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Measurement the natural radioactivity of soil samples from selected regions in Wassit governorate

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Abstract

In this paper, the measurement of natural radioactivity in soil samples from different regions of Wassit governorate by using (HPGe) detector, The results of measurements have shown that the average specific activity concentrations for U-238, Th-232 and K-40 were (22.220±4.3 Bq/kg, 25.305 ±3.7 Bq/kg, 181.446±40.4 Bq/kg) respectively, which was less than the worldwide average given by (UNSCEAR , 2000). While the average values of [H_{ex}, H_{in}, I_{γ} , $(AED)_{out}$, $(AED)_{in}$, D_{γ}, Ra_{eq}], for each sample were found to be (72.377±7.3 Bq/kg, 33.116±3.4 nGy/h, 0.162 ±0.017mSv/y, 0.041 ±0.004 mSv/y, 0.522 ±0.05, 0.256 ±0.03, 0.195 ±0.02), respectively, all of these values were lower than the permissibility limit value given by (UNSCEAR , 2000).

Keyword: Natural radioactivity, HPGe detector, Soil samples, Wassit governorate.

قياس النشاط الاشعاعي الطبيعي في عينات تربة لمناطق مختارة من محافظة واسط

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قسم الفيزياء , كلية التربية , الجامعة المستنصرية

الخلاصة

في هذا البحث تم قياس النشاط الاشعاعي الطبيعي في نماذج تربة لمناطق مختلفة من محافظة واسط باستخدام كاشف الجرمانيوم عالي النقاوة. بينت نتائج القياسات بان معدل تراكيز الفعالية النوعية ^{238}U , ^{232}Th , ^{40}K هي (181.446±40.4 Bq/kg، 25.305 ±3.7 Bq/kg، 22.220±4.3 Bq/kg,))

على التوالي. وقد وجد بان جميع هذه القيم هي اقل من القيم العالمية و المعطاة من قبل اللجنة العلمية للامم المتحدة لتاثيرات الاشعاع الذري (UNSCEAR , 2000) . كما تمت دراسة دلائل الخطورة الاشعاعية [H_{ex}, H_{in}, I_{γ} , $(AED)_{out}$, $(AED)_{in}$, D_{γ}, Ra_{eq}] لكل نموذج والتي كانت (72.377±7.3 Bq/kg ، 33.116±3.4 nGy/h ، 0.162 ±0.017mSv/y ، 0.041 ±0.004 mSv/y ، 0.522 ±0.05 ، 0.256 ±0.03 ، 0.195 ±0.02) على التوالي وقد بينت النتائج المستخرجة لهذه الدلائل بان جميعها كانت اقل من القيم المسموحة و المعطاة من قبل (UNSCEAR , 2000) .

الكلمات الافتتاحية: النشاط الإشعاعي الطبيعي ، كاشف الجرمانيوم ، نماذج التربة ، محافظة واسط .

Introduction

The natural radioactive chains from ^{238}U, ^{235}U and ^{232}Th produce a group of radionuclides with a range of half-lives. Most of the radioisotopes are alpha emitters, so when they are ingested or inhaled, they contribute significantly to the radiation dose that people receive [1]. On the other hand, taking into account that uranium and thorium are always present in soil, their gamma radiation causes external exposures with the consequently absorbed doses [2].

The study of natural soil radioactivity (background radiation) is one of the most important topics that are taught by researchers to aligned to the subject of the environmental importance of the effect on human health, especially if we consider the existence of areas containing high concentrations of natural radioactive isotopes due to the geological composition of these areas, where the focus was on natural chains of (^{238}U, ^{232}Th and ^{40}K), which is considered the most important actors on increasing the radiation dose absorbed by human, where the average global concentrations of these isotopes in the Earth's crust are up to (35Bq/kg, 30Bq/kg and 400Bq/kg) respectively [3].

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions and appear at different levels in the soils of each region in the world. The specific levels of terrestrial environmental radiation are related to the composition of each lithologically separated area, and to the content of the rock from which the soils originate. There are many types of soils depending upon the physical and chemical composition (UNSCEAR, 2000) [4].

Human beings have always been exposed to natural radiations from their surroundings. The exposure to ionizing radiations from natural sources occurs because of naturally occurring radioactive elements in the soil and rocks, cosmic rays entering the earth's atmosphere from outer space and the internal exposure from radioactive elements through food, water and air. Therefore the assessment of gamma radiation dose from natural sources is of particular importance as natural radiation is the largest contributor to the external dose of the world population [5].

The aim of the present work is to measurement the specific activity of (^{238}U, ^{232}Th and ^{40}K), radium equivalent activity, absorbed gamma dose rate, indoor and outdoor annual effective dose rates, external annual effective dose, activity concentration index, internal and external hazard indicies in surface soil samples for some selected regions in Wassit governorate by using high purity germanium (HPGe) detector.

Experimental Procedure

Description of Study Area

Wassit governorate is located in eastern Iraq, on the border with Iran. The Baramadad border crossing in Wassit connects the two countries. Wassit shares internal boundaries with the governorates of Baghdad, Diyala , Qadissiya , Babil, Missan and Thi-Qar as shown in Figure (1) .

Wassit governorate is intersected by the Tigris River, along which a ribbon of irrigated farmland runs, giving way to a dry desert landscape to the northeast. Wassit has a dry, desert climate, with temperatures easily exceeding 45°C in summer. Rainfall is scarce and concentrated in the winter months [6].

Figure (1) Sketch map showing locations of the studied sites in Wassit governorate.

Collection and Preparation of the sample

Surface soil samples were taken from different locations in Wassit governorate. The samples were crushed to small pieces then to fine powder by using electrical mill, then about of (1 kg) and (300 µm) grain size of the samples were obtained , using special sieves (mesh).The samples were dried at (60 °C) for 1 hours and they were packaged in a (1 litter) Marinelli beaker, the sealed marinelli beaker were kept for one month before measurements in order to achieve the secular equilibrium for ^{238}U and ^{232}Th with their respective progenies .

Activity Concentration

Since all the elements of radioactive chains effective in the case of late balance so it is possible to calculate the concentration of an element in the series in terms of the concentration of another element, it has been the focus of effectiveness of a series of Uranium account ^{238}U (Radium -226) by focusing effectively account for nuclide Bismuth -214 (1764 keV), as well as in Thorium -232 series has been the focus of effectiveness of the radioactive nuclide Thallium -208 (2614 keV), which represents the concentration of thorium-232 account, and then the concentration of Potassium-40 account radioactive nuclide (1460 keV) can be effective concentration is calculated by the following equation [7]:

(1) ....

$$A = \frac{NET}{\varepsilon * I_{\gamma} * m * t}$$

Where:

A: activity concentrations of the sample units Bq/kg, ε: Energy efficiency,

m: mass of sample units kg, t: time measurement (3600 sec.).

High Purity Germanium (HPGe) Detector

In the present study (HPGe) detector with an efficiency of 40% and energy resolution of (2.6 keV) at energy (1332.6 keV) for ^{60}Co. The high purity N-type semiconductor detector with physical characteristics of geometry closed-end coaxial, (3×3 inch).

The (HPGe) detector is kept cold by immersing it in a liquid-nitrogen vessel at (-196 $^{\circ}$C) to reduce the leakage current to acceptable levels. The detector is surrounded by lead shield of about 10 cm thickness in order to reduce the background radiation.

Energy Calibration

An essential requirement for the measurement of gamma emitter is the exact identity of photo peaks present in a spectrum produced by the detector system. The energy calibration of germanium detector system was made by measuring the standard sources of known radionuclide with well-defined energies with the energy of interest. The Energy calibration source should be counted long enough to produce well-defined photo peaks.

The energy calibration was performed by using standard source of (1 litter) capacity of marinelli beaker of Europium (^{152}Eu), which has been prepared in this work with energies (121.8, 244.7, 344.3, 411.1, 444.6, 778.9, 964.0, 1085.8, 1112.0 and 1408.0 keV), as shown in Figure (2) .

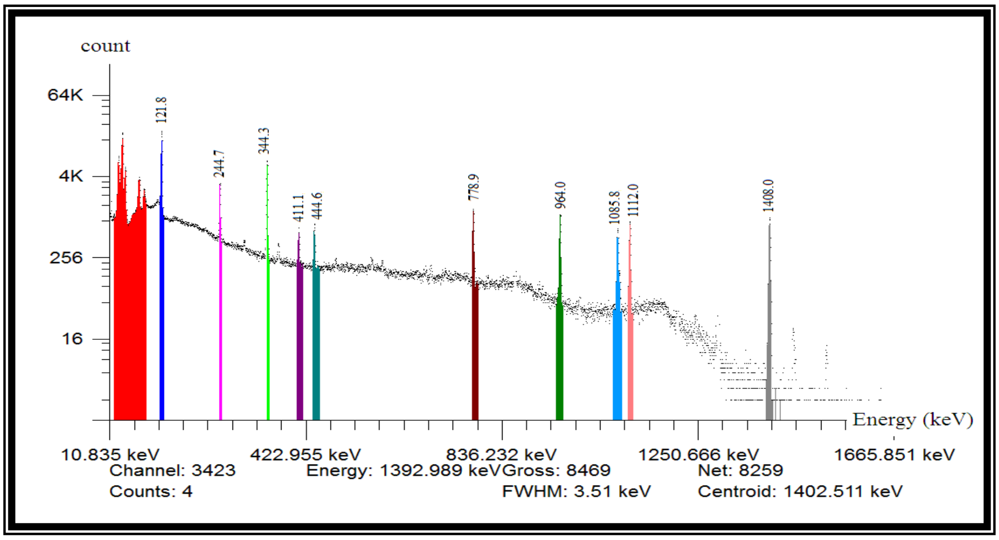

Figure (2) ^{152}Eu spectrum of the prepared standard source.

2- Radium Equivalent

Radium equivalent calculation from the following equation [7] :

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

Where A_U, A_{Th}, A_k activity concentration of a series of Uranium and a series of Thorium and Potassium, respectively, in the equation (2) Assume that (10 Bq/kg) of Uranium and (7 Bq/kg) of Thorium and (130 Bq/kg) of Potassium produces an equal dose of radiation [8].

3- Absorbed Dose Rate

The total rate of the absorbed dose in the air is calculated in terms of the concentrations of (^{238}U, ^{232}Th and ^{40}K), through the following equation [8]:

$$D_{\gamma} = 0.462 A_{Ra} + 0.604 A_{Th} + 0.0417 A_K \quad \text{.....................................(3)}$$

4- The Annual Effective Dose

To calculation, the annual effective dose must take the following consideration, first: conversion factor of absorbed dose to effective dose, second: Internal occupation factor. Use the factor 0.7Sv as a conversion factor from absorbed dose in the air to the annual effective received by the adult dose and use 0.8 as an internal occupation (which is the ratio of time spent at home) and 0.2 is the ratio of time spent abroad, and this data found that the annual effective dose calculated as follows [9] :

$$E_{in}(\text{mSv/y}) = D(\text{nGy.h}^{-1}) \times 10^{-6} \times 8760(\text{h/y}) \times 0.80 \times 0.7(\text{SvGy}^{-1}) \quad \text{........(4)}$$

$$E_{out}(\text{mSv/y}) = D(\text{nGy.h}^{-1}) \times 10^{-6} \times 8760(\text{h/y}) \times 0.20 \times 0.7(\text{SvGy}^{-1}) \quad \text{.........(5)}$$

where the 8760 refers to the number of hours a year. The global average annual effective dose is 0.48 mSv.

5- External Hazard Index

The external guide is a hazard assessment of the risk of natural gamma radiation, is calculated from the following equation [10] .

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1$$

.............................(6)

Where this factor must be less than one , if equal to or greater than one indicates the presence of radiation risk.

Activity Concentration Index (I_γ)

The activity index (I_γ) for soil samples was calculated by using the following equation [10]:

$$I_\gamma = \frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000}$$ …………………(7)

6- Internal Hazard Index

The internal exposure is caused by the inhalation of radon gas and daughters which can be expressed in terms of the internal hazard index and calculates by the following equation [11] :

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1$$

......................................(8)

And this factor must be less than the one to be within the allowable universally border.

Results and Conclusions

The results of the present work was summarized in Table (1) it can be noticed that:

The highest value of specific activity of (^{238}U) was found in (Nuamaniya) region which was equal to (31.020 Bq/kg), while the lowest value of specific activity of (^{238}U) was found in (Jassan) region which was equal to (10.510Bq/kg) ,with an average value of (22.220±4.3 Bq/kg). The present results have shown that values of specific activity for (^{238}U) in Wassit governorate were less than the recommended value of (35 Bq/kg) for the specific activity of (^{238}U) given by (UNSCEAR , 2000) [4].

The highest value of specific activity of (^{232}Th) was found in (Nuamaniya) region which was equal to (29.810 Bq/kg), while the lowest value of specific activity of (^{232}Th) was found in (Jassan) region which was equal to (14.650 Bq/kg), with an average value of (25.305±3.7 Bq/kg). The present results have shown that values of specific activity for (^{232}Th) in Wassit governorate were less than the recommended value of (30 Bq/kg) for the specific activity of (^{232}Th) given by (UNSCEAR, 2000) [4].

The highest value of specific activity of (^{40}K) was found in (Sheek Saad) region which was equal to (251.840 Bq/kg), while the lowest value of specific activity of (^{40}K) was found in (Al-Wahda) region which was equal to (181.446 Bq/kg), with an average value of (204.266±40.4 Bq/kg). The present results have shown that values of specific activity for (^{40}K) in Wassit governorate were less than the recommended value of (400 Bq/kg) for the specific activity of (^{40}K) given by (UNSCEAR , 2000) [4].

The highest value of radium equivalent activity was found in (Nuamaniya) region which was equal to (89.299 Bq/kg), while the lowest value of radium equivalent activity was found in (Jassan) region which was equal to (44.975 Bq/kg) ,with an average value of (72.377±7.3 Bq/kg). The present results have shown that values of radium equivalent activity in Wassit governorate were less than the recommended value of (370 Bq/kg) for the radium equivalent activity given by (UNSCEAR , 2000) [4].

The highest value of absorbed dose rate (D_γ) was found in (Nuamaniya) region which was equal to (40.812 nGy/h), while the lowest value of absorbed gamma dose rate was found in (Jassan) region which was equal to (21.024 nGy/h), with an average value of (33.116± 3.4 nGy/h). The present results have shown that values of absorbed gamma dose rate in Wassit governorate were less than the recommended value of (55 nGy/h) for the absorbed gamma dose rate given by (UNSCEAR , 2000) [4].

The highest value of indoor annual effective dose equivalent was found in (Nuamaniya) region which was equal to (0.200 mSv/y), while the lowest value of indoor annual effective dose equivalent was found in (Jassan) region which was equal to (0.103 mSv/y) ,with an average value of (0.162±0.017 mSv/y). The present results have shown that the indoor annual effective dose equivalent in Wassit governorate were less than the recommended value of (1 mSv/y) for the indoor annual effective dose equivalent given by (UNSCEAR, 2000) [4].

The highest value of outdoor annual effective dose equivalent was found in (Nuamaniya) region which was equal to (0.050 mSv/y) , while the lowest value of outdoor annual effective dose equivalent was found in (Jassan) region which was equal to (0.026 mSv/y), with an average value of (0.041± 0.004 mSv/y). The present results have shown that values of outdoor annual effective dose equivalent in Wassit governorate were less than the recommended value of (1 mSv/y) for the outdoor annual effective dose equivalent given by (UNSCEAR, 2000) [4].

The highest value of activity concentration index was found in (Nuamaniya) region which was equal to (0.640), while the lowest value of activity concentration index was found in (Jassan) region which was equal to (0.334) ,with an average value of (0.522±0.05). The present results have shown that values of activity concentration index in Wassit governorate were less than the recommended value of (1) for the activity concentration index given by (UNSCEAR, 2000) [4].

The highest value of internal hazard index was found in (Nuamaniya) region which was equal to (0.325), while the lowest value of internal hazard index was found in (Jassan) region which was equal to (0.150) ,with an average value of (0.256±0.03). The present results have shown that values of internal hazard index in Wassit governorate were less than the recommended value of (1) for the internal hazard index given by (UNSCEAR, 2000) [4].

The highest value of external hazard index was found in (Nuamaniya) region which was equal to (0.241), while the lowest value of external hazard index was found in (Jassan) region which was equal to (0.121), with an average value of (0.195±0.02). The present results have shown that values of external hazard index in Wassit governorate were less than the recommended value of (1) for the external hazard index given by (UNSCEAR, 2000) [4].

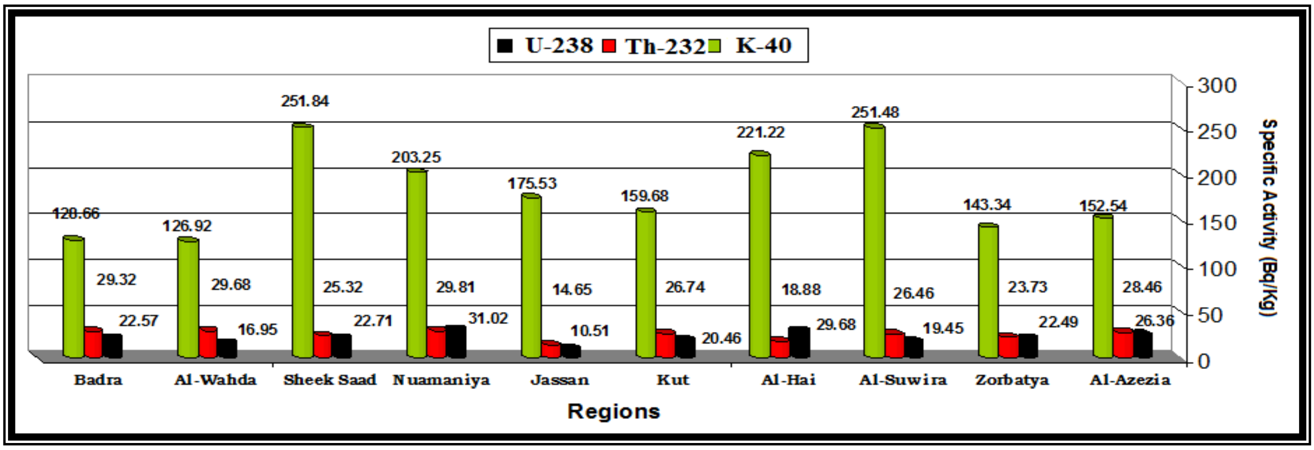

Figure (1) specific activity of (^{238}U, ^{232}Th and ^{40}K) for all regions studies.

Table (1) specific activities of radionuclides with some other parameters in soil samples in Wassit governorate.

Location	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Ra_{eq} (Bq/kg)	D_{γ} (nGy/h)	(A.E.D) (mSv/y)		I_{γ}	Hazard index	
						Indoor E_{in}	Outdoor E_{out}		H_{in}	H_{ex}
Al-Azezia	26.360	28.460	152.540	78.803	35.729	0.175	0.044	0.562	0.284	0.213
Zorbatya	22.490	23.730	143.340	67.461	30.701	0.151	0.038	0.483	0.243	0.182
Al-Suwira	19.450	26.460	251.480	76.652	35.454	0.174	0.043	0.562	0.260	0.207
Al-Hai	29.680	18.880	221.220	73.712	34.341	0.168	0.042	0.534	0.279	0.199
Kut	20.460	26.740	159.680	70.994	32.262	0.158	0.040	0.510	0.247	0.192
Jassan	10.510	14.650	175.530	44.975	21.024	0.103	0.026	0.334	0.150	0.121
Nuamaniya	31.020	29.810	203.250	89.299	40.812	0.200	0.050	0.640	0.325	0.241
Sheek Saad	22.710	25.320	251.840	78.309	36.287	0.178	0.045	0.572	0.273	0.211
Al-Wahda	16.950	29.680	126.920	69.165	31.050	0.152	0.038	0.494	0.233	0.187
Badra	22.570	29.320	128.660	74.404	33.502	0.164	0.041	0.529	0.262	0.201
Ave.	22.220± 4.3	25.305 ±3.7	181.446 ±40.4	72.377± 7.3	33.116± 3.4	0.162 ±0.017	0.041 ±0.004	0.522 ±0.05	0.256 ±0.03	0.195 ±0.02
Min.	10.510	14.650	126.920	44.975	21.024	0.103	0.026	0.334	0.150	0.121

Location	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Ra_{eq} (Bq/kg)	D_{γ} (nGy/h)	(A.E.D) (mSv/y)		I_{γ}	Hazard index	
						Indoor E_{in}	Outdoor E_{out}		H_{in}	H_{ex}
Max.	31.020	29.810	251.840	89.299	40.812	0.200	0.050	0.640	0.325	0.241
worldwide average [4]	35	30	400	370	55	1	1	1	1	1

Conclusions

The results of the present work concerning values of the specific activity for (^{238}U, ^{232}Th and ^{40}K) amd determination the parameters [Ra_{eq} ,D_{γ} , (AED) $_{in}$,(AED) $_{out}$, EAD, I_{γ} , H_{in} and H_{ex}] ,all were found to be lower than their corresponding allowed limits, and hence will pose relatively none series health risk.

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