ISSN 2347-3487

Natural radioactivity in marine sediment of Khor- Abdulla Northern west of the Arabian Gulf

Munaf Qasim Jaber[1], Abdul. R. H. Subber[2] and Noori H.N. Al-Hashmi[3]
Department of Physics, college of education for pure science university of Basrah, Basrah, Iraq
bahry1964@yahoo.com
abdulsubber1948@gmail.com
nalhashmiy@yahoo.com

ABSTRACT

This work presents measurements of natural radionuclides (^{238}U, ^{226}Ra, ^{232}Th and ^{40}K) in the sea sediment using gamma spectroscopy. The sediment samples were collected from coastal and deep water using special equipment for this purpose. This work was performed in Khor-Abdulla, northern west of the Arabian Gulf to establish the baseline data level for naturally occurring radionuclides in the study area and will be useful for tracking and assessing any accentual pollution in the marine environment in the region. The average values of ^{232}Th, ^{238}U,^{226}Ra, ^{40}K are 5.6 Bq/kg, 7.2 Bq/kg, 44.4 Bq/kg and 293.9 Bq/kg respectively. It is found that,the mean radium equivalent Ra_{eq} and effective dose rates are 84.5 Bq/kg and 0.046 mSv/y respectively and they are well below the recommended limit of international committees.

Indexing terms/Keywords

Khor-Abdulla; natural radioactivity; gamma ray; radiation hazards

Academic Discipline And Sub-Disciplines

Provide examples of relevant academic disciplines for this journal: E.g., History; Education; Sociology; Psychology; Cultural Studies;

SUBJECT CLASSIFICATION

E.g., Mathematics Subject Classification; Library of Congress Classification

TYPE (METHOD/APPROACH)

Gamma ray spectroscopy used in finding the activity concentration of natural radioactive nuclides.

Council for Innovative Research

Peer Review Research Publishing System

Journal: JOURNAL OF ADVANCES IN PHYSICS

Vol.9, No.1

www.cirjap.com, japeditor@gmail.com

1. INTRODUCTION

The study of gamma concentration emitted from natural radioactive materials in sea sediment is becoming a subject of great interest. There are many radioactive materials in this sediment, for example the natural ^{238}U, ^{226}Ra, ^{232}Th , ^{40}K and^{137}Cs (NORM). The latest one, some time comes from TEROM fallout from nuclear power station accident. Radium-226 and Radium-228 with their progenies are exist in sediments with level depend on the source of water which they are underneath. The progenies of natural radioactive series, potassium and other radionuclides first appear in the lithosphere level depositing on the soil and rocks, then washed and drained through rivers and finally end up in the estuary and entering marine environment [1-3]. The sediment may be regard as a sing of many natural or manmade materials which pass through the various aquatic chemical and biological operations on the earth's surface [4]. The fate of the sediment depends on many complex factors, such as: their size, date of creation and hazard. Parts of marine sediments are from deposited of radionuclides on the earth's surface, then washed by rain or human activities and drained through rivers to the nearby sea or ocean [5]. Predicting the amount of radionuclide concentration in the marine sediment is an important factor in the researches on the marine biota. This is usually based on the study – state approach used in risk assessment models, which is assumes biogeochemical equilibrium between the radioactivity concentration in water and in marine organism, through the concentration ratio [6].

The main objective of this study in to determine natural radionuclides activity concentration in sediment samples distributed in deep water and coastal sediments of Khor- Abdulla. Gamma ray spectroscopy instrument (NaI) was used in this work. This estuary and its coast are very important environmental and economic, due to the lack of information about the level of radionuclide in it.

2. AREA OF STUDY

The study area was conducted in Khor- Abdulla (KA) which is a semi-enclosed, has a funnel (repressive) shape in the first lower- part with a width of 17 km and with a narrow channel end in the upper - part, with a width of 6.5 km. The eastern coast has a mild decline relative to the heavy decline of the western coast (Kuwait coast). So, the international navigation channel is closer to Kuwait coastal, as shown in Figure 1. The average depth is 10m in most areas. The longitudinal hub (bevel) of the channel is 40 km in the direction of the Arabian Gulf with a width between 6 to 17 km [7]. Salinity value between 32‰ to 38‰ is regarded as a saline lagoon. The tidal system is the same as in the northern part of the Gulf, which is named as semidiurnal; the tidal range value is 2 m to 3 m at spring tide. The maximum value of the surface current, in the downstream, is greater than its like in the root, in both phases (spring and neap tide). The reversible situation is in the upstream and the value was 1.5m/s in the root [8].

Figure 1 Area of study, taken from Google earth.

3. MYTHOLOGY

3.1 Sample preparation

Twenty eight sediment samples used for this study were collected from the Iraqi part of the lagoon. The samples were collected using Sample Grab equipment, shown in Figure 2. The sediments samples were separated from the contamination materials and air-dried at room temperature for a week, then dried to 100^{o}C, milled and sieved through 0.2

mm. The dried samples were put inside Marinelli beakers. The beakers were sealed, gas-tight and stored for four week for secular equilibrium.

Figure 2. The sample grabs equipment.

3.2 Gamma ray spectroscopy

Gamma ray spectroscopy used in this work was 3x3 NaI(Tl) scintillator detector with an energy resolution (FWHM) of 2.2 keV for the 0.662 MeV reference transition for ^{137}Cs. The ready measuring Marinelli beakers are placed on the detector end cap. Both samples and the detector crystal are surrounded by a cylindrical 5cm thickness of lead to suppress the background radiation. The USX software, supplied by manufacturer and multichannel analyser emulation software, data acquisition and online spectrum display was used. Measurement with empty Marilelli beaker, under identical condition, is also perform to estimate the background radiation in the laboratory. The weighted average concentrations of gamma lines; 186 keV from ^{222}Rn, 352 keV from ^{214}Pb, 609 keV from ^{214}Bi, 1120 keV of ^{214}Bi and 1674 keV of ^{214}Bi are used for determining ^{226}Ra. The weighted average concentrations of gamma lines; 338 keV from ^{228}Ac, 911 keV of ^{208}Ac are used for determining ^{232}Th concentration. The weighted average concentrations of gamma lines; 766 keV of ^{234}Pa, 1001 keV from ^{234}Pa are used for determining ^{238}U concentration. The line at 1461 keV was used for determining ^{40}K. The uncertainties in the average concentrations were estimated by the combination of uncertainties in net-count, time, sample mass and detector efficiency for certain energy.

3.3. Calculations

The specific activity concentration in Bq/kg of a radionuclide i and for a photo-peak at energy E is given by [9, 10]

$$A_{Ei} = \frac{NP_i}{t_i I_{\gamma i}(E_\gamma)\varepsilon_i(E_\gamma)M_i} \qquad \text{[Bq/kg]} \qquad (1)$$

where NP is the net peak counts, ε (Eγ) is the absolute full energy peak efficiency of the detector at this particular gamma-ray energy, t is the counting life time, $I_\gamma(E_\gamma)$ the number of gammas per disintegration of this nuclide for transition at energy E (branching ratio) and M the mass in kg of the measured sample. Under assumption that the secular equilibrium reached between ^{232}Th, ^{238}U and their decay products, the measurement of gamma ray concentrations has been done.

Radium equivalent activity (R_{aeq}) is used to assess hazards associated with materials that contain ^{226}Ra, ^{232}Th and ^{40}K in Bq/kg. which is, determined by assuming that 370Bq/kg of ^{226}Ra or 260 Bq/kg of ^{232}Th or 4810 Bq/kg of ^{40}K produce the same γ dose rate. The R_{aeq} of a sample in (Bq/kg) can achieve using the following relation [10];

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K \qquad (2)$$

The external hazard (H_{ex}) is hazard evaluation of outdoor 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 following relation [11]

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

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.

In order to assess the radiological impact of the investigated radionuclides in the soil and sediment sample, the gamma 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 annual effective dose equivalent is given by the following equation [12,13];

ISSN 2347-3487

$$AEDE_{out}(\mu Sv/y) = D(nGy/h \times 8760(h/y) \times 0.2 \times 0.7(Sv/Gy) \times 10^{-6} \quad (4)$$

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

The outdoor occupancy factor consider to be about 0.2 and the world average annual effective dose equivalent (AEDE) from outdoor or indoor terrestrial gamma radiation only is 0.560 mSv/year.

4. RESULTS AND DISCUSSIONS

The results of gamma concentrations measurements of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K of all sediments samples are given in table 1. The activity concentration are in order ^{232}Th < ^{238}U <^{226}Ra <^{40}K , and their ranges are from 0.01 Bq/kg to 20.5± Bq/kg, 0.12 Bq/kg to 28.8 Bq/kg, 1.5 Bq/kg to 138.9 Bq/kg , 3.38 Bq/kg to 645.58 Bq/kg respectively. The average values of ^{232}Th, ^{238}U,^{226}Ra, ^{40}K is 5.6 Bq/kg, 7.2 Bq/kg, 44.4 Bq/kg and 293.9 Bq/kg respectively. The average worldwide values in soil are 45-50 Bq/kg for ^{226}Ra, 27 Bq/kg for ^{232}Th and 400 Bq/kg for ^{40}K . From table 2, one can see the range of Ra_{eq} from 80.0 Bq/kg to 184.2 Bq/kg with arithmetic mean 84.5 Bq/kg, which is less than 370 Bq/kg limit.

Table 1. The activity concentration of natural radionuclides exist in sediment samples taken from KA (sample No. from 1-17 from deep water, 18-25 from coastal and 25-28 from deep water also as shown in figure 1) . All parameters in the table are unit of Bq/kg.

S.NO.	^{226}Ra	^{232}Th	^{238}U	^{40}K
1	37.6±9.9	0.1±0.1	1.5±0.1	548.4±44.2
2	41.6±10.6	5.5±1.0	1.8±0.1	645.6±51.9
3	111.4±38.5	12.9±3.5	18.0±2.6	539.6±42.7
4	18.6±5.2	0.6±0.1	0.8±0.1	424.2±33.6
5	15.4±3.42	14.3±3.8	0.7±0.1	612.7±49.6
6	13.7±3.6	20.5±5.4	0.5±0.2	24.6±2.0
7	5.1±1.4	3.6±0.9	0.12±0.1	330.4±26.6
8	48.6±12.6	13.7±3.6	2.6±0.8	153.7±12.7
9	9.9±3.6	3.8±0.8	0.6±0.2	348.0±27.7
10	29.4±7.4	16.1±4.0	3.6±1.1	484.0±39.4
11	27.5±11.2	6.0±1.6	2.7±1.2	293.4±24.3
12	101.4±37.9	3.5±0.3	15.7±3.8	108.4±8.8
13	1.5±0.3	27.7±7.5	0.2±0.1	57.8±5.3
14	72.9±26.0	3.3±0.7	10.1±2.2	570.5±47.6
15	16.1±3.5	3.6±0.9	2.6±6.1	353.5±28.1
16	75.9±27.0	0.1±0.1	11.1±4.0	405.5±32.8
17	23.9±5.5	1.7±0.3	2.6±0.1	199.5±15.8
18	25. 5±6.2	4.2±1.1	9.9±9.9	1.70±3.3
19	108.3±37.3	6.2±1.4	14.0±9.1	115.6±9.1
20	18.0±7.1	0.9±0.1	7.1±3.6	300.1±23.9
21	18.95± 5.0	9.8±2.3	9.6±4.8	245.4±19.4
22	22.7±5.2	0.1±0.1	3.6±1.7	213.9±17.0
23	43.0±12.6	4.8±1.1	20.8±10.2	403.5±32.7
24	115.5±51.0	1.3±0.2	25.1±10.4	326.6±25.4
25	138.9±46.5	10.2±2.7	28.8±0.1	399.9±32.2
26	7.8±1.7	0.01±0.01	0.2±0.1	59.6±4.7
27	19.3±6.5	1.3±0.4	4.7±2.2	19.7±1.5
28	68.5±5.0	4.8±1.3	7.1±0.1	3.4±0.3

Correlation analysis has been carried out, to understand and modelling the behaviours of natural radionuclides and estimate the distribution probability of them. Figures3 and 4 show the correlation of ^{238}U with ^{226}Ra and ^{238}U with ^{232}Th. The first figure shows a strong and positive correlation R= 86%, while there is no correlation between the second quantities.

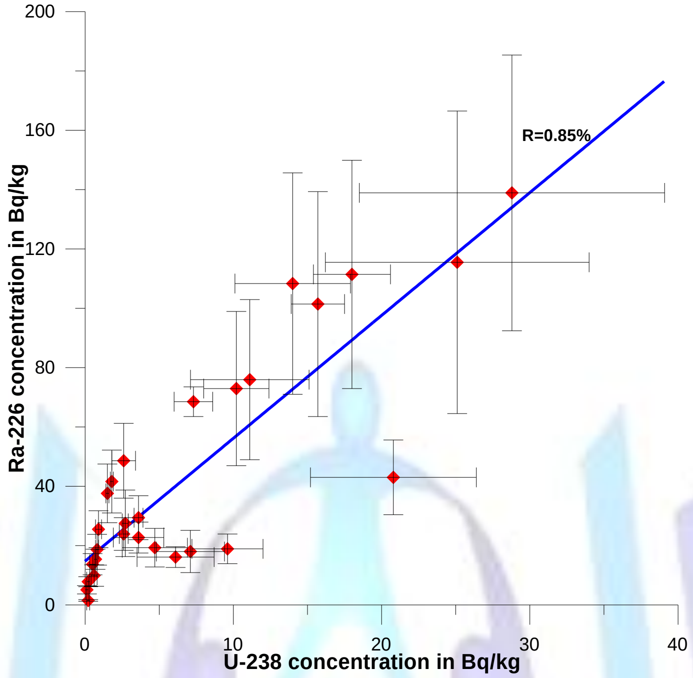

Figure 3 Correlations between ^{226}Ra and ^{238}U

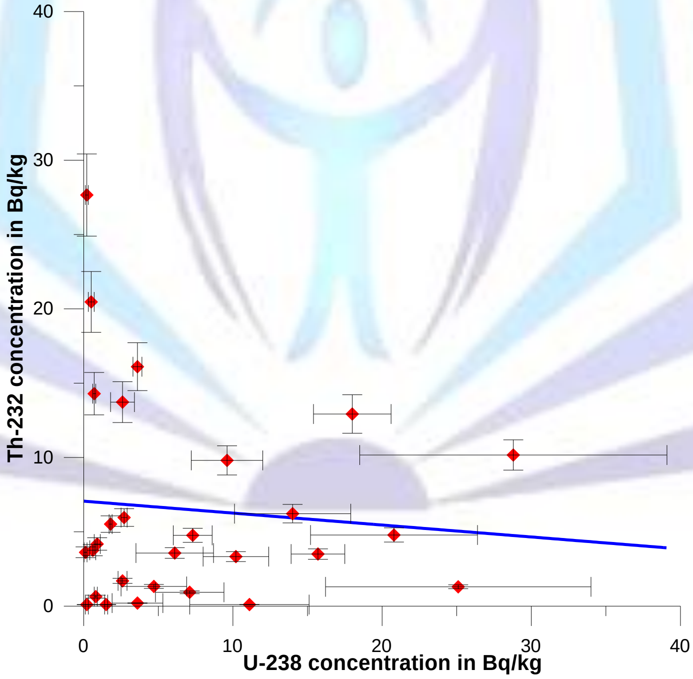

Figure 4 Correlations between ^{232}Th and ^{238}U

In order to assess the health effects from the activity of radionuclides present in the sediment samples, this activity converted to single quantity termed as external hazard index (H_{ex}). The limit of this index must not exceed unity. Table 2, contains the gamma activity concentration external hazard index, which ranged from 0.034 up to 0.498 with arithmetic mean value 0.209 the average value is less than the world average value 0.66.

Table 2 also presents the annual effective dose equivalent due to the external hazard index. The calculated values of annual effective doses rate ranging from 0.007 mSv/y to 0.107 mSv/y, with average value equal to 0.046 mSv/y which is less than the world average value of 0.48- 0.56 mSv/y recommended by (UNSCEAR2000).

Table 2 hazard indices of gamma activity concentration of natural radionuclides (Ra_{eq} in Bq/kg, H_{ex} unit less, D in nGy/h and $AEDE_{out}$ in mSv/y).

S.NO.	Ra eq	Hex	D	$AEDE_{out}$
1	80.0	0.216	40.3	0.049
2	99.1	0.268	49.5	0.061
3	171.5	0.463	81.8	0.100
4	52.1	0.141	26.7	0.033
5	83.0	0.224	41.3	0.051
6	44.9	0.121	19.8	0.024
7	35.7	0.096	18.3	0.022
8	80.1	0.216	37.2	0.046
9	42.1	0.114	21.4	0.026
10	89.7	0.242	43.5	0.053
11	58.6	0.158	28.5	0.035
12	114.8	0.310	53.5	0.066
13	45.4	0.123	19.9	0.024
14	121.6	0.328	59.5	0.073
15	48.4	0.131	24.3	0.030
16	107.2	0.290	52.0	0.064
17	41.6	0.113	20.4	0.025
18	34.7	0.094	16.1	0.020
19	126.1	0.341	58.6	0.072
20	42.4	0.115	21.4	0.026
21	51.8	0.140	24.9	0.031
22	39.2	0.106	19.4	0.024
23	162.5	0.219	39.6	0.049
24	172.5	0.385	67.8	0.083
25	184.2	0.498	87.0	0.107
26	12.4	0.034	6.1	0.007
27	22.7	0.061	10.5	0.013
28	175.6	0.204	34.7	0.043
Max.	184.2	0.498	87.0	0.107
Min.	12.4	0.034	6.1	0.007
Ave.	84.5	0.209	37.2	0.046

The results of activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K, radium equivalent activity, external hazard and annual effective dose of the present sediment samples and other studies are compared in table 3. It found that, in general, that the value of the present measurements for ^{226}Ra lies within the worldwide value, while in the case of ^{232}Th the results of the present work almost equal to the value of neighbouring country (Kuwait). In case of ^{238}U, the value of this work is in the range of all countries. Potasium-40 measured this work is closed to the value of Kuwait. The hazard indices measured in the present work are closed to the range of other countries and less than the worldwide limit.

Table 3 A comparisons of activity concentration, Ra_{eq} external hazard and annual effective dose in KA sediments and other studies in different part of the world.

location	Mean activity in Bq/kg							
	^{226}Ra	^{232}Th	^{238}U	^{40}K	Ra_{eq}	H_{ex}	E_{out}	Ref.
world	50	27	35	400	370	<1	0.56	[14]
Beach sand Egypt		177		815				[15]
Kuwait		6	36	227				[16]
Tagus-Spain	42	63		572				[17]
Upper Egypt	29	45	18	123	100	0.21		[4]
French Rivers1	38	38		599				[18]
Nile delta	18	17		316				[19]
Nigeria		24	16	35				[20]
India		713	35	349	1081	2.92	0.621	[21]
Malaysia					143	0.40	0.201	[3]
Red sea coast Egypt		7.2	23	338				[5]
Aden coast		48.3	46	646				[5]
India		26	3.8	328	66	0.18	0.507	[22]
Present work	44.4	5.6	7.2	294	84.5	0.11	0.046	

5. CONCLUSIONS

The sediment, are successfully analysed for radioactive elements, namely ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K. The results clearly show that the levels of radioactivity of gross sediments do not exceed the limits set by the EPA and are within the range of nearby countries. The data obtained in this study will serve as baseline data for the proper assessment of radiation exposure of the dwellers. A comparison of the present measurements and the results of many closed or far countries reviled a general agreement with their results. Good correlation exists between in selected samples between uranium and radium.

REFERENCES

1. Ahmad- Taufek, A. R., Ahmad- Termizi, R. and Abdul-khalik, W. (2004), Analysis of the concentration of natural radionuclides in rivers in Kota Tinggi District, Malaysia., Journal of nuclear and related Technologies, 1, 41-52.
2. Akram, M, Qureshi R. M., Ahmed, N., Solaija, T. J.,Mashiatullah, A., Ayub, M. A. and Irshad, S. (2004), Determination of natural and aritificial radionuclides in seawater and sediments off Gwadar Coat, Arabian Sea. The Nucleus 41, 19-25.
3. Mei-Wo, Y., Jaffary, N. A. and Ahmed, Z (2011), Radiation hazard from natural radioactivity in the sediment of the east coast Peninsular Malaysia exclusive economic zone (EEZ), The Malaysian Journal of Analytical Sciences, 15(2), 202-212.
4. El-Taher, A. and Abbady, G. E., (2012) Natural radioactivity levels and associated radiation hazard in Nile river sediment from Aswan to El-Minia, Upper Egypt, Indian journal of Pure and Applied Physics, 50, 224-230.
5. Harb, S., El-Kamel, A. H., Zahran, A. M., Abbady A. and Assubaihi F.A, (2012) Measurement of Natural radioactivity in beach sediments from Aden coast on Gulf of Aden, South of Yemen., XI Radiation Physics and Protection Conference, Egypt, 25-28.
6. Konovalenko, L., Bradshaw, C., Kumblad, L. and Kautsky, U., (2014) radionuclide transfer in marine coastal ecosystems, a modelling study using metabolic processes and stie data., Journal of Environmental Radioactivity, 133,48-59.
7. Darmoian, S. A. and Lidqvist, K. (1988). Sediments in the estuarine environment of Iraq; Arabian Gulf, Geo. J., 23,15-37.
8. Reynolds, R. M. (1993). Physical oceanography of the Gulf, Strait of Hormuz, and the Gulf of Oman (Results from the Mt. Mitchell expedition). Mar. Pollut. Bull., 27, 35-59.

9. Oktay, Baykara Sule Karatepe, Mahmut, Dogru, Assesment of Natural Radioactivity and radiological hazards in construction metrial used in Elazig Turkey, *Radiation measurement* 2011; 46,153-158

10. Alaamer, A. S., assessment of Human Exposures to natural sources of radiation in soil of Riyadh, Saudi Arabia, Turkish J. Eng. Env. Sci., (2008), 32, 299-234.

11. Aziz, Ahmed Qureshi, Ishtiaq, Ahmed Khan Jadoon, Ali, AbbasWajid, Ahsan, Attique, Adil Masood, Muhammad Anees, Shahid Manzoor, AbdulWaheed and Aneela Tubassam, (2014), Study of Natural Radioactivity in Mansehra Granite, , Radiation Protection Dosimetry, 158(4), 466–478, doi:10.1093/rpd/nct271

12. UNSCEAR, **2008**,*United Nation scientific Committee on Effect of Atomic Radiation,* VII

13. UNSCEAR, (1993),United Nation scientific Committee on Effect of Atomic Radiation

14. UNSCEAR, (2000), exposure from natural radiation sources, Annex-B. Sources and effects of ionizing radiation, united nation scientific committee on the effects of atomic radiation.

15. Uosif, M. A. M., El- Taher, A., and Abbady, G. E., (2008), Radiological significance beach sand used for climate therapy from Safaga, Egypt ,Radiation protection Dosimetry , 131, 331-339.

16. Saad, H.R., and AL-Azmi , D. , 2002 , Radioactivity concentration in the sediment and their correlation in the coastal structure in the Kuwait Applied Radiation and Isotopes , 56, 991-997..

17. Baeza, A. , del Rio, M., Miro, C., and Paniagua, J. M., (1992), Radiat Protect Dosi ,45(1/4) 261

18. Lamberechts, A., Foulquier, L. and Gamier –Laplace, J., (1992), Radiate Protect Dosi ,45(1/4), 732

19. Ibrahiem, N. M., Shawky, S. M. and Amer, H. A., (1995), Appl Radiat Isot, 46(5)297.

20. Arogunjo, A. M., Farai, I. P., and Fuwape, I. A ., (2004),Dose rate assessment of terrestrial gamma radiation in the delta region of Nigeria .Radiation protection Dosimetry , 108, 73-77.

21. Suresh,Gandhi M. , Ravisankar, R. , Rajalakshmi, A. , Sivakumar, S. , Chandarasekaran, A. , and Pream, Anand D. , (2014) , Measurement of natural gamma radiation in beach sediments of north east coast of Tamilnadu , Indian by gamma ray spectrometry with multivariate statistical approach , Journal of Radiation Research and Applied sciences , 7 , 7-17.

22. Sivakumar, S. , Chandarasekaran, A. , Ravisankar, R. , Ravikumar, S.M. , Prince, Prakash Jebakumar, J. , Vijayagopal, P. Vijayalakshmi, I. and Jose, M.T., (2014) , Measurement of natural radioactivity and evaluation of radiation hazards in coastal sediment of east coast of Tamilnadu using statistical approach , Journal of Taibah University for Science , 8 ,375-384 .