

IDENTIFICATION OF MINOR MINERALS IN RIVER SEDIMENTS THROUGH FTIR STUDY – A NEW APPROACH

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ABSTRACT

This study demonstrates that the grain size analysis gave the detailed mineralogy through Fourier Transform Infrared Spectroscopy. The four selected sites among 39 were subjected to grain size (320, 300, 250, 210, 177, 149, 125, 105, 74, 53 and 44 mm) separation using dry sieving through ASTM mesh sieves. Those grain sizes of four sites were taken as category II whereas the sample as given is taken as category I. FTIR spectrum was taken and analyzed for all the grain sizes of four different sites and additional minor minerals identified in category II when compared to category I. The weight percentage of individual grain size for 320 mm are measured to discuss weathering, erosion and pressure due to sedimentation rate.

KEY WORDS: Cauvery river, Mineral analysis, FTIR, Grain size separation, Sediments

INTRODUCTION

Basically soil is of three different types. Sand, silt and clay can be fractionated from soil on the basis of particle size. Sand is granular form of finely divided rock and mineral particles. The sand composition mainly depends on the local rock sources but most of the constituent of sand in island continent and nontropical coastal settings is silica in the form of quartz. Wind and flow of water are transporting the sand and finally depositing in beaches, dune, sand spits and sand bars. Sand may be obtained in different grain sizes and it is used for many purposes in practical life such as irrigation construction (Bittelli *et al.*, 1999). Sand is main raw materials in glass manufacturing and construction industries.

Excavation of Sand for many industrial purposes can raise environmental concerns over landslides, fish depletion, and flooding. Soil mineralogy is very important for vegetation and minerals decide soil fertility to hold different nutrients. Numerous minerals are found in soil and vary greatly in size and chemical composition. Soil mineralogy and Particle size is having major role in industrial

applications and agriculture. Soil is generally non-toxic but sand-using activities such as sand blasting and separation of the coarse fraction (2 mm) includes gravels, stones, boulders and coarse sands used for building construction require precautions to avoid breathing fine silica dust. Material safety data sheets for silica sand reports excessive inhalation of crystalline silica is very harmful to human health (Zaker *et al.*, 2013).

MATERIALS AND METHODS

Cauvery River, which is 600 km long located between two states (Karnataka and Tamilnadu) in India, is shown in Fig. 1. Sediment samples were collected from 39 sites (Poombhuhar to Hoggenakal) separated by the distance of 20km approximately.

Grain size seperation

Grain size separation was carried out in the laboratory by dry sieving through ASTM mesh sieves. The samples were sieved to 11 grain sizes such as 320, 300, 250, 210, 177, 149, 125, 105, 74, 53 and 44 mm. In the present study, the following

categories were subjected to FTIR analysis.

Category I: Rapid determination of minerals for all the 39 sampling sites.

Category II: Site number 12, 23, 33 and 39 were selected and sieved for the grain sizes of 320 to 44 mm.

RESULTS AND DISCUSSION

Category I

Rapid determination and characterization of minerals through the infrared peaks observed for the presence of quartz, feldspar (microcline, orthoclase and albite), kaolinite, gibbsite, illite, montmorillonite, chlorite, calcite and organic carbons shown in Table 1 already published by the authors (Ramasamy *et al.*, 2004). The representative spectra from category II along with I is shown in Fig. 2 and the observed absorption frequencies are in Table 1. In addition to category I the minerals such as ferrihydrite, haematite, magnetite, cerussite and pyrophyllite are observed. The additional peaks to confirm the existence of those minerals in category I are also identified.

Quartz

When compared to category I the similar peaks are obtained from 320 and 300 mm with increasing intensity. The intensity of quartz peaks decreased sequentially after 300 mm. At the same time, most of the characteristic peaks of quartz are almost absent

in 74, 53 and 44mm grain sized samples. This indicates the elimination or disordered or lowering of crystallinity.

FELDSPAR

The intensity of absorption frequencies of feldspar is very weak in 320mm, whereas the intensity is gradually increased from 320 to 149 mm and in 149 mm the characteristic peak intensity of feldspar is higher than the quartz. After that the feldspar peaks are weakened in the range of 125 - 44 mm. This can be confirmed by the gradual increase in intensity of the peaks at 1012 and 1040 cm^{-1} from 300-149 mm and those intensities are dominated in 149 mm and slowly decreased after 149 mm, which indicates the decrease in crystallinity of feldspar. At 53 and 44 mm, all these feldspar peaks shifted to lower or higher wave number side indicates influence of clay minerals such as kaolinite, montmorillonite, gibbsite, illite, and chlorite. This may be due to transformation of feldspar into clay minerals by leaching of water.

The new shoulder peak centered around 656 cm^{-1} observed only in 320 mm indicates anorthite in trace level. The peak in the range 1760-1780 cm^{-1} and broad band near 3250 cm^{-1} are observed above 125mm. This may be due to the absorption of water in feldspar structure. According to Behrens and Muller (Behrens and Muller, 1995) the spectral feature due to OH vibration in feldspar can only be resolved in thicker samples (higher grain sizes). This

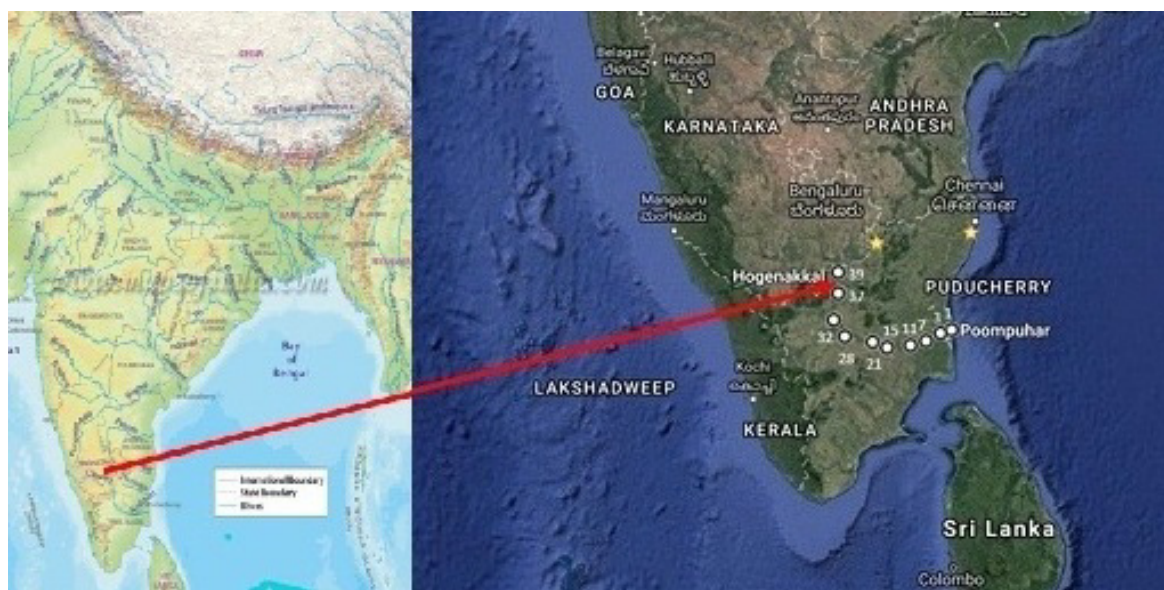


Fig. 1 Location of Cauvery River in India

result is in good agreement with the present study.

Clay minerals and carbonates

The peaks at 466, 3565 cm^{-1} and 540, 3527 cm^{-1} indicate the presence of chlorite and gibbsite respectively from 125 to 44 mm with varying intensity. Two new peaks at 952 and 3668 cm^{-1} due to pyrophyllite are only observed in 105 and

125mm (Russell, 1987). But those minerals are completely absent in category I. With reference to Lyon (Lyon, 1967) the presence of new peak in the region 1384-1388 cm^{-1} is due to the influence of the other carbonate mineral cerrussite.

Magnetic minerals

The magnetic minerals are only identified in 105

Table 1. FTIR absorption frequencies (cm^{-1}), corresponding minerals and sites for Category I and Category II

S. No.	Minerals	Category I		Category II	
		Frequency cm^{-1}	Site Number	Grain Size (μm)	Site Number
1	Albite	425-428	7-9, 13-16, 21, 36 & 39	300-105	12, 23, 33, 39
2	Kaolinite	430-434	3, 4, 5, 10, 17, 33, 34 & 35	300-105	12, 23, 33, 39
3	Chlorite	440-445	1, 28, 32 & 33	438-442	12, 23, 33
4	Quartz	458-462	1-39	320-125	12, 23, 33, 39
5	Haematite	466-472	-	53-44	12, 23, 33, 39
6	Quartz	510-514	11, 18-24 & 28-33	320-74	12, 23, 33, 39
7	kaolinite	533-538	1-10, 12-17 & 25-39	53-44	12, 23, 33, 39
8	Microcline	580-584	1-39	320-125	12,33,39
9	Orthoclase	638-642	1-39	320-44	12, 23, 33, 39
10	Gibbsite	661-666	1, 5, 10, 22, 23, 29-36 &38	53-44	23,39
11	Quartz	690-695	1-39	320-44	12, 23, 33, 39
12	Albite	728-730	7-9, 13-16, 21, 36 & 39	300-44	12, 23, 33, 39
13	Illite	748-753	1, 3, 5, 10, 12, 20, 23 & 29- 35	53-44	12, 23, 33, 39
14	Quartz	775-780	1-39	320-44	12, 23, 33, 39
15	Quartz	799-804	1, 5, 11-31, 36 & 37	320-74	12, 23, 33, 39
16	Montmorillonite	890-894	1, 5,12-15,17,20,21,29,30,36 &39	53-44	12,23,39
17	Calcite	868-872	3, 5, 31-36 & 39	53-44	12, 23, 33, 39
18	Kaolinite	910-913	3, 4, 5, 10, 17, 33, 34 & 35	53-44	12, 23, 33, 39
19	Pyrophyllite	948-954	-	125-74	33,39
20	Ferrihydrate	970-972	-	74	12,23
21	Albite	1008-1010	4,7-29,36&39	320-74	12,23,39
22	Kaolinite	1012-1015	3,4, 5,10,17, 33, 34 & 35	320-74	12, 23, 33, 39
23	Kaolinite	1028-1034	3,4, 5,10,17, 33, 34 & 35	320-74	12, 23, 33, 39
24	Albite	1038-1043	4,7-29,36&39	320-74	12, 23
25	Quartz	1080-1083	1-39	320-74	12, 23, 33, 39
26	Kaolinite	1100-1105	3,4, 5,10,17, 33, 34 & 35	53-44	12, 23, 33, 39
27	Quartz	1172-1175	1,7-29,34,36 & 38	320-125	12, 23, 33, 39
28	Cerussite	1378-1382	-	53-44	12,23
29	Calcite	1425-1430	3,5,31-36 &39	53-44	12, 23, 33, 39
30	Quartz	1613-1615	1,2,6-9,11-16,18-32 & 36-39	320-125	12, 23, 33, 39
31	Kaolinite	1638-1642	3,4, 5,10,17, 33, 34 & 35	53-44	12, 23, 33, 39
32	Feldspar	1775-1780	1-39	320-125	12, 23, 33, 39
33	Organic carbon	2854 & 2924	1-39	320-44	12, 23, 33, 39
34	Orthoclase	3250-3300	1-39	320-125	12, 23, 33, 39
35	Quartz	3380-3440	1,2,6-9,11-16,18-32 & 36-39	320-125	12, 23, 33, 39
36	Kaolinite	3400-3460	3,4, 5,10,17, 33, 34 & 35	53-44	12, 23, 33, 39
37	Illite	3450	-	53-44	12, 23, 33, 39
38	Gibbsite	3527-3530	-	53-44	23,39
39	Chlorite	3562-3566	-	53-44	12,23,39
40	Montmorillonite	3570-3575	1,5,12-15,17,20,21,29,30,36 &39	53-44	12,23,39
41	Kaolinite(disordered)	3616,3670,3720	3,4, 5,10,17, 33, 34 & 35	53-44	12, 23, 33, 39
42	Kaolinite(ordered)	3616,3670,3720	1,2,6-9,11-16,18-32 & 36-39	53-44	12, 23, 33, 39

and 74 mm. According to Fysh and Fredricks (Fysh and Fredricks, 1983) haematite ($\alpha\text{-Fe}_2\text{O}_3$), magnetite (Fe_3O_4) and goethite ($\alpha\text{-FeOOH}$) are the most abundant forms of the iron containing species found in clays and soils. Russell (Russell, 1987) explained the presence of goethite by the peaks 279, 418, 632, 799 and 901 cm^{-1} , magnetite by 347 and 570 cm^{-1} and haematite by 345, 470, 540, 580, 600 and 670 cm^{-1} . A search through the pertinent literature reveals many discrepancies on the location of the characteristic IR bands in the low frequency region ($<600\text{ cm}^{-1}$), which could be used as finger prints in the identification of haematite.

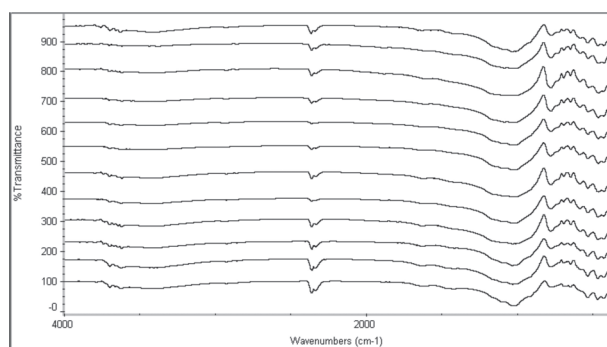


Fig. 2. FTIR Spectrum of site no. 12 with bulk (top one) and 320 to $44\mu\text{m}$ (next to top to bottom)

In the present study, the appearance of the peak at around 535 and 465 cm^{-1} may be due to the presence of antiferromagnetic haematite. The shifting of these two peaks to 470 and 550 cm^{-1} in higher grain sizes may be due to the replacement of Fe by Aluminium. The peak at 970 cm^{-1} in 74 mm shows the transformations of goethite ($\alpha\text{-FeOOH}$) to ferrihydrite ($\gamma\text{-FeOOH}$). The medium shoulder peak appearing in the region $570\text{-}574\text{ cm}^{-1}$ may be due the influence of other magnetic mineral magnetite (Fe_3O_4).

The existence of magnetic minerals and radioactive elements in sediments became a tool to estimate environmental pollution (Ramasamy *et al.*, 2006; Chaparro *et al.*, 2008; Murugesan *et al.*, 2011; Murugesan *et al.*, 2015 and Murugesan *et al.*, 2016). In the present study magnetic minerals cannot be identified from category I because the quantity of magnetic minerals is in trace level due to domination of quartz, feldspar and clay minerals. But in category II, the magnetic minerals are only observed in 74 and 105 mm (McCubbin *et al.*, 2000).

CONCLUSION

In the present study, the trace minerals such as iron

bearing and heavy minerals are missing through rapid determination. Therefore rapid determination (bulk mineralogy) cannot give satisfactory results about all minerals present in the sediment samples. There is a need of thorough analysis for getting more information on minerals.

Four sites are randomly selected and subjected to FTIR characterization through grain size analysis. Eleven minerals were identified through rapid determination (category I), whereas 12 minerals were additionally identified through category II. Quartz is invariably present in all the categories among all these minerals. The domination of quartz peaks was found in 320 and 300 mm samples of category II. The origin of quartz was determined using the characteristic peaks 1618 and 1880 cm^{-1} . Cauvery River is from both vein and metamorphic origin.

The feldspar (orthoclase, microcline and albite) is dominated in $250\text{-}149\text{ mm}$. Three iron minerals (haematite, magnetite and ferrihydrite) were identified in the grain sizes 125 and 105 mm and two additional clay minerals such as cerussite and pyrophyllite were also identified. Nearly eight minor minerals (Haematite, Pyrophyllite, Ferrihydrate, magnetite, Cerrussite, Illite, Gibbsite, and Chlorite) were additionally identified through grain size analysis..

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