Determine the Natural Radioactivity of the Sediment Wetlands in the Sea of Najaf, Iraq

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Abstract: ***The natural radiation of seven sediment samples in the An Najaf Sea which collected randomly have been studied. they were measured using 3"×3" Na(Tl) detection. The mean values concentrations of ^{238}U, ^{232}Th and ^{40}K was (8.621 ± 0.352, 0.353± 0.017 and 446.535 ±4.833) 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 (43.509 ± 0.750 Bq/kg and 22.822 ± 0.375 µSv/y) less than the world average. The heist external and internal hazard and gamma activity concentration index were (0.09748, 0.113636 and 0.298963) lower than unity.***

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

1. Introduction

An Najaf Sea, which is a geological phenomenon prominent in the Middle Euphrates region and the Sea of Najaf is located in the west end of the holy city in Najaf.

An Najaf Sea area is 750Km^2. The high of the lowest point is11mabove sea surface and from a geological side; the floor was covered with modern sediment which thickness was up38m.

The concentration of radioactive isotopes in soil were a path for radioactivity to humans and is an indicator of radioactive accumulation in the environment]2].

Natural sources of radiation are cosmic radiation and terrestrial radiation arising from the decay of naturally occurring radioactive substance, 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 region 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].

2. Experimental Procedures

In this study, The natural radiation of seven sediment samples in the An Najaf Sea which collected randomly have been studied.

After collection the samples are crushed into fine powder by grinder 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 (6) 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 0.9 kg of soil is used per sample.

They were measured using Gamma spectrometer with scintillation detector 3"×3" inch NaI(Tl) from SPECTRUM TECHNIQUES, INC.USA .the sample is placed face to face over the detector for 18000 sec, background contribution are subtracted from the peak area for the measured sample, 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 high energies as that obtained in our results from gamma ray emitted by the progenies of ^{238}U (the gamma line 1765 keV for ^{214}Bi) and ^{232}Th (the gamma line 2614 keV for ^{208}Tl) which are in secular equilibrium with them while ^{40}K was estimated directly by its gamma line of 1460keV [10,11] the fig.(1) determine Location of sample in the Sea of Najaf By using GPS while the fig.2 Illustrates the study areas.

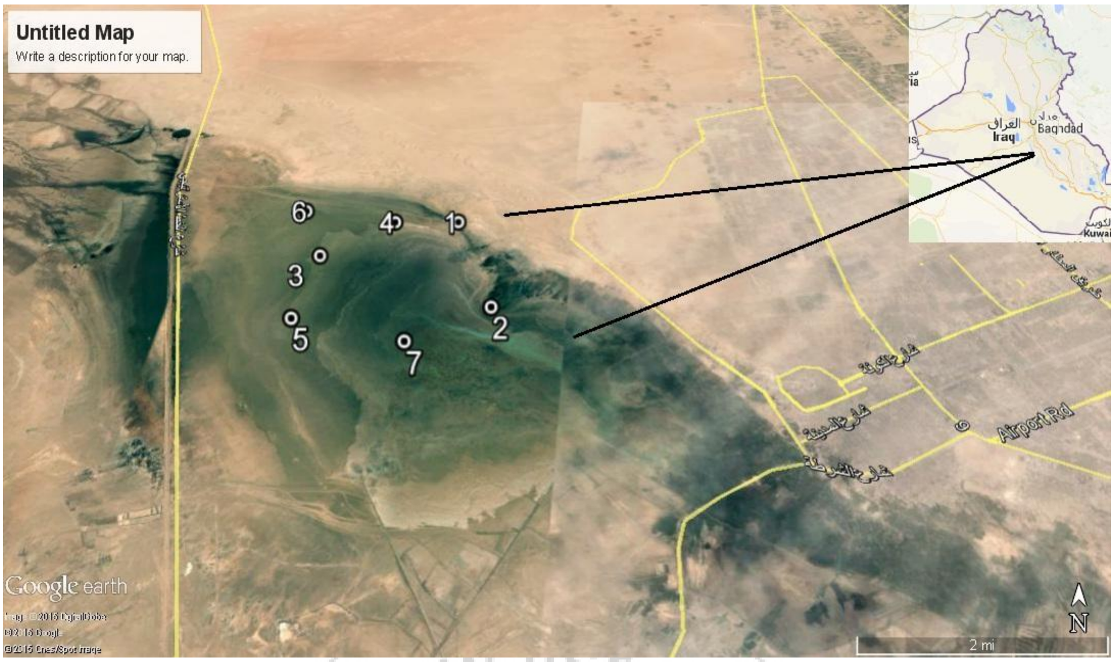

Figure 1: determine Location of sample in the Sea of NajafBy using GPS

(a) (b)

Figure 2:Illustrates the study areas of collect samples

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

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

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, $I\gamma$ 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].

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

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 (outdoors) 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] :

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

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]:

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

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]

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

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]

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

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.

3. Results and Discussions

The specific activity values of 238U,232Th and 40K radionuclide s for 7 soil sample are tabulated in table (1)& fig. 3-5 . They have been found to lie in the range of (14.921±0.475;R4 to 4.943±0.273 ;R3) Bq/kg with an average of 8.621 ± 0.352 Bq/kg, from (0.831± 0.031;R5 to 0.078± 0.009 ;R4) Bq/kg with an average 0.353± 0.017 Bq/kg and (619.649± 5.809 ;R7 to 140.477± 2.766;R1) Bq/kg with an average 535 ±4.833 Bq/kg for 238U, 232Th and 40K respectively .The result shows that all values of 238U, 232Th and 40K specific activity for all soil sample are in the worldwide average (35Bq/kg for 238U, 30 Bq/kg for 232Th and 400 Bq/kg for 40K). [17,18[.

Ra eq values vary from (57.403± 0.843 ;R7 to24.272± 0.674 ; R1) Bq/ kg with average value of (43.509 ± 0.750) Bq/kg .It can see 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), Rate (D) range from (30.311 ± 0.424;R7 to 12.071 ± 0.328;R1) nGy/h with average 22.822 ± 0.375 nGy/h.446.

Table 1: Activity Concentration in (Bqkg-1) in Different Active Soil Samples

Gamma DoseRate (nGy.h^{-1})	Radium equivalent (Bq/Kg)	(Bq/Kg)Specific activity			Sample No.
		^{232}Th	^{238}U	^{40}K	
12.071±0.328	24.272±0.674	0.078±0.009	13.344±0.449	140.477±2.766	R1
20.167±0.345	38.181±0.686	0.554±0.025	5.337±0.284	416.258±4.761	R2
16.081±0.308	30.449±0.613	0.101±0.010	4.943±0.273	329.379±4.235	R3
28.892±0.448	55.565±0.900	0.078±0.009	14.921±0.475	526.396±5.354	R4
27.169±0.386	51.218± 0.765	0.831±0.031	5.534±0.289	577.870±5.610	R5
25.065 ±0.386	47.476±0.768	0.712±0.029	6.748±0.319	515.720±5.300	R6
30.311±0.424	57.403±0.843	0.117±0.011	9.523±0.380	619.649±5.809	R7
22.822 ± 0.375	43.509 ± 0.750	0.353± 0.017	8.621 ± 0.352	446.535 ±4.833	Average
30.311 ± 0.424	57.403± 0.843	0.831± 0.031	14.921±0.475	619.649± 5.809	Max.
12.071 ± 0.328	24.272± 0.674	0.078± 0.009	4.943±0.273	140.477± 2.766	Min.

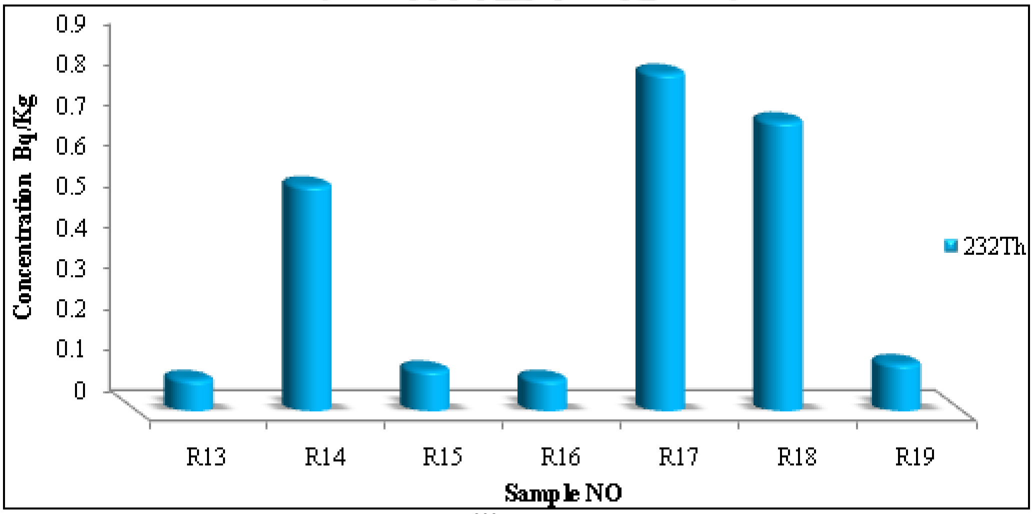

Figure3: Illustrates the concentrations of ^{232}Th in sediment samples taken from the Sea of Najaf

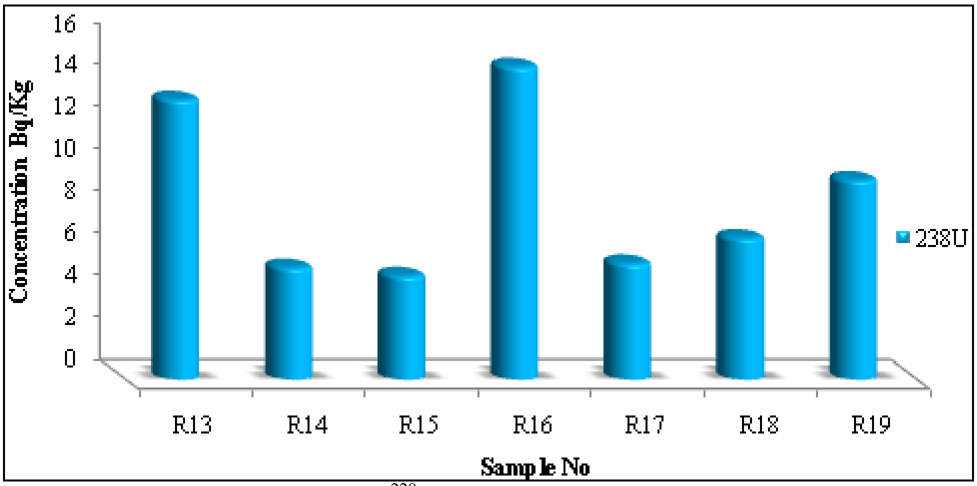

Figure4: Illustrates the concentrations of ^{228}U rates of sediment samples taken from the Sea of Najaf

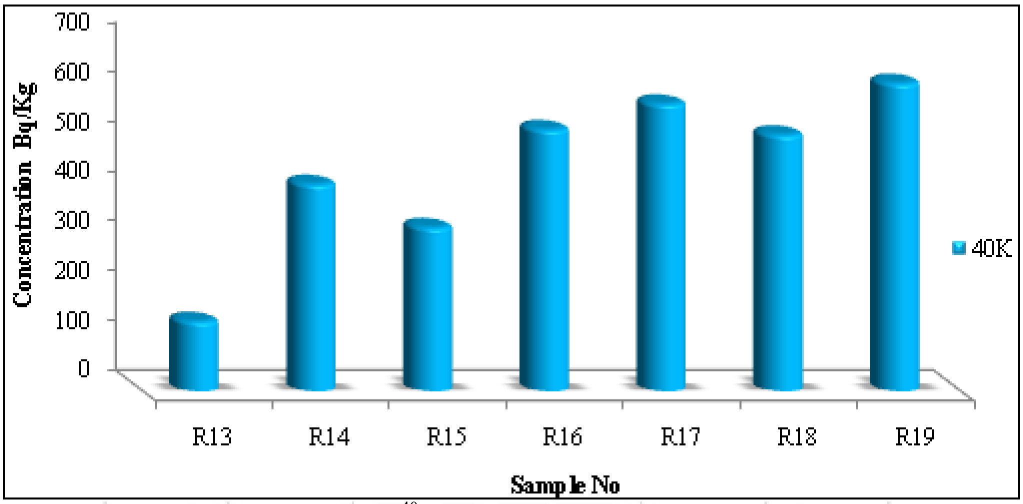

Figure5: Illustrates concentrations of ^{40}K rates of sediment samples taken from the Sea of Najaf

Representative level index (Iγr), External hazard index (Hex) and Internal hazard index (Hin) are calculated andthe Gamma Dose listed in table (2), the (AEDE) rang are from (0.0371 ±00005 ;R7 to 0.0148±0.0004 ;R1) (µSv/y) with average 0.0279 ±0.1408(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 (0.477756;R7 to 0.183391;R1) with average 0.358697, External hazard index (Hex) range from (0.155014;R7 to 0.065571;R1) with average 0.117499 and Internal hazard index (Hin) range from (0.190393 ;R4 to 0.095586;R3) with average 0.1408. 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

Representative level index (I_γ)	Hazard Index		Effective dose rate $mSv.yr^{-1}$		S.No
	Internal ($H_{in} \geq 1$)	External ($H_{ex} \geq 1$)	(Indoor)	(Outdoor)	
0.183391	0.101636	0.065571	0.0592±0.0016	0.0148±0.0004	R1
0.318625	0.117527	0.103103	0.0989±0.0016	0.0247±0.0004	R2
0.253549	0.095586	0.082227	0.0788±0.0015	0.0197±0.000 3	R3
0.451184	0.190393	0.150066	0.1417±0.0021	0.0354±0.0005	R4
0.43045	0.153261	0.138304	0.1332±0.0018	0.0333±0.0004	R5
0.39592	0.146443	0.128205	0.1229±0.0018	0.0307±0.000 4	R6
0.477756	0.180752	0.155014	0.1486±0.0020	0.0371±0.0005	R7
0.358697	0.1408	0.117499	0.1119±0.3586	0.0279 ±0.1408	Average
0.477756	0.190393	0.155014	0.1486±0.0020	0.0371 ±0.**0005**	Max
0.183391	0.095586	0.065571	0.0592±0.0016	0.0148±0.0004	Min.

4. Conclusions

The activity concentrations of ^{238}U, ^{232}Th and ^{40}K for (7) Sediment sample from the Sea of Najaf was determined . The mean values activity concentrations of ^{238}U, ^{232}Th and ^{40}K was (8.621 ± 0.352, 0.353± 0.017 and446.535 ±4.833) Bq kg-1 respectively.

The values of the Radium equivalent activity and annual effective dose was less than the world averageExcept ^{40}K . External and internal hazard and gamma activity concentration (representative level index) indexes were lower than unity.

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