Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6, 3511-3518
2024
Publisher: Learning Gate
DOI: 10.55214/25768484.v8i6.2742

Investigating danger indicators in the soil samples of the Nile Region in Babylon Governorate in Iraq

Salar Hussein Ibrahem[1*]
[1]Department of Physics, College of Education for Pure Sciences, University of Babylon; pure.salar.hussein@uobabylon.edu.iq (S.H.I.).

Abstract: This study was conducted to detect the presence of radionuclides in the Nile region, which is one of the districts affiliated with the Mahaweel district in the Babil Governorate in Iraq and is located to the southeast of the center of the district, where many cancer cases appeared in this area, which necessitated researching whether there is a trace of radioactivity in the soil of this region was used, where the "NaI(Tl) gamma detector" was used, and the activity concentration levels of 238U, 232Th, and 40K were measured and compared with the internationally permissible values for twenty samples of the soil of this region. The radionuclides of the soil were as follows: 238U with an average of (11.72±1.62) Bq/kg, 232Th with an average of (21.04±3.7) Bq/kg and 40 K with an average of (133.55±1.82). Bq/kg. Absorbed dose rate, annual effect, radium equivalent activity, effective dose rate (EDR), and equivalent dose (AEDE) were measured. The radioactivity level index (I), external (Hex) and internal (Hin) risk indices, as well as increased lifetime cancer risk (ELCR) were determined. It was concluded that there is no danger that may threaten the population in this area, and thus the possibility of any health effects of radiation is low. The values obtained are considered among internationally accepted values, meaning that this area is free of harmful radioactivity.
Keywords: *"NaI(T1) detector", Nile region, Soil, Specific activity.*

1. Introduction

Gamma rays, an electromagnetic kind of radiation, are produced by nuclear reactions. It is commonly described as high-energy, short-wavelength electromagnetic radiation.

This tremendous energy can cause serious harm when it is absorbed by living cells. Gamma rays have a deep penetrating property; hence protecting them takes a lot of mass. For greater absorption, materials with a high atomic number and high density are typically employed. Gamma-ray spectrometry can make use of a variety of radiation types. Thallium-activated sodium iodide NaI(Tl) detectors, though frequently employed for gamma-ray spectrometry, cannot match the combination of high resolution and low background that Ge detectors can provide. Knowing the detector's effectiveness inside the counting geometry is necessary to determine the radionuclide concentration. Over the past few years, a number of techniques for figuring out efficiency in these odd geometries have been created. In order to understand the type and concentration of radioactive nuclides and their significance [1-4].

2. Tools and Procedures

As shown in Table (1) and Fig (1), the geographical locations of the Nile region in Babil Governorate in Iraq. Samples were examined at a depth of (25-30) cm underground. Samples weigh one kilogram in Marinelli beaker and kept for 50 days after filtering through a sieve (1 mm) and dried in an oven at 120 °C to remove moisture.

* Correspondence: pure.salar.hussein@uobabylon.edu.iq

Table 1.
The code, location, longitude and latitude of soil samples.

Sample code	Longitude (East)	Latitude (North)
N1	44°31'59.804" E	32°34'29.105"N
N2	44°32′42.291" E	32°34'29.867"N
N3	44°32 17.684" E	32°34'3.309"N
N4	44°31'58.814" E	32°33′24.59"N
N5	44°32′41.692" E	32°33'10.91"N
N6	44°32' 27.984" E	32°32'41.445"N
N7	44°33'0.207" E	32°32'49.304"N
N8	44°32'8.154"E	32°33'10.738"N
N9	44°32'51.094 E	32°32'59.916"N
N10	44°32'9.724"E	32°32'47.022"N
N11	44°32'18.173 E	32°33′19.433"N
N12	44°31'52.225"E	32°33'35.789"N
N13	44°31'19.729"E	32°34'18.532"N
N14	44°31'2.78"E	32°34′16.806"N
N15	44°30'12.787"E	32°34′25.847"N
N16	44°30'15.156"E	32°34'45.902" N
N17	44°30'25.396"E	32°34'31.49″N
N18	44°31'35.289" E	32°34′26.827"N
N19	44°31'24.871"E	32°34'43.822 N
N20	44°30′55.458 E	32°34'35.195″N

Figure 1.
The geographical locations of the Nile region.

Utilizing the detector Na (TI) the radioactivity of -emitting nuclides such ^{238}U, ^{232}Th, and ^{40}K have been discovered and investigated. This system offers a multi-channel analyzer (ORTEC) with 4096 channels that connect to an ADC unit. Software placed on the nuclear facility is used to perform and process nuclear measurements and analyses. Maestro-32, a computer program, is the research facility.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 3511-3518, 2024
DOI: 10.55214/25768484.v8i6.2742

Use radioactive sources with an energy range of (88-1332.5) keV to calibrate the measuring apparatus, such as Co-57, Co-60, Na-22, Cs- 137, and Cd-109.

3. The Theoretical Part

The activity concentration and danger indices are computed as follows after determining the radiation background and calibrating the detector's energy and effectiveness:

3.1. Specific Activity (A)

The radiologic efficacy of ^{238}U has been evaluated using ^{214}Bi with an energy of 1764 keV, monitoring the activity of ^{40}K with an energy of 1460 keV and ^{232}Th with a 2614 keV energy. The specific activity (A) of radionuclides in soil samples was calculated using the following formula [5]:

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

Where:

$Nn.a$: The net count, which is the region beneath each sample's curve after the background has been removed.

$I\gamma$: Gamma index.

m: The sample's weight (1 kg)

t: Measuring time (18000 seconds)

ε: The detector's efficiency

3.2. Equivalent of Radium (Raeq)

It has been established that a radiological index will describe the activity concentrations. Equation (2) is used to get the (^{238}U, ^{232}Th, and ^{40}K) (Ra_{eq}) index [6]:

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

Where:

A_U, A_{Th}, and A_K, respectively, the activity concentrations of (^{238}U, ^{232}Th, and ^{40}K) in (Bq/kg)

3.3. Rate of Air Absorbed Dose (AD)

Equation (3) with terms of terrestrial core concentration, using the amount absorbed in the air can be determined [7-9]:

$$AD\left(\frac{nGy}{h}\right) = 0.462A_U + 0.604A_{Th} + 0.0417A_K \quad (3)$$ **3.4**

3.4. Rate of AnnuaI Effective Dose (AED)

A member's estimated annua1 effective dose equivalent was computed using a conversion factor of (0.7 Sv/Gy), and the absorbed rate's effective dose equivalent was determined using an outdoor occupancy of (20%) and an indoor occupancy of (80%). [10]:

$$(\mathrm{A\ E\ D})\ \mathrm{in}\ (\mathrm{m\ Sv\ /y}) = \mathrm{AD}\left(\frac{\mathrm{nGy}}{\mathrm{h}}\right) \times 10^{-6} \times 8600\mathrm{h} \times 0.8 \times 0.7\left(\frac{\mathrm{sv}}{\mathrm{Gy}}\right) \quad (4)$$

$$(\mathrm{A\ E\ D})\ \mathrm{out}\ (\mathrm{m\ Sv\ /y}) = \mathrm{AD}\left(\frac{\mathrm{nGy}}{\mathrm{h}}\right) \times 10^{-6} \times 8600\mathrm{h} \times 0.2 \times 0.7\left(\frac{\mathrm{sv}}{\mathrm{Gy}}\right) \quad (5)$$

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

Gamma radiation risk can be evaluated using both internal risk transactions (H_{in}) and external risk indices (H_{ex}). Equations (6) and (7) were obtained based on the quality of radiation specific activity [11,12]:

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

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

ISSN: 2576-8484
Vol. 8, No. 6: 3511-3518, 2024
DOI: 10.55214/25768484.v8i6.2742

3.6. Index of Gamma (Iγ)

Equation (8) was used to compute the gamma index (I_γ)for soil samples [13-16]:

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

4. Results and Discussion

The specific action is indicated in Table (2). For twenty samples that were taken from various places in Nile region in Babylon governorate.

Table 2.
Specific activity values for ^{238}U, ^{232}Th, ^{40}K, and **(Ra_{eq}).**

No.	S. C.	Specific activity [Bq/kg]			(Ra_{eq}) [Bq/kg]
		^{40}K	^{238}U	^{232}Th	
1	N1	140.37±1.89	2.94±0.17	22.8 ± 5.7	122.8±9.65
2	N2	132.80±1.83	5.92±0.46	11.8 ± 3.3	111.8±10.92
3	N3	107.54±1.64	1.39±0.22	13.8 ± 2.1	103.8±6.23
4	N4	136.45±0.96	6.01±0.41	25.31 ± 8.4	95.31±7.34
5	N5	150.95±1.96	12.2±0.98	37.27 ± 4.2	137.27±9.91
6	N6	183.29±2.15	11.6±0.62	39.87 ± 4.6	149.87±8.73
7	N7	113.44±1.70	10.1±0.64	27.09 ± 3.1	127.09±9.71
8	N8	148.82±1.31	12.02±0.18	12.73 ± 2.8	112.73±3.54
9	N9	372.92±2.81	28.33±0.96	19.37 ± 4.9	91.37±14.3
10	N10	115.52±1.72	4.39±0.46	22.27 ± 5.1	145.27±6.63
11	N11	365.99±3.04	16.5±0.73	29.14 ± 4.7	129.14±11.63
12	N12	179.56±2.13	6.59±0.39	10.81 ± 3.7	103.81±5.71
13	N13	65.523±0.95	7.52±0.39	14.84 ± 4.7	144.84±5.12
14	N14	167.64±2.06	9.31±0.55	15.91 ± 3.8	155.91±8.84
15	N15	125.68±1.78	6.72±0.47	12.69 ± 5.8	112.69±6.75
16	N16	106.458±0.65	30.31±0.33	34.83 ± 4.9	134.83±5.26
17	N17	148.02±1.94	3.51±0.34	11.15 ± 4.2	161.15±6.78
18	N18	356.85±2.88	29.79±1.05	11.39 ± 5.1	111.39±14.9
19	N19	43.954±1.05	20.56±0.14	15.06 ± 5.7	105.06±7.05
20	N20	116.47±1.72	8.72±0.53	32.82 ± 3.8	132.82±6.46
Max.		372.92±2.81	30.31±0.33	39.87 ± 4.6	161.15±6.78
Min.		43.954±1.05	1.39±0.22	10.81 ± 3.7	91.37±14.3
Av. ±S. D.		133.55±1.82	11.72±1.62	21.04±3.7	124.44±3.76
P. L. [10]		412	33	45	370

With Table 2, the average value of the specific activity of ^{238}U was reported to be (11.72±1.62 Bq/kg), with the lowest and highest values ranging from (1.39±0.22 to 30.31±0.33) (Bq/kg). Sample N3 contained the least value, whereas sample N16 contained the greatest value. Based on Figure 3's representation of the values of various ^{238}U concentrations. The current work's average value is below the UNSCEAR 2000-calculated global average value of 33 Bq/kg [17]. The specific activity of ^{232}Th, on the other hand, has a range between (10.81 ± 3.7 and 39.87 ± 4.6) Bq/kg. The samples N6 and N12 had the highest and lowest values, respectively, with an average value of 21.04±3.7 (Bq/kg), as shown in Figure (4). The current work's average value of ^{232}Th is lower than the global average value (45 Bq/kg). While samples N9 and N19 contained the highest and lowest values of the specific activity of ^{40}K, which ranged from (43.954±1.05 to 372.92±2.81) Bq/kg to these values. The current work's average value of ^{40}K is lower than the global average value (412 Bq/kg) as it is clear in Figure (2).

The Ra_{eq} levels ranged from (91.37±14.3to 161.15±6.78) Bq/kg to (124.44±3.76 Bq/kg on average). All samples' Ra_{eq} concentrations were below the the global average value because the average value is less than 370) Bq/kg)proposed worldwide limit, this appears in Figure (5).

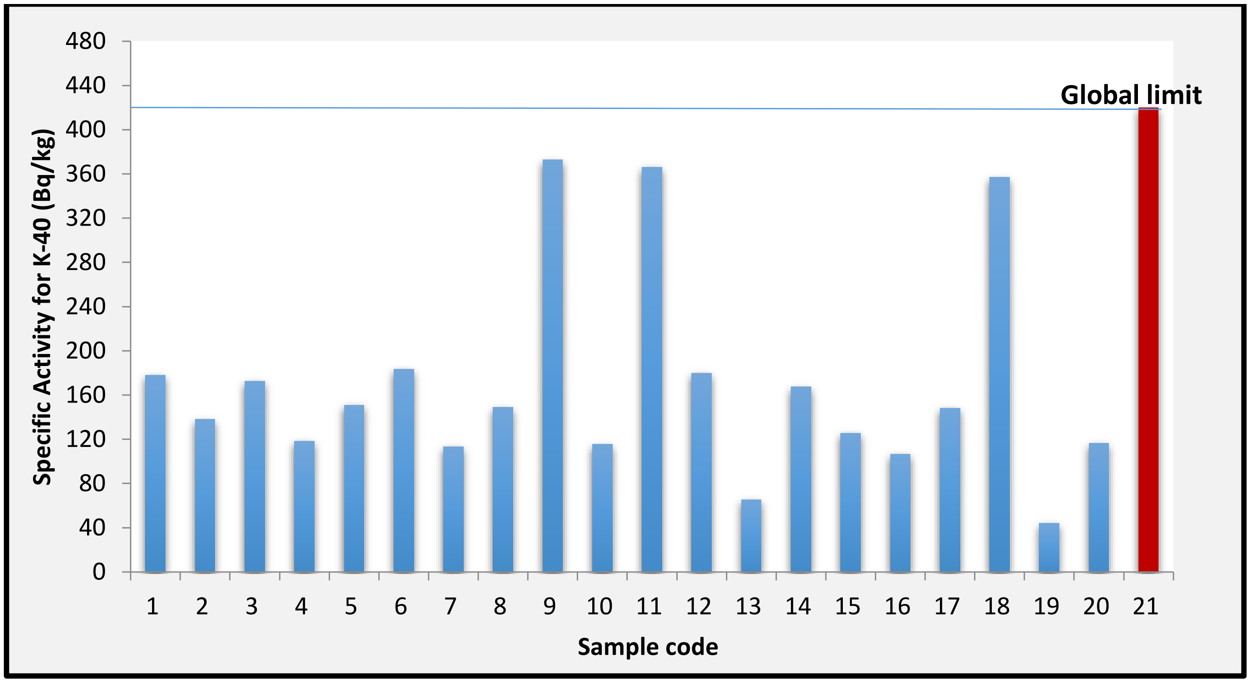
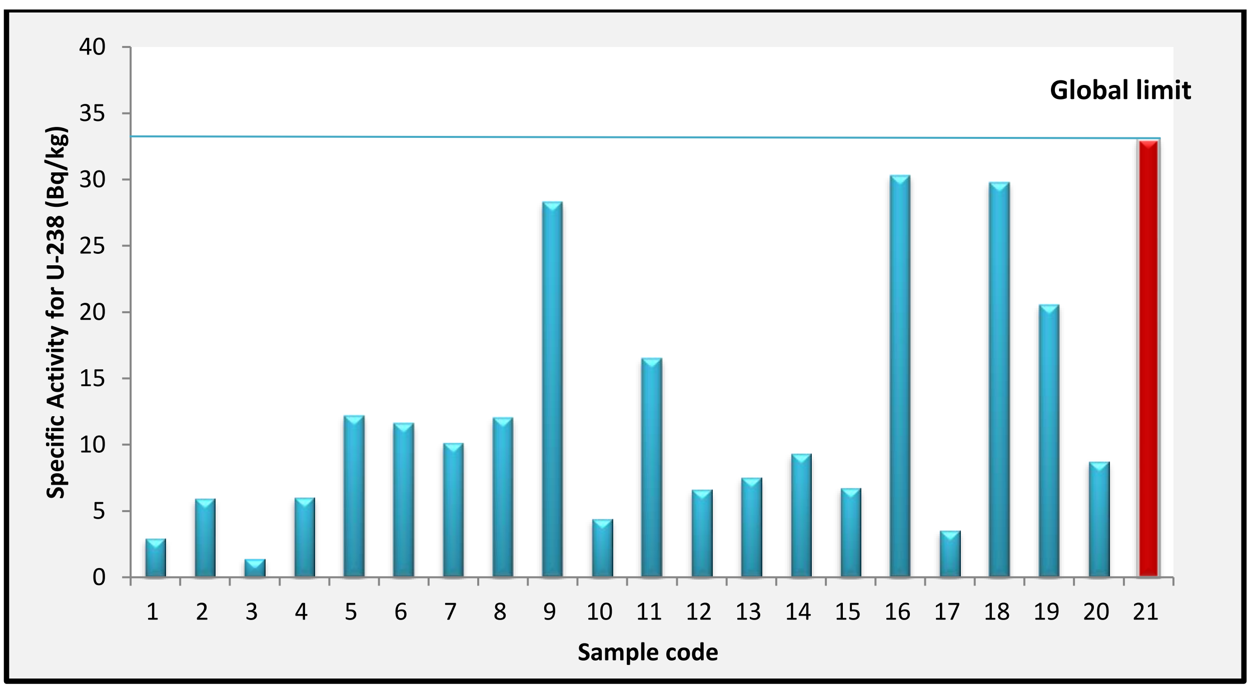


Figure 2.
The samples' specific ^{40}K activity.



ISSN: 2576-8484
Vol. 8, No. 6: 3511-3518, 2024
DOI: 10.55214/25768484.v8i6.2742

Figure 3.
The samples' specific ^{238}U activity.

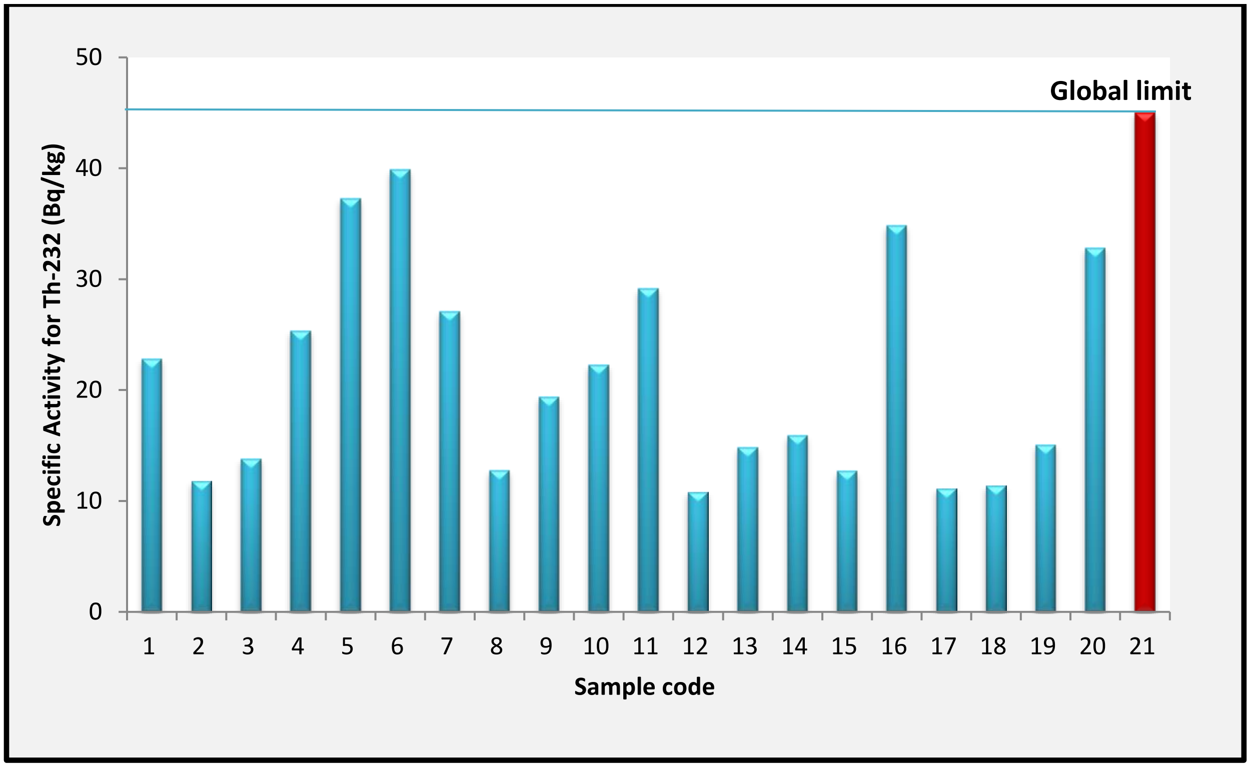


Figure 4.
The samples' specific ^{232}Th activity.

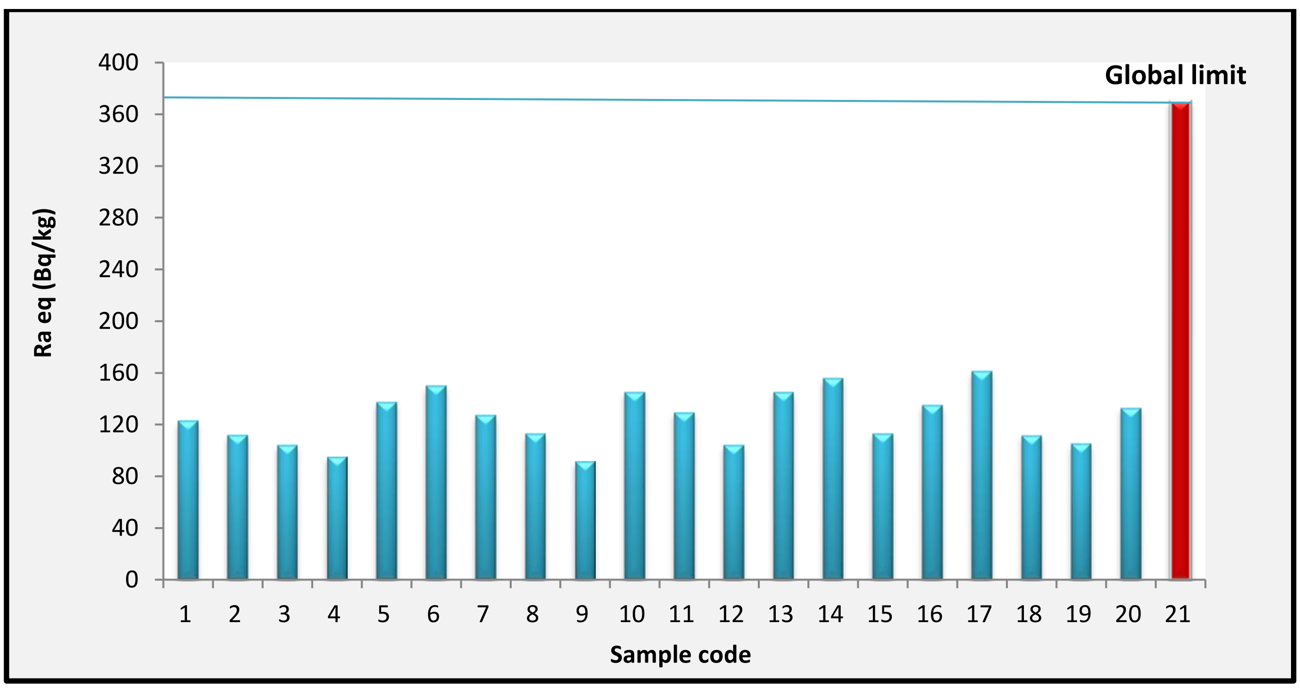


Figure 5.

The samples' Radon equivalent.

Table 3.
Risk indices measurements.

Sample no.	AD (nGy/h)	H_{ex}	H_{in}	Iγ	AEDE (mSv/y)	
					Indoor	Outdoor
N1	45.382	0.28 ± 0.01	0.24 ± 0.01	0.376	0.216	0.029
N2	25.745	0.39 ± 0.01	0.32 ± 0.01	0.189	0.173	0.013
N3	39.933	0.36 ± 0.01	0.30 ± 0.01	0.285	0.156	0.028
N4	28.014	0.44 ± 0.03	0.36 ± 0.02	0.315	0.167	0.027
N5	42.340	0.51 ± 0.01	0.38 ± 0.01	0.406	0.176	0.018
N6	29.881	0.53 ± 0.01	0.42 ± 0.01	0.113	0.162	0.021
N7	32.035	0.40 ± 0.01	0.32 ± 0.01	0.220	0.208	0.026
N8	41.709	0.45 ± 0.01	0.35 ± 0.01	0.310	0.187	0.018
N9	28.809	0.33 ± 0.01	0.27 ± 0.01	0.208	0.122	0.023
N10	43.281	0.42 ± 0.01	0.33 ± 0.01	0.378	0.288	0.028
N11	25.723	0.37 ± 0.01	0.32 ± 0.01	0.187	0.134	0.021
N12	42.853	0.30 ± 0.01	0.29 ± 0.01	0.295	0.189	0.016
N13	29.763	0.45 ± 0.01	0.36 ± 0.01	0.209	0.137	0.018
N14	41.782	0.40 ± 0.01	0.33 ± 0.01	0.336	0.204	0.023
N15	32.811	0.41 ± 0.01	0.31 ± 0.01	0.183	0.181	0.015
N16	21.709	0.46 ± 0.01	0.36 ± 0.01	0.208	0.378	0.022
N17	43.809	0.42 ± 0.01	0.34 ± 0.01	0.378	0.187	0.019
N18	44.261	0.41 ± 0.01	0.35 ± 0.01	0.186	0.311	0.023
N19	23.723	0.38 ± 0.01	0.28 ± 0.01	0.295	0.207	0.028
N20	42.652	0.47 ± 0.01	0.35 ± 0.01	0.209	0.199	0.021
Ave.	33.545	0.41± 0.01	0.33± 0.01	0.244	0.25	0.021
Max	45.382	0.53 ± 0.01	0.42 ± 0.01	0.376	0.378	0.029
Min.	21.709	0.28 ± 0.01	0.24 ± 0.01	0.113	0.122	0.013
Global limit [17]	55	≤ 1	≤ 1	≤ 1	1	1

According to Table 3, an average value rate of (33.545nGy/h), the values for AD ranged from (21.709 to 45.382) nGy/h. Hin values ranged from (0.24 ± 0.01to 0.42 ± 0.01) and Hex values ranged from (0.28 ± 0.01to 0.53 ± 0.01), all of which fell below the global boundaries. With an average of 0.41, the values for (I_{γ}) fell within the usual range for the world. The average values of AEDEin and AEDE out were (0.25 m Sv / year) and (0.021m Sv/ year), respectively, with the ranges being (0.122 to 0.378) m Sv /year and (0.013 to 0.029) m Sv /year, respectively. According to the current findings, all samples' values for Raeq, Hin, Hex, AD, AEDE out, and AEDE in were below the UNSCEAR-recommended value [17].

5. Conclusions

The study's findings showed that all values are within the range of values that are internationally acceptable, meaning that human life is not in risk in Nile region in Babylon governorate.

References

[1] E. Salman, "Radioactive Radon Gas and its Measurement Methods," J Phys Chem Biophys, vol. 13, p. 348, 2023.

[2] 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).

[3] 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).

[4] E. S. Obayes and K. H. Al-Atiya, (2023), " Measurement of radioactivity levels in

[5] selected soil samples in some areas of Babylon/Iraq", AIP Conference Proceedings Vol.3 No.2591, P. 040040-1.

[6] Kazem, A. M., (2015),"Measurement of Natural Radioactivity of Selected Models of the Nebure City Soil in the Governorate of Qadisiyah Using the Kama Spectrum", M.Sc Thesis, University of Kufa.

[7] Murtadha Shakir AL-Nafeiy, Hassan Issa Dawood and Basim Abd ALHassen AL-Mayahi, (2010), "Measurement the natural radioactivity of radionuclides that exist in some soil samples from different locations in Governorate of Karbala", AL-Qadisiya Journal for science Vol.15, No. 2, PP.106-114.

[8] Italians,J. W., Abdul Hussein Bayram (translator), (1986),"Radiation and human health", Dar al-General cultural Affairs, Arab Printing House.

[9] 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).

[10] 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).

[11] 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).

[12] 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).

[13] 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).

[14] N. Sharma, R. Sharma and H.S. Virk, "Environmental radioactivity: A case study of Punjab, India", Advances in Applied Science Research, 2(3) (2011) 186-190. Quartz rock, Tectonophysics, 65 (No.3–4) (2011) 281–290.

[15] 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).

[16] 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).

[17] S. Harb, A. H. EI-Kamel., A.I.AbdeI-Mageed, A.A bbady, and R.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).

[18] 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).

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

[20] 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).

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 3511-3518, 2024
DOI: 10.55214/25768484.v8i6.2742