



## Estimation the Radionuclides concentrations, Risk indicators and annual doses in soils of residential and agricultural regions in Kirkuk city

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### ABSTRACT

The aim of the current study is to measure the Specific activity of the radio nuclides, Risk indicators and annual doses in selected soils samples for the residential and agriculture areas in Kirkuk governorate by using the spectroscopy technique of high-purity germanium detector where 10 soil samples were collected at depth of 20 cm. The present study shows that radioactivity results for the isotopes were as the following: Radium  $^{226}\text{Ra}$ , Actinium  $^{228}\text{Ac}$  and potassium  $^{40}\text{K}$  are  $(27.6 \pm 4.1 - 43.3 \pm 5.4 \text{ Bq.kg}^{-1})$  with average value  $(32.86 \pm 4.95 \text{ Bq.kg}^{-1})$  and  $(12.4 \pm 0.8 - 28.12 \pm 4.2 \text{ Bq.kg}^{-1})$  with average value  $(20.492 \pm 2.77 \text{ Bq.kg}^{-1})$  and  $(225 \pm 9.2 - 327 \pm 12.1 \text{ Bq.kg}^{-1})$  with average value  $(268.76 \pm 9.06 \text{ Bq.kg}^{-1})$  respectively. The factor  $R_{\text{eq}}$  Radium equivalent  $(63.966 - 92.759 \text{ Bq.kg}^{-1})$  and the radioactivity concentration ( $I_{\gamma}$ )  $(0.469 - 0.666 \text{ Bq.kg}^{-1})$ , Hazardous factors of internal and external are  $(0.366280 - 0.247378 \text{ Bq.kg}^{-1})$   $(0.172784 - 0.249254 \text{ Bq.kg}^{-1})$  respectively. The air absorbed does ( $D_{\gamma}$ )  $(30.332 - 43.185) \text{ nGy.h}^{-1}$ , while the Risk indicator for the internal and external annual effective dose were  $(0.148797 - 0.220033) \text{ mSv.y}^{-1}$  and  $(0.037199 - 0.052963) \text{ mSv.y}^{-1}$  respectively. The comparison of the present results present a good agreement with the acceptable standard values of the World Health Organization (WHO) and has not influences on the health, environment and agriculture.

### 1- Introduction

The radiation applications in science, energy, industrial, medical applications and agriculture has been brought huge benefits to the humanity [1]. Radioactivity is defined as the spontaneously transformation of an excited nucleus into a stable nucleus after emitting radiation like  $(\alpha)$ ,  $(\beta^+$ ,  $\beta^-)$  or gamma rays  $(\gamma)$  [2]. The radioactive pollutants is a contamination which may be considered complex problem. The sources of radioactive contamination in the environment vary due to its behavior of newly deposited radioactive nuclides different from the behavior of the nuclides that already founded inside the soil samples [3]. The winds is the main factor in spreading the pollutants as it moves the soil to various areas carrying the pollutants, which leading to contamination of air and surface soil [4]. The current research work for the scanned regions suggests that the level of radionuclide concentrations  $^{238}\text{U}$ , and  $^{234}\text{Th}$  chains in the soil samples of Kirkuk city for the radioactivity of natural and their output  $^{228}\text{Ac}$  and  $^{226}\text{Ra}$  natural sources of  $^{40}\text{K}$  using a the high purity

germanium detector. The measured factors in the present study are radiological risk effects account for human health (radium equivalent activity  $R_{\text{eq}}$ )  $\text{Bq.kg}^{-1}$ , activity concentration indicator ( $I_{\gamma}$ ), the internal risk indicator, the external risk indicator, the absorbed dose rate in air  $\text{nGy.kg}^{-1}$ , the values of internal annual effective dose is equivalent ( $\text{mSv.y}^{-1}$ ) and the values of external annual effective dose equivalent ( $\text{mSv.y}^{-1}$ ).

### 2 - The theoretical part

#### 2-1 Specific Activity concentration (N)

Specific activity is defined as the radioactivity of per units of mass or volume of the natural radioactive material, which measured in a ( $\text{Bq/kg}$  or  $\text{Bq/m}^3$ ). It's given by the equation [5].

$$N \left( \frac{\text{Bq}}{\text{kg}} \right) = \frac{N}{\varepsilon(e_{\gamma}).I_{\gamma}(e_{\gamma}).m.t} \dots \dots (1)$$

N : net count under the peak.

$\varepsilon(e_{\gamma})$  :  $\gamma$  ray detector efficiency.

$I_\gamma(e_\gamma)$  : the percentage proloaloityof  $\gamma$  ray emission from the radionuclides under study.

m : mass of the sample measured by kg.

t : count time in second.

## 2-2 Radium Equivalent Activity ( $Ra_{eq}$ )

Radium equivalent activity ( $Ra_{eq}$ ) stand for a factor which is used to ensure the uniform distribution of natural radionuclide's,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$  measured by ( $\text{Bg.kg}^{-1}$ ). Which is calculated by using the following equation [6,7].

$$Ra_{eq} \left( \frac{\text{Bq}}{\text{kg}} \right) = N_{Ra} + 143 \times 10^{-2} N_{Th} + 7.7 \times 10^{-2} N_K \dots \dots (2)$$

$N_{Ra}$ ,  $N_{Th}$  and  $N_K$  are the Specific activity of  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$  respectively. The maximum acceptable value for the equivalent radium is (370)  $\text{Bg.kg}^{-1}$  [7,8].

## 2-3 Gamma ray indicator Concentration Indicator ( $I_\gamma$ )

The gamma  $\gamma$  radiation risk indicator is a radiometric factor in which the risk levels  $\gamma$  rays associated with natural radionuclide's are estimated, and they can be calculated using the following equation:

$$I_\gamma \left( \frac{\text{Bq}}{\text{kg}} \right) = \frac{N_{Ra}}{150} + \frac{N_{Th}}{100} + \frac{N_K}{1500} \dots \dots (3)$$

The risk indication for  $\gamma$  rays is less than unity [5,9].

## 2-4 Risk Indicators

Risk indicator defined as a radiological factor used to measuring internal and external radiation risks. The internal Risk indicator ( $R_{in}$ ) and the external risk indicator ( $R_{ex}$ ) calculated by using the following equation [6,10].

$$R_{in} \left( \frac{\text{Bq}}{\text{kg}} \right) = \frac{N_{Ra}}{185} + \frac{N_{Th}}{259} + \frac{N_K}{4810} \leq 1 \dots (4)$$

$$R_{ex} \left( \frac{\text{Bq}}{\text{kg}} \right) = \frac{N_{Ra}}{370} + \frac{N_{Th}}{259} + \frac{N_K}{4810} \leq 1 \dots (5)$$

The internal Risk indicator ( $R_{in}$ ) and the external Risk indicator ( $R_{ex}$ ) should be less than unity [9,11].

## 2-5 Absorbed Dose Rate in Air ( $D_\gamma$ )

The average absorbed dose of  $\gamma$ -rays in air  $D_\gamma$  at (1m) above ground level can be calculated using the following equation.

$$D_\gamma (\text{nGy.h}^{-1}) = 46.2 \times 10^{-2} N_{Ra} + 60.4 \times 10^{-2} N_{Th} + 4.17 \times 10^{-2} N_K \dots (6)$$

The conversion factors used for calculating the gamma absorbed dose in the air correspond to ( $46.2 \times 10^{-2}$  nGy/h) for  $^{226}\text{Ra}$ , ( $60.4 \times 10^{-2}$  nGy/h) for  $^{232}\text{Th}$  and ( $4.17 \times 10^{-2}$  nGy/h) for  $^{40}\text{K}$  [5,6].

## 2-6 Annual Effective Dose Equivalent (AEDE)

The annual effective dose equivalent represents a radiation parameter which used to determine the health effects of the absorbed dose measured by ( $\text{mSv.y}^{-1}$ ). The annual effective dose estimates using

the conversion factor ( $0.7 \text{ Sv.Gy}^{-1}$ ) which converts the absorbed dose in air to the effective dose, as well as using the internal occupancy factor (80%) and the external occupancy factor (20%) can be calculated using the following equation [12,13].

$$\begin{aligned} \text{AEDE}_{in} (\text{mSv.y}^{-1}) &= D_\gamma (\text{nGy.h}^{-1}) \times 10^{-6} \\ &\times 8760 \text{h.y}^{-1} \times 0.7 \text{Sv.Gy}^{-1} \\ &\times 80\% \dots (7) \end{aligned}$$

$$\begin{aligned} \text{AEDE}_{out} (\text{mSv.y}^{-1}) &= D_\gamma (\text{nGy.h}^{-1}) \times 10^{-6} \times \\ &8760 \text{h.y}^{-1} \times 0.7 \text{Sv.Gy}^{-1} \times 20\% \dots (8) \end{aligned}$$

## 3- Experimental part

All the radioactivity parameter has been measured by using quantity and quality analysis for gamma rays using high-purity germanium detector. In Radiation protection center: RPC Ministry of Environment.

### 3-1 Description of the study area

The coordinates details of the selected locations for the present study are illustrated in table (1) and shown in figure (1) were obtained by using GPS.

**Table (1): The detailed samples information for the locations and dates study.**

| Sample code | Name                             | Longitude | Latitude |
|-------------|----------------------------------|-----------|----------|
| S1          | Laylan                           | 44.5277   | 35.3125  |
| S2          | Laylan/<br>Yahyaawa              | 44.5067   | 35.3232  |
| S3          | Chemana                          | 44.4882   | 35.4896  |
| S4          | Seakanyan                        | 44.3610   | 35.5566  |
| S5          | Kirkuk city residential<br>group | 44.4458   | 35.4858  |
| S6          | Barwdkhana                       | 44.4258   | 35.4838  |
| S7          | Shorja                           | 44.4065   | 35.4550  |
| S8          | judgments residential<br>group   | 44.3910   | 35.4516  |
| S9          | Panja Ali                        | 44.4359   | 35.4172  |
| S10         | Daqwq                            | 44.4866   | 35.1459  |

### 3-2 Preparation Soil Samples

Some precaution must be taken into consideration in collecting and preparing the samples under study is that keep these samples clean and preventing them from contamination. Four sample where collected in different time intervals during the period 22-27/1/2019, at a depth of (20 cm) beneath the soil surface. The soil samples are dried to remove the moisture and left it for a period of seven days to ensure the full equilibrium and homogeneity situation and then grind in order to become a fine powder, and sifted with (0.2 mm) pores clamp to remove the gravel and plant roots sticking, the samples were weighed using a high sensitivity scale of 0.0001/gm. And (500 g) are taken from each dried soil, then the samples are placed in a pot Marinelli Beaker which this design of vessel is similar to the detector neck.

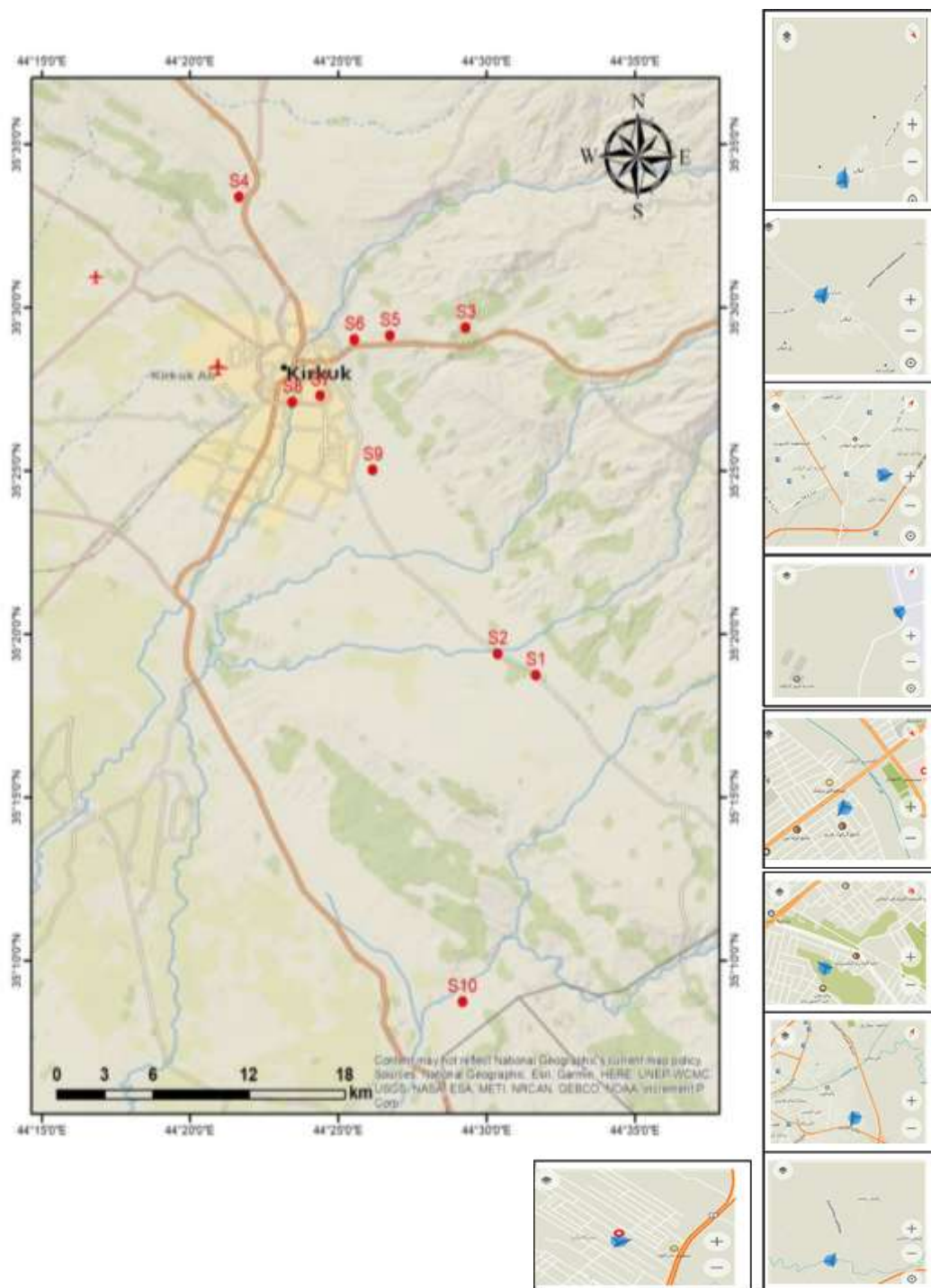


Fig. 1: The locations under study in Kirkuk city

**3-3 Radioactivity Measurement System:** The detector system which , shown in fig (2). gamma-rays were detected by using a germanium

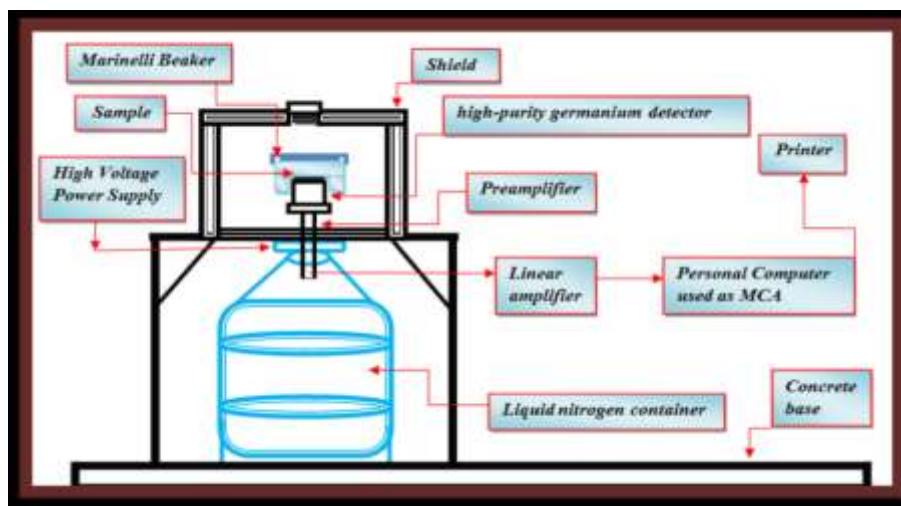


Fig. 2: sketch of detecting set-up.

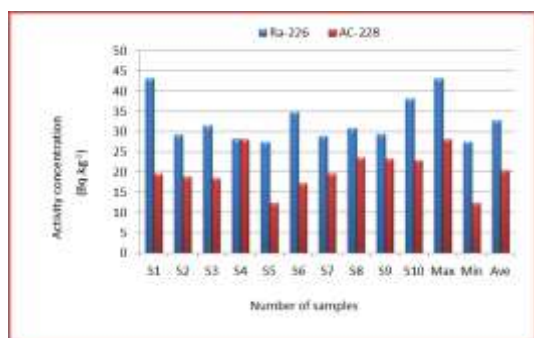
#### 4- Measurement of Specific Activity for Soil Sample

Nowadays modern techniques are capable of fabrication a high purity germanium crystals with trace quantity of impurities and reagent used is the production company (Canberra). Voltage detector (4000V) supplied by (TENNELEC). The germanium detector needs for (17 – 18 – 19 °C) temperature and cooled by liquid nitrogen during operation to erasing the noise pulses of the current leakage that is generated in room temperature [14]. Detector is walled by bulletproof armor of thickness (10 cm) to reduce the effect of natural radiation background on the samples understudy to detector interface which enclosed by layers of aluminum, iron, copper and cadmium sheets respectively [15]. The qualitative activity of the soil sample is measured by placing the samples into template soil inside Marinelli pot as it installed on germanium detector for an interval (3600 sec) and then measuring the sample efficiency by using equation (1). Table (2) illustrates the measurement of the specific activity for soil samples in Kirkuk city, The highest results for specific activity of radium was  $(43.3 \pm 5.4 \text{ Bq.kg}^{-1})$  for sample (S1) which is higher than the world average value of  $(35 \text{ Bq.kg}^{-1})$  [16,17] which may be results from the chimney dust of Laylan Cement factory

which employing rock stones brought from Bazayan district in Sylumania contains high amounts of  $^{226}\text{Ra}$  radioactive element that mixed with soils of that region. Inspection of the same table, we found the lowest value is  $(27.6 \pm 4.1 \text{ Bq.kg}^{-1})$  in the sample (S5) with average value  $(32.86 \pm 4.95 \text{ Bq.kg}^{-1})$  and the  $^{214}\text{Pb}$  specific activity in (S2) was the lowest which is  $(17.4 \pm 2.9 \text{ Bq.kg}^{-1})$  and the highest value is for the (S1) was  $(21.5 \pm 4.6 \text{ Bq.kg}^{-1})$  with average  $(22.53 \pm 3.02 \text{ Bq.kg}^{-1})$  which by comparison with World average value show the result of present study is lower. The highest results for specific Activity of Thorium series of ( $^{228}\text{Ac}$ ) is  $(23.12 \pm 4.2 \text{ Bq.kg}^{-1})$  for sample (S4) which is lower than the World average value of  $(30 \text{ Bq.kg}^{-1})$  [16,17], while the lowest value is  $(12.4 \pm 0.8 \text{ Bq.kg}^{-1})$  in the sample (S5) with average value  $(20.492 \pm 2.77 \text{ Bq.kg}^{-1})$  as show in Fig (3), and the  $^{214}\text{Pb}$  specific activity in (S5) was the lowest which is  $(14.4 \pm 0.6 \text{ Bq.kg}^{-1})$  and the highest value was for the (S4) was  $(27.2 \pm 5.3 \text{ Bq.kg}^{-1})$  with average  $(21.6 \pm 3.09 \text{ Bq.kg}^{-1})$  which by comparisen with World average value show the result of the present study is less than the World average value.

**Table (2): The specific activity of  $^{238}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{40}\text{K}$  radionuclides in soil samples.**

| Number of Sample                | Specific Activity Concentrations ( $\text{Bq.kg}^{-1}$ ) |                   |                   |                   |                   |
|---------------------------------|----------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|
|                                 | $^{238}\text{U}$                                         |                   | $^{232}\text{Th}$ |                   | $^{40}\text{K}$   |
|                                 | $^{214}\text{Pb}$                                        | $^{226}\text{Ra}$ | $^{212}\text{Pb}$ | $^{228}\text{Ac}$ |                   |
| S1                              | 21.5 $\pm$ 4.6                                           | 43.3 $\pm$ 5.4    | 17 $\pm$ 2.6      | 19.6 $\pm$ 3.8    | 272 $\pm$ 8.9     |
| S2                              | 17.4 $\pm$ 4                                             | 35 $\pm$ 3.1      | 18.6 $\pm$ 2.1    | 19 $\pm$ 3.2      | 312 $\pm$ 12.4    |
| S3                              | 24.1 $\pm$ 3.1                                           | 31.6 $\pm$ 5.4    | 26.1 $\pm$ 5.9    | 18.6 $\pm$ 3      | 327 $\pm$ 12.1    |
| S4                              | 26.5 $\pm$ 3.2                                           | 28.4 $\pm$ 4.8    | 27.2 $\pm$ 5.3    | 28.12 $\pm$ 4.2   | 313.6 $\pm$ 9.5   |
| S5                              | 21.4 $\pm$ 2.9                                           | 27.6 $\pm$ 4.1    | 14.4 $\pm$ 0.6    | 12.4 $\pm$ 0.8    | 242 $\pm$ 6.4     |
| S6                              | 19.8 $\pm$ 2.9                                           | 35 $\pm$ 6.3      | 15.6 $\pm$ 3.2    | 17.4 $\pm$ 2.6    | 225 $\pm$ 9.2     |
| S7                              | 23.4 $\pm$ 4.7                                           | 29 $\pm$ 5.9      | 22.2 $\pm$ 3.8    | 19.8 $\pm$ 2.9    | 245.6 $\pm$ 6.4   |
| S8                              | 21.6 $\pm$ 2.4                                           | 31 $\pm$ 4.7      | 22.2 $\pm$ 2.6    | 23.6 $\pm$ 1.8    | 235 $\pm$ 5.9     |
| S9                              | 24.2 $\pm$ 2.4                                           | 29.5 $\pm$ 3.1    | 26.5 $\pm$ 2.9    | 23.4 $\pm$ 2.3    | 282 $\pm$ 10.3    |
| S10                             | 25.4 $\pm$ 3.2                                           | 38.2 $\pm$ 6.7    | 26.2 $\pm$ 1.9    | 23 $\pm$ 3.1      | 234 $\pm$ 9.5     |
| Max                             | 26.5 $\pm$ 3.2                                           | 43.3 $\pm$ 5.4    | 27.2 $\pm$ 5.3    | 28.12 $\pm$ 4.2   | 327 $\pm$ 12.1    |
| Min                             | 17.4 $\pm$ 4                                             | 27.6 $\pm$ 4.1    | 14.4 $\pm$ 0.6    | 12.4 $\pm$ 0.8    | 225 $\pm$ 9.2     |
| Ave                             | 22.53 $\pm$ 3.02                                         | 32.86 $\pm$ 4.95  | 21.6 $\pm$ 3.09   | 20.492 $\pm$ 2.77 | 268.76 $\pm$ 9.06 |
| International standards [16,17] | 35                                                       |                   | 30                |                   | 420               |

**Fig. 3: Specific activity of ( $^{226}\text{Ra}$  –  $^{228}\text{Ac}$ ) radionuclide.**

The highest results for specific activity of potassium ( $^{40}\text{K}$ ) was ( $327 \pm 12.1 \text{ Bq.kg}^{-1}$ ) for sample (S3) which is lower than the standard value of ( $420 \text{ Bq.kg}^{-1}$ ) [16,17], while the lowest value is ( $225 \pm 9.2 \text{ Bq.kg}^{-1}$ ) in the sample (S6) with average value ( $268.76 \pm 9.06 \text{ Bq.kg}^{-1}$ ) as shown in figure (4). The specific activity for  $^{137}\text{Cs}$  value throughout areas understudy found to be equals to ( $1.5 \text{ Bq.kg}^{-1}$ ) which is about ten times less than the standard value ( $14.8 \text{ Bq.kg}^{-1}$ ) [18].

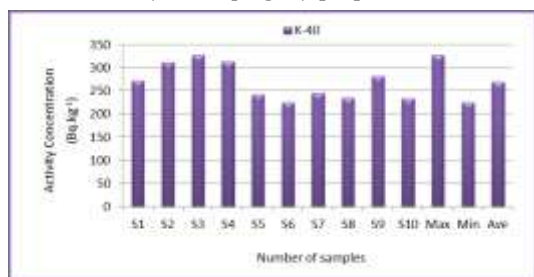
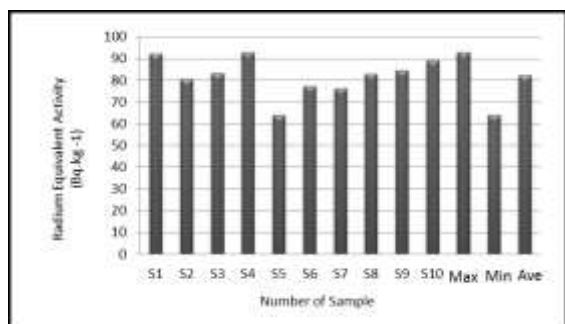
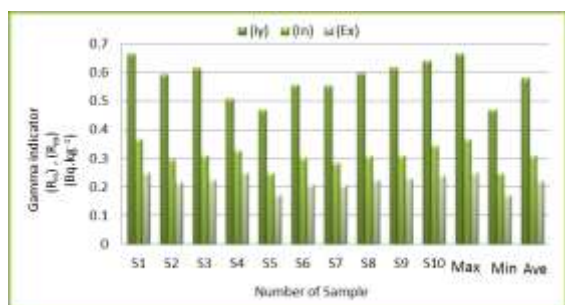
**Fig. 4: The specific activity of the radionuclide ( $^{40}\text{K}$ ).**

Table (2) summarize the radium equivalent which obtained by using equation 2, the results show that the value of Radium equivalent ( $R_{\text{eq}}$ ) in soil samples ranging ( $S5 = 63.96$  to  $S1 = 92.27 \text{ Bq.kg}^{-1}$ ), and the total activity of radium ( $82.29 \text{ Bq.kg}^{-1}$ ) as shown in figure (5). The present study results affirm that the activity rate of radium equivalent for the selected regions is less than the international standards of activity equivalent of radium ( $370 \text{ Bq.kg}^{-1}$ ).

Table (3) shows that the gamma indicator ( $I_\gamma$ ) in soil samples in the range ( $S5 = 0.47$  to  $S1 = 0.67$ )  $\text{Bq.kg}^{-1}$ , and the total rate value is ( $0.5823$ ) as illustrated in figure (6). The obtained results remark that the activity concentration parameter in region to be less than the world average ( $0.8$ ) [16,17]. The lower and higher values for internal risk indicator ( $R_{\text{in}}$ ) in soil samples are ( $S5 = 0.25$  up to  $S1 = 0.367$ ) and total activity ( $0.30955$ ) as shown in figure (6), the rate of internal risk indicator ( $R_{\text{in}}$ ) in the regions found to be less than the international standards of unity [16,17]. The lower and higher values for external risk indicator ( $R_{\text{ex}}$ ) in soil samples are ( $S5 = 0.173$  up to  $S1 = 0.249$ ) and the overall rate ( $0.2221$ ) as shown in figure (6). The rate of external risk indicator in regions considered less than the international standards acceptable value of unity [16,17].

Table (3): The measured radiation parameters.

| Number of Samples                  | (Bq.kg <sup>-1</sup> ) |                   |                |           | (D <sub>γ</sub> )<br>(nGy.h <sup>-1</sup> ) | Annual Effective Dose<br>(mSv.y <sup>-1</sup> ) |           |
|------------------------------------|------------------------|-------------------|----------------|-----------|---------------------------------------------|-------------------------------------------------|-----------|
|                                    | (Ra <sub>eq</sub> )    | (I <sub>γ</sub> ) | Risk Indicator |           |                                             | AEDE                                            |           |
|                                    |                        |                   | In             | Ex        |                                             | In                                              | Out       |
| S1                                 | 92.272                 | 0.666             | 0.366280       | 0.249254  | 43.185                                      | 0.220033                                        | 0.052963  |
| S2                                 | 80.494                 | 0.593             | 0.296605       | 0.217415  | 38.023                                      | 0.186526                                        | 0.046631  |
| S3                                 | 83.377                 | 0.615             | 0.310611       | 0.225206  | 39.470                                      | 0.193622                                        | 0.048405  |
| S4                                 | 92.759                 | 0.509             | 0.327286       | 0.250529  | 43.183                                      | 0.211836                                        | 0.052958  |
| S5                                 | 63.966                 | 0.469             | 0.247378       | 0.172784  | 30.332                                      | 0.148797                                        | 0.037199  |
| S6                                 | 77.207                 | 0.557             | 0.303150       | 0.208556  | 36.062                                      | 0.176906                                        | 0.044219  |
| S7                                 | 76.225                 | 0.555             | 0.284267       | 0.205888  | 35.599                                      | 0.174633                                        | 0.043658  |
| S8                                 | 82.843                 | 0.599             | 0.307547       | 0.223763  | 38.376                                      | 0.188257                                        | 0.047064  |
| S9                                 | 84.676                 | 0.619             | 0.308444       | 0.228708  | 39.522                                      | 0.193879                                        | 0.048470  |
| S10                                | 89.108                 | 0.641             | 0.343941       | 0.240697  | 41.298                                      | 0.202592                                        | 0.050648  |
| Max                                | 92.759                 | 0.666             | 0.366280       | 0.249254  | 43.185                                      | 0.220033                                        | 0.052963  |
| Min                                | 63.966                 | 0.469             | 0.247378       | 0.172784  | 30.332                                      | 0.148797                                        | 0.037199  |
| Ave                                | 82.2927                | 0.5823            | 0.3095509      | 0.2221142 | 38.505                                      | 0.1897081                                       | 0.0472215 |
| International standards<br>[16,17] | 370                    | 0.8               | 1              | 1         | 55                                          | 0.45                                            | 0.07      |

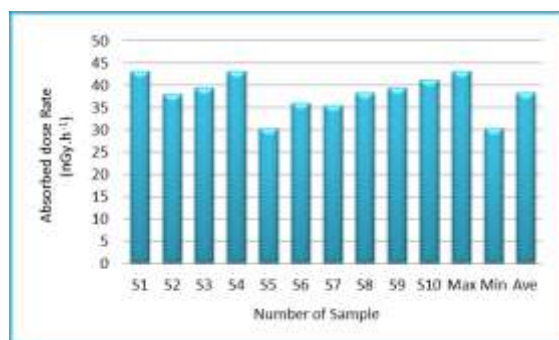
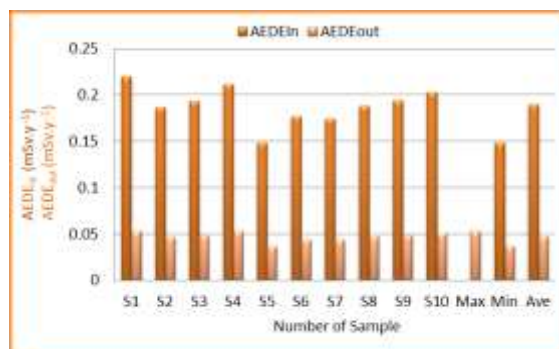
Fig. 5: The radium equivalent activity Ra<sub>eq</sub> (Bq.kg<sup>-1</sup>) in the samples.Fig. 6: The gamma indicator I<sub>γ</sub>(Bq.kg<sup>-1</sup>) and the internal (R<sub>in</sub>) and external (R<sub>ex</sub>) risk indicator in the samples.

The results of Calculated absorbed dose rate in air (D<sub>γ</sub>) of the soil samples are shown in table (3) are ranged between (S5 = 30.33 to S1 = 43.18) nGy.h<sup>-1</sup>, and the overall rate (38.505) nGy.h<sup>-1</sup> as shown in figure (7). The results of the current study for the average absorbed dose rate is more less than the universal average dose rate value which is equals to (55) nGy.h<sup>-1</sup> [16,17].

The Annual Effective Dose Equivalent rate (AEDE<sub>in</sub>) views that values for internal measured in (nGy.h<sup>-1</sup>) for soil samples ranging (S5 = 0.15 to S1 = 0.22) nGy.h<sup>-1</sup> and the total rate is (0.189 nGy.h<sup>-1</sup>) as shown in figure (8). The current results maintain that

the average annual effective dose of internal exposure in the regions found to be less than the international standards of (0.45 nGy.h<sup>-1</sup>).

The annual effective dose rate of external exposure (AEDE<sub>out</sub>) in soil samples are obtained by application the equation (8), the values ranging from (S5 = 0.037 to S1 = 0.053) mSv.y<sup>-1</sup> and with rated value equals to (0.047) mSv.y<sup>-1</sup> as shown in figure (8). The results of the current study that the outdoor annual effective dose rate is less than the universal standards acceptable value (0.07) mSv.y<sup>-1</sup> [16,17].

Fig. 7: Absorbed dose in air (nGy.h<sup>-1</sup>) in the soil sample.Fig. 8: Internal annual effective dose equivalent (mSv.y<sup>-1</sup>) AEDE<sub>in</sub>, external annual effective dose equivalent (mSv.y<sup>-1</sup>) AEDE<sub>out</sub> in the soil sample.

## Conclusion

The survey of the all results like activity concentration indicator ( $I_\gamma$ ), internal risk indicator ( $R_{in}$ ), external risk indicator  $R_{out}$ , the values of absorbed dose in air ( $D_\gamma$ )  $nGy.kg^{-1}$ , internal annual effective dose equivalent ( $AEDE_{in}$ ), external annual effective dose equivalent ( $AEDE_{out}$ ), of the soil samples containing  $^{226}Ra$ ,  $^{232}Th$  and  $^{40}K$ , are acceptable result as well as the elements  $^{232}Th$  and

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## تقييم تراكيز النويدات المشعة، معاملات الخطورة والجرعة السنوية في ترب مناطق سكنية وزراعية لمدينة كركوك

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### الملخص

إن الهدف من الدراسة الحالية هو قياس الفعالية الإشعاعية النوعية وحساب معاملات الخطورة والجرعة السنوية في نماذج الترب المنتخبة لمناطق سكنية وزراعية لمحافظة كركوك باستخدام التقنية الطيفية لكاشف الجرمانيوم عالي النقاوة (HPGe). حيث تم جمع عشرة عينات بعمق (20) سنتيمتر من التربة لتلك المناطق. بينت الدراسة الحالية أن نتائج النشاط الإشعاعي لنظائر الراديوم  $^{226}\text{Ra}$  والاكنتيوم  $^{228}\text{Ac}$  والبوتاسيوم  $^{40}\text{K}$  في هذه العينات تتراوح  $(27.6 \pm 4.1 - 43.3 \pm 5.4)$  بيكرل/كغم بمعدل  $(32.86 \pm 4.95)$  بيكرل/كغم و  $(12.4 \pm 0.8 - 28.12 \pm 4.2)$  بيكرل/كغم بمعدل  $(20.492 \pm 2.77)$  بيكرل/كغم و  $(225 \pm 9.2 - 327 \pm 12.1)$  بيكرل/كغم بمعدل  $(268.76 \pm 9.06)$  بيكرل/كغم على التوالي. مكافئ الراديوم  $\text{Ra}_{\text{eq}}$  كان  $(63.966 - 92.759)$  بيكرل/كغم ومعامل تركيز الفعالية الإشعاعية ( $I_\gamma$ ) يبلغ  $(0.469 - 0.666)$  بيكرل/كغم، معاملات الخطورة الداخلية والخارجية بلغت  $(0.247378 - 0.366280)$  بيكرل/كغم و  $(0.172784 - 0.249254)$  بيكرل/كغم على التوالي، قيم الجرعة الممتصة بواسطة الهواء ( $D_\gamma$ )  $(30.332 - 43.185)$  نانوغري/ساعة، بينما الجرعة الفعالة الداخلية والخارجية السنوية بلغت  $(0.148797 - 0.220033)$  ملي سيفرت/سنة و  $(0.037199 - 0.052963)$  ملي سيفرت/سنة على التوالي. تُظهر مقارنة النتائج الحالية توافقاً جيداً مع القيم القياسية المقبولة ولم تتعدى القيم المسموحة لمنظمة الصحة العالمية (WHO) ولا توجد تأثيرات سلبية لهذه المعاملات على الصحة والبيئة والزراعة.