

DISTRIBUTION AND CHARACTERIZATION OF MINERALS AND NATURALLY OCCURRING RADIONUCLIDES IN RIVER SEDIMENTS

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Abstract: The distribution and characterization of minerals in Ponnaiyar River sediments are carried out using Fourier Transform Infrared (FTIR) spectroscopic technique. The minerals such as quartz, feldspar in different structure, kaolinite, calcite, gibbsite, montmorillonite, smectite, organic carbon and palygorskite are identified. The relative distribution of major minerals such as quartz, feldspar (orthoclase and microcline) and kaolinite are determined by calculating extinction co-efficient. From this calculation, the amount of kaolinite is very much lesser than quartz and lesser than orthoclase and microcline feldspar. The naturally occurring radionuclides (^{238}U , ^{232}Th and ^{40}K) and associated absorbed dose rate are determined by Gamma ray spectroscopic technique. The determined activity concentrations and average absorbed dose rate of all sites are fall within the typical world and Indian average values. Correlation analysis is carried out for distributions of quartz, feldspar (orthoclase and microcline) and kaolinite and naturally occurring radionuclides, with associated absorbed dose rate. Correlation analysis shows that the kaolinite (clay mineral) may act as a booster of level of natural radioactivity.

Keywords: FTIR, Gamma ray spectroscopy, Minerals, Radioactivity, River sediments

1. INTRODUCTION

Most natural solids are minerals. Sediments are not exemptions. Sediments are detrital products of rocks and bear the mineralogical properties of the original rock formation. The principal constituents of most of the sediments are quartz, feldspar, carbonates and clay minerals. Of these, quartz is overwhelmingly the most abundant. Feldspar, though more abundant in parent igneous rock, is of intermediate durability and so runs second place to quartz in sediments. The others, though more durable than feldspar, are simply for less abundant in source materials (Dott & Batten, 1976). The mineralogical properties of sediments, reflects the geological history of transport and sorting process. The Fourier Transform Infrared (FTIR) absorption spectra of sediments contain more information about mineralogy (Ramasamy et al., 2006a). It is used by mineralogists and sedimentary petrologists in the aspect of mineralogical application. The Infrared spectra of river sediments from Cauvery and Vellar

have been characterized by Ramasamy et al., 2005 & 2006 (a).

Naturally occurring radionuclides are widespread in the earth environment and it exists in various geological formations such as earth crust, rocks, soils, plants, water and air. When rocks are disintegrated through natural process, radionuclides are carried to soil by rain and flows (Taskin et al., 2009). Natural radioactive metals leached from wastes materials also contaminate surrounding ground water, soils and biota (Petrescu & Bilal, 2006 & 2007). The way minerals incorporate the radionuclide depend on several geological conditions, but is most strongly dependent on the mineral species and geological formation from which they originate. All of the U and Th decay series elements are incompatible in the major rock forming minerals such as quartz, olivine and pyroxenes. There are, however, less incompatible in trace or accessory minerals (Orgun et al., 2007). The ^{238}U and ^{232}Th radionuclides are associated with heavy minerals, whereas ^{40}K is concentrated within

the clay minerals (Tsabaris et al., 2007). El-Gamal et al., (2007) reported that, the mineralogical structure of the sediments is one of the controlling factors for level of radioactivity in river sediments.

The river sediments are used as major mixing material in building construction in India. Hence, the main scope of this study is to identify and characterize the various minerals and naturally occurring radionuclides present in river sediments by FTIR and gamma ray spectroscopic techniques and also, to study the correlation between the minerals and radionuclides in sediments.

2. MATERIALS AND METHODS

2.1. Study area

In the present study, sediment samples were collected from various sites of the Ponnaiyar River. The geographical location of study area is presented in Table 2. It is originated on the hills of Nandidrug in Kolar districts of Karnataka state, and flows south and then east for 400 Km through Karnataka and Tamilnadu, and terminated at Cuddalore, Tamilnadu in Bay of Bengal. It is entered in Tamilnadu at Dharmapuri district. It covers four districts (Dharmapuri, Thiruvannamalai, Villupuram and Cuddalore) in Tamilnadu. A dam is constructed on this river at Satthanur, Chengam taluk, Thiruvannamalai district. Capacity of this dam nearly 4600 M CFT. The sediments of this river are excavated only for building constructions. The small hydraulic structure and barrages were constructed for drinking and agriculture purposes respectively on the study area.

2.2 Geology of the study area

The river area is predominantly built up with granite and gneisses rocks of archean period. The granite is of very good quality and extensive outcrops and masses of it are commonly found. The chief components of rocks are hornblende and feldspar.

Foliation is seldom seen. In the plains of reserve forest, quartz is found. The diamond granite is also found in scattered pockets in the areas of Chitteri hills (Dharmapuri and Krishnagiri subdivisions). Charnokite rocks of archean period are also seen in some area. At the tail end of the basin, pockets of sand stone, clays pebble of tertiary period, and limestones of cretaceous period are found.

2.3. Sample collection and preparation

The present study area (Ponnaiyar River) covers a total length of 200 Km, from which 40 locations were selected. Each location is separated by a distance of 4-5 Km approximately. All sediment samples were collected at 0-10 cm depth during the summer season (April-May 2008). Each sample has a weight of 3-4 kg approximately. The collected samples were dried at room temperature in open air for two days and stored in black polythene bags.

2.3.1. Sample preparation and techniques- (1)

FTIR

Wet grinding was carried out by placing 30 to 50mg of the sample in an agate mortar along with 20 to 25 drops of ethanol. The ground samples were dried in a hot air oven at 110°C to remove the moisture content and sieved to various grain sizes such as 74, 53 and 44µm. Using the KBr pellet technique, each grain sized sample was mixed with KBr at various ratios viz., 1:10, 1:20, 1:30, 1:40 and 1:50. The mixture was then pressed into a transparent disc in an evacuable dye at sufficiently high pressure. The samples in the ratio 1:30 was taken for further analysis, since it gives rise to maximum transmittance and observable peaks (Ramasamy et al., 2006a). Using the Perkin Elmer RX1 FTIR spectrometer, the infrared spectra for all sediment samples were recorded in the region 4000-400 cm⁻¹. The resolution of the instruments is 0.001cm⁻¹ and the accuracy is ±4 cm⁻¹.

2.3.2. Gamma ray spectroscopic technique

The samples were dried in an oven 110°C till the constant dry weight was obtained, crushed and homogenized. The homogenized samples were packed in a 250 ml plastic container (9cm x 6.5cm: Height x Diameter) to its full volume with uniform mass. These containers shielded hermetically and also shielded externally to ensure that all daughter products of uranium and thorium, in particular, radon isotope formed, do not escape. A time of four weeks was allowed after packing to attain secular equilibrium between Ra-226 and its short-lived daughter products. The net weight of the sample was determined before counting.

The gamma ray spectrometer with NaI (TI) detector was used to determine the concentration of primordial radionuclides (²³⁸U, ²³²Th and ⁴⁰K). The detector was shielded by 15 cm thick lead on all four sides and 10 cm thick on top. The energy resolution of 2.0 Kev and relative efficiency of 33% at 1.33Mev was achieved in the system with the

counting time of 10000 seconds. The Standard International Atomic Energy Agency (IAEA) sources were used for calibration. From the counting spectra, the activity concentrations of ^{238}U , ^{232}Th and ^{40}K was determined using computer program. The peak corresponds to 1460Kev (K-40) for ^{40}K , 1764.5 Kev (Bi-214) for ^{238}U and 2614.5Kev (Th-208) for ^{232}Th were considered in arriving at the activity levels (Bq/kg).

3. RESULTS AND DISCUSSION

The FTIR spectra are recorded for all sediment samples and their frequencies (cm^{-1}) obtained from these spectra are tabulated with corresponding minerals in table 1. The minerals such as quartz, microcline feldspar, orthoclase feldspar,

kaolinite, calcite, gibbsite, montmorillonite, smectite, organic carbon and palygorskite are identified by comparing the observed wave numbers with available literatures (Ramasamy et al., 2006a; Russell 1987 and Ramasamy et al., 2004a).

Quartz is one of the non clay mineral and invariably present in all samples. The presence of quartz in the samples can be explained by Si-O asymmetrical bending vibrations around 464 cm^{-1} , Si-O symmetrical bending vibrations around 694 cm^{-1} , Si-O symmetrical stretching vibrations at around 778 and 796 cm^{-1} , while the 1082 and 1162 cm^{-1} absorption region arises from Si-O asymmetrical stretching vibrations due to low Al for Si substitution. The observation of peaks near 514 - 520 cm^{-1} also indicates that presence of quartz.

Table 1. The observed absorption wave numbers and corresponding minerals from FTIR spectra

S. No.	Mineral Name	Site number	Observed Wave numbers (cm^{-1})
1	Quartz	S ₁ -S ₄₀	460-464
		S ₁ -S ₄₀	514-520
		S ₁ -S ₄₀	693-694
		S ₁ -S ₄₀	777-778
		S ₁ -S ₄₀	794-796
		S ₁ -S ₄₀	1080-1084
		S ₁ -S ₄₀	1162-1164
		S ₆ , S ₉ , S ₁₃ -S ₁₉ , S ₂₂ , S ₃₁ , S ₃₅ -S ₃₇	1615-1620
2	Microcline Feldspar	S ₁ -S ₄₀	583-587
3	Orthoclase Feldspar	S ₁ -S ₄₀	647-650
		S ₁ , S ₃ , S ₁₅ , S ₂₁ , S ₂₃ , S ₂₉	532-537
		S ₁ -S ₄₀	1015-1019
4	Kaolinite	S ₁ , S ₃ , S ₁₀ , S ₁₅	1030-1037
		S ₆ , S ₁₀ , S ₁₅ -S ₁₉ , S ₂₄ , S ₃₂ , S ₃₅ -S ₃₆	3618-3622
		S ₁ , S ₂ , S ₂₃ , S ₃₃ , S ₂₉ , S ₃₄	3690-3691
5	Gibbsite	S ₁ -S ₄₀	662-670
6	Calcite	S ₂ , S ₃ , S ₄ , S ₃₃ , S ₃₆	1420-1438
7	Montmorillonite	S ₃₆	878
8	Palygorskite	S ₁ , S ₇ , S ₂₁ , S ₃₃ , S ₂₉ , S ₃₆	3611-3615
9	Organic Carbon	S ₁ -S ₄₀	2923-2929
		S ₁ -S ₄₀	2852-2865
10	Smectite	S ₂₇	523

With the view of Keller and Pickett, 1949, the observed absorption peaks at 1615-1620 cm^{-1} in some sites indicate the presence of quartz in river sediments are weathered from metamorphic origin. These assignments are in good agreement with the observation on the quartz mineral obtained by Ramasamy et al., (2004a; 2005 and 2006a). The characteristic feature of quartz is a doublet centered at or around 796 and 778 cm^{-1} . Usually, the intensities of the above doublet are not comparable.

Feldspar is also frequent constituents in sediments. This group of minerals are of several types such as orthoclase, microcline, sanidine (K-

feldspar), albite (Na - feldspar) and anorthite (Ca-feldspar). Though three feldspars (orthoclase, microcline and sanidine) are having the same chemical formula (KAlSi_3O_8) but they have different structures (orthoclase-monocline, microcline-triclinic and sanidine-tetrahedral). The peak corresponding the range 583-587 cm^{-1} is due to the O-Si-(Al)-O bending vibration for microcline and in the range 647-650 and 532-537 cm^{-1} is due to the Al-O coordination vibrations indicates the presence of orthoclase feldspar (Ramasamy et al., 2006a).

Table 2. The Extinction-coefficient of Quartz, Microcline Feldspar, Orthoclase Feldspar and Kaolinite of Ponnaiyar river sediments along with latitude and longitude

Site Number	Latitude	Longitude	Extinction Co-efficient			
			Quartz	Microcline	Orthoclase	Kaolinite
S ₁	12°10'606"N	78°50'464"E	92.65	26.65	8.39	1.10
S ₂	12°07'978"N	78°53'950"E	40.91	6.73	3.38	1.19
S ₃	12°06'415"N	78°55'087"E	171.82	26.83	21.11	2.29
S ₄	12°06'414"N	78°55'075"E	156.53	6.65	5.09	2.52
S ₅	12°06'416"N	78°55'080"E	77.25	13.55	5.16	2.87
S ₆	12°00'677"N	79°03'273"E	137.30	18.92	12.27	3.05
S ₇	12°00'104"N	79°04'169"E	107.01	15.58	8.6	3.10
S ₈	12°00'271"N	79°05'481"E	139.57	17.15	10.42	3.08
S ₉	11°58'786"N	79°06'923"E	95.70	18.69	6.85	3.10
S ₁₀	11°58'007"N	79°07'880"E	147.14	34.99	19.41	3.16
S ₁₁	11°57'860"N	79°09'838"E	110.38	6.81	8.65	3.22
S ₁₂	11°58'400"N	79°12'726"E	107.01	17.04	10.28	3.30
S ₁₃	11°56'876"N	79°14'198"E	92.31	15.29	8.6	3.39
S ₁₄	11°56'734"N	79°18'353"E	62.06	8.39	6.81	3.17
S ₁₅	11°54'832"N	79°18'771"E	153.10	29.83	17.48	3.73
S ₁₆	11°54'402"N	79°20'273"E	127.93	6.65	15.58	3.82
S ₁₇	11°55'082"N	79°22'377"E	49.35	20.58	5.09	3.22
S ₁₈	11°54'172"N	79°24'086"E	112.09	46.43	10.35	3.92
S ₁₉	11°52'354"N	79°26'245"E	210.10	24.02	23.09	4.88
S ₂₀	11°52'065"N	79°28'584"E	106.21	37.10	10.35	4.25
S ₂₁	11°51'688"N	79°29'731"E	165.43	27.45	20.84	4.01
S ₂₂	11°51'309"N	79°30'778"E	111.24	8.39	11.96	4.03
S ₂₃	11°50'533"N	79°33'457"E	70.63	11.82	5.92	4.03
S ₂₄	11°50'367"N	79°33'916"E	132.11	42.84	10.55	4.09
S ₂₅	11°50'406"N	79°35'451"E	275.75	8.33	27.36	4.19
S ₂₆	11°49'579"N	79°36'488"E	47.67	20.45	5.06	4.24
S ₂₇	11°49'328"N	79°37'131"E	127.23	29.64	13.89	4.25
S ₂₈	11°49'001"N	79°37'273"E	141.86	6.65	13.72	4.32
S ₂₉	11°48'090"N	79°37'994"E	45.98	22.23	5.09	4.33
S ₃₀	11°47'853"N	79°38'736"E	112.9	34.99	12.04	4.42
S ₃₁	11°47'124"N	79°39'249"E	171.82	8.44	15.68	4.48
S ₃₂	11°48'021"N	79°39'755"E	71.64	25.82	5.12	4.57
S ₃₃	11°48'464"N	79°40'249"E	159.2	15.19	13.98	4.68
S ₃₄	11°47'414"N	79°41'792"E	108.66	24.17	10.42	4.69
S ₃₅	11°47'549"N	79°42'287"E	181.57	17.26	17.93	4.79
S ₃₆	11°47'482"N	79°42'758"E	35.68	10.03	5.09	5.01
S ₃₇	11°46'831"N	79°43'642"E	88.88	13.38	8.65	4.95
S ₃₈	11°46'821"N	79°44'201"E	71.13	8.28	6.81	4.97
S ₃₉	11°46'405"N	79°45'821"E	66.31	6.65	5.09	5.07
S ₄₀	11°45'350"N	79°47'685"E	78.36	10.25	6.85	5.16

Kaolinite is the clay mineral. The presence of absorption band at or around 3690, 3620, 1030 and 1015 cm^{-1} indicate the presence of clay mineral constituents as kaolinite (Ramasamy et al., 2006a and Ramasamy et al., 2004a).

The intensity of the bands varies from sample to sample which indicates its the quantity. According to Russell, (1987) and Ramasamy et al., (2005), if four peaks are observed in the region 3697-3620 cm^{-1} , the minerals are said to be ordered state. However, in the present study only two peaks are observed at 3690 and 3620 cm^{-1} in some sites. This suggests the minerals may be in disorder state.

Calcite is the most common carbonate mineral in sediments. From the existence of a peak in the range 1420-1438 cm^{-1} it is easily recognized that the calcite is present in site no. S₂-S₄, S₃₃ and S₃₆. The existence of a peak near 665, 878, 523, 2925 & 2855 and 3612 cm^{-1} respectively indicate that presence of gibbsite, montmorillonite, smectite, organic carbon and palygorskite

3.1. Relative distribution of quartz, feldspar (orthoclase and microcline) and kaolinite

With reference to the number of peaks and intensity, the minerals such as quartz, feldspar (orthoclase and microcline) and kaolinite are consider as major or main minerals. The other minerals are accessory. Therefore in the present study, the author is interested to study the relative distribution of quartz, feldspar (orthoclase and microcline) and kaolinite in Ponnaiyar River sediments. The relative distribution of major minerals can be quantified by calculating the extinction co-efficient for the characteristic peaks quartz, orthoclase feldspar, microcline feldspar and kaolinite at around 778, 647, 585 and 1015 cm^{-1} respectively for all sites using the formula (Ramasamy and Ponnusamy, 2009). From the calculated values (Tab. 2), maximum extinction co-efficient values for quartz, microcline feldspar, orthoclase feldspar and kaolinite are 275.75, 46.43, 27.36 and 5.16 in the site no. S₂₅, S₁₈, S₂₅ and S₄₀ respectively. In the same way, minimum values are 35.68, 6.65, 3.38 and 1.10 are in the site no. S₃₆, S₂₈, S₂ and S₁ respectively. With the maximum and minimum limits of the above said minerals, the other sites may be arranged for the containment of the same mineral quantitatively in an order. In overall view, the amount of kaolinite is very much lesser than quartz and lesser than orthoclase and microcline feldspar.

3.2. Activity concentration of ^{238}U , ^{232}Th and ^{40}K

The activity concentration of natural radionuclides (^{238}U , ^{232}Th and ^{40}K) for all samples is determined (Tab. 3). It varies from site to site, because river bottoms can exhibit large variation in chemical and mineralogical properties (Krmr et al., 2009). The mean activity concentration ranges for ^{238}U , ^{232}Th and ^{40}K are BDL - $11.60 \pm 6.13\text{Bq/kg}$ with an average $7.31 \pm 3.41\text{Bq/kg}$, BDL - $106.11 \pm 9.20\text{Bq/kg}$ with an average $46.85 \pm 5.25\text{Bq/kg}$ and 201.23 ± 19.90 - $467.71 \pm 34.34\text{Bq/kg}$ with an average $384.03 \pm 26.82\text{Bq/kg}$ respectively. In all sampling sites, mean activity concentration is of the order $^{238}\text{U} < ^{232}\text{Th} < ^{40}\text{K}$. In particular S₂, the activity concentration of ^{238}U is high, which may be due to the solubility and mobility of U (VI) O_2^{2+} (Powell et al., 2007). However, the S₄₀ is having high ^{232}Th and ^{40}K concentrations. This can be attributed to the mineralogical composition of the sediment (Tsabaris et al., 2007). The activity concentration of ^{238}U is lower than other radionuclides. This may be due to the formation of the hexavalent uranyl cation, UO_2^{2+} , which is more soluble and mobile in most environments relative to U(IV), under oxidizing condition (Powell et al., 2007). The increasing trend of ^{40}K is due to presence of clay sediments (El-Gamal et al., 2007).

The concentration of ^{238}U , ^{232}Th and ^{40}K for all measured samples are below the world and Indian average values (World average value of ^{238}U , ^{232}Th and ^{40}K is 50Bq/kg, 50 Bq/kg and 500Bq/kg respectively. Indian average value of ^{238}U , ^{232}Th and ^{40}K is 28.67 Bq/kg, 63.83 Bq/kg and 327.6 Bq/kg respectively). However in some sampling sites, concentration of ^{232}Th is higher than world average value, indicating that clay mineral may exist at that sampling site. Ramasamy et al., (2004b and 2006b) reported the values of Palar and Cauvery rivers, which are higher than the present values.

3.3. Absorbed dose rate

The mean activity concentrations of ^{238}U , ^{232}Th and ^{40}K are converted in to dose rate based on the conversion factor given by UNSCEAR (2000) (Tab. 3).

$$D = (0.462C_U + 0.604 C_{Th} + 0.0417 C_K) \text{ nGy h}^{-1}$$

Where D is the absorbed dose rate (nGy h^{-1}), C_U , C_{Th} and C_K are the activity concentrations (Bq/kg) of ^{238}U , ^{232}Th and ^{40}K in river sediments respectively. The range of absorbed dose rates is from 14.72nGy/h to 88.95nGy/h with average of 47.07nGy/h. Average

absorbed dose rate for all samples are lower than the world average value (51nGy/h) (UNSCEAR 2000).

3.4. Correlation analysis

In order to determine inter- relation between the minerals and concentrations of radionuclides in the sediments, Pearson correlation analysis is carried out using SPSS for windows 16.0 software, and is shown in table 4 as the linear correlation matrix.

From the correlation analysis, the distribution of quartz and feldspar are poorly correlated with individual activities of ^{238}U , ^{232}Th and ^{40}K and absorbed dose rate (Tab. 4). But the distribution of Kaolinite (clay minerals) is well positively correlated with individual activities of ^{232}Th and ^{40}K and absorbed dose rate (Tab. 4).

Table 3. Radio nuclide Activity concentration of ^{238}U , ^{232}Th and ^{40}K and absorbed dose rate in the Ponnaiyar River sediments.

Site no.	Activity concentration (Bq/kg)			Absorbed dose rate (nGy/h)
	^{238}U	^{232}Th	^{40}K	
S ₁	9.51±4.21	6.11 ± 4.69	201.23±23.96	16.48
S ₂	11.6±6.13	6.91 ± 9.20	287.81±25.36	21.53
S ₃	7.89±3.96	BDL	279.10±26.17	18.61
S ₄	8.11±4.11	7.21± 4.19	282.64±25.11	19.89
S ₅	7.97±3.65	8.76 ±4.33	305.01±27.28	21.69
S ₆	7.32±3.54	8.18 ±3.95	329.52±25.32	22.06
S ₇	8.13±4.21	9.55 ± 4.33	306.83±34.34	22.32
S ₈	7.23±3.95	8.98 ± 4.26	342.63±26.17	23.05
S ₉	7.11±3.65	11.88 ± 3.62	384.97±26.42	26.51
S ₁₀	7.54±3.45	10.99 ± 4.01	378.79±25.96	25.92
S ₁₁	7.88±3.65	12.35 ± 4.26	385.55±26.44	27.18
S ₁₂	8.01±4.51	19.32 ± 4.44	363.05±19.90	30.51
S ₁₃	7.32±3.11	15.39 ± 4.37	388.55±26.44	28.88
S ₁₄	7.13±2.98	20.94 ± 4.51	381.11±26.98	31.83
S ₁₅	7.56±3.41	24.26 ± 4.60	354.77±26.14	32.94
S ₁₆	7.54±3.65	26.25 ± 4.57	382.33±29.11	35.28
S ₁₇	6.98±3.98	25.68 ± 4.59	380.21±25.69	34.59
S ₁₈	7.12±3.48	29.71 ± 4.75	388.97±27.41	37.45
S ₁₉	7.56±3.85	33.95 ± 4.76	388.08±27.39	40.18
S ₂₀	6.99±3.01	37.90 ± 5.07	397.01±27.78	42.68
S ₂₁	7.21±3.21	38.2 ± 5.15	385.55±26.44	42.48
S ₂₂	7.24±3.26	42.36 ± 5.56	399.32±29.12	45.58
S ₂₃	6.96±3.01	48.69 ± 5.87	402.68±27.01	49.42
S ₂₄	6.71±2.98	58.48 ± 3.80	406.82±30.53	55.39
S ₂₅	6.64±2.69	66.25 ± 4.21	408.10±25.78	60.10
S ₂₆	6.98±3.11	59.68 ± 4.44	405.04±25.58	56.16
S ₂₇	6.68±2.96	58.69± 5.26	405.11±28.82	55.43
S ₂₈	6.97±2.89	68.59 ± 5.01	403.94±32.17	61.49
S ₂₉	6.69±2.65	70.96 ± 6.18	418.53±27.18	63.40
S ₃₀	7.24±3.21	74.52 ± 6.11	430.36±27.16	66.30
S ₃₁	6.45±3.14	78.36 ± 6.25	424.09±25.68	68.46
S ₃₂	6.98±2.96	87.23 ± 6.54	420.55±27.72	73.45
S ₃₃	BDL	74.52 ± 6.01	424.72±32.57	65.72
S ₃₄	6.68±2.65	89.65 ± 6.98	434.59±28.69	75.36
S ₃₅	6.57±2.56	95.64± 6.34	426.24±30.18	78.58
S ₃₆	BDL	96.64 ± 6.24	437.71±27.81	79.63
S ₃₇	6.56±2.68	94.65 ± 6.21	455.89±20.62	79.21
S ₃₈	BDL	97.26± 6.98	442.09±25.68	80.18
S ₃₉	6.59±2.87	96.48 ±6.16	454.21±22.32	80.82
S ₄₀	6.52±2.98	106.11± 7.16	467.71±22.54	86.17
Average	7.31±3.41	46.85±5.25	384.113± 26.82	47.07
Maximum	11.6±6.13	106.11±9.20	467.71± 34.34	88.95
Minimum	BDL	BDL	201.23±19.9	14.72

Table 4. Correlation analysis of Extinction coefficient of Quartz, Microcline Feldspar, Orthoclase Feldspar and Kaolinite and concentration of Radionuclides of Ponnaiyar River sediments

	^{238}U	^{232}Th	^{40}K	ADR	E-Q	E-MCF	E-OCF	E-KA
^{238}U	1							
^{232}Th	-0.623	1						
^{40}K	-0.769	0.818	1					
ADR	-0.638	0.999	0.847	1				
E-Q	-0.107	-0.089	-0.076	-0.093	1			
E-MCF	-0.098	-0.118	-0.061	-0.118	0.116	1		
E-OCF	-0.132	-0.046	0.013	-0.044	0.901	0.221	1	
E-KA	-0.822	0.852	0.922	0.869	0.075	-0.005	0.137	1

^{238}U , ^{232}Th and ^{40}K are the concentrations of natural radionuclides (Bq/Kg). ADR – Absorbed Dose rate (nGy/h). E-Q - Extinction co-efficient of Quartz. E-MCF - Extinction co-efficient of Microcline Feldspar. E-OCF- Extinction co-efficient of Orthoclase Feldspar and E-KA- Extinction co-efficient Kaolinite.

4. CONCLUSION

The infrared analysis of the Ponnaiyar River sediments indicates the presences of minerals such as quartz, feldspar (orthoclase and microcline) and kaolinite as major minerals. The others such as calcite, gibbsite, smectite, montmorillonite, palygorskite and organic carbons are considered as accessory minerals. The appearance of peak at 1615-1620 cm^{-1} shows the presence of quartz in river sediments are weathered from metamorphic origin. The calculated extinction co-efficient values show that, the amount of quartz is greater than feldspar (orthoclase and microcline) and very much greater than kaolinite in all the sites. The average activity concentrations and absorbed dose rate of the present study sediments are within the world and Indian average value, although some extreme values have been determined.

According to UNSCEAR, 2000 report, activity concentration and calculated absorbed dose rate (radiation hazard index) are lower than recommended level. Therefore, the sediments of Ponnaiyar river does not pose any significant radiological threat to the population. The obtained positive correlation ($r = 0.87$) between the distribution of kaolinite (clay minerals) and absorbed dose rate shows that, clay minerals like kaolinite may act as a booster of level of radioactivity.

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