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# Seasonal variation of mineral assemblage along the west coast of Kanya Kumari District

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***ABSTRACT***
*The aim of the present research is to investigate the seasonal impact on the status of heavy mineral distribution along south west Tamil Nadu coast, India. A total of 10 samples have been collected to study distribution pattern of minerals in respect of seasonal and height variation. Beaches between Rajakkamangalam and Colachel have attained predominant transport rate in northern direction. Surface sediment samples have been collected in each location for quantifying the heavy mineral weight percentage during the period of pre, monsoon and post monsoon. Sediments have also been studied by EDAX analysis to evaluate the changes and occurrence of heavy minerals in beach sands. The abundant heavy and light minerals such as quartz, calcite, rutile, Kayonite, Montmorlinite, Calcite, Garnet, Illminite, Silliminaite and organic Carbon are identified from the study. The present study showed that the heavy minerals associated with sediments indicate that they are derived from metamorphic terrain dominated by Precambrian gneiss and quartzite of Indian Peninsular Shield.*

***Key words:*** *Heavy Minerals, EDAX , Monsoon, Distribution, Percentage*.

## 1. INTRODUCTION

Beaches are one of the important coastal landforms and the most studied feature of coastal morphology. Beach sands contain the most economically important mineral accumulations; wave action deposit sand on the beach and the heavy minerals are concentrated when backwash carries some of the lighter minerals such as quartz back into the sea. Mineral deposits are formed as a result of the selective concentration of valuable minerals derived from the weathering of pre-existing rocks, and accumulated by wind or water. Mineral sand deposits are a loose aggregate of unlithified mineral or rock particles of sand size (generally 0.02 to 2.0 mm) forming an unconsolidated or moderately consolidated sedimentary deposit.

Beach placer deposits around the world are known for ilmenite, rutile, zircon, monazite, sillimanite and garnet. By definition, heavy minerals are generally considered to be those having a specific gravity of 2.9 or greater. (This value has not been chosen arbitrarily but rather due to the fact that liquid bromoform [$CHBr_3$], often used for separation purposes, has a specific gravity of 2.89). In placer deposits, however, it is possible for such heavy minerals to be selectively concentrated during transport and deposition of unconsolidated sediments because of their high density. Thus it should be of no surprise that placers play an important role in modern day mining activities for those heavy minerals with commercial value.

The Indian coastline of 5,500 km stretch is marked by accumulation of various types and grades of mineral deposits. Several scientists have made their attempts to study the minerals, in terms of their occurrence, distribution, chemical composition, texture and provenance to understand the transportation trends of sediments. In India, beach sand mineral exploration and exploitation started in 20th century after the accidental discovery of monazite from the beach sands of Travancore State by a German Scientist, Schombery. In the west coast, beach placers have been reported in Kerala (Prabhakara Rao, 1968) and Ratnagiri (Mane and Gawade, 1974. In Tamilnadu, Chandrasekar (1992) reported that the Coastal stretch from Nagore to Tirumullaivasal is rich in zircon, garnet and kyanite. Mineralogical assemblages in beaches vary from one region to another depending on a number of factors like host rocks in the province, climate conditions prevailing in the area, agents and mechanism of transport and hydraulic condition during deposition[1].

Long shore sediment transport rates are estimated based on the observed data. The estimated annual gross long shore sediment transport rate is higher due to recent manmade structures and the net transport is towards the west. The southwesterlywaves move the sediment

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northwards, whereas the NE waves transport the sediment southwards.

The beach level has been low in July and high in April and the range is 75m. The total volume of sand transported is 1,810 $m^3$ only. The range of wave heights is between 0.5 to 2.5 m during 2007 and 0.5 to 2.2 m during 2008, whereas the wave period is from 8 sec to 15.5 sec and 9.2 sec to 12.8 sec for 2007 and 2008, respectively. The study indicates that the beach is essentially stable but shows only seasonal fluctuations. Colachel, which is being subjected to erosion phase during Southwest monsoon season, regains the profiles by January or February. Long shore currents are stronger in June, July and August and steady during rest of the year [2].It is assumed a few traversing streams originating from the nearby Western Ghats maintain the supply of heavies to the shore face. These heavies are greater in number and variety probably because of close proximity of the source region. Later, these dumped heavies are sorted out hydro dynamically based on their physical properties largely specific gravity by breakers, surf and swash zone processes supplemented by long shore currents [3]. Formation and concentration of heavy minerals differ from place to place and locations to locations, based on various factors such as geo dynamic, sea wave directions and dynamics, geo interstitial separation, under water current, sea wave height and spread, other sorting factors influenced by the confluence of sea and river and so on [5].

Geological formation between Kanyakumari to Rajakkamangalam-Charnockite and alluvium formations and Rajakkamangalam to Colachel-Granite gneiss -N-NW to S-SE (garnetiferous biotite gneiss). Beach sand- lateran deposits of sand, Zircon, rutile, illemanite and garnet. Kanyakumari to colachel area is underlain by the peninsular gneissic terrain of Indian. Sub-recent of Calcareous lime shell is noticed near kanyakumari. All along the west coast from Kanyakumari, Colachel area is covered by thick lateritic soil dotted with a few out crops [9].

## 2. EXPERIMENTAL

Beach samples have been collected from 10 sampling sites, stretching from Rajakkamangalam to Colachel along the South West Coast of Tamilnadu (Fig 1). From the sampling sites, approximately 1 kg sample has been taken by *Conrad bunker drilling* method shown in the figure-2 and collected in a plastic bag during the following periods,

Pre-monsoon - 08/03/2011 to 10/04/2011
Monsoon - 04/08/2011 to 05/10/2011
Post Monsoon - 10/03/2012 to 05/04/2011

**Table1.** Rainfall data of sampling locations.

| Sl.No | Location | Average Rainfall(2012) |
|---|---|---|
| 1. | Colachel | 1,400 mm |
| 2. | Kottilpadu | 1,450 mm |
| 3. | Mondaikadu | 1,500 mm |
| 4. | Puthur | 1,200 mm |
| 5. | Chinnavilai | 1,500 mm |
| 6. | Muttom | 1,300 mm |
| 7. | Azhikkal | 1,400 mm |
| 8. | Pozhimugam | 1,405 mm |
| 9. | Thickurichy | 1,410 mm |
| 10. | Rajakkamangalam | 1,375 mm |

The distance between each station falls around 2 kms. At each sample site, covering a sampling area of 1 $m^2$, samples have been collected, each weighing about one kilogram. In each station, 3 samples have been collected from the surface and from a depth of 3ft and 6ft. All the samples have been brought to the laboratory, cleaned, and dried for 24 hrs. at a temperature of 110 $^{\circ}$C in a hot air oven. These dried samples have been powdered using agate mortar and then pulverized to particle sizes, not greater than 2mm mesh screen. Then the prepared samples have been placed in plastic pouches and transported to the STIC laboratory, Cochin University campus, Cochin, Kerala, India.

## 3. RESULTS AND DISCUSSION

Once the particle extents have been determined, the chemical identity of a particle is determined. The

EDAX analyzer collects an x-ray spectrum, from which a human operator can identify the significant x-ray peaks. The image analyzer monitors regions of interest defined by x-ray lines of interest. For many mineral analyses, only 11common elements are necessary. They are, in increasing atomic number: Na, Mg,Al ,Si, P, Si, C1, K, Ca, Ti, and Fe. Additional elements can be also monitored if they are suspected to occur in trace quantities. Based on the relative intensities of the x-ray signals, particles are classified into one of several mineral categories. In fact, for many minerals, it is necessary only to define the elements that must be present to define a mineral. Quartz and calcite are examples for which only a single element is needed (Si and Ca, respectively)[4]**.**

The Table-2 shows the consolidated figure of mineral accumulation.

In our study SW monsoon (June to September) is considered as the monsoon period, and the period (February to May) as pre and (October to January) Post-monsoon. In general, during the month of February to May the sea remains calm and the

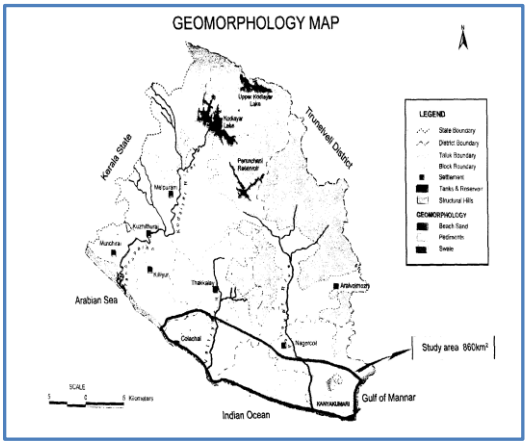


**Figure 1:** Geomorphology map.

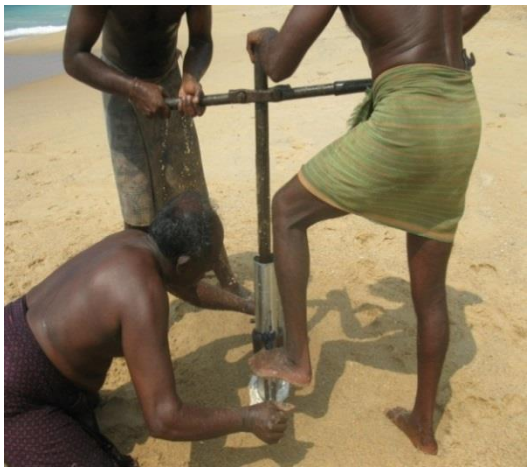

**Figure 2:** (*Sample collection at **Colachel** site, by Conrad bunker drilling method).* The samples collected from different sites under study are labeled as
*R-Rajakkamangalam,T-Thickurichy, Z-Pozhimugam,A-Azhikkal,U-Muttom, N-Chinnavilai,P-Puthur,M-Mondaikadu, K-Kottilpadu,C-Colachel.*


**Figure 3:** Location Map.

The location map of the study area is shown in the Figure 3.

process of accretion takes place resulting in the backshore sand dune. The wave after the monsoon season is in gradual phase. During the monsoon, heavy rainfall occurs in the study area and the sea is rough with high tide. High tide and wave current in the period of SW monsoon produces soil erosion .It is determined that few of the economically viable minerals such as Illminite, Rutile, Garnet, Corundum, Quartz and Calcite are predominant in all the 10 sample locations which are globally considered as mineral deposit zone. In terms of colour, the heavy minerals are always not black. At some locations of kanyakumari, some patches are red due to exclusively occurrences of garnet .In this area transition from black to red hue not abrupt but gradual with progressive increase in the proportion of garnet until the sand is almost made up of garnet. This may be due to the disintegration and decomposition of host rock which contains the relatively resistant garnet minerals on the floor of the ocean [8]. While analyzing the EDAX spectrum of various seasons of different locations, heavy mineral deposition takes place quantitatively at the end of the monsoon season and prevails till the period of pre-Monsoon.

The above set of graphs shows the elemental % of minerals at various locations of the study area. Si, Fe, Ti deposition increases with depth, and the sign of heavy mineral presence at pre monsoon is more than that after monsoon. So, the monsoon may have washed out the heavy minerals due to sea erosion or high wave current. In general silicon, which is the resource of several minerals, seems to be dominant irrespective of various seasons. The surface deposition of silicate surge to a huge growth from the monsoon. Digging to a depth of 3ft shows the Titanium availability, which indicates the presence of heavy minerals such as rutile and Illmnite. Al, which is the chief elemental source for Sillimanite, Corundum has been showing a growth figure of 19.98% to 28.65% with the sample collected in the surface of ***Colachel*** sampling location.Concentration of Si, Fe, Ti, C and Na is more beyond 3ft, mineral accumulation does not show a remarkable change with respect to season. At ***Kottilpadu*** the heavy mineral assemblage goes sharply higher towards the inner surface of the earth with a ft. of 3 and 6. The source element of Rutile, Illminite, Silliminate, Halite, Augite, Montmorrillonite and Magnesite get surfaced while sampling in all the 3 seasons. The rough sea during the south-west and North-East monsoon that is the period, noted as monsoon period in this study, makes geomorphological change of shoreline which results in the deposition of huge amount of mineral after monsoons. At ***Kottilpadu*** Al, Ti and Ca are found abundantly below the surface. In the post monsoon period certain mineral accumulation

**Table 2**: Consolidated figure of mineral accumulation at different locations during the pre-monsoon, monsoon and post monsoon seasons.

| Sl.No | Location | Minerals | Trace Element |
|---|---|---|---|
| 1. | Rajakkamangalam | Quartz,Halite,Garnet,Calcite | C,Na,Al,Cl |
| 2. | Thickurichy | Garnet,Calcite,Quartz | C,Na,Al |
| 3. | Pozhimugam | Quartz,Illminite,Augite,Garnet,Calcite | C,Na,Al,Ti |
| 4. | Azhikkal | Quartz,Garnet,Dolomite,Calcite | Al, Mg |
| 5. | Muttom | Quartz,Calcite,Kyanite,Illminite, Potassium feldspar | Ti,Fe,Na,Cu |
| 6. | Chinnavilai | Quartz,Calcite,Kyanite,Illminite, Garnet,Rutile,Corrundum | Mg,Ca, Ti,Na,C |
| 7. | Puthur | Quartz,Calcite, Kyanite, Garnet | Na,Cl,Ca,C |
| 8. | Mondaikadu | Quartz,Calcite,Illminite,Rutile,Corrundum | Fe,Ti,Ca,C |
| 9. | Kottilpadu | Quartz,Illminite,Augite,Corrundum | Ca,Ti,Na |
| 10. | Colachel | Quartz,Kyanite,Rutile, Illminite | Fe,Ca |

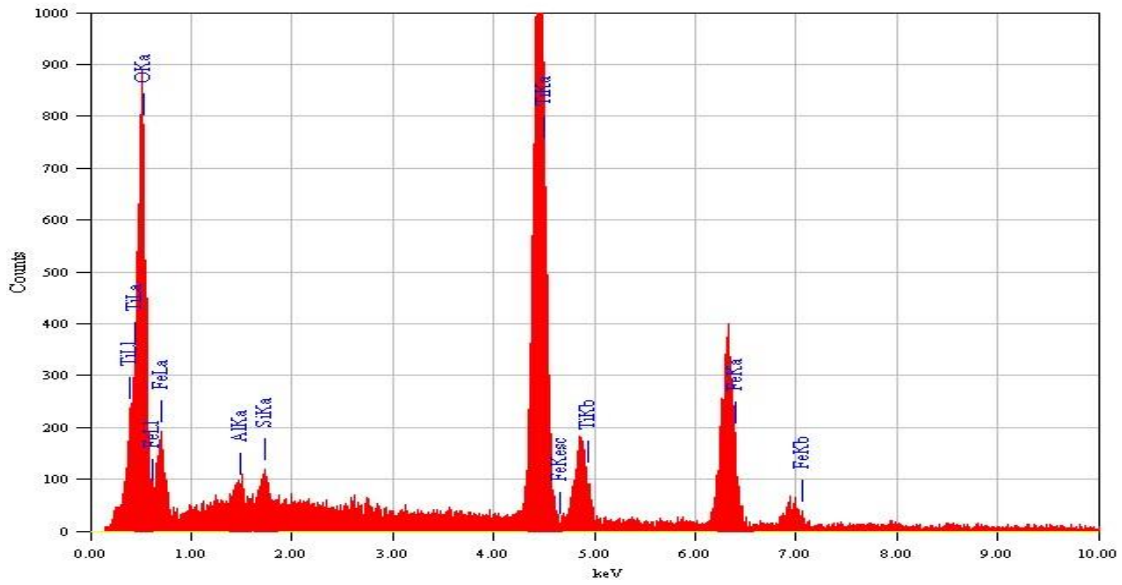


**Figure 4:** EDAX spectrum.

The figure.4 shows the EDAX spectrum of the colachel sampling location which is predominant with rutile element during the pre-monsoon period along with other trace elements is found in the surface region. The sea erosion due to the high wave current of SW monsoon makes a certain amount of mineral deposition in the surface level. All types of rare earth elements quantify with reasonable percentage from the sample collected from the location south to Kottilpadu. Aluminum, one of the constituent elements of Corundum, Garnet, Sillimanite figures out on a huge accumulation from December (i.e North East Monsoon), at different layers of sand. Oxide ore too seems to be the highest, from the study made in various seasons. Minerals such as Calcite, Magnesite, Illite and Gypsum are earthed extensively under the detailed study. In almost all the 10 locations, pre-monsoon period makes a suitable position of mineral accumulation. The element Aluminum is surfaced with a considerable margin after the monsoon. In the sampling location of ***Muttom*** which is geographically an extension stretch of rare earth at the hub of Manavalakurichi, experiences higher heavy mineral deposition in the pre-monsoon and the post monsoon season. Half kilometer away from the estuary of Valliar, this location shows the enrichment of minerals such as Monozaite, Garnet, Rutile, Quartz, Calcite, Kyanite, Illminite, Potassium feldspar. The black colour of Muttom sample shows the predominance of Titanium rather than the Magnetite.The minerals in this sediment reveals the nature of rock; as the igneous rock transported by river Valliyar from the inland region and the rock in the sea give the mineral constituents caused by to the shore wave of post monsoon. Muttom and adjacent areas are characteristised by extensive occurrence of fine sandy loam known as Teris. Their genetic properties are disputed, though generally an Aeolian origin is ascribed to them. The vegetation is of semi-arid type and the topography is similar to Bad Lands of the United States [7]. In the depth of 6ft, the mineral deposition is more as the calm sea

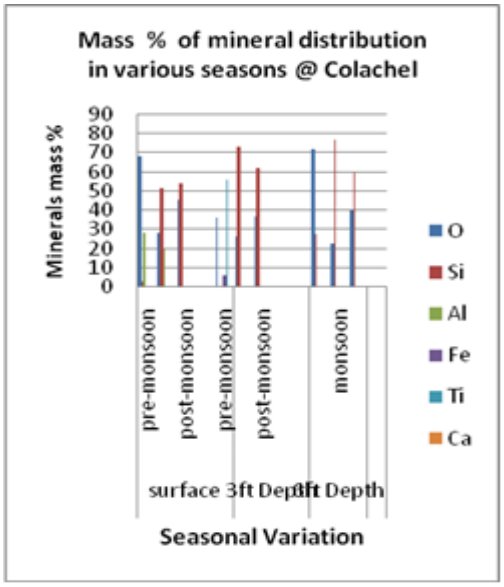


**Figure 5:** Seasonal variation of minerals @ Colachel.

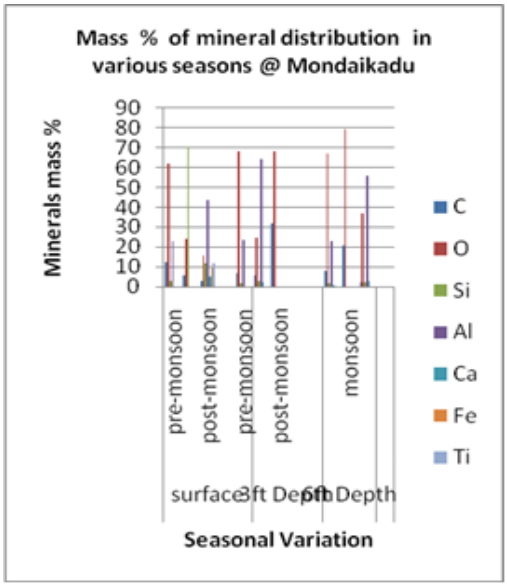


**Figure 7:** Seasonal variation of minerals @ Mondaikadu.

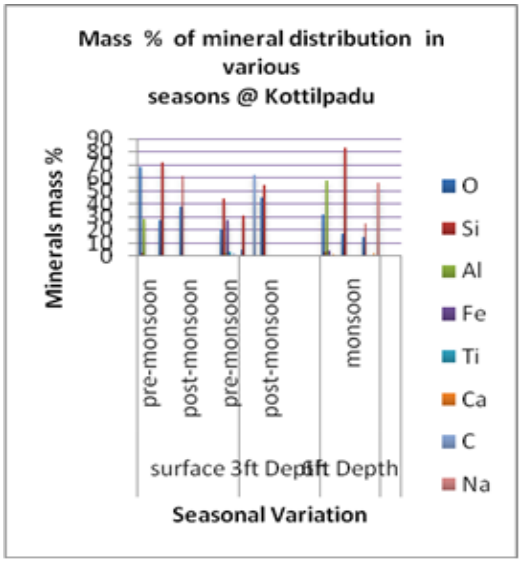


**Figure 6:** Seasonal variation of minerals @ Kottilpadu.

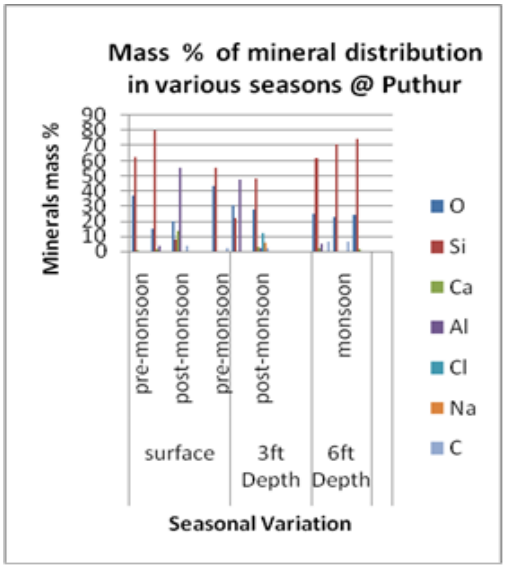


**Figure 8:** Seasonal variation of minerals @ Puthur.

after the SW monsoon settles more heavy mineral content sand. Estuary presence shows the enrichment of minerals transported by rivers from the source rock. ***Azhikkal, Pozhimugam, Thickurichy*** locations seems to be the major hub for the Garnet mineral. The Charnockite group of rocks is well exposed around ***Rajakkamangalam.*** Sub-recent origin of Calcareous limestone is noticed near Kanyakumari. Lateral Deposits or Bay Deposits of sand, Zircon, Rutile, Illminite and Garnet are very common phenomena along the entire sea coast of study area of Kanyakumari, right from Rajakkamangalam to Colachel.

## 4. CONCLUSIONS

To conclude with the elaborate study of pre, post and monsoon seasons of various samples, it was identified that, during the month of (February to May) the sea remains calm and process of accretion takes place resulting to the backshore sand dune. The wave before and after the monsoon season will be in gradual phase, which will be soothing the accumulation of heavy minerals. During the monsoon, both NE and SW (June to September) heavy rainfall occurs in the study area and the sea will be rough with high tide resulting sea erosion. Estuary presence at Rajakkamangalam and Manavalakurichi shows the enrichment of minerals transported by rivers from the source rock.

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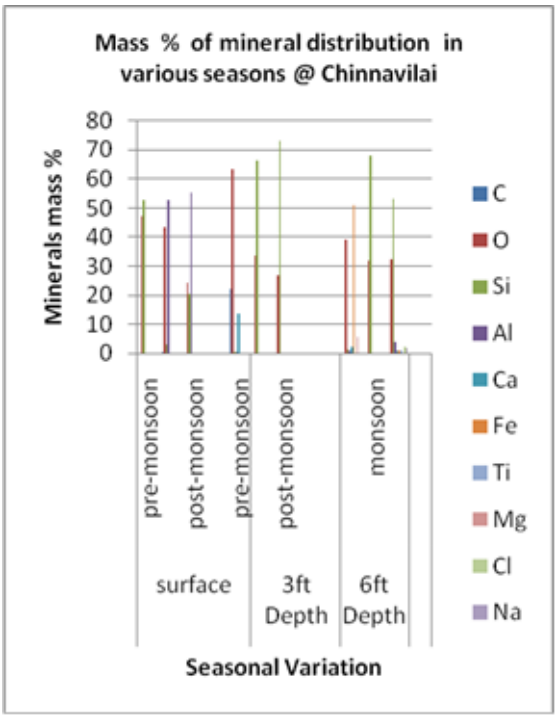


**Figure 9:** Seasonal variation of minerals @ Chinnavilai.

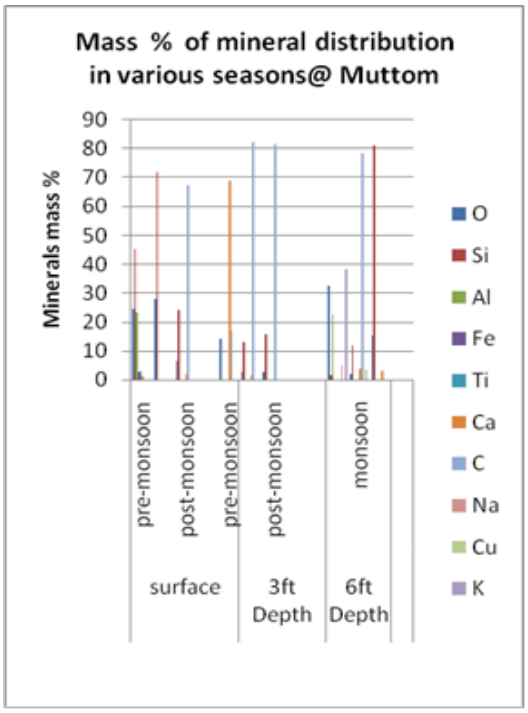


**Figure 11:** Seasonal variation of minerals @ Muttom.

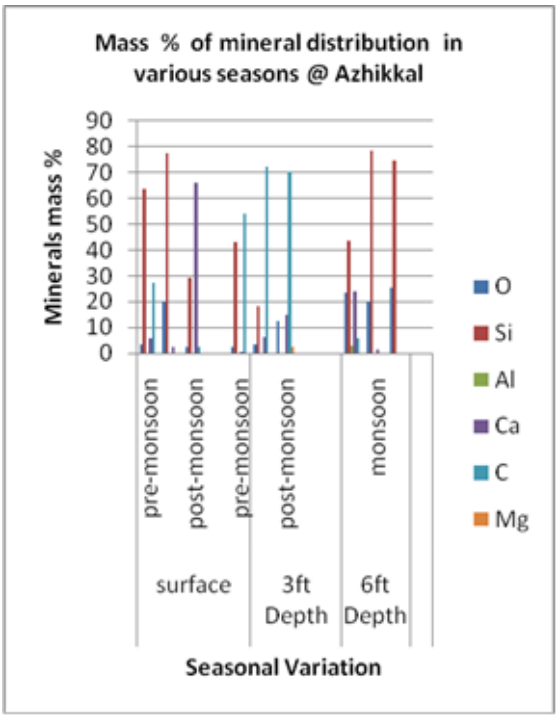


**Figure 10:** Seasonal variation of minerals @ Azhikkal.

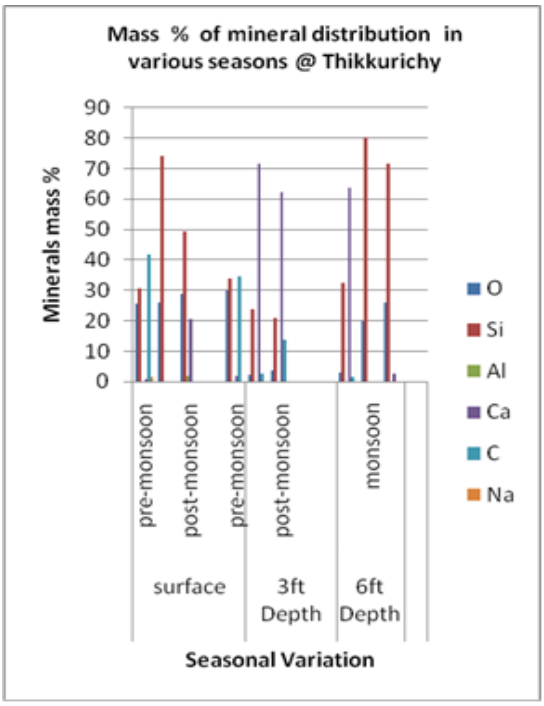


**Figure12:** Seasonal variation of minerals @ Thikkurichy

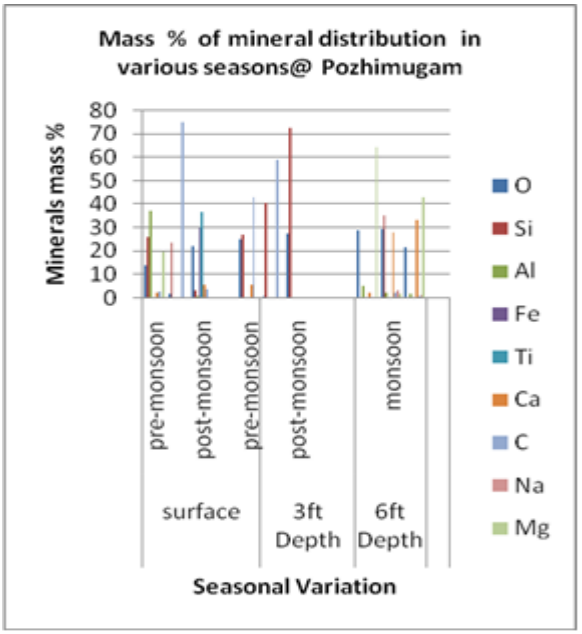


**Figure 13:** Seasonal variation of minerals @ Pozhimugam

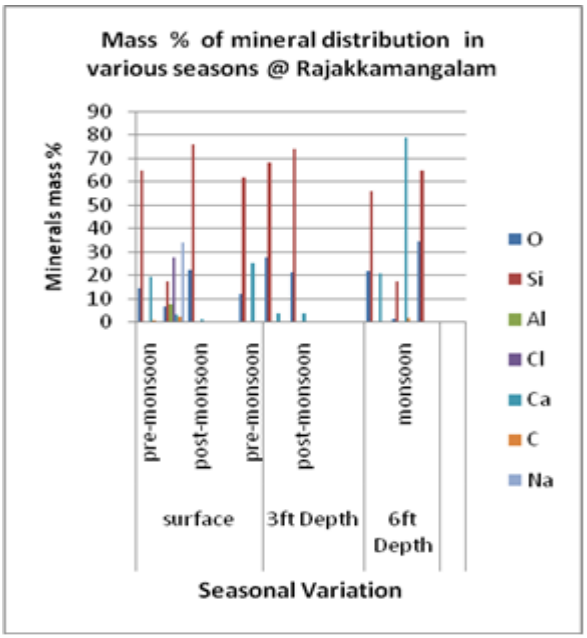


**Figure14:** Seasonal variation of minerals @ Rajakkamangalam.

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