



## **Geochemical Analysis of Sediment Sands of Cauvery and Kollidam Rivers in Tiruchirappalli District, Tamil Nadu, India**

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### **ABSTRACT**

*The mineralogical composition of 30 sedimental samples of upper surface from Cauvery and Kollidam Rivers in Tiruchirappalli district, Tamil Nadu, India has been analyzed by using Fourier transform infrared spectroscopy. The compounds observed in the spectrum are quartz, kaolinite, feldspar, calcite, hematite, biotite, magnetite, illite, and organic carbon. From the observed compounds, quartz has been found in almost all the samples. The metallic elements have been analyzed by atomic absorption spectrometry and the presence of iron, manganese; zinc and copper are found to be low compared to standard values. The percentage of sand, silt, and clay in the samples has been estimated by granulometric analysis.*

**Key words:** *Granulometric analysis, Atomic absorption spectrometer, Fourier transform infrared, Sediment sands, Mineralogical composition.*

### **1. INTRODUCTION**

River sediments are composed of natural solids of which most of them are minerals [1]. These minerals and organic waste are drained into the river by erosion and anthropogenic activities. The use for fertilizers, herbicides and pesticides, mineralogical waste from the industries are drained into the river and hence the river sediments are considered as a natural sink of elemental contaminants [2-5]. The geophysical properties of the lithic fragments sediments are determined by the properties of original rock formation [4,6]. The river sand is used mainly for construction purposes along with other building materials. The components such as quartz, feldspar, kaolinite and other clay materials are present in the sediments. Quartz, a non-clay material, which is predominant in the sand samples [7]. The other minerals except quartz and feldspar occupy a minimum amount of their composition in the sediment sand samples [8]. The presence of minerals in the sediments provides useful information of the mineralogical composition of the region.

Numerous conventional methods have been employed for the characterization of the minerals. Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction analysis and thin section analysis are the important tools for the analysis of the minerals.

FTIR technique is a non-destructive tool used to analyze the minerals. The molecular structure of a

compound has its own molecular motion that causes the change in its dipole moment and has its unique characteristic peak in the spectrum [9]. FTIR is a reliable and simple technique with ease process of sample preparation. It requires a small sample size and a fast process to obtain a spectrum [10]. It is also a potential tool to characterize the sand sediments with high accuracy and good resolution and hence it is preferred than the other techniques [11,12]. Numerous research work have been carried out in the river sediments in different regions of Tamil Nadu, India, and the present work established the mineralogical analysis in the banks of Cauvery and Kollidam rivers of agricultural landscape in Tiruchirappalli district. The determination of grain size is the most fundamental property of the sediments that provides the information of sedimentation, transport of sediments and the history of deposition [13]. The presence of heavy metals depend on the porosity and surface area of the samples [14].

The novelty of the study is to determine the presence and distribution of various minerals in the sediments by FTIR technique in Cauvery and Kollidam rivers in Tiruchirappalli district, Tamil Nadu, India. Second is to estimate the percentage of sand, silt, and clay by granulometric analysis, third is to determine the presence of elements such as copper, zinc, manganese, and iron by atomic absorption spectroscopy.

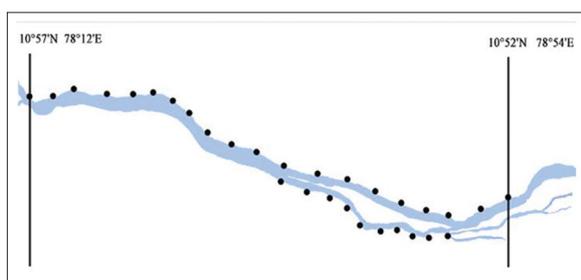
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The present study area covers 83 km in Tiruchirappalli district where the geographical coordinates extend from latitude N - 10°57", E - 78°12" to N - 10°52", E - 78°54". Cauvery river originates from Kodugu hills of Karnataka in western Ghats and flows toward east covering two states and drains into the bay of Bengal. It runs to about 965 km toward east irrigating many districts. Two huge dams are constructed across the river in the study area. The river forms a wide sandy bed from Sri Ramasamudram to Vathalai and splits up into two rivers namely Cauvery and Kollidam and joins at great anicut and forms an island, named as Srirangam. Cretaceous, archean and granite rocks, fertile alluvial soil, poor quality black soil occupies the landscape in the district. Thirty sediment samples have been collected at a distance of 3-4 km along the river in the district. The sampling sites are shown in Figure 1. The places where the samples have been collected are given below.

1. Sriramasamudram east
2. Sriramasamudram west
3. Natham
4. Thirunarayanapuram
5. Mahendramangalam
6. Manamedu
7. Santhapalam (Musuri)
8. Musuri
9. Savanthilingapuram
10. Aiyampalayam
11. Amoor
12. Vathalai
13. Jeeyapuram
14. Mutharasanallur
15. Kamarasampettai
16. Kudamuruti
17. Kondayampettai
18. Ponnurangam
19. Puthapuram
20. Thogur
21. Kallanai (Cauvery)
22. Koohur
23. Mukkombu
24. Kiliyanallur
25. Thudaiyur
26. Srirangarayapuram



**Figure 1:** Sample spots along the rivers in Tiruchirappalli district.

27. No.1. Tollgate
28. Valadi
29. Thirumanamedu East
30. Kallanai (Kollidam)

Sand sediments were collected along the Cauvery and Kollidam rivers during dry season. The spots where the sediments collected are shown in Figure 1. Using Peterson Grab, the samples were taken and packed in plastic cover bags and transported to the lab. The subjected sample was washed with distilled water to remove the water-soluble materials. It was placed in a hot air oven for 2 h at 120°C. They were sieved with a 1 mm mesh to get a homogenous one.

## 2. MATERIALS AND METHODS

### 2.1. Sample Preparation for FTIR

A few milligrams (30-50 mg) of homogenous sediment sample were powdered by adding 20-25 drops of ethanol in an agate mortar. The samples were again dried at 120°C to avoid a broad spectral peak as the presence of OH would affect the interpretation of the spectrum. The obtained powdered sample was mixed with KBr in the ratio of 1:20 at which the mixture gave a maximum transmittance than the other ratios. The mixture was subjected to a pressure using a piston and a pellet of 1 mm in thickness and 13 mm in diameter was obtained. The pellet was then subjected to Perkin Elmer RX1 FTIR spectrometer and the spectrum was recorded between 4000 and 400  $\text{cm}^{-1}$ . The accuracy and resolution of the instrument is 4  $\text{cm}^{-1}$  and 0.001  $\text{cm}^{-1}$ , respectively.

### 2.2. Sample Preparation for Textural Analysis and Atomic Absorption Spectroscopy

5 g of air dried sand sediment have been grinded and was sieved through a 2 mm sieve. A pinch of sodium hexa-meta-phosphate is added as a dispersing agent. It is subjected to 230 ASTM size mesh and washed with distilled water. The percentage of silt, sand and clay could be determined by pipette method.

Fine sieved homogenous mixture of samples is subjected to atomic absorption spectrometry. The elements such as copper, iron, zinc, and manganese present in the sediment sand samples are estimated.

## 3. RESULTS AND DISCUSSION

### 3.1. Granulometric Analysis

The percentage of distribution of sand, silt and clay at the study sites are given in Table 1. The percentage of the sand value ranges from 99.6% to 97.2%, which shows that most of the sediment has more amount of quartz (Sand particles). Clay occupies a very small proportion of about 0.03-0.01%, hence the presence of clay minerals are minimum in all the samples. The percentage of silt in the samples ranges between 6.17% and 0.38%. The distribution of heavy metals depends on the percentage of sand, silt, and clay [15].

**Table 1:** Percentage of sand, clay and silt and concentrations of zinc, manganese, copper and iron for 30 sediment samples along the rivers.

Serial number	Sand (%)	Clay (%)	Silt (%)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)
1	97.2	0.03	2.77	0.84	3.77	1.02	4.45
2	99.6	0.03	0.37	0.86	3.93	1.01	3.82
3	99.6	0.02	0.38	0.75	4.23	0.96	3.79
4	96.4	0.03	3.57	1.22	4.27	1.62	3.86
5	99.4	0.03	0.57	1.08	4.31	0.96	3.78
6	98.2	0.02	1.78	1.06	4.29	1.02	3.87
7	99.4	0.02	0.58	0.62	4.43	1.01	4.34
8	99.8	0.02	0.18	1.09	4.39	0.94	3.87
9	99.8	0.01	0.19	0.92	4.43	0.93	3.34
10	99.4	0.02	0.58	1.08	4.39	0.98	2.74
11	99	0.01	0.99	1	4.44	0.92	4.05
12	97.2	0.02	2.78	1.02	4.45	0.96	3.79
13	99.2	0.03	0.77	1.03	4.53	0.94	3.7
14	99.2	0.03	0.77	0.98	4.53	0.93	4.04
15	99.2	0.03	0.77	0.97	4.7	0.97	4.01
16	98	0.02	1.98	0.89	4.51	0.93	3.83
17	99.4	0.03	0.57	0.84	4.69	1.01	3.76
18	99.6	0.02	0.38	0.97	4.5	1.00	3.92
19	99.4	0.01	0.59	0.94	4.53	1.01	4.24
20	99.6	0.01	0.39	0.94	4.5	0.96	3.82
21	94.2	0.03	5.77	0.95	4.51	0.98	4.34
22	99.8	0.02	0.18	0.85	4.53	0.97	4.08
23	99.4	0.02	0.58	1.03	4.4	1.01	4.53
24	99.6	0.02	0.38	0.89	4.75	1.01	4.18
25	99.6	0.02	0.38	0.9	4.89	0.96	3.78
26	93.8	0.03	6.17	0.9	4.67	0.89	4.03
27	99.6	0.02	0.38	0.9	4.77	0.97	4.2
28	98.2	0.02	1.78	0.98	4.98	0.83	3.91
29	99.6	0.03	0.37	0.98	4.72	0.96	3.87
30	96.8	0.03	3.17	0.9	4.53	0.98	3.81

Heavy metals are adsorbed by the fine grain sediments from water. These sediments have high capacity to retain the metals [16]. However, heavy metals cannot deposit at the bottom of the river as sediments due to strong water currents [17]. There are a number of geological phenomena where the heavy metals could be accumulated to a very high toxic level, thus creates an imbalance to the environment without any visible signs. The accumulation of heavy metals may depend on the weathering of rocks, population, industrial wastes, use of fertilizers, etc. [18].

From Figure 2, it is noted that the percentage of sand occupies more than 99% in most of the samples. Since the amount of clay is minimum, it is negligible when compared to sand and silt percentage.

### 3.2. Presence of Trace Minerals

#### 3.2.1. Copper

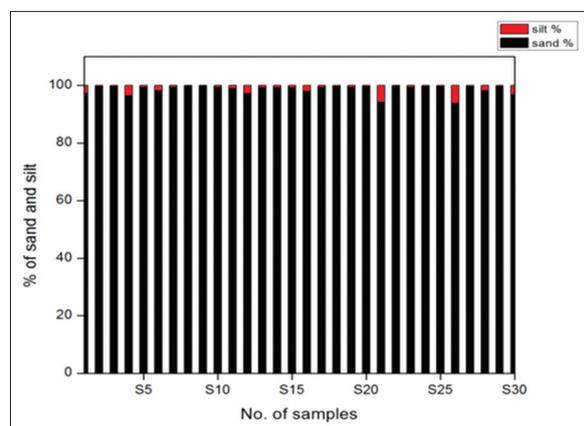
Copper is present in the sediments as it reacts with organic matter in aqueous phase and is bound to the oxidation of organic matter [19]. The distribution of copper does not depend on the particle size [20]. The marine sediments have a copper concentration of 1,00,000 ppm [21]. The presence of copper in the sediments is shown in Table 1 and the mean distribution of copper in the sediments is as shown in Figure 3. Copper ranges from 1.62 to 0.83 ppm. The copper concentration level lies to an approximate value of 1.00 ppm and only at the sample site 4 it has a maximum value of 1.64 ppm. It is of a very low value when compared to the standards and produce no harmful to the environment.

### 3.2.2. Zinc

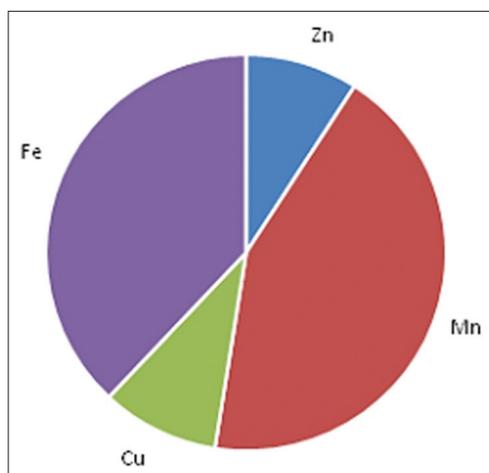
Zinc is an essential element and occurs naturally as silicates and oxides [22]. The concentration of zinc varies with texture of the samples as it is estimated as in large quantities in the very fine sand and occupies a lower quantity in clay size particles [23]. Zinc is released by the discharge of anthropogenic activities and is not considered to be toxic [24]. It is also an important mineral for the human body and is present in the mafic minerals [21,25]. The excess of zinc may lead to disorderliness in the human body [26]. The presence of zinc in the sediment samples is shown in Table 1. The first site has a lower value of 0.84 ppm and the fourth sample site has a value of 1.22 ppm. The critical value of zinc for plants is 100 ppm [27]. Figure 3 shows, which the zinc occupies 9% among the other calculated elements.

### 3.2.3. Iron

About 10-18 mg of iron is needed for adults per day [28]. The deficiency of this mineral might cause anemic to the human beings. The increase of iron content in the environment might be due to anthropogenic activities. A maximum of 4.53 ppm is present at the sample site



**Figure 2:** Percentage of distribution of sand and silt in the samples.



**Figure 3:** Percentage of distribution of selected metals in the sediment samples.

23 and the amount of iron concentration for 30 samples is given in Table 1. The amount of iron from the collected sites is collectively shown as 38% among the other estimated elements as shown in Figure 3. As the pH increases the aqueous concentration of Fe, Mn, Zn, and Cu are decreased due to the precipitation such as amorphous  $Al(OH)_3$ ,  $Cu(OH)_2$ , and ferrihydrite.

### 3.2.4. Manganese

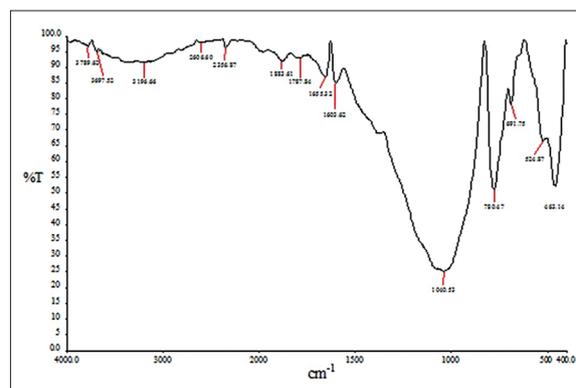
Manganese exists as  $Mn^{2+}$  in an acid environment and as oxides in industrial sources. Manganese is not hazardous but its concentration above the permissible limits may cause turbidity and affects the sense of taste. Table 1 shows the amount of manganese at the sampled sites. From Figure 2, 43% of manganese is present in the samples among the estimated elements. A maximum value of 4.77 ppm and a minimum of 3.77 ppm amount of manganese are present in the sediments. These values are low when compared with the standard values.

### 3.3. FTIR Analysis of Sediment Samples

The FTIR analyses of 30 sediment samples in frequencies ( $cm^{-1}$ ) are shown in Table 2. The presence of quartz, clay minerals, feldspar, and carbonates are the common minerals present in rocks [29]. The minerals are identified from the spectrum with the available literature [1,4,6,7,9,12]. Figure 4 shows a sample of the FTIR spectrum of minerals at the sediment site 26. Table 2 shows the minerals corresponding to its wave number in frequencies and the sites containing those minerals.

#### 3.3.1. Quartz

Quartz is the second abundantly available mineral on earth crust and is common in granite, sedimentary, metamorphic, craterous rocks. Heaney et al., had worked and reported on the quantitative analysis of quartz from dust, soil and coal through FTIR analysis [30]. In FTIR, the spectrum silicate lies in the mid infra-red region lies between 1200 and  $400\text{ cm}^{-1}$ . At  $1000\text{ cm}^{-1}$  silicon is bonded with oxygen and has a stretching vibration, at  $780\text{ cm}^{-1}$  it has tetrahedral and tetrahedral ion vibrations and at  $690\text{ cm}^{-1}$  it has an octahedral vibration. The observed peaks in FTIR ( $cm^{-1}$ ) spectra range from



**Figure 4:** A sample of Fourier transform infrared spectrum of sand site number 26.

**Table 2:** FTIR observed frequencies of sediment samples with mineral identification.

Serial number	Mineral name	Observed wave number (cm <sup>-1</sup> )	Sample site number
1	Quartz	455-462	S14, S15, S16, S18, S22, S23, S24, S25, S26, S28, S29
		771-784	S1-S30
		796-798	S6, S14, S15, S16, S18, S22, S23, S25, S26, S28
		1070-1077	S12, S15, S17, S21, S22, S23, S24, S25
		1600-1610	S18, S27, S30
		1635-1639	S7, S9, S10, S11, S13, S19, S18, S24
2	Feldspar	530-535	S5, S15, S19, S23
		574-578	S10, S14, S16, S21, S26, S28, S30
		620-624	S11, S12, S20
		638-645	S3, S4, S5, S18, S19
		653	S6
3	Kaolinite	491-497	S3, S4, S5, S19, S20
		1027, 933	S1, S17, S19, S20
		1064-1068	S14, S15, S16, S24, S25, S28
		3440-3449	S1, S2, S4, S6, S8, S9, S10, S27, S29, S30
		3650-3667	S13, S14, S16, S17
		3690	S20
4	Biotite	711-713	S18, S19
		719-721	S3, S4, S5, S14
5	Calcite	842	S27
		875	S5, S17
		1450-1459	S1, S2, S27, S29
		1479	S22, S23, S24, S28, S30
6	Hematite	563	S9
		572-578	S10, S16, S26, S28, S30
7	Magnetite	628-632	S13, S18, S19
8	Illite	927-929	S13, S20
		1637-1644	S10, S14, S22, S24
		1652-1654	S23
9	Organic carbon	1731-1733	S1, S2, S27, S29
		1739-1748	S11, S17, S20
		1760-1762	S4, S5, S19
		2851-2855	S14, S15, S16, S21, S22, S23, S30
		2880-2886	S3, S4, S5, S6, S11, S13, S17, S18, S19, S20
		2923-2927	S1, S14, S21, S22, S23, S24, S25, S26, S28

455-462, 771-784, 796-798, 1070-1077, 1600-1610, and 1635-1639 suggest the presence of quartz in the samples and can be explained by Si-O asymmetrical bending vibration at 492 cm<sup>-1</sup> and 455 cm<sup>-1</sup>, and at 778 and 796 cm<sup>-1</sup> Si-O symmetrical stretching vibration is found. Quartz is almost present in all the samples.

### 3.3.2. Feldspar

About 60% of the earth's surface is occupied by feldspar. Three major groups of feldspar are found

in nature such as alkali feldspar, barium feldspar, and plagioclase feldspar. Feldspar exists as silicates of aluminum with calcium, sodium and potassium. The kinetic properties of feldspar depend on the structural binding of feldspar with water [31]. Plenty of research work had been done on feldspars by geophysicists [32-34]. The presence of feldspar in all the samples can be explained by 645-650 Al-O- co-ordination vibrations and 530-535 Si-O asymmetrical bending vibration. The observed peaks at the

regions ( $\text{cm}^{-1}$ ) 620-624, 645-650, 638-640, 530-535, 574-578 suggest the presence of feldspar.

### 3.3.3. Clay minerals

Clay minerals like kaolin, smectite, illite, montmorillonite are extensively used in chemical and mineralogical industries. It finds its way in technological investigations as they are much cheaper than activated carbon. Among the clay minerals kaolin is important and is naturally present in the environment. It absorbs both organic and inorganic materials and are non-toxic, its brightness and whiteness is used in industrial applications [35]. In the fingerprint region of FTIR spectrum a minimum amount of clay mineral is found. The chemical composition of kaolinite is  $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ . The FTIR spectra peaks ( $\text{cm}^{-1}$ ) in 30 samples between the regions of 491-497, 933, 1064-1068, 1027, 3440-3449, 3690, 3650-3667, show the presence of kaolinite and can be explained by 935 OH- deformations and at 3690-3695 inner surface OH stretching vibration. The presence of kaolinite in the environment samples is highly disordered.

Hematite ( $\text{Fe}_2\text{O}_3$ ), is an iron mineral found in the FTIR spectral peaks ( $\text{cm}^{-1}$ ) at 563, 572-578. The presence of biotite and magnetite are observed from the peaks 711-713, 719-721 and 628-632 respectively. The peaks at 1629-1631, 1677-1681 suggest the presence of palygorskite.

### 3.3.4. Calcites

Among the carbonate minerals, calcite is the most commonly found mineral in sand samples. The thermodynamically most stable state of calcium carbonate is calcite [35]. The observed peaks in 30 FTIR spectra of calcite ( $\text{cm}^{-1}$ ) are 842, 875, 1450-1459, 1479. The presence of calcite can be explained by 875  $\text{Fe}^{3+}$  (Al-OH) bonds.

### 3.3.5. Organic carbon

The peaks appearing in the region ( $\text{cm}^{-1}$ ) 1731-1733, 1739-1748, 1760-1762, 2851-2855, 2880-2886, 2923-2927 shows the presence of organic carbon in all the sediment samples.

## 4. CONCLUSION

From granulometric analysis the percentage of sand, silt and clay had been determined. Silt occupies only a minor portion in the sediment sand samples, whereas clay content is very low than the other two. The percentage of sand, silt and clay from the textural analysis helped us to predict that the clay minerals are of in low quantities. The value of elements such as zinc, manganese, iron and copper in ppm are in low quantities than the standard values and are not harmful to the environment. Minerals such as quartz, feldspar and clay minerals are present in the sediment samples. Quartz is invariably present in all the samples. Quantitative analysis of FTIR is considered to be a

useful tool for the mineralogical analysis in sediments. The present study confirms that the landscape around the bank of rivers is quiet suitable for agriculture, to sustain the ecosystem the river should be preserved against the anthropogenic activities.

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