Research Article

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Natural Radioactivity Levels in Soil Samples of AL- Sadr and AL-Forat AL-Aosat Hospitals in Najaf

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Abstract

This work was undertaken with the purpose of measuring natural radioactivity, due to ^{238}U, ^{232}Th and ^{40}K in 30 soil samples collected from two hospitals in the governorate of (AL-Najaf), in Iraq.

The samples were distributed (15) samples per hospital, and Radiation risks were also calculated for all soil samples.

The natural radioactivity was measured using NaI (Tl) detector, the results of the specific activity at the Al Sadr Hospital were ^{238}U ranged from (5.89±0.36 to 21.38±0.69) (Bq/kg) with average value 12.60±0.51 (Bq/kg).

^{232}Th from (0.44±0.06 to 14.67±0.37) (Bq/kg) with average value (4.46±0.19) (Bq/kg), and ^{40}K from (252.14±2.54 to 478.24±3.50) (Bq/kg) with average value (346.95±289) (Bq/kg). AL-Forat AL-Aosat hospital results were ^{238}U ranged from (0.69±0.12 to 27.63±0.74) (Bq/kg) with average value (12.84±0.51) (Bq/kg), ^{232}Th from (1.47±0.11 to 9.3±0.31 (Bq/kg) with average value 6.19±0.24 (Bq/kg), and ^{40}K from (192.88±2.27 to 338.52±3.08) (Bq/kg) with average value (254.29±2.54) (Bq/kg).

The radiation risks calculated, Radium Equivalent (Raeq), external Hazard index (Hex), absorbed dose rate (ADr), total Annual Effective Dose Equivalent (AEDE), and the Excess Life Cancer Risk (ELCR).

The results were for Al Sadr Hospital (45.7063(Bq/kg), 0.1234, 23.0648(nGy/h), 0.0283(mSV/y), 1.247439702×10-3) respectively.

For AL-Forat AL-Aosat hospital were (41.2655 (Bq/kg), 0.111, 20.3772 (nGy/h), 0.0250(mSV/y)`, 1.102083688×10-3) respectively.

The results in the two hospitals were compared with the global allowable values ratio within the permissible ranges specified by UNSCER, OCDE, and ICRP; we concluded that all the sites in this study are safe.

Introduction

Environmental radiation activity and external exposure associated with gamma radiation depends mainly on the geological and geographical conditions and shows different radiation levels of soil for each region of the world [1].

External exposure means that exposure to radiation is from outside the body, i.e., the product of natural nuclides in the environment; the internal exposure is inside the body and enters the body through nutrition [2].

Exposure to ionizing radiation may cause cancer, as well as radiation can be used to treat most cancers, so radiation activity should be monitored carefully to minimize the size of potential risks [3,4].

So we will try to study the radioactivity of the soil in some important sites and vital in the province of Najaf in direct contact with citizens' lives to prevent the dangers of radiation, by taking samples from different locations in two hospitals in the province and the number of samples is 30 samples

All the required calculations were made and placed in special tables; these results were represented as graphs of the two hospitals. All the results were within the internationally permitted range, except for two sites in Al-Sadr Hospital, which were slightly higher.

Materials and Methods

In this study samples collected from two hospitals, thirty sites were selected from these hospitals and distributed regularly, 15 soil samples per hospital.

Leave them for at least a month to reach the balance of radiation, and heating these samples to get rid of the moisture in the second phase Grind the soil sample into small granules to reach the true radioactive balance of the sample.

Samples were saved for at least a month, to reach the balance of radiation, and heating these samples to get rid of the moisture, in the second phase grind the soil sample into small granules to reach the true radioactive balance of the sample.

These are the sample preparation stages before they are placed in the system.
The third stage is to place the samples in a special system (NaI(Tl)) detector for (30,000) seconds, then save the results on the computer, and then enter them in special equations to obtain the required risk factors [5].

The detector calibrated by using standard radioactive sources, the energy of these sources are closed to the energy of.

The samples in order to calculate the detector efficiency,the standard source put over the detector with a geometric.

Match exactly to the geometrical sample form and with the same distance between the sample and the detector.

It was found that the efficiency decrease when the energy of the radioactive source increase, and the same thing, when the volume of sample increase on (600ml) [6].

All the required calculations were made and placed in special tables; these results were represented as graphs of the four hospitals.

All the results were within the internationally permitted range, except for two sites in Al-Sadr Hospital, which were slightly higher [7].

Specific Activity

The specific activity is defined as activity per unit mass of radioactive substance and the reported in units such as Curie per gram or Becquerel per kilogram [8].

The definition of activity pointing to the number of transformations per unit time. It can be measured by the second unit; the quantity activity is measured in disintegrations per second or in other words (dps)

From equation (1), the specific activity of each radioactive nucleus can be calculated

$$A(Bq \setminus kg) = \frac{C}{\varepsilon \cdot \gamma \cdot m \cdot t} \quad \text{.....} \quad (1)$$

where (A) the specific activity of the radionuclide It is measured in unity Bq/kg, (C) is net peak count (background subtracted), (ε) the counting efficiency, (γ) the percentage of gamma emission probability of the radionuclide under consideration, (t) the counting time It is measured in unity second and (m) the mass of the sample and It is measured in unity kg [9].

Radium Equivalent Activity

These indicators are used to obtain total activity ^{232}Th, ^{226}Ra and ^{40}K in (Bq/kg) and risk assessment of materials containing ^{232}Th ,^{226}Ra and^{40}K in (Bq/kg) by using to Radium equivalent activity and It is defined mathematically as follows [10].

$$Ra_{eq}(Bq/kg) = A_U + 1.43A_{Th} + 0.077A_K \quad \text{.....} \quad (2)$$

Where Au, AK, and Ath are the specific activities of Uranium, potassium, and Thorium respectively.

While defining Rae activity, it is assumed that 10 Bq\kg of 226Ra, 7 Bq\kg of 232Th and 130 Bq\kg of 40K produced an equal gamma-ray dose, the maximum value of (Ra_{eq}) must be less than the acceptable limit safe of 370 Bq\kg [11].

Absorbed Dose Rates (AD_r)

Through the following equation, we will be able to calculate total percentage of air intake in terms of concentrations of the terrestrial nuclei [12].

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

Where A_U, A_{Th}, and A_K are the specific activities of ^{238}U, ^{40}K and ^{232}Th in Bq/kg respectively.

External Hazard Index (Hex)

The presence of natural radionuclides causes the emission of gamma-ray in the environment. The external hazard index (Hex) is used in order to estimate the biological hazard of the natural gamma radiation and this risk indicator is calculated by applying the following equation [13,14].

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad \text{.....} \quad (4)$$

Where A_U, A_{Th}, and A_K are the specific activities (Bq /kg) and to solve the equation, the values of the variables must be compensated ^{226}Ra, ^{40}K and ^{232}Th, respectively The value of this index must be less than one unit in order to keep the radiation hazard insignificant. The maximum value of Hex equal to unity corresponds to the higher limit of radium Equivalent activity (370 Bq/k).

Annual Effective Dose Equivalent (AEDE)

In order to calculate another important factor of risk, which is the effective annual dose, consideration should be given to the calculation of the effective dose and the factor of concern. In order to calculate the effective dose of the gamma emission factor in the air. The annual effective external dose was calculated which can be calculated by applying the following equation [15]:

(AEDE)Outdoor (mSv/y) =AD (n Gy/h)×10^{-6}×8760h/y×0.20×0.7Sv/Gy)……(5)

It can be noted that the number 8760 refers to the total number of hours per year.

Excess Life-time Cancer Risk (ELCR)

Where Excess Life-time Cancer Risk is coefficient increase the seriousness of cancer a lung lifetime and this explains the continuing increase in the number of deaths in most of the world's cities [16].

$ELCR = AEDE \text{ X } DL \text{ X } RF$..... (6)

AEDE: The Annual Effective Dose Equivalent.
DL: Thenormal age of human.

RF (s/v): The risk factor is the range of 0.569139 to 0.74732 with an average o.639954 by offsetting these variables we will get the (ELCR).

Results and Discussion

The specific activity for Al Sadr Hospital

The results of the specific activity of this region is showen in table (1) for ^{40}K, ^{238}U, and ^{232}Th in (15) soil samples collected from (Al Sadr Hospital).

The specific activity of ^{238}U, ^{232}Th and ^{40}K in this region varies from 5.89±0.36 to 21.38±0.69 (Bq/kg) with average value 12.60±0.51 (Bq/kg), from 0.44±0.06 to 14.67±0.37 (Bq/kg) with average value 4.46±0.19 (Bq/kg), and from 252.14±2.54 to 478.24±3.50 (Bq/kg) with average value 346.95±289 (Bq/kg) respectively.

The result of the specific activity of ^{238}U and ^{232}Th of soil samples collected from this location was within the world average [17].

Except for ^{40}K, were two of the samples were higher than the world average in (S7) and (S11), where their results were as follows (478.24±3.50) and (422.6±2.55) respectively.

Note that the average allowed globally is as follows 35 (Bq/kg), 45 (Bq/kg) and 420 (Bq/kg) for ^{238}U, ^{232}Th and ^{40}K respectively, recommended by UNSCER 2000 [7].

The difference in results in table (1) can be observed and there is a variance in specific activity.

This difference is because the soil samples taken from the different sites of the hospital are sometimes located in agricultural gardens that use certain fertilizers that lead to this difference.

Due to the difference in the soil of the study area where there were clay soil and sandy soil, and some were planted, which was taken from the gardens of the hospital.

Table1: Results of specific activity in soil samples at Al-Sadr Hospital

No.	Sample code	Specific activity (Bq/kg)		
		238U	232Th	40K
1	s1	12.57±0.52	6.068±0.23	**322.24±2.77**
2	s2	13.42±0.53	0.44±0.06	**318.35±2.74**
3	s3	12.49±0.50	4.44±0.19	**344.20±2.77**
4	s4	5.89±0.36	5.30±0.22	**370.94±3.00**
5	s5	17.61±0.63	4.36±0.20	**325.09±2.86**
6	s6	6.20±0.38	5.21±0,22	**343.04±2.97**
7	s7	17.86±0.64	4.96±0.22	**478.24±3.50**
8	s8	10.13±0.41	0.92±0.08	**269.83±2.24**
9	s9	21.38±0.69	3.26±0.17	**391.84±3.13**
10	s10	10.55±0.49	4.13±0.20	**252.14±2.54**
11	s11	13.35±0.59	2.61±0.17	**422.6±2.55**
12	s12	12.80±0.53	3.86±0.19	**415.43±3.23**
13	s13	14.55±0.57	14.67±0.37	**322.55±2.85**
14	s14	11.61±0.46	4.99±0.19	**296.46±2.47**
15	s15	8.66±0.41	1.63±0.11	**331.26±2..69**
Average±S.D		12.60±0.51	4.46±0.19	**346.95±289**
UNSCEAR 2008[17]		35.00	45.00	**420**

Radiological effects

The table (2) shows the radiological risks of (15) soil samples collected from Al Sadr Hospital, the radiological risks are (Req, Hex, Adr out, AEDEout, and ELCR), and the details of the table were as follows:

1. Req: The highest value 61.79 (Bq/kg) and the lowest value was 32.24 (Bq/kg) and the average is 45.7063(Bq/kg).
2. Hex: The highest value 0.167 (Bq/kg) and the lowest value was 0.087 (Bq/kg) and the average is 0.1234(Bq/kg).
3. Adr out: The highest value 31.28 (Bq/kg) and the lowest value was16.51 (Bq/kg) and the average is 23.0648(Bq/kg).
4. AEDEout: The highest value 0.0384 (msv/y) and the lowest value was 0.0202 (msv/y) and the average is 0.0283(msv/y).
5. ELCR$\times10^{-3}$: The highest value 1.691793697×10^{-3} and the lowest value was 0.892903814×10^{-3} and the average is 1.247439702×10^{-3}.

When we compare between the value of the world average and the results of radiological risks for the current work table (2), we find that all results are within the allowable globally.

Table 2: Values of (Raeq, Adr, Hex, AEDE out, and ELCRX) in Al-Sadr Hospital

No.	Sample code	R_{eq} (Bq/ g)	Hex	$(AD_r)_{out}$ (nGy/h)	$AEDE_{out}$ (mSV/y)	ELCRX10^{-3}
1	S1	46.07	0.124	23.02	0.0282	1.244978912
2	S2	38.58	0.104	19.76	0.0242	1.068439678
3	S3	45.34	0.122	22.88	0.0281	1.237488515
4	S4	42.06	0.114	21.49	0.0264	1.16237443
5	S5	48.89	0.132	24.41	0.0299	1.31997147
6	S6	40.09	0.108	20.42	0.0250	1.104151826
7	S7	61.79	0.167	31.28	0.0384	1.691793697
8	S8	32.24	0.087	16.51	0.0202	0.892903814
9	S9	56.23	0.152	28.25	0.0346	1.52776934
10	S10	35.87	0.097	17.95	0.0220	0.970978038
11	S11	49.65	0.134	25.42	0.0312	1.374939122
12	S12	50.33	0.136	25.65	0.0315	1.387008615
13	S13	60.37	0.163	29.29	0.0359	1.583971897
14	S14	41.58	0.112	20.83	0.0255	1.126576288
15	S15	36.50	0.099	18.83	0.0231	1.018249882
Average±S.D		45.7063	0.1234	23.0648	0.0283	1.247439702
N.V		370	1	55	0.07	----------

The specific activity for AL-Forat AL-Aosat hospital

The soil samples were taken from the AL-Forat AL-Aosat Hospital and the number of 15 samples, the results were calculated and included in table (3).

Were analyzed and the area under the peaks of elements was calculated (^{238}U, ^{232}Th, and ^{40}K),and through the information in table (3) we can observe the following results, the values of specific

activity for ^{238}U have been found in the range from 0.69±0.12 to 27.63±0.74 (Bq/kg) with average value 12.84±0.51 (Bq/kg), and the values of specific activity for ^{232}Th varies from 1.47±0.11 to 9.3±0.31 (Bq/kg) with average value 6.19±0.24 (Bq/kg), and the values of specific activity for ^{40}K have been found in the range from 192.88±2.27 to 338.52±3.08 (Bq/kg) with average value 254.29±2.54 (Bq/kg).

The obtained results are comparable to the worldwide average recommended by UNSCEAR 2008 which are 35, 45 and 420 Bq/kg for ^{238}U, ^{232}Th and ^{40}K respectively [17].

This difference in results is due to the same reason as in the first hospital

The results of the specific activity of ^{238}U, ^{232}Th, and ^{40}K it is noted that all the results were within the recommended level globally and that all sites are safe sites from the risk of radiation.

Table 3: Values of specific activity in AL-Forat AL-Aosat hospital

No.	Sample code	Specific activity (Bq/kg)		
		238U	232Th	40K
1	f1	1.31±0.16	1.47±0.11	**226.59±2.29**
2	f2	8.14±0.44	5.65±o.23	**324.09±2.95**
3	f3	10.8±0.51	6.99±0.26	**192.88±2.27**
4	f4	23.77±0.72	7.18±0.25	**250.96±2.48**
5	f5	0.69±0.12	4.61±0.20	**244.38±2.44**
6	f6	4.63±0.33	4.55±0.21	**287.54±2.79**
7	f7	22.34±0.69	7.37±0.25	**222.14±2.30**
8	f8	16.68±0.61	5.85±0.23	**257.27±2.56**
9	f9	12.17±0.51	5.89±0.23	**268.08±2.56**
10	f10	14.31±0.60	9.3±0.31	**338.52±3.08**
11	f11	10.98±0.51	8.49±0.29	**260.5±2.63**
12	f12	27.63±0.74	6.56±0.23	**256.69±2.41**
13	f13	11.63±0.52	7.61±0.27	**222.53±2.41**
14	f14	12.37±0.55	6.4±0.25	**229.95±2.53**
15	f15	15.13±0.58	4.87±0.21	**232.34±2.40**
Average±S.D		12.84±0.51	6.19±0.24	**254.29±2.54**
UNSCEAR 2008[17]		35.00	45.00	**420**

2 Radiological effects

Fifteen soil samples were collected from various areas within AL-Forat AL-Aosat hospital,shows the radiological risks.

Through the results and calculations reached in table (4), shows the radiological risks of (15) soil samples collected.

Below we list the highest and lowest values of the risk factors for (Req, Hex, ADrout, AEDEout, ELCR) calculated and sequenced respectively.

1. Req: The highest value 56.78 (Bq/kg) and the lowest value was 20.86 (Bq/kg) and the average is 41.2655 (Bq/kg).
2. Hex: The highest value 0.153 (Bq/kg) and the lowest value was 0.056 (Bq/kg) and the average is, 0.1115 (Bq/kg).
3. Adr out: The highest value 27.54 (Bq/kg) and the lowest value was 10.97 (Bq/kg) and the average is 20.3772 (Bq/kg).
4. AEDEout: The highest value 0.0338 (mSV/y) and the lowest value was 0.0134 (mSV/y) and the average is 0.0250(mSV/y).
5. ELCR$\times10^{-3}$: The highest value 1.489631027$\times10^{-3}$ and the lowest value was 0.593136073×10-3 and the average is, 1.102083688$\times10^{-3}$.

When we compare between the value of the world average and the results of radiological risks for the current worktable (4), we find that all results are within the allowable globally.

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When we compare between the value of the world average and the results of radiological risks for the current worktable(4),we find that all results are within the allowable globally.

Table 4: Values of (Raeq, Adr, Hex, AEDE out, and ELCRX) in AL-Forat AL-Aosat hospital

No.	Sample code	R_{eq} (Bq/kg)	H_{ex}	$(ADr)_{out}$ (nGy/h)	$AEDE_{out}$ (mSV/y)	ELCRX10^{-3}
1	f1	20.86	0.056	10.97	0.0134	0.593136073
2	f2	41.17	0.111	20.78	0.0255	1.124080516
3	f3	35.65	0.096	17.37	0.0213	0.939631786
4	f4	53.36	0.144	25.91	0.0318	1.401082092
5	f5	26.10	0.070	13.37	0.0164	0.723227221
6	f6	33.28	0.090	16.96	0.0208	0.916999804
7	f7	49.98	0.135	24.16	0.0296	1.306734082
8	f8	44.86	0.121	22.07	0.0271	1.193486064
9	f9	41.23	0.111	20.46	0.0251	1.106518444
10	f10	53.68	0.145	26.50	0.0325	1.433384012
11	f11	43.18	0.117	21.21	0.0260	1.147013153
12	f12	56.78	0.153	27.54	0.0338	1.489631027
13	f13	39.65	0.107	19.38	0.0238	1.048064468
14	f14	39.23	0.106	19.28	0.0236	1.04264977
15	f15	39.98	0.108	19.70	0.0242	1.065616805
AVERAGE		41.2655	0.111	20.3772	0.0250	1.102083688
N.V		370	1	55	0.07	----------

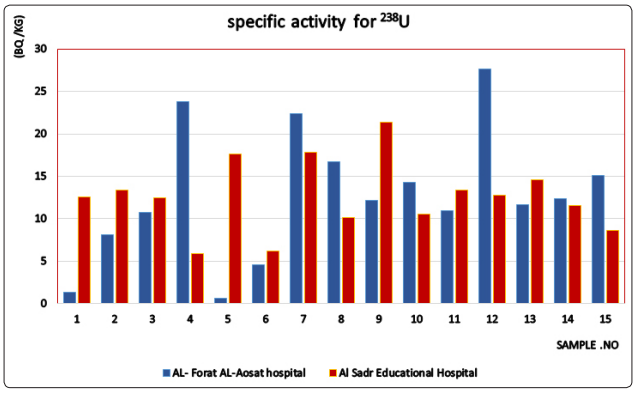

Figure 1: Comparison of Values for the specific activity for (^{238}U) in all the hospital.

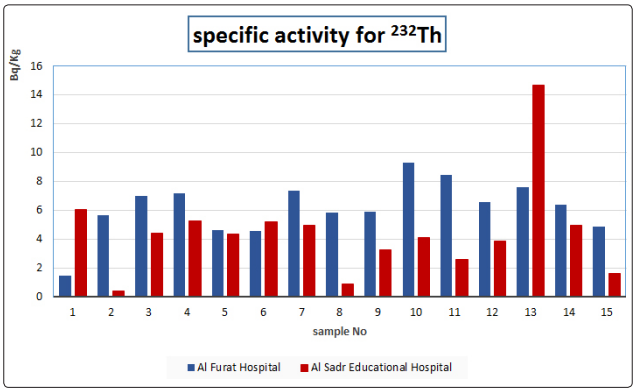

Figure 2: Comparison of Values for the specific activity for (^{232}Th) in all the hospital

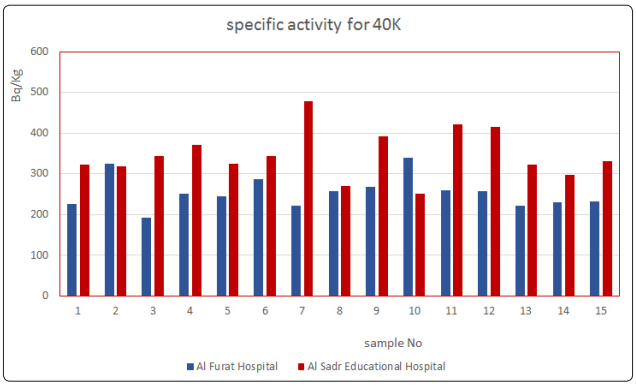

Figure 3: Comparison of Values for the specific activity for (^{40}K) in all the hospital

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