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Study on the Natural Radioactivity in Some Building Material

دراسة حول النشاط الاشعاعي الطبيعي لبعض المواد الانشائية

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Abstract:

As a result of intense daily use of building material by people, in this search the natural radiation of samples were measured (block, brick, gypsum, thermo stone, cement and plaster). The detection and measurement system are made up of a nuclear detector was used, . The radioactive sources (^{137}Cs, ^{22}Na, ^{60}Co) were used detector

The results showed that values of activity concentrations of ^{238}U,^{232}Th and ^{40}K are less than level of (MCL) proposed by United States Environmental Protection Agency (USEPA). The values of the Radium equivalent activity and annual effective dose are less than the maximum permissible levels recommended by world health organization, the heist external and internal, hazard and gamma activity concentration index were lower than unity

الخلاصة:

نتيجة الاستخدام المتزايد من قبل البشر لاستخدام المواد الانشائية تم في هذا البحث قياس الاشعاع الطبيعي لعينات من مواد البناء (البلوك والطابوق والجبس والحجر الحراري والاسمنت والجص) باستخدام عداد وميضي باستخدام المصادر المشعة (السيزيوم137 والكوبلت60 والصوديوم22) لغرض معايرة الكاشف

وأظهرت النتائج أن قيم تركيز النشاط الإشعاعي (^{238}U, ^{232}Th, ^{40}K) هي أقل من الحدود التي اقترحتها وكالة حماية البيئة الأمريكية (USEPA). وكانت قيم مكافئ الراديوم والجرعة الفعالة السنوية أقل من الحد الأقصى المسموح الذي أوصت به منظمة الصحة العالمية، وكذلك وجد بان عامل الخطورة الخارجية والداخلية، و تركيز كاما أقل من الحد المسموح به

1. Introduction

The term radioactive contamination refers to the presence of radioactivity in the environment where this radioactivity is higher than the maximum limit so that hurts humans organisms (1). Human are exposed to natural radiation as a result of cosmic rays and other radioactive materials such as uranium , thorium in the Earth's surface and radon gas within the building materials (2)

This gas is a poison and its emitted from the soil containing uranium. In addition to that its heavier than air at about (7.5) times(3). as well nucleus is dissolved, resulting from the emission of alpha rays and generating nuclei radioactive polonium (^{218}Po), which has a half-life (3.05) minutes(3). Polonium is solid material emit of alpha rays so that its can be electrically charged, leads to adhesion , charged minutes lingering dust in the air to produce fallout minutes and these minutes can cause health risks may develop when exposure to them for a long time than its cause lung cancer when inhaled and collected as a result of deposition in the respiratory tract (3)

These isotopes can be found in nature with varying concentrations different of one region to another. its can be concentrated dimensions moves from home to sites of human life abound as a result of some industries, such as non-nuclear industries: phosphate fertilizers, oil, gas and electricity used coal as fuel (4)

The building material used for house building influences the radiation dose of human beings due to natural radioactive substances. The radiation within buildings made of bricks or concrete is higher than in buildings made of some type of pre-assembled units as wood since this building material contains less natural radioactive substances .Table (1) shone that.

Table (1) Radiation exposure of some type building material, * due to shielding(5)

Building material	*Additional radiation exposure(mSv/year)*
Wood	-0.2* to 0
Chalky sandstone, sandstone	0 to 0.1
Brick, concrete	0.1 to 0.2
Natural stone, technically produced gypsum	0.2 to 0.4
Slag brick, granite	0.4 to 2

2 . Theoretical part

The specific activity of each radionuclide is calculated using the following equation(6)

$A = (N_{net}/ \varepsilon.I_{\gamma}.m.t) \pm((N_{net})^{1/2}/ \varepsilon. I_{\gamma}.m.t)$ (Bq/kg) …….(1)

Where *Nnet* is the net count (area under the specified energy peak after back ground subtraction) , ε is the efficiency of the detector, I_{γ} 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).(6) Table (2) shown information of isotopic were used in measure

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Isotopic	Efficiency %	I_{γ}	Energy (KeV)
^{40}K	0.0024	0.1066	1460
^{214}Bi	0.0007	0.1517	1764
^{208}Tl	0.00024	0.35	2614

Depending on the specific effectiveness of each of uranium, thorium and potassium are measured at each of the radium equivalent, the absorbed dose rate in air, internal and external annual effective dose and concentration as well as the efficiency coefficient of samples by using the following equations

$Ra_{eq}(Bq/Kg) = A_u+1.43A_{Th}+.077A_k$ ……..(2)(7)
Where Ra_{eq} is the Radium equivalent
A_u, A_{Th}, A_k are specific effectiveness of each (uranium, thorium and potassium) respectively

$AD(nGy/h) = 0.462A_u+0.621A_{Th}+0.0417A_k$ ……....(3)(8)
Where AD is the absorbed dose rate in air

The internal and external hazard index is account depending on the step guide that has already been proposed in 1983 by the International Union for the prevention of radiation to set limits combines dose rate for each of the external exposure and exposure to indoor-ray gamma,where this information is collected in the shrines of fractures within the relationship of radioactivity qualitative radionuclide aim to evidence indicates how dangerous according to the following equation (9). .

$H_{ex} = (A_U)/185 + (A_{Th})/259 + (A_K)/4810$ ……(4)(9)

Where H_{ex} is the external hazard index

$H_{in} = (A_U)/370 + (A_{Th})/259 + (A_K)/4810$ ……(5)(10)

Where H_{in} is the internal hazard index

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 of(0.7 Sv/Gy).The outdoor occupancy factor which is about (0.2) (11) .

The annual effective dose equivalent was given by the following equation
Indoor (mSv\y) =A D (nGy/h)×8760 h× 0.8 × 0.7 Sv/Gy × 10-6--------(6)

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

$$I_{\gamma r} = A_U / 300 + A_{Th} / 200 + A_K / 3000 .....(7)$$

The index Iγr was correlated with the annual dose due to the excess external gamma radiation caused by superficial material. Values of index $I \leq 1$ correspond to 0.3 mSv/y, while $I \leq 3$ 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 $I \leq 3$ should be avoided(12)

3 . Experimental part

(3 . 1) Samples Preparation

All samples were collected from different locations then it was crushed mechanically to fine powder, and then is dried by electric furnace at about (100c) to remove moisture then it was riddled with using a clip-diameter holes (2mm) to obtaining a homogeneous samples Ahomogeneous samples were packed in inside plastic bags have capacity (1kg)and sealed tightly with cap kept aside for about four weeks to ensure the equilibrium has been reached.

(3 . 2) . detection system

The detection and measurement system used in this search, it is made up of a nuclear detector 2x2 inch NaI(TI) from EG&G ortec that working at (750)volt with the efficiency of (60%) at Gamma ray energy . The viability of discrimination detector of energy in the limits (6.5 – 8.56)% for the energy values (0.662 – 1.332)MeV Detector is associated with the following successive parts of the primary amplifier, the electrical signal, the main amplifier and electronic computer which includes a multi-channel analyzer .

(3 . 3) . Calibration of System

A . energy in the detector calibration

Calibration is a linear relationship between the pulse of detector and energy gamma rays. The several standard radioactive sources (^{137} Cs, ^{22} Na, ^{60} Co and ^{133}Ba) were used to calibration of radiation Gamma. as shown in Figure (1)

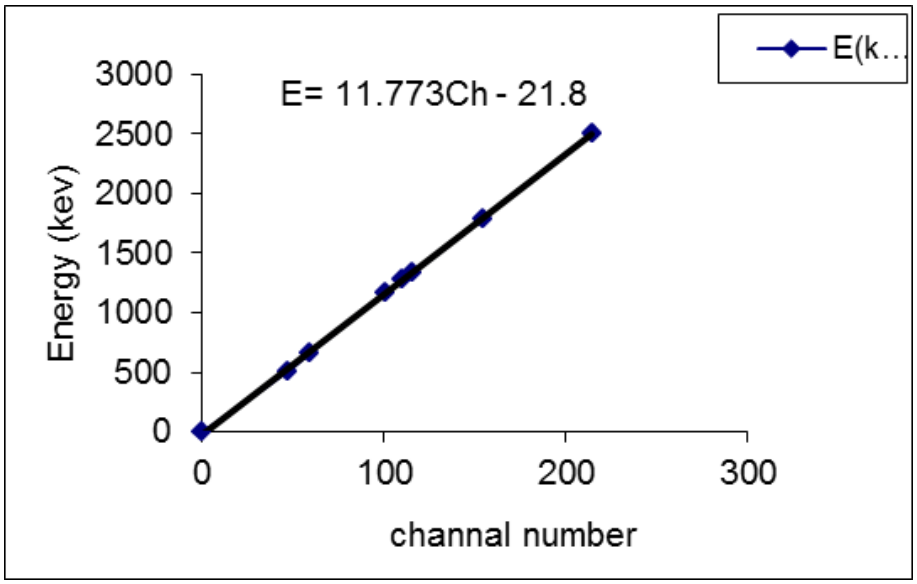

Figure (1) the relationship between the channel number and energy gamma rays

B - Calibration efficiency

Detector efficiency is the ratio between the number of photons gamma rays to the number of pulses emitted , always detector efficiency is less than 100% and its can be calculate by the following equation

$$\varepsilon = [N/(A.I_{\gamma}. t)] \times 100\% \quad \text{.....(6)}$$

Decay equation is used to measure the final specific activity of the standard radioactive sources , also radioactivity which is recorded by the detector for the energy of the standard active sources for (3600sec) is measured then the efficiency can be measured by equation (6) , Figure (2) shows the relationship between efficiency and energy the standard sources .

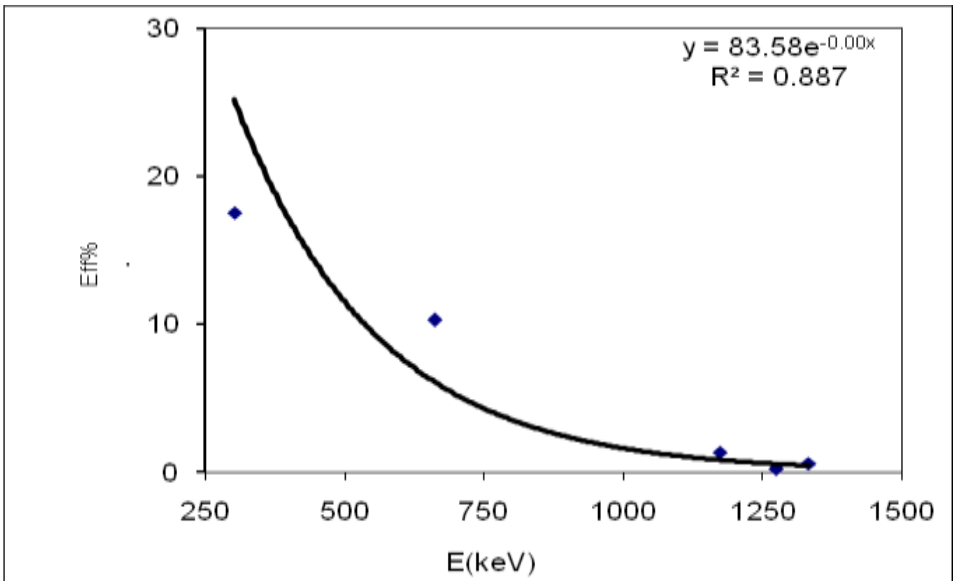

Figure (2) calibration of efficiency of the system

4. Method of measurement

Wash Mrneli Bequre (is pot made of plastic with a capacity of one liter and has a cylinder prove in his center which is placed on the crystal of the detector) by acid, hydrochloric diluted and then with distilled water then place (0.5KG) of each sample in the container and surround it by a shield made of lead, which consists of two parts , the first part thickness (5cm) and height (10cm) , the second part caver with thick (5cm) and diameter (cm) that the installation of the shield in this way achieves a high efficiency during the measurement

Finally , specific activity of samples for (3600) Sec were measured then the area under the peak for the spectrum of gamma rays was calculate .The effectiveness of radiation quality can be calculated from equation (1) after subtracting the background radiation value (a measurement system in the case of free samples). The spectrum of gamma rays for samples (2) and (4) are show in figures (3a and 3b)

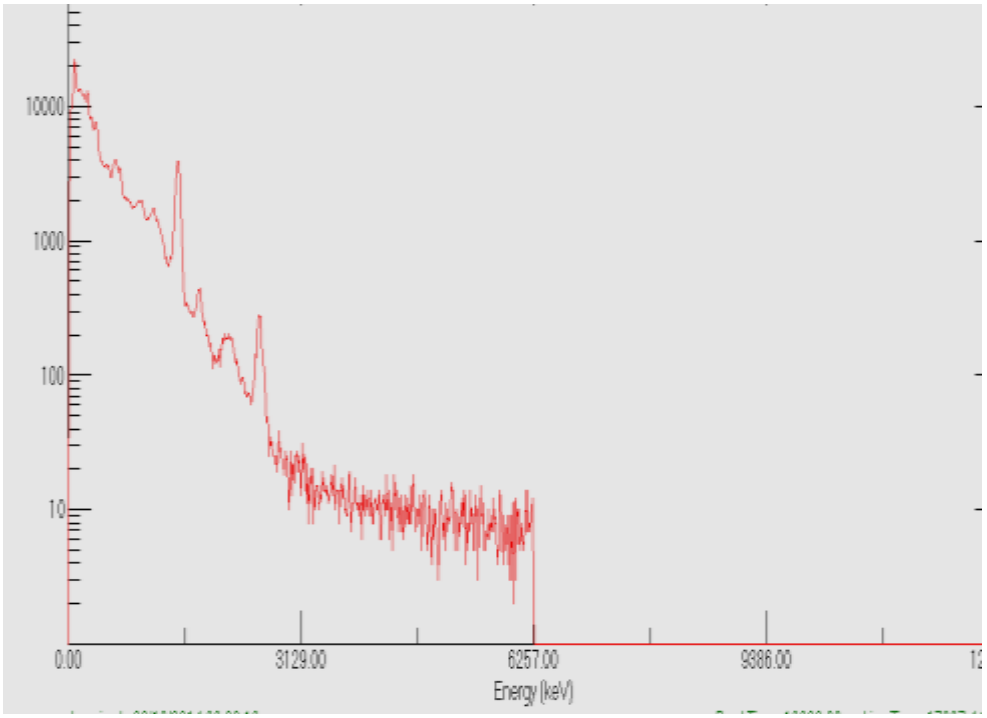

Figure (3a) spectrum of Gamma ray of the sample(2)

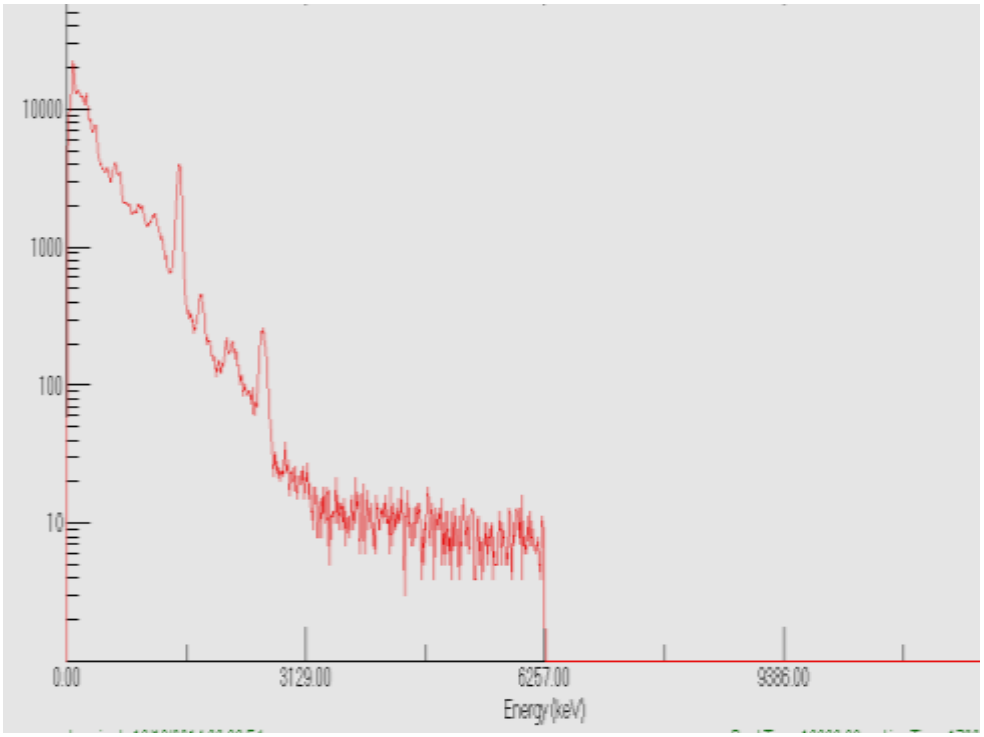

Figure (3b) spectrum of Gamma ray of the sample(4)

5. Result and discussion

The specific activity values of 238U, 232Th and 40K radionuclide's for (6) samples of the building material shown in Figure (3). It can be noted that the specific activity values lie in the range of (1.04± 0.73;S4 to 23.01 ± 3.47;S6) Bq/kg, from (1.98 ± 1.14;S1 to 22.48 ±3.85;S5) Bq/kg and(11.07 ± 1.50;S2 to 138.1 ± 5.47;S4) Bq/kg for 238U, 232Th and 40K respectively. according to the instructions of the International Commission approved the result shows that all values of 238U, and 40K ., amounting to specific activity for all samples are within the limits (35Bq/kg for 238U, 30 Bq/kg for 232Th and 400 Bq/kg for 40K) (13).

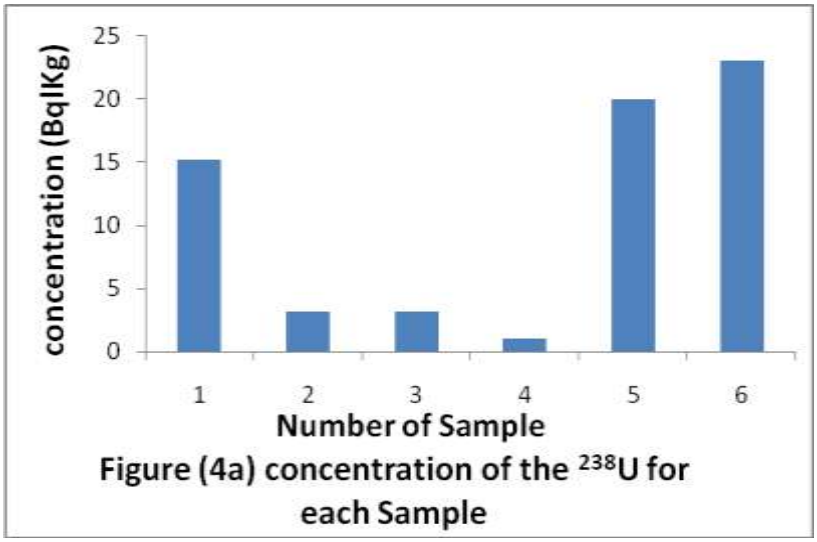

Figure (4a) concentration of the ^{238}U for each Sample

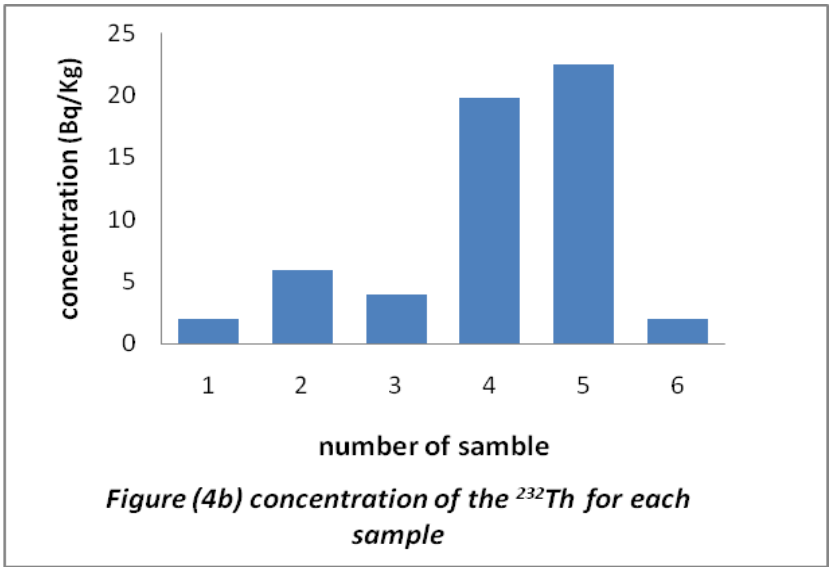

Figure (4b) concentration of the ^{232}Th for each sample

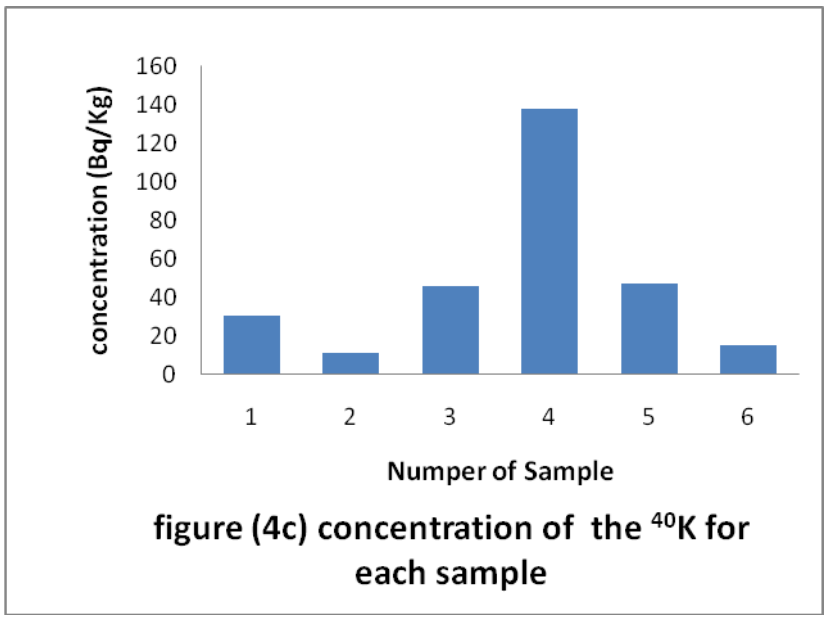

figure (4c) concentration of the ^{40}K for each sample

So, in this paper, Internal hazard index (Hin) is investigated figure in below show that, it can be observe that the Internal hazard index range from (0.013;S3 to 0.032;S5) , it was lower than limit according to the Radiation Protection (13) .

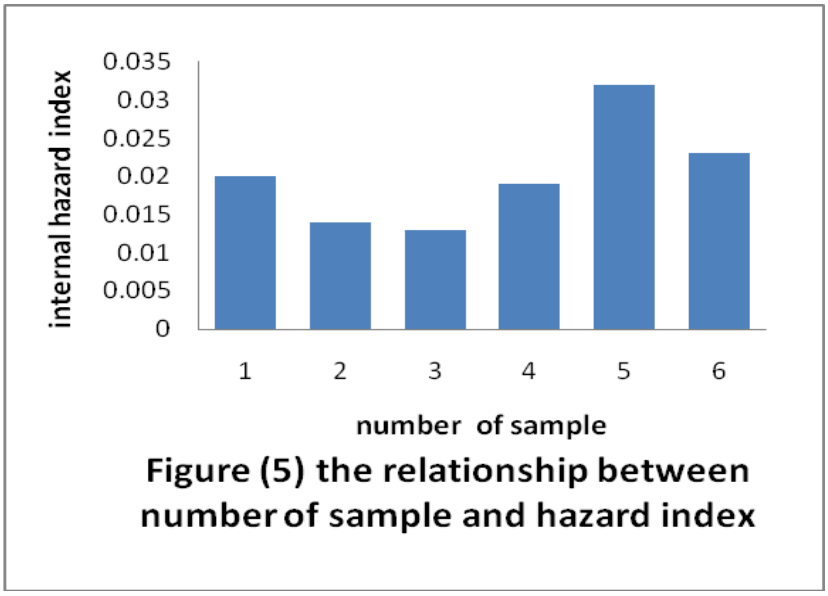

Figure (5) the relationship between number of sample and hazard index

The radium equivalent activities was calculated and listed in table (2).Ra eq values vary from (12.3 ± 3.8;S3 to 55.66 ± 8.9;S6) Bq/ kg Bq/kg. It can seen be that the Ra eq values for all samples are lower than the recommended value 370 Bq/ kg (14)

Gamma Dose Rate (D) range from 5.9 ± 1.7 (;S3 to 25.4 ± 4.0;S6) nGy/h. the Annual Effective Dose rang are from (.0070 ±0.002;S2 to 0.031±0.0004;S5)(mSv/y) , all the samples have the annual effective dose less than the, Representative Activity concentration index (Iγ) range from (0.08;S4 to 0.38;S6)

Table (2) the equivalent radiation and annual absorbed dose to the studied of the samples

Number of sample	Type of sample	Location of the sample	Effective dose rate ($mSv.Yr^{-1}$)	Absorbed dose rate($nGy.h^{-1}$)	radium equivalent (BqlKg)	Activity concentration index
1	block	Diwanya	.011	9.1 ± 2	20.3 ± 4.5	0.14
2	brick	Muthana	0.014	6.3 ± 1.8	27.02 ± 5.2	0.18
3	Thermo stone	Najaf	0.0072	5.9 ± 1.7	12.3 ± 3.8	0.09
4	gypsum	Iran	.0070	5.9 ± 1.9	12.5 ± 4.2	0.08
5	plaster	Najaf	0.023	19.5 ± 2.9	40.05 ± 6.3	0.26
6	cement	Muthana	0.031	25.4 ± 4.0	55.66 ± 8.9	0.38

6. Conclusions

In this search we can be conclusive that

1 - According to the instructions of the International Commission approved the result shows that the specific activity values of 238U, 232Th and 40K radionuclide's for (6) samples of the building material are within the limits (35Bq/kg for 238U, 30 Bq/kg for 232Th and 400 Bq/kg for 40K)

2 - The Internal hazard index range from (0.013;S3 to 0.032;S5) , it was lower than limit according to the Radiation Protection

3 - The radium equivalent activities was vary from (12.3 ± 3.8;S3 to 55.66 ± 8.9;S6) Bq/ kg. the Ra eq values for all samples are lower than the recommended value 370 Bq/ kg.

4 - Gamma Dose Rate (D) range from (5.9 ± 1.7;S3 to 25.4 ± 4.0;S6) nGy/h. the Annual Effective Dose rang are from (.0070 ±0.002;S2 to 0.031±0.0004;S5)(mSv/y) , all the samples have the annual effective dose less than the unity, Representative Activity concentration index (Iγ) range from (0.08;S4 to 0.38;S6)

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