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ORIGINAL ARTICLE

The Measurement of the Total Excess Lifetime Cancer Risk in Soil Samples from Tar Al-Najaf in Al-Najaf Al-Ashraf-Iraq

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ABSTRACT
The radioactivity of the dissected earth formations of Tar Al-Najaf in Al-Najaf Al-Ashraf Governorate has been studied, which is considered one of the most important archaeological areas in the province, as Tar Al-Najaf is one of the natural phenomena prominently present in the governorate; it cuts sharply to form a rocky cliff, as well as overlooks from the southern end of a plateau Al-Najaf and on the sea of Al-Najaf, in a clear and surprising way, Al-Najaf flew, by selecting 50 sites to take samples from the region. Spectral measurements were made using a thallium-activated sodium iodide detector (NaI (TI) (3 " × 3")). It was found that the specific activity of ^{238}U, ^{232}Th and ^{40}K in the studied ranged between $(27.644 \pm 1.505)\ Bq.kg^{-1}$ to $(6.530 \pm 0.509) Bq.kg^{-1}$ with average $(15.955) Bq.kg^{-1}$, $(31.06 \pm 1.73) Bq.kg^{-1}$ to $(8.356 \pm 1.013) Bq.kg^{-1}$ with average (21.728) $Bq.kg^{-1}$ and (475.391 ± 7.870) $Bq.kg^{-1}$ to (95.173 ± 1.994) $Bq.kg^{-1}$ with average (281.197) $Bq.kg^{-1}$ respectively. The value of Absorbed Dose Rate in Air was also calculated, it was between (47.389) (nGy/h) to (16.366) (nGy/h) with average (34.950), the Annual Effective Dose in door between (0.234) (mSv/y) to (0.080) (mSv/y) with average (0.171), the Annual Effective Dose out door between (0.058) (mSv/y) to (0.020) (mSv/y) with average (0.0423),the excess lifetime cancer risk (in) between (0.0423) to (0.280) , with average (0.599), and the Excess lifetime cancer risk (out) between (0.205) to (0.070), with average (0.149). Comparing the present results with the globally considered values, it was found that the radiation levels of the studied samples are within the permissible limits.

Keywords: Natural radioactivity, gamma spectrum, NaI(TI) detector , Tar Al-Najaf area .

INTRODUCTION
The earth's crust contains small amounts of uranium, thorium, and radium, as well as many other radioactive isotopes, including potassium. Natural radioactive materials represent one of the most important sources of human exposure to radiation, although these materials contain low levels of the natural radioactive background; the cumulative dose can be high, as the rate of exposure to radiation received by humans from natural sources is greater than the rate of exposure to radiation from industrial sources [1,2]. Radiation is defined as energy emitted from a source, and transmitted through the surrounding medium, which is either a material medium or a vacuum, and an interaction may occur between this emitted energy and the surrounding medium, and then it absorbs or absorbs part of it, or penetrates it without any significant interaction between them. Radiation is classified into ionizing radiation and non-ionizing radiation [3]. This study aims at calculating the rate of the absorbed dose in the air resulting from these nuclides and also calculating the annual effective dose and calculating the lifetime probability of developing cancer resulting from exposure to radioactive elements that affect human health, which are integrated with the current and future studies, and then the results obtained will be compared for the measured models with the allowed international average.

The Area Studied: Al-Najaf Tar is considered one of the most important historical archaeological areas in the province, as it is considered one of the natural phenomena prominently present in the province, as it cuts the plateau sharply to form the rocky cliff, as well as overlooking the southern end of the Najaf plateau and the sea of Najaf in a clear and sudden way to be Al-Najaf Tar [4]. The study area consisted of rock formations, including the formation of Injanah ((Upper Miocene)) and the hole formed ((Middle Miocene)), as well as the tor of Najaf is clearly visible as the tor extends from the eastern, northeastern and northern edge of the Bahr al-Najaf depression from the west of the city of Abi Sakhir from the intersection of the point $(31^o\ 54'N - 44^o\ 29'E)$ and heads northwest and parallel to the Abu Sakhir - Najaf road to the west of the holy city of Najaf, specifically at the shrine of Safi al-Safa. Where it takes the form of an arc heading towards the west at the point $31^o\ 59'N - 44^o\ 18'E$ and its length at this point is (21) km, and then it descends south at the point $43^o\ 50'.32^o\ 07'$ and its length is (68.5) km, and the road and its hills end at the point $43^o\ 48'.32^o\ 06'$, and the total length of the AL Tar is (74.5) km, Figure (1) [5].

Figure 1: Landforms of the Tar Al-Najaf area - Al-Najaf Al-Ashraf[5]

The Method and Material of Work: The study area (Tar Al-Najaf) archaeological site in Al-Najaf Governorate was chosen for the study. The natural radioactivity of samples from the soil, and (50) samples were collected distributed along the study area, with a distance of (1km) between one sample and another, and the coordinates of the sites were recorded using the positioning device (G.P.S). After locating the site, drilling is done and the sample is extracted and placed in bags capacity (3kg) and numbered according to the location, and then transferred to the setting and measurement place in the research laboratory of the Department of Physics - College of Education for Girls, University of Kufa. In order to measure the radioactivity of the samples, the soil must be free of moisture, because measuring the specific effectiveness depends on the weight of the sample, and to get rid of this moisture, the samples must be dried by exposing it to the sun for about 2 to 3 days in an open area so that it reaches a constant weight, and then the samples are ground and then sift them using a clamp with very small holes of approximately (0.5 mm) to remove the pebbles attached to it to obtain a homogeneous soil free of impurities. It is then weighed by (1kg) using a sensitive balance and placed in special containers for measurement called (Marnelli Baker) after washing it with dilute hydrochloric acid, then washed with distilled water to prepare it for measurement. It is a cylindrical container that contains a hole in its center to place the reagent crystal in it so that the sample surrounds the crystal, which allows for high measurement efficiency. These containers are tightly wrapped with adhesive tape with special information written on it. The samples are left stored in these containers for a month to obtain a state of radioactive equilibrium, after which the natural radioactivity of the isotopes ^{238}U, ^{232}Th, and ^{40}K, is measured by a gamma-ray detection system using a sodium iodide detector with Thallium NaI(TI).

Calculation of Specific Activity: When uranium ^{238}U is balanced with its radioactive offspring and thorium ^{232}Th and its offspring, given that the activity of all the elements of the two radiation chains is in balance, so it is possible to calculate the concentration of an element in any chain in terms of the concentration of another element. Since a group of gamma rays is emitted whose returns can be distinguished, the concentration of the activity of each of ^{232}Th is by calculating the activity concentration of thallium ^{208}Tl radionuclides with energy $(2614.511 keV)$ and ^{238}U by calculating the activity concentration of bismuth nuclides ^{214}Bi with energy of $(1764.539 keV)$, as well as calculating the concentration of potassium radioactive nuclide ^{40}K with energy of $(1460.822 keV)$ through equation (1) [6].

$$A = \frac{N_{net}}{\varepsilon . I_{\gamma} . m . t} \pm \frac{\sqrt{N_{net}}}{\varepsilon . I_{\gamma} . m . t} \ldots (1)$$

Where N_{net}: is the net area under the curve of the optical peak after subtracting the radioactive background from it

ε: the calculated efficiency of the photo peak at a given energy

I_{γ} : The intensity of the gamma rays

m : mass of the model (kg)

t : measurement time (sec)

Absorbed Dose Rate in Air 3.2: It is possible to calculate the total percentage of the dose absorbed in the air in terms of the concentrations of ground cores through the following equation:

$$AD\left(\frac{nGy}{h}\right) out = 0.463A_U + 0.599A_{Th} + 0.0417A_K \ldots\ldots (2)$$

$$AD\left(\frac{nGy}{h}\right) in = 0.92A_U + 1.14A_{Th} + 0.081A_K \ldots\ldots (3)$$

$$AD\ total = (AD)out + (AD)in \ldots\ldots (4)$$

Since $(0.462, 0.621, 0.0417)$ are the conversion factors for naturally occurring radionuclides [7]

The Annual Effective Dose 3.3: To calculate the annual effective dose, the conversion factor must be taken into account (from the absorbed dose to the effective dose and the internal occupancy factor), and to calculate the effective dose of the gamma-ray emitting element in the air, UNSCER 2000 has published the conversion constant 0.7Sv/Gy as a conversion factor of the absorbed dose in air to the annual effective dose received by adults and used 0.80 which is the ratio of time spent indoors and 0.02 is the ratio of time spent outdoors. From these data, it was found that the annual effective dose is calculated as follows [8,9]:

$$AEDE_{in}\left(\frac{mSv}{y}\right) = ADin \times 10^{-6} \times 8760h \times 0.8 \times 0.7SvG/y \ldots (5)$$

$$AEDE_{out}\left(\frac{mSv}{y}\right) = ADout \times 10^{-6} \times 8760h \times 0.2 \times 0.7SvG/y \ldots (6)$$

$$AEDE\ total = (AEDE)out + (AEDE)in \ \ldots\ldots (7)$$

As 8760 refers to the number of hours in a year.

Excess Lifetime Cancer Risk ELCR 3.4: To calculate the lifetime probability of developing cancer resulting from exposure to natural radioactive elements ^{238}U, ^{232}Th, and ^{40}K, the following equation is used: [10]

$$ELCR_{in} = AEDE_{in} \times E_{LD} \times C_{RF} \ldots (8)$$

$$ELCR_{out} = AEDE_{out} \times E_{LD} \times C_{RF} \ldots (9)$$

$$ELCR_{total} = ELCR_{in} + ELCR_{out} \ldots (10)$$

Where $AEDE_{in}$ and $AEDE_{out}$: is the annual effective dose coefficient

ELD: Mean life expectancy (70 years)

CRF: fatal risk factor per Sv which is equal to 0.05 for the general population according to ICRP. [11]

CONCLUSIONS AND RESULTS

The specific activity of ^{238}U, ^{232}Th and ^{40}K radionuclides in fifty soil samples from Tar al-Najaf ground shapes has been calculated using equation (1) after preparing the samples for measurement with (NaI (TI) (3" × 3")) detector. The specific activity of ^{238}U, ^{232}Th and ^{40}K has been explained in table (1) and figure (1), whereas the Absorbed Dose Rate in Air and Annual Effective Dose have been shown in table (2). The Excess Lifetime Cancer Risk Dose has been shown in table (3). The obtained results were compared with the permissible global average, they were within the acceptable worldwide limit [12-14].

Table 1: The specific activity of ^{238}U, ^{232}Th and ^{40}K radionuclides in fifty soil samples from Tar al-Najaf ground shapes with their locations.

No. Sample	Locations		Specific Activity Concentrations Bq/kg		
	Longitude (°E)	Latitude (°N)	^{238}U	^{232}Th	^{40}K
S1	44°20′19″	31°58′0.4″	15.048±0.819	18.069±0.893	163.513±2.767
S2	44°20′16″	31°58′05″	12.630±0.741	19.132±0.907	151.345±2.629
S3	44°20′12 ″	31°58′07″	8.639±0.635	18.990±0.936	140.288±2.621
S4	44°20′07″	31°58′09″	13.824±0.838	22.528±1.064	155.127±2.876
S5	44°20′08″	31°58′12″	6.649±0.514	16.783±0.813	130.351±2.333
S6	44°20′06″	31°58′11″	12.703±0.738	15.923±0.822	134.098±2.457
S7	44°20′04 ″	31°58′13″	13.582±0.718	14.981±0.750	116.961±2.160
S8	44°18′27″	31°59′20″	6.530±0.509	16.586±0.808	95.173±1.994
S9	44°18′26″	31°59′23″	8.240±0.594	20.041±0.922	152.155±2.617
S10	44°18′24″	31°59′25″	17.367±0.822	27.239±1.024	144.309±2.428
S11	44°17′12 ″	32°00′51″	17.501±0.754	18.281±0.767	124.273±2.059
S12	44°17′11 ″	32°00′53 ″	7.313±0.488	19.834±0.800	126.069±2.078
S13	44°17′09″	32°00′56″	19.219±1.256	30.960±1.586	411.147±5.952
S14	44°17′07″	32°00′58″	22.404±1.376	29.277±1.564	404.507±5.990
S15	44°17′05″	32°00′58″	27.644±1.505	28.650±1.524	387.227±5.773
S16	44°17′04″	32°01′00″	24.878±1.463	29.128±1.575	448.723±6.366
S17	44°17′04″	32°01′02″	25.264±1.470	22.962±1.394	460.688±6.433
S18	44°17′04″	32°01′03″	19.461±1.258	21.429±1.313	293.125±5.004
S19	44°17′00 ″	32°01′02″	19.877±1.302	22.620±1.381	330.284±5.437
S20	44°17′00″	32°01′11″	0.8959.600±	17.840±1.213	343.962±5.488
S21	44°16′58″	32°01′13″	18.134±1.329	31.060±1.730	397.415±6.376
S22	44°16′55″	32°01′11″	14.293±1.239	27.007±1.694	145.681±4.052
S23	44°16′53 ″	32°01′13″	18.942±1.367	18.546±1.345	407.950±6.498
S24	44°16′56″	32°01′15″	9.396±0.996	18.803±1.401	378.087±6.471
S25	44°16′53″	32°01′17 ″	11.832±15.319	28.039±1.742	395.624±6.739
S26	44°16′50″	32°01′15 ″	20.499±1.572	23.741±1.682	443.065±7.487
S27	44°16′48″	32°01′17 ″	20.888±1.310	18.794±1.236	307.773±5.153
S28	44°16′50″	32°01′19 ″	14.897±1.250	25.534±1.628	395.944±6.601
S29	44°16′48″	32°01′21 ″	16.182±1.304	20.688±1.466	375.625±6.435
S30	44°16′45″	32°01′20 ″	21.735±1.643	8.356±1.013	475.391±7.870
S31	44°16′44″	32°01′21 ″	23.195±1.705	19.847±1.569	429.115±7.513
S32	44°16′41″	32°01′23 ″	9.187±1.075	31.503±1.980	578.114±8.737
S33	44°16′43″	32°01′26 ″	20.517±1.525	23.552±1.625	400.812±6.904
S34	44°16′41″	32°01′28 ″	22.104±1.582	20.411±1.513	401.525±6.910
S35	44°16′40″	32°01′30 ″	19.434±1.402	22.132±1.488	519.768±7.429
S36	44°16′37″	32°01′28 ″	20.633±1.591	23.695±1.696	549.480±8.414
S37	44°16′34″	32°01′32 ″	19.107±1.465	20.349±1.504	420.169±7.039
S38	44°16′37″	32°01′33 ″	18.786±1.449	28.986±1.790	454.529±7.302
S39	44°16′39″	32°01′37 ″	22.933±1.646	21.052±1.569	406.330±7.099
S40	44°16′38″	32°01′38 ″	23.451±1.692	25.981±1.771	420.209±7.338
S41	44°18′26″	31°59′25 ″	21.625±1.544	21.395±1.528	451.131±7.226
S42	44°18′27″	31°59′23 ″	14.507±1.099	12.456±1.013	267.248±4.835
S43	44°18′28″	31°59′20 ″	10.913±1.059	18.538±1.374	340.161±6.061
S44	44°18′29″	31°59′18 ″	18.933±1.583	23.972±1.772	482.179±8.184
S45	44°18′30″	31°59′17 ″	17.262±1.202	26.447±1.480	271.942±4.889
S46	44°18′31″	31°59′16 ″	11.015±1.075	27.299±1.683	430.949±6.887
S47	44°18′32″	31°59′15 ″	2.454±0.455	15.746±1.148	137.140±3.490
S48	44°18′33″	31°59′14 ″	24.985±1.707	22.641±1.617	514.627±7.939
S49	44°18′34″	31°59′13 ″	12.102±0.991	30.779±1.572	263.856±4.742
S50	44°18′35″	31°59′12 ″	20.514±1.606	23.160±1.698	387.302±7.151
Max.			27.644±1.505	31.060±1.730	578.114±8.737
Min.			6.530±0.509	8.356±1.013	95.173±1.994
Ave.			16.967	22.682	332.990
W. Ave.			33	45	420
Global range			(15-50)	(7-50)	(100-700)

Table 2: The Absorbed dose rate in air, Annual effective dose and Excess lifetime cancer risk in fifty soil samples from Tar al-Najaf ground shapes.

No. Sample	AD (nGy/h) in door	AD (nGy/h) out door	AD (nGy/h) total	AEDE (mSv/y) in door	AEDE (mSv/y) out door	AEDE (mSv/y) total
S1	46.966	24.203	71.169	0.118	0.029	0.148
S2	44.924	23.278	68.202	0.114	0.028	0.142
S3	40.201	20.992	61.194	0.102	0.025	0.128
S4	50.064	25.990	76.055	0.127	0.031	0.159
S5	35.137	18.388	53.525	0.090	0.022	0.112
S6	40.064	20.668	60.733	0.101	0.025	0.126
S7	38.449	19.773	58.222	0.096	0.024	0.121
S8	31.961	16.751	48.7128	0.082	0.020	0.102
S9	41.951	21.942	63.894	0.107	0.026	0.134

S10	57.630	29.906	87.536	0.146	0.036	0.183
S11	46.277	23.763	70.040	0.116	0.029	0.145
S12	38.758	20.327	59.085	0.099	0.024	0.124
S13	85.041	44.070	129.111	0.216	0.054	0.270
S14	85.582	44.173	129.756	0.216	0.054	0.270
S15	88.313	45.361	133.675	0.222	0.055	0.278
S16	91.276	47.007	138.284	0.230	0.057	0.288
S17	85.817	43.980	129.797	0.215	0.053	0.269
S18	65.219	33.544	98.764	0.164	0.041	0.205
S19	69.922	35.988	105.911	0.176	0.044	0.220
S20	56.317	29.215	85.533	0.143	0.035	0.179
S21	83.040	43.084	126.125	0.211	0.052	0.264
S22	54.657	28.483	83.141	0.139	0.034	0.174
S23	70.871	36.379	107.251	0.178	0.044	0.223
S24	59.953	31.126	91.079	0.152	0.038	0.190
S25	76.982	39.972	116.954	0.196	0.049	0.245
S26	80.862	41.634	122.497	0.204	0.051	0.255
S27	64.821	33.199	98.020	0.162	0.040	0.203
S28	73.865	38.301	112.167	0.187	0.046	0.234
S29	68.071	35.111	103.182	0.172	0.043	0.215
S30	67.695	34.305	102.001	0.168	0.042	0.210
S31	77.930	39.895	117.826	0.195	0.048	0.244
S32	89.933	46.983	136.917	0.230	0.057	0.288
S33	77.249	39.767	117.016	0.195	0.048	0.243
S34	75.312	38.607	113.920	0.189	0.047	0.236
S35	84.327	43.405	127.733	0.212	0.053	0.266
S36	89.556	46.103	135.659	0.226	0.056	0.282
S37	73.996	38.041	112.038	0.186	0.046	0.233
S38	85.986	44.508	130.494	0.218	0.054	0.272
S39	77.169	39.553	116.723	0.194	0.048	0.242
S40	84.191	43.310	127.501	0.212	0.053	0.265
S41	79.972	41.056	121.029	0.201	0.050	0.251
S42	48.695	24.930	73.626	0.122	0.030	0.152
S43	57.986	30.047	88.033	0.147	0.036	0.184
S44	82.844	42.721	125.565	0.209	0.052	0.261
S45	67.001	34.708	101.709	0.170	0.042	0.212
S46	75.070	39.125	114.196	0.191	0.047	0.239
S47	30.687	16.221	46.908	0.079	0.019	0.099
S48	89.576	45.915	135.492	0.225	0.056	0.281
S49	66.364	34.716	101.081	0.170	0.042	0.212
S50	75.721	38.968	114.689	0.191	0.047	0.238
Max.	91.276	47.007	138.284	0.230	0.057	0.288
Min.	30.687	16.221	46.908	0.079	0.019	0.099
Ave.	66.605	34.390	100.995	0.168	0.042	0.210
W. Ave.	84 [12]	59 [12]	143 [14]	0.41 [14]	0.07 [12]	0.48 [12]

Table 3: The Excess lifetime cancer risk in fifty soil samples from Tar al-Najaf ground shapes.

No. Sample	ELCR (In door)	ELCR (Out door)	ELCR (Total)
S1	0.415	0.103	0.519
S2	0.399	0.099	0.499
S3	0.360	0.090	0.450
S4	0.446	0.111	0.557
S5	0.315	0.078	0.394
S6	0.354	0.088	0.443
S7	0.339	0.084	0.424
S8	0.287	0.071	0.359
S9	0.376	0.094	0.470
S10	0.513	0.128	0.641
S11	0.408	0.102	0.510
S12	0.349	0.087	0.436
S13	0.756	0.189	0.945
S14	0.758	0.189	0.948
S15	0.778	0.194	0.973
S16	0.807	0.201	1.008
S17	0.755	0.188	0.943
S18	0.575	0.143	0.719
S19	0.617	0.154	0.772
S20	0.501	0.125	0.627
S21	0.739	0.184	0.924
S22	0.489	0.122	0.611
S23	0.624	0.156	0.780
S24	0.534	0.133	0.668
S25	0.686	0.171	0.857
S26	0.714	0.178	0.893
S27	0.570	0.142	0.712
S28	0.657	0.164	0.822
S29	0.602	0.150	0.753
S30	0.589	0.147	0.736
S31	0.684	0.171	0.856
S32	0.806	0.201	1.008
S33	0.682	0.170	0.853
S34	0.662	0.165	0.828
S35	0.745	0.186	0.931
S36	0.791	0.197	0.989
S37	0.653	0.163	0.816
S38	0.764	0.191	0.955
S39	0.679	0.169	0.848
S40	0.743	0.185	0.929
S41	0.704	0.176	0.881
S42	0.428	0.107	0.535
S43	0.515	0.128	0.644
S44	0.733	0.183	0.916
S45	0.595	0.148	0.744
S46	0.671	0.167	0.839
S47	0.278	0.069	0.348
S48	0.788	0.197	0.985
S49	0.596	0.149	0.745
S50	0.669	0.167	0.836
Max.	0.807	0.201	1.008
Min.	0.278	0.069	0.348
Ave.	0.590	0.147	0.738
W. Ave.	1.16 [13]	0.29 [14]	1.45 [14]

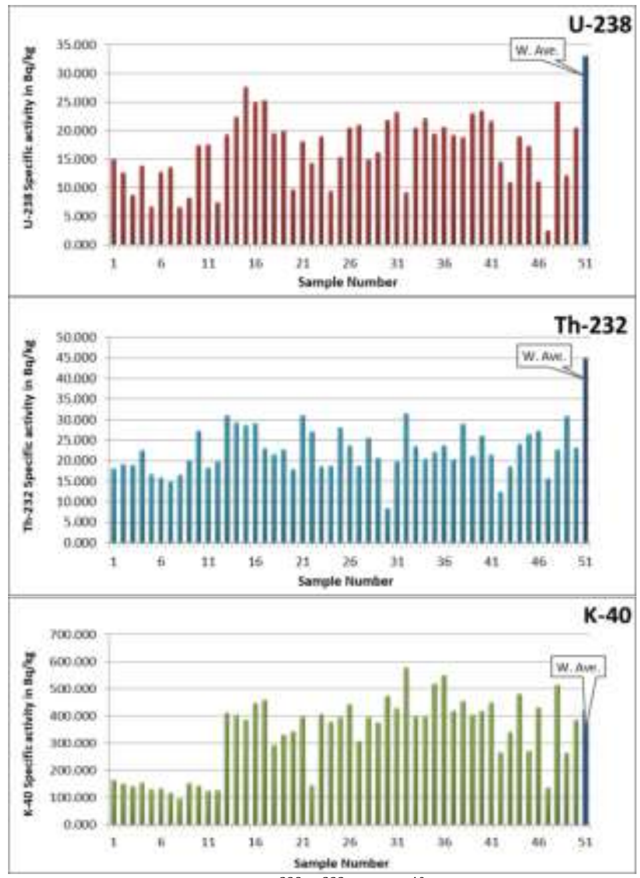

Figure 1: The specific activity of ^{238}U, ^{232}Th and ^{40}K radionuclides in fifty soil samples from Tar al-Najaf ground shapes.

DISCUSSION

The concentration of the radionuclides' has been varied from one location to another depending on the natural distribution of radionuclides, i.e. it is of random origin, and that the concentrations are within the global average [13-16], stating that they do not pose a threat to human health, especially as they are considered archaeological and wonderful tourism areas that reflect the history of the formation of landforms as it is considered one of the prominent geological features within this region of the governorate Najaf, which could continue to be an important area for tourists which is an important pillar and a real treasure for Iraq. Therefore, it must be preserved and taken into account to make it one of the important urban areas. It is clear that the highest value of the specific activity of uranium ^{238}U was $(27.644 \pm 1.505)\ Bq/kg$ in sample (15), and the lowest value was $(6.530 \pm 0.509)\ Bq/kg$ in sample (8) and the average of these values was $15.955)\ Bq/kg)$.

It was found that the highest value of the specific activity of thorium- ^{232}Th was (31.060 ± 1.730) Bq / kg in sample (21), and the lowest value was (8.356 ± 1.013) Bq /kg in sample (30), and the average of these values was (21.728) Bq / kg. For potassium ^{40}K, the highest value of specific activity was (475.391 ± 7.870) Bq / kg in model (30), and the lowest value was (95.173 ± 1.994) Bq /kg in sample (8), and the average of these values was (281.197) Bq /kg. As for the highest value of Absorbed Dose Rate in Air in door, it was (91.276) (nGy/h) in sample (16), and the lowest value was (30.687) (nGy/h) in sample (47), and the average of these values was (66.605). As for the highest value of Absorbed Dose Rate in Air out door, it was (47.007) (nGy/h) in sample (17), and the lowest value was (16.221) (nGy/h) in sample (47), and the average of these values was (34.390). As for the highest value of Absorbed Dose Rate in Air total, it was (138.284) (nGy/h) in sample (16), and the lowest value was (46.908) (nGy/h) in sample (47), and the average of these values was (100.995). The highest value of the Annual Effective Dose in door was (0.230) (mSv/y) in sample (32), and the lowest value was (0.079) (mSv/y) in sample (47), and the average of these values was (0.168). As for the highest value of the Annual Effective Dose out door, it was (0.057) (mSv/y) in sample (16), and the lowest value was (0.019) (mSv/y) in sample (47), and the average of these values was (0.042). The highest value of the Annual Effective Dose total was (0.288) (mSv/y) in sample (32), and the lowest value was (0.099) (mSv/y) in sample (47), and the average of these values was (0.210). The highest value of the excess lifetime cancer risk (in) was (0.807), and the lowest value was (0.278), and the average of these values was (0.590). The highest value of the excess lifetime cancer risk (out) was (0.201), and the lowest value was (0.069), and the average of these values was (0.147). As for the highest value of the excess lifetime cancer risk (total) was (1.008), and the lowest value was (0.348), and the average of these values was (0.738).

REFERENCES

1 Maher O. G. and Abu Saleh R. M. ," Radiation measurements in soil in the middle of Gaza-strip using nuclear track detectors CR-39 ", Journal Al-Aqsa University , Vol.10, pags 273-280 ,2006 .

2 United Nations Scientific Committee on the Effects of Ionizing Radiation Report, "Sources and Effects of Ionizing Radiation", United Nations, New York , 2000 .

3 Ali Hussein Shalash, Geography of Soil, 2nd Edition, Dar Al-Masra for Publishing and Distribution, Amman, 2009.

4 Musa Jaafar Al-Attiyah, “The Land of Najaf: History and Geological Heritage,” Najaf Heritage, Issue 1,

5 Ayed Jassem Al-Zamili and Montaser Sabah Al-Hasnawi, “Geography and Geomatics,” Journal of the Geographical and Cartographic Research Center, Issue 32, 2021.

6 Heiyam N. , Ali K. and Hussein J. , " Measurement Natural Radioactivity in Soil Samples from Important historical locals in Alnajaf Alashraf city, Iraq", Journal of Advances in Chemistry, Vol.(8) , No.(1) , PP:1472-1478 , (2014).

7 International Atomic Energy Agency Vienna، "Radiation Oncology Physics"، A Handbook for teachers and students، (2005).

8 Jean. G. Interaction of photons with matter. Postfach 2340، 76125 Karlsruhe، Germany; (2007).

9 Serway M. ,"Modern Physics",3ed Edition, Thomson Learning, Inc, United States of America, (2005).

10 Jevremovic T., “Nuclear principles in engineering”, Springer science, Business Media Inc., United States of America , (2005).

11 Gordon R.G., “Practical Gamma-ray Spectrometry”, 2nd Edition, John Wiley & Sons , New York, (2008).

12 United Nation Scientific Committee on the Effects of Atomic. (UNSCEAR). Radiation Sources and effects of ionizing radiation. New York, USA: United NationsReport of the United Nations Scientific Committee on the Effect of Atomic Radiation to General Assembly, 2000.

13 Taskin H. , Karavus M. , Ay P. , Topuzoglu A. , Hindiroglu S. and Karahan G. , "Radionuclide concentrations in soil and lifetime cancer risk due to the gamma radioactivity in Kirklareli , Turkey " , Environ Radioact , 100:49-53 , 2009 .

14 R. S. Mohammed and R. S. Ahmed , "Estimation of excess lifetime cancer risk and radiation hazard indices in southern Iraq " , Environ Earth Sci , 2017 .