most of the total radiation exposure of the human population [1], and exposure to natural radiation is the largest component of all exposure for people and form the baseline upon which exposures of a man-made source are possible [2], knowledge of the dose received from natural radioactivity is very important in the discussion not only of effects on health, but also of the incidence of radiation of man-made sources [1]. Investigation of natural radiation background is of great importance because it is the main source of exposure for human [3]. Natural environment radioactivity and the associated external exposure due to gamma radiation depend mainly on the geological and geographical condition, and appear at different levels in the soil of earth region in the world [4, 5-16]. The specific levels of terrestrial environmental radiation are related to the composition of each litho logically separated area, and to the content of the rock from which the soils originate [17]. The aim of this study was undertaken with the purpose of measuring natural radioactivity due to ^{238}U, ^{232}Th and ^{40}K and gamma concentration index, so as to compare them with the recommended limits.

II. Materials and Methods

A Seven soil samples were collected from different areas in Najaf governorate. The samples were dried and pulverized. Each sample was then weighed and sealed in Marinelli beaker. Gamma spectroscopic measurement was performed using a NaI (Tl) detector. The detector is surrounded by a lead shielding. The spectrometer has been calibrated for energy by acquiring a spectrum from four standard sources of gamma radiations supplied by spectrum techniques LLC. These sources are ^{22}Na, ^{60}Co, ^{54}Mn, and ^{137}Cs. The natural radioactivity of soil samples is determined from the ^{238}U, ^{232}Th, and ^{40}K contents (TABLE I).

The specific activity of each radionuclide (As) is calculated using the following equation [18].

$$A_s(Bq\ kg^{-1}) = \frac{C}{\varepsilon\ \gamma\ m\ t} \quad (1)$$

wher C is net count

The absolute photo peak detection efficiency as a function energy and measured geometry is determined in order to measure the true activities. The counting efficiency curve is plotted in Fig. 1.

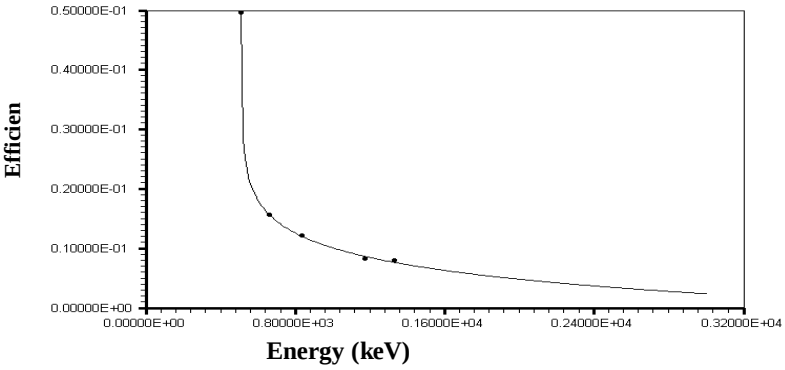

Fig. 1. The efficiency calibration curve of 3×3 NaI (Tl) detector

TABLE I
PERCENTAGE OF GAMMA EMISSION PROBABILITY OF ^{238}U, ^{232}TH, AND ^{40}K

Isotope	E_γ (keV)	I_γ%	ε%
^{40}K	1460	10.6	1.910
^{238}U	1764	15.8	1.44
^{232}Th	2614	100	0.805

A. Radiological hazard index

1) Radium equivalent activity (Raeq)

In order to represent or evaluate the radiological hazards associated with the three different radiations of ^{238}U, ^{232}Th and ^{40}K, a single quantity, a common operator called radium equivalent activity (Ra_{eq}). It is mathematically defined by the equation below [19, 20].

$$Ra_{eq}(Bq\ kg^{-1}) = A_U + 1.43A_{Th} + 0.077A_K \quad (2)$$

where A_U, A_{Th}, and A_K are the specific activities of uranium, thorium and potassium, respectively. The maximum value of Raeq must be less than the acceptable safe limit of 370 Bq kg^{-1} [21].

2) Activity concentration index (Iγ)

Activity concentration indexes are used to estimate the dangerous due to gamma radiation associated with the natural radio nuclides (^{238}U, ^{232}Th, and ^{40}K), in the study, another radiation hazard index, the activity concentration index (Iγ) is defined as [22].

$$I_\gamma = \frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_k}{3000} \quad (3)$$

If the value of the activity concentration index is 1 or less, then Iγ is normal. But if the value exceeds 1 it may be risk [23].

Fig. 2 shows an example of a low-resolution image which would not be acceptable, whereas Fig. 3 shows an example of an image with adequate resolution. Check that the resolution is adequate to reveal the important detail in the figure.

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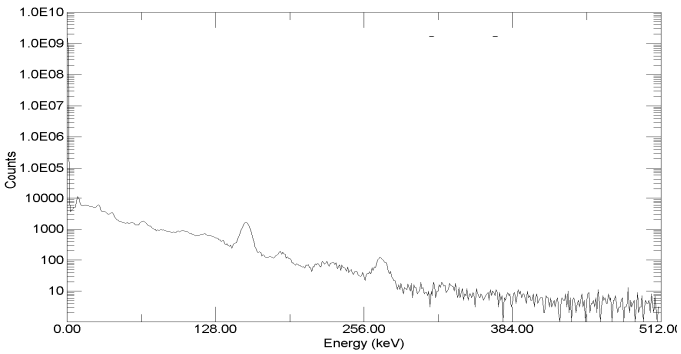

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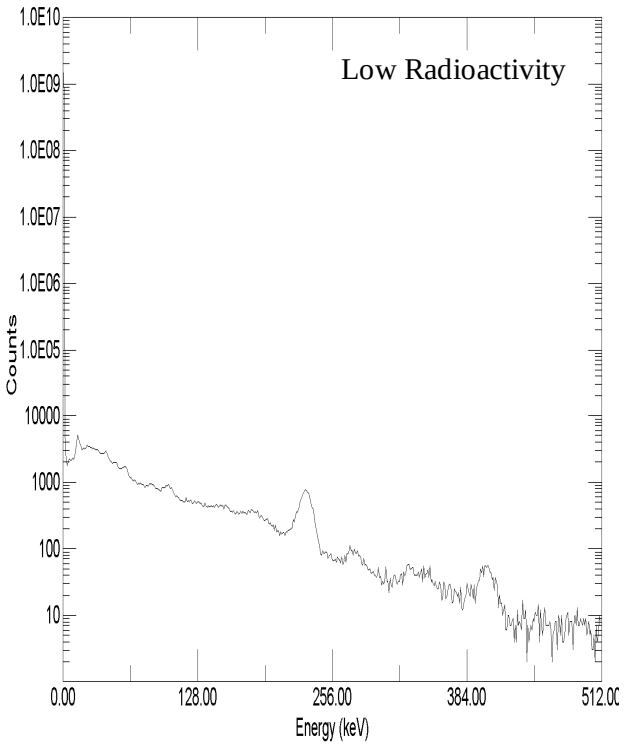

Fig. 2. High and low radioactivity of soil spectrums

III. RESULTS AND DISCUSSION

Activity levels of U, Th, and K of the various soil samples were presented in TABLE II.

TABLE III
SPECIFIC ACTIVITY FOR (^{238}U, ^{232}TH, AND ^{40}K) IN Bq kg^{-1}, Ra_{eq} (Bq kg^{-1}), AND I_γ IN STUDIED SAMPLES

Site code	Location	^{232}Th	^{238}U	^{40}K	Ra_{eq}	I_γ
S_1	Kufa	9.09±26	304.35±78	209.22±17	333.47	1.12
S_2	Sea of Najaf	7.58±16	19.00±34	572.75±23	73.95	0.29
S_3	Center of Najaf	8.60±18	21.70±28	245.28±40	52.89	0.19
S_4	Cement industrial region	3.17±13	1.08±1.00	283.55±31	27.45	0.11
S_5	Alqazueeny	10.33±17	29.75±42	41.32±11	47.71	0.16
S_6	Almanathera	4.93±12	11.83±31	84.02±13	25.35	0.09
S_7	Abassia	8.37±19	21.90±40	313.87±12	58.04	0.21
Avg		7±17	58±36	250±21	88.41	0.31

Soil ^{238}U, ^{232}Th, and ^{40}K in the study area were found to be 58.51±36.28, 7.43±17.28, and 250±21 Bq kg^{-1}, respectively. From TABLE II, the higher ^{238}U and ^{232}Th concentrations in soil samples are noted in site S1 in Kufa and site S5 in Alqazueeny, respectively, and the higher ^{40}K concentration noted in site S2 in Sea of Najaf, whereas the lower ^{238}U, ^{232}Th concentrations are noted in site S4 in Cement industrial region, and the lower ^{40}K concentration noted in site S5 in Alqazueeny. The world average concentrations are 35 and 45 Bq kg^{-1} for ^{238}U and ^{232}Th, respectively. The typical ranges are 16 Bq kg^{-1} to 116 Bq kg^{-1} for ^{238}U and 7 Bq kg^{-1} to 50 Bq kg^{-1} for ^{232}Th. The world average concentration is 420 Bq kg^{-1} for ^{40}K, and the typical range is 100 Bq kg^{-1} to 700 Bq kg^{-1} for ^{40}K [2]. The average value of Ra_{eq} is 88.41 Bq kg^{-1} as shown in TABLE II, which are less than the 370 Bq kg^{-1} recommended maximum levels of radium equivalents in soil [21]. The average value of I_γ is 0.31. The value of I_γ in sampling site S1 are higher than unity, which may cause harm to people in this region.

IV. Conclusions

The The results have shown that all samples studied, except sample S1, Kufa, contain average activity concentration of 238U higher than the world average. Whereas 232Th concentration in all samples was lower than the world average. Average activity concentration of 40K was exceeded the world average in sample S2 (Najaf Sea) may be because the local geology and to the content of the rock from which the soils originate which contain potassium element where the place was a Sea before thousands years.

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