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RESEARCH ARTICLE

Assessment of Natural Radioactivity and Radiological Hazard in Soil Samples of the Most Popular Tourist Place in Babylon, Iraq

Inaam H. Kadim*, Ahmed. Y. Ali, Hussain. A. Laken, Fatin Fadhil

Department of Physics, College of Education for Pure Sciences, University of Babylon, Iraq.

***Corresponding Author Email:** *anaam_hani@yahoo.com*

Abstract

In the present investigation, the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in soil samples collected from the most popular tourist place in Babylon, Iraq are determined using gamma ray spectroscopy. The measured activity concentration ranges from 5.8 to 30.4 Bq kg^{-1} with an average value of 14.92 Bq kg^{-1} and 2.9 to 45.39 Bq kg^{-1} with an average value of 24.7 Bq kg^{-1} and 110.6 to 369.9 Bq kg^{-1} with an average value of 285.13 Bq kg^{-1}, for ^{238}U, ^{232}Th and ^{40}K, respectively. The radium equivalent activity ranges from 19.06 to 85.64, which is lower than the safe limit 370 Bq kg^{-1} as set by the Organization for Economic Cooperation and Development. The absorbed dose of all the investigated samples varies from 10.32 to 40.03 $nGyh^{-1}$.The annual effective dose equivalent ranges from 0.04 to 0.047 mSv. The values of internal and external hazard index of all the samples ranges from 0.3 to 0.1, and 0.08 to 0.26 45 respectively. It is observed that the soil of tourist place in Babylon is suitable for construction purpose without posing any health hazard.

Keywords: *NaI Tl) detector, Natural radioactivity, Annual Effective Dose, Soil samples.*

Introduction

Human exposure to natural radiation source of cosmic rays and other radioactive materials found in the earth's crust since its inception, as it consists of nuclides radioactive With old of degeneration alpha and beta rays and gamma particles, and can enter these particles into the human body through food and breathing is the most important sources of natural exposure They are, potassium (^{40}K) and carbon (^{14}C) and three important natural chains are: uranium (^{238}U) and thorium (^{232}Th) and actinium (^{235}U)[1].

The ionizing radiation in turn are divided into two types of radiation: radiation electromagnetic that occur ionization in the center, which pass it if the radiation energy increased in all 100eV as they vary in wavelength considerably since because they include radio and short waves and infrared waves, visible light and X atoms ultraviolet UV, X-ray radiation and γ-ray and others [2].

The other type of radiation are of a recipe particulate matter, such as cosmic rays that reach us through outer space and also the radiation resulting from the elements or isotopes of radioactivity and the radiation can either be charged, such as α alpha and beta β or neutral, such as neutrons[1] . The radiation sources are divided into two main exporters: natural sources and which produce natural radiation without human intervention in the emitted include radiation from the sun or cosmic rays and radiation that results from atoms of elements that have self-radiation [2] property. Industrial sources that the man they generate from various sources or be the cause of human activity, including the emitted radiation produced by nuclear explosions or nuclear reactors or UV, etc. which the rights they generate in different ways and sources of X-rays.

The depleted uranium core industrial sources of environmental pollution, where it is material and radioactive an accidental result arises from the process of enriching uranium, a nuclear waste has caused serious environmental problems, and as a result of the enrichment process that took place in the countries of the world, especially the United States to use ^{235}U in nuclear weapons or for the production of energy in the reactors accumulated large quantities of depleted uranium, which include the uranium, a number of mass fraction is found 238 and outputs its dissolution is a component of heavy and radioactive material[3] , where the proportion of radiation in depleted uranium, 60% of the radiation of natural uranium and the difference between natural uranium and depleted uranium back to the proportion of presence ^{238}U, which increased by 0.5% down as a case, or 0.35% as a case again and reduce the proportion of ^{235}U the same amount of depleted uranium[3].

The aim of the present work is study radioactive background in the holy areas of the province of Babylon, are one of the important areas in the province, so it was necessary to attention to these areas and the study of natural radioactivity levels in those areas because of their religious and tourist importance at determine the effect of the output from the soil of radiation on human health by measuring the qualitative effectiveness of each of the ^{40}K potassium , ^{238}U uranium and ^{232}Th thorium activity compared to the level of World radiation.

Geology of the Area

Five selected places of the most holy regions in Hilla (is Iraqi town in the province of Babylon), by four samples of each region to become the total number of samples twenty sample .Located about 100 km south of the capital Baghdad (32 ° 32'50 "N 44 ° 14'40" E) is located on both sides of the River Hillah (a branch of the Euphrates River), at Latitude (29´ 32˚) north, longitude (26´ 44˚) east, as shown in Fig.1 [4].

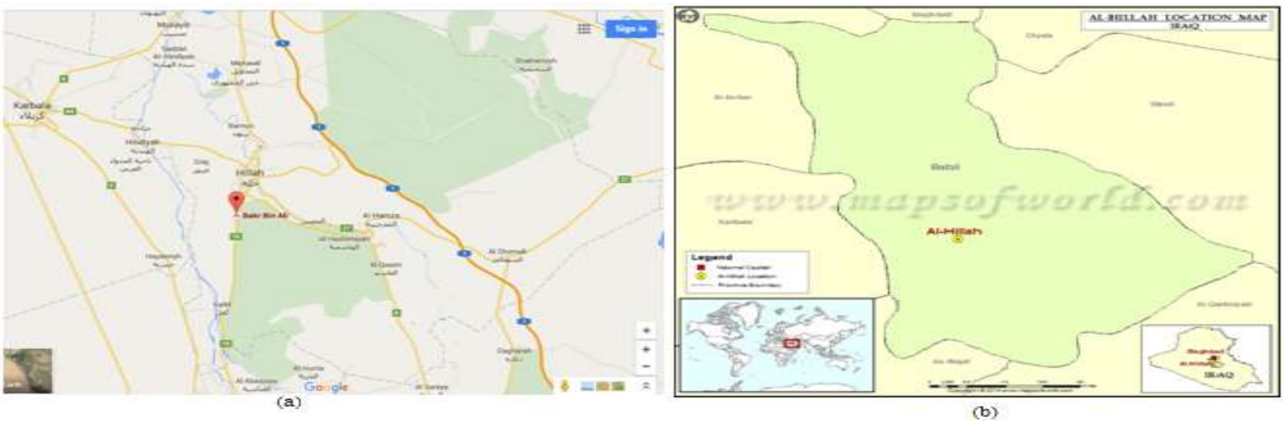
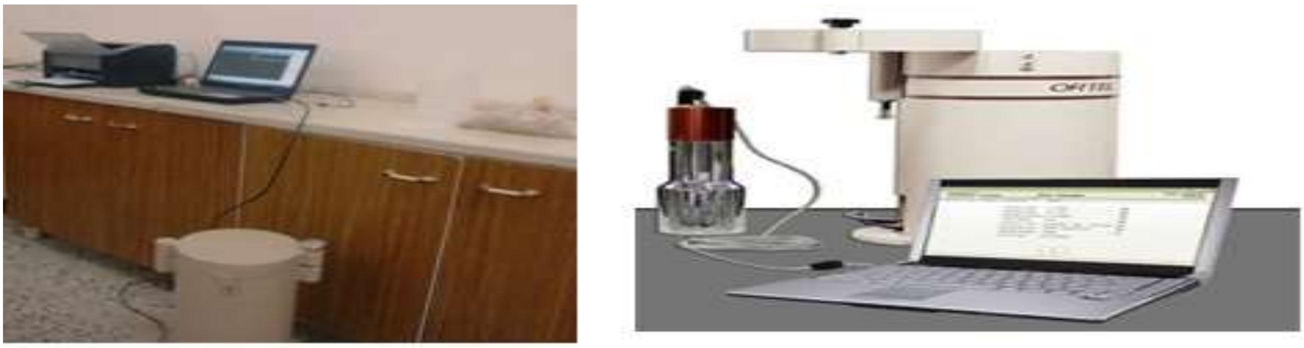


Fig. 1: (a, b): Geological map of the region selected in the research [4]

Materials and Methods

The radioactivity of radionuclide's emitting gamma rays to measure by reference to the power of the high penetration of gamma rays in the material using counting and electronic analysis used in the detection consisting of an array of detectors of nuclear radiation sodium iodide system Restaurant thallium NaI(TI) (3"× 3") and the supplier of the company (Alpha Spectra, Inc.-12I12 / 3) provider is a multi-channel analyzer (MCA) (ORTEC -Digi Base) that contains a 4096 channel connecting unit called ADC (Analog to digital Convertor)[5] helps the analyst to convert the next pulse into digital numbers, though nuclear measurements and analysis done by a computer software called (MAESTRO - 32) as shown in Figure 2 (a) and (b).



(a) (b)

Fig. 2: (a ,b) The gamma spectroscopy detection system used in the present study

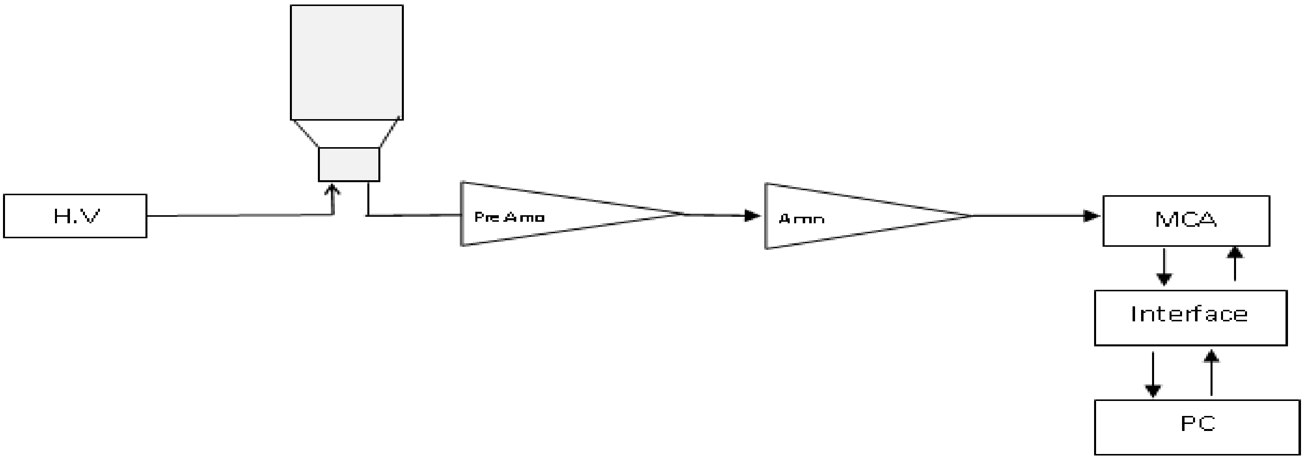


Fig. 3: NaI(Tl) detector(3"x3") operating diagram

Each prepared soil container was placed on a shielded, NaI (Tl) Scintillator, detector 3″×3″ , and by 1.8 KeV energy resolution (FWHM) at the 1.33 Me V reference transition of ^{60}Co. The samples were measured for a counting time of 18000 second, and samples were mass (1Kg), to obtain a statistically small error (3-5%) for the γ−ray peaks of interest.

Further details of the high-resolution spectrometry system, as well as of the data analysis technique are presented elsewhere[6] Following the spectrum analysis, count rates for each detected photo peak and activity concentration in units of Bq.Kg^{-1} for each of the detected nuclides are calculated [6]. The total uncertainty of the radioactivity measurements, which is also applicable to the calculated gamma dose and effective dose rates, was typically in the range 3−10%. It has been calculated by taking into consideration the counting statistical error (3%) and other weighted systematic errors that mainly include the uncertainty in the efficiency calibration (0.5−8%) [7]. Depending on the peak background of the measured spectra, the Minimum Detectable Activity (MDA) was calculated to be 1.0×10^{-2} Bq.Kg^{-1} for both ^{232}Th and ^{238}U, and 4.0×10^{-2} Bq.Kg^{-1} for ^{40}K, for the counting time of 18000 second [6, 7].

The Radioactive Samples Test

The radiation backgrounds (B.G) were calculated to sub it from the energy spectrum for the studied samples using the following equation [8].

$$B.G(Bq) = \frac{Area}{I_\gamma\%\ \zeta\%\ T} \qquad (3)$$

The specials radioactivity was calculated for each sample with time of 18000 second, by using Eq. (4) [8].and tabulated in Table 1.

$$Specific\ Acticity\ (Bq.Kg^{-1}) = \frac{\frac{Area}{T} - B.G}{I_\gamma\%\ \zeta\%\ m}\ (4)$$

Where
Area: net area under the photo peak position.
m: mass of sample unit (Kg).

Calculation of Radiation Hazard Indices

Many of the radioactive materials decay naturally and when these materials decay produces external radiation field which exposed humans. In terms of dose, the principal primordial radio nuclides are ^{232}Th, ^{238}U and ^{40}K. Thorium and uranium head series of radio nuclides that produce significant human exposure, so we can measure the radiation exposure dose and assess the bio logical effects on humans. These include

Radium Equivalent Activity (Raeq) of the Following Equation [9]

$$Ra_{eq}(Bq/Kg) = A_U + 1.43A_{Th} + 0.077A_K \quad (5)$$

Where A_K, A_{Th}, A_U is the qualitative effectiveness of a series of uranium and thorium series and potassium, respectively. Where the highest value of Raeq must be less than the allowable limit internationally (370 Bq.Kg^{-1}) as (Tab.1).

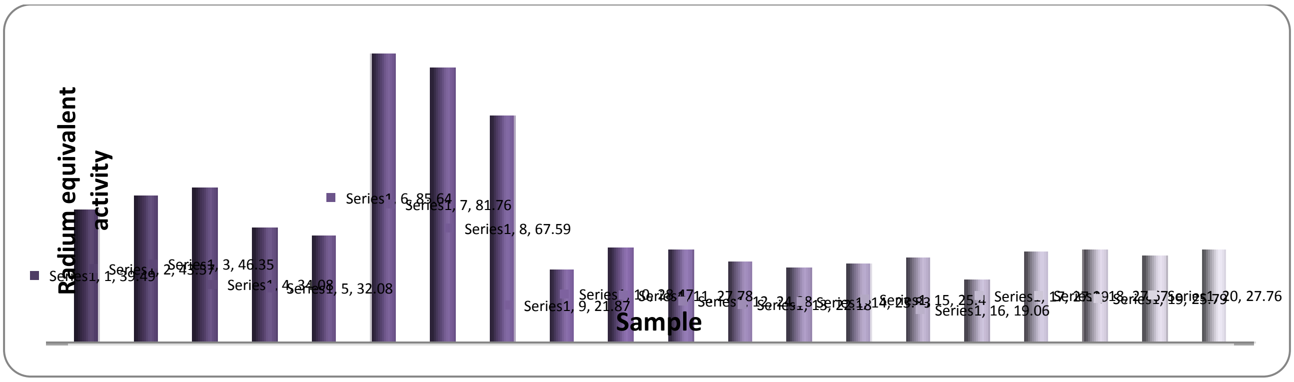


Fig. 4: Graphical representation of radium equivalent activity

The Absorbed Dose Rate in Air

The absorbed dose rate in air express the received dose in the open air from the radiation emitted from radio nuclides concentrations in water. The absorbed dose rate can be determined by using Eq. (6) and tabulated in Table 1.

$$AD(nGy/h) = 0.462A_U + 0.621A_{Th} + 0.0417A_K \quad (6)$$

Where 0.461, 0.623 and 0.0414 nGy.h^{-1}/Bq Kg^{-1} are the conversion factors of ^{226}Ra, ^{232}Th and ^{40}K, respectively [10].

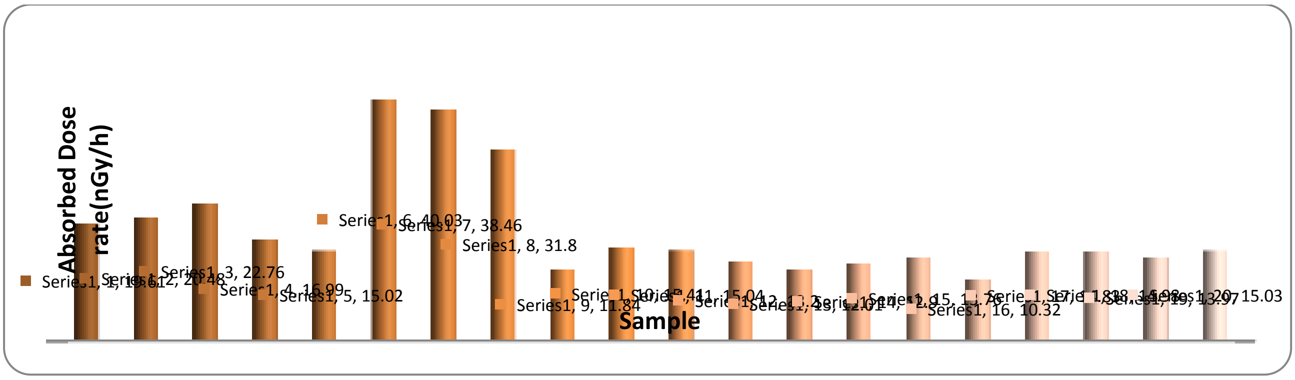


Fig. 5: Graphical representation of the total absorbed dose rate

The Annual Effective Dose

The annual effective doses were obtained using the following equations [10]. And the values are tabulated in Table1.

$$Indoor(^{mSv}/_{y}) = AD\left(^{nGy}/_{h}\right) \times 8760h \times 0.8 \times 0.7\, ^{Sv}/_{Gy} \times 10^{-6} (7)$$

$$Outdoor(mSv/y) = AD(nGy/h) \times 8760h \times 0.2 \times 0.7\, Sv/Gy \times 10^{-6} \quad (8)$$

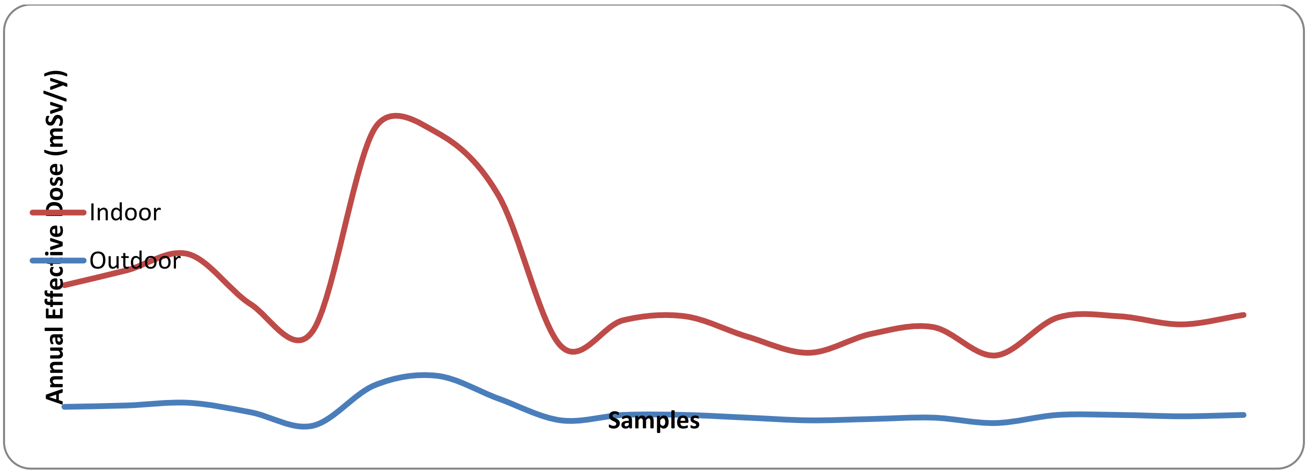


Fig. 6: Graphical representation of annual effective dose (indoor& outdoor)

The External Hazard Index (Hex)

The external risk guide is to assess the risk of natural gamma radiation, is calculated by Eq. (9) [11].

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (9)$$

Where A_U, A_{Th} and A_K, are the radioactivity concentrations in Bq.Kg^{-1} of ^{238}U, ^{232}Th and ^{40}K .respectively (Tab.1). The value of this index must be less than one for the radiation hazard to be negligible if equal to or greater than one indicates the presence of radiation risk [12].

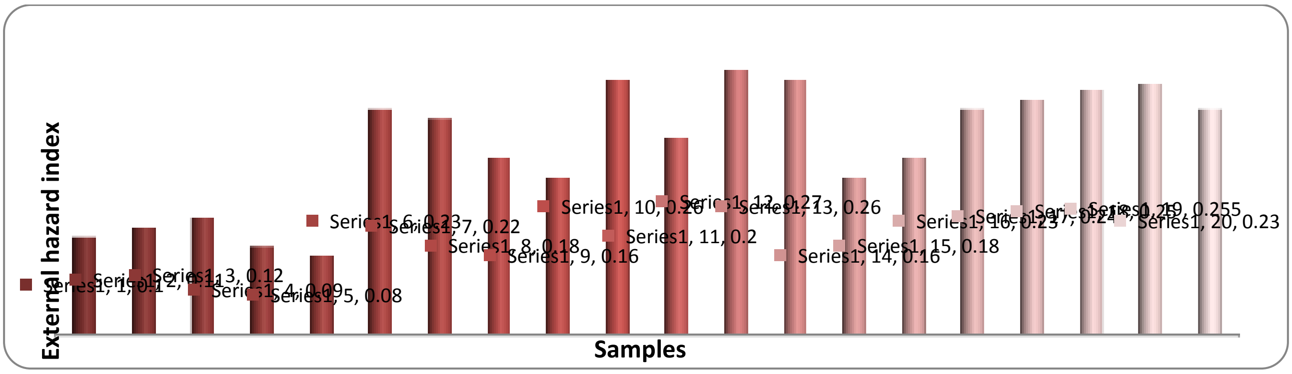


Fig. 7: Graphical representation of the external hazard index

The Internal Hazard Index (H_{in})

Internal exposure is due to inhalation of radon and his counterpart, can be calculated by using Eq. (10) [13].

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (10)$$

The value of this index must be less than one for the radiation hazard to be negligible [14] as tabulated in Table 1.

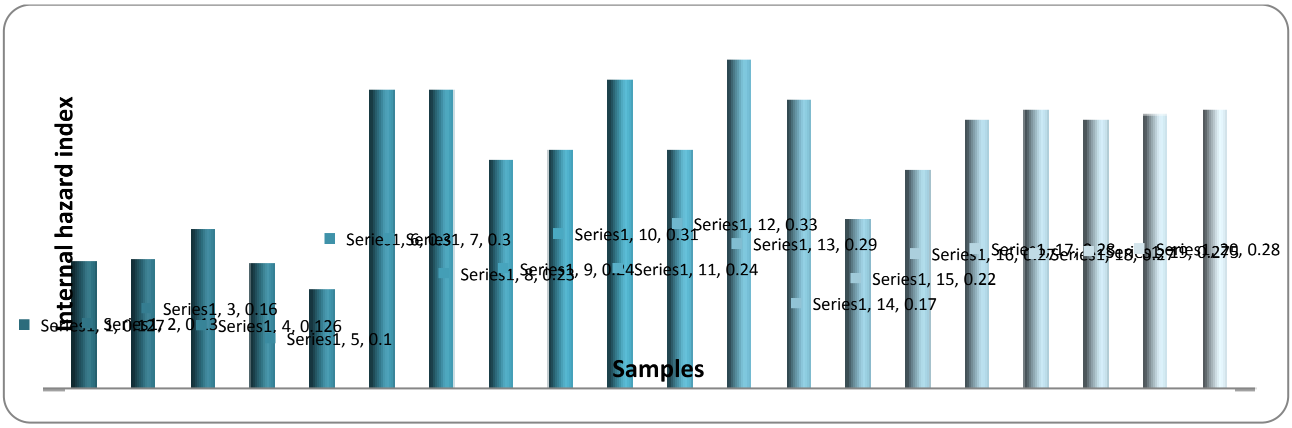


Fig. 8: Graphical representation of the internal hazard index

Activity Concentration Index ($I\gamma$)

Coefficient is used to measure the risk arising from gamma radiation associated with natural radio nuclides (^{238}U , ^{232}Th and ^{40}K) in the studied material is calculated by Eq.(11)[13] and tabulated in Table 1.

$$I_\gamma = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \quad (11)$$

The value of $I\gamma$ must be less than unity in order to keep the radiation hazard insignificant [15].

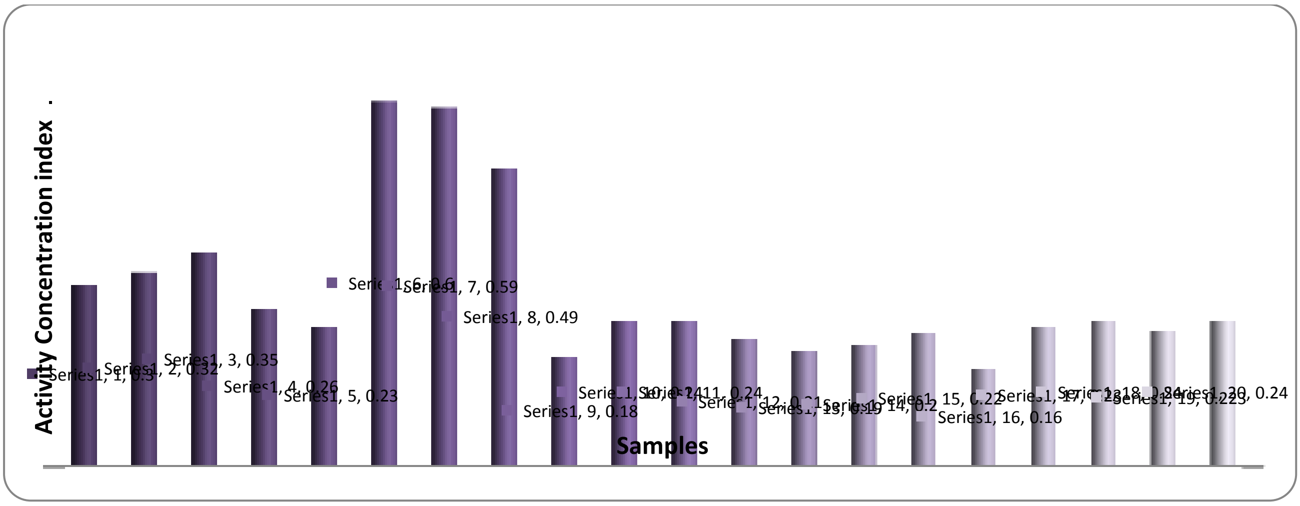


Fig. 9: Graphical representation of the activity concentration index

Results and Discussion

To explain the disparity in the values of specific activity radionuclide in the study area for surface models has been drawing the relationship between the values of quality activity unit (Bq/Kg) as in Figures (12), (13), (14).

Table 1: Specific activities of radio nuclides, absorbed dose, Rate of annual effective dose, hazard indices and Activity concentration index of soil samples taken from the surface

Sample	Specific activity (Bq/Kg)			Ra_{eq} (Bq/Kg)	Absorbed Dose rate AD(nGy.h^{-1})	The Effective Annual Dose (mSv.y^{-1})		Hazard Index		Activity concentration index (I_γ)
	^{238}U	^{232}Th	^{40}K			Indoor	Outdoor	External (H_{ex}≤1)	Internal (H_{in} ≤ 1)	
1	7.79	7.56	271.2	39.49	19.61	0.09	0.024	0.1	0.127	0.3
2	5.86	17.2	170.07	43.57	20.48	0.1	0.025	0.11	0.13	0.32
3	14.74	7.56	269.9	46.35	22.76	0.11	0.027	0.12	0.16	0.35
4	12.81	2.9	222.1	34.08	16.99	0.08	0.02	0.09	0.126	0.26
5	11.8	6.5	110.6	32.08	15.02	0.07	0.01	0.08	0.1	0.23
6	26.29	27.76	255.1	85.64	40.03	0.19	0.04	0.23	0.3	0.6
7	30.4	22.11	256.2	81.76	38.46	0.18	0.047	0.22	0.3	0.59
8	21.19	19.5	230.8	67.59	31.8	0.15	0.03	0.18	0.23	0.49
9	28.3	8.64	284.09	21.87	11.84	0.055	0.014	0.16	0.24	0.18
10	13.04	39.73	369.7	28.47	15.41	0.07	0.018	0.26	0.31	0.24
11	14.02	23.77	360.8	27.78	15.04	0.073	0.018	0.2	0.24	0.24
12	13.97	43.23	316.6	24.38	13.2	0.06	0.016	0.27	0.33	0.21
13	11.39	45.39	288.05	22.18	12.01	0.05	0.014	0.26	0.29	0.19
14	4.92	21.61	309.5	23.83	12.9	0.063	0.015	0.16	0.17	0.2
15	14.19	21.03	329.9	25.4	13.76	0.067	0.016	0.18	0.22	0.22
16	17.1	35.16	247.5	19.06	10.32	0.05	0.012	0.23	0.27	0.16
17	16.7	32.25	355.7	27.39	14.83	0.072	0.018	0.24	0.28	0.23
18	7.67	42.23	359.4	27.67	14.98	0.073	0.018	0.25	0.27	0.24
19	7.5	42.8	335.04	25.79	13.97	0.068	0.017	0.255	0.275	0.223
20	18.8	27.1	360.5	27.76	15.03	0.074	0.018	0.23	0.28	0.24

The samples (1-4) represents the soil shrine of the Prophet Abraham, samples (5-8) represents the soil Ms. Sharifa, samples of (9-12) represent soil shrine of the Prophet Ayoub, while samples from the (13-16) represent soil shrine son of Mr. Bakr bin Ali, and finally samples (17-20) represent soil The shrine of Mr. Ben Taous.

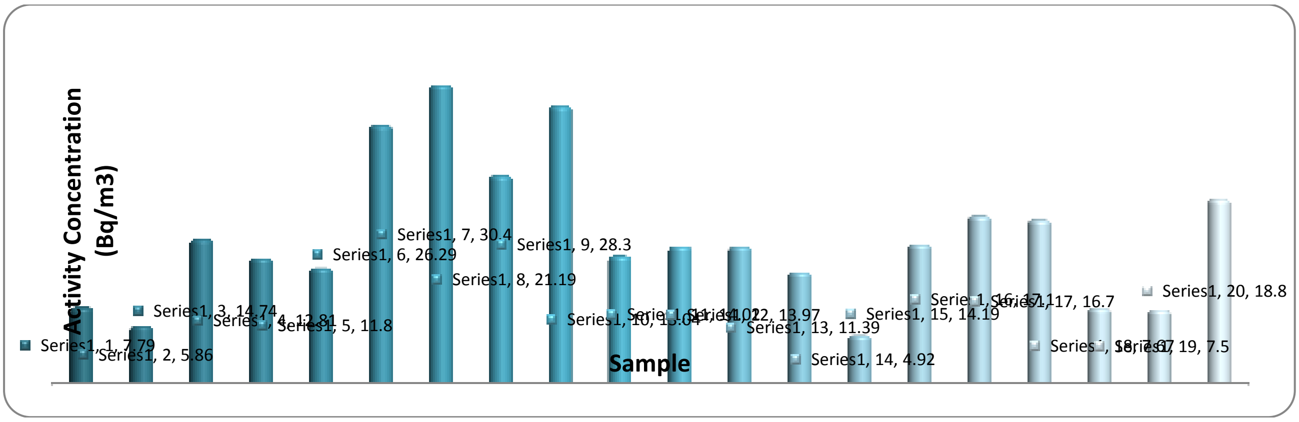


Fig. 10: Specific activities of 238U in the surface soil

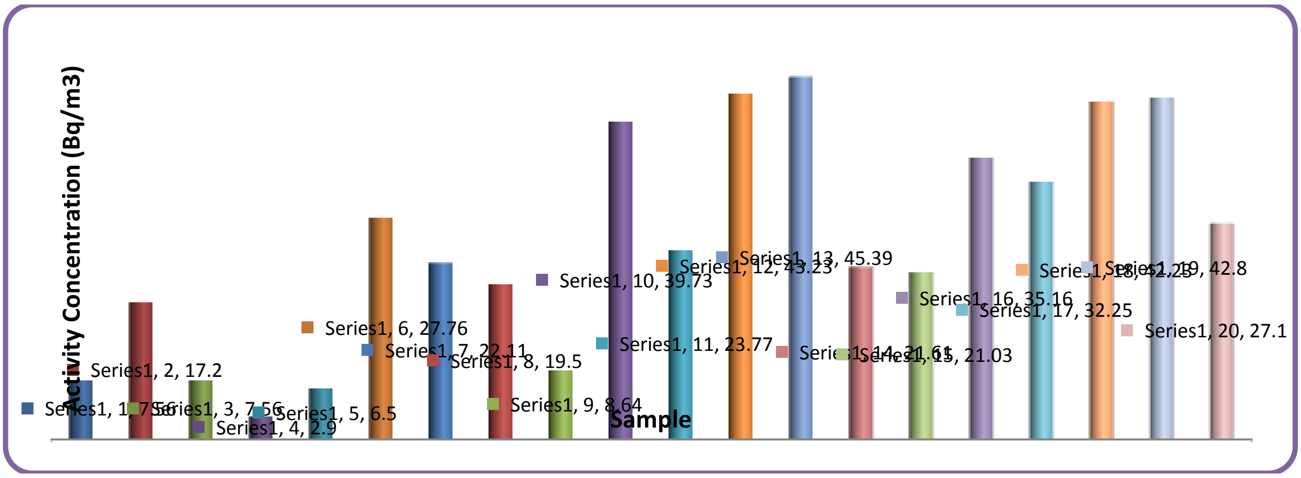


Fig. 11: Specific activities of 232Th in the surface soil

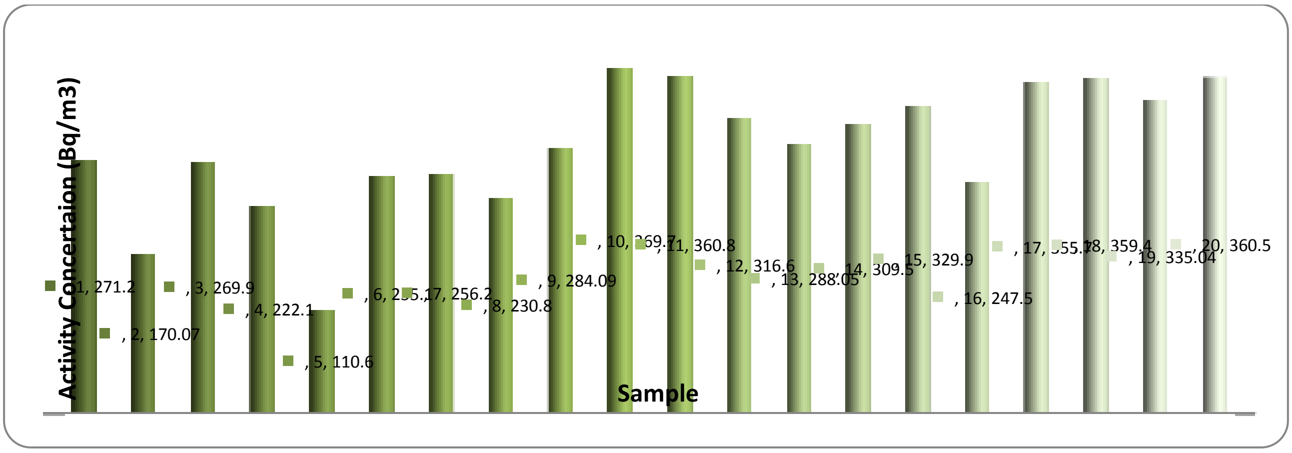


Fig. 12: Specific activities of 40K in the surface soil

Table 2: Shows the specific radioactivity for a selected soil samples for some provinces compared to the present work

Sample	specific activity (Bq/Kg)		
	^{238}U	^{232}Th	^{40}K
Iraq- Qadissiyah [13]	3.7	15.2	370.5
Iraq- Babel [13]	3.8	20.8	410.8
Iraq- Najaf [13]	6.12	14.1	430.05
Iraq- Najaf [14]	(11-25)	(2.3-11.9)	(25.3-66.5)
Iraq- Kufa[15]	(15.9-102)	(9.5-74.5)	(70.1-4358)
Iraq- Karbala [13]	4.8	16.9	379.4
Iraq- Baghdad [13]	4.2	24.3	462.5
Present study	**10.6**	**6.8**	**208.8**

Conclusion

From the present study of the radioactivity levels in some selected location in Babylon province located in the middle of Iraq, we had concluded that;

- The highest value of the specific activity for **^{238}U** is (30.4 Bq/kg) in sample (37) which represents the soil of Ms. Sharifa shrine , while the lowest value of the specific activity is (4.92 Bq / kg) in sample (14), which represents the shrine of Ayoub**.** While the highest value of the specific activity for **^{232}Th** is (45.39 Bq / kg) in sample (14) which represents the soil of the shrine of Ayoub, while the lowest value of the Specific activity is (2.9 Bq / kg) in the sample (4), which represents the shrine of Bakr bin Ali. As for the concentration of **^{40}K**it has the highest valueis (369.7 Bq / kg) in sample (10) which represents the soil of the shrine of Abraham , while the lowest value of the specific activity is (110.6 Bq / kg) in the sample (5), which represents the soil of the shrine Mr. Ben Taous.
- In this study, we observed that sample **(6)** has the highest value of the concentration of the radium equivalent and absorbed dose rate is ((85.64 Bq/Kg) **&** (40.03 nGy.h^{-1})) respectively, while the sample **(16)** has the lowest value of **Ra_{eq}** and **AD** is ((19.06 Bq/Kg) & (10.32 nGy.h^{-1})) respectively.
- As for the indoor annual effective dose it has the highest value is (0.19mSv.y^{-1}) in sample (6) while the lowest value is (0.05 mSv.y^{-1}) in sample (16). While the outdoor annual effective dose it has the highest value is (0.01 mSv.y^{-1}) in sample (5) while the lowest value is (0.047 mSv.y^{-1}) in sample (17).
- The highest value to the external hazard index is (0.26) in sample (10) while the lowest value is (0.08) in sample (5). While the internal hazard index was (0.3) in the sample (12) while the lowest value was (0.1) in the sample (5).
- Therefore, the concentrations of ^{238}U ^{232}Th and ^{40}K are found to be normal and within the average world range [16] and there are no immediate environmental hazards to its inhabitants.

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