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RESEARCH ARTICLE

A STUDY ON THE SIGNIFICANCE OF CLAY MINERAL BEHAVIOUR IN ESTUARY AND BEACH SEDIMENTS OF KARAİKAL COAST, EAST COAST OF INDIA

G. Ramesh, T. Ramkumar, M.V. Mukesh and T. Immanuvel David.

Department of Earth Sciences, Annamalai University, Annamalainagar, Tamil Nadu.

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Corresponding Author*G.Ramesh.****Abstract**

The present study was carried out in order to study about the clay minerals and their variation along the coast and the estuarine environments of Arasalar River at Karaikal. The clay minerals composition of coastal and estuarine sediments is of broad interest because of its sensitivity as an indicator of environmental change (Lanson, 1997). Clay minerals of surficial sediments have been used widely as a first order guide to the source, environment and the transport paths of fine grained sediments. The forty sediment samples were selected for the clay mineral studies in both environments. Sampling was done for two years at 3 different stations at the estuary and 2 stations (A&B) at the coast very adjoining to either end of the mouth of the river during 8 seasons starting from premonsoon-2011 to summer-2013. The sediments less than two micron size are classified as clay, have plate like crystals with layered lattice structures showing high ion exchange capacity. Owing to this property, clay minerals have an important role in the nature of sedimentation, chemistry and deposition of sediments. This simplified ion exchange process is complicated by various factors like, quality and type of cations presents in solution, pH, Eh, type of clay mineral, size etc., this process further gets intricate when river born clay comes into contact with estuarine waters. During the study period, illite was most abundant clay mineral in the sediments of the Arasalar river estuary. It varied from 70.01 to 87.39%. Along the beach, illite concentration in sediments varies over a range of 65.99 to 85.44%. The higher percentage of illite was observed during monsoon and premonsoon seasons. Kaolinite+Chlorite peak reflecting the second dominant minerals over the other minerals. It ranged from 9.76 to 26.88% and the higher percentage was observed during premonsoon and summer seasons along the coast. It is ranged from 9.96 to 28.01%. Montmorillonite content varied from 0.81 to 3.12%. It is found in higher concentration during premonsoon and monsoon seasons. Along the beach it ranged from 1.36 to 9.91%. The concentration of gibbsite varied from 0.65 to 6.03% and the higher percentage of the gibbsite was observed during postmonsoon season. Along the beach it varied from 0.73 to 4.47 %. Thus in the present study the concentration of clay minerals like illite, kaolinite, chlorite, montmorillonite, gibbsite and their seasonal variations gives a lead in deciphering the source of sediments and their interaction of Physico chemical parameters during different seasons were discussed.

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Introduction:-

The coasts separate continents from seas and may develop in various geomorphic and sedimentological variants. There are many excellent works dealing with the classification and types of coast. Widely accepted classifications are those of Shepard (1963, 1976). The coastal zone of India is important in view of its productive eco systems,

concentration of population and for exploitation of renewable and non-renewable natural resources (Nayak *et al.*, 1996). The coastal vegetation plays an important role in the deltaic environment by enhancing the sedimentation and stabilization of the seashore and sea bottom. It provides habitat and nursery areas for many commercially important fish and crustaceans (Robertson and Duke, 1987) and plays an important roll in chemical buffering, water quality maintenance and storage of genetic materials (Saenger *et al.*, 1983) besides contributing considerable amount of organic matter (Odum and Heatel, 1972; Day *et al.*, 1973; Prakash *et al.*, 1973; Boto 1982; Untawale and Jagtap, 1991) thereby increasing the productivity of the coastal waters.

Description of the study area:-

The Arasalar estuary is situated at karaikal (Lat.79° 52' E Long.10° 55'N) of Bay of Bengal. The arasalar is a tributary of the river Cauvery, having a total run of 24 km. It enters Karaikal region, a little east of Akalanganni. It forms the natural boundary line separating Niravi Commune from Tirunallar on the north-west and Karaikal on the north east. The Nattar, branching off from Arasalar at Sakkotai in Thanjavur District, runs a distance of 11.2km in a south-easterly direction across Nedungadu and Kottucheri Communes before emptying itself into the sea.

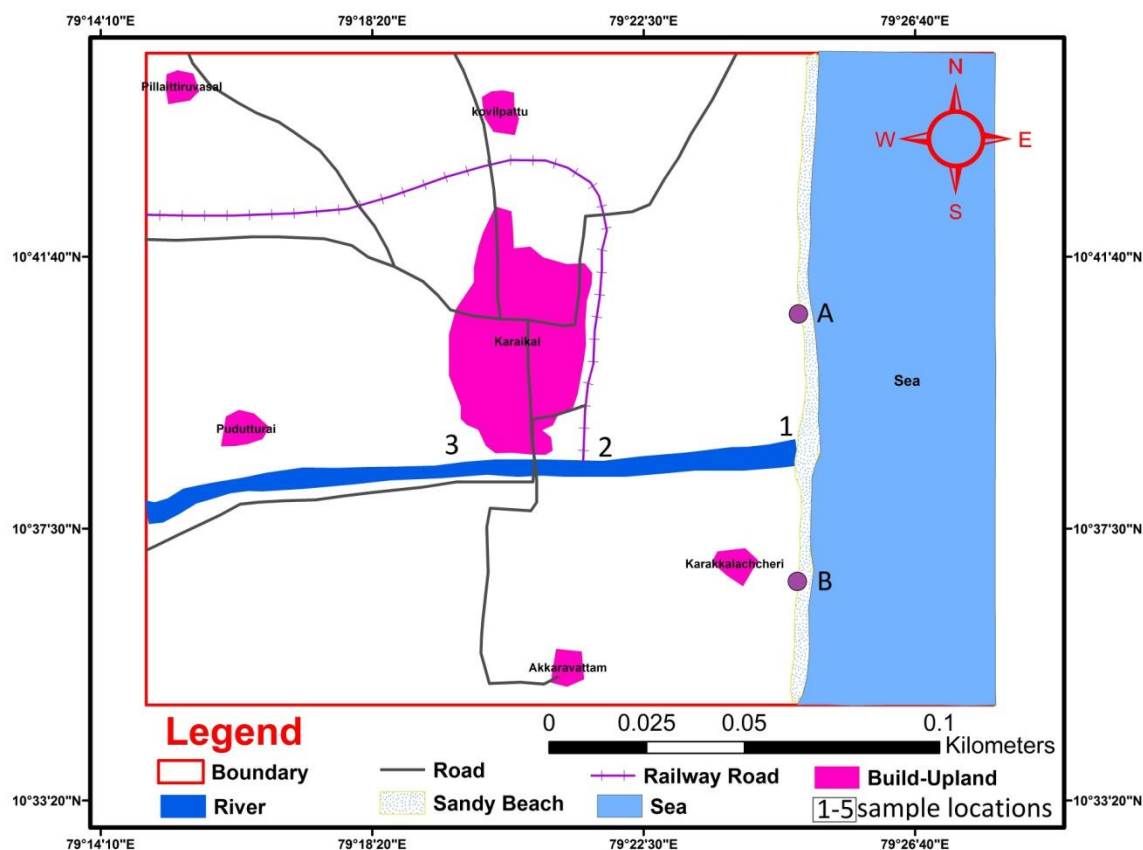


Figure 1. Location and sampling map of the study area

The Vanjiar fed by the Arasalar, takes its course along the northern boundary of Tirunallar Commune, drops on a south-easterly curve towards Karaikal Commune and merges with the Arasalar, south-east of Karaikal town after covering a distance of about 9 km. The Nular, also fed by the Arasalar, runs a distance of 13.77 km. before it joins Vanjiar northeast of Karaikal town. The study area comprises of estuarine and coastal environment. The estuarine environment from the mouth of the river in downstream to fresh water in upstream direction extends about 9 km. The coastal environment comprises of beach and near shore from the mouth of river. Totally 5 samples were collected along the estuary and the beach. Estuary samples represent 1,2 and 3 where Station 1 is situated nearby

mouth of the estuary (marine zone), station 2 and 3 in a mixed environment. Along the beach the sampling stations are represented as A&B.

Materials and methods:-

Sediments were collected using a grab sampler. The samples were collected from Karaikal coasts during the period of two years (2011-2013) covering all the seasons. About 2 Kg. of sediment samples are collected using grab sampler. These samples were taken to the lab for the XRD analysis. The X-ray diffraction analysis is a valuable tool in determining the mineralogy of sediments and rocks especially for clay minerals. Not only can mineral species be identified, but in some cases a semi quantitative determination of mineral phases can also be made. Indeed it is the most important technique in evaluating the chemical composition is some solid solution series.. The forty sediment samples were selected for the clay mineral studies in both environments. The sampling stations along the estuary were represented as 1, 2, and 3. In the beach the sampling stations are represented as A&B.

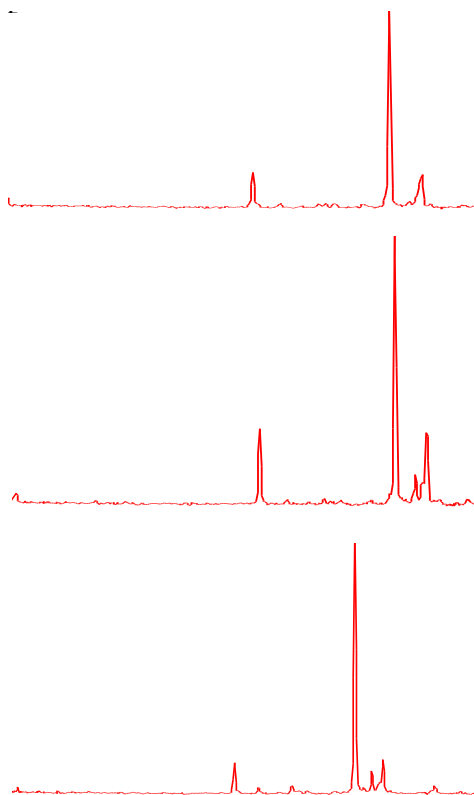
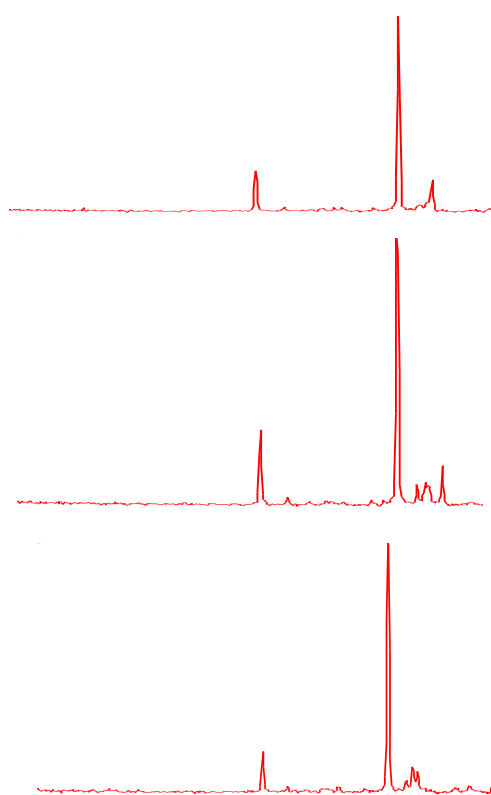
Result and discussion:-

1. Illite (i)

During the study period, illite was most abundant clay mineral in the sediments of the Arasalar river estuary. It varied from 70.01 to 87.39%. The higher percentage of illite was observed during monsoon and premonsoon seasons. This relates to the illite is the most dominant mineral species of clay minerals in the quaternary sediments of the study area. Relatively higher concentration of illite was observed at the mouth region (station - 1) when compared to the estuary (station - 2) and freshwater zone (station - 3). This may be attributed to the formation of this mineral from montmorillonite. It is observed that salinity is highest at this place. Montmorillonite was converted to illite by absorbing more potassium ions from saline waters. A similar type of transformation have also been reported in Cauvery deltaic sediments (Seralathan, 1979, Seralathan and Seetaramaswamy, 1982, Vaithyanathan *et. al.*, 1992). Grim *et. al.*, (1949), Grim (1950, 1968) and Griffin and Ingram (1955) have stated that kaolinite is unstable in alkaline waters and therefore it would tend to alter to illite or chlorite in estuarine and marine environments. Along the beach, illite concentration in sediments varies over a range of 65.99 to 85.44% during the study period. The highest percentage of illite was observed during summer season in both the stations when compared to the other seasons. This may be related to either by the conversion of feldspars to illite or by the transportation of illite from the Tirumalairajan and Arasalar rivers where it might finally deposited. A similar observation was made by Seetharamaiah and Swamy (1995) in Bhimunipattanam to Pudimadaka coast of India and Moon *et. al.*, (2000) in Youngjong island of Korea.

Table1. Showing the seasonal percentage of clay minerals in estuary from 2011-2013

2011-2012								
Seasons/ Stations	Monsoon				Post monsoon			
	I	K+C	M	G	I	K+C	M	G
1	93.22	16.36	3.06	2.33	86.17	23.34	-	2.78
2	86.03	26.11	3.58	2.57	85.02	26.49	-	3
3	80.03	13.78	2.21	2.61	81.66	16.42	-	
	Summer				Pre-monsoon			
1	90.06	15.7	-	3.57	92.01	22.72	-	2.63
2	81.26	24.32	2.94	9.94	88.44	18.96	2.59	4.3
3	83.31	24.38	4.79	2.21	86.21	21.64	7.27	15.65
2012-2013								
Seasons/ Stations	Monsoon				Post monsoon			
	I	K+C	M	G	I	K+C	M	G
1	92.16	16.13	4.44	5.47	90.72	18.11	-	4.32
2	85.12	12.75	-	-	86.32	17.58	-	-
3	82.65	21.73	6.25	-	81.02	19.58	-	-
	Summer				Pre-monsoon			
1	93.01	24.96	-	-	93.01	24.77	9.64	-
2	89.36	20.22	6.12	4.29	90.32	24.63	3.2	-
3	81.43	12.58	3.87	3.98	82.16	15.19	7.16	-
I-Illite, -K+C-Kaolinite+Chlorite, M- Montmorillonite, G- Gibbsite								

Monsoon**Post Monsoon**

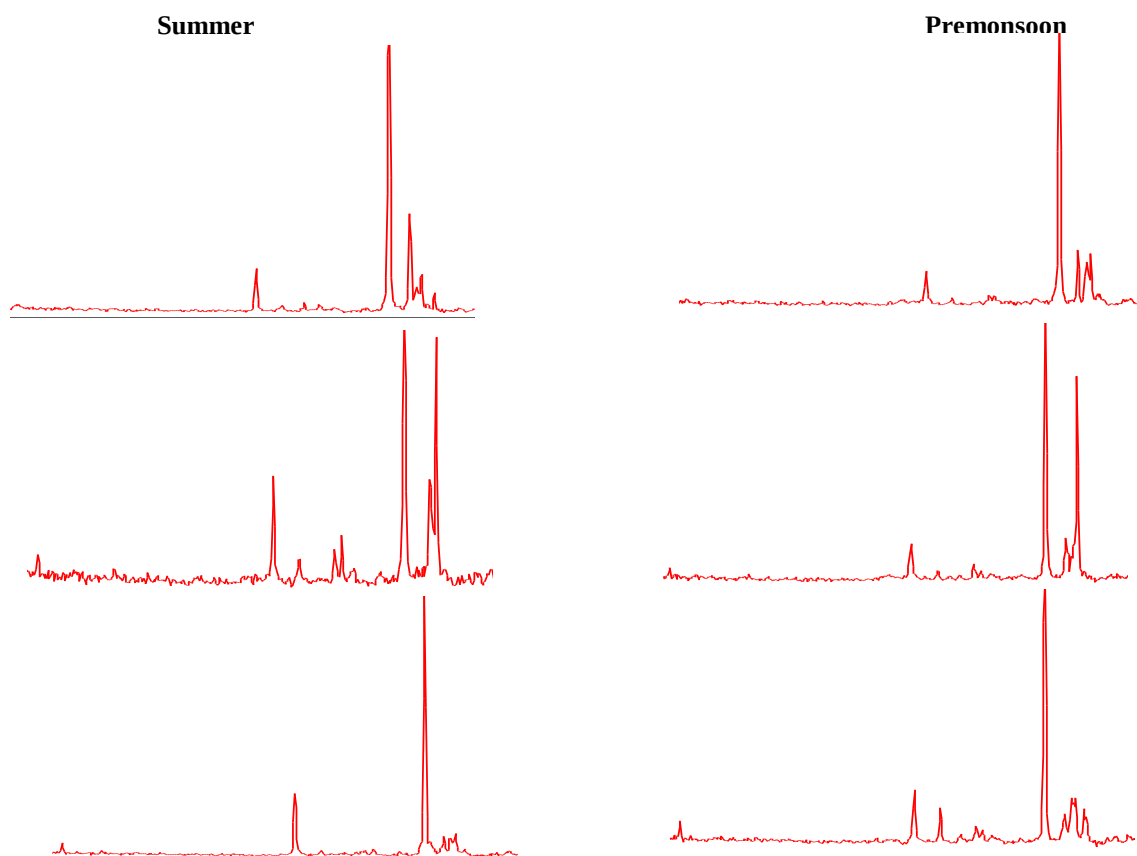
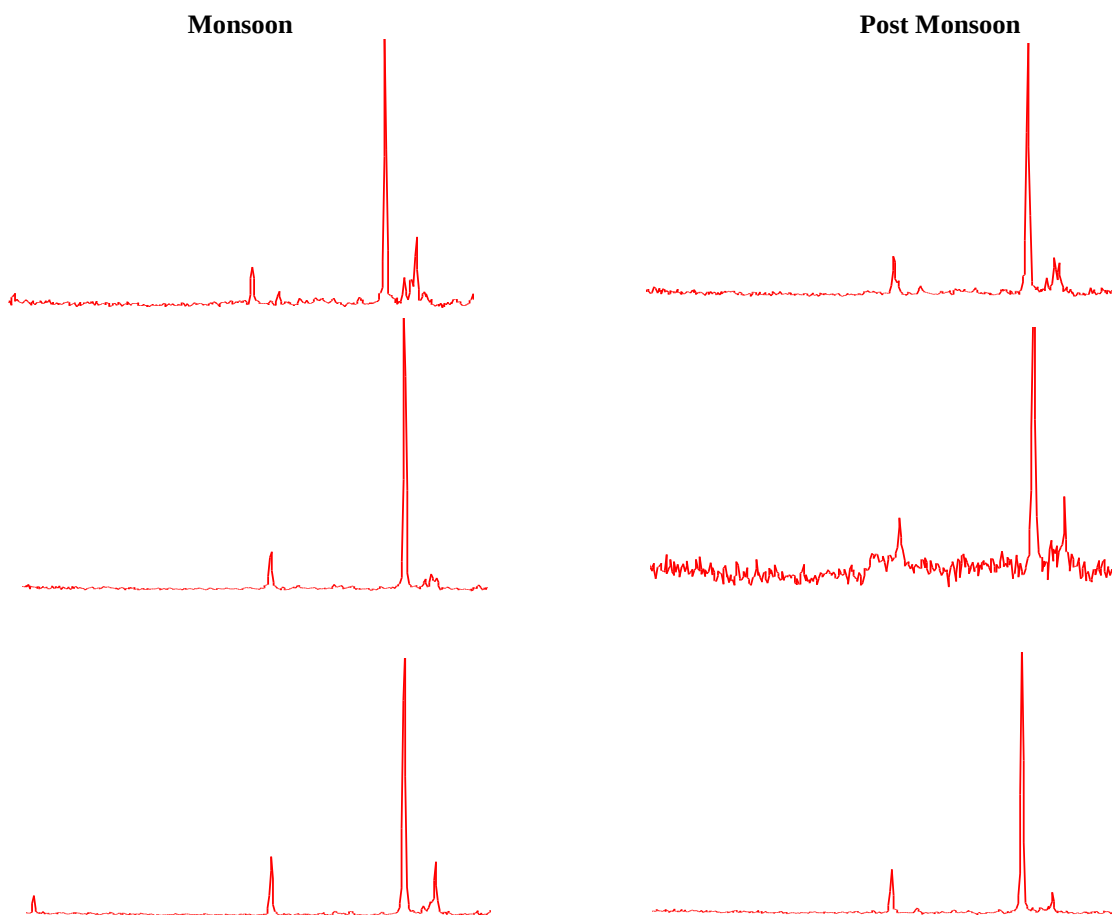


Figure. 2 XRD Patterns of estuarine region during 2011-2012



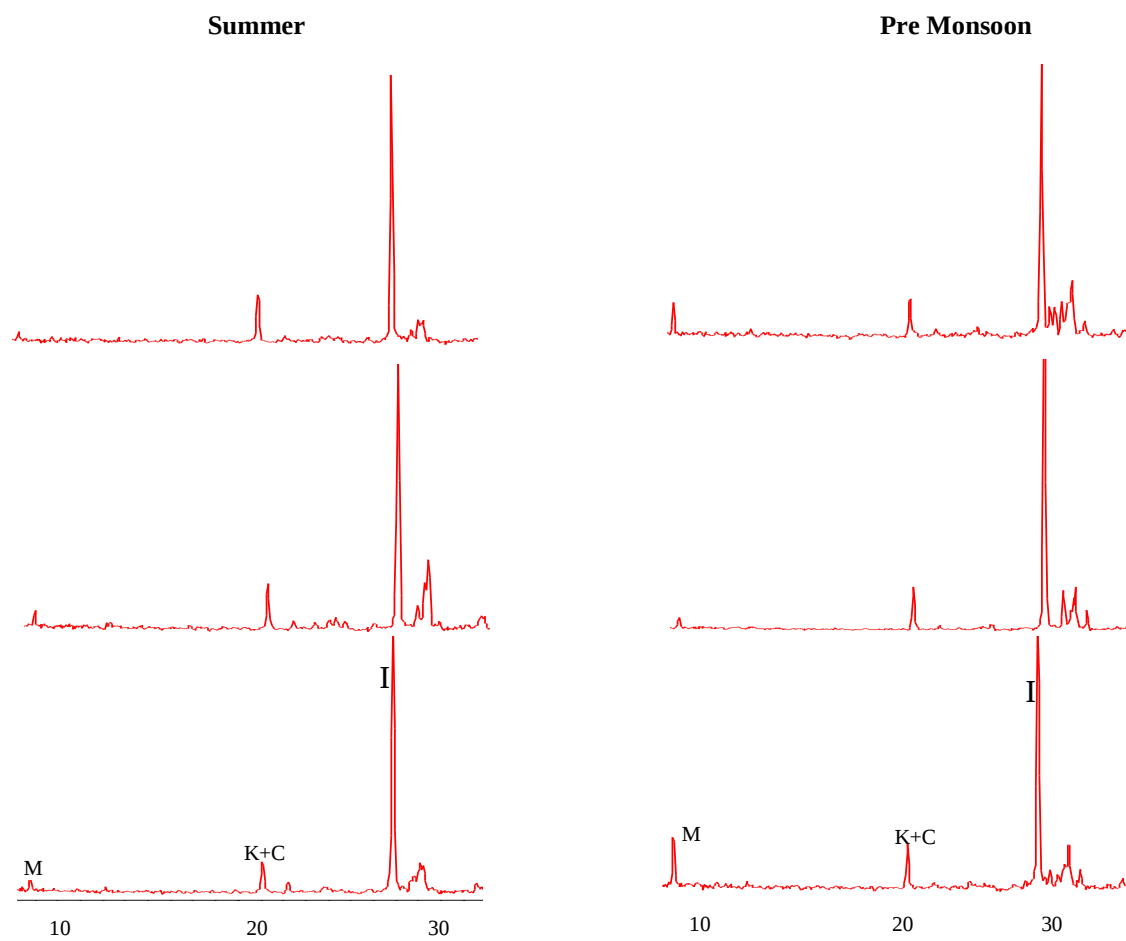


Figure.3 XRD Patterns of estuarine region during 2012-2013

BEACH								
2011-2012								
Seasons/	Monsoon				Postmonsoon			
Stations	I	K+C	M	G	I	K+C	M	G
A	86.32	26.65	11.9	-	85.32	16.96	1.24	4.46
B	83.01	16.67	-	-	81.07	19.49	-	4.68
	Summer				Premonsoon			
A	89.22	14.16	6.54	3.35	82.16	13.75	4.7	-
B	80.16	12.87	2.08	3.04	80.15	26.33	-	3.95
2012-2013								
Seasons/	Monsoon				Postmonsoon			
Stations	I	K+C	M	G	I	K+C	M	G
A	79.16	22.33	1.86	1.81	68.03	20.32	1.42	1.86
B	71.12	18.28	2.5	3.37	60.22	18.36	1.32	-
	Summer				Premonsoon			
A	86.34	23.17	1.54	2.28	69.22	21.55	-	-
B	81.68	19.43	1.96	1.87	69.01	22.54	1.43	-

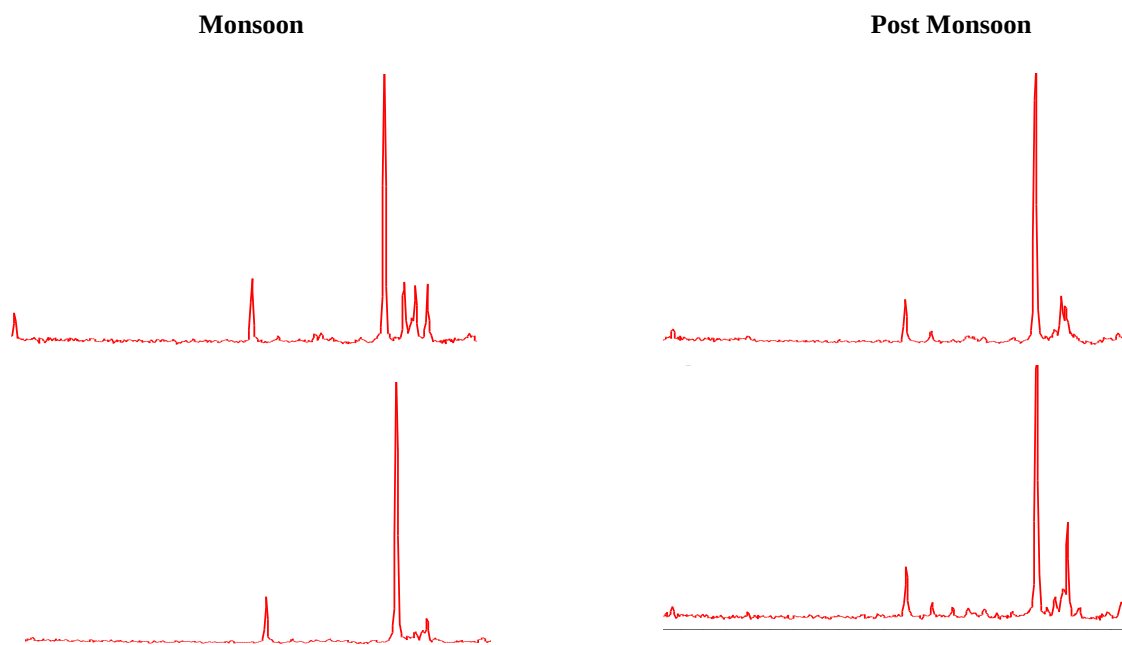


Figure. 4 XRD Patterns of Beach region during 2011-2012

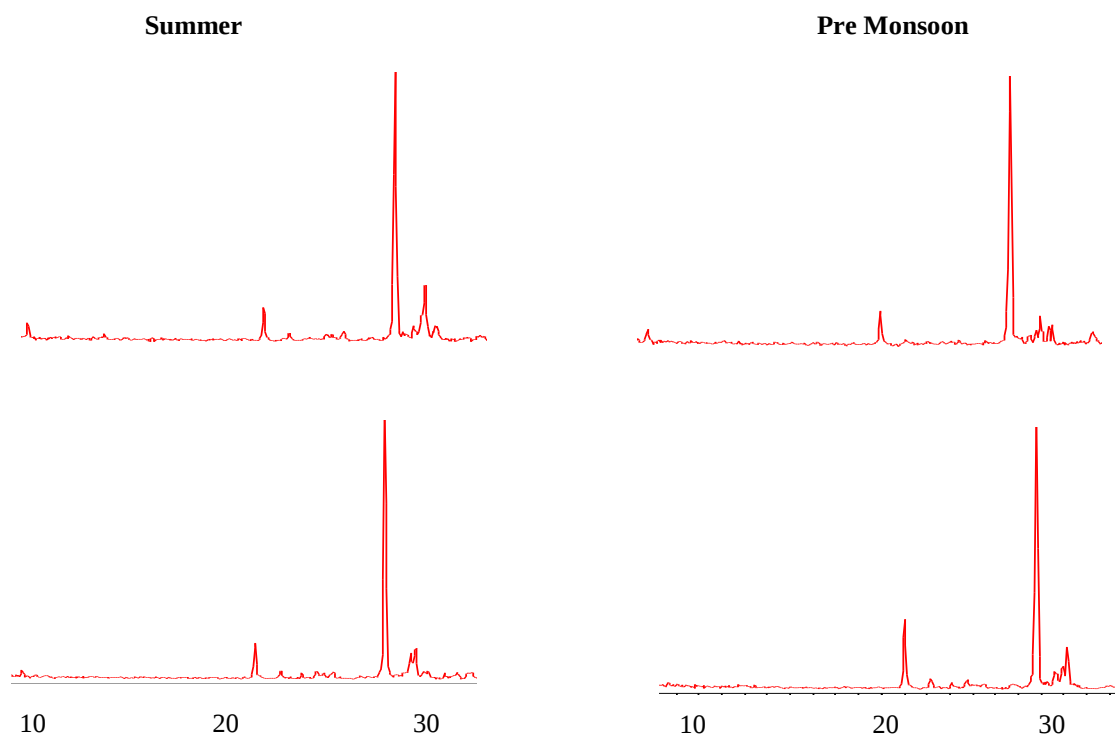


Figure. 5 XRD Patterns of Beach region during 2011-2012

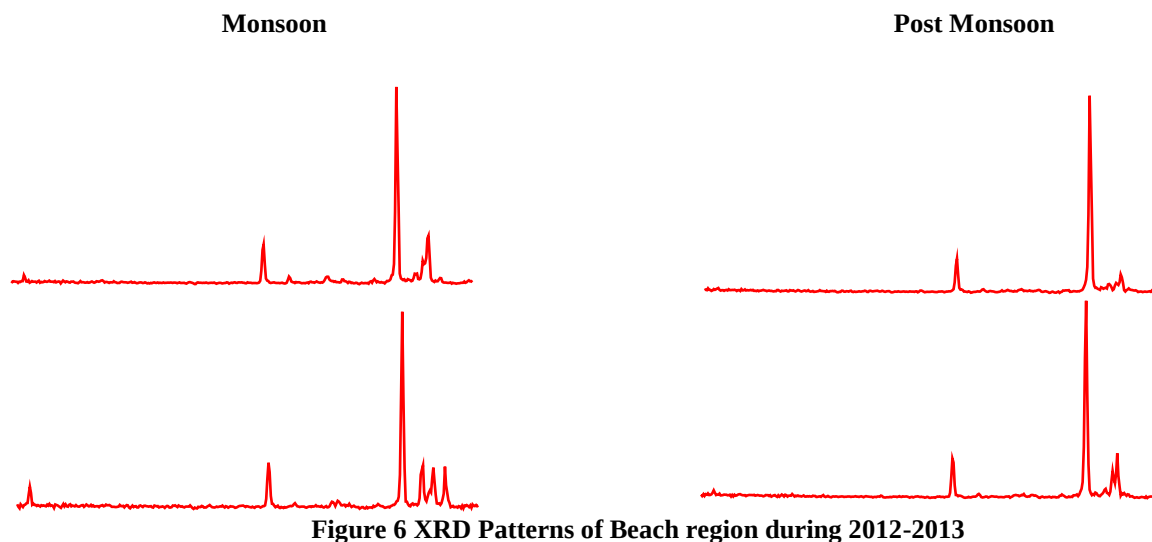


Figure 6 XRD Patterns of Beach region during 2012-2013

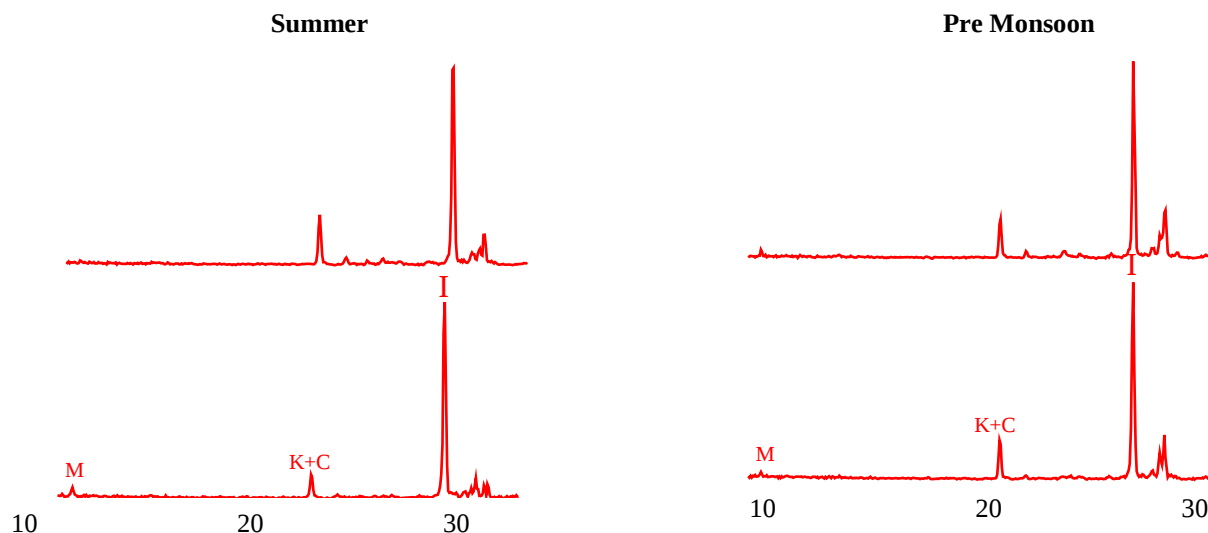


Figure. 7 XRD Patterns of Beach region during 2012-2013

I. Kaolinite+chlorite (k+c)

Kaolinite+Chlorite peak reflecting the second dominant minerals over the other minerals. It ranged from 9.76 to 26.88%. The higher percentage of kaolinite+chlorite was observed during premonsoon and summer seasons. In general, the Cauvery river system drains mainly through metamorphic rocks composed of quartz and feldspar which are comparatively resistant to weathering (Subramanian *et. al.*, 1985). It is noted that active chemical weathering of the feldspar and micas takes place where a river flowing over a metamorphic terrain leading to the formation of kaolinite+chlorite. The significant point to be noticed is the presence of substantial amount of biotite in the source rocks. Under normal chemical weathering conditions biotite is very vulnerable to weathering and easily altered into chlorite (Gibbs, 1977 and Yang, 1988). From the above clarification it may be inferred that the kaolinite and chlorite formation is mainly controlled by the drainage basin rock types (Mohan and Damodaran, 1992 and Ramanathan *et. al.*, 1994). The source rocks are gneiss and schists, shales and quaternary sediments and their weathering products in tropical humid climate brought by major river Cauvery along with tributaries like Tirumlairejan and Arasalar. Apart from the river source, strong current and wave action on the quaternary sediments. A higher percentage of kaolinite+chlorite were observed in northern part when compared to

the southern part of the beach sediments. It is ranged from 9.96 to 28.01%. This indicates the source rocks are gneiss and schists, shales and quaternary sediments and their weathering products in tropical humid climate brought by major river Cauvery along with tributaries like Tirumalairajan and Arasalar. Apart from the river source, strong current and wave action on the quaternary sediments along the beach also add the finer kaolinite+chlorite to the beach sediments.

II. Montmorillonite (m)

In the study area, montmorillonite content varied from 0.81 to 3.12%. It is found in higher concentration during premonsoon and monsoon seasons. This indicates the source rocks which have considerable amount of magnesium content, released upon weathering, leading to the formation of montmorillonite as alteration product (Grim, 1968). The increased content of montmorillonite in sediments related to the difference in the salinity of water. As explained by Gibbs (1977), montmorillonite has the smallest size, this would also help montmorillonite to remain in suspension for long time than kaolinite and enrich in concentration. Along the beach, a higher percentage of montmorillonite was observed at northern part of the beach when compared to the southern part. It ranged from 1.36 to 9.91% during the study period. In the beach sediments the concentrations of montmorillonite have been derived mainly from the river of Tirumalairajan and Arasalar. These rivers confluence at this place and the surface currents which are directed towards north favor for higher concentration. From this it can be deduced that the supply of montmorillonite minerals is mainly from Tirumalairajan and Arasalar rivers. A similar type of results were noticed by Petschick *et al.*, (1996) and from their study areas in south Atlantic coast and Kakinada bay and western Bay of Bengal respectively.

III. Gibbsite (g)

During the study period, the concentration gibbsite varied from 0.65 to 6.03%. The higher percentage of the gibbsite was observed during postmonsoon season. Gibbsite is most important product of silicate alteration in lateritic soils where in intense leaching results in complete dislocation and the octahedral layer remains free and eventually crystallizing to gibbsite. The higher percentage of gibbsite may be due to the weathering of gneissic rock and quaternary sediments and also the same minerals brought by the various rivers of the study area. Along the beach, the gibbsite concentration during the study period, varied from 0.73 to 4.47 %. A higher percentage of gibbsite was observed in the southern part of the study area. It may be attributed to the weathering of gneissic rock and quaternary sediments and also the same minerals brought by the various rivers of the study area. A similar observation for the concentration of gibbsite was made by Bukahari and Nayak (1996) in Mandovi estuary and Gingele *et al.*, (2001) in Indonesia and Australian coast. The mineralogical study indicates the major groups of minerals present in the sediment are quartz, feldspar, mica, pyroxene and amphibole. These minerals are derived from the Precambrian granites and gneisses from the catchment area. From the above discussion, it is concluded that the clay minerals are mainly derived from the weathering and alteration of river sediments and their source rocks. Their distribution in the estuarine and beach environments depends mainly on the differential flocculation and size segregation.

Summary and conclusion:-

The present study was carried out to compare the behaviour of clay minerals along the estuary and the beach in the coastal environments of Arasalar river estuary at Karaikal. The clay minerals composition of coastal and estuarine sediments is of broad interest because of its sensitivity as an indicator of environmental change (Lanson, 1997). Clay minerals of surficial sediments have been used widely as a first order guide to the source, environment and the transport paths of fine grained sediments. Sampling was done for two years at 3 different stations at the estuary and 2 stations at the coast very adjoining to either end of the mouth of the river during 8 seasons starting from premonsoon-2011 to summer-2013. During the study period, illite was most abundant clay mineral in the sediments of the Arasalar river estuary. It varied from 70.01 to 87.39%. The higher percentage of illite was observed during monsoon and premonsoon seasons. This relates to the illite is the most dominant mineral species of clay minerals in the quaternary sediments of the study area. Relatively higher concentration of illite was observed at the mouth region (station - 1) when compared to the estuary (station - 3) and freshwater zone (station - 5). This may be attributed to the formation of this mineral from montmorillonite. It is observed that salinity is highest at this place. Montmorillonite was converted to illite by absorbing more potassium ions from saline waters. Along the beach, illite concentration in sediments varies over a range of 65.99 to 85.44% during the study period. The highest percentage of illite was observed during summer season when compared to the other seasons. This may be related to either by the conversion of feldspars to illite or by the transportation of illite from the Tirumalairajan and Arasalar rivers where it might finally deposited. Kaolinite+Chlorite peak reflecting the second dominant

minerals over the other minerals. It ranged from 9.76 to 26.88%. The higher percentage of kaolinite+chlorite was observed during premonsoon and summer seasons. It is noted that active chemical weathering of the feldspar and micas takes place where a river flowing over a metamorphic terrain leading to the formation of kaolinite+chlorite. A higher percentage of kaolinite+chlorite were observed in northern part when compared to the southern part of the beach sediments. It is ranged from 9.96 to 28.01%. This indicates the source rocks are gneiss and schists, shales and quaternary sediments and their weathering products in tropical humid climate brought by major river Cauvery along with tributaries like Tirumalairajan and Arasalar. Apart from the river source, strong current and wave action on the quaternary sediments along the beach also add the finer kaolinite+chlorite to the beach sediments. In the study area, montmorillonite content varied from 0.81 to 3.12%. It is found in higher concentration during premonsoon and monsoon seasons. In the study area, montmorillonite content varied from 0.81 to 3.12%. It is found in higher concentration during premonsoon and monsoon seasons. This indicates the source rocks which have considerable amount of magnesium content, released upon weathering, leading to the formation of montmorillonite as alteration product. Along the beach, a higher percentage of montmorillonite was observed at northern part of the beach when compared to the southern part. It ranged from 1.36 to 9.91% during the study period. In the beach sediments the concentrations of montmorillonite have been derived mainly from the river of Tirumalairajan and Arasalar. The concentration of gibbsite varied from 0.65 to 6.03%. The higher percentage of the gibbsite was observed during postmonsoon season. Gibbsite is most important product of silicate alteration in lateritic soils where in intense leaching results in complete dislocation and the octahedral layer remains free and eventually crystallizing to gibbsite. Along the beach, the gibbsite concentration during the study period, varied from 0.73 to 4.47 %. A higher percentage of gibbsite was observed in the southern part of the study area. It may be attributed to the weathering of gneissic rock and quaternary sediments and also the same minerals brought by the various rivers of the study area.

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