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MEASURING OF NATURAL RADIOACTIVITY IN SOME SOIL SAMPLES OF AL-SUWAIRA REGION IN WASIT GOVERNORATE, IRAQ

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Abstract

The activity and the concentration of natural radionuclides of the three elements (^{40}K, ^{238}U, and ^{232}Th) were determined in 20 soil samples, collected from Al-Suwaira district of Wasit Governorate. The results showed that the radioactivities of element in this study were within the acceptable standard levels. In addition, the radium equivalent activity, average air volume, annual effective dose rate and external risk index were assessed and found to be among the internationally tolerable values. The radioactivity of, ^{238}U ranged from (8.5733 ± 0.72)to (36.472 ± 0.84) Bq / kg with an average of (20.810±1.08)Bq / Kg, while it was for ^{232}Th ranged from (46.913 ± 3.29)to (70.576 ± 2.36) Bq / Kg with an average of (62.301±2.79) Bq / Kg and ^{40}K ranged from (146.436 ± 3.58)to(215.705 ± 3.66) Bq / Kg with an average (180.227±2.46) Bq / Kg, It is found that the average of radiological effects like the radium equivalent (Ra_{eq}), the absorbed dose Rate (Dr),external hazard index (H_{ex}), internal hazard index (H_{in}), representative gamma hazard index (I_{γ}), the effective dose equivalent (AEDE) lifetime the excess cancer risk (ELCR) due to natural radioactivity in soil samples for depth (0-15)cm were (123.779±4.82) Bq/Kg, (55.819±2.14) nGy/h, (0.334±0.01), (0.409±0.01), (0.881±0.03), (0.342±0.01) mSv/y and (0.547±0.02)x10^{-3}, respectively, which was attributed to the increasing the natural radioactivity in the soil of Al- Suwaira district.

Key words : Natural radioactivity, Absorbed dose, External hazard, Annual dose, Excess lifetime cancer risk.

Introduction

Radioactivity is a phenomenon that occurs naturally in a number of substances. Atoms of the substance spontaneously emit invisible but energetic radiations, which can penetrate materials that are opaque (Katungi, 2007). Natural radioactivity is energy generated by those of the radioactive elements that exist in the earth's crust (Mould, 1993). There are two types of the radiation sources Natural Radiation and Artificial Radiation (L'Annunziata, 2016). The naturally occurring radionuclides present in the soil including ^{238}U, ^{232}Th and ^{40}K are source of the natural radioactivity. This mainly enters into the body via food product, drinking water, forestry products. Almost 90% of human radiation exposure arises from the natural sources such as cosmic radiation, exposure to radon gas and terrestrial radiation (Kilic and Aykamis, 2009). The aim of this the study is to investigate the natural radioactivity of ^{238}U, ^{232}Th and ^{40}K in soil samples which was collected from different locations in the Al- Suwaira province in Wasit city in Iraq as shown in Fig. 1.

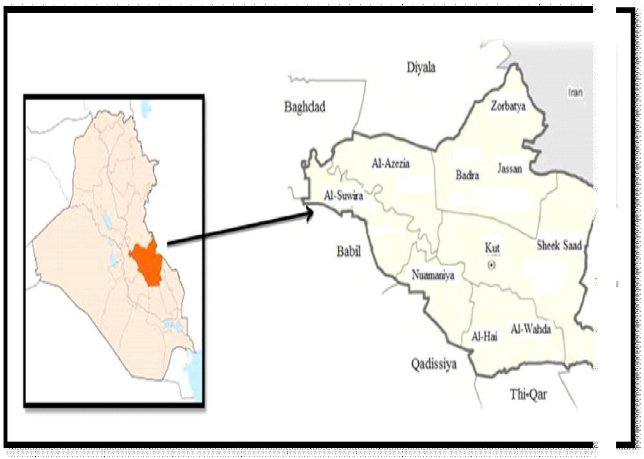

Fig. 1: Geographical map of Al- Suwaira district location, Wasit, Iraq.

Material and Methods

Twenty soil samples were collected at a depth of 15 cm from an elected area of 1777 Km^2 from Al-Suwaira district of Wasit Governorate. Following the guided notes of the standards recommended by the International

Atomic Energy Agency (IAEA). First, the samples were cleaned to remove undesirable materials. Next, the samples were placed under the sun. After that, the samples were analyzed for the selective homogeneous particle size by a sieve then 300 μm producing net the weights of 750 g. A sample was then filled in a single cubic in marinelli cup of fixed size to ensure the engineering homogeneity around the detector. The multivariate analyzer 1024 channel range to the surrounding using ORTEC cylindrical chamber diameter consists of two parts, one of the stainless steel of 20 cm and the second part of the lead with a width of 5 cm. The was calibrated for an energy acquisition by using a set of the radioactive standard sources spectrometer of known such as ^{137}Cs, ^{60}Co and ^{22} Na. Energy efficiency was performed in a gamma spectrometer using the same calibration sources in a one cup of marinelli to cover power from 511.006 to 2500 keV. A standard source was placed over the detector with an exact geometrical match between geometric sample and sample detector. A samples was placed in the middle of the chamber inside the shield with a period of about 4 hours. The energy with secular equilibrium was and determined at 1764 KeV from gamma power transition of ^{214} Bi probability of 15 % at 2614 KeV from gamma transfer energy of ^{208} Tl, probability 98% respectively, while activity is ^{40}K balance with them respectively, while activity is ^{40}K. It is determined using a 1460 KeV a gamma ray line Probability of 12%.

Theoretical calculations

Specific Activity (A)

The qualitative efficacy (A) can be measured by the following equation (Manavhela, 2007).

$$A\left(Bq-kg\right)=\frac{N}{\varepsilon\times I_{\gamma}\times M\times t} \quad (1)$$

Where (*N)* net gamma counting rate (counts per second), (ε)efficiency of the detector

($I_{\tilde{a}}$) intensity of the gamma-line in a radionuclide, (*M*) mass of the sample, kg.

(t) is the live time for collecting spectrum in the seconds (Cottingham *et al.,* 2001).

External Hazard Index (H_{ex})

Measurement of Hazard Indices Depending on the specific efficacy of uranium, thorium and potassium, several risk factors were measured, including:

Radium Equivalent: The radium equivalent (Ra_{eq})

This indices are use to obtain the sum of the those activities ^{232}Th, ^{238}U and ^{40}K in (Bq/kg) and assess hazards associated with materials that contain ^{232}Th, ^{238}U and^{40}K in (Bq/kg) by using to radium equivalent activity and is mathematically defined as (Alaamer, 2008).

$$Ra_{eq}\left(Bq-kg\right)=A_U+1.43A_{Th}+0.077A_K \quad (2)$$

A_{Th}, $A_{U\ and}$ A_K are the specific efficiency of the uranium chain and the thorium and potassium series, respectively. In equation (2) it is assumed that 10Bq / Kg of uranium, 7Bq / Kg of thorium and 130Bq / Kg of potassium produces an equal dose of radiation. The highest value of Ra_{eq} should be less than the global limit 370 Bq / Kg (Jassim *et al.,* 2016).

Absorbed Dose Rate in Air (AD)

The total rate of the absorbed air dose (AD) can be measured in terms of concentrations of terrestrial nuclei by the following equation (European Commission, 1999).

$$AD\left(nGy/h\right)=0.462\,A_U+0.621\,A_{Th}+0.0417\,A_K \quad (3)$$

Effective Annual Dose

The annual effective dose was measured using the following equations (Pierce and Preston, 2000).

AEDE Indoor

$$\left(mSv\,y\right)=AD\left(nGy-h\right)\times 8760h\times 0.8\times 0.7\,Sv-Gy\times 10^{-6} \quad (4)$$

AEDE Outdoor

$$\left(mSv\,y\right)=AD\left(nGy-h\right)\times 8760h\times 0.2\times 0.7\,Sv-Gy\times 10^{-6} \quad (5)$$

The coefficient 0.7 Sv / Gy was used as a factor of conversion from 0f the air-absorbed dose to the effective annual dose received by adults and 0.8 the time spent inside and 0.2 was the proportion of time spent abroad, 8760 refers to the number of hours of the year, and the global average effective annual dose is 0.47 mSv (El-Taher and Makhluf, 2010).

External Hazard Index (H_{ex})

The external risk guide is an assessment of the risk of natural gamma radiation is calculated from the following equation (Mahur *et al.,* 2010).

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (6)$$

It should be less than one, if it is equal to or greater than one indicates a radiological hazard. (Hussain *et al.,* 2010) Internal risk index (H_{in}). The internal exposure is the result of the inhalation of radon and its fluids, which can be expressed in terms of internal risk factor (Michael *et al.,* 2007), and is calculated by the following equation (Singh *et al.,* 2009).

$$H_{in} = \frac{A_U}{158} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (7)$$

This factor must be less than one to be within the internationally permissible limits (U.N.S.C., 2000).

Activity Concentration Index (I_{γ})

The representative level index I_{γ} of the soil is used to estimate the level of gamma radiation hazard associated with natural gamma emitters in the soil. It was evaluated using the relation given by (Kogan, 1979).

$$I_{\gamma} = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \quad (8)$$

Excess lifetime cancer risk (ELCR)

The value of excess lifetime cancer risk can be calculated

$$ELCR = AEDE.DL.RF \quad (9)$$

where ELCR – excess lifetime cancer risk Sv-1, DL – average duration of life estimated to be 70 years, RF – risk factor , Sv *i.e.* fatal cancer risk per Sievert For stochastic effects, ICRP uses RF as 0.05 for the public (E.C.E., (2000).

Results and discussion

Specified Activity

The results of specific activity for ^{238}U, ^{232}Th and ^{40}K radionuclide in a sample from the center of the Al-Suwaira district of Wasit Governorate is displayed in the Table 1, a set of activity defined for ^{238}U, it ranged from (8.5733 ± 0.72) Bq / Kg in S1 as a minimum value to (36.472 ± 0.84(Bq / Kg in S6 as a maximum. In ^{232} Th certain activity ranged from (46.913 ± 3.29)Bq / Kg in S19 to (70.576 ± 2.36)Bq / Kg in S18. While the activity was specified at ^{40}K Ranged from (146.436 ± 3.58) in S1 to (215.705 ± 3.66) Bq/ Kg in S6. Geochemical composition of the soil was sandy clay. It seems the thorium Activity Higher than uranium activity in some samples. It is obviously seen that the radioactivity of thorium is several times higher than that of uranium in the same sites. Also, it is noted that radioactivity of ^{40}K exceeds significantly much higher than both of ^{238}U and ^{232}Th. Moreover, this can be due to the abundance of ^{40}K in the soil because a lot of Potassium containing fertilizers was used in the vicinity of sampling locations. The results of an average particular radioactivity of collected soil samples in this study were below the global average levels according to UNSCEAR 2000 (Unscear, 2000). which is 35, 30 and 400 Bq / Kg for ^{232}Th and ^{40}K respectively.

Table 1: Results of natural radioactivity Center of the Al-Suwaira district of Wasit Governorate.

No.	Sample Code	Specific activity (Bq/Kg)		
		U-238	Th-232	K-40
1	S1	8.5733±0.72	49.588±2.57	146.436±3.58
2	S2	15.210±1.47	64.506±2.41	187.194±2.67
3	S3	18.155±0.94	59.002±2.36	147.641±2.55
4	S4	25.175±4.03	65.740±2.72	209.503±2.37
5	S5	33.728±0.82	64.094±2.46	206.376±2.20
6	S6	36.472±0.84	69.084±2.26	215.705±3.66
7	S7	21.040±1.17	61.059±1.95	165.478±1.99
8	S8	26.022±1.00	66.100±2.57	158.350±2.25
9	S9	8.6137±1.06	55.246±2.41	178.703±2.23
10	S10	17.409±1.47	65.792±2.21	179.053±2.39
11	S11	15.109±1.41	62.551±2.62	189.744±2.14
12	S12	11.573±0.44	66.975±2.21	167.085±3.54
13	S13	24.651±1.04	65.895±2.36	208.612±3.16
14	S14	18.962±1.47	64.660±2.31	177.585±3.96
15	S15	25.639±1.21	55.761±2.88	154.804±2.28
16	S16	25.074±1.06	66.923±2.36	207.232±3.68
17	S17	22.109±1.00	62.448±2.21	191.736±1.99
18	S18	16.299±1.54	70.576±2.36	186.582±2.70
19	S19	26.042±0.92	46.913±3.29	167.959±2.18
20	S20	30.339±0.76	63.117±2.00	158.770±2.30
Max		36.472±0.84	70.576±2.36	215.705±3.66
Min		8.5733±0.72	46.913±3.29	146.436±3.58
Average±S.D		20.810±1.08	62.301±2.79	180.227±2.46

Radiation effect

Table 2 shows the results $Ra_{eq,}$ $D_{r,}$ $H_{ex,}$ H_{in} and I_{γ} from the soil samples collected from Al-Suwaira district of Wasit Governorate The equivalent radium activity calculated for the same soil sample ranges from (162.174 ± 4.32) to (90.760 ± 4.67) Bq/Kg an average (123.779±4.82) Bq / Kg. That the analysis of all

Table 2: Results Ra_{eq},D_r,H_{ex},H_{in} and $I_{\ddot{a}}$ from the soil samples collected from Al-Suwaira district of Wasit Governorate.

I_γ	H_{in}	H_{ex}	D_r (nGy/h)	Ra_{eq} (Bq/kg)	Sample Code	No.
0.650±0.03	0.276±0.01	0.245±0.01	40.861±2.08	90.760±4.67	S1	1
0.871±0.03	0.384±0.01	0.329±0.01	54.891±2.29	121.868±5.13	S2	2
0.809±0.03	0.373±0.01	0.307±0.01	51.184±2.01	113.896±4.52	S3	3
0.964±0.05	0.456±0.03	0.365±0.02	61.192±3.65	135.316±8.11	S4	4
1.003±0.03	0.503±0.01	0.381±0.01	63.991±2.00	141.275±4.52	S5	5
1.077±0.03	0.542±0.01	0.410±0.01	68.746±1.94	151.872±4.36	S6	6
0.861±0.02	0.403±0.01	0.327±0.01	54.539±1.83	121.097±4.11	S7	7
0.940±0.03	0.452±0.01	0.358±0.01	59.674±2.15	132.739±4.86	S8	8
0.729±0.03	0.304±0.01	0.273±0.01	45.739±2.08	101.377±4.69	S9	9
0.893±0.03	0.401±0.01	0.338±0.01	56.366±2.15	125.278±4.81	S10	10
0.852±0.03	0.376±0.01	0.321±0.01	53.737±2.37	119.168±5.32	S11	11
0.791±0.02	0.303±0.01	0.297±0.01	49.286±1.72	110.213±3.87	S12	12
0.962±0.03	0.453±0.01	0.364±0.01	61.008±2.08	134.944±4.67	S13	13
0.891±0.03	0.406±0.01	0.337±0.01	56.320±2.28	125.100±5.08	S14	14
0.831±0.03	0.409±0.01	0.316±0.01	52.928±2.44	117.298±5.50	S15	15
0.974±0.03	0.460±0.01	0.369±0.01	61.785±2.11	136.732±4.73	S16	16
0.899±0.03	0.420±0.01	0.340±0.01	56.990±1.92	162.174±4.32	S17	17
0.938±0.03	0.414±0.01	0.355±0.01	59.138±2.25	131.590±5.04	S18	18
0.754±0.04	0.380±0.01	0.286±0.01	48.169±2.56	106.062±5.80	S19	19
0.939±0.02	0.468±0.01	0.358±0.01	59.833±1.69	132.822±3.81	S20	20
1.077±0.03	0.542±0.01	0.410±0.01	68.746±1.94	162.174±4.32	Max	
0.650±0.03	0.276±0.01	0.245±0.01	40.861±2.08	90.760±4.67	Min	
0.881±0.03	0.409±0.01	0.334±0.01	55.819±2.14	123.779±4.82	Average±S.D	

soil samples from radium is equivalent to the activity value well and the minimum permissible 370 Bq / kg (H.H.D., 2016). The absorbed dose rate ranges from (68.746 ± 1.94) to (40.861 ± 2.08) nGy/h an average of (55.819±2.14) nGy / h, the world's outdoor exposure due to gamma rays (nG / h), based on UNSCEAR 2000 (Unscear, 2000). The recorded value in the study area for most samples is important for health and does not show any serious effects on people living there. In the end, the use of a specific activity measured in the soil is the detection of radioactive dose, which is delivered externally in the form of gamma dose. External The risk index was calculated from (0.410 ± 0.01) to (0.245 ± 0.01) at an average of (0.334±0.01) and the mean values were lower than the unit according to the Radiation Protection Report (Charles, 2001). These radionuclides are some sources The internal exposure ranged from (0.542 ± 0.01) to (0.276 ± 0.01) with an average of (0.409±0.01) and representative gamma hazard index from (1.077 ± 0.03) to (0.650 ± 0.03) with an average of (0.881±0.03) so the values calculated for the values were lower than the unit according to the radiation protection report (Oleiwi and Rasool, 2018). The values of calculated values for samples from this site are shown in Table 2. Values range from 3.213 to 0.345 at 1.0137. This calculated code is lower than the international values (Charles, 2001). The internal, external and total values of the AEDE are listed in Table 3. These mean values were (0.421 ± 0.01) to (0.250 ± 0.01) and average of (0.342±0.01) mSv / y, respectively, noting that these values are than the corresponding global values 0.42, 0.08 and 0.50 mSv / y respectively (askin *et al.,* 2009). Calculated increase The lifetime risk of cancer from this site is shown in Table 3. These values vary from(0.674 ± 0.01) to(0.400 ± 0.02) × 10^{-3} liters 0.583 × 10^{-3} with an average of (0.547±0.02) x10^{-3}. According to these results.

Conclusions

The measurement level of the natural radioactivity, of the studied soil sample in the Al-Suwaira district of Wasit Governorate, normal levels of radioactivity concentration, All of the obtained^{40} K values show levels within of the natural permissible values. Preliminary, values for Radium equivalent, (Ra_{eq}), Radiation hazard index (H_{ex}) and Annual Effective dose equivalent indicate that of the areas monitored can be regarded as having normal

Table 3: Results of $AEDE_{indoor}$, $AEDE_{outdoor}$, AEDE and ELCR of the Al-Suwaira district of Wasit Governorate.

No.	Sample Code	$AEDE_{indoor}$ (mSv/y)	$AEDE_{outdoor}$ (mSv/y)	AEDE (mSv/y)	ELCRX10^{-3}
1	S1	0.200 ± 0.01	0.050 ± 0.00	0.250 ± 0.01	0.400 ± 0.02
2	S2	0.269 ± 0.01	0.067 ± 0.00	0.336 ± 0.01	0.538 ± 0.02
3	S3	0.251 ± 0.00	0.062 ± 0.00	0.313 ± 0.01	0.502 ± 0.01
4	S4	0.300 ± 0.01	0.075 ± 0.00	0.375 ± 0.02	0.600 ± 0.03
5	S5	0.313 ± 0.00	0.078 ± 0.00	0.392 ± 0.01	0.627 ± 0.01
6	S6	0.337 ± 0.00	0.084 ± 0.00	0.421 ± 0.01	0.674 ± 0.01
7	S7	0.267 ± 0.00	0.066 ± 0.00	0.334 ± 0.01	0.535 ± 0.01
8	S8	0.292 ± 0.01	0.073 ± 0.00	0.365 ± 0.01	0.585 ± 0.02
9	S9	0.224 ± 0.01	0.056 ± 0.00	0.280 ± 0.01	0.448 ± 0.02
10	S10	0.276 ± 0.01	0.069 ± 0.00	0.345 ± 0.01	0.553 ± 0.02
11	S11	0.263 ± 0.01	0.065 ± 0.00	0.329 ± 0.01	0.527 ± 0.02
12	S12	0.241 ± 0.00	0.060 ± 0.00	0.302 ± 0.01	0.483 ± 001
13	S13	0.299 ± 0.01	0.074 ± 0.00	0.374 ± 0.01	0.598 ± 0.02
14	S14	0.276 ± 0.00	0.069 ± 0.00	0.345 ± 0.01	0.552 ± 0.02
15	S15	0.259 ± 0.01	0.064 ± 0.00	0.324 ± 0.01	0.519 ± 0.02
16	S16	0.303 ± 0.01	0.075 ± 0.00	0.378 ± 0.01	0.606 ± 0.02
17	S17	0.279 ± 0.00	0.069 ± 0.00	0.349 ± 0.01	0.559 ± 0.01
18	S18	0.290 ± 0.01	0.072 ± 0.00	0.362 ± 0.01	0.580 ± 0.02
19	S19	0.236 ± 0.01	0.059 ± 0.00	0.395 ± 0.01	0.472 ± 0.02
20	S20	0.58 7± 0.01	0.01 ± 0.366	0.00 ± 0.073	0.293 ± 0.00
Max		0.674 ± 0.01	0.421 ± 0.01	0.084 ± 0.00	0.337 ± 0.00
Min		0.400 ± 0.02	0.250 ± 0.01	0.050 ± 0.00	0.200 ± 0.01
Average±S.D		0.547±0.02	0.342±0.01	0.068±0.00	0.273±0.01

levels of natural radioactivity.

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