Measurement The Specific Activity and Hazard Indices of ^{238}U, ^{232}Th, and ^{40}K in Soil Sample for Different sites in Babylon Governorate, Iraq

Esraa S. Obayes[1] and Khalid H.Hatif Al-Atiya[1]

[1]*Department of Physics, Collage of Science, University of Babylon, Babel, Iraq*

**E-mail: esraa.qataa@student.uobabylon.edu.iq*

Abstract

The purpose of this study investigation to measure the specific activates and hazard indices in soil samples at different locations in Babylon governorate. The measurements have been done using spectral analysis technique for NaI(TI) detector. The results of specific activity for ^{238}U, ^{232}Th and ^{40}K in soil samples have ranged between from (0.508 ± 0.113 to 3.507 ± 0.298 Bq/kg) with average value 1.536 ± 0.190 (Bq/kg), the specific activity of ^{232}Th was ranged from (1.504 ± 0.191 to 20.527 ± 0.705) with the average value of (9.474±0.460Bq/kg), while for ^{40}K was ranged from (251.211 ± 3.199 to 440.833 ± 4.238 Bq/kg) with the average value of (333.481 ± 3.678 Bq/kg).When we compared the current work's results to the global average, we discovered that the values were within the recommended range.

Keywords: Specific Activity, Hazard Indices, Gamma Ray, NaI(TI).

DOI Number: 10.14704/nq.2022.20.9.NQ44415 **Neuro Quantology 2022; 20(9):3652-3658**

1. Introduction

Radiation is emitted from a variety of natural and man-made sources. This includes radioactivity from naturally occurring radioactive in the environment as well as cosmic radiation. Several branches of study are interested in learning about natural radionuclide concentration levels in soil and their distribution in the environment [1]. The population's background radiation exposure is caused by natural radionuclides in the soil. The terrestrial component of the natural background is determined by the compositions of soils and rocks, which include natural radionuclides.

Natural radioactivity levels are determined by geological factors, mostly rocks and soil, where they can be found in various amounts [2]. Irradiation of the human body from external sources is mainly by gamma radiation from radionuclides in the ^{238}U, ^{232}Th and ^{40}K. Uranium series (^{238}U) and its compounds (^{214}Bi) are highly toxic, which is a threat to human health and ecological balance [3]. Uranium can enter the human body in a number of ways, including directly via inhaling uranium-bearing dust particles or drinking uranium-bearing water, or indirectly through the food chain from fertile soil layers [4,5]. The purpose of this study is measured the concentration of ^{238}U, ^{232}Th and ^{40}K in soil samples collected from different sites in Babylon governorate, Iraq due to the increase in cancerous diseases in Babylon governorate and to know the relationship between cancerous and radioactivity.

2. Materials and Methods

2.1 Area of Study

Thirty soil samples are collected from 10 different locations of Babylon governorate as shown in the figure (1). These districts and sub-districts were chosen to research the radiation activity in the region of Babylon governorate due to the increase in cancerous diseases resulting from the radioactive elements in the soil. Where statistics were obtained from the cancer control center in Babylon heath directorate, and it was found there are huge numbers of cases of cancerous diseases.

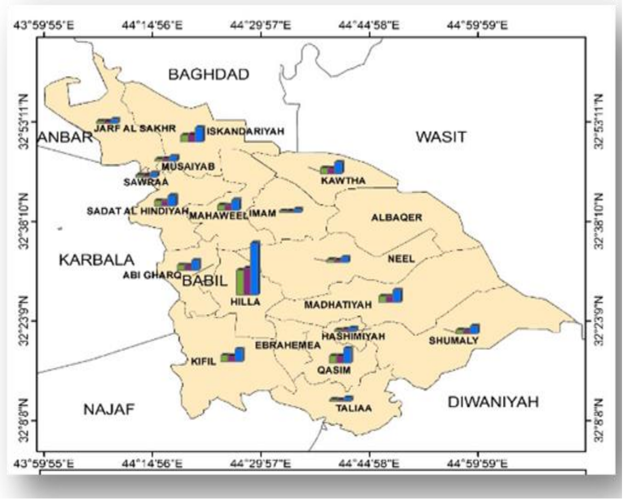

Figure (1): Map sites of study area.

2.2 Preparation of the samples

After collecting the samples, they were dried by 110 °C using an electric oven, then crushed and filtered with a diameter clamp (1mm) to obtain the soil moisture-free and uniform and then placed (1kg) in a Marinelli beaker and kept for one month to achieve equilibrium for nuclei and their cores [1].

2.3 The nuclear detector system

Activity concentrations of the natural radionuclides were measured using NaI(TI) detector of (3"×3") crystal dimension coupled with MCA (multi-channel analyzer) as shown in figure 2. MCA has a 4096-channel through interface that connects to an ADC (Analog to Digital Converter). MAESTRO-32 program analyzes gamma-ray spectroscopy measurements [6]. The energy of NaI(Tl) was calibrated by obtaining a spectrum from radioactive standard sources with known energies, such as (C0-60, Ba-133,Co-57, Cs-137, Na-22).

Figure (2): Detection system

3. The Measurements of Sample

After measuring the radiation background and calibrating energy and efficiency of the detector, the activity concentration and hazard indices are calculated in the following equations.

3.1 Specific Activity (A)

The quality of radiologic efficacy was calculate of ^{238}U has been calculated in terms of ^{214}Bi with energy (1764 KeV), ^{232}Th in terms of (^{208}Tl) with energy (2614 keV) and measuring the activity of 40K with energy (1460 KeV). The following equation was used to calculate the specific activity (A)of radionuclides in soil samples [7]:

$$A = \frac{Nn.a}{I\gamma.\varepsilon.m.t} \pm \frac{\sqrt{Nn.a}}{I\gamma.\varepsilon.m.t}\left[\frac{\mathrm{Bq}}{\mathrm{Kg}}\right] \quad (1)$$

Where:

Nn. a: The net count (area under the curve for each sample after back ground subtraction)

Iγ: The transition probability of the emitted gamma ray

m: Weight of the sample

t: Time of measurement (12000 s)

ε: The efficiency of the detector

3.2 Radium Equivalent (Raeq)

Radiological index has been established to describe the activity concentrations. (Raeq) index of (^{238}U, ^{232}Th, and ^{40}K) is calculated by the equation [8]:

$$(\text{Raeq Bq/kg}) = AU + 1.43ATh + 0.077AK \quad (2)$$

Where: AU, ATh and AK are the activities concentrations of (^{238}U, ^{232}Th and ^{40}K) in (Bq/kg) respectively.

3.3 Absorbed Dose Rate in Air (AD)

The absorbed dose in the air can be computed using the following equation in terms of the concentration of terrestrial cores [9]:

$$AD(\frac{nGy}{h}) = 0.462A_U + 0.604A_{Th} + 0.0417A_K \quad (3)$$

3.4 Annual Effective Dose Rate (AED)

A conversion factor of was used to compute the anticipated annual effective dose equivalent received by a member this (0.7 Sv/Gy), this was used to calculate the effective dose equivalent of the absorbed rate an outdoor occupancy of (20 %) and (80 %) for indoors [10]:

$$(AED)in\ (mSv/y) = AD\ (\frac{nGy}{h}) \times 10^{-6} \times 8760h \times 0.8 \times 0.7 (\frac{sv}{Gy}) \quad (4)$$

$$(AED)out(mSv/y) = AD(\frac{nGy}{h}) \times 10^{-6} \times 8760h \times 0.2 \times 0.7 (\frac{sv}{Gy}) \quad (5)$$

3.5 External (H_{ex}) and Internal (H_{in}) Hazard Indices

Internal risk transactions (Hin) and external hazard index (Hex) can be calculated to measure the risk of gamma rays and related radiation. The following two equations were obtained based on the quality of radiation specific activity [11]:

$$Hex = \frac{Au}{370} + \frac{ATh}{259} + \frac{Ak}{4810} \quad (6)$$

$$Hin = \frac{Au}{185} + \frac{ATh}{259} + \frac{Ak}{4810} \quad (7)$$

3.6 Gamma Index (Iγ)

The following equation was used to compute the gamma index (I_γ) for soil samples [12]:

$$I\gamma = \frac{Au}{150} + \frac{ATh}{100} + \frac{Ak}{1500} \quad (8)$$

4. Results and discussion

The specific activity for thirty soil samples collected from different sites from Babylon has been present in Table 1. The highest and lowest value of specific activity of ^{238}U have been ranged from (0.5083 ± 0.11366 to 3.50739 ± 0.2985) (Bq/Kg) with average value 1.536 ± 0.1907 (Bq/Kg). The minimum value has been found in samples S24, while the maximum value in sample S22. From Figure 3 shows the values of specific concentrations for ^{238}U. The average value of the current work is less than the worldwide average value (30 Bq/kg) calculated by UNSCEAR 2000 [13]. On the other hand, the highest and lowest value of specific activity of ^{232}Th, which ranges from (1.504 ± 0.191to 20.527 ± 0.705) (Bq/Kg) with average value 9.474 ± 0.460 (Bq/Kg) as shown in figure (4). The average value of ^{232}Th of the current work is less than the worldwide average value (35 Bq/kg). Whereas, the highest and lowest value of specific activity of ^{40}K, which ranges from (251.211 ± 3.199 to 440.833 ± 4.238) (Bq/Kg) with average value 333.481 ± 3.678 (Bq/Kg) as shown in figure (5). The maximum value of specific activity of ^{40}K was in Al-Hilla (S18) higher than the worldwide average value (400 Bq/kg), which is due to the presence of phosphate fertilizers in this agricultural region.

Table (1): Specific activity values for ^{238}U, ^{232}Th and ^{40}K

Sample No.	Sampling Regions	Specific Activity (Bq/Kg)		
		^{238}U	^{232}Th	^{40}K
S1	Al-Nile	1.397±0.188	14.291±0.588	359.637±3.828
S2		2.084±0.230	5.750±0.373	307.707±3.541
S3		0.686±0.132	20.527±0.705	353.604±3.796
S4	Al-Qasim	0.813±0.143	13.707±0.576	251.211±3.199
S5		1.042±0.162	3.542±0.293	387.150±3.972
S6		0.711±0.134	3.469±0.290	273.304±3.330
S7	Abi-Gharaq	0.686±0.132	8.662±0458	398.604±4.030
S8		1.042±0.162	7.521±0.427	255.736±3.228
S9		1.016±0.160	9.632±0.483	330.248±3.668

S10	Al-Emam	0.711±0.134	1.771±0.207	288.834±3.431
S11		1.092±0.166	7.424±0.424	326.579±3.648
S12		1.524±0.196	9.608±0.482	342.598±3.736
S13	Al-Showmali	1.067±0.164	17.106±0.644	369.012±3.878
S14		2.617±0.257	13.539±0.573	309.052±3.549
S15		1.397±0.188	3.955±0.309	284.269±3.403
S16	Hillah-Districts	1.092±0.166	11.768±0.534	379.039±3.930
S17		1.855±0.217	6.721±0.403	325.642±3.643
S18		0.609±0.124	4.464±0.329	440.833±4.238
S19	Al-Midhatiya	0.609±0.124	1.504±0.191	347.204±3.771
S20		2.846±0.268	17.761±0.656	405.493±4.065
S21		2.160±0.234	9.390±0.477	287.004±3.420
S22	Al-Hashimiyah	3.507±0.298	8.856±0.463	355.927±3.808
S23		0.965±0.156	10.603±0.507	311.171±3.561
S24		0.508±0.113	8.468±0.453	299.065±3.491
S25	Al-Ibrahimiya	2.439±0.249	17.324±0.648	377.653±3.923
S26		1.982±0.224	8.807±0.462	352.055±3.788
S27		2.567±0.255	14.291±0.588	343.332±3.740
S28	Al-Taleea	2.287±0.241	13.976±0.582	329.962±3.667
S29		2.567±0.255	6.187±0.387	309.786±3.553
S30		2.211±0.237	3.591±0.295	302.734±3.512
Ave±SD		**1.536±0.19**	**9.474±0.460**	**333.481±3.678**
Max±SD		**3.507±0.298**	**20.527±0.705**	**440.833±4.238**
Min±SD		**0.508±0.113**	**1.504±0.191**	**251.211±3.199**
Global limit		**30**	**35**	**400**

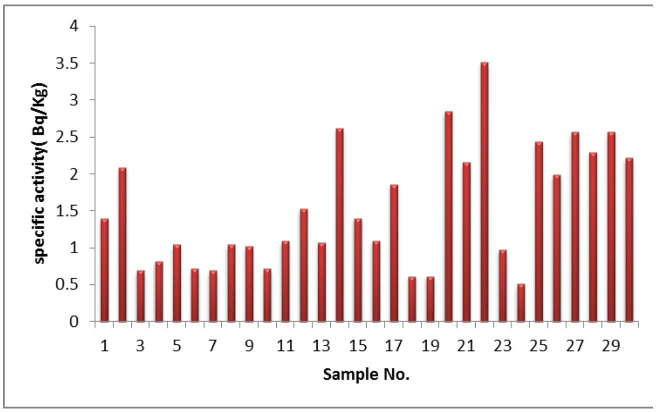

Figure (3): The specific activities of ^{238}Uof the samples.

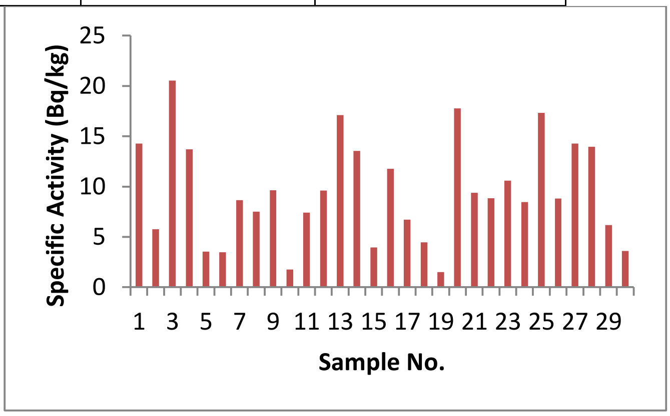

Figure (4): The specific activities of ^{232}Th of the samples.

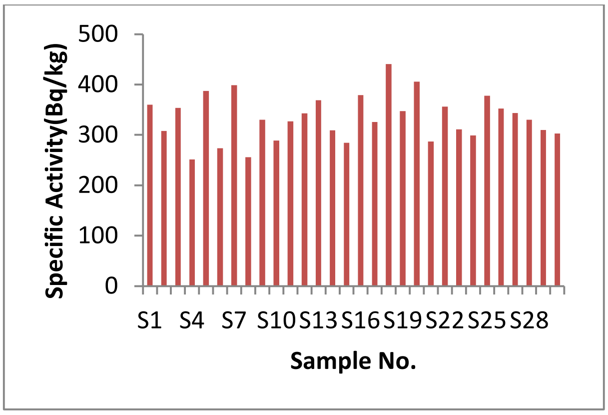

Figure (5): The specific activities of ^{40}K of the samples

From Table 2, the value of Raeq was ranged from (25.484 to 59.468 Bq/Kg), with the value rate of (40.763 Bq/kg). The Raeq values for all soil samples were less than the suggested high value (370 Bq/kg), as be observed. For AD, The minimum value of AD was (13.473nGy/h), while the maximum value of AD was (29.254nGy/h) with value rate of (20.499nGy/h). The values of Hex and Hin was varied from (0.068 to 0.160) and from (0.074to 0.168) respectively with the value rate of (0.110) and (0.114) respectively. The value of (Iγ) was ranged from (0.224 to 0.424) with the value rate of (0.326). The values of AEDEin and AEDEout was ranged between (0.066to 0.143mSv/y) and from (0.016to 0.035mSv/y) respectively with the average value of (0.100mSv/y) and (0.025mSv/y) respectively. The present results have shown that values of (Raeq, AD, Hex, Hin, AEDEin and AEDEout,) for soil samples were less than the recommended value given by UNSCEAR [13].

Table (2): Measurements of Hazard Indices in our current work.

No.	$Ra_{(eq}$Bq/kg	AD(nGy/h)	H_{ex}	H_{in}	Iγ	AEDE(mSv/y)	
						Indoor	outdoor
S1	28.98	15.01	0.078	0.080	0.285	0.073	0.018
S2	49.52	24.51	0.133	0.137	0.357	0.122	0.030
S3	34.009	17.36	0.091	0.097	0.307	0.085	0.0212
S4	57.26	27.80	0.154	0.156	0.377	0.136	0.034
S5	39.75	19.36	0.107	0.109	0.405	0.094	0.023
S6	35.91	18.82	0.096	0.099	0.224	0.092	0.023
S7	26.71	13.88	0.072	0.074	0.305	0.068	0.013
S8	43.76	22.31	0.118	0.120	0.261	0.109	0.027
S9	31.49	15.81	0.085	0.087	0.302	0.077	0.019
S10	40.22	20.22	0.108	0.111	0.295	0.099	0.024
S11	25.48	13.47	0.068	0.077	0.241	0.066	0.016
S12	36.85	18.73	0.099	0.102	0.309	0.091	0.022
S13	41.64	20.95	0.112	0.116	0.352	0.102	0.025
S14	53.94	26.50	0.145	0.148	0.384	0.131	0.032
S15	45.77	22.50	0.123	0.130	0.342	0.114	0.027
S16	28.94	14.95	0.078	0.081	0.301	0.073	0.018
S17	47.107	23.61	0.127	0.130	0.342	0.115	0.028
S18	36.54	18.61	0.098	0.103	0.373	0.091	0.022

S19	40.93	21.43	0.110	0.112	0.280	0.151	0.026
S20	29.49	15.69	0.079	0.0812	0.289	0.076	0.019
S21	59.46	29.25	0.160	0.168	0.387	0.143	0.035
S22	37.68	18.79	0.101	0.107	0.345	0.092	0.023
S23	43.57	21.96	0.117	0.127	0.319	0.107	0.026
S24	40.08	20.00	0.108	0.110	0.311	0.098	0.024
S25	35.64	17.96	0.096	0.097	0.339	0.088	0.022
S26	56.29	27.63	0.151	0.158	0.424	0.135	0.033
S27	41.68	21.06	0.112	0.117	0.331	0.103	0.025
S28	49.44	24.37	0.133	0.140	0.380	0.119	0.029
S29	47.68	23.49	0.128	0.134	0.361	0.115	0.028
S30	35.26	17.94	0.095	0.102	0.280	0.088	0.022
Ave.	**40.76**	**20.49**	**0.110**	**0.114**	**0.326**	**0.100**	**0.025**
Max	**59.46**	**29.25**	**0.160**	**0.168**	**0.424**	**0.143**	**0.035**
Min	**25.48**	**13.47**	**0.068**	**0.074**	**0.224**	**0.066**	**0.016**
Global limit	**370**	**55**	**≤ 1**	**≤ 1**	**≤ 1**	**1**	**1**

5. Conclusions

The results of the specific activity for ^{40}K found to be higher than specific activity of ^{232}Th and ^{238}U. The concentration of ^{40}K anomalous was (440.833±4.238 Bq/kg) and above the permissible limit (400 Bq/kg) due to minerals in the soil. (Raeq, AD, Hex, Hin, AEDEinand AEDEout,)for soil samples was allowed limit live conditions. The results collected from Babylon is safety.

References

1-M.S.Aswood, A.A. Abojassim, and M.S. Al Musawi,''Natural radioactivity measurements of frozen red meat samples consumed in Iraq'', Radiation Detection Technology and Methods, 3(4), 57, (2019).

2- M.S.Aswood, M.S. Jaafar, and N. Salih,'' Estimation of annual effective dose dueto natural radioactivity in ingestion of vegetables from Cameron Highlands, Malaysia'', Environmental Technology & Innovation, 8, 96-102, (2017).

3- A.Al-Hamzawi, M. Jaafar, and N.Tawfiq,'' Uranium concentration in blood samples of Southern Iraqi leukemia patients using CR-39 track detector'', J RadioanalNuclChem 299:1267-1272, (2014).

4- A. Al-Hamzawi, F.Nada , N. Tawfiq, M. S.Aswood, and A.F. Najim. "Determination of radon concentrations near mobile towers in selected cities of Babylon governorate, Iraq." In Journal of Physics: Conference Series, 1234(1), p. 012026, (2019).

5-A.Al-Hamzawi, M.Jaafar, and N.Tawfiq, ''The relationship between uranium contamination and cancerous diseases of Southern Iraqi patients'',Pensee J 76(3),36-41,(2014).

6- H.M.Dia, S.A. Nouh , A. Hamdy, and S.A. EL-Fiki, ''Evaluation of natural radioactivity in a cultivated area around a fertilizer factory, Nuclear and Radiation Physics'', 3 1,53-62,(2008).

7- N.Shawkat , ''Radioactive pollution and environmental sources in the province of Nineveh'', Master Thesis Baghdad University,(2000).

8- A. El-Taher, and M.A.Uosif , ''The Assessment of the Radiation Hazard Indices due to Uranium and Thorium in Some Egyptian Environmental Matrices. Journal of Physics. D: Applied Physics. 39, 4516-4521,(2006).

9-S.Harb,A.H.EI-Kamel., A.I.AbdEI-Mageed,A.A bbady, andR.Wafaa, " Concentration of U-238, U-235, RA-226, TH-232 and K- 40 for Some Granite Samples in Eastern desert of Egypt" Proceedings of the 3rd Environmental Physics Conference, 19-23 Feb. Aswan, Egypt,109-117,(2008).

10- A.El-Taher, and S.Makhluf, ''Natural radioactivity levels in phosphate fertilizer and its environmental implications in as suit governorate'', Upper Egypt, Indian Journal of Pure & Applied Physics, 48, 697-702,(2010).

11- M.Oleiwi, ''Assessment of Natural Radioactivity in Some Soil Samples from Kutha District in Babylon Governorate, Iraq'', Jordan Journal of Physics, 14(3), 267-274, (2021).

12-S.A.Al-Hamdani,and M. Abdul K.Al-Sadi,''Radioactivity Assessment With Different Samples (Soil, Sediment) Selected From AL-Basra Governorate , Iraq ''Plant Archives 20, 3103-3110, (2020).

13- UNSCEAR, ''United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the general assembly''. Annex B: Exposures from Natural Radiation Sources, New York,(2000).