Assessment excess lifetime cancer risk of soils samples in Maysan neighborhood adjacent to the middle Euphrates cancer center in Najaf / Iraq

(1)Hiba Ghmeedh Adhab, (2)Shaymaa Awad Kadhim alshebly, (3)Dr. Emad Kareem Alsabari
Medical physics/ Ministry of Education / Najaf-Iraq(1)
University of Kufa/ Faculty of Science/ Physics Department/ Najaf- Iraq(2)
College of medicine/university of kufa / Middle Euphrates Center Cancer(3)
Email: nooralardhy@gmail.com
shaymaa.alshebly@uokufa.edu.iq

Abstract:
In this study, 30 samples of soils were taken from in Maysan neighborhood adjacent to the middle Euphrates cancer center in Najaf / Iraq, gamma-ray spectrometer system connected with the NaI detector was used to measure the specific activity of the ($^{238}$U, $^{232}$Th, $^{40}$K) nuclei, the specific activity values were varied from ($1.41\pm0.71$ Bq/kg) to ($30.95\pm0.74$ Bq/kg) with an average value ($10.03\pm 1.04$) for $^{226}$Ra, for $^{232}$Th from ($0.71\pm0.27$) to ($15.44\pm0.30$ Bq/kg) with an average value ($4.96\pm0.37$), The measurements of the specific activity of the $^{40}$K varied from ($92.77\pm1.95$ to $589.77\pm3.18$ Bq/kg with an average value ($198.43\pm3.13$).
Radium equivalent activity, outdoor and indoor absorbed doses, the Outdoor, Indoor and total annual effective dose equivalent (AEDE), external and internal hazard index (H_{ex}, H_{in}) in the range of ($32.415\pm1.817$(Bq/kg)), ($20.936\pm1.075$(nGy/h)), ($0.019\pm0.001014$(mSv/year)), ($0.121\pm0.0061$(mSv/year)), ($0.087\pm0.004$), ($0.114\pm0.007$ respectively , Representative level index $I_{\gamma}$ and excess lifetime cancer risk (ELCR), Representative Alpha index ($I_{\alpha}$) and annual gonadal dose rate (AGDE) were calculated with range, ($0.248\pm0.012$(Bq kg-1)), ($0.423*10^{-3}$), ($0.052$(Bq/Kg)), ($119.404$( mSv/y)) respectively. These results were compared with recommended values ($370$ Bq/kg) for Ra_{eq}, 59 nGy/h for D_{out}, 84 nGy/h for D_{in}, 0.07 mSv/year for D_{eff_{out}}, 0.41 mSv/year for D_{eff_{in}}, 0.48 mSv/year for D_{eff_{tot}}, $\leq 1$ for H_{ex} and H_{in}, $<1$ for $I_{\gamma}$, $<1$ for $I_{\alpha}$, $300$ μSv/y for AGDE by UNSCEAR International Commission on Radiological Protection (ICRP) and European Commission (EC), and Their values were less than the permissible limits except for one sample out of 30 samples have specific activity values of...
40K, Annual Gonadal Equivalent Dose (AGED) in sample (S6) higher than the worldwide average value (412 Bq/kg) and (300 µSv/y) recommended by the UNSCEAR, besides, the value of ELCR was lower than the world permissible value of 1.45×10⁻³ (UNSCEAR, 2000). As a result, health hazards originated by natural radiation from soil samples in this region is low and insignificant.

Keywords: soil, radiological hazards, Gamma spectroscopy, radioactivity, Najaf Governorate.

1. Introduction

The world's population interacts with radioactivity on a daily basis, and it is a part of our lives. Radiation in our environment comes by naturally occurring radioactive materials, Cosmic, Terrestrial and Internal Radiation are main natural source of external exposure to radiation, uranium (238U) with half-life of 4.5×10⁹ years, thorium (232Th) with half-life 1.405×10¹⁰ years, and potassium (40K) with half-life of 1.25×10⁹ years considered as[1], the essential sources of Natural radioactivity to which humans are exposed to significant amounts from it usually, which are found naturally in the soils, water, air and also building materials known as terrestrial radiation, ⁴⁰K is one of the natural radioisotopes that contribute to the largest part of the radiation dose for people and is considered an essential element in the cellular composition of muscle cells in the human body[2]. The other factor of Natural radioactivity is high-energy cosmic rays coming from the sun into the atmosphere or man-made radioactive products such as radioisotopes used in industry, medicine and agriculture, nuclear power plants and as well as nuclear reactors[3]. The concentration of radionuclides in the earth's crust is the primary factor in determining the level of radiation around the world. Uranium, thorium, and decay products are radionuclides that pose a potential risk to human health due to the emission of ionizing radiation. It is important to study the distribution, properties of radionuclides and their effect on the environment. Similar studies have been carried out in many parts of the world to investigate any changes and to assess the health risks posed by radioactivity [4-10]. This study is devoted to reporting the activity concentration levels of both natural radionuclides (238 U, 232 Th, 40 K) in soil samples collected from different sites of Maysan neighborhood adjacent to the middle Euphrates cancer center in Najaf / Iraq. To our knowledge, An investigation of radionuclide activity levels and distributed in the soil of this region has not been performed yet. Therefore, this study is very important, to investigate whether the area is appropriate for healthy living for humans, estimating the relationship between radionuclides in the environment and determine the amount of radiation doses as well as the biological impact on humans from environmental source.

2. Materials and methods

2.1. Study area

The study area was determined in Maysan neighborhood adjacent to the middle Euphrates cancer center in Najaf / Iraq, was located in the Northeast part of the city of AL- Najaf province and North of the city of Kufa. located astronomically along a longitude 44°21 East and at a width of 32°03 North. Given the importance of this region and its population density And its proximity to the middle Euphrates cancer center, it was chosen to study the levels of radioactivity.
2.2. Sample collection and preparation

The soil samples were collected from 60 different locations, 30 samples were taken for this study during the summer season in September and October of 2019. as shown in Figure 2, The soil samples were taken randomly From unpaved dirt areas due to the large number of buildings and paved streets into the area, Most of the soil samples were taken from the area surrounding the middle Euphrates cancer center adjacent to Maysan neighborhood AL- Najaf province, they are the most accurate and important in this study. The collection procedures were as follows: for each sample, the soil position was determined and the ground was cleared of stones, pebbles, vegetation, and roots, and any other biological materials. 1kg of soil was taken at depths of 15-20 cm below the soil surface. The removal and collection of the soil was done with a steel shovel. Samples were then placed in plastic bags, numbered and the relevant information noted in a notebook ( date of sample, original location, sample number). The sample bags then transported to the laboratory of the physics department of the Faculty of Science, University of Kufa for further processing and preparation procedures activity measurements.
Figure (2): Map of Maysan showing the sample collection locations.

The Global Positioning System (GPS) was used to locate the sampling points as shown in Table 1, which shows the locations of samples coordinate for latitude and longitude.

Table (1): samples coordinate for latitude and longitude.

| Sample code | Geographical position |
|-------------|-----------------------|
|             | Latitude | Longitude |
| S1          | 32°02'50.4"N | 44°21'23.3"E |
| S2          | 32°03'45.1"N | 44°20'56.7"E |
| S3          | 32°03'29.8"N | 44°22'02.0"E |
| S4          | 32°03'33.5"N | 44°21'09.5"E |
| S5          | 32°03'35.6"N | 44°21'59.1"E |
| S6          | 32°03'31.3"N | 44°21'16.3"E |
| S7          | 32°03'25.8"N | 44°21'06.3"E |
| S8          | 32°03'13.5"N | 44°21'12.0"E |
| S9          | 32°02'49.8"N | 44°22'25.2"E |
| S10         | 32°02'44.7"N | 44°21'26.0"E |
| S11         | 32°03'52.5"N | 44°21'06.4"E |
S12 | 32°02'44.9"N | 44°22'16.3"E  
S13 | 32°03'08.9"N | 44°22'18.3"E  
S14 | 32°02'53.1"N | 44°21'34.6"E  
S15 | 32°03'04.7"N | 44°21'27.9"E  
S16 | 32°03'43.5"N | 44°21'55.3"E  
S17 | 32°02'34.1"N | 44°21'45.2"E  
S18 | 32°03'26.1"N | 44°21'20.5"E  
S19 | 32°03'01.9"N | 44°21'32.6"E  
S20 | 32°02'36.9"N | 44°21'41.7"E  
S21 | 32°02'32.2"N | 44°21'45.2"E  
S22 | 32°02'32.0"N | 44°21'46.8"E  
S23 | 32°02'59.6"N | 44°21'31.1"E  
S24 | 32°02'31.2"N | 44°21'40.3"E  
S25 | 32°02'28.2"N | 44°21'48.4"E  
S26 | 32°02'30.2"N | 44°21'54.3"E  
S27 | 32°02'34.3"N | 44°21'52.3"E  
S28 | 32°02'53.7"N | 44°22'26.5"E  
S29 | 32°04'01.4"N | 44°21'24.4"E  
S30 | 32°02'56.5"N | 44°22'33.8"E  

The samples were prepared for measurement after dried under the heat using the oven at 80° C for 1 day, to obtain a constant weight, dried samples were grinded and passed in (800μm) stainless steel mesh sieve to achieve homogeneity and a high-quality sample was obtained. earlier the real weights of the soil samples were measured by subtracting the weight of the cup and by using a digital weighing balance, the samples were packed into (1-liter) polyethylene Marinelli beaker to obtain a geometric homogeneity around the detector and sealed tightly[11, 12]. To reach secular equilibrium before performing radioactivity measurements, the samples were stored for about 1 month. Soil samples were analyzed to measure the radioactivity of natural radioactive nuclei by using an Ortec- digiBASE gamma-ray spectrometer based on the 3" × 3" NaI detector with 6.8% energy resolution at 662 keV for $^{137}$Cs. The ScintiVision$^{TM}$-32
software was installed in the computer for data analysis, and the energy and efficiency of the system were calibrated. That cycle of counting was carried out for 4 hours per sample. At the same time, an empty Marinelli was used to calculate the mean background radiation[13].

The values of energies 1460 keV for $^{40}$K, 1764 keV for $^{214}$Bi and 2614 keV for $^{208}$Tl were adopted to measure the radioactivity for the $^{40}$K, $^{226}$Ra and $^{232}$Th nuclei respectively.

3. Calculations

For each isotope, the specific activity in Bq/kg units was calculated by using the equation (1) [13].

$$\mathcal{A}_n = \frac{(C_n - C_b)}{\varepsilon \lambda \gamma m_s} \quad \ldots(1)$$

where $\mathcal{A}_n$ is the specific activity of each radionuclide in Bq/kg, $C_n$ the count rate in cps for a sample, $C_b$ the count rate in cps for background, $\varepsilon$ and $\lambda$ are detection efficiency and representative level index, $\gamma$ is the counting time and $m_s$ is the mass of the sample in kg.

The distribution of $^{226}$Ra, $^{232}$Th and $^{40}$K, nuclei in soil are not uniform, so a common factor was used to compare its combined radiological effects. This factor is called the Radium equivalent activity ($\mathcal{R}_{aeq}$). The permissible Radium equivalent activity values for safe use should be less than 370 Bq/kg, as recommended by the UNSCEAR (2000) report. Equation (2) was used to calculate the radium equivalent activity ($\mathcal{R}_{aeq}$) [14].

$$\mathcal{R}_{aeq} = \mathcal{A}_{Ra} + 1.43\mathcal{A}_{Th} + 0.077\mathcal{A}_K \quad \ldots(2)$$

Where $\mathcal{A}_{Ra}$, $\mathcal{A}_{Th}$ and $\mathcal{A}_K$ are the specific activity of $^{226}$Ra, $^{232}$Th, and $^{40}$K respectively.

Equation (3) was used to calculate the outdoor dose ($D_{out}$), and the average value is (59 nGy/h) as recommended by the UNSCEAR (2000) report [15].

$$D_{out} = 0.427\mathcal{A}_{Ra} + 0.662\mathcal{A}_{Th} + 0.043\mathcal{A}_K \ (\text{nGy/h}) \quad \ldots(3)$$

While the indoor absorbed dose rate for soil samples was calculated by using equation (4),

$$D_{in} = 0.92\mathcal{A}_{Ra} + 1.1\mathcal{A}_{Th} + 0.08\mathcal{A}_K \ (\text{nGy/h}) \quad \ldots(4)$$

the recommended value of indoor absorbed dose rate is 84 nGy/h.

The Outdoor and Indoor annual effective doses have been obtained by using equation (5) and (6). Total annual effective dose equivalent (mSv/year) was calculated by using equation (7) [16]:

$$D_{eff\ Outdoor} (\text{mSv/yr}) = \text{Absorbed Dose} (D_{out}) (\text{nGy/h}) \times 8760 \ h/\text{y} \times 0.2 \times 0.7 \text{ Sv/Gy} \times 10^{-6} \quad \ldots(5)$$

$$D_{eff\ Indoor} (\text{mSv/yr}) = \text{Absorbed Dose} (D_{in}) (\text{nGy/h}) \times 8760 \ h/\text{y} \times 0.8 \times 0.7 \text{ Sv/Gy} \times 10^{-6} \quad \ldots(6)$$

Where:

$$D_{eff\ tot} (\text{mSv/yr}) = D_{eff\ Outdoor} + D_{eff\ Indoor} \quad \ldots(7)$$

the world average value is 0.48 mSv, of which 0.41 mSv comes from indoor and 0.07 mSv from outdoor[14].

The external ($H_{ex}$) and internal ($H_{in}$) hazard indices were calculated using Equations (8) and (9) [17].
If the calculated values of indices are greater than unity, Radioactivity may cause harm to the population.

Representative level index for soil samples \((I_\gamma)\) was calculated from the equation \((10)\) [18]:

\[
I_\gamma = \frac{1}{150} A^{226}_{Ra} + \frac{1}{100} A^{232}_{Th} + \frac{1}{1500} A^{40}_{K}
\]  

…(10)

Representative Alpha index \((I_\alpha)\): The excess Alpha radiation due to the Radon inhalation originating from the soil samples, must be little than one. Alpha index \((I_\alpha)\) was calculated as follow \([19]\):

\[
I_\alpha = \frac{A_{Ra}}{200}
\]  

…(11)

Also in this research we wanted an account, Annual Gonadal Equivalent Dose \((AGED)\), the gonads, the bone marrow and the bone surface cells are considered as organs of one of the important things that UNSCEAR has attached great importance because of their sensitivity to radiation. An increase in \((AGED)\) has been known to affect the bone marrow, causing destruction of the red blood cells that are then replaced by white blood cells. The equivalent annual dose of gonads \((AGED)\) from \((A_{Ra}, A_{Th}, A_{K})\) activity concentrations of \(^{226}Ra, ^{232}Th\) and \(^{40}K\), respectively then we can calculate annual gonadal equivalent dose [20].

To calculate the excess lifetime cancer risk due to gamma-ray radiation from the equation \((11)\) was used [21]:

\[
ELCR = AEDE \times LS \times RF
\]  

where \(AEDE\) (mSv/year) is the total of Annual Effective Dose Equivalent \((AEDE_{outdoor} + AEDE_{indoor})\). LS is a mean life span (approximately 70 years), and RF is the risk factor \((1/Sv)\), which reflects the fatal cancer risk per Sievert. ICRP(International Commission on Radiological Protection) uses values of 0.05 For stochastic impacts.

4. Results and Discussion

The specific activity values calculated for the 30 soil samples were listed in Table 2 besides the Radium equivalent activity of soil samples.

| Table (2). Specific activity, Radium equivalent activity of soil samples. |
|---|---|---|---|
| ID | Specific Activity \((Bq/kg)\) | Ra\text{\_eq} \((Bq/kg)\) |
|---|---|---|
| | \(^{238}U\) | \(^{232}Th\) | \(^{40}K\) |
| S1 | 4.18±0.81 | 1.71±0.27 | 123.43±2.37 | 16.121±1.379 |
| S2 | 1.41±0.71 | 3.83±0.26 | 145.43±2.23 | 18.082±1.253 |
| S3 | 3.67±0.97 | 1.31±0.34 | 173.29±2.37 | 18.883±1.633 |
| S4 | 6.89±0.70 | 0.71±0.27 | 92.77±1.95 | 15.052±1.234 |
| S5 | 3.32±0.97 | 2.93±0.27 | 183.37±2.52 | 21.629±1.547 |
| S6 | 30.95±0.74 | 15.44±0.30 | 589.77±3.18 | 98.438±1.412 |
| S7 | 6.64±0.71 | 4.12±0.27 | 200.34±2.43 | 27.959±1.285 |
| S8 | 12.13±1.07 | 4.35±0.32 | 208.22±2.90 | 34.388±1.741 |
|   |   |   |   |   |
|---|---|---|---|---|
| S9 | 6.65±0.91 | 6.15±0.29 | 204.91±2.42 | 31.225±1.507 |
| S10 | 10.35±1.44 | 2.82±0.47 | 160.59±3.53 | 26.753±2.389 |
| S11 | 18.06±0.64 | 11.05±0.25 | 408.23±2.97 | 65.295±1.223 |
| S12 | 8.70±1.48 | 3.00±0.52 | 163.85±4.06 | 25.611±2.533 |
| S13 | 2.58±1.42 | 2.77±0.38 | 176.76±3.82 | 20.14±2.253 |
| S14 | 17.96±0.80 | 6.08±0.24 | 161.91±2.33 | 39.11±1.322 |
| S15 | 6.28±0.88 | 4.47±0.33 | 217.90±2.87 | 29.44±1.578 |
| S16 | 8.88±1.27 | 1.59±0.53 | 116.09±3.44 | 20.09±2.294 |
| S17 | 1.60±1.60 | 2.46±0.42 | 158.85±3.82 | 17.34±2.498 |
| S18 | 21.57±0.78 | 9.95±0.26 | 292.63±2.83 | 58.33±1.371 |
| S19 | 11.95±0.68 | 9.81±0.25 | 284.74±2.60 | 47.90±1.245 |
| S20 | 8.29±1.21 | 1.81±0.40 | 144.45±3.47 | 22.00±2.053 |
| S21 | 6.87±1.48 | 3.30±0.38 | 173.91±3.61 | 24.97±2.296 |
| S22 | 9.77±1.33 | 3.72±0.42 | 119.11±3.16 | 24.25±2.181 |
| S23 | 21.27±0.68 | 10.92±0.28 | 273.96±2.85 | 57.98±1.297 |
| S24 | 5.33±1.45 | 5.07±0.55 | 165.59±4.03 | 25.33±2.551 |
| S25 | 14.92±1.12 | 4.57±0.47 | 113.87±4.23 | 30.21±2.124 |
| S26 | 9.92±0.71 | 3.55±0.52 | 115.71±3.30 | 23.90±1.704 |
| S27 | 6.66±1.39 | 3.13±0.42 | 135.88±2.74 | 21.59±2.208 |
| S28 | 17.94±1.21 | 7.24±0.55 | 178.70±4.34 | 42.04±2.338 |
| S29 | 5.80±0.92 | 5.11±0.40 | 205.74±3.47 | 28.94±1.757 |
| S30 | 10.57±1.27 | 5.97±0.51 | 262.97±4.16 | 39.35±2.317 |
| Min. | 1.41±0.71 | 0.71±0.27 | 92.77±1.95 | 15.05±1.234 |
| Max. | 30.95±0.74 | 15.44±0.30 | 589.77±3.18 | 98.43±1.412 |
| Ave. | 10.03±1.04 | 4.96±0.37 | 198.43±3.13 | 32.415±1.817 |

World average\[14, 15\]

|   |   |   |   |
|---|---|---|---|
|   | 35 | 45 | 412 | 370 |
Figure (3). The specific activity of natural radionuclides in soils sample.

Figure (4). Distribution of specific activity and radium equivalent activity in study samples.
From Table(2) and figure (3) we can see that the values of $^{226}$Ra specific activity for the soil samples in this study ranged between the minimum and maximum values. The lowest value was recorded in sample S2, which was $(1.41\pm0.71$Bq/kg), The maximum value of a specific uranium activity was recorded in sample S6, which was $(30.95\pm0.74$ Bq/kg) with an average value$(10.03\pm 1.04)$. For $^{232}$Th from $(0.71\pm0.27)$ to $(15.44\pm0.30$ Bq/kg) with an average value $(4.96\pm0.37)$.

In this study, all specific activity values of soil samples measured for uranium and thorium nuclei were significantly lower than the worldwide average (35 Bq/kg for $^{226}$Ra and 45 B/q for $^{232}$Th) recommended by UNSCAER 2000.

The measurements of the specific activity of the $^{40}$K varied from $92.77\pm1.95$ to $589.77\pm3.18$ Bq/kg with an average value $(198.43\pm3.13)$, where the minimum and maximum value of $^{232}$Th and $^{40}$K was found in sample S4 and sample S6 respectively.

Only one sample out of 30 samples has specific activity values of $^{40}$K higher than the worldwide average value (412 Bq/kg) recommended by the( UNSCAER2000), The other values were below the worldwide average.

Specific activity values showed that there was only a significant increase in $^{40}$K concentrations, also Figure (3) and (4) shows that the specific activity resulting from the decay of the uranium chain ($^{226}$Ra) is higher than the specific activity of the thorium chain ($^{232}$Th).

Values of $\text{Ra}_{eq}$ were also calculated and oscillates between $15.052\pm1.234$ Bq/kg to $98.438\pm1.412$ Bq/kg with an average of $32.415\pm1.817$ Bq/kg, the minimum value was found in sample S4 and the maximum value was found in sample S6 as shown in Table(2). It is observed that the values of $\text{Ra}_{eq}$ in thirty samples were less than the acceptable safe limit of 370 Bq/kg.

Table(3). Outdoor and indoor absorbed dose, Outdoor and indoor Annual effective dose, and Total annual effective dose equivalent for studies soil samples.

| ID  | Outdoor absorbed dose (nGy/h) | Indoor absorbed dose (nGy/h) | Outdoor annual effective dose equivalent (mSv/y) | Indoor annual effective dose equivalent (mSv/y) | Total annual effective dose equivalent (mSv/y) |
|-----|-----------------------------|-----------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| S1  | $8.220\pm0.627$             | $10.686\pm0.815$            | $0.010\pm0.00076$                              | $0.052\pm0.0039$                              | $0.062\pm0.0046$                              |
| S2  | $9.390\pm0.571$             | $12.207\pm0.742$            | $0.011\pm0.00070$                              | $0.059\pm0.0036$                              | $0.07\pm0.0043$                               |
| S3  | $9.884\pm0.738$             | $12.849\pm0.960$            | $0.012\pm0.00090$                              | $0.063\pm0.0047$                              | $0.075\pm0.0056$                              |
| S4  | $7.403\pm0.560$             | $9.624\pm0.728$             | $0.009\pm0.00068$                              | $0.047\pm0.0035$                              | $0.056\pm0.0041$                              |
| S5  | $11.241\pm0.700$            | $14.614\pm0.910$            | $0.013\pm0.00085$                              | $0.071\pm0.0044$                              | $0.084\pm0.0052$                              |
| S6  | $48.795\pm0.650$            | $63.434\pm0.845$            | $0.059\pm0.00079$                              | $0.311\pm0.0041$                              | $0.37\pm0.0048$                               |
| S7  | $14.178\pm0.587$            | $18.431\pm0.763$            | $0.017\pm0.00072$                              | $0.090\pm0.0037$                              | $0.107\pm0.0044$                              |
| S8  | $17.014\pm0.789$            | $22.119\pm1.025$            | $0.020\pm0.00096$                              | $0.108\pm0.0050$                              | $0.128\pm0.0059$                              |
| S9  | $15.723\pm0.682$            | $20.440\pm0.887$            | $0.019\pm0.00083$                              | $0.100\pm0.0043$                              | $0.119\pm0.0051$                              |
| S10 | $13.194\pm1.080$            | $17.152\pm1.404$            | $0.016\pm0.00132$                              | $0.084\pm0.0068$                              | $0.1\pm0.0081$                                |
| S11 | $32.580\pm0.565$            | $42.355\pm0.734$            | $0.039\pm0.00069$                              | $0.207\pm0.0036$                              | $0.246\pm0.0042$                              |
| S12 | $12.748\pm1.149$            | $16.573\pm1.494$            | $0.015\pm0.00141$                              | $0.081\pm0.0073$                              | $0.096\pm0.0087$                              |
| S13 | $10.531\pm1.020$            | $13.690\pm1.326$            | $0.012\pm0.00125$                              | $0.067\pm0.0065$                              | $0.079\pm0.0077$                              |
| S14 | $18.658\pm0.600$            | $24.251\pm0.781$            | $0.022\pm0.00073$                              | $0.113\pm0.0038$                              | $0.14\pm0.0045$                               |
| S15 | $15.009\pm0.720$            | $19.512\pm0.936$            | $0.018\pm0.00088$                              | $0.095\pm0.0045$                              | $0.113\pm0.0053$                              |
The calculated Outdoor absorbed dose (nGy/h) and Indoor absorbed dose (nGy/h) of samples was listed in Table (3). The values ranged from 7.403±0.560 to 48.795±0.650 and 9.624±0.728 to 63.434±0.845 with an average value of 16.104±0.827 nGy/h and 20.936±1.075 nGy/h respectively.

The calculated indoor, outdoor, and total AEDE values are exhibited in Table (3). The calculated values for Deff Out (mSv/year) varied from 0.009±0.00068 to 0.059±0.00079 with an average value 0.019±0.001014, for Deff In (mSv/year) varied from 0.047±0.0035 to 0.311±0.0041 with an average value 0.102±0.0052, Deff tot the Total annual effective dose equivalent (mSv/year) were found to lie in the range of 0.056±0.0041 to 0.37±0.0048 with an average value 0.121±0.0061.

The minimum and maximum value of Dout, Din, Deff_out, Deff_in, Deff_tot was found in sample S4 and S6 respectively. Furthermore, All values for the above coefficients were below the worldwide average as shown in Table (3).

Table (4). External and internal radiation hazards and other radiological parameters for studies of soil samples.

| ID | External radiation hazard, $H_{ext}$ | Internal radiation hazard, $H_{int}$ | Representative level index $I_yr$ (Bq/kg) | Representative Alpha index $I_α$ (Bq/Kg) | Annual Gonadal Equivalent Dose (AGED) $*10^{-3}$ (mSv/yr) |
|----|-------------------------------------|--------------------------------------|------------------------------------------|------------------------------------------|-------------------------------------------------|
| S1 | 0.043±0.003                         | 0.054±0.005                           | 0.127±0.009                              | 0.020887                                 | 58.79623                                         |
| S2 | 0.048±0.003                         | 0.052±0.005                           | 0.144±0.008                              | 0.007033                                 | 66.02452                                         |
| S3 | 0.050±0.004                         | 0.060±0.007                           | 0.153±0.01                              | 0.018329                                 | 71.21888                                         |
| S4 | 0.040±0.003                         | 0.059±0.005                           | 0.114±0.008                              | 0.034456                                 | 53.40061                                         |
| S5 | 0.058±0.004                         | 0.067±0.006                           | 0.173±0.01                              | 0.016624                                 | 80.08404                                         |
| S6 | 0.265±0.003                         | 0.349±0.005                           | 0.753±0.01                              | 0.154731                                 | 345.3532                                         |
| S7 | 0.075±0.003                         | 0.093±0.005                           | 0.219±0.009                              | 0.033177                                 | 100.6507                                         |
While the internal and external hazard index $(H_{int}, H_{ext})$ was calculated and varies from $0.051\pm0.01$ in samples (4) to $0.349\pm0.005$ in samples (6) and $0.040\pm0.003$ in samples (4) to $0.265\pm0.003$ in samples (6), with an average of $0.114\pm0.007$ and $0.087\pm0.004$ respectively, all of them are less than unity (the permissibility value).

The representative level index $I_{\gamma r}$ of soil samples are calculated and listed in Table (4). The minimum value is $0.114\pm0.008$ Bq/kg noted in the sample (S4) and the maximum value is $0.753\pm0.01$ Bq/kg recorded in sample (S6), with an average value of $0.248\pm0.012$ Bq/kg. All soil samples have $I_{\gamma r}$ value lower than 1 Bq/kg which is due to the low content of $^{238}$U, $^{232}$Th, and $^{40}$K in the samples.

Representative Alpha index $I_{\alpha}$ was also calculated, and found that the lower values of $I_{\alpha}$ in Sample (S2) with values $0.007033$ (Bq.Kg$^{-1}$), but the highest value ranged 0.154731 (Bq.Kg$^{-1}$) in Sample (S6) with an average value of 0.052. It is important to indicate that the gonads has sensibility to radiation exposure, an increase in (AGED) causing negative health problems, so it is appropriate to measure the annual equivalent annual gonad dose (AGED) concentration of $^{226}$Ra, $^{232}$Th and $^{40}$K and found its minimum value equals 53.401 (mSv.y$^{-1}$) in samples (S4) while the maximum value 345.353 (mSv.y$^{-1}$) in samples (S6) with an average value of 119.404 (mSv.y$^{-1}$), from this

|     |     |     |     |     |
|----|----|----|----|----|
| S8 | 0.092±0.004 | 0.125±0.007 | 0.263±0.01 | 0.060671 | 121.0607 |
| S9 | 0.084±0.004 | 0.102±0.006 | 0.242±0.01 | 0.033248 | 110.6060 |
| S10 | 0.072±0.006 | 0.100±0.01 | 0.204±0.01 | 0.051743 | 94.21168 |
| S11 | 0.176±0.003 | 0.225±0.005 | 0.503±0.008 | 0.090296 | 230.1803 |
| S12 | 0.069±0.006 | 0.092±0.01 | 0.197±0.01 | 0.043514 | 90.88628 |
| S13 | 0.054±0.006 | 0.061±0.009 | 0.162±0.01 | 0.012877 | 75.02248 |
| S14 | 0.105±0.003 | 0.154±0.005 | 0.288±0.009 | 0.089798 | 131.7458 |
| S15 | 0.079±0.004 | 0.096±0.006 | 0.231±0.01 | 0.031401 | 106.5071 |
| S16 | 0.054±0.006 | 0.078±0.009 | 0.152±0.01 | 0.044402 | 70.53566 |
| S17 | 0.046±0.006 | 0.051±0.01 | 0.141±0.01 | 0.007992 | 65.10155 |
| S18 | 0.157±0.003 | 0.215±0.005 | 0.438±0.009 | 0.107843 | 200.1455 |
| S19 | 0.129±0.003 | 0.161±0.005 | 0.367±0.008 | 0.059747 | 167.3523 |
| S20 | 0.059±0.005 | 0.081±0.008 | 0.169±0.01 | 0.041442 | 78.54466 |
| S21 | 0.067±0.006 | 0.086±0.01 | 0.194±0.01 | 0.034337 | 89.60656 |
| S22 | 0.065±0.005 | 0.091±0.009 | 0.181±0.01 | 0.048842 | 83.13294 |
| S23 | 0.156±0.003 | 0.214±0.005 | 0.433±0.009 | 0.106351 | 197.3979 |
| S24 | 0.068±0.006 | 0.082±0.01 | 0.196±0.01 | 0.026641 | 89.66299 |
| S25 | 0.081±0.005 | 0.121±0.008 | 0.221±0.01 | 0.074595 | 100.9451 |
| S26 | 0.064±0.004 | 0.091±0.006 | 0.178±0.01 | 0.049582 | 81.83349 |
| S27 | 0.058±0.005 | 0.076±0.009 | 0.166±0.01 | 0.033301 | 76.33252 |
| S28 | 0.113±0.006 | 0.162±0.009 | 0.311±0.01 | 0.089692 | 141.8004 |
| S29 | 0.078±0.004 | 0.093±0.007 | 0.226±0.01 | 0.029009 | 103.8829 |
| S30 | 0.106±0.006 | 0.134±0.009 | 0.305±0.01 | 0.052838 | 140.1714 |
| Min. | 0.040±0.003 | 0.051±0.01 | 0.114±0.008 | 0.007033 | 53.401 |
| Max. | 0.265±0.003 | 0.349±0.005 | 0.753±0.01 | 0.154731 | 345.353 |
| Ave. | 0.087±0.004 | 0.114±0.007 | 0.248±0.012 | 0.052 | 119.404 |
| World average [22] | ≤1 | ≤1 | <1 | <1 | 300 |
result, The Representative Alpha index and annual gonad equivalent dose less than the average global value.

The (ELCR) for Outdoor annual effective dose equivalent (mSv/year), ranged from 0.0315*10^{-3} to 0.206*10^{-3} with an average value of 0.066*10^{-3}. For Indoor annual effective dose equivalent (mSv/year) it is from 0.1645*10^{-3} to 1.088*10^{-3} with an average of 0.357*10^{-3}. The total (ELCR) was estimated from 0.196*10^{-3} to 1.295*10^{-3} by using eq.(11) with an average value of 0.423*10^{-3} which is lower compared with the world permissible value of (0.29*10^{-3} for outdoor and 1.16*10^{-3} for indoor and 1.45*10^{-3} for ELCR total) (UNSCEAR,2000).

**Conclusions**

The current study was conducted in order to give baseline data for the natural radioactivity level in the Maysan neighborhood adjacent to the middle Euphrates cancer center in Najaf province. In this paper, The specific activities of 226Ra, 232Th and 40K radionuclides were determined by using gamma-ray spectrometry in soil samples are within the limit proposed by national and international radiation protection agencies, also, the results and average values of radiological hazard indices namely radium equivalent (Ra_{eq}), Outdoor and Indoor absorbed dose(nGy/h), the Outdoor, Indoor and total annual effective dose equivalent (AEDE), external and internal hazard index (Hex, Hin) , Representative Alpha index I_{\alpha} and Representative level index I_{\gamma r} were calculated and found lower when compared to the world mean recommended by UNSCEAR reports. Annual gonadal equivalent dose (AGED) was calculated to evaluate the radiation hazard of natural radioactivity, which mean the average of all samples is safe healthy excepted in sample (S6).

While the excess Lifetime cancer risk (ELCR) was calculated and found equals 0.423*10^{-3}, It was lower than the world permissible value of 1.45*10^{-3} (UNSCEAR,2000) [14, 17]. also, only one sample (S6) has the Specific Activity of 40K greater than the permissible limit. The constant changes in physical and chemical factors, humidity, temperature in the surface layers of the environment over time are a possible reason behind this rising. In addition to the difference in the geological formations of the soil from one location to another. As a result, soils of this region are safe, No harmful radiation effects have been observed for the population living in this region.

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