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The Study of Radioactivity in Soil Samples from Al-Salaam Neighborhood in Al-Najaf Al-Ashraf Governorate, Iraq

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Abstract: ***An assessment of the natural radioactivity in Soil Samples from Al-Salaam neighborhood where the choice of 10 sampling site of the region, and collect two samples from each site of the first depth (0-10 cm) and depth of the second (10-30) cmto reach (20) 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 (5.53±0.36, 6.11±0.36 and 107.33±1.69) 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 (22.55±1.08Bq/kg and 11.06±0.47nGy/h)within the world average.The heist external and internal hazard and the outdoor and indoorannual effective doseand gamma activity concentration index were (0.0758±0.0038,0.0608±0.0028, 0.0133±0.0005mSv/yr , 0.0540±0.0023mSv/yr and 0.1696±0.0075)respectively, lower than unity.***

Keywords: Radioactivity, Soil Samples

1. Introduction

Al-Salaam neighborhood is one of the important cities in Al-Najaf Al-Ashraf Governorate because contain a number of the population and schools, sports arenas and shops. The natural radioactivity in the soil caused by a series of uranium 238U and 232Th series thorium and potassium 40K[1], The main source of radiation suffered by the man comes from radioactivity in the environment from natural sources available, nuclear weapons and nuclear tests and accidents, and natural radionuclides in the soil and contribute to the background radiation in the population exposure through inhalation and ingestion [2].Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soils and rocks play an important role in radiation protection and measurement. Some of the exposures are fairly ingestion of 40K in foods. However, other exposures vary widely depending on location. Cosmic rays, for example, are more intense at higher altitudes and concentrations of uranium and thorium in soils are elevated in localized areas. High levels of uranium and its decay products in rock and soil, and thorium in monazite sands are the main sources of high natural background radiations that have been identified in several areas of the world [3].

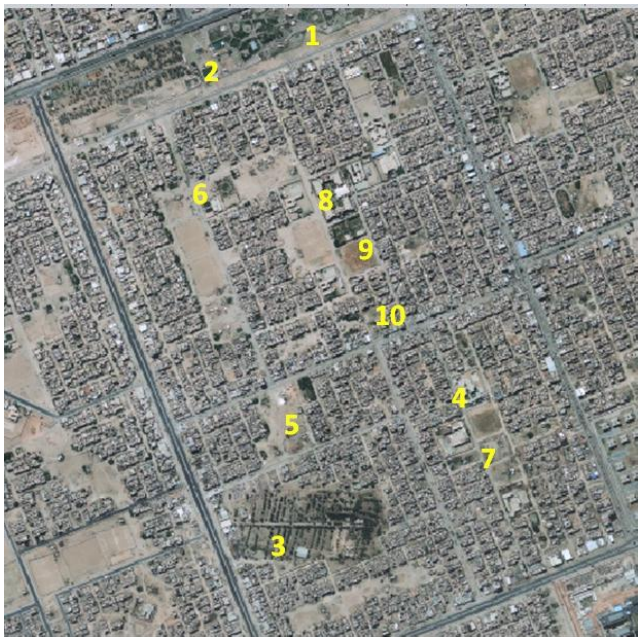
2. Experimental Procedures

The soil samples measured at (0-10)cm and (10-30)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 .the 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-Salaam neighborhood

Sample No.	Samples Name
1	The city of Games
2	Versus Samsung
3	Baniqia private Schools
4	Gifted school
5	Sports arena
6	The health center in Al-Salaam neighborhood
7	Al-Sabikoon primary school
8	Imam Aliprivate Schools
9	Sports arena
10	One of the homes



(Figure 1) is Al-Salaam neighborhood map indicating the locations models

Radium equivalent activity (Ra_{eq})

The radium equivalent activity (Ra_{eq}) is given by [6]:

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

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 [7]:

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

The Annual Effective Dose:

The annual effective dose equivalentwas estimated by [8]

Indoor (mSv\y) =A D (nGy/h)×8760 h× 0.8 × 0.7 Sv/Gy× 10^{-6}……..(3)

Outdoor (mSv\y) =A D (nGy/h)×8760h×0.2 × 0.7 Sv/Gy× 10^{-6}…….(4)

External Hazard Index (H_{ex})

The external hazard index (Hex) was given by the following equation [9]

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

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[10]

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

Activity Concentration Index (I_γ)

The activity Concentration Index (I_γ)was given by the following equation[11]

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

3. Results and Discussions

The Activity concentration of ^{238}U ,^{232}Th and ^{40}K radionuclides for 10 soil samples in depth (0-10)cm are tabulated in table(2). They have been found to lie in the range of (1.21±0.17;3 to 8.15±0.46;6) Bq/kg with an average of 5.44±0.36Bq/kg, from (3.64±0.31;10 to 10.14±0.52;4) Bq/kg with an average 5.66±0.38Bq/kg and (34.24±0.97;5 to 179.74±2.23;8) Bq/kg with an average 103.02±1.65Bq/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) [11,12]. The radium equivalent activities was calculated and listed in table (2) .Ra eq values vary from (15.24±0.88;10 to 28.98±1.16;8) Bq/ kg with average value of (21.49±1.06) Bq/kg .The absorbed dose rate(AD)calculated and listed in table (2) range from (7.44±0.458;5 to 14.51±0.540;8) nGy/h with average 10.54±0.484nGy/h.It can seen be that the Ra eq values and absorbed dose rate(AD) for all samples are lower than the recommended worldwide [11,12].

Table 2: The absorbed dose rate,Radium equivalentRa_{eq} and Activity concentration of (238U,232Th and 40K) for samples in depth (0-10)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	12.54±0.522	25.47±1.13	5.34±0.37	7.28±0.43	137.14±1.95
2	12.01±0.528	24.66±1.14	5.95±0.39	7.17±0.43	116.51±1.79
3	9.84±0.440	19.06±0.94	7.35±0.44	1.21±0.17	95.19±1.62
4	13.43±0.585	27.94±1.27	10.14±0.52	5.98±0.39	96.75±1.63
5	7.44±0.458	16.00±1.00	5.12±0.37	6.03±0.39	34.24±0.97
6	11.71±0.513	24.07±1.11	4.80±0.35	8.15±0.46	117.57±1.80
7	7.82±0.418	15.89±0.90	4.02±0.32	3.81±0.31	82.13±1.51
8	14.51±0.540	28.98±1.16	6.17±.40	6.32±0.40	179.74±2.23
9	8.65±0.44	17.63±0.95	4.15±0.35	4.73±0.35	90.27±1.58
10	7.51±0.40	15.24±0.88	3.64±0.31	3.81±0.31	80.66±1.49
Min.	7.44±0.458	15.24±0.88	3.64±0.31	1.21±0.17	34.24±0.97
Max.	14.51±0.540	28.98±1.16	10.14±0.52	8.15±0.46	179.74±2.23
Average	10.54±0.484	21.49±1.06	5.66±0.38	5.44±0.36	103.02±1.65

The specific activity values of ^{238}U ,^{232}Th and ^{40}K radionuclides for 30 soil samples in depth (10-30)cm are tabulated in table(3). They have been found to lie in the range of (2.17±0.23;2 to 6.77±0.42;3) Bq/kg with an average

of 5.62±0.37Bq/kg, from (4.34±0.34;10 to 9.60±0.51;3) Bq/kg with an average 6.57±0.41Bq/kg and (56.01±1.24;9 to 167.21±2.15;2) Bq/kg with an average 111.65±1.73Bq/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) [11,12]. The radium equivalent activities was calculated and listed in table (3) .Ra eq values vary from (16.37±0.95;10 to 30.26±1.29;3) Bq/ kg with average value of (23.62±1.10) Bq/kg .The absorbed dose rate(AD)calculated and listed in table (3) range from (7.91±0.43;10 to 14.84±0.57;1) nGy/h with average 11.59±0.47nGy/h.It can seen be that the Ra eq values and absorbed dose rate(AD) for all samples are lower than the recommended worldwide [11,12].

Table 3: The absorbed dose rate, Radium equivalent Ra_{eq} and Activity concentration of (238U,232Th and 40K) for samples in depth (10-30)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	14.84±0.57	29.47±1.23	8.05±0.46	6.64±0.41	147.00±2.02
2	14.35±0.52	28.51±1.12	9.41±0.50	2.17±0.23	167.21±2.15
3	14.70±0.59	30.26±1.29	9.60±0.51	6.77±0.42	126.66±1.87
4	12.30±0.54	25.38±1.18	7.29±0.44	6.64±0.41	107.78±1.73
5	10.16±0.49	20.95±1.06	5.17±0.37	6.30±0.40	94.08±1.61
6	10.47±0.48	21.44±1.05	4.56±0.34	6.64±0.41	107.45±1.72
7	12.94±0.35	26.17±1.15	7.78±0.45	4.60±0.34	135.52±1.94
8	9.96±0.35	20.25±1.01	4.61±0.35	5.48±0.38	106.14±1.71
9	8.27±0.46	17.45±1.01	4.91±0.36	6.11±0.40	56.01±1.24
10	7.91±0.43	16.37±0.95	4.34±0.34	4.87±0.35	68.68±1.38
Min.	7.91±0.43	16.37±0.95	4.34±0.34	2.17±0.23	56.01±1.24
Max.	14.84±0.57	30.26±1.29	9.60±0.51	6.77±0.42	167.21±2.15
Average	11.59±0.47	23.62±1.10	6.57±0.41	5.62±0.37	111.65±1.73

Be calculated the Indoor and Outdoor Annual Effective Dose, Activity Concentration Index (I_γ),External hazard index (Hex) and Internal hazard index (Hin) and listed in table (4) The Indoor Effective Dose range from (0.0365±0.0022;5 to 0.0711±0.0026;8) µSv/y with average 0.0515±0.0023µSv/y, the Outdoor Annual Effective Dose rang are from (0.0091±0.0004;5 to 0.0177±0.0006;8) (µSv/y) with average 0.0128±0.0005(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 (0.1143±0.0070;5 to 0.2236±0.0082;8) with average 0.1617±0.0073, External hazard index (Hex) range from (0.0411±0.0023;10 to 0.0782±0.0031;8) with average 0.0580±0.0027 and Internal hazard index (Hin) range from (0.0514±0.0032;10 to 0.0953±0.0042;8) with average 0.0727±0.0038. According to the Radiation Protection 112 the External and internal hazard and gamma activity concentration were lower than unity [11].

Table 4: External hazard index (H_{ex}),internal hazard index (H_{in}),the annual effective dose and activity concentration index (I_γ) in depth (0-10) 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	0.1933±0.0080	0.0884±0.0042	0.0688±0.0030	0.0615±0.0025	0.0153±0.0006
2	0.1850±0.0079	0.0860±0.0042	0.0666±0.0030	0.0589±0.0025	0.0147±0.0006
3	0.1451±0.0067	0.0547±0.0030	0.0514±0.0025	0.0465±0.0021	0.0116±0.0005
4	0.2058±0.0089	0.0916±0.0045	0.0754±0.0034	0.0658±0.0028	0.0164±0.0007
5	0.1143±0.0070	0.0595±0.0037	0.0432±0.0027	0.0365±0.0022	0.0091±0.0004
6	0.1807±0.0078	0.0870±0.0042	0.0650±0.0030	0.0574±0.0025	0.0143±0.0006
7	0.1204±0.0064	0.0532±0.0033	0.0429±0.0024	0.0383±0.0020	0.0095±0.0005
8	0.2236±0.0082	0.0953±0.0042	0.0782±0.0031	0.0711±0.0026	0.0177±0.0006
9	0.1333±0.0067	0.0604±0.0035	0.0476±0.0025	0.0424±0.0021	0.0106±0.0005
10	0.1156±0.0062	0.0514±0.0032	0.0411±0.0023	0.0368±0.0019	0.0092±0.0004
Min.	0.1143±0.0070	0.0514±0.0032	0.0411±0.0023	0.0365±0.0022	0.0091±0.0004
Max.	0.2236±0.0082	0.0953±0.0042	0.0782±0.0031	0.0711±0.0026	0.0177±0.0006
Average	0.1617±0.0073	0.0727±0.0038	0.0580±0.0027	0.0515±0.0023	0.0128±0.0005

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 (0.0388±0.0021;10 to 0.0721±0.0029;3) µSv/y with average 0.0566±0.0024µSv/y, the Outdoor Annual Effective Dose rang are from (0.0097±0.0005;10 to 0.0180±0.0007;3) (µSv/y) with average 0.0138±0.0005 (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 (0.1217±0.0067;10 to 0.2257±0.0091;3) with average 0.1776±0.0078, External hazard index (Hex) range from (0.0442±0.0025;10 to 0.0817±0.0034;3) with average 0.0637±0.0029 and Internal hazard index (Hin) range from (0.0574±0.0035;10 to 0.1000±0.0046;3) with average 0.0789±0.0039. External and internal hazard and gamma

activity concentration were lower than unity according to the Radiation Protection 112 [11].

Table 5: External hazard index(H_{ex}),internal hazard index (H_{in}),the annual effective dose and activity concentration index (I_γ) in depth (10-30) 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	0.2228±0.0087	0.0975±0.0044	0.0796±0.0033	0.0710±0.0028	0.0153±0.0006
2	0.2201±0.0080	0.0828±0.0036	0.0770±0.0030	0.0704±0.0025	0.0176±0.0006
3	0.2257±0.0091	0.1000±0.0046	0.0817±0.0034	0.0721±0.0029	0.0180±0.0007
4	0.1891±0.0083	0.0865±0.0043	0.0685±0.0032	0.0603±0.0026	0.0150±0.0006
5	0.1565±0.0075	0.0736±0.0039	0.0565±0.0028	0.0498±0.0024	0.0124±0.0006
6	0.1615±0.0074	0.0758±0.0039	0.0579±0.0028	0.0514±0.0023	0.0128±0.0005
7	0.1988±0.0081	0.0831±0.0040	0.0706±0.0031	0.0635±0.0026	0.0158±0.0005
8	0.1534±0.0072	0.0695±0.0037	0.0547±0.0027	0.0488±0.0023	0.0122±0.0005
9	0.1272±0.0071	0.0636±0.0038	0.0471±0.0027	0.0405±0.0022	0.0101±0.0005
10	0.1217±0.0067	0.0574±0.0035	0.0442±0.0025	0.0388±0.0021	0.0097±0.0005
Min.	0.1217±0.0067	0.0574±0.0035	0.0442±0.0025	0.0388±0.0021	0.0097±0.0005
Max.	0.2257±0.0091	0.1000±0.0046	0.0817±0.0034	0.0721±0.0029	0.0180±0.0007
Average	0.1776±0.0078	0.0789±0.0039	0.0637±0.0029	0.0566±0.0024	0.0138±0.0005

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