Measure The Rate of Radiation Activity in Sediment Samples from the depth of Salihia River in Tanumah , Basrah Governorate

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Abstract:

The concentration levels of ^{226}Ra, ^{232}Th and ^{40}K in soil have a great concern in the recent decades, due to its effect on the human health. The activity of the radionuclide's namely ^{238}U, ^{232}Th ,^{40}K are measured in sediment samples collected from different locations of Salihia River in Tanumah in Basra governorate- Iraq. Using Sodium Iodide NaI(TL) detector, based on high-resolution gamma and an energy resolution of (%8 keV) for the 622 KeV gamma transition of ^{137}Cs. The range of concentrations of ^{226}Ra,^{232}Th, ^{238}U, and ^{40}K, in the samples varies from (22.28±0.03 to12.43±0.42) Bq/kg, (3.85±0.27 to1.1±0.19) Bq/kg, (2.36±0.2 to 1.05±0.09) Bq/kg and (398.11±24.73 to 318.19±19.7) Bq/kg. The radium equivalent rate (Raeq) calculated from concentration of ^{232}Th,^{238}U and ^{40}K ranges between (30.66 to22.3) Bq/kg with mean value(25.959) Bq/kg. The absorbed dose Rate (D γ) for the soil samples in the study area range from (22.05 to 28.97) nGy/h with an average value of (25.806) nGy/h. The annual effective dose rate ($AEDE_{oo}$) range (0.03 to 0.12)mSv/y with an average value of(0.0333) mSv/y. The annual effective dose rate ($AEDE_{in}$) range (0.11 to 0.12) mSv/y with an average value of(0.129) mSv/y. The internal hazard index (Hin) range (0.15 to 0.22) with an average value of(0.189). The external hazard index (Hex) range (0.12 to 0.16) with an average value of (0.139). The values of the specific activity of (^{226}Ra,^{238}U, ^{232}Th, ^{40}K), radium equivalent activity, indoor and outdoor annual effective dose rates, internal and external hazard indices, all were found to be lower than their corresponding allowed limits.

Keywords: Natural radioactivity, γ−spectrometry, Sodium Iodide NaI(Tl)

Introduction:

Radiation represent the most hazardous source of environment pollution. Radiation usually generated from industrial and natural radioactive isotopes [1].
Such radionuclide's resulted from decay chains of ^{238}U and ^{232}Th as well as ^{40}K, They are very long lived with some long lived progeny, viz.,^{226}Ra [2]. Radionuclide's distribution in the geosphere depends on geological media distribution that usually derived. The processes that concentrate these radionuclide's at a specific location in specific media isotopes which is deployed in the environment elements, including soil and concentrations that vary beyond soil type of the depth and region. Building materials are generally mode of soil. Usually building materials contain packaging materials concrete bricks, gravel, cement and gypsum. Packing materials are mode of tile, ground, alabaster, ceramic, , granit, …).The building materials exposed to radionuclide's that results from the ^{40}K, ^{238}U and ^{232}Th from building materials, power plants, and from phosphate fertilizers [1].

The radiations such as microwaves, infra−red, and ultra violet are not considered. The only radiations considered are ^{238}U , ^{232}Th and ^{40}K which are emitted by radioactive materials. These are known as ionizing radiations. To measure ionizing radiation dose in human milli sievert (mSv) is used. Emitted radiation from radioactive materials usually classified in three main types viz.,alpha particles (positively charged helium nuclei)have low penetration i.e. do not give rise to a measurable dose. They can give higher doses when incorporated into the body by inhalation or ingestion. Beta particles (equivalent to electrons) can give dose, especially those with high energy that penetrate through thickness of two cm of aluminum [3]. Gamma radiation from natural radioactive isotopes, such as ^{40}K, ^{232}Th and ^{238}U series radionuclide's and decay products (also called terrestrial background radiation), which are found at minimal levels in all major terrestrial configurations, source of irradiation to the human body. Precisely, environmental natural radioactivity and relased external exposure as a result of gamma radiation dependent on geographic conditions and geological mainly and can be detected at different soil levels of each region [4].

The natural terrestrial gamma radiation dose rate has important contribution to the average dose rate received by the human population [5,6].To assess the health risk estimation of the radiation dose distribution is an important factor changes to in soil environmental radioactivity due to anthropogenic activities[7]. Human usually exposed to the natural terrestrial radiation outdoors which originates mainly from the upper 30 cm of the soil [8].Long half–lives radionuclide's which compared to the earth age or their decay products available in terrestrial material viz., ^{232}Th, ^{238}U and ^{40}K are of great interest. These radionuclide's are not uniformly distributed, so that knowledge of its distribution in soil plus the rock play vital role in radiation and protection measurement [9]. Gamma– ray from these radiations is the main external sources of irradiation to the human body. Their concentrations in soil are determined by the radioactivity of the rock together the nature of the process of the formation of the soils [10,11].Significant component of these radionuclide's in soil generate background radiation exposure to the population[12].

The target of this work is the measurement of the concentration in different types of sediment of activity of natural radionuclide's (^{238}U, ^{232}Th and ^{40}K) from the depth of the River Salihia with the use of a gamma –ray spectrometer for the sake of assessment of the radiation hazard and to determine the radioactivity concentrations of naturally occurring radionuclide's found in the depth of the River Salihia via the calculation of the radiological parameters viz., absorbed dose rate due to the sediment samples, external and internal hazard indices and radium equivalent dose.

Reliable way to measure the natural radiation of naturally occurring radionuclide's the gamma–ray spectrometer usually used. The study is important in this regard, since data gathered can be locally used in to determination whether controls are needed so that, it enriches the global data bank, giving rise to accurate estimate of the global average values of radiative amounts and doses.

2- Materials and Methods

2-1 The Study Area

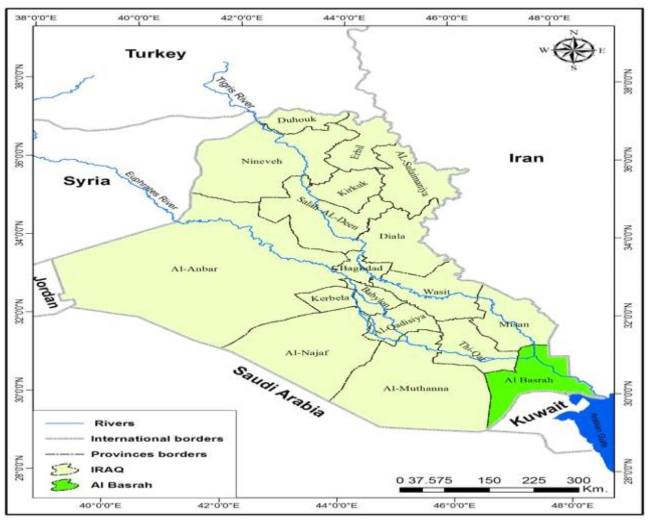
AL-Salihia River is located in Tanumah district which is located in the eastern part of Basra governorate as shown in fig (1) [13], and is thus this district is the part of the southeastern border of Iraq, and it is Located on the banks of the Shatt al-Arab, Where it covers an area of [2055 square kilometers it lies between longitudes (47°30` -48°30`) East and latitudes (31° -30° 25`) North [14] as shown in figure Iraq figure(2) [15]. The importance of this study is due to the fact that this river is pass throw agricultural and residential areas in Basrah Governorate. The above causes make it is necessary for baseline study such as this to determine the basic radioactivity levels which will serve as reference data for future studies.

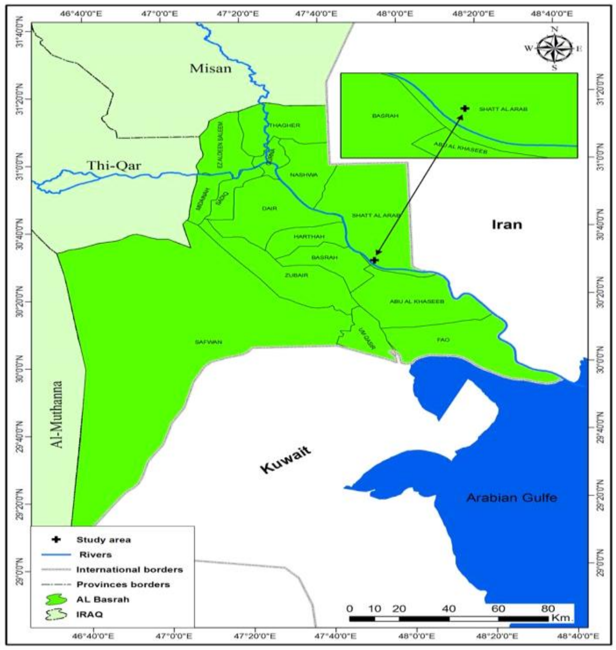
2-2 Sample Collection and Preparation

A total of 30 sediment samples was collected from AL-Salihia River in Tanumah district. The sediment samples were collected in December 2019 and the point of collection of each sample were given a unique code as shown in figure as 3[16]. After transporting the samples to the laboratory, all samples were dried at 80C° for two hours, pulverized, homogenized, and sieved through 75µm. The sieved sediment samples were weighed, and stored in Mirilany beakers 1.4 litter . These plastic beakers are well-sealed for 4 weeks to allow secular equilibrium of ^{226}Ra with its decay products in the uranium series transferred for radio nuclide analysis[17].In this study, the collected sediment samples were analyzed using a passively shielded Sodium Iodide (NaI(Tl)) detector to determine the level of activity concentration from ^{238}U,^{232}Th,^{226}Ra and ^{40}K.

The collected soil samples were analysed using a passively shielded Sodium Iodide (NaI)detector detector 3x3 inch with a 1024 channel computer analyzer USX supplied by Spectrum Technique Company. The detector was employed with lead shielding, 4 cm thickness, which reduced the background. The detector was calibrated using standard sources of ^{137}Cs (peak 662 keV) and ^{60}Co (peaks 1173, 1333 keV). The detector, based on high-resolution gamma and an energy resolution of (%8 keV) for the 622 KeV. gamma transition of ^{137}Cs The efficiency calibration was achieved using eight standard sources include the calibration sources. The system was running freely, for 12h live time, to evaluate the background spectrum. The Marinalli beaker contains sample was placed over the detector for counting. Activity concentration A_i of any gamma-rays line taken to represent this parameter for the environmental radionuclide's has been calculated using the relation [18]. One of the sample spectrum shown in figure(4).

where ε is absolute gamma peak efficiency of the detector at this particular gamma-ray energy, decay intensity for the specific energy peak (including the decay branching ratio information), M the mass of the sample in kg and t is the counting time of the measurement in second.To evaluate activity concentrations of natural radionuclides, one has to recognized the belong city of each peak according to gamma decay of each isotope [19]. For ^{226}Ra we are looking for the gamma ray lines 295 keV(19.2%), 352 keV (37.1%), 609 keV (46.1%), 1120 keV (15%) and 1760 keV (15.4%). The peak of 186 keV assumed to be from ^{235}U since it has slight effect on the total concentration after subtracting the background, 42.8% for ^{226}Ra and the rest for ^{235}U. The determination of existence of ^{232}Th was achieved by 338 keV (12%), 911 keV (29%), 964 keV (5.05%) and 969 keV (17%). The case of ^{238}U is recognized by 1001 keV (83%), 766 keV (29%) and 2204 keV (5%). For ^{40}K, this directly determined using 1460 keV (10%) peak.

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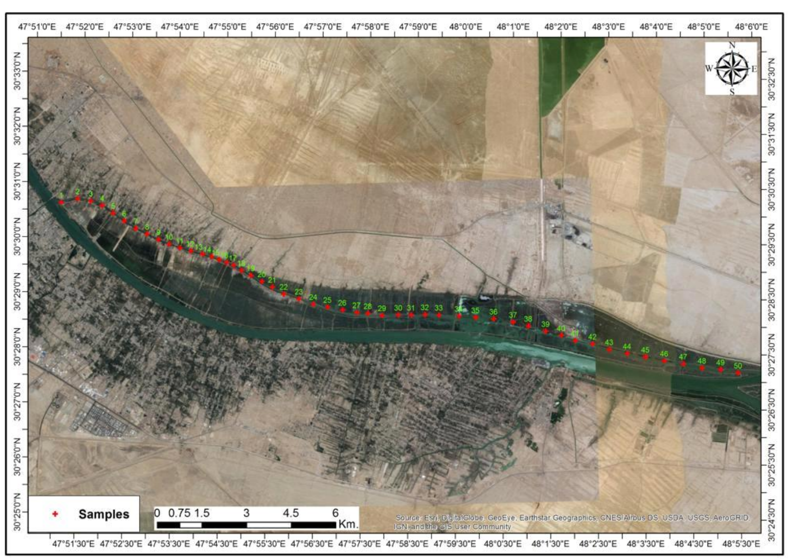
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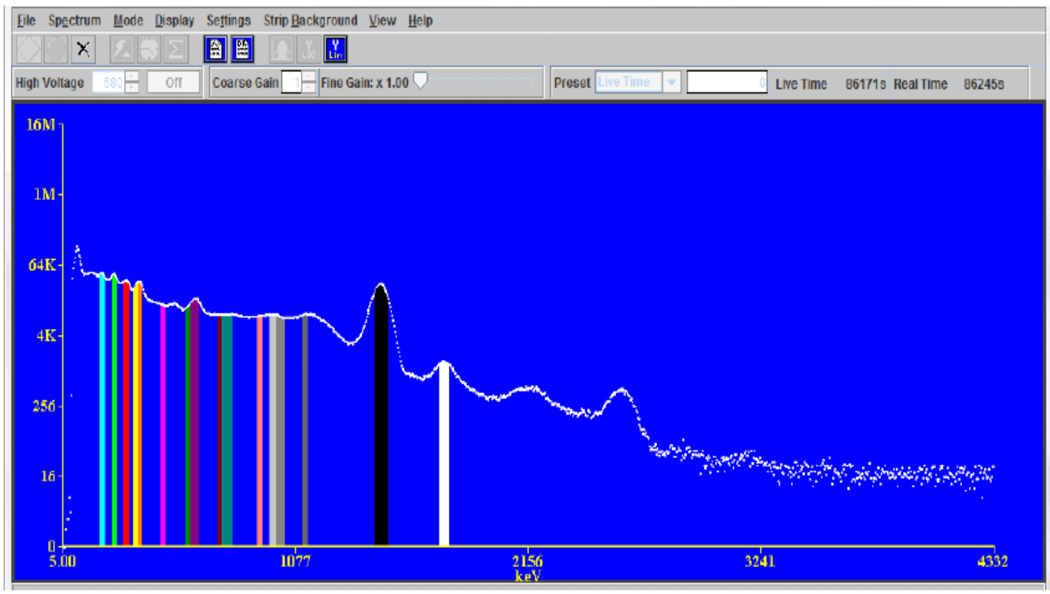
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2-3GAMMA RADIATION PARAMETERS

1-Radium Equivalent Activity (Raeq):

To represent the activity concentrations of ^{226}Ra,^{238}U, ^{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 (Raeq) which is used to ensure the uniformity in the distribution of natural radionuclides^{238}U, ^{232}Th and ^{40}K and is given by the expression[20]:

$$\mathbf{Raeq\ (Bq/kg) = A_{Ra} + 1.43A_{Th} + 0.077A_K} \quad \dots (1)$$

Where A_{Ra}, A_{Th} and A_K are the specific activity concentrations of^{226}Ra , ^{232}Th and ^{40}K in (Bq/kg) respectively.

2- Absorbed Gamma Dose Rate (D γ):

Outdoor air, gamma absorbed dose rate (D) in (nGy/h) due to terrestrial gamma rays at (1 m) above the ground surface which can be computed from specific activities A_{Ra}, A_{Th} and A_K of ^{226}Ra, ^{232}Th and ^{40}K in (Bq/kg) respectively using the following relation [20]:

$$\mathbf{D(=0.462\ A_{Ra}+0.604\ A_{Th}+0.0417\ A_K\ (nGy.h^{-1})} \quad \dots (2)$$

3-Annual Effective Dose Rate (AED):

The estimated annual effective dose equivalent received by a member was calculated by using a conversion factor of (0.7 Sv/Gy), which was used to convert the absorbed rate to human effective dose equivalent with an outdoor occupancy of 20 % and 80 % for indoors[21]:

$$AEDE_{out}(mSv.y^{-1})=D(nGy.h^{-1})\times 8760h\times 0.7Sv.Gy-1\times 0.2\times 10^{-6}...(3)$$

$$AEDE_{in}(mSv.y^{-1})=D(nGy.h^{-1})\times 8760h\times 0.7Sv.Gy-1\times 0.8\times 10^{-6}...(4)$$

4-External (Hex) and Internal (Hin) Hazard Indicies:

The external hazard index is obtained from (Raeq) expression through the supposition that it's allowed maximum value (equal to unity) correspond to the upper limit of Raeq (370 Bq/kg). Internal exposure to ^{222}Rn and its radioactive progeny is controlled by the internal hazard index (Hin) as given below[20]:

....(5)

The external hazard index (Hex) can then be defined as given below[20]:

....(6)

This index value must be less than unity in order to keep the radiation hazard to be insignificant.

3-RESULTS AND DISCUSSION

The measured values of natural radioactivity concentration for ^{226}Ra, ^{232}Th, ^{238}U and ^{40}K for different location of Sallhia River in the Tanumah area of Basra Governorate, table (1)shows the results obtained for the qualitative effectiveness levels of different isotopes in sediment models of the Salihia River which amounted to 30 model sit can be noticed that the highest value of specific activity of (^{238}U) was found in station(S_{24}) , which was equal (2.36±0.2)Bq/kg . While the lowest value of specific activity of U^{238} was found in (S_9) region, which was equal to (1.05±0.09) Bq/kg, with an average value of (1.671±0.143)Bq/kg. Figure (5) shows the specific activity levels of uranium−238, thorium−232, potassium−40 and radium−226 in sediment models of the Salihia River.

Number of samples	^{226}Ra Bq/kg	^{232}Th Bq/kg	^{238}U Bq/kg	^{40}K Bq/kg
S_1				
S_2				
S_3				
S_4				
S_5				
S_6				
S_7				
S_8				
S_9				
S_{10}				
S_{11}				
S_{12}				
S_{13}				
S_{14}				
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S_{22}				
S_{23}				
S_{24}				
S_{25}				
S_{26}				
S_{27}				
S_{28}				
S_{29}				
S_{30}				
max			*2.36±0.2*	*398.11*
min			*1.05±0.09*	*318.19±19.7*
Avere ge	*19.209±0.1 12*	*2.50±0.34*	*1.671±0.1 43*	*389.5 ±22.808*

The highest value of specific activity of (^{232}Th) was found in station (S_{13}), which was equal to (3.85±0.27)Bq/kg), while the lowest value of specific activity of (^{232}Th) was found in(S_{14}) region, which was equal to(1.1±0.19 Bq/kg), with an average value of (2.50±0.34)Bq/kg). The highest value of specific activity of (^{40}K) was found in (S_{18}) region, which was equal to (398.11Bq/kg) which is lower than the commanded level(370) according to UNSCEAR .It may be due to The territory of this region is characterized by an elevation of 1 m above sea level has been reflected these natural characteristics positively on the characteristics of agricultural soil and the extension of irrigation and drainage networks and the process of good water drainage, in addition to the nature of the soil in this district is a sedimentary soil formed by water rivers Tigris and Euphrates and Shatt al-Arab and due to the different sedimentation processes and their different locations, the soil types and their characteristics varied relatively and due to the circumstances that the region has gone through wars and neglect of agriculture and turning them into residential areas and thus reduced the main factor causing this high proportion of the counterpart ^{40}K due to lack of fertilizers, especially industrial ones. while the lowest specific activity concentration of (^{40}K) was found in (S_{10}) regions which was equal to (318.19±19.7Bq/kg), with an average value of (389.5 ±22.808)Bq/kg. The highest value of specific activity of(^{226}Ra) was found in station(S_{24}) which was equal to (23.28±0.03)Bq/kg and the lowest value was (12.43±0.24)Bq/kg which was found in station(S_{12}), with an average value of(19.209±0.112Bq/kg).From Table (2) it can be noticed that the highest value of radium equivalent activity (Raeq) was found in (S_{24})

station, which was equal to (30.66)Bq/kg, while the lowest value of radium equivalent activity was found in (S_3) station which was equal to (22.3)Bq/kg, with an average value of (25.959)Bq/kg. The highest value of the absorbed gamma dose rate ($D\gamma$) wasfound in (S_{22})station, which was equal to (28.97)nGy/h, while the lowest value of the absorbed gamma dose rate was found in (S_{12}) region which was equal to (22.05)nGy/h, with an average value of (25.806)nGy/h. The highest value of indoor annual effective dose rate ($AEDE_{in}$) was found in (S_2) stations, which was equal to (0.21)mSv/y, while the lowest value of indoor annual effective dose rate($AEDE_{in}$) was found in (S_{12}.S_9) stations which was equal to (0.11)mSv/y, with an average value of (0.129)mSv/y . The highest value of outdoor annual effective dose rate ($AEDE_{oo}$) was found in (S_{22})station, which was equal to (0.04)mSv/y, while the lowest value of outdoor annual effective dose rate was found in (S_1…$S_{21,}$$S_{23...}$$S_{30}$) stations which was equal to (0.03mSv/y), with an average value of (0.033mSv/y). The highest value of internal hazard index (Hin) was found in (S_{22})station, which was equal to (0.22), while the lowest value of internal hazard index was found in (S_{12}) station which was equal to (0.15), with an average value of (0.189). The highest value of external hazard index (Hex) was found in (S_{16})station which was equal to (0.16) ,while the lowest value of external hazard index was found in (S_{12})station which was equal to (0.12), with an average value of (0.139). Figure(6) shows the radiation hazard indicators in the Salihia river sediment models

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Number of samples	Ra_{eq} Bq/kg	H_{ex}	H_{in}	Dɣ nGy/h	$AEDE_{in}$ mSv/y	$AEDE_{oot}$ mSv/y
S_1	26.76	0.14	0.2	26.1	0.13	0.03
S_2	25.26	0.13	0.18	24.5	0.21	0.03
S_3	22.3	0.13	0.17	24.67	0.12	0.03
S_4	23.7	0.13	0.18	24.1	0.12	0.03
S_5	25.4	0.14	0.19	25.5	0.13	0.03
S_6	28.9	0.15	0.2	28.23	0.14	0.03
S_7	25.79	0.14	0.19	26.59	0.13	0.03
S_8	27.4	0.15	0.2	26.99	0.13	0.03
S_{21}	29.5	0.15	0.21	27.75	0.14	0.03
S_{22}	30.32	0.16	0.22	28.97	0.14	0.04
S_{23}	25.63	0.14	0.2	26.39	0.13	0.03
S_{24}	30.66	0.15	0.2	27.44	0.13	0.03
S_{25}	23.7	0.13	0.18	23.93	0.12	0.03
S_{26}	24.6	0.13	0.18	24.28	0.12	0.03
S_{27}	26.47	0.14	0.19	25.96	0.13	0.03
S_{28}	27.39	0.14	0.2	26.85	0.13	0.03
S_{29}	26.92	0.15	0.2	27.42	0.13	0.03
S_{30}	24.72	0.14	0.19	26.33	0.13	0.03
Average	***25.959***	***0.139***	***0.189***	***25.806***	***0.129***	***0.033***
max	***30.66***	***0.16***	***0.22***	***28.97***	***0.21***	***0.12***
min	***22.3***	***0.12***	***0.15***	***22.05***	***0.11***	***0.03***

CONCLUSIONS

After describing the treatment and samples preparation, the data obtained of the specific activity of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}k for sediment samples in the studied region in Al–Salihia river in Basra governorate ,some soil samples from the study area showed low activity and some high and moderate activity This is due to the geology nature of the soil but the rate of results in general is lower than the value of the global limit which is equal to(33 Bq/kg)(35 Bq/kg), (30 Bq/kg), (400 Bq/kg), respectively [17,22].Main sources of external radiation exposure are Uranium and Thorium, their decay products and ^{40}K. The internal exposure is due to radon and its radioactive daughters, present in the environment, which has the maximum contribution towards the average effective dose received by human beings .Current results have shown that radium equivalent activity values, absorbed gamma dose rate, annual effective dose rate $AEDE_{oo}$ and annual effective doses $AEDE_{in}$, hazard indices(Hin) and (Hex) for the soil samples in the studied region in Al–Salihia river were lower than the value of the global limit which is equal to (370Bq/kg),(55 nGy/h), (1 mSv/y), (1 mSv/y), (1)and (1), respectively [20,23]. The levels of results in present study confirm the absence of any unusual nuclear activities within the region.

Reference:

1- Huda, A. A., 2011. "Determination of natural radioactivity levels in the state of Qatar using high- resolution gamma-ray spectrometry". Ph.D. Thesis, University of Surrey, Guildford, Surrey, UK.

2- Todsadol, S., 2012. "An evaluation of the level of naturally occurring radioactive materials in soil samples along the Chao Phraya river basin." Ph.D. Thesis, Department of physics faculty of engineering and physical sciences university of Surrey.

3- Radiochemical Methods Group,2002, “Radioactivity in the Environment” No.6 in a series of essays on Radioactivity produced by the Royal Society of Chemistry, London, pp. 1-4 .

4- UNSCEAR, 2000. Sources and Effects of Ionizing Radiation. Report to General Assembly, with Scientific Annexes, United Nations, New York

5- Tso MY, Leung JK,2000. Population dose due to natural radiations in Hong Kong. Health Phys,8:555-78

6- UNSCEAR,1993. Sources and Biological Effects of Ionizing Radiation (Report to the General Assembly). New York: United Nations.

7- Obed RI, Farai IP, Jibiri NN,2005. Population dose distribution due to soil radioactivity concentration levels in 18 cities across Nigeria. J RadiolProt, 25:305-12.

8- Chikasawa K, Ishii T,2001.Ugiyama H. Terrestrial gamma radiation in Kochi Prefecture, Japan. J Health Sci,47:361-72.

9- Rani A, Singh S,2005. Natural radioactivity levels in soil samples from some areas of Himachal Pradesh, India using γ- ray spectrometry. Atmospheric Environ, 39:6306-14.

10- Orabi H, Al-Shareaif A, El Galefi M,2006. Gamma-ray measurements of naturally occurring radioactive sample from Alkharje City. J RadioanalNucl Chem,269:99-102.

11- Al-Jundia J, Al-Bataina BA, Abu-Rukah Y, Shehadeh HM,2003.Natural radioactivity concentrations in soil samples along the Amman Aqaba Highway, Jordan. Radiat Measurements,36:555-60.

12-Goddard CC,2002. Measurement of outdoor terrestrial gamma radiation in the Sultanate of Oman. Health Phys,82:869-74.

13- Worked by the researcher Using program Arc :GIS, version 10.4, 2017. depending on Ministry of Water Resources, General Authority for Surveying, Map Production Division, Geological Map of Iraq, Drawing Scale 1: 1000000, 2017.

14- Ministry of Planning and Development Cooperation, Directorate of Agricultural Statistics in Basra Governorate, Comprehensive Agricultural Report 2001.

15-Worked by the researcher Using program Arc :GIS, version 10.4, 2017 ,depending on the following source: Ministry of Water Resources, General Authority for Surveying, Map Production Division, Geological Map of Basrah Province, Drawing Scale 1: 500000,2017.

16 -Esri Digital , 2017,Globe ,Geo Eye, Earthstar Geographics, CNES/Airbus DS,USGS, Aerogrid, IGN, and the GIS user Community.

17-R. Begy, H.Simon, and C.Cosma, Rom. Journ. Phys, 2013. 58, pp 22-28.

18-Amrani D and Tahtat M., 2001. "Natural radioactivity in Algerian building materials". Applied Radiation and Isotopes, 54, 687-689.

19- P. Papachristodoulou, C. A. Assimakopoulos, P.A, Paronis N E., and K. G. Loannides., 2003. Use of HPGe γ-ray spectroscopy to assess the isotopic composition of uranium in soil., Journal of Environmental Radioactivity 64, 195-203.Journal of Environmental Radioactivity, 64, 195-203.

20- Aziz Ahmed Qureshi, Ishtiaq Ahmed Khan Jadoon, Ali Abbas Wajid, Ahsan Attique, Adil Masood , Muhammad Anees, Shahid Manzoor, Abdul Waheed and Aneela Tubassam ., 2014. "Study of natural radioactivity in Mansehra granite, Pakistan" environmental concerns, Radiation Protection Dosimetry, 158(4), 466-478.

21- R. Mehra,S. Singh, and K.Singh., 2009. Indian J. Phys ,83(7),1031-1037.

22- Jurina, I., Ivanić, M., Troskot-Čorbić2, T., Barišić, D., Vdović, N., and Sond, I.,2013" Activity concentrations and distribution radionuclides in surface and core of sediments of the Neretva Channel (Adriatic Sea ,Croatia)", Journal of Geologia Croatica, vol. 66, No.2, pp: 143–150.

23- Al- Ubaidi, A. M.,2015" Environmental Radioactivity of Al-Rashidiyah Site - Baghdad", Ph.D. Thesis, University of Baghdad, College of Science for Women,