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Evaluation of the Radioactivity of Selected Soil Samples from University of Karbala

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Abstract. The radio nuclear quality radio activity (40K,232Th, and 238U) was measured. by (Iodide Sodium standard system activated with Thallium 3x3, NaI(Tl) Detector). Four samples of soils were collected at a depth (5cm-20cm) from the various locations in University of Karbala in the city of Karbala. to calibrate detector (137Cs,60Co and 22Na) were used. Through the comparing between The results in this search and the international standards for soil pollution showed that the activity concentrations values of 238U.232Th, and 40K are lower than international recommended limits. Radium equivalent activity as well as the annual dosage that works values are lower than the maximum permissible levels recommended by world health organization, In both stations, the values of the internal and external hazard indexes as well as gamma activity concentration were less than unity.

Keywords: Natural Radioactivity; annual effective dose ; Samples of Soils and University of Karbala.

1. Introduction

Natural radiation sources is estimated to be constitute (80%) of collective total radiation exposure. to the human population . These radionuclide have various sources, of which earth crust,rocks, soils, water, plants, minerals, sediments and air .Natural radioactivity levels relying on geological and geographical. conditions and appears at. Various concentration in soil of each. geological region. Exposure to natural radiation sources, is mainly because of cosmic and gamma rays emitted from building materials, rocks, food ,soil and water sediment [1].

According to the World Health Organization (WHO) have found people are exposed by ionizing radiation from other natural sources like soil and water, vegetation and other man-made sources like X-rays . Ionizing radiation is energy produced by atom in the form of electromagnetic wave or particles. The process in which atoms naturally decay is known as radioactivity, and the excess energy is said to give out ionising radiation. In radioactivity, unstable elements that break down and emit particles which produce ionization are known as radionuclides [2] .

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) identifies four major sources of natural radiation: cosmic rays and gamma radiation, radioactive elements in soil and water and radioactive particles which enter the human body and become ingested. Cosmic rays relate to astral activities and terrestrial rays to content of the Uranium, potassium and thorium in the earth's crust. Radon and thoron that are the two radioactive noble gases, being generated by the radioactive decay of uranium and thorium correspondingly, a substantial portion of natural exposure to radiation is through inhalation of these gases. Ingestion is the other mode of internal exposure that results from taking tiny particles of the radioactive minerals in foods and drinking water [3] .

Several areas in theworld among these, China, Japan , Iran, India, Brazil ,Australia etc., possess high concentration of natural radiation. recently, studies around regions with elevated background radiation worldwide have been of significance role for risk estimation because of low-level long-term whole body exposures tothe world population. The high radiation concentration are because of the exhibit large amountsradioactive minerals that are found in soils, sediments, and rocks naturally [4]. Hence, in this investigation, (^{40}K,^{232}Th, and ^{238}U) concentrations measurements has been carried out for the various locations in University of Karbala in the city of Karbala. The University of Karbala is one of the Iraqi universities. It is located in the city of Karbala, the center of Karbala province, one of the provinces of the Middle Euphrates in Iraq which established in 1987[5] .The building of university are located on several sites. Its main location is in the north of Karbala next to Al-Zawra neighborhood. The Colleges of Education, Sciences, Arts, law college and the Engineering College of the main compound of the university[6]. The College of Medicine andNurses are located behind the Karbala General Hospital and the College of Agriculture located in the area of Nuria. The main objectives for this work include the exploration of the possibility of uranium in the concerned area as well as the relevant health hazards that may ensue from it. In light of the above formulated objectives, this study aims at determining the radioactivity levels in the soils collected from different parts of University of Karbala, with the intention of establishing natural radiation risks to the health of university community and the outside world.[7]

2 . Theoretical part

The specific activity (A) can be calculates of each radionuclide by the following equation

$$A=(N_{net}/\varepsilon.I\gamma.M.t)\pm((N_{net})^{1/2}/\varepsilon.I\gamma.M.t)(Bq.kg^{-1})\ldots\ldots(1)$$

where Nnet is the net count, expressed in (c/s) (area under peak of the specified energy after background removal), ε is the detector efficiency, and t is the duration (provided in seconds) for the spectrum collection. Finally, (Iɤ) and (M) stand for the sample weight (in kg) and the discharged gamma ray's transition probability, respectively.[8]. Radium equivalent, or Raeq in Bq kg−1, is a single quantity that can reflect the activities caused by 238U, 232Th, and 40K.It is based on the premise that the gamma-radiation dosage rate of (238U, 232Th, and 40K) is equal to (370 Bq kg−1, 259 Bq kg−1, and 4810 Bq kg−1). This represents a weighed total for the activities of the three nuclides of the natural radio. The following connection was used to compute the activity of the radium equivalent (Raeq)[8 ,9].

$$R_a\ (Bq/Kg) = A_U + 1.43\ A_{Th} + 0.677A_K \ldots \qquad \ldots\ldots\ldots(2)$$

The unique activities of 238U, 232Th, and 40K are represented by the symbols AU, ATh, and AK, respectively. stated as Bqkg-1.)4). Additionally dangerous to the respiratory system is radon (222Rn). The internal hazard index Hin, which is defined as the relations[10], measures the exposure to radon (222Rn) both internally and externally.

$$H_{in} = (A^{238}U)/185 + (A^{232}Th)/259 + (A^{40}K)/4810 \qquad \ldots\ldots\ldots(3)$$

$$H_{ex} = (A^{238}U)/370 + (A^{232}Th)/259 + (A^{40}K)/4810 \ldots \quad \ldots.(4)$$

Hex stands for the external Hazard Index. Hin and Hex maximum values ought to be less than unity and less than unity, respectively [11]. is in line with the maximum (Raeq) activity limit (370Bq/kg) to maintain a negligible radiation risk. An estimate of the annual effective dosage (AED) can be obtained by taking consideration into account[12].

(a) The amount of this absorbed dose and the environmental dose conversion factor to derive or obtain the effective dose conversion coefficient in the air.

(b) The factor for indoor occupancy.

The Dose Rate data, which was derived from the radionuclide concentration values in the soils, is used to calculate the annual effective doses. The factor of (0.7 Sv/Gy) is adopted to convert the rate of absorbed dose in air to the effective dose received by adults, and it is taken into consideration that people spend, on average, 20% of their time outside[13.14]:

$$ADE(nGy/h) = 10^{-6}\times 0.20\times 0.7Sv/G \ \times 8760h \times \text{ Annual effective dose outdoors } (mSv/y) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

$$ADE(nGy/h) = 10^{-6}\times 0.80\times 0.7S0\ v/G \ \times 8760h \times \text{ Indoor annual effective dosage } (mSv/y) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

$$AED=0.462A_U+0.621A_{Th}+0.417A_k \text{ ………………………… ……………(7)}$$

The natural radioactivity in soil is mainly (238 U, 232 Th) decay series and 40 K. These radionuclides circulate in soil and rocks at different concentrations depending on the general and geographical characteristics of the area in question. These radionuclides are present in the soil, and their activity concentrations are making parts of the background radiation dose to man .

Radiological Hazard Indices: To assess the potential radiological hazards associated with the natural radioactivity in soil, several radiological hazard indices are commonly employed.

- Radium equivalent activity (Raeq): Raeq is a commonly used hazard index which by way of 226Ra, 232Th and 40K is expressed in unit of radium. using the equation [15]:

$$Raeq=C_{Ra}+1.43C_{Th}+0.077C_K \text{ …………… (8)}$$

This could be expressed as follows: C_{Ra} , C_{Th} and C_K activity concentrations of 226 Ra, 232Th and 40K respectively in Bq/kg.

- External hazard index (Hex): Hex deems the external radiation risk because of the gamma emission radiation. It is given by [16] :

$$Hex= C_{Ra}/370 + C_{Th}/259 + C_K / 4810 \leq 1 \text{ ……………(9)}$$

- Internal hazard index (Hin): Hin calculates the internal dose equivalent from radon and its progeny inside the house. It is calculated as [17]:

$$Hex= C_{Ra}/185 + C_{Th}/259 + C_K / 4810 \leq 1 \text{ ……………(9)}$$

- Absorbed dose rate (D): In this case, The numerical value of the hitherto mentioned absorbed gamma dose rate in air at 1 m above the ground surface is determined through the equation [18] :

$$D(nGy/h)=0.462\, C_{Ra}+0.604\, C_{Th}+0.0417\, C_K \text{ …………(10)}$$

- Annual effective dose equivalent (AEDE): AEDE defines the amount of dose equivalent a person is exposed to in one year. It is calculated using [19] :

$$EDE(\mu Sv/y)=D(nGy/h)\times 8760h\times 0.2\times 0.7(Sv/Gy)\times 10^{-3} \text{ …….(11)}$$

where 0.2 is the occupancy factor that outside space, and thus the conversion factor 0. 7 Sv/Gy refers to the Conversion factor for converting from the absorbed dose in air and the effective dose.

3 . Experimental Part

(3.1) Samples Collection

All soil samples were taken from various locations in Karbala university by instrument called Auger where a depth 5cm-20cm. The geographical location of each soil sample wasconsider in order to study radio activity. then the collected soil samples were packaged, labeled , and taken to Physics Laboratory, at Karbala University for preparation, measurement and analysis.

It was also realized that proper sampling methods and recordation of samples are very vital in determining the real sampling size of increased values of soil radioactivity. This interval of the depth was chosen for the analysis of soil radioactivity as it indicates the root layer and topsoil which are the zones that have a tendency to attract radionuclides . Exporting the samples to controlled laboratory allows taking measurements with high accuracy with the help of the appropriate radiation detecting instruments [20] .

(3 . 2) Samples Preparation

1- All Soil samples were collected at a depth (5-20)cm from various locations from Karbala university

2- The Soil samples were crushed to small pieces

3- It is dried to , remove moisture, fine powder by electric furnace at about (100c)

4- A clip-diameter holes (2mm) was use to riddled the soil samples to obtaining a homogeneoussamples

5- Finally , The obtained homogeneous samples were packed into plastic bags have capacity (1kg)and sealed tightly with cap kept aside for about one month prior in order to achieve the equilibrium has been reached

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(3-3)detection system

In the present study the detector 3x3 inch NaI(TI) , which working at (750volt) have been used as quality radio activity detection and measurement system . The viability of energy discrimination detector in the rang 6.5 – 8.56 % for the energy values 0.662 Mev – 1.332Mev. Detector is associated with the following series parts of the main amplifier, the primary amplifier, the electrical signal and electronic computer that includes a multi-channel analyzer.

NaI(Tl) detectors are used in the study of natural radioactivity in soil samples because of their efficiency and good energy resolution . Therefore, the correct setup of detectors and calibration methods are relevant for the actual quantification of the given radionuclide concentrations. More complex procedures such as the real time autoradiography employing gaseous detectors are also being considered to detect radioactive particles in complex environments of samples [21].

(3- 4) System Calibration

A) **calibration of the detector**

The proportional behavior of the detector out pulse with the energy gamma that falls on the crystalline capacity is termed as calibration. The emitter gamma spectrum can be calibrated using reference sources with known energy and intensities. As seen in Figure (1), a variety of common sources, including Co60, Na22, and Cs137, were used to derive energies for the current investigation.

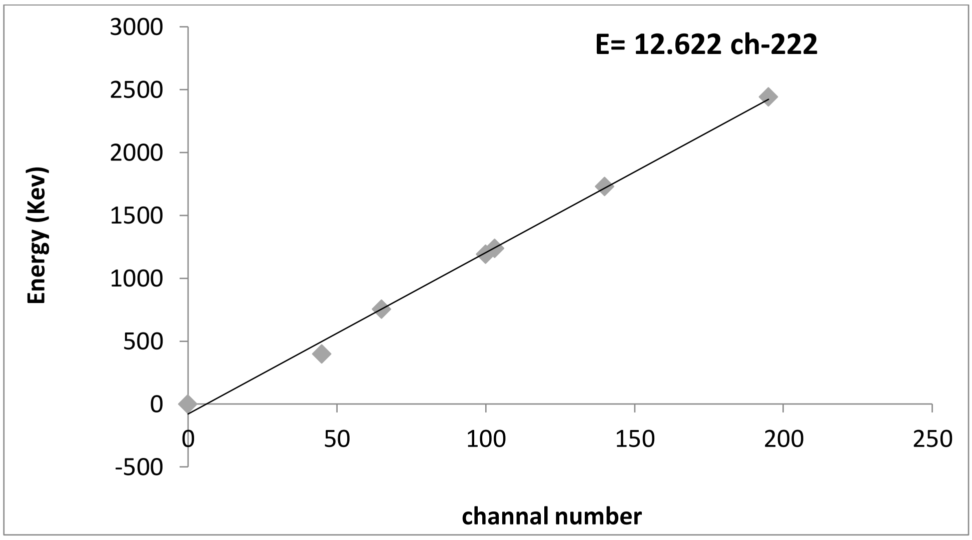


Fig (1) the establishing of the channel number of energy gamma rays

B - efficiency Calibration

The ratio of photons falling on a detector to the number of pulses emitted from it is known as detector efficiency. is provided by the equation

$\varepsilon = [Nl\ (A.I_{\gamma}.\ t)] \times 100\%$ ………(8)

The efficiency of the detector was determined using the record sources' energies after calibrating the detector to obtain the final specific activity of the radioactive sources using the decay equation. The detector obtained radioactivity for each energy from the energies of the radioactive sources for a period of 3600s.

The relationship between energy and efficiency for the standard sources used is depicted in Figure (2).

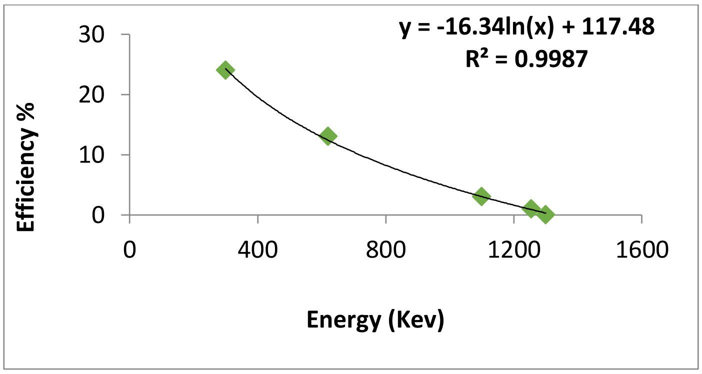


Fig (2) This illustrates how energy and efficiency are related to the common sources utilized

4. Method of measurement

Wash Mrneli Bequre (is pot made of plastic with a capacity of one liter and has a cylinder prove in his center which is placed on the crystal of the detector) by acid, hydrochloric diluted and then with distilled water then place (0.5KG) of each sample in the container and surround it by a shield made of lead, which consists of two parts , the first part thickness (5cm) and height (10cm) , the second part caver with thick (5cm) and diameter (cm) that the installation of the shield in this way achieves a high efficiency during the measurement. Finally , measure specific activity of samples for (3600) Sec then Calculate the area under the peak for the spectrum of gamma rays and thus the effectiveness of radiation quality can be calculated from equation (1) after subtracting the background radiation value (a measurement system in the case of freesamples).

It is also important to maintain measurement process; therefore, there is a uniform procedure in the preparation and analysis of each soil sample. Prior to filling the container to produce a new batch of the above product, the plastic container, Mrneli Bequre, is well washed using diluted hydrochloric acid to remove any contamination. It is then washed with distilled water to remove any of the remaining acid on the object's surface. The tight cleaning process to the instrument minimizes and washouts any influence from external forces on the measurements [22].

When the samples are filled in the container they are covered with a precisely designed lead shield. This shield is vital as it reduces the chances of picking interferences from other radiation sources. The two-part lead shield ensures comprehensive coverage: the first part, having the thickness of 5 cm and height of 10 cm, offers a shield vertically; however, the second part, a cover with thickness of 5 cm and proper diameter, offers a shield horizontally. This configuration enables maximal effectiveness as well as specificity of the detection system [23].

The process of measurement consists in irradiation of each sample with the detector for 3600 seconds. This duration is chosen to get the sufficient number of responses in order to get the statistically significant results. Gamma-ray spectrum is obtained and chosen peaks related to particular radionuclides are being examined. The area under these peaks is then computed and this shall give the activity concentration of the radionuclides in the sample. Because of the facilitation of background noise in the determination of these counts, background radiation is usually taken and subtracted from the sample counts[24] .

Therefore, by adhering to this systematic approach, the study will be in a better position of establishing the radioactivity levels in the soil samples from University of Karbala for given coordinates in order to offer a dint for evaluating environmental and health implications [25] .

5. Result and discussion

The specific activity values of ^{238}U, ^{232}Th, and ^{40}K radionuclide's for (5) samples of the soils shown in Figure (3). It can be noted that the specific activity values lie in the range of (10.77± 1.116;S1 to 24.99 ± 1.699;S4) Bq/kg, from (8.11 ± 0.356;S3 to 6.120 ±1.757;S2) Bq/kg and(120.328 ± 3.469;S3 to 311.6 ± 6.159;S2) (Bq/kg) for ^{238}U, ^{232}Th, and ^{40}K respectively. according to instructions of the International Commission approved the results show that allvalues of ^{238}U, and ^{40}K ., amounting to specific activity for (4) soil samples are within the limits (30 , 35 , and 400) (Bq/kg) for (^{232}Th, ^{238}U , and ^{40}K) respectively. [26].

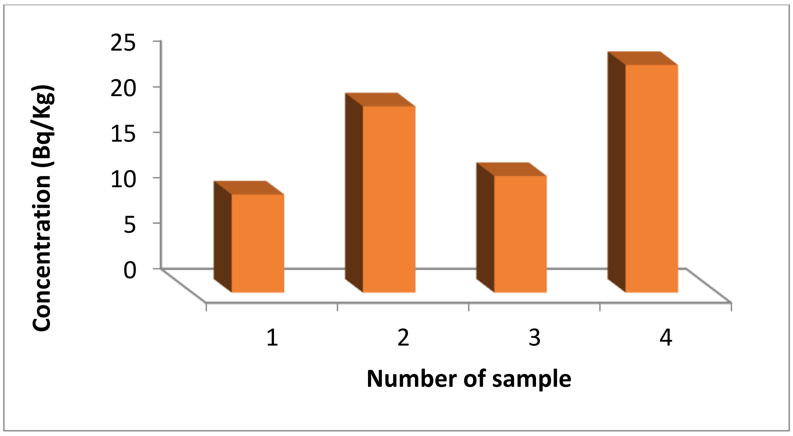


Fig (3a):Concentration of the ^{238}U for sample.

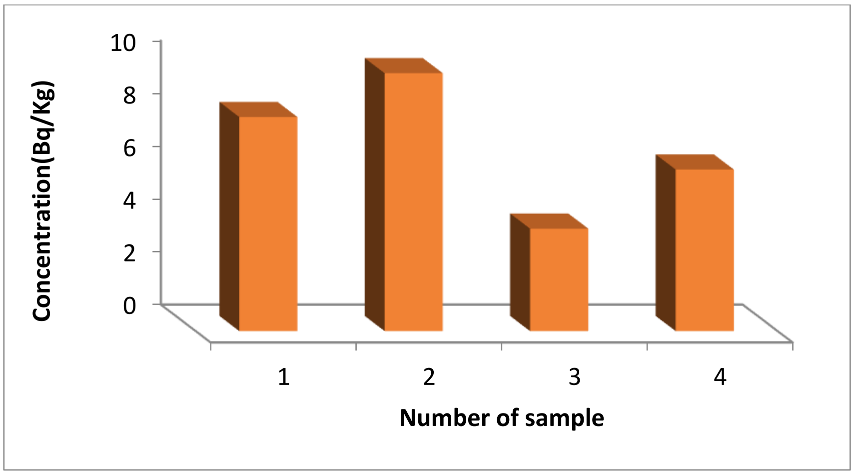
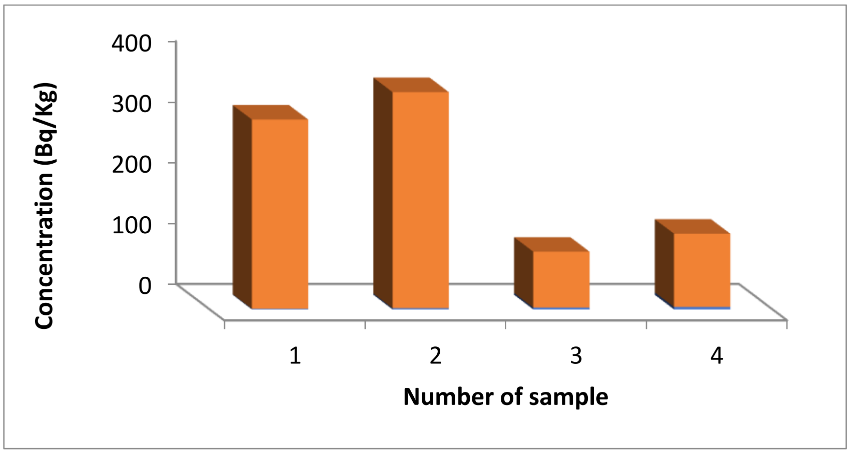


Fig (3b):Concentration of the ^{238}Th for sample.



Fig(3b) Concentration of the ^{40}K for sample

So, in this paper, Internal hazard index (Hin) is investigated figure in below show that, it can be observe that the (Hin) range from (0.107;S3 to 0.206;S2) , it was lower than limit according to the Radiation Protection.[27].

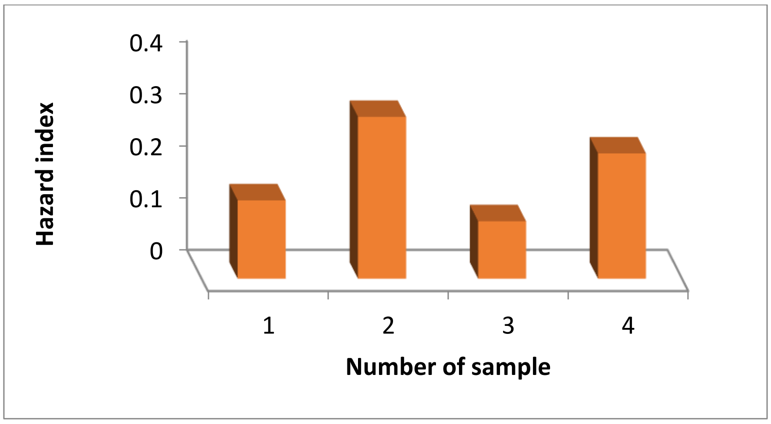


Fig. (4) The relationship between the hazard index and sample size.

activities of (Ra_{eq}) for all samples were calculated and summarized into table (1). values of (Ra_{eq})found vary from (24.70±1.79;S3 to 54.33±2.59;S2) (Bq/ kg). for all soil samples these values of radium equivalent were low compared with recommended value (370 Bq/ kg) [28]. Value of the gamma dose rate ,D between (15.66±0.88;S3 to 24.99±1.93;S2) nGy/hr. rang of the annual effective dose are between (.0.058±0.017;S3 to 0.155±0.054±0.0104;S2) (msv/y) its lower than unity, Representative Activity concentration index (Iγ) range from (0.20;S32 to 0.48;S2)

Table (1) The yearly absorbed dose and equivalent radiation to the samples under study

No.of sample	Location of the sample	Effective dose rate ($mSv.Yr^{-1}$)	Absorbed dose rate($nGy.h^{-1}$)	Radium equivalent(Bq/Kg)	Activity concentration index
1	College of Medicine	0.022± 0.33	22.43±1.44	27.66±3.22	0.26
2	Art college	0.155±0.054	24.99±1.93	54.33±2.59	0.48
3	Culture college	0.058±0.017	15.66±0.88	24.70±1.79	0.20
4	College of Education for Pure Sciences	0.024±321	19.78±2.11	31.09±1.11	0.38
5	Engineering college	0.097±0.019	17.94±2.33	44.05±6.59	0.30
6	Department of physics in education callage	0.075±0.022	16.88±1.99	33.199±4.63	0.22

6. Conclusion

The radioactivity levels of soil samples obtained from a variety of locations on the University of Karbala campus were assessed in this study. The results indicated that six of the total samples had specific activity values that were within the limits established by the International Commission for 238U (35 Bq/kg), 232Th (30 Bq/kg), and 40K (400 Bq/kg). The internal hazard index (Hin) values were less than the limit set by the Radiation Protection guidelines, ranging from 0.107 (S3) to 0.206 (S2). The radium equivalent activities were significantly lower than the recommended value of 370 Bq/kg, ranging from 24.70±1.79 to 54.33±2.59 Bq/kg. The gamma dose rate (D) varied from 15.66±0.88 to 24.99±1.93 nGy/hr, and the annual effective dose was between 0.022±0.33 and 0.155±0.054 mSv/y, which is less than unity. The representative activity concentration index (Iγ) was 0.20 to 0.48. These results indicate that the soil samples from the University of Karbala have radioactivity levels that are within the permissible range and do not present any substantial radiological hazards to the university population or the surrounding environment. Nevertheless, it is advisable to conduct routine monitoring and evaluations of the radioactivity levels in the area to guarantee the safety and well-being of the community.

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