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Measurement Natural Radioactivity in Soil Samples from Important historical locals in Alnajaf Alashraf city, Iraq.

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ABSTRACT

Al-Najaf Al-Ashraf city one of the most important ,oldest, historical and religious cities in Iraqi country which includes hundreds of holy shrines and historical mosques which over the built hundreds of years. The natural radiation of forty two samples of soil which collected randomly in June 2013 from different religious and historical places were measured using 3"×3" Na(Tl) detection. The mean values activity concentrations of 238U, 232Th and 40K was (23.59±4.37, 12.10±0.54 and 60.68±2.30) Bq kg-1 respectively , specific activity for all soil sample were in the worldwide average. The average values of the Radium equivalent activity and annual effective dose were (22.455 Bq/kg and 25.375 µSv/y) less than the world average .The heist external and internal hazard and gamma activity concentration index were (0.274 , 0.412 and 0.705) lower than unity.

Keywords

Gamma ray spectrometry; Na(Tl) detector; Raeq activities and annual effective dose.

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INTRODUCTION

Al Najaf city have been Enjoyed in religious and cultural prestigious, they are a natural extension of Kufa capital of the Islamic caliphate days of Imam Ali bin Abi Talib (peace be upon him), in al Najaf city many shrines and most important mosque.

Shrine of Imam Ali -also known as Alhaidariya holy - in the center of Najaf it refers as the advantage Islamic architectural style construction, and is considered one of the most important mosques and religious shrines in Iraq because it includes the remains of the Imam Ali bin Abi Talib who was martyred in 40 AH (661 AD).

Shrine of the Prophets Hood and Saleh is located in the Najaf cemetery major behind the city wall the old hand and the Valley of Peace shrine of prophets Hood and Saleh on the campus of one meant visitor to prayer and blessing, also Camille ibn Ziyad Nakha'I Shrine who realized the life of the Messenger of Allah 18 years old, and Imam Ali as well as the shrine of Muslim Ibn Aqil “al Hussein ambassador” and al Sahaabi Maitham al Tamar shrine and the house of Imam Ali which known as Bait Fatima and al sahlaa mosque and many other religious and historical places.

In this research the natural radioactivity level of elected soils of these shrines , religious places and historical holy has been studied because of religious and historical importance in addition to the large number of visitors It is important to identify the concentration of radioactive isotopes in soil because it constitutes a path for radioactivity to humans and is an indicator of radioactive accumulation in the environment [1,2].

Natural sources of radiation are cosmic radiation and terrestrial radiation arising from the decay of naturally occurring radioactive substance ,if the half life of a radionuclide found in geological strata approximates the estimated age of the earth ,then the radionuclide is primordial .it was presumably present from the time of the earth’s beginning .Inventories of primordial radionuclide s are essential parts of the natural background level of radioactivity in the environment .the concentrations of the natural radio nuclides ^{238}U ,^{232}Th ,their daughter products and ^{40}K ,present in the soil and rocks which in turn depend upon the local geology of each reigion in the world are causes of variation of doses. Some areas are high natural background areas because in these areas levels of uranium and its decay products in rock and soil ,high background radiation areas are due to local geology ,location altitude and geochemical effects that cause enhanced levels of terrestrial radiation[3-9].

EXPERIMENTAL PROCEDURES :

The soil samples measured at (0-5)cm depth level were collected from sampling points located at religious and historical places .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 Cº 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 ^{214}Bi was used to determine ^{238}U series activity, and the line at 2614 keV of ^{208}Tl for ^{232}Th series. Also the peak at 1460 keV was used for ^{40}K activity [10,11]

The specific activity of each radionuclide is calculated using the following equation

$$A = \frac{N_{net}}{\varepsilon . I_{\gamma} . m . t} \pm \frac{\sqrt{N_{net}}}{\varepsilon . I_{\gamma} . m . t} [Bq.kg^{-1}] \quad \dots \dots \dots \dots (1)$$

Where N_{net} is the net count (area under the specified energy peak after back ground subtraction) in (c/s) , $\sqrt{N_{net}}$ is the random error in (c/s) , ε is the efficiency of the detector , Iγ is the transition probability of the emitted gamma ray ,t is the time (in sec)for spectrum collected and m is the sample weight (in kg).

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 (Raeq) in Bq.kg-1 [12-14].

$$Ra_{eq} = A_U + 1.43 A_{Th} + 0.077 A_K \dots .(2)$$

Where A_U , A_{Th} and A_K are specific activity concentration in Bq.kg-1 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.

Gamma Dose Rate (D)

The total dose rate D in the air (out doors) due to uniform distribution of all the ^{226}Ra, ^{232}Th and ^{40}K in the beach soil 1 m above the ground surface was estimated by [12-14]:

$$D = 0.427 A_U + 0.662 A_{Th} + 0.043 A_K \ldots.(3)$$

Where D is the dose rate in (nGy.h^{-1}) and A_U , A_{Th} and A_K are the concentrations of uranium, thorium and potassium, respectively.

Annual Effective Dose Equivalent (AEDE)

In order to estimate the annual effective dose rate in air the conversion coefficient from absorbed dose in air to effective dose received by an adult had to be taken into consideration .This value is published in UNSCEAR (2000)[5] of(0.7 Sv/Gy).The outdoor occupancy factor which is about (0.2) .

The annual effective dose equivalent was given by the following equation[12-16] :

$$\mathrm{AEDE}\,(\mu\mathrm{Sv/y}) = \mathrm{D(nGy/h)} \times 8760\mathrm{(h/y)} \times 0.2 \times 0.7\mathrm{(Sv/Gy)} \times 10^{-3} \ \ldots.(4)$$

Representative level index (Iγr)

In order to examine whether the sample meets limits of dose criteria ,Another radiation hazard index, representative level index Iγr, used to estimate the level of γ- radiation hazard associated with the radionuclides in specific investigated samples ,is defind as the following equation [12-15]:

$$I_{\gamma r} = A_U / 300 + A_{Th} / 200 + A_K / 3000 \ldots..(5)$$

The index Iγr was correlated with the annual dose due to the excess external gamma radiation caused by superficial material. Values of index I ≤1 correspond to 0.3 mSv/y, while I ≤3 correspond to 1 mSv/y. Thus, the activity concentration index should be used only as a screening tool for identifying materials which might be of concern to be used as covering material. According to this dose criterion, materials with I ≤ 3 should be avoided[15].

External hazard index (H_{ex})

The external hazard index (H_{ex}) was given by the following equation[12-15]

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

Internal hazard index (H_{in})

The internal exposure to ^{222}Rn and its radioactive progeny is controlled by the internal hazard index (H_{in}) is given by [13,14]

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \ldots\ldots(7)$$

For the safe use of a material in the construction of dwellings, index (H_{in}) should be less than unity and the maximum value of (H_{in}) to be less than unity.

RESULTS AND DISCUSSIONS:

The specific activity values of ^{238}U ,^{232}Th and ^{40}K radionuclide s for 42 soil sample are tabulated in table (1). They have been found to lie in the range of (5.89±2.23;S3 to 36.20±5.52;S29) Bq/kg with an average of 23.59±4.37 Bq/kg, from (0.72±0.16;S28 to 31.68±1.04;S16) Bq/kg with an average 12.10±0.54 Bq/kg and (20.89±1.38;S6 to 90.63±2.87;S18) Bq/kg with an average 60.68±2.30 Bq/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) [17,18].

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Table (1): Concentrations of radionuclide for each sample in ($Bq.kg^{-1}$) .

Sample No.	Samples Name	A ^{238}U	A ^{232}Th	A ^{40}K
S1	the Imam Ali holy shrine (1)	11.82±2.5205	14.74±0.5661	41.73±1.5554
S2	the Imam Ali holy shrine (2)	25.23±3.8935	11.06±0.5185	61.83±2.0017
S3	the Imam Ali holy shrine (3)	5.89±2.2274	19.31±0.8110	74.74±2.6052
S4	the Imam Ali holy shrine (4)	26.94±4.7623	16.66±0.7532	41.41±1.9392
S5	Maqam Hood and Saleh	21.89±4.2927	2.15±0.2703	82.55±2.7379
S6	Maqam Imam al hoja	27.78±4.8362	26.87±0.9567	20.89±1.3772
S7	Beer alawee Mosque	19.36±4.0375	8.69±0.5439	79.01±2.6786
S8	Maqam Ibrahim al gamr	35.36±5.4559	23.43±0.8934	22.70±1.4359
S9	Fatima shrine (1)	17.68±3.8579	29.50±1.0023	30.88±1.6745
S10	Fatima shrine (2)	19.36±4.0375	20.03±0.8259	60.84±2.3506
S11	Fatima shrine (3)	21.89±4.2927	22.27±0.8710	88.09±2.8283
S12	Fatima shrine (4)	17.68±3.8579	26.57±0.9512	80.82±2.7092
S13	Safee alsafa shrine (1)	12.63±3.2605	22.14±0.8683	72.65±2.5685
S14	Safee alsafa shrine (2)	26.94±4.7623	7.83±0.5165	48.13±2.0906
S15	Safee alsafa shrine (3)	24.41±4.5336	25.75±0.9365	57.21±2.2794
S16	Maqam roqea bint al Hassan	16.84± 3.7650	31.68±1.0387	22.70±1.4359
S17	Camille ibn Ziyad shrine (1)	15.15± 3.5718	22.99±0.8849	42.68±1.9688
S18	Camille ibn Ziyad shrine (2)	30.31± 5.0512	30.52±1.0195	90.63±2.8688
S19	Camille ibn Ziyad shrine (3)	17.68 ±3.8579	22.24±0.8704	68.56±2.4953
S20	Hussienieh Al rasol ala'adm - Mashkhab	21.05± 4.2094	23.47±0.8940	38.32±1.8655
S21	Hussienieh Mashkhab-Mashkhab	16.00± 3.6696	30.31±1.0161	65.57±2.4401
S22	mosque Al rasol ala'adm-Mashkhab	15.15±3.5718	15.33±0.7225	77.19±2.6476
S23	Sons of Imam Kadhim shrine	30.31 ±5.0512	11.38±0.6225	86.82±2.8078
S24	Nabi Younis shrine	15.15±3.5718	22.14±0.8683	69.02±2.5035
S25	Maitham al Tamar shrine	27.78±4.8362	0.78±0.1633	59.84±2.3312
S26	Faithful home (1)	31.15±5.1209	1.09±0.1927	41.59±1.9435
S27	Faithful home (2)	28.62±4.9089	1.46±0.2233	69.47±2.5117
S28	Faithful home (3)	20.20±4.1243	0.72±0.1561	89.27±2.8472
S29	Faithful home (4)	36.20±5.5205	1.02±0.1866	86.00±2.7946
S30	Alsahlaa mosque (1)	31.15±5.1209	1.12±0.1957	54.31±2.2207
S31	Alsahlaa mosque (2)	31.99±5.1896	0.75±0.1598	54.31±2.2207
S32	Alsahlaa mosque (3)	19.36±4.0375	0.78±0.1633	59.39±2.3224
S33	Alsahlaa mosque (4)	22.73±4.3745	0.82±0.1669	54.49±2.2244
S34	Muslim Ibn Aqil shrine (1)	28.62±4.9089	0.89±0.1737	63.48±2.4
S35	Muslim Ibn Aqil shrine (2)	29.47±4.9806	1.46±0.2233	84.73±2.7738

S36	Muslim Ibn Aqil shrine (3)	27.78±4.8362	1.23±0.2044	51.49±2.1624
S37	Muslim Ibn Aqil shrine (4)	33.67±5.3245	1.57±0.2310	52.40±2.1814
S38	Aolad al Hassan shrine -Manathira	28.62±4.9089	1.53±0.2285	77.64±2.6554
S39	Kufa mosque (1)	21.05±4.2094	1.50±0.2259	61.48±2.3629
S40	Kufa mosque (2)	31.15±5.1209	1.16±0.1986	40.41±1.9157
S41	Kufa mosque (3)	16.84±3.7650	1.23±0.2044	60.21±2.3383
S42	Kufa mosque (4)	31.99±5.1896	1.87±0.2526	63.11±2.3941
Average		23.59±4.37	12.10±0.54	60.68±2.30
Max.		36.20±5.52	31.68±1.04	90.63±2.87
Min.		5.89±2.23	0.72±0.16	20.89±1.38

The radium equivalent activities was calculated and listed in table (2) .Ra_{eq} values vary from (5.143;S40 to 50.872;S18) Bq/ kg with average value of (22.455) Bq/kg .It can seen be that the Ra_{eq} values for all samples are lower than the recommended value 370 Bq/ kg[17,18].Gamma Dose Rate (D),Annual Effective Dose Equivalent (AEDE), Representative level index (Iγr) ,External hazard index (H_{ex}) and Internal hazard index (H_{in}) are calculated and listed in table (2) the Gamma Dose Rate (D) range from (10.590;S41 to 37.041;S18) nGy/h with average 20.691 nGy/h, the (AEDE) rang are from (12.988;S41 to 45.427;S18) (μSv/y) with average 25.375(μSv/y) all the soil samples have the annual effective dose less than the world average 460 (μSv/y) [17,18], Representative level index (Iγr) range from (0.073;S40 to 0.705;S18) with average 0.311 , External hazard index (H_{ex}) range from (0.027;S40 to 0.274;S18) with average 0.120 and Internal hazard index (H_{in}) range from (0.041;S40 to 0.412;S18) with average 0.181. External and internal hazard and gamma activity concentration were lower than unity according to the Radiation Protection 112 [17].

Table (2): Radium equivalent ($Bq.kg^{-1}$) , Dose rate (nGy/h) ,AEDE (μSv/y), the internal and external hazard indexes representative level index for all samples.

Sample No.	Ra_{eq}	D(nGy/h)	AEDE (μSv/y)	H_{in}≤1	H_{ex}≤1	I_{yr}≤1
S1	24.654	16.600	20.359	0.199	0.132	0.340
S2	20.915	20.754	25.453	0.169	0.112	0.291
S3	33.969	18.514	22.706	0.274	0.182	0.469
S4	27.614	24.310	29.813	0.222	0.148	0.378
S5	9.759	14.316	17.558	0.078	0.052	0.142
S6	40.665	30.551	37.467	0.328	0.218	0.554
S7	18.858	17.415	21.358	0.152	0.101	0.265
S8	35.551	31.587	38.738	0.287	0.191	0.486
S9	44.769	28.403	34.833	0.362	0.241	0.614
S10	34.114	24.142	29.608	0.274	0.182	0.468
S11	39.427	27.880	34.192	0.317	0.211	0.544
S12	44.781	28.611	35.089	0.361	0.240	0.618
S13	37.415	23.172	28.418	0.303	0.202	0.519
S14	15.699	18.759	23.006	0.125	0.083	0.215
S15	42.007	29.931	36.707	0.338	0.225	0.576
S16	47.581	29.135	35.731	0.384	0.256	0.649
S17	36.385	23.525	28.852	0.294	0.196	0.501
S18	50.872	37.041	45.427	0.412	0.274	0.705

S19	37.287	25.221	30.931	0.302	0.201	0.517
S20	37.076	26.170	32.095	0.299	0.199	0.507
S21	48.710	29.717	36.444	0.394	0.262	0.672
S22	28.358	19.936	24.450	0.229	0.152	0.394
S23	23.561	24.205	29.685	0.189	0.126	0.329
S24	37.480	24.094	29.549	0.302	0.201	0.517
S25	6.316	14.955	18.340	0.050	0.033	0.090
S26	5.339	15.811	19.390	0.042	0.027	0.074
S27	7.920	16.179	19.842	0.063	0.042	0.114
S28	8.343	12.940	15.869	0.066	0.044	0.122
S29	8.762	19.832	24.322	0.069	0.046	0.126
S30	6.164	16.380	20.088	0.049	0.032	0.089
S31	5.638	16.491	20.225	0.045	0.029	0.081
S32	6.190	11.340	13.908	0.049	0.032	0.089
S33	5.871	12.590	15.440	0.046	0.030	0.084
S34	6.722	15.538	19.056	0.053	0.035	0.096
S35	9.176	17.195	21.087	0.073	0.048	0.132
S36	6.387	14.889	18.259	0.050	0.033	0.089
S37	6.975	17.669	21.670	0.055	0.036	0.097
S38	8.515	16.576	20.328	0.068	0.045	0.124
S39	7.130	12.623	15.480	0.057	0.038	0.104
S40	5.143	15.805	19.383	0.041	0.027	0.073
S41	6.866	10.590	12.988	0.054	0.036	0.098
S42	8.127	17.614	21.602	0.064	0.042	0.115
Average	22.455	20.691	25.375	0.181	0.120	0.311
Max.	50.872	37.041	45.427	0.412	0.274	0.705
Min.	5.143	10.590	12.988	0.041	0.027	0.073

Figure 1: Map of Al-Najaf city

CONCLUSIONS:

The activity concentrations of ^{238}U, ^{232}Th and ^{40}K for (42) soil sample from differences religious and historical places was determined . The activity concentrations were measured using Na(Tl) detection. The mean values activity concentrations of ^{238}U, ^{232}Th and ^{40}K was (23.59±4.37, 12.10±0.54 and60.68±2.30) Bq kg^{-1} respectively . The values of the Radium equivalent activity and annual effective dose was less than the world average .External and internal hazard and gamma activity concentration (representative level index) indexes were lower than unity.

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