Natural Radioactivity of Some Local Building Materials in the Middle Euphrates in Iraq.

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Abstract :

U-238, Th-232 and K-40 and their daughter products effect on human health is the main motivation behind several environmental studies including the soil and building materials [1, 2, 3]. The gamma spectrometry method with a NaI (Tl) detector, coupled with multi channel Analyzer, (MCA 4096 channels) has been used for radiometric measurements.

Sampling of seven building materials were taken from the middle Euphrates region distributed by five samples from Najaf province and two from Babylon province.

The specific activities of U-238, Th-232 and K-40 were calculated based on the photo peaks of 1764 keV (Bi-214), 2614 keV(Tl-208) and 1460 keV (K-40) .

Values for Bi-214 vary from 32.99 to 128.75 Bq kg^{-1} (average of 76.49 Bq kg^{-1}), For Tl-208, From 1.98 to 14.78 Bq kg^{-1} (average of 7.27 Bq kg^{-1}) and for K-40, from 135.02 to 977.79 Bq kg^{-1} (Average 548.75 Bq kg^{-1}).

These values allowed the determination of the elemental concentrations as well as the Hazard-Index.

Concentrations of radionuclide were calculated in the (ppm) units that belongs to the Uranium and Thorium series by using the standard dilution and addition method using the standard sample (S-14) which are supplied by the IAEA.

The average of Hazard-index and specific activity of building materials was with in the allowed limits.

Introduction:

Natural environment radionuclide are responsible for the mast external exposure of gamma radiation .This contribution radionuclide of the natural series U-238 , Th-232 followed by K-40 universally present in the Earth [1,2,3] .The world mean specific concentration of K-40 (Activity per unit mass) is 370 Bq kg^{-1},varing from 100 to 700 Bq kg^{-1} [3] .

The united Nations Scientific committee on the effects of Atomic Radiation , UNSCEAR(1993),establish that ,the world mean dose from natural radiation sources of normal areas is estimated to be 2.4 $mSvy^{-1}$, while that for all man-made sources ,including medical exposure, is about 0.8 $mSvy^{-1}$ [4].Thus 75 % of the radiation dose received by humanity is come from natural radiation sources .Based on these radiation levels from this fact one can certify that the knowledge of primordial radionuclide ,such U-238, Th-232 and K-40, is very important for evaluation of the rate of exposure and absorbed dose by the population [5,6,7] .

The relevance of the U-238 ,Th-232,and K-40 study is mainly due to their long half life ,importance of potassium -40 for living organisms with a uniform distribution, and because it is responsible for 98% of gamma emission of the primordial radionuclide present in the earth[12,13].

The aim of this work was to calculate the radioactivity and concentration of U-238, Th-232, and K-40 in some type local building materials in middle Euphrates area of Iraq.

The present work is important because there is no reference regarding the area concerning U-238, Th-232, and K-40 radiation and concentration in the building materials in middle Euphrates region of Iraq.

For this purpose, seven samples of building materials were taken from two provinces Najaf and Babylon, had been studied using gamma-ray spectrometry techniques.

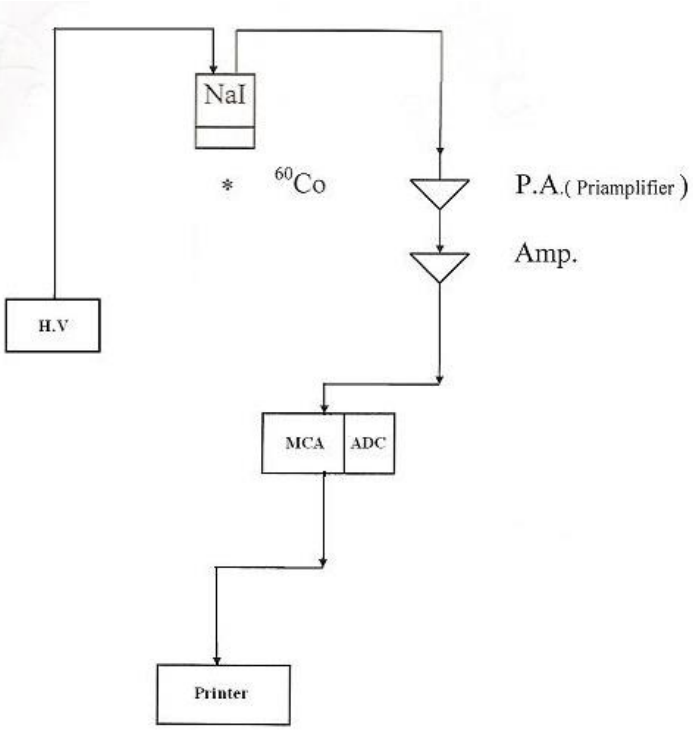
Experimental .

Seven Building material samples utilized in this work were taken from the middle Euphrates region distributed by five samples from Najaf province and two samples from Babylon province. Each sample was dried, weighted, and meshed perfectly to pas 1mm mesh.

In this study, a 1.4l polyethylene Marinelli beaker was used as a sampling and measuring container. Before use, the containers were washed with dilute hydrochloric acid and rinsed with distilled water. Each beaker was filled up by 1 Kg weight. Every sample was counted for 8000s.

To reduce the background effect ,the detector was enveloped by 5×10×20 cm lead block covering [10] .The measurement time for each sample was standardized at 8000s. The counting efficiency of U-238, Th-232 and K-40 in the energies of approximately, 1764 keV, 2614 keV and 1460 keV respectively was determined with Eu-252, multi-gamma emitting, with energies varying from 39 keV to 2 MeV. Back ground was measured under the same conditions of sample measurement.

The activities of the U-238 , Th-232 and K-40 were determined by gamma-ray spectrometry NaI (Tl) of (3"×3" crystal dimention) coupled to Canberra MCA (multi channel analyzer) with 4096 channels as shown in fig.(1) .



Fig(1). The block diagram of Gamma ray spectroscopy.

This system was calibrated for energy and efficiency. The energy calibration was carried out by acquiring a spectrum from radioactive standards of known energies like Cs-137 Eγ=662 keV and Co-60 Eγ =1332 keV as shown in figs. 2 and 3 .Energy calibration curve was represented in Fig. (4).

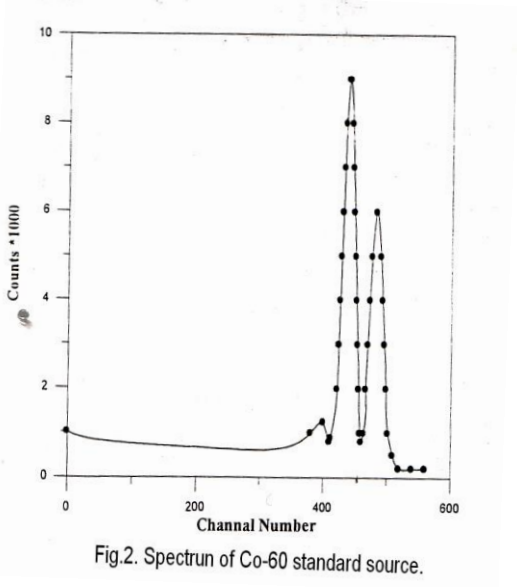


Fig.2. Spectrun of Co-60 standard source.

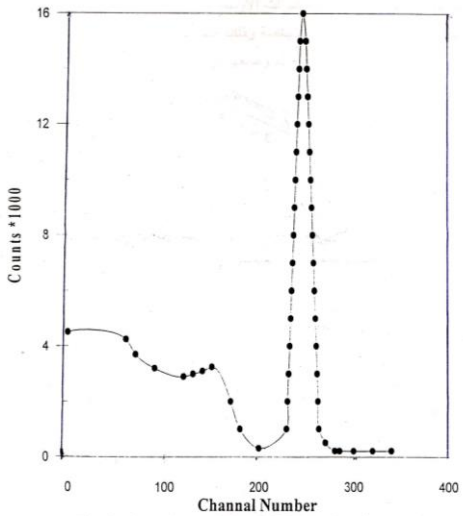


Fig.3. Spectrun of Cs-137 standard sourse.

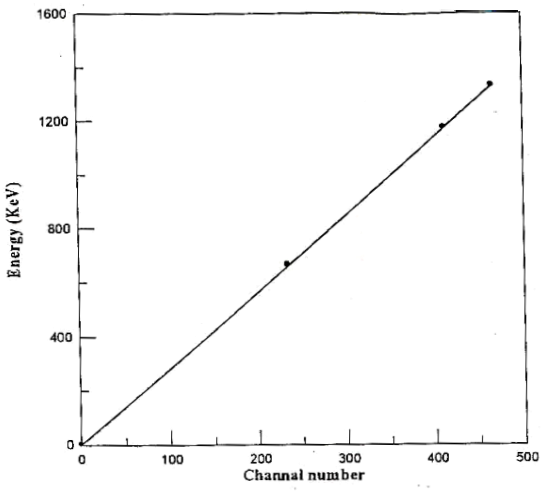


Fig.(4) Energy Calibration Curve.

The Energy resolution was 7.2 % at 662 keV.
For the efficiency calibration we used Eu-152 standers source. Table(1) includes the percentage of energy efficiency and percentage of gamma emission probability of Eu-152.

The efficiency calibration curve permits us to calculate the percentage of energy efficiency for the energies of radionuclide under consideration see table (2).

$E_\gamma(keV)$	I_γ %	ε %
121.8	33.2	6.9
344.3	31.4	4.4
778.9	15.2	2.1
964	17.3	1.7
1085.8	10	1.6
1112	16.4	1.5
1407	24	1.4

Tabel 1. Percentage of energy efficiency and Percentage of gamma emission probability of Eu-152.

$E_\gamma(KeV)$	I_γ %	ε %
1460	10.7	1.2
1764	15.8	1.1
2614	100	0.8

Table (2).Percentage of energy efficiency and Percentage of gamma emission probability of the three radionuclide under study

Results and Discussion

The gamma-ray transitions at energies of (1764 keV Bi-214),(2614 keV Tl-208,and 1460 keV K-40 were used to determine the activity and concentration of U-238 ,Th-232 ,and K-40 respectively [8,9,10].

The spectrum of samples were analyzed .Figures (5) to (11) ,show the gamma-ray spectra of samples .The accumulation time for each-spectrum with was 8000s to obtain good statistics .The resolved photo peaks were appeared in the gamma-ray spectra .

Based on the calculations of the counting efficiency of the Eu-152 standard source ,it was possible to calculate the specific activities of (U-238 ,Th-232 ,and K-40),with the energies (1764 keV Bi-214, 2614 keV Tl-208, and 1460 keV K-40) respectively passed on equation 1 .[1,10,11].

$$A = \frac{C}{\varepsilon\% I_{\gamma} m t} - BG \qquad (1)$$

Where A is the specific activity, C is the area under the photo peaks, $\varepsilon\%$: Percentage of energy efficiency.

I_{γ} is the percentage of gamma-emission probability of the radionuclide under consideration , t is counting time , M is mass of sample and BG is background .

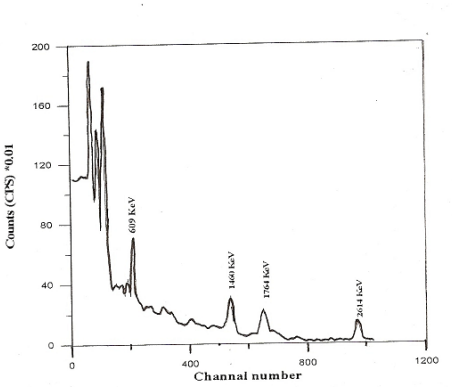


Fig.(5).Spectrum of Najaf cement.

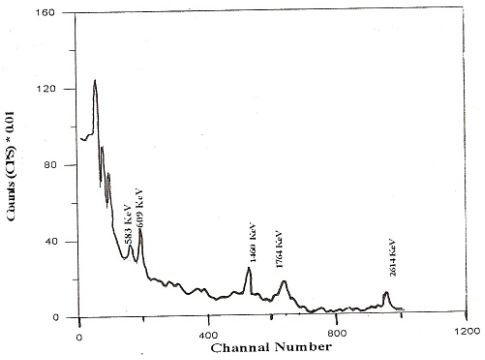


Fig.(6).Spectrum of Najaf block.

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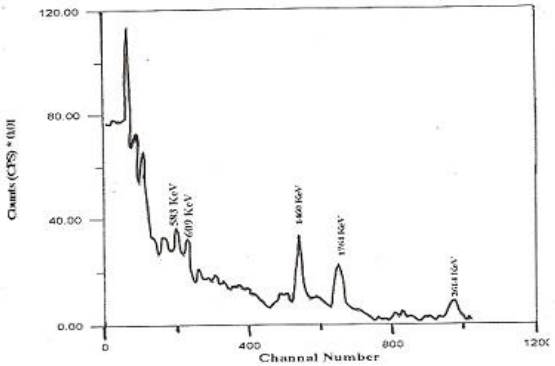

Fig.(7).Spectrum of Najaf gypsum.

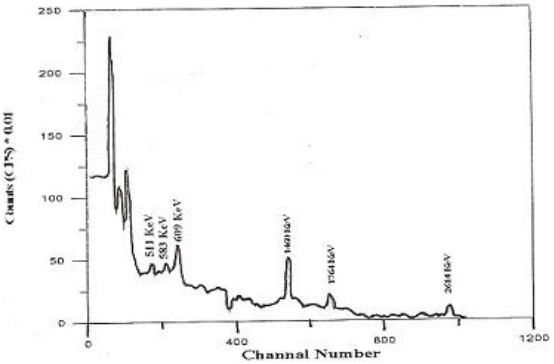

Fig.(8).Spectrum of Najaf brick.

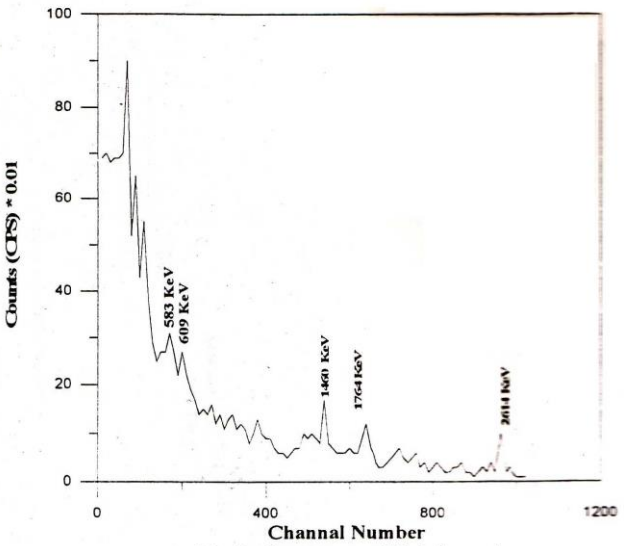

Fig.9. Spectrum of Najaf sand.

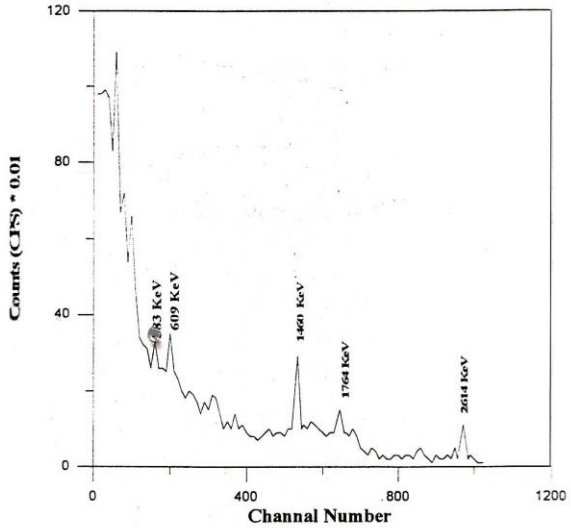

Fig.10. Spectrum of Babylon block.

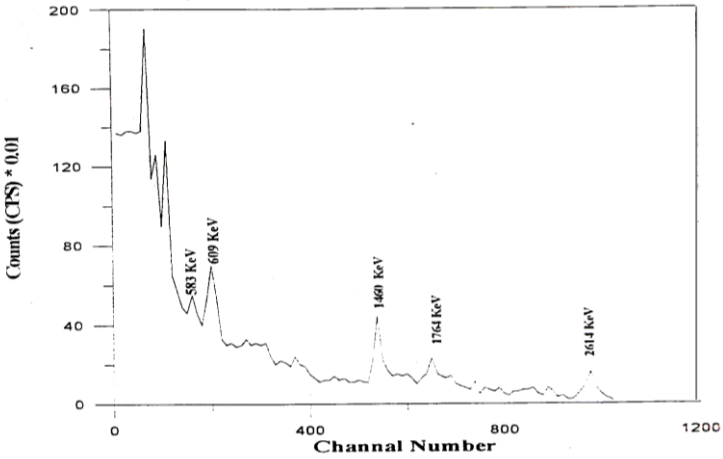

Fig.11. Spectrum of Babylon brick.

Table (3) shows the radionuclide activities and their values for U-238, Th-232, and K-40 in different building materials in different location in middle Euphrates of Iraq.

Furthermore , the maximum activity value of U-238 is recorded in the Najaf cement which was 128.75 Bq kg^{-1},and the minimum value is recorded in Najaf gypsum which was 32.99 Bq kg^{-1}.The maximum activity value of Th-232 is recorded in Najaf brick (14.78 Bq kg^{-1}), and minimum value recorded in Najaf sand (1.98 Bq kg^{-1}) and the maximum activity value of K-40 recorded in Najaf brick (977.79 Bq kg^{-1}) and the minimum value recorded in Najaf sand (135.02 BqKg-1) .Table (4) .shows the range and average value of activity of U-238 ,Th-232,and K-40 radionuclide ,which are (32.99 to 128.75) with average value of 76.49 Bq kg^{-1}ranged from 1.9 to 14.78 with average value of 7.27 Bq $kg^{-1}$and 135.02 to 977.79 with average value of 548.75 Bq kg^{1}.

No.	Samples	Specific Activity (Bq Kg^{-1})		
		Bi-214(1764 keV)	Th-232(2614 keV)	K-40(1460 keV)
1	Najaf cement	128.75±3.21	07.62±0.42	480.72±7.38
2	Najaf block	85.75±2.56	05.42±0.22	382.10±4.83
3	Najaf gypsum	032.99±1.84	03.75±0.29	517.22±7.17
4	Najaf brick	120.04±3.87	14.78±0.55	977.79±10.10
5	Najaf sand	043.57±1.84	01.98±0.22	135.02±3.72
6	Babylon block	65.08±3.25	05.67±0.36	414.71±6.62
7	Babylon brick	59.25±0.48	11.61±0.39	933.69±9.48

Table (3).Specific Activity of Bi-214 ,Th-232 and K-40 in the Samples .

No.	Nuclide	Energy (keV)	Average (Bq)	Range (Bq kg^{-1})
1	Bi-214	1764	076.49 ± 2.44	032.99 – 128.75
2	Th-208	2614	00727 ± 0.35	001.98 – 14.780
3	K-40	1460	548.75 ± 7.43	135.02 – 977.79

Table (4) Range and Average values of specific activity of Bi-214, Th-232, and K-40 in the Samples.

Table (5) represents a comparison of our results with others recorded in various countries. This table show that the mean activity of K-40 of the present study is higher than the mean activity of united states, west Germany, Bangladesh, Spain, USSR and India whereas those of china, Nordic countries, Finland and Italy is higher than of Iraq.

To evaluate the elemental concentration of each radionuclide, we have used dilution and addition method by using standard sample (S-14) which contains 29 ppm of U-238 and 610 ppm of Th-232.This sample was supplied by (IAEA) (International Atomic Energy Agency). The calibration curves of Known U-238 and Th-232 contents were established and utilized as shown in fig.(5) for U-238 and fig.(6) for Tl -232.

Country	Specific Activity (Bq kg^{-1})			References
	U-238	Th-232	K-40	
United states	35.000	35.00	370	14.15
China	40 ± 340	49 ± 28	580 ± 20.00	14
Nordic countries	20 - 120	25 - 80	600 – 1300	14
West Germany	14.800	0.18.50	< 259	16
Finland	37.000	043.00	1034	16
Bangladesh	88.1 ± 4.80	68.2 ± 5.20	256.4 ± 16.3	17
Spain	14.06 ± 0.10	17.39 ± 0.09	266.77 ± 3.8	18
Italy	67.00	138.00	580	19
USSR	14.8 – 37	0140.80	259	16
India	22.00	09.30	233	16
Middle of Iraq	76.49 ± 2.44	007.27 ± 0.35	548.75 ± 7.43	This work

Table (5) Specific activity of U- 238, Th-232 and K-40 in the investigated samples and work conducted in various countries.

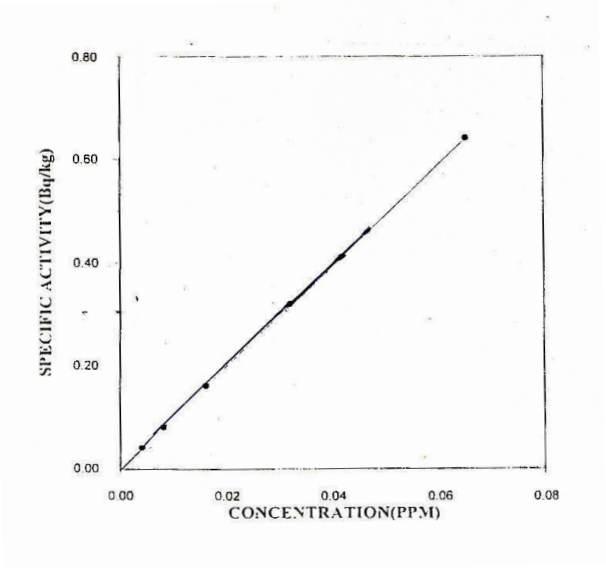

Fig.5 Concentration calibration curve of U-238 in the standard sample (S-14).

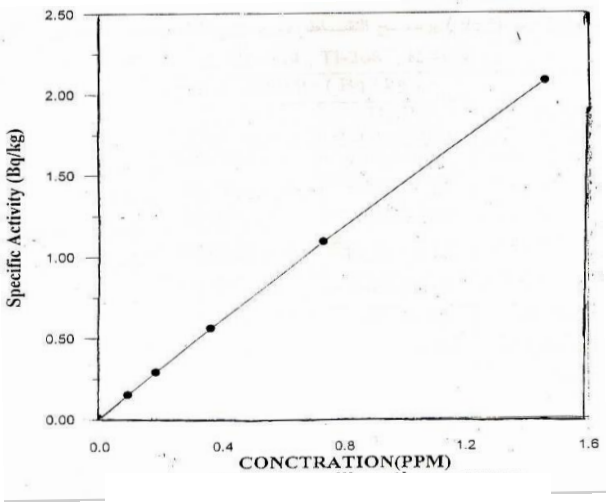

Fig.6 Concentration calibration curve of Th-232 in the standard sample (S-14).

Table (6) shows the elemental concentration in ppm unit of Bi-214 and T1-208 radionuclide in the sample .The maximum concentrations of above two radionuclide were found in Najaf cement (13.08 ppm) respectively.

Table (7) includes the range and average values of concentration that belong of decay series of U-238 and Th-232.The average concentration of U-238>Th-232. The concentration of U-238 and was ranged from 3.35 to 13.08 ppm and for Th-232 was ranged from 1.40 to 10.55 ppm.

Concentration			
No.	Samples	Bi-214 (1764 keV)	Tl-208 (2614 keV)
1	Najaf cement	13.08± 0.32	05.44± 0.30
2	Najaf block	008.7± 0.27	03.87± 0.16
3	Najaf gypsum	03.35± 0.18	02.67± 0.21
4	Najaf brick	12.19± 0.39	10.55± 0.15
5	Najaf sand	04.42± 0.18	01.41± 0.15
6	Babylon block	06.61± 0.33	04.05± 0.26
7	Babylon brick	06.02± 0.04	08.29± 0.27
	Average	07.35±0.24	005.18±0.21

Table (6). Concentration (in ppm units) of radionuclide under study.

No.	Nuclide	Average(ppm)	Range(ppm)
1	Bi-214	7.78	03.35 – 13.08
2	Tl-208	5.18	01.40 – 10.55

Table (7) Rang and average values of elemental concentration of Bi-214, Tl-208 radionuclide in the building material samples.

The hazard – index H can be used to estimate the level of gamma radiation hazard which is associated with natural radionuclide in the building material samples . Radiation hazard due to the activity concentration of U-238,Th-232,and K-40 ,were assessed by two different indices (6) .In this work we applied equation 2 which is a weighted sum of activates of the radionuclide and consideration ,based on the estimation that (185 Bq kg^{-1} for U-238), (259 Bq $kg^{-1}$for Th-232), and (4810 Bq $kg^{-1}$for K-40) produce the same gamma –ray dose rates [11,12].

$$H = \frac{As\ {}^{238}U}{185} + \frac{As\ {}^{232}Th}{259} + \frac{As\ {}^{40}K}{4810} \qquad (2)$$

Where As ^{238}U, As ^{232}Th and As ^{40}K represent the concentration specific activity of Uranium, Thorium and Potassium respectively.

Table (8) .shows that the value of H ranged from 1.12 to 0.26 .The maximum value of H was recorded in Najaf - brick and the minimum value was recorded in Najaf sand .However the average value of H was (0.55) and it was with in the allowed limits.

Average value of Hazard index of U-238, Th-232, and K-40 in building materials from work conducted in various countries is presented in table (9) .

No.	Sample	Hazard index
1	Najaf cement	0.81
2	Najaf block	0.56
3	Najaf gypsum	0.29
4	Najaf brick	0.90
5	Najaf sand	0.27
6	Babylon block	0.45
7	Babylon brick	0.55

Table (8) Hazard index of the building materials samples

Country	Hazard index	References
United states	0.40	14
China	0.52	14
Nordic countries	0.32	14
West Germany	0.20	16
Finland	0.58	16
Bangladesh	0.80	17
Italy	1.01	19
USSR	0.19	16
India	0.20	16
Middle of Iraq	0.55	This work

Table (9) Comparison of hazard index in Iraq with some other countries .

Conclusion:

In this study we measured radiation in building materials in middle Euphrates of Iraq using gamma-ray spectrometry technique.
The regions of study were Najaf and Babylon provinces .The results have shown a variation in the values of Activity and elemental concentration of natural radionuclide of U-238, Th-232,and K-40 .This variation of radiation is due to some factors which are summarized as follows :

- The nature of the soil, rocks, sediments
- The proximity of the region to the Uranium, Thorium and Potassium sources .
- The concentration of suitable compleaing agents which can increase the solubility of the above three radionuclide and their daughters.

The results show that gamma spectrometry is an important tool for environment monitoring of U-238, Th-232, and K-40, by this method, the distribution the Activity as well as the elemental concentration could be determined.

The measured activities of U-238, Th-232 in the studied area were higher than the permissible activity levels which are in general 41.0 and 250 Bq kg^{-1} for U-238 and K-40, respectively, where as potassium activity level was smaller than the permissible level .

It has been proposed that some factors are likely to influence the uranium, Thorium and Potassium concentration in natural soil, ground water [14, 15].
Radiation hazards due to the activities concentration of U-238, Th-232, and K-40, were within the allowed limits.

Recommendations:

The present work suggests that more investigation about the radioisotopes in different places in middle Euphrates of Iraq should be carried out in order to map the natural nuclides contamination in building materials, soil, drinking water, ground water, tap water, bottled water and the gross alpha contamination.

It is important to starting with making epidemiological studies of the general population to determine lung cancer incidence due to high level of radiation, This would give a good motivation to remedial the area of radiation contamination and to protect people of radiation risks.

We recommend upgrading the existing equipments to get better quality and higher resolution with new equipments.

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