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Natural Radioactivity Measurement in Soil Samples from the new Kufa University location, Iraq

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Abstract

Al-Najaf Al-Ashraf city on of the most important cities in Iraqi country it was chosen as the cultural Islamic capital for 2012 by the Islamic world ,Kufa university will be played big role of liability, cultural and education efficacies, this city had been exposed to artillery bombard expand along different areas in 1991 and 2003 in our research we try to test the studying area to know The total absorbed dose rate and the most possible hazards for this reasons the study was done. The natural radiation of thirty two samples of soil which collected randomly in June 2012 from the new Kufa University location were measured using Na(Tl) detection. The mean values activity concentrations of ^{238}U, ^{232}Th and ^{40}K was (25.73±11.23 , 3.72±0.81 and 165.16±9.39) Bq kg^{-1} respectively . The highest value of the Radium equivalent activity was (30.870) $Bq.kg^{-1}$ in (S2) which mean that all the soil samples values lower than (370Bq kg^{-1}) the world average .

External and internal hazard and gamma activity concentration (representative level index) indexes were lower than unity for all samples . The average value of absorbed dose rate calculated from activity concentration of ^{238}U , ^{232}Th and ^{40}K was (20.553) nGy h^{-1} this value coincident to recommended. Annual effective dose in (μSv/y) varies from (36.912) (μSv/y) in (S15) to (15.460) (μSv/y) in (S8) , all the soil samples have the annual effective dose less than the world average 460 (μSv/y).

The results can be consider as base values for distribution of natural radionuclides in the region and will be used as references information to assess any changed in the radioactive background level due to geological processes.

Keywords: Gamma ray spectrometry ,Na(Tl) detector , Ra_{eq} activities and annual effective dose.

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Introduction

Kufa university is an Iraqi thought and knowledge institution found on 23 December 1987 in Al- Najaf Al-asraf governorate composed of 19 colleges and four training center including academic teaching and training developed , computer , Kufa studies , and toefl center the total area is (25.6 km^2) . Knowledge on radioactivity content of the various radionuclides in the soil play an important role in health physics. The main aim of this work is to estimate the concentrations of natural radionuclides 238U, 232Th and 40K in soil samples from Kufa University location. Studies the radiation levels and radionuclide distribution in the university environment provide vital radiological baseline information ,such information is essential in understanding human exposure from natural and man made sources of radiation and necessary in establishing rules and regulations to radiation protection [1,2]. Human beings are always exposed to background radiation that stems both from natural and man-made sources. Natural radioactivity is widespread in the earth environment and it exists in various geological formations such as earth crust, rocks, soils, plants, water and air. Natural radioactive concentration mainly depends on geological and geographical condition and appears at different level in soils of each different geological region [3].

Soil radionuclide activity concentration is one of the main determinants of the natural background radiation.[4] Over 60 radionuclides can be found in nature ,and they can be placed in three general categories ,primordial ,cosmogenic and human produced .Radionuclides are found naturally there is no where on earth that we not find natural radioactivity [5]

Uranium and thorium are common natural radioelements. These radionuclides are present in soil in varying concentrations related to the nature of the parent rocks during soil genesis.[6]

Natural Occurring Radioactive Materials (NORM) are Known to be present in rocks and soil .The natural radionuclides of concern are mainly of ^{238}U, ^{232}Th or its progenies and ^{40}K. Most of the radioisotopes are alpha emitters, so when they are ingested or inhaled, they contribute significantly to the radiation dose that people receive on the other hand, taking into account that uranium and thorium are always present in soil, their gamma radiation causes external exposures with the consequent absorbed doses.[6,7].

Material and methods

In order to measure the natural radioactivity in soil, a total of 32 surface soil samples were collected randomly in June 2012 , from the new Kufa University location area which located in Al-Najaf AL-Ashraf city ,Iraq as shown in fig.(1), then dried at about 60 C^o for 48 hour to remove any moist .The sample were crushed to fine grain size and sieved in order to homogenize it and remove big size.

The powdered samples were packed in a marinelli beaker , one kilogram from each sample and sealed tightly cap kept aside for about 4 week to ensure the equilibrium has been reached between 226 Ra and its decay products of short half –life and 228Ra and its decay products before they were taken for gamma spectrometric analysis , each sample was counted for 15 hour on the Gamma-ray spectrometer with scintillation detector NaI(Tl) 3"× 3" crystal dimension , supplied by (Alpha spectra, Inc. Scintillation Detectors) coupled with a multi channel analyzer (MCA)(ORTEC-DigiBase)with range of 4096 channel joined with ADC (Analog to digital converter)unit ,through interface .The spectroscopic measurements and analysis are performed via the (MASTRO-32) software into the PC of the laboratory . The detector was maintained in a vertical position and shielded by ORTEC cylindrical chamber ,the shielding consists of two parts the upper one is composed of lead 5cm thick and 20 cm long surrounding the crystal with a cover that is 5cm thick and has a diameter of 22 cm . The activity of a specific radionuclide with a gamma energy transition could be expressed using the following equation [10,11].

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

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).

because of the poor resolution of NaI(Tl) detector at low gamma energies which haven't well separated photo peak ,thus the measuring of the activity concentrations is possible at a good separated photo peaks at high energies as that obtained in our results from gamma ray emitted by the progenies of 238U (the gamma line 1765 keV for 214Bi) and

232Th (the gamma line 2614 keV for 208Tl) which are in secular equilibrium with them while 40K was estimated directly by its gamma line of 1460keV .[10,11]

Radium equivalent activity (Raeq):

Distribution of 226Ra, 232Th and 40K 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 [11-13].

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

Where ARa , ATh and AK are specific activity concentration in Bq.kg-1 of 226Ra, 232Th and 40K, respectively. The index is useful to compare the specific activity of materials containing different concentrations of 226Ra, 232Th and 40K.

Gamma Dose Rate (D)

The total dose rate D in the air (out doors) due to uniform distribution of all the 226Ra, 232Th and 40K in the beach soil 1 m above the ground surface was estimated by [11-13]:

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

Where D is the dose rate in (nGy.h-1) and AU , ATh and AK 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) 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[11-14] :

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

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 [11-14]:

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

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[14].

External hazard index (Hex)

The external hazard index (Hex) was given by the following equation[11-14]

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

Internal hazard index (Hin)

The internal exposure to 222Rn and its radioactive progeny is controlled by the internal hazard index (Hin) is given by [12,13]

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

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

Results and Discussions

The activity concentrations of natural nuclides 238U, 232Th and 40K for the soil samples was collected from the new location of Kufa University are shown in Table 1. The rang of activity concentrations of 238U varies from 45.46±15.15 Bq kg-1 in soil sample (S9)to 10,10±7.14 Bq kg-1 (S20 and S22), for 232Th varies from 7.97±1.28 Bq kg-1 (S31)to 0.2±0.2 Bq kg-1 (S6) and from 302.95±12.85 Bq kg-1 (S3) to 96.99±7.27 Bq kg-1 (S31) for 40K , with overall mean values of (25.73,3.72 and 165.16) Bq kg-1 respectively. World average concentrations are 35 ,30 and 400 Bq kg-1 for 238U, 232Th and 40K respectively [3]. The concentration for 238U is much comparable and it which because of geological reasons or because of the city had been exposed to artillery bombard expand along different areas in 1991 and 2003, in spite of the mean value of 238U concentration was highest than the world mean but the total effective dose was less than the world average, while 232Th and 40K concentration was lower as compared .

The range values of the Radium equivalent activity Bq kg-1 was (10.488) Bq.kg–1in (S7) to (30.87) Bq.kg–1from (S2) which mean that all the soil samples values lower than (370Bq kg-1)[15].

Annual effective dose in (μSv/y) varies from(15.46) (μSv/y) (S8) to (36.912) (μSv/y) (S15) table:(2), all the soil samples have the annual effective dose less than the world average 460 (μSv/y) [3]. External and internal hazard and gamma activity concentration (representative level index) indexes can be used as an estimation of radiation hazard .The highest values of external and internal Hazard and gamma activity concentration (representative level index) indexes (0.164) , (0.247) and (0.445) all was observed in (S2) .While the lowest values was (0.055), (0.084) and (0.155) all from (S7). External and internal hazard and gamma activity concentration indexes were lower than unity according to the Radiation Protection 112 [16].

The absorbed dose rate calculated from activity concentration of 238U , 232Th and 40K range between 12.606 nGy h-1(S8) to 30.098 nGy h-1(S15) with average value 20.253 nGy h-1 this value coincident to recommended [17].

Conclusions

The variation in concentration of radionuclides for thirty two soil sample was determined . The activity concentrations of 238U, 232Th and 40K were measured using Na(Tl) detection. The mean values activity concentrations of 238U, 232Th and 40K was(25.73±11.23,3.72±0.81 and 165.16±9.39) 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.

The results can be consider as base values for distribution of natural radionuclides in the region and will be used as references information to assess any changed in the radioactive background level due to geological processes.

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

Sample No.	Location name	A ^{238}U	A ^{232}Th	A ^{40}K	Ra eq $Bq.kg^{-1}$
S 1	Primordial Gate	35.36±13.36	5.93±1.10	115.51±7.93	19.924
S 2	University divan	30.31±12.37	7.77±1.26	242.47±11.49	30.870
S 3	Pharmacy college	25.26±11.29	3.68±0.87	302.95±12.85	29.074

S 4	Nursing college	30.31±12.37	1.02±0.46	187.44±10.11	17.050
S 5	Computer& Mathematical College	20.20±10.10	3.07±0.79	205.96±10.59	21.885
S 6	Science College	25.26±11.29	0.20±0.20	139.49±8.72	11.641
S 7	Medicine College deanery	30.31±12.37	0.41±0.29	121.51±8.14	10.488
S 8	Medical physics Dep./ Medicine College	15.15±8.75	1.02±0.46	126.95±8.32	11.906
S 9	Judicial medicine/ Medicine College	45.46±15.15	1.63±0.58	111.70±7.80	12.825
S 10	Chemistry Dep./ Medicine College	10.10±7.14	6.13±1.12	187.98±10.12	25.006
S 11	Anatomy Dep./ Medicine College	15.15±8.75	4.29±0.94	127.50±8.33	16.502
S 12	Laser unity	30.31±12.37	1.23±0.50	145.48±8.90	13.685
S 13	Internet unit / Medicine College	35.36±13.36	1.43±0.54	187.98±10.12	17.554
S 14	Central library	25.26±11.29	6.13±1.12	139.49±8.72	21.150
S 15	Academic teaching and Training Development Center	35.36±13.36	6.13±1.16	254.45±11.77	30.124
S 16	Technician center for dentistry 1	25.26±11.29	6.54±0.79	187.98±10.12	24.860
S 17	Technician center for dentistry 2	30.31±12.37	3.07±0.41	145.48±8.90	17.289
S 18	Education sport college	25.26±11.29	0.82±1.26	194.52±10.30	16.938
S 19	Spot room	20.20±10.10	7.77±0.54	150.93±9.07	23.700
S 20	Playground	10.10±7.14	1.43±0.87	193.43±10.27	17.609
S 21	Engineering college deanery	15.15±8.75	3.68±0.9	218.49±10.91	22.632

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S 22	Engineering college1	10.10±7.14	4.70±0.79	225.03±11.07	25.752
S 23	Engineering college 2	20.20±10.10	3.07±1.12	181.99±9.96	20.161
S 24	Engineering college workshops	35.36±13.36	6.13±1.23	187.98±10.12	25.006
S 25	Mechanical Engineering Dep.	25.2±11.29	7.36±1.23	115.51±7.93	20.571
S 26	Unmarried masters suites	25.26±11.29	0.82±0.41	114.97±7.91	10.691
S 27	The university hospital	30.31±12.37	2.04±0.65	116.06±7.95	13.623
S 28	The sideling gate	30.3±12.37	0.61±0.35	122.05±8.15	11.066
S 29	University accommodations 1	35.36±13.36	6.95±1.19	170.00±9.62	24.182
S 30	University accommodations 2	35.3±13.36	3.07±0.79	164.01±9.45	18.776
S 31	University accommodations 3	20.2±10.10	7.97±1.28	96.99±7.27	19.778
S32	University accommodations 4	20±10	3.07±0.79	102.98±7.49	14.016
Average		25.73±11.23	3.72±0.81	165.16±9.39	19.260
Max		45.46±15.15	7.97±1.28	302.95±12.85	30.870
Min		10.10±7.14	0.20±0.20	96.99±7.27	10.488

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Table (2): Dose rate (nGy/h) ,AEDE (μSv/y), the external and internal hazard indexes representative level index for all samples.

Sample No.	Location name	D(nGy/h)	AEDE (μSv/y)	Hin≤1	Hex≤1	Iγr≤1
S 1	Primordial Gate	23.988	29.419	0.155	0.101	0.269
S 2	University divan	28.508	34.962	0.247	0.164	0.445
S 3	Pharmacy college	26.246	32.188	0.234	0.156	0.433
S 4	Nursing college	21.677	26.585	0.135	0.089	0.249
S 5	Computer& Mathematical College	19.513	23.931	0.173	0.114	0.314
S 6	Science College	16.918	20.748	0.093	0.061	0.173
S 7	Medicine College deanery	18.437	22.611	0.084	0.055	0.155
S 8	Medical physics Dep./ Medicine College	12.606	15.460	0.095	0.063	0.174
S 9	Judicial medicine/ Medicine College	25.297	31.024	0.099	0.064	0.176
S 10	Chemistry Dep./ Medicine College	16.455	20.181	0.198	0.130	0.353
S 11	Anatomy Dep./ Medicine College	14.794	18.143	0.132	0.088	0.238
S 12	Laser unity	20.009	24.539	0.109	0.072	0.200
S 13	Internet unit / Medicine College	24.128	29.591	0.139	0.092	0.257
S 14	Central library	20.841	25.559	0.167	0.110	0.295
S 15	Academic teaching and Training Development Center	30.098	36.912	0.239	0.158	0.432
S 16	Technician center for dentistry 1	23.197	28.448	0.199	0.132	0.356
S 17	Technician center for dentistry 2	21.226	26.032	0.136	0.089	0.243
S 18	Education sport college	19.690	24.148	0.135	0.089	0.251
S 19	Spot room	20.258	24.845	0.189	0.125	0.336
S 20	Playground	13.578	16.652	0.141	0.093	0.261
S 21	Engineering college deanery	18.301	22.444	0.182	0.121	0.333
S 22	Engineering college1	17.102	20.973	0.204	0.135	0.369
S 23	Engineering college 2	18.482	22.667	0.159	0.104	0.286
S 24	Engineering college workshops	27.240	33.407	0.198	0.130	0.353
S 25	Mechanical Engineering Dep.	20.622	25.290	0.164	0.108	0.288
S 26	Unmarried masters suites	16.269	19.952	0.085	0.056	0.156
S 27	The university hospital	19.285	23.651	0.106	0.069	0.189
S 28	The sideling gate	18.595	22.805	0.088	0.058	0.161
S 29	University accommodations 1	27.008	33.122	0.193	0.128	0.344
S 30	University accommodations 2	24.180	29.654	0.147	0.097	0.265
S 31	University accommodations 3	18.074	22.166	0.158	0.104	0.276
S32	University accommodations 4	15.085	18.500	0.109	0.071	0.193
Average		20.553	25.207	0.153	0.101	0.276
Max		30.098	36.912	0.247	0.164	0.445
Min		12.606	15.460	0.084	0.055	0.155

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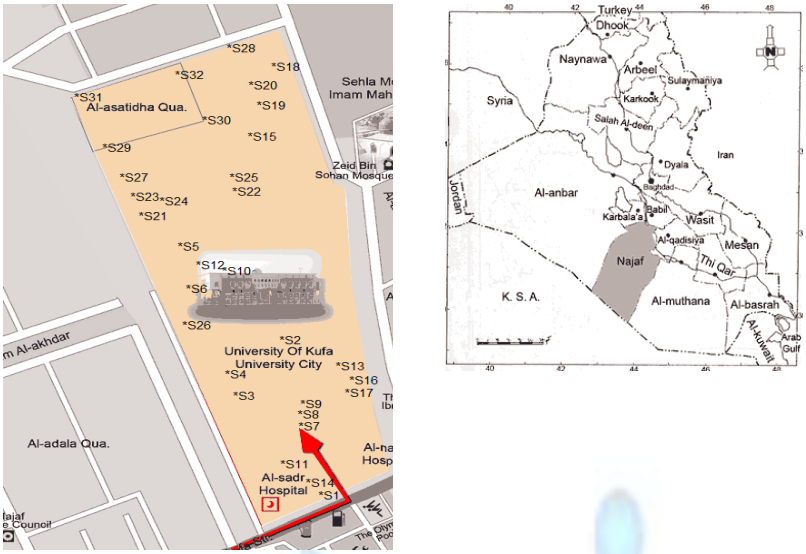

Fig. 1: Map of Al-najaf Al-Ashraf city where the new Kufa University location surveyed during the present investigations.

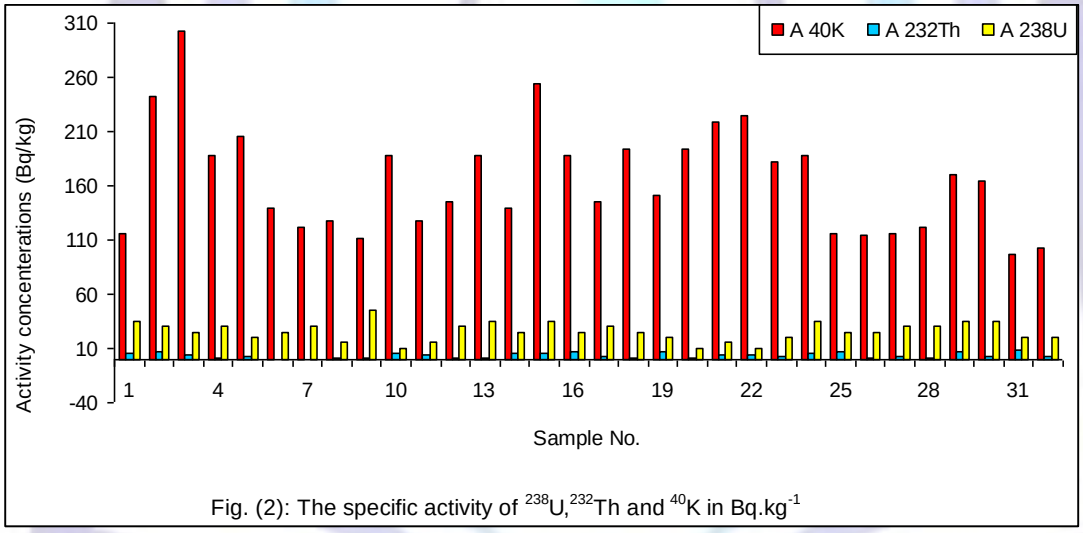

Fig. (2): The specific activity of ^{238}U, ^{232}Th and ^{40}K in $Bq.kg^{-1}$