International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

The Study of Radioactivity in Soil Samples from AL-Haidriya City in Al-Najaf Al-Ashraf Governorate, the first depth (10-20) cm and a Second Depth (30-40) cm

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Abstract: ***To study the radioactivity of the soil City Alhaidariya in Al-Najaf Al-Ashraf Governorate was chosen (30) sampling sites of the city and collect from each site two samples the first depth (10-20) cm and a second depth (30-40) cm to reach (60) sample and The gamma rays spectral measurements were done for all samples by using Iodide Sodium activated by Thallium NaI(Tl), its dimension 3"× 3". The mean values activity concentrations of 238U, 232Th and 40K was (12.51±3.58, 10.62±2.55 and 72.35±3.88) Bq/ kg respectively, specific activity for all soil sample were in the worldwide average. The average values of the Radium equivalent activity and absorbed dose rate were (33.34±6.34Bq/kg and 15.51±2.90nGy/h)within the world average. The heist external and internal hazard and the outdoor and indoor annual effective dose and gamma activity concentration index were (0.0900±0.0173, 0.0331±0.0269, 0.0189±0.0034 mSv/yr , 0.0760±0.0142 mSv/yr and 0.2384±0.0446)respectively, lower than unity.***

Keywords: gamma rays, spectral measurements, radioactivity, Governorate, soil

1. Introduction

Alhaidariya City is one of the important cities in Al-Najaf Al-Ashraf Governorate because contain a number of the population and schools, hospitals and government departments, sports arenas and mosques. The natural radioactivity in the soil caused by a series of uranium ^{238}U and ^{232}Th series thorium and potassium ^{40}K[1],And environmental radioactivity and external exposure associated with him through the Kama radiation depends mainly on geological and geographical conditions and shows the different levels in the soil of each region of the world[2].The level of main natural radioactivity on the surface of the earth are very few and it changed strongly depending on the location, where decrease at the surface of the oceans and increase in areas that contain rocks on a large amount of radioactive material. As the level of radiation, which are exposed to human consists of three sections, the Kama radiation resulting from radioactive materials in the ground, and the radiation resulting from the effects of radioactive elements in human tissue, and resulting from the foods we eat, as well as cosmic rays[3].

2. Experimental Procedures

The soil samples measured at (10-20)cm and (30-40)cm depth level .The location of the samples is shown on table (1) and figure (1) after collection, samples are crushed into fine powder by grinder ,fine quality of the sample is obtained using scientific sieve .before measurement samples are dried in an oven at a temperature of 60 C° for 72 h, each sample is packed and sealed in an airtight PVC container and kept for about (4) weeks period to allow radioactive equilibrium among the daughter products of radon (^{222}Rn), thoron (^{220}Rn) and their short lived decay products . an average (1) kg of soil is used per sample.

To measured the specific activity we used NaI(Tl) a system which consist of a scintillation detector NaI(Tl) of (3"×3") crystal dimension, supplied by (Alpha Spectra, Inc), coupled with a multi-channel analyzer (MCA) (ORTEC –Digi Base) with range of 4096 channel joined with ADC (Analog to Digital Convertor) unit, through interface. The spectral data was converted directly to the PC of the laboratory introduced by using (MAESTRO-32) software. The detector was enclosed in a graded lead shield. The gamma spectra of the collected samples were measured and the activities of 238U series, 232Th series and 40K in each sample were determined by measuring the characteristic gamma-peaks of their daughters. The line at 1764 keV of 214Bi was used to determine 238U series activity, and the line at 2614 keV of 208Tl for 232Th series. Also the peak at 1460 keV was used for 40K activity [4,5].

Table 1: represents the symbols studied sites in Al-haidariya city

Sample No.	Samples Nam
1	AL-Haidariya advisory
2	AL-Shemous elementary school
3	One of the homes of citizens
4	Khan AL-Nass (archaeological)
5	Al-Haidariya Mosque
6	Municipality Directorate Al-haidariya
7	General Hospital Al-haidariya
8	AL-Kazimi School
9	AL-Fatimyat School
10	One of the homes of citizens
11	The Department of Water Project Al-Haidariya
12	FatemaALKubra School
13	AL-Zanabeq Kindergarten
14	AL-Emam AL-Hussain Mosque

15	AlbuForaiha Mosque
16	One of the shops
17	Al-Haidariya Court
18	Directorate of Agriculture Al-Haidariya
19	Versus Hussienieh Zahra
20	KuramaaAL_Arab School for Boys
21	Goods Ala
22	Versus market Al-Haidariya
23	AL- Issawi for Construction Materials
24	Versus Advisory
25	One of the houses nearby
26	One of the houses nearby
27	Police station Al-Haidariya
28	One of the mosques
29	Park of Al-Zahra neighborhood
30	Mosque of Imam Ali

Figure 1: is Al-haidariya map indicating the locations models

Radium equivalent activity (Ra_{eq}):
Distribution of ^{238}U, ^{232}Th and ^{40}K in environment is not uniform, so that with respect to exposure to radiation, the radioactivity has been defined in terms of radium equivalent activity (Ra_{eq}) in Bq/kg [2]

$$Ra_{eq}\left(\frac{Bq}{kg}\right) = A_U + 1.43A_{Th} + 0.077A_K \quad (1)$$

Where A_U ,A_{Th} and A_K are specific activity concentration in Bq/kg of ^{238}U ^{232}Th and ^{40}K, respectively. The index is useful to compare the specific activity of materials containing different concentrations of ^{238}U,^{232}Th and ^{40}K.

The absorbed dose rate(AD):
The total dose rate D in the air was estimated by [6]:

$$AD(nGr/h) = 0.427A_U + 0.662A_{Th} + 0.043A_K \quad (2)$$

The Annual Effective Dose:
The annual effective dose equivalent was given by the following equation [7]

Indoor (mSv\y) =

$$A\ D\ (nGy/h)\times 8760\ h\times 0.8\times 0.7\ Sv/Gy\times 10^{-6} \quad (3)$$

Outdoor (mSv\y) =

$$A\ D\ (nGy/h\ )\times 8760h\times 0.2\times 0.7\ Sv/Gy\times 10^{-6} \quad (4)$$

External Hazard Index(H_{ex}):
The external hazard index (Hex) was given by the following equation[8]

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (5)$$

Internal Hazard Index (H_{in}):
The internal exposure to ^{222}Rn and its radioactive progeny is controlled by the internal hazard index (Hin) is given by[9]

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (6)$$

Activity Concentration Index (I_γ):
The activity Concentration Index (I_γ) was given by the following equation [10]

$$I_\gamma = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_k}{1500} \quad (7)$$

3. Results and Discussions

The specific activity values of ^{238}U ,^{232}Th and ^{40}K radionuclides for 30 soil sample are tabulated in table(2). They have been found to lie in the range of (3.65±1.33;17 to 20.92±3.30;19) Bq/kg with an average of 9.37±4.41Bq/kg, from (1.98±1.14;12 to 15.87±3.24;4) Bq/kg with an average 7.66±2.18Bq/kg and (30.61±2.57;18 to 152.43±5.75;5) Bq/kg with an average 67.32±3.71Bq/kg for ^{238}U ,^{232}Th and ^{40}K respectively .The result shows that all values of ^{238}U ,^{232}Th and ^{40}K specific activity for all soil sample are in the worldwide average (35Bq/kg for ^{238}U , 30 Bq/kg for ^{232}Th and 400 Bq/kg for^{40}K) [10,11]. The radium equivalent activities was calculated and listed in table (2) .Ra eq values vary from (13.74±4.12;11 to 48.72±8.08;19) Bq/ kg with average value of (25.61±5.39) Bq/kg .The absorbed dose rate(AD)calculated and listed in table (2) range from (6.56±1.88;11 to 22.47±3.65;19) nGy/h with average 12.02±2.52nGy/h.It can seen be that the Ra eq values and absorbed dose rate(AD) for all samples are lower than the recommended worldwide [10,11].

Table 2: The absorbed dose rate, Radium equivalent Ra_{eq} and Activity concentration of (238U, 232Th and 40K) for samples in depth (10-20) cm

Sample No.	absorbed dose rate(AD)(nGy/h)	Ra_{eq}(Bq/Kg)	^{232}Th(Bq/Kg)	^{238}U(Bq/Kg)	^{40}K(Bq/Kg)
1	10.13±2.44	21.86±5.39	6.61±2.09	8.89±2.15	45.60±3.14
2	11.90±2.32	26.03±5.18	2.64±1.32	17.26±3.01	64.99±3.74
3	8.93±2.18	19.31±4.84	3.96±1.62	9.94±2.28	47.99±3.22
4	20.75±3.61	45.35±7.99	15.87±3.24	18.13±3.09	56.45±3.50
5	17.82±2.95	37.01±6.49	9.25±2.47	12.03±2.50	152.43±5.75
6	14.15±2.90	30.17±6.35	15.21±3.17	4.70±1.56	48.20±3.23
7	16.21±2.90	34.36±6.41	7.27±2.19	16.21±2.91	104.20±3.23
8	9.03±1.97	18.58±4.34	3.30±1.47	6.80±1.88	91.63±4.46
9	13.40±2.71	28.23±5.96	9.25±2.47	8.37±2.09	85.99±4.32
10	16.31±3.12	35.08±6.87	11.90±2.80	12.55±2.56	71.44±3.93
11	6.56±1.88	13.74±4.12	4.62±1.74	3.66±1.38	44.94±3.12
12	8.02±1.80	16.70±3.98	1.98±1.14	7.84±2.02	78.17±4.12
13	9.48±2.27	20.04±5.01	5.95±1.98	6.80±1.88	61.45±3.65
14	12.75±2.62	26.62±5.73	9.92±2.56	5.75±1.73	86.85±4.34
15	14.16±2.84	30.62±6.28	7.93±2.29	14.12±2.71	66.88±3.81
16	13.69±2.67	28.89±5.88	7.27±2.19	10.98±2.39	97.50±4.60
17	12.19±2.60	25.61±5.68	11.90±2.80	3.65±1.33	64.05±3.72
18	8.68±2.16	18.53±4.78	4.62±1.74	6.80±1.88	30.61±2.57
19	22.47±3.65	48.72±8.08	14.55±3.10	20.92±3.30	90.76±4.43
20	7.78±1.98	16.17±4.35	4.62±1.74	4.70±1.56	62.97±3.69
21	9.84±2.39	20.93±5.26	7.93±2.29	5.75±1.73	49.72±3.28
22	7.84±1.89	16.21±4.15	3.30±1.47	5.75±1.73	74.48±4.02
23	9.81±2.46	21.23±5.44	7.93±2.29	7.32±1.95	33.22±2.68
24	12.58±2.81	27.25±6.20	11.24±2.72	8.37±2.09	36.48±2.81
25	9.66±2.34	20.43±5.13	7.27±2.19	5.76±1.83	55.59±3.47
26	9.74±2.26	20.59±4.99	5.29±1.87	7.84±2.02	67.31±3.82
27	15.81±3.05	34.32±6.76	9.92±2.56	15.17±2.81	64.49±3.74
28	8.87±2.12	18.62±4.68	4.62±1.74	6.80±1.88	67.53±3.82
29	12.53±2.74	27.12±6.06	8.59±2.38	10.98±2.39	49.94±3.29
30	9.54±2.23	20.10±4.92	5.29±1.87	7.32±1.95	67.75±3.83
Min.	6.56±1.88	13.74±4.12	1.98±1.14	3.65±1.33	30.61±2.57
Max.	22.47±3.65	48.72±8.08	15.87±3.24	20.92±3.30	152.43±5.75
Average	12.02±2.52	25.61±5.39	7.66±2.18	9.37±4.41	67.32±3.71

The specific activity values of ^{238}U ,^{232}Th and ^{40}K radionuclides for 30 soil sample are tabulated in table(3). They have been found to lie in the range of (1.04±0.73;3 to 35.05±4.28;4) Bq/kg with an average of 15.66±2.76Bq/kg, from (5.95±1.98;22 to 29.10±4.38;25) Bq/kg with an average 13.59±2.93Bq/kg and (40.17±2.95;24 to 152.43±5.75;5) Bq/kg with an average 77.39±4.05Bq/kg for ^{238}U ,^{232}Th and ^{40}K respectively .The result shows that all values of ^{238}U ,^{232}Th and ^{40}K specific activity for all soil sample are in the worldwide average (35Bq/kg for ^{238}U , 30 Bq/kg for ^{232}Th and 400 Bq/kg for^{40}K) [10,11]. The radium equivalent activities was calculated and listed in table (3) .Ra eq values vary from (18.13±4.53;11 to 72.80±9.91;5) Bq/ kg with average value of (41.07±7.30) Bq/kg .The absorbed dose rate(AD)calculated and listed in table (3) range from (8.72±2.09;3 to 34.09±4.51;5) nGy/h with average 19.01±3.28nGy/h.It can seen be that the Ra eq values and

absorbed dose rate(AD) for all samples are lower than the recommended worldwide [10,11].

Table 3: The absorbed dose rate, Radium equivalent Ra_{eq} and Activity concentration of (238U, 232Th and 40K) for samples in depth (30-40)cm

Sample No.	absorbed dose rate(nGy/h)	Ra_{eq}(Bq/Kg)	^{232}Th(Bq/Kg)	^{238}U(Bq/Kg)	^{40}K(Bq/Kg)
1	19.76±3.50	43.22±7.74	13.88±3.03	18.83±3.13	58.84±3.57
2	23.72±3.17	50.62±8.17	17.19±3.37	16.74±2.95	120.73±5.12
3	8.72±2.09	18.13±4.53	9.25±2.47	1.04±0.73	49.94±3.29
4	26.42±3.98	58.95±8.87	13.88±3.03	35.05±4.28	52.55±3.37
5	34.09±4.51	72.80±9.91	28.43±4.33	20.40±3.26	152.43±5.75
6	27.65±4.20	60.35±9.28	23.14±3.91	21.97±3.39	68.61±3.86
7	22.98±3.51	49.98±7.81	9.92±2.56	27.20±3.77	111.61±4.92
8	15.42±2.93	33.38±6.50	7.93±2.29	16.21±2.91	75.56±4.05
9	17.01±3.01	36.47±6.64	7.93±2.29	17.26±3.01	102.06±4.70
10	22.20±3.66	48.58±8.11	13.88±3.03	23.01±3.47	74.04±4.01
11	14.50±2.97	31.31±6.56	11.24±2.72	10.98±2.39	55.15±3.46
12	22.43±3.72	48.26±8.19	20.50±3.68	13.07±2.61	79.21±4.06
13	17.57±3.23	38.17±7.15	11.24±2.72	16.74±2.95	69.48±3.88
14	25.78±3.97	55.44±8.74	21.82±3.79	16.47±2.95	97.28±4.59
15	19.90±3.40	43.10±7.53	11.90±2.80	19.35±3.18	87.29±4.35
16	15.28±3.05	33.28±6.76	10.58±2.64	14.12±2.71	52.33±3.37
17	15.18±2.99	32.28±6.55	13.22±2.95	7.84±2.02	71.65±3.94
18	13.35±2.68	28.40±5.92	7.27±2.19	11.50±2.45	84.25±4.27
19	17.83±3.23	37.95±7.11	14.55±3.10	10.46±2.33	86.85±4.34
20	10.80±2.42	22.72±5.32	7.27±2.19	6.80±1.88	71.65±3.94
21	18.57±3.37	39.89±7.42	16.53±3.30	10.98±2.39	68.40±3.85
22	11.57±2.42	24.27±5.33	5.95±1.98	8.89±2.15	89.24±4.40
23	12.40±2.76	26.94±6.11	9.25±2.47	10.46±2.33	42.12±3.02
24	19.58±3.56	42.85±7.86	17.19±3.37	15.17±2.81	40.17±2.95
25	31.14±4.44	67.44±9.78	29.10±4.38	19.35±3.19	84.03±4.27
26	16.54±3.07	35.42±6.78	10.58±2.64	13.60±2.66	86.85±4.34
27	20.19±3.50	43.87±7.73	13.88±3.03	18.31±3.09	74.04±4.01
28	14.97±2.89	32.32±6.40	7.93±2.29	15.17±2.18	75.35±4.04
29	19.34±3.45	42.10±7.62	13.88±3.03	17.26±3.01	64.71±3.74
30	15.64±2.97	33.80±6.58	8.59±2.38	15.69±2.86	75.56±4.05
Min.	8.72±2.09	18.13±4.53	5.95±1.98	1.04±0.73	40.17±2.95
Max.	34.09±4.51	72.80±9.91	29.10±4.38	35.05±4.28	152.43±5.75
Average	19.01±3.28	41.07±7.30	13.59±2.93	15.66±2.76	77.39±4.05

The Indoor and Outdoor Annual Effective Dose, Activity Concentration Index (I_γ),External hazard index (Hex) and Internal hazard index (Hin) are calculated and listed in table (4) The Indoor Effective Dose range from (0.0321±0.0092;11 to 0.1102±0.0179;19) μSv/y with average 0.0589±0.0123 μSv/y, the Outdoor Annual Effective Dose rang are from (0.0080±0.0023;11 to 0.0275±0.0044;19) (μSv/y) with average 0.0147±0.0030(μSv/y) all the soil samples have the annual effective dose less than the world average 460 (μSv/y) [10,11], Representative level index (Iγ) range from (0.1006±0.0288;11 to 0.3455±0.0560;19) with average 0.1848±0.0387, External hazard index (Hex) range from (0.0371±0.0111;11 to 0.1316±0.0218;19) with average 0.0691±0.0150 and Internal hazard index (Hin) range from (0.0470±0.0148;11 to 0.1881±0.0307;19) with average 0.0946±0.0208. External and internal hazard and gamma activity concentration were lower than unity according to the Radiation Protection 112 [10].

Table 4: External hazard index(H_{ex}),internal hazard index (H_{in}),the annual effective dose and activity concentration index (I_γ) in depth (10-20) cm

Sample No.	Activity Concentration Index (I_γ)	Internal Hazard Index (H_{in})	External Hazard Index(H_{ex})	Effective dose rate $mSv.yr^{-1}$	
				Indoor	Outdoor
1	0.1558±0.0373	0.0830±0.0203	0.0590±0.0145	0.0497±0.0119	0.0124±0.0029
2	0.1846±0.0357	0.1169±0.0221	0.0703±0.0140	0.0584±0.0113	0.0146±0.0028
3	0.1379±0.0335	0.0790±0.0192	0.0521±0.0130	0.0438±0.0107	0.0109±0.0026
4	0.3184±0.0553	0.1720±0.0299	0.1225±0.0216	0.1018±0.0177	0.0254±0.0044
5	0.2744±0.0453	0.1324±0.0243	0.0999±0.0175	0.0874±0.0145	0.0218±0.0036
6	0.2156±0.0443	0.0942±0.0214	0.0814±0.017	0.0694±0.0142	0.0173±0.0035
7	0.2502±0.0445	0.1373±0.0252	0.0935±0.0173	0.0795±0.0142	0.0198±0.0035
8	0.1395±0.0303	0.0685±0.0168	0.0502±0.0117	0.0443±0.0096	0.0110±0.0024
9	0.2057±0.0415	0.0988±0.0217	0.0762±0.0161	0.0657±0.0133	0.0164±0.0033
10	0.2503±0.0477	0.1286±0.0255	0.0947±0.0185	0.0800±0.0153	0.0200±0.0038
11	0.1006±0.0288	0.0470±0.0148	0.0371±0.0111	0.0321±0.0092	0.0080±0.0023
12	0.1242±0.0277	0.0663±0.0162	0.0451±0.0107	0.0393±0.0088	0.0098±0.0022
13	0.1458±0.0348	0.0725±0.0186	0.0541±0.0135	0.0465±0.0111	0.0116±0.0027
14	0.1954±0.0400	0.0874±0.0201	0.0719±0.0154	0.0625±0.0128	0.0156±0.0032
15	0.2181±0.0435	0.1209±0.0243	0.0827±0.0169	0.0694±0.0139	0.0173±0.0034
16	0.2109±0.0409	0.1077±0.0223	0.0780±0.0159	0.0672±0.0131	0.0168±0.0032
17	0.1861±0.0397	0.0790±0.0190	0.0691±0.0153	0.0598±0.0127	0.0149±0.0031
18	0.1337±0.0332	0.0712±0.0184	0.0500±0.0129	0.0426±0.0106	0.0106±0.0026
19	0.3455±0.0560	0.1881±0.0307	0.1316±0.0218	0.1102±0.0179	0.0275±0.0044
20	0.1196±0.0304	0.0564±0.0160	0.0436±0.0117	0.0381±0.0097	0.0095±0.0024
21	0.1508±0.0366	0.0720±0.0189	0.0565±0.0142	0.0483±0.0117	0.0120±0.0029
22	0.1210±0.0290	0.0593±0.0159	0.0438±0.0112	0.0385±0.0092	0.0096±0.0023
23	0.1503±0.0377	0.0771±0.0199	0.0573±0.0146	0.0481±0.0121	0.0120±0.0030
24	0.1925±0.0430	0.0962±0.0224	0.0736±0.0167	0.0617±0.0138	0.0154±0.0034
25	0.1481±0.0358	0.0707±0.0185	0.0552±0.0138	0.0474±0.0114	0.0118±0.0028
26	0.1501±0.0347	0.0768±0.0189	0.0556±0.0134	0.0478±0.0111	0.0119±0.0027
27	0.2433±0.0468	0.1337±0.0258	0.0927±0.0182	0.0776±0.0150	0.0194±0.0037
28	0.1366±0.0326	0.0686±0.0177	0.0502±0.0126	0.0435±0.0104	0.0108±0.0026
29	0.1925±0.0420	0.1029±0.0228	0.0732±0.0163	0.0614±0.0134	0.0153±0.0033
30	0.1469±0.0343	0.0741±0.0186	0.0543±0.0133	0.0468±0.0109	0.0117±0.0027
Min.	0.1006±0.0288	0.0470±0.0148	0.0371±0.0111	0.0321±0.0092	0.0080±0.0023
Max.	0.3455±0.0560	0.1881±0.0307	0.1316±0.0218	0.1102±0.0179	0.0275±0.0044
Average	0.1848±0.0387	0.0946±0.0208	0.0691±0.0150	0.0589±0.0123	0.0147±0.0030

The Indoor and Outdoor Annual Effective Dose, Activity Concentration Index (I_γ),External hazard index (Hex) and Internal hazard index (Hin) are calculated and listed in table (5) The Indoor Effective Dose range from (0.0427±0.0102;3 to 0.1672±0.0221;5) μSv/y with average 0.0932±0.0161μSv/y, the Outdoor Annual Effective Dose rang are from (0.0106±0.0025;3 to 0.0418±0.0055;5) (μSv/y) with average 0.0232±0.0039 (μSv/y) all the soil samples have the annual effective dose less than the world average 460 (μSv/y) [10,11], Representative level index (Iγ) range from (0.1328±0.0318;3 to 0.5220±0.0689;5) with average 0.2920±0.0506, External hazard index (Hex) range from (0.0489±0.0122;3 to 0.1966±0.0267;5) with average 0.1109±0.0196 and Internal hazard index (Hin) range from (0.0517±0.0142;3 to 0.2540±0.0355;4) with average 0.1532±0.0331. External and internal hazard and gamma activity concentration were lower than unity according to the Radiation Protection 112 [10].

Table 5: External hazard index(H_{ex}),internal hazard index (H_{in}),the annual effective dose and activity concentration index (I_γ) in depth (30-40) cm

Sample No.	Activity Concentration Index (I_γ)	Internal Hazard Index (H_{in})	External Hazard Index(H_{ex})	Effective dose rate $mSv.yr^{-1}$	
				Indoor	Outdoor
1	0.3036±0.0536	0.1676±0.0294	0.1167±0.0209	0.0969±0.0171	0.0242±0.0042
2	0.3640±0.0568	0.1819±0.0300	0.1367±0.0220	0.1163±0.0182	0.0290±0.0045
3	0.1328±0.0318	0.0517±0.0142	0.0489±0.0122	0.0427±0.0102	0.0106±0.0025
4	0.4076±0.0611	0.2540±0.0355	0.1592±0.0239	0.1296±0.0195	0.0324±0.0048
5	0.5220±0.0689	0.2517±0.0356	0.1966±0.0267	0.1672±0.0221	0.0418±0.0055
6	0.4237±0.0643	0.2224±0.0342	0.1630±0.0250	0.1356±0.0206	0.0339±0.0051
7	0.3549±0.0540	0.2085±0.2085	0.1350±0.0211	0.1127±0.0172	0.0281±0.0043
8	0.2378±0.0450	0.1340±0.0254	0.0901±0.0175	0.0756±0.0143	0.0189±0.0035
9	0.2625±0.0460	0.1451±0.0260	0.0985±0.0179	0.0834±0.0147	0.0208±0.0036
10	0.3417±0.0561	0.1934±0.0312	0.1312±0.0219	0.1089±0.0179	0.0272±0.0044
11	0.2224±0.0455	0.1142±0.0242	0.0845±0.0177	0.0711±0.0146	0.0177±0.0036
12	0.3430±0.0569	0.1657±0.0292	0.1303±0.0221	0.1100±0.0182	0.0275±0.0045
13	0.2703±0.0495	0.1483±0.0273	0.1031±0.0193	0.0862±0.0158	0.0215±0.0039
14	0.3947±0.0607	0.1949±0.0316	0.1497±0.0236	0.1264±0.0195	0.0316±0.0048
15	0.3062±0.0521	0.1687±0.0289	0.1164±0.0203	0.0976±0.0166	0.0244±0.0041
16	0.2348±0.0468	0.1280±0.0256	0.0899±0.0182	0.0749±0.0149	0.0187±0.0037
17	0.2323±0.0457	0.1083±0.0231	0.0871±0.0177	0.0745±0.0146	0.0186±0.0036
18	0.2056±0.0411	0.1078±0.0226	0.0767±0.0159	0.0655±0.0131	0.0163±0.0032
19	0.2731±0.0495	0.1307±0.0255	0.1025±0.0192	0.0874±0.0158	0.0218±0.0039
20	0.1658±0.0371	0.0797±0.0194	0.0613±0.0143	0.0529±0.0119	0.0132±0.0029
21	0.2841±0.0516	0.1374±0.0265	0.1077±0.0200	0.0911±0.0165	0.0227±0.0041
22	0.1783±0.0371	0.0896±0.0202	0.0655±0.0144	0.0567±0.0118	0.0141±0.0029
23	0.1904±0.0423	0.1010±0.0228	0.0727±0.0165	0.0608±0.0135	0.0152±0.0033
24	0.2998±0.0544	0.1567±0.0288	0.1157±0.0212	0.0960±0.0174	0.0240±0.0043
25	0.4760±0.0679	0.2344±0.0350	0.1821±0.0264	0.1527±0.0218	0.0381±0.0054
26	0.2544±0.0471	0.1324±0.0255	0.0956±0.0183	0.0811±0.0150	0.0202±0.0037
27	0.3103±0.0536	0.1679±0.0292	0.1185±0.0209	0.0990±0.0171	0.0247±0.0042
28	0.2307±0.0443	0.1283±0.0249	0.0873±0.0173	0.0734±0.0141	0.0183±0.0035
29	0.2971±0.0528	0.1604±0.0287	0.1137±0.0206	0.0949±0.0169	0.0237±0.0042
30	0.2409±0.0456	0.1337±0.0255	0.0913±0.0177	0.0767±0.0146	0.0191±0.0036
Min.	0.1328±0.0318	0.0517±0.0142	0.0489±0.0122	0.0427±0.0102	0.0106±0.0025
Max.	0.5220±0.0689	0.2540±0.0355	0.1966±0.0267	0.1672±0.0221	0.0418±0.0055
Average	0.2920±0.0506	0.1532±0.0331	0.1109±0.0196	0.0932±0.0161	0.0232±0.0039

References

[1] M.Abusini, K.Al-ayasreh and J.Al-Jundi, "Determination of Uranium, Thorium and Potassium Activity Concentrations in Soil Cores in Araba Valley, Jordan" , Radiation Protection Dosimetry, Vol. (128), No.(2), P: 213–216, (2008).

[2] H. M.Diab,"Evaluation of Natural Radioactivity in a Cultivated Area Around A Fertilizer Factory" , Nuclear and Radiation Physics, Vol.(3), No. (1), P: 53-62, (2008).

[3] M. Ibrahim Al-Jarallah, A.Abdullah "radiation and water," the first edition (1983).

[4] IAEA , International atomic energy agency, Update of x ray and gamma ray decay data standards for detector calibration and other applications, Vol:(1) ,Vienna ,(2007).

[5] IAEA, International atomic energy agency, "Guidelines for radioelement mapping using gamma ray spectrometry data", Vienna, (2003).

[6] K.M.Thabaynehand M.MJazzar, "Natural Radioactivity Levels and Estimation of Radiation Exposure in Environmental Soil Samplesfrom Tulkarem Province – Palestine ", University of Hebron , Palestine , (2012).

[7] United Nations Scientific Committee on the Effects of Atomic Radiation "Sources and Effects of Ionizing Radiation"; New York; (1996).

[8] A.EL-Taher and S.Makhluf," Natural radioactivity levels in phosphate fertilizer and its environmental implication in Assuit governorate, Upper Egypt", Indian Journal of Pure & Applied Physics, Vol.(48),P:697-702, (2010) .

[9] P.Michael,M.Leo and L.Nollet, "Radionuclide Concentrations in Food and the Environment", Taylor & Francis group,1st edition, Boca Raton London New York, (2007).

[10] European Commission. Radiation Protection 112" Radiological protection principles concerning the natural radioactivity of building materials", Brussels, European Commission, (1999).

[11] International Commission on Radiological Protection, ICRP publication 65, Annals of the ICRP 23(2). Pergamon Press, Oxford, (1993).