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# Measurement of Natural gamma radiation in samples of Ktaiban river north Basra Governorate southern Iraq, by using Gamma Spectroscopy

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**Abstract**

In this study measurements of natural radionuclides ($^{238}U$, $^{226}Ra$, $^{232}Th$, and $^{40}K$) in the river sediment using gamma spectroscopy have been conducted. NaI(Tl) 3x3 gamma-ray spectrometry was employed for the radioactivity measurements and specific activity data were presented. The sediment samples were collected from the bottom of the river using special equipment called a grab sampler for this purpose. The study area was lie in the north of Basrah city in Iraq, that position is (47° 45' 40"E, 30°30'42" N and 47° 47' 10" E, 30°30'43 " N) to establish the baseline data level for naturally occurring radionuclides in the study area and will be useful to assess what levels of radioactive isotopes are present in the area because it represents an agricultural activity for the city or any accentual pollution. The average values of $^{232}Th$, $^{238}U$,$^{226}Ra$, $^{40}K$ are 5.26±1.4 Bq/kg, 8.58±2.4 Bq/kg, 33.86±3.4 Bq/kg and316.02±70.78 Bq/kg respectively. It is found that, the mean radium equivalent $Ra_{eq}$ 65.72±22.73 Bq/kg.

**Keywords**: Natural radioactivity, Basrah, NaI(Tl) detector, Radium equivalent activity, Gamma spectroscopy.

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## 1. Introduction

There has been an increasing concern about toxicity arising due to naturally occurring radioactive material (NORM) in some districts of Basra Governorate located in the southern part of Iraq. The natural radionuclides with $^{238}U$, $^{232}Th$,$^{226}Ra$, and their progenies together with $^{40}K$. This assures the importance of the assessment of radiation levels and related of the assessment of radiation levels and the related radiological hazards to which the population might be exposed. Nearly in all nations, scientists probed for a long time ago and are still probing the earth's crust and for a long time in the future to measure the radiation levels and quantify the hazards and doses affecting people, animals, and plants. In recent years, the purpose of protecting the environment and human health epidemiological surveillance in rivers bank site has intensified, in order to improve the prevention, diagnosis and treatment of diseases associated with pollutants [1].

## 2. Marine Radio - Ecology

The relation study among the ionization, radiation, radioactive material, and environment is called ***radio marine habitats- ecology*** that care of radionuclide transport and ionization radiation effect on the individual kinds, groups, and environment system.[2]

The marine habitats are considered a complex and important ecosystem because they cover 70% of the earth’s surface, so they interact together with other physical systems and chemical as salinity, temperature, light and marine current. Oceans and seas may be divided into. [3]

(1) Physical region depends on the depth (0-15m, 15m-200m, and 200m-3000m).

(2) A biological region depends on the biota type as float (zooplankton, phytoplankton).

(3) Depth as (algae, fixed, and mussel).

The characteristics and specialty of any Ecosystem are important to role-play among the concentration, and transfer of the radioactive element that is consisted of :

(1) Climate: determining the kind of biota which is a different concentration in the

bodies since the raining climate sedimentation of the radioactive on the soil so that the wind transfer radiation element from place to another place.

(2) Topography: the radiation elements are collective in the low region more than from plane region exposed for the wind.

(3) Water depth: in the Ecosystem marine habitats, the radiation element concentration increases and decreases depending on the water column, the radioactive mixing with water about 75 m in seas but 10m in the lakes, that deal with $^{137}Cs$, $^{90}Sr$ concentration in the Lakes more than ease.

Some of the radionuclides are soluble in water, and since most of them are heavy nuclei, then one is expected to detect them in the groundwater and sediments. The solubility and movement of radionuclides in groundwater in highly effective in the quality of water [4]. The occurrence of natural radionuclides activity In groundwater and sediment of the revers has been studied during the last years [5-11]. The development of nuclear science and technology plus the many wars in the area has led to increasing amounts of nuclear waste containing radioactive elements being released and disposed of in the environment; consequently, in river sediments [12-15]. River sediments can be employed as building materials and thus the knowledge of their granulometric distribution, as well as the radioactivity concentration in each particle size fraction and the mineralogy of the investigated sediment, strictly correlated with its natural radioactive content, is extremely useful from a radiological point of view [16].

The present work was aimed to determine the activity concentrations and distribution of key natural radionuclides ($^{238}$U, $^{235}$U, $^{234}$U, $^{230}$Th, $^{226}$Ra, $^{210}$Pb, $^{232}$Th, $^{228}$Ra, and $^{40}$K) along the basins of Kitaiban river. Furthermore, the results of the analysis were used to assess the radiological risk to local populations through several radiological hazard parameters. These parameters include the Radium Equivalent Activity Index ($Ra_{Eq}$), the Outdoor gamma absorbed dose rate, the Annual Effective Dose Equivalent.

## 3. Materials and methods

### 3.1. Study area

The present study area covers a river in the Sedimentary plain of Iraq in Basrah Governorate about 530 km south of Baghdad city and the position are (47° 45' 40"E, 30°30'42" N and 47° 47' 10" E, 30°30'43 " N) , Ktaiban river with length about 7 Km. The sample's location was recorded in terms of degree - minute - second (Latitudinal and Longitudinal position) using a handheld Global Positioning System (GPS) (Model: GARMIN GPS-12) unit. Each location is separated by a distance of (400 to 500) m approximately.

Fig.1 shows the collected sample locations. The present study area covers many important industries as an electric power station, water filter station, and the project of conveying water to the Faw city south of Basrah.

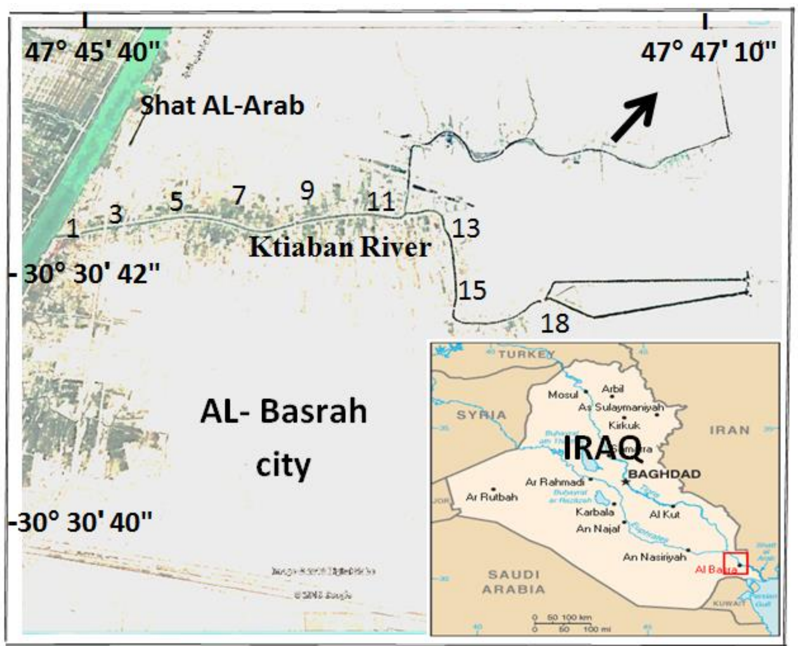


Fig.1 shows the collected sample location, Google map -2018.

**3.2. Sample collection**

Sediment samples were collected using the same grab at all the locations, Superficial sediment: the van Veen grab figure 2. The level of the tide is fixed because the mouth of the river it is closed in time for collection. The sediment samples were collected from a depth of (20-30) cm from the bottom and the weight of the samples was about 2 kg. The samples were transported to the laboratory and keep it in air for about seven days to dry at room temperature. The samples were collected and placed in an oven at 100-110°C for about 24 h after that sieved through a 2 mm mesh size sieve.

The homogenized sample was placed in a (500-750)g Marinelli beaker.
The container was sealed and kept aside for about a month to equilibrium between $^{226}$Ra and its daughter products before being taken for gamma-ray spectrometric analysis[4].

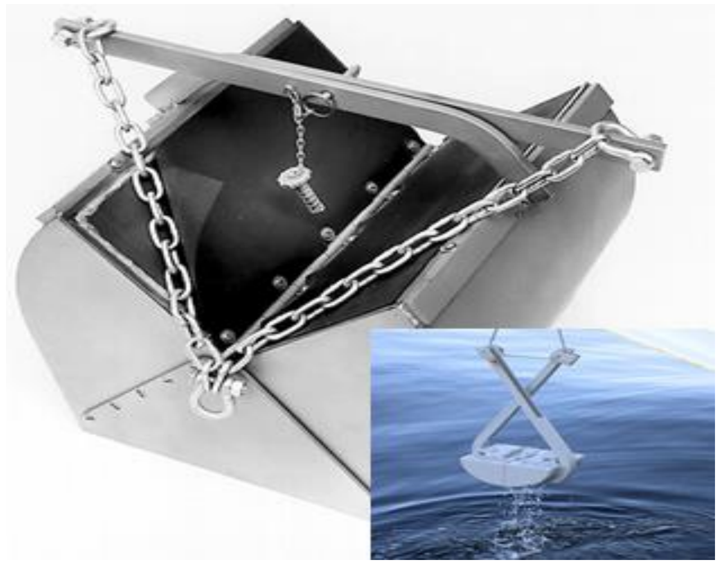

Fig 2. Superficial sediment: the van Veen grab

### 3.3 Gamma-ray spectrometric analysis preparation

The spectral gamma analysis consists of a counter time of bout 14400 s with NaI(Tl) detector and lead shielding which reduces the background. The concentration of various radionuclides of interest was determined Bq/Kg.
The information carriers produced due to the interaction of gamma rays with the detector medium vary with the type of detector. When gamma rays interact with a scintillation medium, the energy of the incident gamma photons are converted into light energy. These packets of light energy called scintillations act as information carriers.

## 4. Theoretical Aspect

After measuring the count rate (area under the peak) for each peak shown in figure 1, the activity concentration for each environmental isotopes calculated from [17]

$$A = \frac{Net\ count}{\varepsilon \times I_{\gamma} \times M \times t} \qquad (1)$$

where ε is the absolute gamma peak efficiency of the detector at this particular gamma-ray energy, $I_{\gamma}$ 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.

### 4.1.Radium Equivalent Activity Index ($Ra_{eq}$)

The Radium Equivalent Activity Index ($Ra_{eq}$) allows a single number to describe the gamma output and the radiation hazards associated with different mixtures of $^{238}U$, $^{232}Th$ and $^{40}K$ in samples. It was estimated using a well-established relation where $A_{Ra}$,

$$Ra_{eq}(Bq.kg^{-1}) = A_{Ra} + 1.43\, A_{Th} + 0.077\, A_K \qquad (2)$$

$A_{Th}$ and $A_K$ are the activity concentration in Bq・$kg^{-1}$ of $^{226}Ra$, $^{232}Th$ and $^{40}K$ respectively in sediment soil. It is assumed that 370 Bq・kg−1 of $^{226}Ra$, 259 Bq・kg−1 of $^{232}Th$ and 4810 Bq・kg−1 of $^{40}K$ produce the same gamma-ray dose rate (UNSCEAR, 2000). The world average of $Ra_{Eq}$ in soil is 370 Bq・$kg^{-1}$

### 4.2.External hazard index

The external hazard index is an evaluation of the hazard of the natural gamma radiation. The prime objective of this index is to limit the radiation dose to the admissible permissible dose equivalent limit around $1mSvy^{-1}$. In order to evaluate this index, one can use the fallowing relation [18]

$$H_{ex} = (A_{Ra}/370) + (A_{Th}/259) + (A_k/4810) \qquad (3)$$

This model takes into consideration that the external hazard which is caused by gamma-rays corresponds to a maximum radium-equivalent activity of 370 Bq/kg for the soil.

### 4.3.The annual effective dose rate

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 must be considered. This value is published in UNSCEAR 2000 and UNSCEAR 1993, to be 0.7 $SvGy^{-1}$ for environmental exposure to gamma rays of moderate energy. The outdoor occupancy factor is about 0.2. The annual effective dose equivalent is given by the following equation [18];

$$AEDE\left(\frac{\mu Sv}{y}\right) = D(nGy/hx8760\left(\frac{h}{y}\right)x0.2x0.7\left(\frac{Sv}{Gy}\right)x10^{-6} \quad (4)$$

where $D\left(\frac{nGy}{h}\right) = 0.0417A_K + 0.462A_{Ra} + 0.606A_{Th}$ (5)

The world average annual effective dose equivalent (AEDE) from outdoor or indoor terrestrial gamma radiation only is 0.560 mSv/year.

## 5. Results and Discussions

The results of gamma measurement after samples treatment in Gamma Spectroscopy table 1., the activity concentration in Bq/kg arrangements,Ra-226 changed from 63.3±5.9 Bq/kg to 9.21±2.3Bq/kg, Th-232 from 10.74±2.3Bq/kg to 2.54±0.8Bq/kg, U-238 from25.82±9.5 Bq/kg to 1.15±0.2 Bq/kg, K-40 from 670.31±121.45 to 101.30±23.4Bq/kg and $Ra_{eq}$ from 108.55±21.3 Bq/kg to 29.56±5.45 Bq/kg .The average values are (33.86±3.4, 5.26±1.4, 316.02±70.78, 8.58±2.4, 65.72±22.73 ) Bq/kg for Ra226, Th232, , K40 , U238, $Ra_{eq}$) Bq/kg respectively. The average worldwide values in soil are 45-50 Bq/kg for $^{226}$Ra, 27Bq/kg for $^{232}$Th, 35 Bq/kg for $^{238}$U and 400 Bq/kg for $^{40}$K. From the table1. the activity concentration Th-232< U-238< Ra-226< K-40, these values of activity concentration of isotopes in study area represented of a Geological natural so that human and agricultural activity. The correlation between U-238 and Ra-226 ($R^2$ = 0.79) explain in Figure 3, and the correlation between Ra-226 and $Ra_{eq}$ ($R^2$ = 0.75) explain in Figure 4.

The distributions of radioactivity isotopes in samples along the river position was explained in the Figure5, which appeared the increased in concentration whenever they were farther, we go from the mouth of the main river towards the end of the branch river and the highest values are clearly shown in samples 11 to 14, where it was observed that there is human and agricultural activity near these samples more than others, with the irrigation of farms being drained into the river again. It is clear that the speed of the river's flow is very weak, it draws water from the river for agriculture only, and the tides are also weak, about 0.5 meters or less as a result of its distance from the sea, which is equivalent to 140 km. It is like stagnant water, without clear rotation and circulations.

As can be seen from Table 1 and Table 2, the $Ra_{eq}$ values for sediment samples varied from 29.56±5.45Bq/kg to 108.55±21.3 Bq/kg with average value 65.72±22.73 Bq/kg and these values has a great connection with the absorbed gamma dose**,** external hazard index and annual effective dose parameters as seen from the equasiona 3,4 and 5. The external index $H_{ex}$ which assess the health effect from sedement radioactivity varied from 0.080 mSv/y to 0.293 mSv/y with an average value 0.178 mSv/y which is below the limit of ICRP (1 mSv/y). The calculated annual effective dose rate AEDE values ranged from 0.0173 mSv/y to 0.066 mSv/y with average value 0.095, all the values are less than the recommended limit.

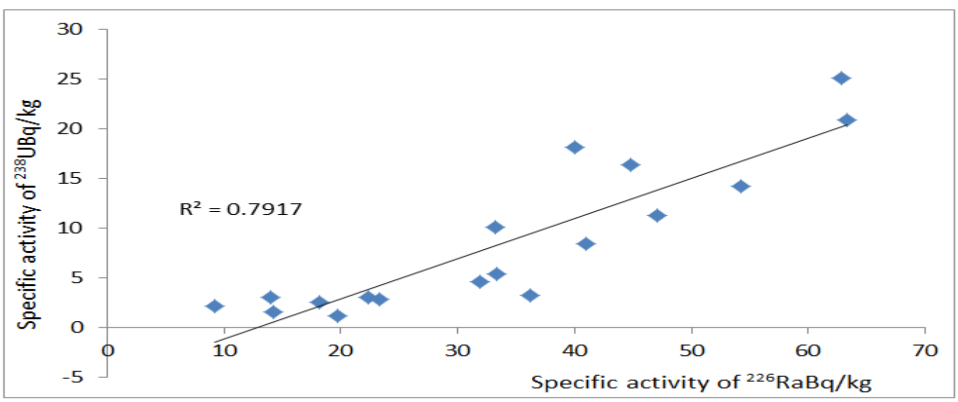


Figure 3. The Correlation between $^{238}U$ and $^{226}Ra$.

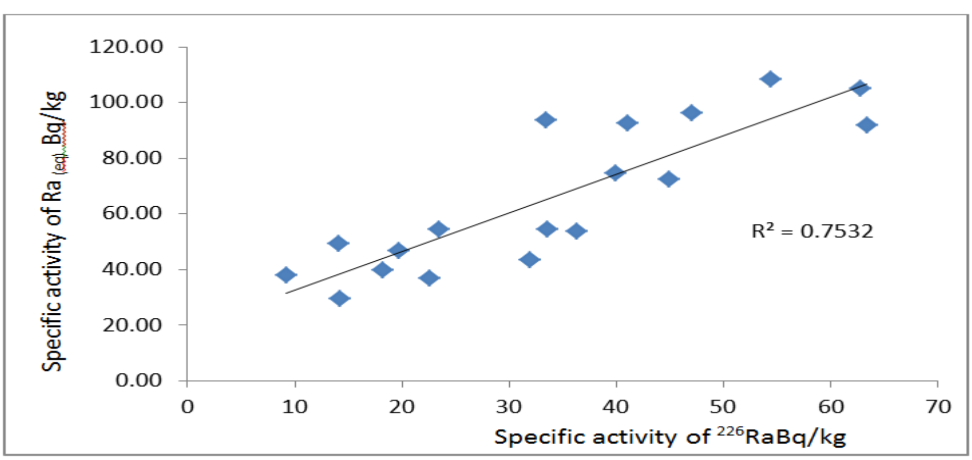


Figure 4. The Correlation between $Ra_{eq}$ and $^{226}Ra$.

Table1. The activity concentration of samples from study area.

| .NO. | $^{226}Ra$(Bq/kg) | $^{232}Th$(Bq/kg) | $^{40}K$(Bq/kg) | $^{238}U$(Bq/kg) | $R_{eq}$(Bq/kg) |
|---|---|---|---|---|---|
| 1 | 31.94±2.33 | 2.54±0.33 | 101.30±14.11 | 4.51±1.1 | 43.37±12.23 |
| 2 | 33.46±11.5 | 6.94±1.24 | 145.75±28.45 | 5.4±1.2 | 54.61±15.23 |
| 3 | 14.18±5.07 | 4.57±1.76 | 114.89±46.1 | 1.63±0.4 | 29.56±9.32 |
| 4 | 14.10±3.78 | 10.74±3.28 | 258.75±92.87 | 3.01±0.9 | 49.38±17.76 |
| 5 | 36.28±11.02 | 4.66±1.04 | 144.04±29.86 | 3.15±1.1 | 54.03±22.21 |
| 6 | 18.20±3.90 | 3.16±0.89 | 221.46±52.96 | 2.55±0.8 | 39.77±18.62 |
| 7 | 22.45±5.60 | 3.98±1.43 | 114.61±28.65 | 3.09±0.9 | 36.97±15.87 |
| 8 | 9.213±2.78 | 6.94±2.35 | 241.8±72.56 | 2.14±0.8 | 37.76±16.81 |
| 9 | 19.7±9.88 | 5.26±2.73 | 256.94±128.47 | 1.15±0.2 | 47.01±20.74 |
| 10 | 23.42±5.87 | 4.90±1.76 | 312.86±78.22 | 2.80±0.4 | 54.52±21.27 |
| 11 | 33.29±1.49 | 6.00±1.30 | 670.31±30.14 | 10.25±1.9 | 93.48±33.21 |
| 12 | 40.99±7.49 | 2.87±0.90 | 614.25±140.35 | 8.37±1.5 | 92.39±33.90 |
| 13 | 54.28±9.44 | 3.97±1.07 | 631.09±122.70 | 14.10±2.1 | 108.55±35.71 |
| 14 | 47.04±3.44 | 4.63±0.45 | 555.40±29.89 | 11.21±2.3 | 96.43±36.43 |
| 15 | 39.98±10.04 | 5.95±0.12 | 343.34±10.59 | 18.07±2.1 | 74.93±22.24 |
| 16 | 62.80±8.55 | 9.08±0.23 | 382.39±5.28 | 25.82±3.9 | 105.23±32.63 |
| 17 | 63.30±10.76 | 3.98±0.33 | 300.99±32.82 | 20.81±3.3 | 92.17±34.12 |
| 18 | 44.91±12.44 | 4.55±0.53 | 278.26±23.78 | 16.36±2.1 | 72.84±25.70 |
| **Av.** | **33.86±3.4** | **5.26±1.4** | **316.02±70.78** | **8.58±2.4** | **65.72±22.73** |
| **Max** | **63.3±5.9** | **10.74±2.3** | **670.31±121.45** | **25.82±9.5** | **108.55±21.3** |
| **Min** | **9.21±2.3** | **2.54±0.8** | **101.30±23.4** | **1.15±0.2** | **29.56±5.45** |

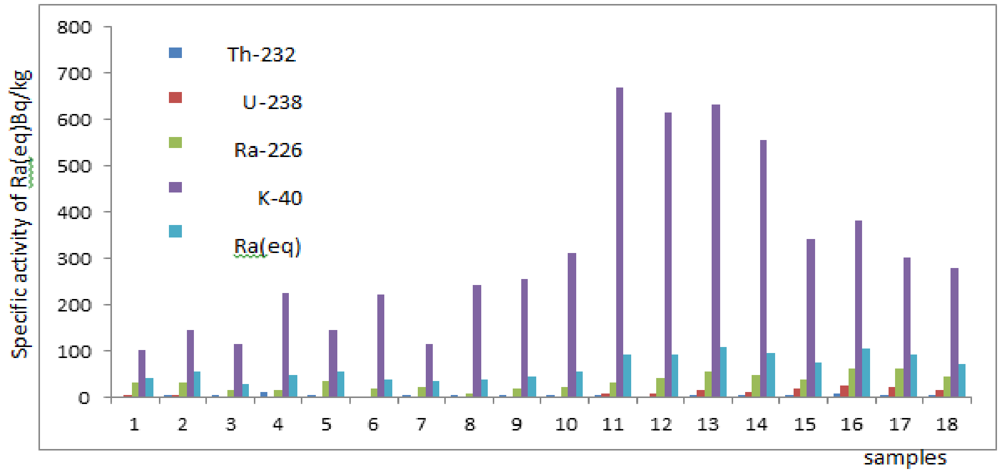


Figure 5. Radioactive of samples along with river distribution.

Table (2) The Radium equivalent, External hazard and Annual Effective Dose, External, for different types of sediment.

| S. No | $Ra_{eq}$ Bq/kg | $H_{ex}$ $mSv/y$ | D nGy/h | $AEDE$ $(mSv/y)$ |
|---|---|---|---|---|
| 1 | 43.37±12.23 | 0.117 | 20.51973 | 0.025165 |
| 2 | 54.61±15.23 | 0.147 | 25.74194 | 0.03157 |
| 3 | 29.56±9.32 | 0.079855 | 14.11149 | 0.017306 |
| 4 | 49.38±17.76 | 0.133369 | 23.81252 | 0.029204 |
| 5 | 54.03±22.21 | 0.145992 | 25.59179 | 0.031386 |
| 6 | 39.77±18.62 | 0.107432 | 19.55824 | 0.023986 |
| 7 | 36.97±15.87 | 0.09987 | 17.56302 | 0.021539 |
| 8 | 37.76±16.81 | 0.101966 | 18.54511 | 0.022744 |
| 9 | 47.01±20.74 | 0.12697 | 23.00336 | 0.028211 |
| 10 | 54.52±21.27 | 0.14726 | 26.8357 | 0.032911 |
| 11 | 93.48±33.21 | 0.252497 | 46.96791 | 0.057601 |
| 12 | 92.39±33.90 | 0.249568 | 46.29083 | 0.056771 |
| 13 | 108.55±35.71 | 0.293235 | 53.79963 | 0.06598 |
| 14 | 96.43±36.43 | 0.260479 | 47.69844 | 0.058497 |
| 15 | 74.93±22.24 | 0.202407 | 36.39374 | 0.044633 |
| 16 | 105.23±32.63 | 0.284287 | 50.46174 | 0.061886 |
| 17 | 92.17±34.12 | 0.249024 | 44.20776 | 0.054216 |
| 18 | 72.84±25.70 | 0.196796 | 35.10916 | 0.043058 |

## 6. Conclusion

The activity levels and distribution of natural terrestrial radionuclides of $^{226}Ra$, $^{232}Th$, and $^{40}K$ were measured by gamma-ray spectrometry system for sediment samples collected from eighteen points in Kaitban river. The activity concentrations of $^{226}Ra$, $^{232}Th$ and $^{40}K$ in the studied sediments are found to be normal and most of the samples are below the recommended limit. The average concentration of natural radionuclides $^{238}U$ and $^{232}Th$ and all radiological parameters are lower than worldwide limit. This means that the water of the river is safe to use. This study can be used as a baseline for future investigations and the data obtained in this study may be useful for natural radioactivity mapping in Basra Governorate and also be used as reference data for monitoring possible radioactivity pollution.

**References**

[1] Guogang Jia, Monica Buchetti , Daniela Conti , Leandro Magro , Sara Mariani, Radioecological studies of the main naturally occurring radionuclides in the area of Gela Phosphate Industry (Italy) through radioanalytical separation and measurement techniques, 2022, *Applied Radiation and Isotopes*, 184, 110173, https://doi.org/10.1016/j.apradiso.2022.110173

[2] Regional training course " Method and measurement on environmental radionuclides", Syria , 24-4/4-5, 2000.

[3] Regional training course on the" analysis of radionuclides in the marine environment", Karlsruhe, Germany, 11-15 August, 2014.

[4] Fatima, I., Zaidi, J. H., Arif, M. and Tahir, S. N. A. Measurement of natural radioactivity in bottled drinking water in Pakistan and consequent dose estimates. 2007, Radiat. Prot. Dosim. 123(2), 234–240.

[5] Isam Salih, M. M., Pettersson, H. B. L. and Lund, E.Uranium and thorium series radionuclides in drinking water from drilled bedrock wells: correlation to geology and bedrock radioactivity and dose estimation. 2002.,Radiat. Prot. Dosim. 102, 249–258

[6] Hakam, O. K., Choukri, A., Reyss, J. L. and Lferde, M.Determination and comparisons of uranium and radium isotopes activities and activity ratios in samples from some natural water sources in Morocco. 2001, J. Environ. Radioact. 57, 175–189.

[7] Palmer, M. R. and Edmond, J. M. Uranium in river water. 1993, Geochim. Cosmochim. Acta 57, 4947–4955.

[8] Ivanovich, M. and Harmon, R. S. Uranium Series Disequilibrium: 1993 Application to Earth, Marine and Environmental Sciences. Clarendon Press.

[9] Benedik, L. and Jeran, Z. Radiological characterization of natural and mineral

drinking waters in, 2012, Slovenia. Radiat. Prot. Dosim. 151(2), 306–313.

[10] Stalder, E., Blanc, A., Haldimann, M. and Dudler, V. Occurrence of uranium in Swiss drinking water. 2012, Chemosphere 86, 672–679.

[11] Kralik, C., Friedrich, M. and Vojir, Simin Mehdizadeh, Reza Faghihi Sedigheh Sina1 and Shahrzad Derakhshan1, Measurement of natural radioactivity concentration in drinking water samples of Shiraz City , 2013, Radiation Protection Dosimetry , Vol. 157, No. 1, pp. 112–119 doi:10.1093/rpd/nct114

[12] Ramasamy, V., Murugesan, S., & Mullainathan, S. Gamma ray spectrometric analysis of primordial radionuclides in sediments of Cauvery River in Tamilnadu, India. 2004, Ecologica, 2, 83-88.

[13] M.Suresh Gandhia, R. Ravisankar, A. Rajalakshmi, S. Sivakumar, A. Chandrasekaran, D. Pream Anand, "Measurements of natural gamma radiation in beach sediments of north east coast of Tamilnadu, India by gamma ray spectrometry with the multivariate statistical approach", 2014, Science Direct journal of Radiation Research and Applied Sciences7 - l 7.

[14] UNSCEAR, United Nations Scientific Committee on the, "Effects of Atomic Radiation Sources and Effects of Ionizing Radiation", UNSCEAR report 1 to the general assembly, with scientific annexes, United Nations sales Publication, United Nations, New York, 2000.

[15] F Caridi , G Acri , G Belmusto , V Crupi , G Faggio , R Grillo , G Messina , G Paladini1,a, V Venuti and D Majolino, Natural radioactivity and mineralogical composition of different particle size fractions of a river sediment from Calabria, southern Italy: a case study, 2021, Journal of Physics: Conference Series 2162 , 012001 IOP Publishing doi:10.1088/1742-6596/2162/1/012001

[16] Alharbi W. R., Natural Radioactivity and Dose Assessment fro Brand of Chemical and organic Fertilizers used in Saudi Arabia, 2013, Journal of Modern Physics, 4,344-348.

[17] UNSCEAR, (2000),United Nation scientific Committee on Effect of Atomic Radiation

[18] Aziz Ahmed Qureshi1, Ishtiaq Ahmed Khan Jadoon, Ali AbbasWajid, Ahsan

Attique, Adil Masood,Muhammad Anees, Shahid Manzoor, AbdulWaheed and Aneela Tubassam,,Study of Natural Radioactivity in Mansehra Granite,2014 , Radiation Protection Dosimetry, 158(4), 466–478, doi:10.1093/rpd/nct271