Calculation of radioactivity levels for various soil samples of Karbala - Najaf road (Ya- Hussein) / Iraq

Shatha F.Alhours¹, Shaymaa Awad Kadhim², Abdulhussein A. Alkufi³, Asmahan Asaad Muhmood⁴, Inass Abdulah Zgair⁵
¹,³ Physics Department/ Faculty of Education for girls/ University of Kufa /Iraq
²,⁴,⁵Department of Physics /Faculty of Science/ University of Kufa /Iraq

E-mail¹: Shathaf.alfatlawi@uokufa.edu.iq
E-mail²: shaymaa.alshebly @uokufa.edu.iq
E-mail³: husseinalkuf@gmail.com

Abstract
Ya- Hussein an outer road that links the governorates of Najaf and Karbala / Iraq , the soil on this road is a sandy desert . The study was conducted to calculate the radioactivity and the risk indicators for this soil, because this study is of great importance due to the contribution of many factors to increasing the concentrations of radionuclides as they are transported through the soil then to humans and endanger their lives. We have estimated ²²⁶Ra, ²³² Th and ⁴⁰ K concentrations in the paper, with their radiological risks in 15 soil sample types gathered from road Ya - Hussein / Iraq, investigated by using gamma ray spectrometry detector NaI (Tl). The result showed the soil sampling concentrations of ²²⁶Ra, ²³² Th, and ⁴⁰ K were there an average among 17.386±1.327 , 15.889±0.556 and 553.269±4.997 with unit ( Bq.kg⁻¹) respectively . Likewise (H_in ; H_ex) hazard indices , total annual effective dose which was below the internationally recommended limits and excess life-time cancer risk (ELCR) were calculated ( 0. 793*10⁻³ ) was lower than the worldwide value. All parameters were statistically studied, and the correlation between the parameters studied was calculated, Pearson's correlation and ( P value ) among the variables .The correlation between gamma index (I_γ) and Alpha index (I_α) was strong, positive and direct ,where it was statistically significant (p-value < 0.05) . The studied area is considered safe and the samples are free from radiation safety threats then the soil does not pose a health risk in this road .Thus this study can be considered as a baseline for future studied on the studied area.

Key Words : soil, radionuclide, hazard index ,annual effective dose, Iraq.

1. Introduction
Humans are either exposed to ionizing radiation from natural sources or of man-made materials all the way through their lives. Hence knowledge of concentrations of radionuclides and emissions of environmental radionuclides are essential for ensure the level and concentration of radiation exposure
at rates which are acceptable[1]. Normal radionuclides exist in all human environments stuff for the earth, water, air, food and even our own body contain radioactive elements which occur naturally. The main sources of ionizing radiation in soil are the long-lived as $^{226}\text{Ra}$, $^{232}\text{Th}$ and $^{40}\text{K}$ and their decay series [2]. Analysis of these radionuclides in soil is an important part of the environmental monitoring program. These natural radioactive sources are the major contributors to the largest contributor of the radiation doses received by humanity [3]. In view of the importance of the topic and its direct effects on human health, many studies were conducted in Najaf and other Iraqi cities, for example Study of concentrations of radionuclides in agricultural soil in the Ghammas region of Iraq using gamma ray spectrometry detector NaI(Tl) [4]. Estimation of concentrations of radionuclides in agricultural soil from different region of Najaf / Iraq [5]. Long-lived gamma-ray measurement in soil samples collected from city central of Al-Diwaniyah, Iraq [6]. In another study, the risk of cancer(ELCR) due to radiation and risk indicators was estimated in Abu Al-Khasib and Al-Dayr in Basrah Governorate, southern Iraq [7]. Natural radioactivity was calculated for forty two soil samples from religious and archaeological sites in Najaf governorate/ Iraq, were measured by using( 3 "x 3") NaI(Tl) detection[8]. Radiation sources make up nearly natural sources of radiation include nearly 80% radiation exposure to world population. Existing radionuclides both natural or manmade, in the ecosystem radionuclides, can be taken by animals and plants and will enter through the food chain into the human body [9]. In general, there are natural radionuclides in the soil and their chains, such as Thorium series and Uranium chain, which affect human health directly or indirectly. The external exposure to the natural radionuclides depends on the geological and geographical conditions of the region and this explains the difference in the concentrations of these radionuclides and their effect in every region of the world[10]. Therefore, measurements of natural radioactivity in soils and radiation doses have most Interest from the researchers who led surveys nationwide around the world. Therefore, as soil, the concentrations must be carefully measured to predict any potential danger to humans. The primary purpose of this study is to determine the natural specific activity, and to estimate the radiation hazard indices namely radium equivalent activity ($R_{aeq}$), representative level index ($I_{r}$), absorbed dose rate ($\text{D}_{in}$, $\text{D}_{out}$), effective dose rate ($\text{D}_{eff}$), external hazard index ($H_{ex}$), internal hazard index ($H_{in}$), Pearson's correlation, P-value and the risk cancer in soil samples in Ya- Hussein road.

2. Methodology

2.1. Study area . Samples were taken from Ya- Hussein road, 15 samples were collected from this road, the starting point from the city of Najaf to north towards Karbala. The distance between one sample and another is 250 meters as shown in figure (1). This road was chosen because of its importance as it is considered a road a major, link between the two cities is usually used as a passage for pedestrian crossing at religious occasions, where people spend about two months each year on this road to perform religious rituals and set up camps so that the citizen is exposed to the soil of the area directly.

2.2. Sample Collection and Preparation . This study was conducted on 15 soil samples collected from Ya - Hussein road Al-Najaf - Karbala / Iraq. To determine the concentration of radionuclides in the soil, samples were immediately brought to the laboratory for preparation and storage of samples. Each sample was passed through a sieve with a mesh to produce particle sizes less than 0.8 mm thus obtaining a homogeneous sample powder with a weight of one kilogram, placing the samples in a tightly closed plastic container, then storing them separately for 30 day to allow a radiative equilibrium between $^{226}\text{Ra}$ and then $^{232}\text{Th}$ and short-lived degradation products[11]. Radionuclides of $^{226}\text{Ra}$, $^{232}\text{Th}$ and $^{40}\text{K}$ were measured in soil samples using a NaI (Tl) gamma ray spectrometer detector.

2.3. Statistical Analysis. Statistical descriptions were performed using SPSS for Windows, standard version 20.0. analysis of the data was carried out by frequency distributions (Pearson
correlation) to assess the statistical significance in all parameters measured in the soil samples.

2.4. Gamma spectrum analysis. The concentration of radioisotopes present in the soil such as and 226Ra, 232Th and 40K were determined using the gamma ray spectroscopy technique on the high ability of this radiation to penetrate different materials. This spectrometer consists of a NaI(Tl) luster detector with crystal dimensions (3’’ x 3’’), supplied by Alpha spectra, Inc.-12112/3, and equipped with a multi-channel analyzer (MCA) (ORTEC-Digi base) with a range of 4096 channel connected to ADC (analog to digital converter), through the interface. Measurements and spectroscopy are calculated using the MAESTRO-32 software on a windows computer.

2.5. Efficiency and Energy Calibrations (ε). The purpose of efficiency calibration is to find a relationship between energy and the maximum peak energy efficiency of gamma ray spectroscopy system, and that was done using standard calibration sources (22Na, 54Mn, 60Co and 137Cs) as shown in figure(2), from the international energy agency where it was used to derive the energy calibration curve and find out the efficacy of the detector NaI (Tl) gamma - ray spectrometer detector with high accuracy and that is absolutely necessary to determine levels of radioactivity in soil samples using the relationship[4]:

\[
\varepsilon = \frac{CPS}{A_t * I_{\gamma}} * 100\% \hspace{1cm} \text{(1)}
\]

Where( CPS ) is counts per second, (\(A_t\)) presents activity of the source, and (\(I_{\gamma}\)) is gamma - ray intensity per decay.

Figure (1) : A map showing the locations of sampling for Ya- Hussein road
3. Calculation Of Concentration of Radionuclide and Hazard Indices

3.1. Concentration of Radionuclides. The radionuclide concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K were calculated in a unit of (Bq kg$^{-1}$) using the equation [12]:

$$A_n = \frac{(C_n - C_b)}{t \varepsilon \gamma I \gamma m_s}$$

where $A_n$: is the specific activity of each radionuclide in (Bq kg$^{-1}$), $C_n$: the count rate in CPS for sample, $C_b$: the count rate in CPS for background, $t$: is the checking time, $\varepsilon \gamma$ and $I \gamma$ are detection efficiency and emission probability of $\gamma$:ray, $m_s$ :is the mass of the sample in (Kg).

3.2. Hazard Indices. the relationship between natural radionuclides Can be determined $^{226}$Ra, $^{232}$ Th and $^{40}$K and the risks resulting from them by a set of indicators. In this study, excess life-time cancer risk (ELCR) and nine hazard indicators were calculated as follows:

3.2.1. The radium equivalent : activity (Ra eq) it is used to describe gamma output from different mixtures of Radium, Thorium and Potassium in substances. It was calculated from the following equation[13]:

$$R_{a eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K$$

Where $A_{Ra}$, $A_{Th}$, $A_K$ are activity concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K, respectively.

3.2.2. The internal ($H_{in}$) and external ($H_{ex}$) hazard indices: there are calculated by equations (4) and (5) [13]:

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

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810}$$
values of ($H_{in}$), ($H_{ex}$)Should be less than unity in order not to pose a threat of the population.

3.2.3. The outdoor dose ($D_{out}$) is calculated from the following equation and the average value is 59 (nGy.h$^{-1}$) as mentioned by the UNSCEAR (2000B) report [14].
$$D_{out} = 0.462A_{Ra} + 0.604A_{Th} + 0.0417A_{K} \ldots \ldots \ldots (6)$$

3.2.4. The indoor absorbed dose ($D_{in}$) for the soil samples is calculated by using formula (7) [14].
$$D_{in} = 0.92A_{Ra} + 1.1A_{Th} + 0.08A_{K} \ldots \ldots \ldots (7)$$
The recommended value of indoor absorbed dose rate is 84 (nGy.h$^{-1}$).

3.2.5. Alpha index ($I_\alpha$). The excess alpha radiation because of the Radon inhalation originating from the soil samples was assessed through alpha index, also it was little than one. Alpha index ($I_\alpha$) was calculated as follow [4, 15]:
$$I_\alpha = \frac{A_{Ra}}{200} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (8)$$

3.2.6. Gamma index ($I_\gamma$). This indicator was used to calculate the risk arising from Gamma radiation associated with radioactive natural nuclei ($^{238}$U, $^{232}$Th and $^{40}$K) in the studied samples and calculated from the following equation [4]:
$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_{K}}{1500} < 1 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9)$$
Its value must be less than one in order not to present any risk to human health.

3.2.7. The annual effective dose ($D_{eff}$). Equivalent from outdoor terrestrial gamma radiation was [16]:
$$D_{eff} = \text{Outdoor dose(nGy. h}^{-1}) \times 0.7(\text{Sv}. \text{Gy}^{-1}) \times 8760(\text{h} \cdot \text{y}^{-1}) \times 0.2 \ldots \ldots \ldots (10)$$
While for indoor exposure, by using an occupancy factor of 0.8, the annual effective dose equivalent was:
$$D_{eff} = \text{Indoor dose (nGy. h}^{-1}) \times 0.7(\text{Sv}. \text{Gy}^{-1}) \times 8760(\text{h} \cdot \text{y}^{-1}) \times 0.8 \ldots \ldots \ldots (11)$$

4. Excess Life-time Cancer Risk (ELCR)
The risk of cancer due to radiation effects which is called excess lifetime cancer risk (ELCR) can be calculated from the following equation [17].
$$ELCR = AEDE \times LS \times RF \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (12)$$
AEDE: The Annual Effective Dose Equivalent.

LS: is a mean life span for adult (50 years).

By offsetting these variables we will get the (ELCR) of $^{226}$Ra, $^{232}$Th and $^{40}$K in the soil samples . The value of risk factor (RF) for stochastic effects in the population is 0.05 per Sievert as recommended by ICRP [18]. The average annual committed effective dose for the measured in soil in this study (0.317 mSv.y$^{-1}$), that used to estimate the risk of cancer for an adult person using the equation (12) which gives a risk factor of (0.793*10$^{-3}$). The estimated values are significantly less than the ICRP cancer risk of (1.45 × 10$^{-3}$). This indicates that the soil in this road is safe and has no negative effects on human health [19].

4. Results and Discussion

Concentrations of radionuclide $^{226}$Ra, $^{232}$Th and $^{40}$K were measured for fifteen samples from the soil taken from Ya-Hussein road using a detector NaI (Tl). From table (1), we have found that the concentration of $^{226}$Ra is in the sample S12 as high as possible, in the sample S01 the lowest possible and at the rate of 17.386 ± 1.327 (Bq.Kg$^{-1}$) as for the concentration of $^{232}$Th has the largest value at the site S07 and the lowest value at the site S01 and the rate of 15.889 ± 0.556 (Bq.Kg$^{-1}$) while the concentration of $^{226}$Ra, $^{232}$Th are less than the permissible limits globally. The concentration of $^{40}$K is higher than the permissible limits globally average value (420 Bq.Kg$^{-1}$) recommended by the UNSCEAR at all locations of studied samples except for sample S01 where equal to 298.088 ± 4.164 (Bq.Kg$^{-1}$), it represents the lowest value and also less than the permissible limits, while the maximum value is at the sample S03 and reaches 682.304 ± 5.664 (Bq.Kg$^{-1}$) either the average Potassium concentration in this study is 553.269 ± 4.997 (Bq.Kg$^{-1}$) and is considered high. The reason could be that the soil in this road is sandy and it is known that sandy soil is characterized by the presence of organic materials in addition to solid waste and the reason may be the release of Potassium during the adsorption process from the surface and edges of the silica layer, as well as this region is characterized by burying very large quantities of food residue, each. These reasons led to a high concentration of Potassium in this road. In order to compare the radionuclide concentrations in soil samples, the ratios were used to provide a simple explanation of the relationship between these concentrations. The ratios of ($^{232}$Th - $^{226}$Ra) in table (2) show that $^{232}$Th concentrations are lower than $^{226}$Ra, concentrations at a rate of 0.9138 ± 0.420 but both are lower than $^{40}$K concentrations due to the large increase in Potassium concentration. also, the ratio between the concentrations of ($^{40}$K - $^{226}$Ra) and ($^{40}$K - $^{232}$Th) is slightly close together in soil samples 31.821 ± 3.784, 34.819 ± 9.016 respectively, which confirms the difference between $^{40}$K concentration and $^{226}$Ra, $^{232}$Th concentrations, where the ratios of ($^{232}$Th - $^{226}$Ra), ($^{40}$K - $^{226}$Ra) and ($^{40}$K - $^{232}$Th) were higher than average world UNSCEAR2000.

From table (3), we find that the highest values of $\mathcal{R}_{aeq}$, $I_\gamma$ in Sample S07 with an average 82.710 ± 2.508, 0.643 ± 0.017 (Bq.Kg$^{-1}$) respectively, but the highest $I_\alpha$ value is found in Sample S12 with an average 0.086 ± 0.006 (Bq.Kg$^{-1}$) but the lowest $\mathcal{R}_{aeq}$, $I_\gamma$, and $I_\alpha$ values in Sample S01, the reason may be the location of this sample near the center of Najaf city, so the reason could be the low level of Potassium depending on the reasons mentioned above. All values for these three indicators were less than the permissible limit, note that the relationship between $I_\gamma$ and $I_\alpha$ is shown in figure (3).

According to table (4), the minimum value of outdoor and indoor absorbed dose, outdoor and Indoor annual effective dose, external and internal hazard indexes are at sample S01, while the maximum value is at sample S07, and the reason for this is that the location of this sample is approximately the middle of the studied area, where it is far from the city and its rough sandy soil and salinity ratio it is very high.

Table (5) shows the relationship between analysis of laboratory data as radionuclide concentrations and hazard indicators for the studied soil samples. Where we found Pearson's correlation was very direct strong relation and positive between the concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K nuclides and $\mathcal{R}_{aeq}$, where it was statistically significant (p-value < 0.05) it turns out that there is a strong statistical
significance. While Pearson's correlation showed significant strong positive correlations (1.000**, p value 0.00) for each outdoor and indoor absorbed dose, outdoor and indoor annual effective dose. This correlation among variables indicates to not significant correlations (P = 0.900) were found between $^{232}$Th-$^{226}$Ra) and ($^{40}$K-$^{226}$Ra) While An inverse relationship and there is no statistical significance between ($^{40}$K-$^{232}$Th), ($^{232}$Th-$^{226}$Ra) (0.035, P value 0.900) Pearson's correlation showed significant middle positive correlations (1.000**, p value <0.001) for ($^{40}$K-$^{232}$Th) and ($^{40}$K-$^{226}$Ra). Pearson correlation showed significant strong positive correlations (1 to 0.999**, p value 0.000) for external and internal hazard indexes with outdoor and indoor absorbed dose, outdoor and indoor annual effective dose. Finally Pearson's correlation showed great strong positive (0.853**, p value 0.000) and there is strong statistical significance between Iγ and Iα.

Table 1. The concentration of $^{226}$Ra, $^{232}$Th and $^{40}$K in the soil samples under study

| ID  | $^{232}$Th (Bq.Kg$^{-1}$) | $^{226}$Ra (Bq.Kg$^{-1}$) | $^{40}$K (Bq.Kg$^{-1}$) |
|-----|--------------------------|---------------------------|------------------------|
| S01 | 7.928±0.442              | 10.064±1.207              | 298.088±4.164          |
| S02 | 15.913±0.555             | 20.484±1.420              | 515.573±4.914          |
| S03 | 19.011±0.621             | 17.594±1.397              | 682.034±5.664          |
| S04 | 18.559±0.602             | 18.163±1.397              | 664.673±5.219          |
| S05 | 16.337±0.621             | 19.797±1.397              | 575.157±4.997          |
| S06 | 14.849±0.621             | 13.948±1.255              | 616.028±5.025          |
| S07 | 19.322±0.630             | 21.005±1.633              | 682.914±5.358          |
| S08 | 15.988±0.527             | 19.892±1.349              | 558.748±5.108          |
| S09 | 15.828±0.489             | 16.221±1.255              | 522.681±4.636          |
| S10 | 13.681±0.546             | 12.148±1.160              | 462.652±4.720          |
| S11 | 14.595±0.546             | 17.618±1.397              | 514.268±4.942          |
| S12 | 17.241±0.583             | 23.278±1.302              | 607.976±5.164          |
| S13 | 14.990±0.536             | 15.700±1.349              | 575.074±5.025          |
| S14 | 16.233±0.508             | 16.245±1.089              | 452.324±4.886          |
| S15 | 17.862±0.517             | 18.636±1.302              | 570.576±5.136          |
| Ave. | 15.889±0.556             | 17.386±1.327              | 553.269±4.997          |
| Max. | 19.322±0.630             | 23.278±1.633              | 682.914±5.664          |
| Min. | 7.928±0.442              | 10.064±1.089              | 298.088±4.164          |

Table 2. The ratio of $^{226}$Ra, $^{232}$Th and $^{40}$K in the soil samples under study

| ID  | $^{232}$Th - $^{226}$Ra | $^{40}$K - $^{226}$Ra | $^{40}$K - $^{232}$Th |
|-----|--------------------------|------------------------|------------------------|
| S01 | 0.787±0.366              | 29.618±3.448           | 37.597±9.410           |
| S02 | 0.776±0.391              | 25.169±3.279           | 32.398±8.846           |
| S03 | 1.080±0.444              | 38.778±4.053           | 35.899±9.113           |
| S04 | 1.021±0.431              | 36.594±3.736           | 35.813±8.661           |
| S05 | 0.852±0.444              | 29.052±3.577           | 35.205±8.041           |
| S06 | 1.064±0.495              | 44.165±4.485           | 41.485±8.688           |
| S07 | 0.919±0.386              | 32.511±3.279           | 35.343±9.493           |
| S08 | 0.803±0.390              | 28.089±3.784           | 34.946±9.688           |
| S09 | 0.975±0.390              | 32.221±3.694           | 33.021±9.469           |
| S10 | 1.126±0.495              | 38.083±4.067           | 33.815±8.642           |
| S11 | 0.828±0.390              | 29.188±3.537           | 35.235±9.049           |
| S12 | 0.740±0.448              | 26.117±3.965           | 35.263±8.846           |
| S13 | 0.954±0.397              | 36.627±3.723           | 38.362±9.363           |
| S14 | 0.999±0.466              | 27.843±4.485           | 27.863±9.041           |
Table 3. Radiation hazard Indices of Gamma and Alfa rays in the soil Samples under study

| ID  | $\mathcal{R}_{eq}$(Bq.Kg$^{-1}$) | $I_y$(Bq.Kg$^{-1}$) | $I_\alpha$(Bq.Kg$^{-1}$) |
|-----|----------------------------------|---------------------|---------------------------|
| S01 | 44.354±2.161                     | 0.345±0.015         | 0.050±0.005               |
| S02 | 82.939±2.593                     | 0.639±0.018         | 0.102±0.007               |
| S03 | 97.318±2.722                     | 0.762±0.019         | 0.087±0.006               |
| S04 | 95.882±2.660                     | 0.749±0.749         | 0.090±0.006               |
| S05 | 87.446±2.670                     | 0.678±0.018         | 0.098±0.006               |
| S06 | 82.616±2.530                     | 0.652±0.018         | 0.069±0.006               |
| S07 | 101.22±2.948                     | 0.788±0.020         | 0.105±0.008               |
| S08 | 85.779±2.497                     | 0.664±0.020         | 0.099±0.006               |
| S09 | 79.102±2.312                     | 0.614±0.017         | 0.081±0.006               |
| S10 | 67.337±2.304                     | 0.526±0.016         | 0.060±0.005               |
| S11 | 78.088±2.558                     | 0.606±0.018         | 0.088±0.006               |
| S12 | 94.747±2.534                     | 0.732±0.017         | 0.116±0.008               |
| S13 | 81.417±2.504                     | 0.637±0.017         | 0.078±0.006               |
| S14 | 74.288±2.192                     | 0.572±0.015         | 0.081±0.005               |
| S15 | 88.114±2.438                     | 0.683±0.017         | 0.093±0.006               |
| Ave. | 82.710±2.508                  | 0.643±0.017         | 0.086±0.006               |
| Max. | 101.22±2.948                  | 0.788±0.020         | 0.116±0.008               |
| Min. | 44.354±2.161                    | 0.345±0.015         | 0.050±0.005               |
| Worldwide[20] | 370                        | < 1                | < 1                       |

Figure 3. Comparison between Gamma and Alfa Rays in the soil Samples
Table4. Hazard indices in the soil sample under study

| ID   | Outdoor Absorbed Dose (nGy h⁻¹) | Indoor Absorbed Dose (nGy h⁻¹) | Outdoor annual effective dose equivalent (mSv y⁻¹) | Indoor annual effective dose equivalent (mSv y⁻¹) | H_eff | H_eff |
|------|---------------------------------|---------------------------------|-----------------------------------------------|-----------------------------------------------|-------|-------|
| S01  | 22.36±0.987                    | 29.07±1.284                    | 0.027±0.001                                   | 0.142±0.006                                   | 0.119±0.005 | 0.146±0.009 |
| S02  | 41.45±1.185                    | 53.86±1.541                    | 0.050±0.001                                   | 0.264±0.007                                   | 0.223±0.007 | 0.279±0.010 |
| S03  | 49.43±1.251                    | 64.26±1.627                    | 0.060±0.001                                   | 0.315±0.007                                   | 0.262±0.007 | 0.310±0.011 |
| S04  | 48.62±1.219                    | 63.20±1.585                    | 0.059±0.001                                   | 0.310±0.007                                   | 0.258±0.007 | 0.308±0.010 |
| S05  | 44.00±1.222                    | 57.20±1.589                    | 0.0539±0.001                                  | 0.280±0.007                                   | 0.236±0.007 | 0.289±0.010 |
| S06  | 42.27±1.163                    | 54.95±1.512                    | 0.051±0.001                                   | 0.269±0.007                                   | 0.223±0.006 | 0.260±0.010 |
| S07  | 51.125±1.345                   | 66.46±1.749                    | 0.062±0.001                                   | 0.326±0.008                                   | 0.274±0.007 | 0.330±0.012 |
| S08  | 43.10±1.145                    | 56.03±1.488                    | 0.052±0.001                                   | 0.274±0.007                                   | 0.231±0.006 | 0.285±0.010 |
| S09  | 39.88±1.059                    | 51.84±1.377                    | 0.048±0.001                                   | 0.254±0.006                                   | 0.213±0.006 | 0.257±0.009 |
| S10  | 34.13±1.059                    | 44.38±1.377                    | 0.041±0.001                                   | 0.217±0.006                                   | 0.181±0.006 | 0.214±0.009 |
| S11  | 39.29±1.170                    | 51.08±1.521                    | 0.048±0.001                                   | 0.250±0.007                                   | 0.210±0.006 | 0.258±0.010 |
| S12  | 47.49±1.164                    | 61.74±1.514                    | 0.058±0.001                                   | 0.302±0.007                                   | 0.255±0.006 | 0.318±0.010 |
| S13  | 41.35±1.147                    | 53.76±1.492                    | 0.050±0.001                                   | 0.263±0.007                                   | 0.219±0.006 | 0.262±0.010 |
| S14  | 37.13±1.011                    | 48.27±1.315                    | 0.045±0.001                                   | 0.236±0.006                                   | 0.200±0.005 | 0.244±0.008 |
| S15  | 44.31±1.119                    | 57.61±1.455                    | 0.054±0.001                                   | 0.282±0.007                                   | 0.237±0.006 | 0.288±0.010 |
| Ave. | 41.73±1.150                    | 54.25±1.495                    | 0.051±0.001                                   | 0.266±0.007                                   | 0.223±0.006 | 0.270±0.010 |
| Max. | 51.125±1.345                   | 66.46±1.749                    | 0.062±0.001                                   | 0.326±0.008                                   | 0.273±0.007 | 0.330±0.012 |
| Min. | 22.36±0.987                    | 29.07±1.284                    | 0.027±0.001                                   | 0.142±0.006                                   | 0.119±0.005 | 0.146±0.008 |

Worldwide[21] | 59 | 84 | 0.07 | 0.41 | <1 | <1

Table4. Pearson Correlation and P-value for all parameters studied

| Variables | Correlations | ²²⁶Ra | ²³²Th | ⁴⁰K | Ra_eq |
|-----------|--------------|-------|-------|-----|-------|
| ²²⁶Ra     | Pearson Correlation | 1 | 0.752** | 0.634* | 0.810** |
|           | P value       |       | 0.001 | 0.111 | 0.000 |
| ²³²Th     | Pearson Correlation | 0.752** | 1 | 0.883** | 0.956** |
|           | P value       |       | 0.001 | 0.000 | 0.000 |
| ⁴⁰K       | Pearson Correlation | 0.634* | 0.810** | 1 | 0.958** |
|           | P value       |       | 0.001 | 0.000 | 0.000 |
| Ra_eq     | Pearson Correlation | 0.810** | 0.956** | 0.958** | 1 |
|           | P value       |       | 0.000 | 0.000 | 0.000 |

| Variables | Correlations | D_out | D_in | D_eff | D_eff |
|-----------|--------------|-------|------|-------|-------|
| D_out     | Pearson Correlation | 1 | 1.000** | 1.000** | 1.000** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| D_in      | Pearson Correlation | 1.000** | 1 | 1.000** | 1.000** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| D_eff     | Pearson Correlation | 1.000** | 1.000** | 1 | 0.999** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| D_effi    | Pearson Correlation | 1.000** | 1.000** | .999** | 1 |
|           | P value       |       | 0.000 | 0.000 | 0.000 |

| Variables | Correlations | ²³²Th | ²²⁶Ra | ⁴⁰K | ²²⁶Ra | ⁴⁰K | ²³²Th |
|-----------|--------------|-------|-------|-----|-------|-----|-------|
| ²³²Th     | Pearson Correlation | 0.590** | 0.810** | 0.958** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| ²²⁶Ra     | Pearson Correlation | 0.634* | 0.810** | 1.000** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| ⁴⁰K       | Pearson Correlation | 0.810** | 0.956** | 0.958** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| ²²⁶Ra     | Pearson Correlation | 0.752** | 0.634* | 0.810** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| ⁴⁰K       | Pearson Correlation | 0.634* | 0.810** | 1.000** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| ²³²Th     | Pearson Correlation | 0.752** | 0.634* | 0.810** |
|           | P value       |       | 0.000 | 0.000 | 0.000 |
| Variables | Correlations | $H_{ex}$ | $H_{in}$ |
|-----------|--------------|----------|----------|
| $232^{\text{Th}}-226^{\text{Ra}}$ | Pearson Correlation | 1 | 0.822** 0.035 |
| $P$ value | 0.000 | 0.900 |
| $40^{\text{K}}-226^{\text{Ra}}$ | Pearson Correlation | 0.822** | 1 | 0.596* |
| $P$ value | 0.000 | 0.019 |
| $40^{\text{K}}-232^{\text{Th}}$ | Pearson Correlation | 0.035 | 0.596* | 1 |
| $P$ value | 0.900 | 0.019 |

**high significant of correlation at the level (0.01)(2-tailed) , also *correlation is significant at the level (0.05)level(2-tailed).

**Conclusions.**

After obtaining information about the levels of natural radioactivity and understanding the behavior of these radionuclides in the soil of Ya-Hussein road, it was found that the values mentioned in this paper are within the normal level of radiation and less than the average global value. Likewise, the effective dose in the soil of this road falls within safety limits except for the potassium concentration, which is higher than the values recommended by [22]. This data can be considered as a baseline when making population exposure estimates in this road. Pearson's correlation is strong and statistically significant in all comparisons except ($^{40}\text{K}-232^{\text{Th}}$, $^{226}\text{Ra}$). Finally, the ELCR is lower than average world. UNSCEAR2000B[21] This study is considered exceptional and preliminary for this region and can be adopted in the future for research in this field.
Acknowledgments. This study was supported by the Department of Physics / College of Science / University of Kufa / Iraq, by providing research laboratories ready to provide a service to the community and implement research that contributes to keeping pace with scientific progress.

References

1. Council, N.R., "Health effects of exposure to low levels of ionizing radiation: BEIR V." Vol. 5. 1990: National Academies.
2. El-Sawy, M.M., "The Management of Combined Cases of Laryngocele Through Lateral Thyrotomy Approach." AAMJ, 2012. 10(3).
3. Li, Y., et al., "Challenges in multiscale modeling of polymer dynamics." Polymers, 2013. 5(2): p. 751-832.
4. Hamza, Z.M., S.A. Kadhim, and H.H. Hussein, "ASSESSMENT THE NORMS FOR AGRICULTURAL SOILS IN GHAMMAS TOWN, IRAQ." Plant Archives, 2019. 19(1): p. 1483-1490.
5. Makki, N.F., et al., "Natural Radioactivity Measurements in different regions in Najaf city, Iraq." International Journal of Computer Trends and Technology, 2014. 9(6): p. 286-289.
6. Aswood, M.S., A.A. Salih, and M.S.A. Al Musawi, "Long-lived gamma-ray measurement in soil samples collected from city central of Al-Diwaniyah, Iraq." in Journal of Physics: Conference Series. 2019. IOP Publishing.
7. Alsalihi, A., A.A. Abbas, and R. Abualhail, "Measurement of Radioactivity in Flour and Macaroni Consumed in Basrah Governorate, Iraq and Evaluation of Gamma Dose Rates, Radiological Hazard Indices, Excess Life Time Cancer Risk and Ingestion Effective Dose." Journal of Basrah Researches (Sciences), 2017. 43(2A): p. 58-69.
8. Majeed, H.N., A.K. Hasan, and H.J. Hamad, "Measurement Natural Radioactivity in Soil Samples from Important historical locals in Alnajaf Alashraf city, Iraq." Journal: Journal of Advances in Chemistry, 2014. 8(1).
9. Myasoedov, B. and F. Pavlotskaya, "Measurement of radioactive nuclides in the environment." Analyst, 1989. 114(3): p. 255-263.
10. Yaprack, G. and M. Aslani, "External dose-rates for natural gamma emitters in soils from an agricultural land in West Anatolia." Journal of radioanalytical and nuclear chemistry, 2010. 283(2): p. 279-287.
11. Avella, M., et al., "Biodegradable starch/clay nanocomposite films for food packaging applications." Food chemistry, 2005. 93(3): p. 467-474.
12. SALMAN, A.Y., et al., "Measurement of Radiation Contamination by 226Ra, 232Th and 40K in Different Types of Rice Implanted in Iraq." Annals of Agri-Bio Research, 2019. 24(2): p. 289-293.
13. Alaboodi, A.S., A.M. Hassan, and A.A. Muhmood, "Study the Health risk of Radioisotopes in different samples of salt in markets of Iraq." in Journal of Physics: Conference Series. 2019. IOP Publishing.
14. Bachev, H.I. and F. Ito, "Implications of Fukushima nuclear disaster for Japanese agri-food chains." International Journal of Food and Agricultural Economics (IJFAEC), 2014. 2(1128-2016-92026): p. 95-120.
15. Salih, N.F., "Determination of natural radioactivity and radiological hazards of 226Ra, 232Th, and 40K in the grains available at Penang Markets, Malaysia, using high-purity germanium detector." ARO-The Scientific Journal of Koya University, 2018. 6(1): p. 71-77.
16. Rangaswamy, D., et al., "Measurement of terrestrial gamma radiation dose and evaluation of annual effective dose in Shimoga District of Karnataka State, India." Radiation Protection and Environment, 2015. 38(4): p. 154.
17. Avwiri, G., C. Ononugbo, and I. Nwokeoji, "Radiation Hazard Indices and Excess Lifetime cancer risk in soil, sediment and water around mini-okoro/oginigba creek, Port Harcourt,"
12

Rivers State, Nigeria. Comprehensive Journal of Environment and Earth Sciences, 2014. 3(1): p. 38-50.

18. James, A. and A. Birchall, New ICRP lung dosimetry and its risk implications for alpha emitters. Radiation Protection Dosimetry, 1995. 60(4): p. 321-326.

19. Mohammed, R. and R. Ahmed, Estimation of excess lifetime cancer risk and radiation hazard indices in southern Iraq. Environmental Earth Sciences, 2017. 76(7): p. 303.

20. Radiation, U.N.S.C.o.t.E.o.A., Sources and effects of ionizing radiation: sources. Vol. 1. 2000: United Nations Publications.

21. UNSCEAR, S., Effects of Ionizing Radiation-United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2000 Report to the General Assembly with Scientific Annexes, United Nations, New York. 2006, United Nations Scientific Committee on the Effects of Atomic Radiation. ...

22. UNSCEAR, U., Report to the General Assembly, with scientific annexes. UN, New York, 2000.