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RESEARCH ARTICLE

Radiological Assessment of Hazard Index for Clay Sample in Iraq

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ABSTRACT

The concentration of the radiation dose was calculated in several types of Iraqi clays obtained from quarries at AL-Rutba region, west of Anbar province, Iraq, using sodium Iodide Thallium [NaI (TI)] detector. The clay samples are main raw material including in the industry of ceramics, bricks, cement etc... The average specific activity value of ^{238}U, ^{232}Th and ^{40}K and radium equivalent activity (Ra_{eq}) were calculated The indoor and outdoor of gamma dose rate have been computed and compared with worldwide limit. So in safety range we found all results in the healthy range.

Keywords: Radioactivity, Radiation Hazard, Clay, Iraq.

INTRODUCTION

The rock-forming minerals has its characteristic background radioactivity due to disintegration of potassium, uranium and thorium that refer to all rocks have a natural radioactivity. It is important to know the radioactivity and investigate the up normal levels, where higher levels indicated there is addition of these elements to rocks by a geological process while the lower indicted a removal of these elements by for example weathering leaching process. The main problem is to find the anomalous level that will be effect the human. Natural uranium (half-life 4.49 x 10^9 y) are transformed by a series of a Mona lies that emit alpha, beta particles and gamma ray until they reach the stable lead element (Skvar, Skvar and Golovchenko, 2003). The report of the United Nations on natural radiation sources confirms the importance of knowing the level of natural radiation activity in the environment in order to assess the exposure of human radiation (UNSCEAR, 1982). The samples from the quarries and enterer in many industries contain quantities of radiation activity inside them, and these radiations has several risk including tuberculosis and lunch cancer and other disease by swallowing or inhaling a mounts of free silica during mixing mud for example. Many searchers measurement the naturel radioactivity in the most of the world such as for clay samples in Tiruvannamalaidistrict, Tamilnadu, India by using NaI(TI) detector. The results had shown that the activity concentration of these radio nuclides is compared with word average values (Raghu et al.,2016). Concentrations of

^{238}U, ^{232}Th and ^{40}K in virgin soil and agricultural in Najaf city south western part of Iraq by using NaI (TI) detector given values lower than the worldwide average (Hussain ,et al., 2017). Determined the natural radioactivity in clays was used as raw materials (bricks, ceramic, cement, etc.) in Albanian all results were safety and within worldwide average (Anastas, 2000). As clays is the main material in different products as building materials, it was exhibit radiation levels of uranium, thorium and potassium and the known these levels are very important to have the main radiological hazards to workers in the quarries. The work give a good understanding of the radionuclide distribution in the quarries compare the results with the global average value of the united nations (Report,1988).

MATERIALS AND METHODS

Samples collected from the main quarries at different dimensions, for the purpose of study the a mount of radiation activity issued, from the AL-Rutba region west of Anbar province- Iraq.. Samples have different type and color with total of (9) sample collected from (7) quarries, Fig.1.After samples taken in polythene bags and dried the wet samples at room temperature and sampling configuration to grind in porcelain mill well to convert it into a powder with grain size 4mm (4000 microns) and began to put a quantity of each type of samples (500 grams) separately inside the [NaI(TI)] detector four a full hour to reach secular equilibrium. Using the count spectra for each sample, the activity determine in Bq/kg.

RESULTS AND DISCUSSION

Specific activity

It is radiation efficiency during the mass unit of radioactive material for the calculated for each of the ^{238}U, ^{232}Th and ^{40}K radionuclides by using relation (Yousuf and Abullah, 2015).

$$A \quad (Bq/kg) = \frac{N}{\varepsilon(E_\gamma)\cdot I_\gamma(E_\gamma)\cdot M\cdot t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..1$$

Where *N*: count of gamma rays, $\mathcal{E}\ (E_\gamma)$: The efficiency of gamma rays detector, $I_\gamma\ (E_\gamma)$: The relative intensity of each energy of the irradiated source, M: Mass the form in unity *(Kg)*, *t*: The time of count (*3600min*).

Table 1 shown the mean results of the specific activity for all samples. The highest activity value of (^{238}U) is (29.540*Bq/kg*), while the lowest (15.730*Bq/kg)*, with an average value of (23.449±3.9*Bq/kg*). These results in all samples were less than the recommended value (35*Bq/kg*) given by (UNSCEAR, 2000), Fig. 2. For (^{232}Th), maximum value is (31.290*Bq/kg*), while the minimum is (15.430*Bq/kg*), with an average value of (26.346±2.5*Bq/kg*) and these values were less than the recommended value (30*Bq/kg*) given by (UNSCEAR, 1993) except (R.R.I) was more than recommended. The variation in these values in uranium and thorium reflect the thorium accompanies uranium in the magmatic series (Moura et al., 2011). Thorium activity concentration is higher than uranium one due to difficultly of thorium migration from the minerals crystals lattice because of its greater ionic radius, besides the uranium have a great dispersions and nobility that causing fall back from the crystals.

The present results of specific activity of (^{40}K) have shown that values of specific activity for (^{40}K) in all samples were less than the recommended value of (400*Bq/kg*) given by (UNSCEAR, 2000) as it is shown in the Fig. 2. The clay content a main minerals that consider as main sources of potassium either released from the surface of clay particle or absorbed inside layer crystal lattices as it is has large size that cause fixed potassium ion . So this content may appear as high values as our samples in calculation.

Radium equivalent activity (Ra_{eq})

To represent the activity concentrations of ^{238}U (^{226}Ra), ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with them, a common radiological index has been introduced. The index is called radium equivalent activity (Ra_{eq}) which is used to ensure the uniformity in the distribution of natural radionuclides ^{238}U (^{226}Ra), ^{232}Th and ^{40}K and it is given by the following relation (*Vosniakos*, Zavalaris and Papaligas, 2003)

Ra_{eq} $(Bq/kg) = A_U + 1.43A_{Th} + 0.077A_K$……………………………………………2

Where, A_U , A_{Th} and A_K are the specific activities concentrations of ^{238}U, ^{232}Th and ^{40}K in (*Bq/kg*) units. The highest value (88.439 *Bq/kg*) and the lowest value (48.850*Bq/kg*), with mean value (78.482±8.01 *Bq/kg*), as it shown in Table 2, are presents that radium equivalent activity in all samples were less more than the recommended safe limit of (370 *Bq/kg*) (OECD, 1979), as its show in Fig. 3, and this refer to no significant radiological hazard for all samples.

Annual effective dose equivalent

The estimated annual effective dose equivalent received by a person was obtained by using a conversion factor of (0.7*Sv/Gy*), which was used to convert the absorbed rate in air to human effective dose equivalent with an outdoor occupancy of (20%) and (80%) for indoors and by using the following relations (UNSCEAR, 1993) :

$(AED)_{in}\ (mSv/y) = D_\gamma\ (nGy/h) \times 10^{-6} \times 8760\ h/y \times 0.80 \times (0.7\ Sv/Gy)$………………………3

$(AED)_{out}\ (mSv/y) = D_\gamma\ (nGy/h) \times 10^{-6} \times 8760h/y \times 0.20 \times (0.7\ Sv/Gy)$.

The total effective dose, $A_{tot} = A_{in} + A_{out}$, are ranged from 0.139 to 0.249 and still less than (1) that given by (UNSCEAR, 2000), Fig. 4. All results are shown in Table 2. This indicate that the doses come from ionize radiation that may came from radiation of uranium and thorium are less than the recommended dose level for exposure of the worker in the quarries.

Absorbed gamma dose rate (D_γ)

Outdoor air absorbed gamma dose rate (D_γ) in (*nGy/h*) due to terrestrial gamma rays at (1 m) above the ground surface which can be computed from specific activities using the following relation with main coefficients:

$D_\gamma\ (nGy/h) = 0.462A_U + 0.604A_{Th} + 0.0417A_K$………………………………………………4

The value that estimated for absorbed dose rate (D_γ) was found in range 40.650 to 22.574 *nGy/h* with average value of 36.147±3.6 *nGy/h*, as it is shown in Table 2. The present results shows that were less than the recommended value of 55 *nGy/h* for the absorbed gamma dose rate given by (UNSCEAR, 2000), Fig. 5.

Activity concentration index (I_γ)

This index used to estimate the gamma radiation that combined with concentration of specified natural radionuclide which calculated by (Mohammed and Jazzar,2013):

$$I_\gamma = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \leq 1 \quad \ldots\ldots 5$$

The highest value of activity concentration index was found in (R.W.K) sample which was equal to (0.319), while the lowest value of activity concentration index was found in (R.R.C) sample which was equal to (0.177), with an average value of (0.285±0.028) as it is shown in Table 2. All samples has less than the recommended value of (1) for the activity concentration index given by (UNSCEAR, 2000), Fig. 6.

External and internal index (H)

The internal hazard index (H_{in}) gives the internal exposure to radon that lead to cancer and short-lived progeny of radon. The internal hazard is given by the relation (Jose et al. , 2005):

$$H_{in} = \frac{A_U}{185 Bq/kg} + \frac{A_{YH}}{259 Bq/kg} + \frac{A_K}{4810 Bq/kg} \quad \leq 1 \qquad ....6$$

To give the external gamma radiation jet from clay sample one must evaluate the external hazard index that given by relation (Beretka & Matthew, 1985):

$$H_{ex} = \frac{A_U}{370 Bq/kg} + \frac{A_{TH}}{258 Bq/kg} + \frac{A_K}{4810 Bq/kg} \quad \leq 1 ....7$$

The internal and external hazard values must be less than unity in order to keep the radiation hazard to be pettiness. The calculated values of two indexes are shown in Table 1and Fig.7. Radioactivity may cause harm to the population if the calculated value is higher the unity, so the results show values bellow limit for two indexes.

CONCLUSIONS

Form the observation a fall the results obtained and comparing them with the global limit it was found that the specific effectiveness values ^{238}U and ^{40}K were within the permissible limits (35*Bq/kg*) to ^{238}U and (400*Bq/kg*) ^{40}K [8], as for ^{232}Th where there was a value for a specimen higher than the limit which is (30*Bq/kg*) UNSCEAR (2000), this is due to the geological nature of the studied area. This study also showed that all other results of the absorbed dose, the annual effective dose and the radium efficacy of the equivalent of the studied samples were all of which are within the internationally permitted limits are not dangerous to living organisms, andthe internal and external Hazard present in most of the studied are relativity lower that the average of world wide, as it acceptable dose limits of the UNSCEAR (2000), it can therefore be inferred from the results obtained that the people living in AL-Rutba area generally receive acceptable dose.

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Table 1. Activity concentration of Radionuclide and Hazard Indexes (Internal, External)

Code samples	Samples name	Activity concentration(Bq/kg)			Hazard indices(Bq/kg)	
		U-238	K-40	Th-232	H_{in}	H_{ex}
R.R.C	Rutba Red Clay	15.730	143.570	15.430	0.174	0.132
R.Z.S	RutbaZfl al-selka	17.080	243.820	27.820	0.250	0.204
R.W.K	Rutba White Kaolin	29.540	231.550	28.720	0.319	0.239
R.R.I	Rutba Red Iron	23.420	233.250	31.290	0.296	0.233
R.F	RutbaFeldspare	27.320	173.760	27.530	0.290	0.216
R.A.C	RutbaAmij Clay	23.680	288.910	26.820	0.292	0.228
R.W.C.C	Rutba White Clay colored	25.230	183.910	29.210	0.287	0.219
R.W.C.W	Rutba White Clay Woolen	18.760	202.430	28.050	0.252	0.201
R.R.C.C	Rutba Red Clay Colored	27.370	263.210	26.810	0.306	0.232
Ave	_	23.449± 3.9	225.439 ± 37.6	26.346 ± 2.5	0.275± 0.032	0.212 ± 0.022
SD	σ	11.82	4.5	46.17	0.043	0.032

Table 2. Main hazard indices that calculated for clay samples.

Code samples	Samples name	Ra_{eq} (Bq/kg)	D_γ (nGy/h)	Effective dose (mSv/y)			Iɣ (Bq/kg)
				AED_{in}	AED_{out}	AED_{tota}	
R.R.C	Rutba Red Clay	48.850	22.574	0.111	0.028	0.139	0.177
R.Z.F	RutbaZfl al-selka	75.637	34.862	0.171	0.043	0.214	0.277
R.W.K	Rutba White Kaolin	88.439	40.650	0.199	0.050	0.249	0.319
R.R.I	Rutba Red Iron	86.125	39.446	0.194	0.048	0.242	0.312
R.F	RutbaFeldspar	80.067	36.496	0.179	0.045	0.224	0.287
R.A.C	RutbaAmij Clay	84.279	39.187	0.192	0.048	0.237	0.309
R.W.C.C	Rutba White Clay colored	81.161	36.968	0.181	0.045	0.226	0.291
R.W.C.W	Rutba White Clay Woolen	74.459	34.051	0.167	0.042	0.209	0.270
R.R.C.C	Rutba Red Clay Colored	85.975	39.814	0.195	0.049	0.244	0.303
Ave	-	78.482 ± 8.01	36.147 ± 3.6	0.177 ± 0.018	0.044 ± 0.005	0.220 ±0.0115	0.285 ± 0.028
SD	Standard deviation	12.037	5.53	0.027	0.006		0.043

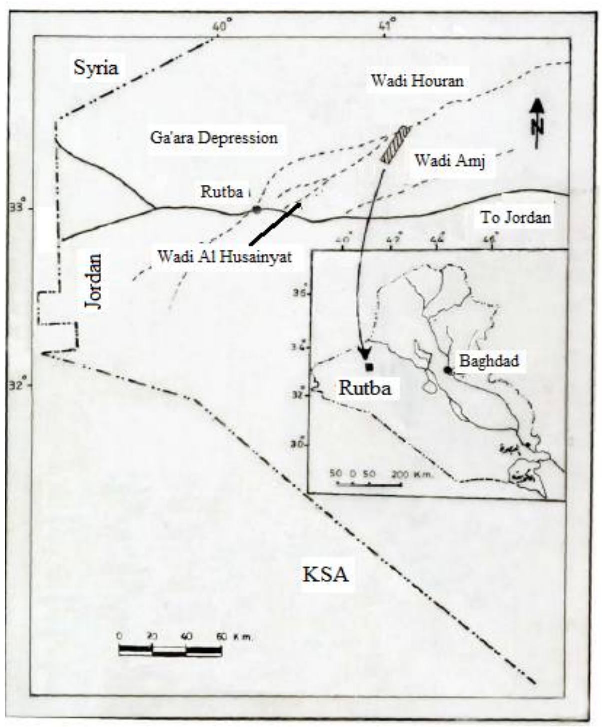

Fig.1. Represented the region of clay samples, west of Iraq.

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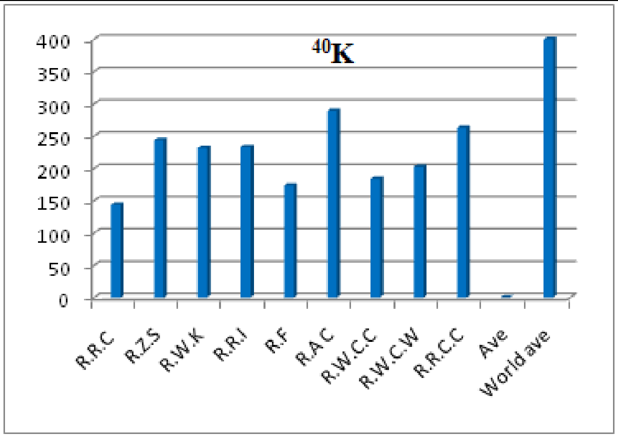

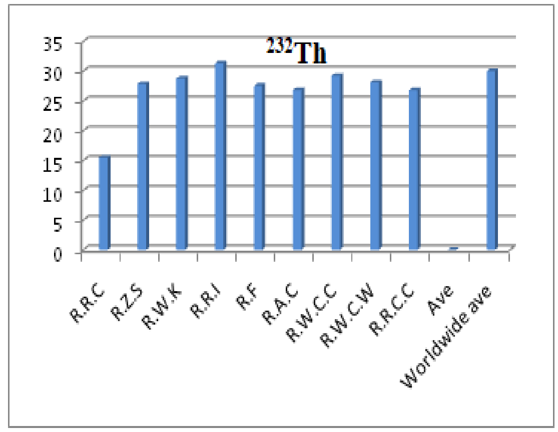

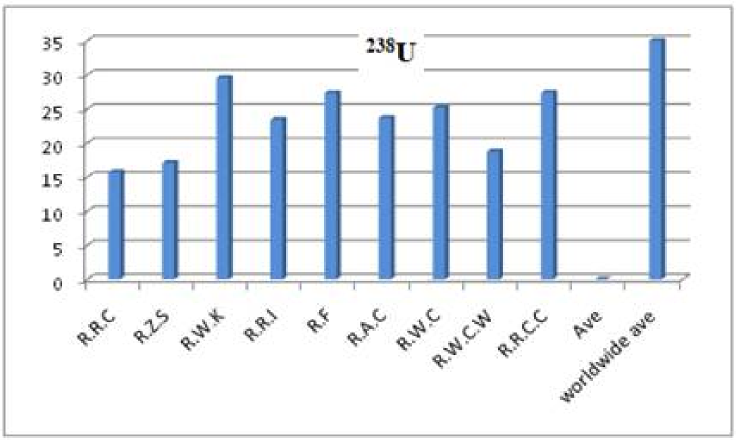

Fig .2. ^{238}U**,** ^{232}Th **and** ^{40}K **concentration in samples.**

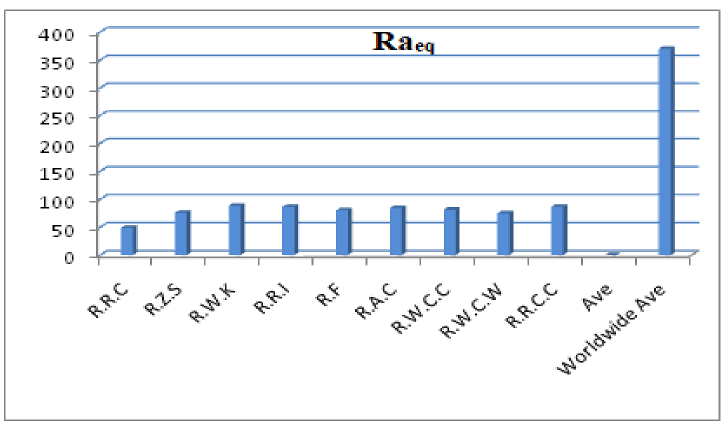

Fig.3. Ra_{eq} *(Bq/kg)* **concentration in samples**

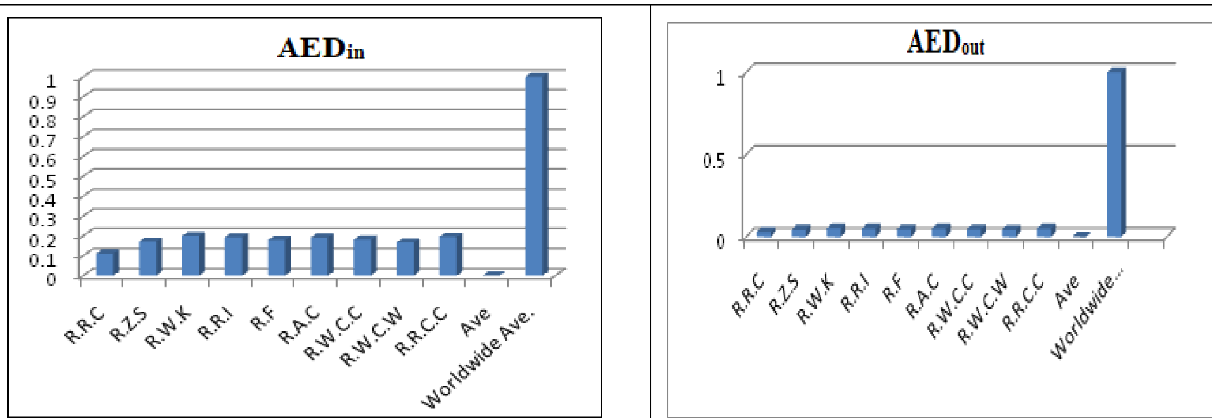

Fig.4.Indoor and outdoor Annual Effective Dose Equivalent.

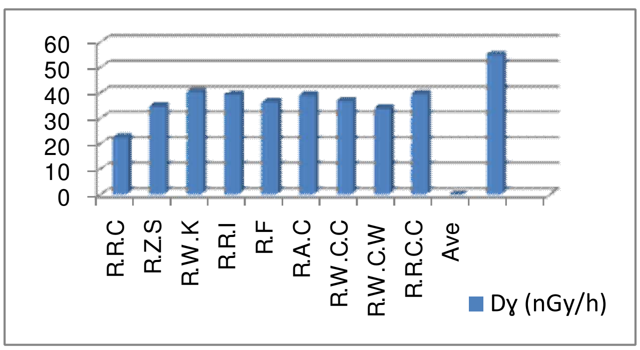

Fig. 5. Absorbed dose rate ($D_γ$).

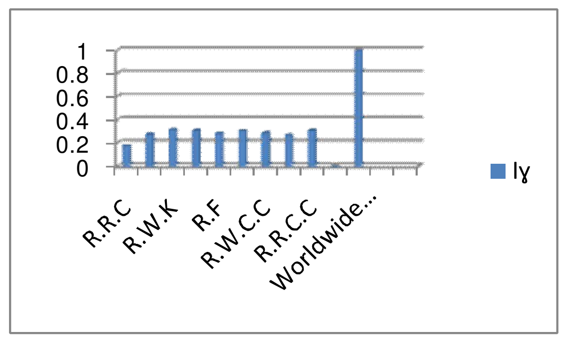

Fig.6. Activity concentration Index ($I_γ$).

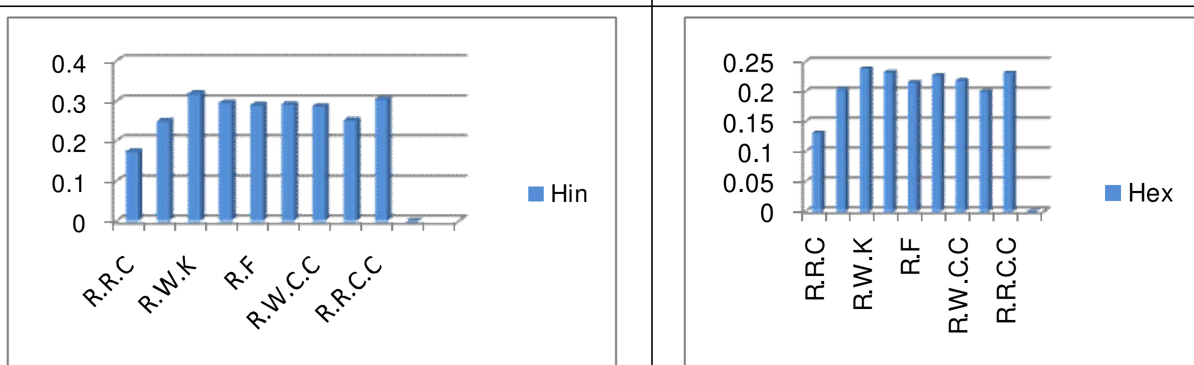

Fig. 7. Internal and External Hazard Index.