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Characteristic of Gaja Cyclone Sediments in Parts of Nagapattinam District, Tamil Nadu

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ABSTRACT

The present study aims to understand the characteristics of the post-cyclone sediments along the coast of the Nagapattinam district. Two locations were chosen; one at Vellapallam coast and the other at the Kovilpathu. A pit was made at each location and 8 sub-samples from each pit were taken for the present study. Based on the textural analysis, detailed statistical studies have been carried out. The mean size of the first location (Vellapallam coast) ranges from 1.797 to 2.823phi. The mean size of the second location (Kovilapathu) ranges from 1.01 to 2.58phi. The frequency curves of both locations show positive skewness indicating the presence of fine sediments. Nearly 4 sub-samples from both the location show negative skewness indicating the presence of coarse sediments. From the Φ Vs Wt% plots, it is observed that the samples are showing a different kind of sorting. But a majority of the sediments shows well sorted to moderately well sorted, few are very well sorted at the bottom of the trench. These indicate that the sand is equally distributed as we go deeper. The kurtosis parameter shows that the samples in the first location range from Platykurtic to Very Leptokurtic. The kurtosis parameter shows that the samples in the second location range from Very Platykurtic to Platykurtic. The sediments reflect a majority of the materials in these samples were transported in saltation mode for long-distance. In the first location sample no. 4,5 and 6 shows a sudden angularity and in the second location sample no. 2 and 3 show high angularity than the other sediments. Zircon, Pink Garnet, Magnetite, Ilmenite, Hornblende, Rutile are the common heavy minerals found in Nagapattinam shore. Based on the textural characteristics of the sediments, it is inferred that 11cm (i.e., from 15cm to 26cm) thick sediments in trench 1 and 13cm (i.e., from 9cm to 22cm) thick sediments at trench 2 might deposited due to cyclone like high energy event.

INTRODUCTION

A cyclone is a tremendously vast environment that revolves around a stable low-pressure centre. Cyclones have inward spiralling winds that rotate a couple of low-pressure zones. The world of lowest atmospheric pressure within a cyclone's core (also termed as the eye during a mature tropical cyclone) is the world of lowest atmospheric pressure within the region. The pressure gradient force (from the pressure within the cyclone to the pressure outside the cyclone) and the Coriolis effect force should be balanced towards the centre; otherwise, the cyclone would collapse due to the pressure differential. This is evidenced by the inward spiralling winds that rotate against the direction to the Earth and in the direction of Earth's spin in the Northern and Southern Hemisphere respectively.

On a synoptic scale, the most severe low-pressure systems include cold-core polar cyclones and extratropical cyclones. Tropical cyclones, mesocyclones, and polar lows are warm-core cyclones that occur on the smaller mesoscale. The scales of subtropical cyclones are intermediate.

The sedimentological characteristics, micro fauna and heavy minerals have been used to identify the catastrophic events in Hawaii [Moore, 2000], Thailand [Jankaew et al., 2008], Pacific Northwest [Atwater and Moore, 1992; Benson et al., 1997], Kamchatka [Pinegina et al., 2003], Cascadian subduction zone [Darienzo and Peterson, 1995], Northern Sumatra [Monecke et al., 2008], Japan [Nanayama et al., 2003], Chile [Cisternas et al., 2005], and Atlantic coast [Hind Azidane et al., 2020]. Tamil Nadu has traditionally been regarded as one of the state's most susceptible to tropical cyclones. Tamil Nadu has 13 million hectares of land and has a 1,076-kilometer coastline, accounting for around 15% of India's coastline. The state is vulnerable to a variety of natural disasters, with Cyclones, Floods, and Droughts being the most common. Gaja (2018), Ockhi (2017), Vardha (2016), Nilam (2012), Thane (2011), Jal (2010), and Nisha (2010) are some of the tropical cyclones that have impacted Tamil Nadu (2008). A low-pressure system formed over the Gulf of Thailand as a result of the cyclonic storm. On the 10th of November, this feeble air mass became a depression in the Bay of Bengal, which then strengthened into a cyclonic storm on Veterans' Day, earning the name 'Gaja.' Gaja made landfall in Tamil Nadu, precisely at Vedharanyam. At the time of landfall, winds were gusting to 100/120 km/h. The highest recorded speeds were 165 kmph in Adhirampattinam and 160 kmph in Muthupet. Nagapattinam, Thanjavur, Thiruvarur, Pudukottai, Karaikal, Cuddalore, Trichy, and Ramanathapuram were all hit by the cyclone Gaja. The objective of the study is to find out the characteristic features exhibited by the Gaja cyclone deposited sediments and to find out the thickness of deposition in Vellapallam and Kodiyakkarai areas.

STUDY AREA

The study area lies in Nagapattinam district (Fig.1). The first location is at Vellapallam coast and the second location is at Kovilpathu (Table 1). In both the locations, a trench was made and the samples were taken. In the first location, a pit was made for 55cm and in the second location a pit having a depth of 42cm was made and the samples were taken. Eight sub-samples from each pit were taken. Sample numbers L1S1 to L2S2 denote the samples taken from Vellapallam and L2S1 to L2S8 are the samples taken from Kovilpathu region.

Table 1 - Latitude – Longitude of the pit samples

Location	Depth of the pit (cm)	Lattitude	Longitude
1	55	10°31’13.10” N	79°51’40.89” E
2	42	10°32’10.94” N	79°51’41.43” E

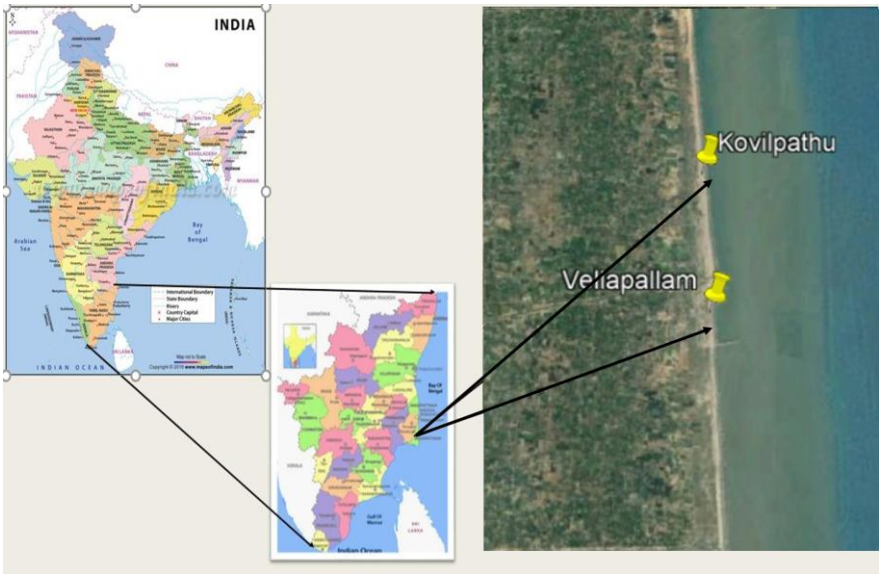

Fig. 1 Study area map

The investigation region frames a piece of Nagapattinam area. The study area falls between the latitude N 10°37'10" and longitude E 79°51'21". Conveyance of the Cauvery, Arasalar, Tirumalairajanar, Vellar, Adappar, Vettar, and Vedaranyam butt-centric are the primary streams streaming around here. The examination region is encircled by Tanjore area in the west, Cuddalore region in the north, Palk Waterway in the south and Cove of Bengal in the east. The topography of the investigation region involves both riverine and marine alluvial stores. The alluvial stores of the waterway Cauvery and its feeders lie over the Tertiary sandstone. They comprise of sand, gravelly sand, dirt and sandy earth. The thickness of the Quatenary residue expands north of Kollidam Stream. The silt has been depicted as alluvial plain stores (Cauvery development) of the Cauvery and its feeders, tight fluvio marine deltaic plain stores (Nagapattinam arrangement) and marine beach front plain stores (East Coast development) Geographical developments are going in age from the Archean to Late alluvium. The sedimentary segment contains various intrusive and backward scenes.

2.1 Climate and Precipitation:

The normal most extreme temperature of the locale all in all is about 320°C and the normal least temperature is 24.60°C. Residue storms, hurricanes and dusty breezes blow from different quarters towards the finish of May. The Southwest breezes begins on April, continues in June and ends in September. Upper east rainstorm starts in October and lasts till January. The estate produce is affected by the storms. The air is silent and undisturbed during a Southwest storm. The Upper East storm, which begins in October and ends in December, accounts for around 60% of the total annual precipitation. During the months of June to September, southwest rainfall downpours occur. During a south west rainfall, the usual typical and true precipitation is 265.2 and 250.6 mm, respectively, but during a north east downpour, it is 908.8 and 969.2 mm, respectively (Santha and Brinda Devi, 2020).

2.2 Geology of the area:

Topographically, the direct waterfront study region can be extensively separated into i) the northern part which has the hard rock region, ii) Tertiary residue including the Coromandal Arrangement, in the focal part and iii) Quaternary silt of fluvial and fluvio-marine beginning found in the fluvial and deltaic regions in the southern part. Moreover, the unconsolidated sea shore and sand/dirt stores are winning up and down the coast. Study region involves rocks of the Archaean, Permian, Cretaceous, Tertiary and quaternary (counting Later) periods. Sastri et al., [1981] had recognized two sedimentary bowls viz; the Palar bowl and the Cauvery bowl, to be available around here. The Palar Bowl covers around 4000 sq.km on surface and 2800 sq. km. in seaward regions. Sastri et al., (1981) had additionally suggested that the Cauvery bowl is a square blamed, pericratonic bowl containing a horst-graben bowl engineering. It incorporates a few discouragements isolated from each other by sub-surface edges moving NE – SW course.

3. METHODOLOGY

The sedimentological analysis, heavy minerals and microfossils (foraminifera) investigations gives a clear insight about the depositional environment for the genesis of the sediments. The samples were sent to AMS dating. Extensive studies have been done for both recent and old sedimentary environments which led gain knowledge about grain size parameters, nature of transportation, and depositional mechanisms of sediments [Folk and Ward, 1957; Mason and Folk, 1958; Friedman, 1962; Visher, 1969; Valia and Cameron, 1977; Wang et al., 1998; Asselman, 1999; Malverez et al., 2001]. The coastal sediments are finer in size and it is evident that velocity of the transporting agent gets reduced along their depositional pathways [Folk, 1980]. The standard deviation is used for sediment sorting and indicates fluctuations in the depositing agent's kinetic energy or velocity conditions [Ramanathan et al. 2009]. Kurtosis

values show that some sediments were sorted somewhere else in a high-energy condition prevailing environment as mentioned by Friedman, [1962].

3.1 Grain size analysis

The grain size of beach sediment investigations reveals about the inherent features of sediments as well as their depositional environment. It is also an aid in understanding the nature and energy flux of the many mechanisms that move the sediments [Rajaganapathy et al., 2012]. The three important investigations for sedimentologists are: (a) Determining grain size and expressing it on a grade scale; (b) To find out methods to quantity grain size and represent in a graphical and statistical way; and (c) To bring out genetic relevance of all the data [Boggs, 1995]. A 125g of samples collected from each station were treated with H_2 O_2 and 1:10 HCl and dried. The fractions were sieved through a set of meshes (25, 35, 45, 60, 80, 120, 170, 230 ASTM and pan) to get separate fraction of sediments for qualitative and quantitative analysis. Individual dry grains of the sample give efficient sieving results. The nest of sieves was placed in a Ro-Tap mechanical shaker for 10 minutes. Based on sieve interval selected, the grain size parameters were computed in phi units graphically. The quantity of the sand sediments which is retained in each sieve is collected and weighed. The percentage of each sieve fraction is obtained by dividing the weight of each fraction by the total weight of all the sieved samples. The weighed samples were noted against the corresponding sieve sizes. Weight percentages, mean, and various statistical parameters which includes standard deviation, skewness and kurtosis are also determined.

3.2 Coarse fraction analysis

Particle size distributions are dependent on statistics, and the statistical parameters will often be described in terms of how the data will be used. These estimated statistical characteristics may provide insight into numerous elements of the sediment grains' environmental, depositional, and transport circumstances, allowing them to be linked to certain sedimentary systems [López G.I.,2017]. The mean, median, and mode are three often used parameters. The average size of all the samples is referred to the mean. The median is the diameter of fraction which is the mid-point in a grain size distribution, that is, 50% of the weighed sample is coarser and the remaining 50% is finer than the median. The highest frequency shown by the particle size is referred to the Mode. The Frequency distribution curve will be symmetrical only when all these three data coincide.

3.3 Textural analysis

Various surface textures are found in coastal sediments. They may originate by different processes like abrasion, attrition, corrosion, tectonic polishing and etching. Sometimes authigenic growths are also seen on grain surfaces due to precipitation during the process of diagenesis and

weathering. The particle form or sphericity of all the samples from both the locations was studied under the microscope. Nearly 100 grains from each sample and classified accordingly. They are classified into angular, sub angular, sub rounded, rounded and well-rounded and the results in numbers are tabulated.

3.4 Heavy mineral analysis

Heavy minerals are concentrated naturally by hydrodynamic sorting, usually in shallow marine or fluvial depositional setting. Heavy mineral separation has been done by following bromoform method of separation [Milner, 1962]. The cleaned fraction of 80 mesh was separated for heavy minerals using bromoform (2.89 specific gravity) as separating medium and centrifuged for 10 minutes. After separating the lighter fraction carefully, the heavy minerals were transferred to small glass bottles. High density liquids are used in the separation of heavy minerals. The heavy minerals differ from the light minerals by a considerable difference in their densities. According to this density variation, the highly dense mineral tends to sink and the lighter mineral floats at the top.

RESULT AND DISCUSSION

4.1 Grain size and coarse fraction analysis

To understand the grain size distribution and sediment settling in the study area, detailed grain size analysis has been carried out. In 125g dry sample, the sand sized sediments were separated and different fraction of sand materials separated. Individual weight of each fraction has been measured. Weight % and cumulative weight % calculated. The Φ size Vs Weight% and Φ size Vs Cumulative weight % calculations made. All the plots have been prepared (Fig. 2 to Fig. 5) and the grain size characteristics is discussed. The size-recurrence appropriation of different grain-size boundaries of the Vellapallam coast and Kovilpathu regions are resolved.

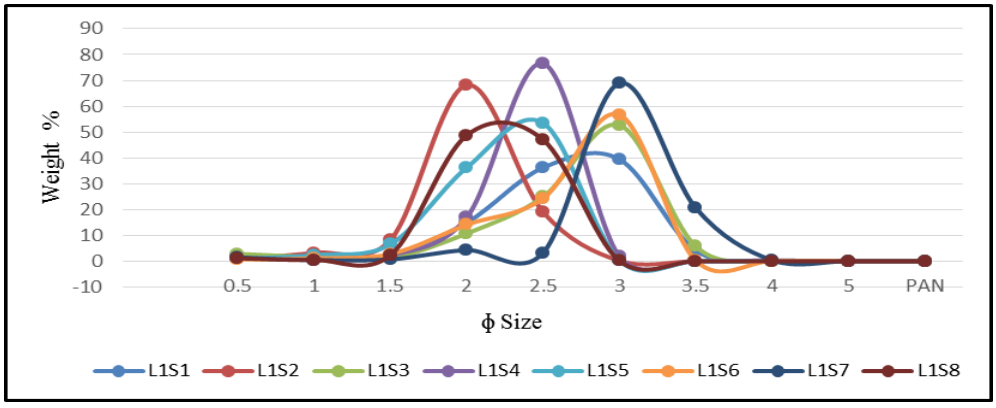

Fig. 2 ϕ Vs. Weight % graph of Vellapallam region

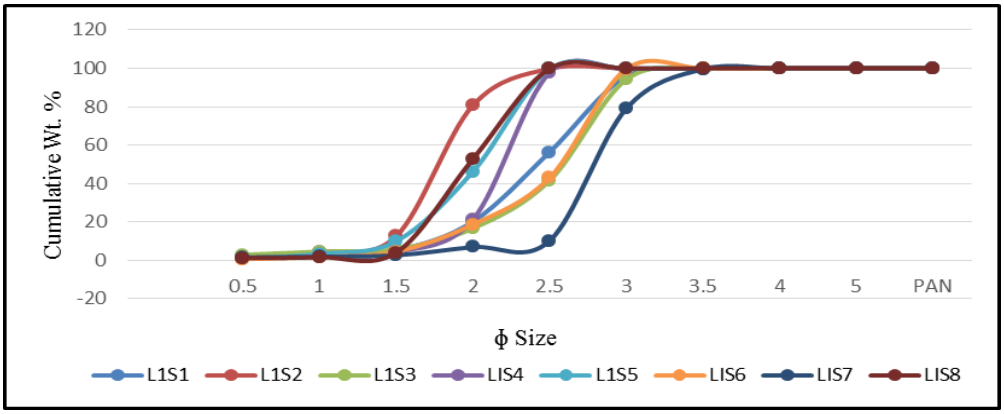

Fig. 3 ϕ Vs. Cumulative Weight % graph of Vellapallam region

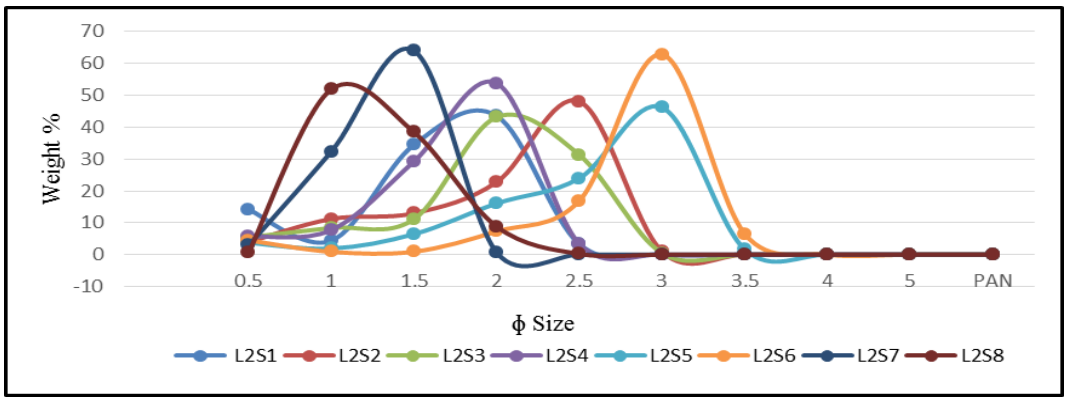

Fig. 4 ϕ Vs. Weight % graph of Kovilpathu region

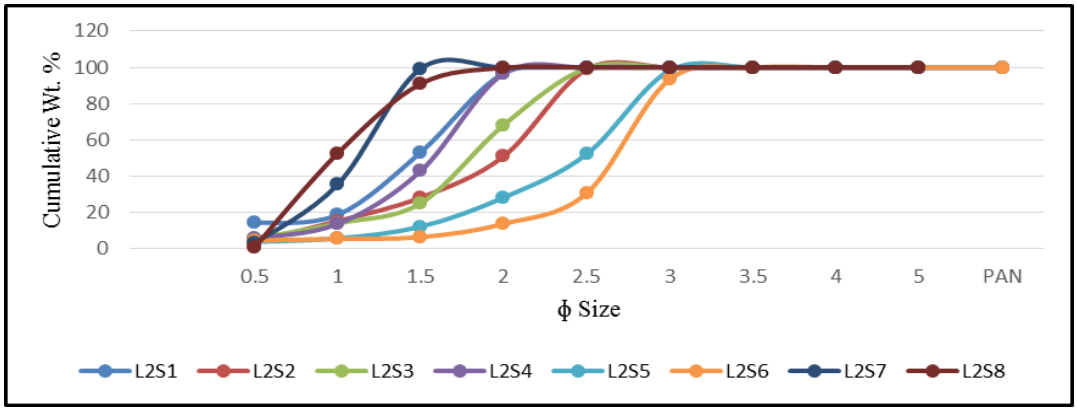

Fig. 5 ϕ Vs. Cumulative Weight % graph of Kovilpathu region

The mean size of the beach sands in the first location (Vellapallam coast) ranges from 1.797 to 2.823 and between 1.01 and 2.58 for the samples collected from the Kovilpathu coast.

Frequency curves of the Vellapallam coast indicate that sub-sample no. L1S1, L1S2, L1S4, and L1S8 have Positive Skewness which shows that they are fine sediments. Sample nos. L1S3, L1S5, L1S6, and L1S7 show Negative Skewness, indicating that these deposits are coarse sediments.

Frequency curves of the Kovilpathu area show that the sub-sample nos. L2S1, L2S4, L2S7, and L2S8 have Positive Skewness which shows that they are fine sediments. The sub-sample nos. L2S2, L2S3, L2S5, and L2S6 show Negative Skewness indicating these deposits are coarse sediments.

The samples are showing a different kind of sorting. But a majority of the sediments shows well sorted to moderately well sorted, few are very well sorted at the bottom of the trench. These indicate that the sand is equally distributed as we go deeper.

The skewness of the sediments is Strongly coarsely skewed in an average. The sand materials from the first location show very coarse skewed. The kurtosis parameter shows that the samples in the first location range from Platykurtic to Very Leptokurtic.

The sand materials from the second location show very coarse skewed. The kurtosis parameter shows that the samples in the second location range from Very Platykurtic to Platykurtic.

The sediments reflect majority of the materials in these samples were transported saltation mode for long distance followed suspension and little by traction mode.

4.2 Textural analysis

All the samples from both the locations were observed under the microscope. In the first location sub sample nos. L1S4, L1S5 and L1S6 shows a sudden angularity and in the second location sample no. L2S2 and L2S3 show high angularity than the other sediments (Table 2 & 3). This indicates that these samples are not transported to a long distance and may be deposited by sudden high energy activity.

Table 2 - Sphericity of the grains under microscope of Vellapallam area

Sample No.	Angular	Sub-angular	Sub-rounded	Rounded	Well-rounded
L1S1	15	18	37	20	10
L1S2	22	12	44	22	12
L1S3	18	8	32	38	5
L1S4	30	42	25	20	10
L1S5	36	43	20	22	9
L1S6	31	35	26	12	10
L1S7	23	28	40	15	10
L1S8	20	22	41	25	2

Table 3 - Sphericity of the grains under microscope of Kovilpathu area

Sample No.	Angular	Sub-angular	Sub-rounded	Rounded	Well-rounded
L2S1	27	28	19	10	3
L2S2	38	39	26	12	6
L2S3	35	28	18	13	5
L2S4	28	27	32	15	1
L2S5	18	20	36	16	8
L2S6	20	19	43	13	9
L2S7	12	26	20	12	1
L2S8	25	27	26	13	3

4.3 Heavy mineral analysis

The samples were analysed for the identification of heavy mineral concentration using the heavy liquid (Bromoform) and the results were obtained. Zircon, Pink Garnet, Magnetite, Ilmenite, Hornblende, Rutile are the common heavy minerals found in Nagapattinam shore.Zircon, Pink Garnet, Magnetite, Ilmenite, Hornblende, Rutile are the common heavy minerals found in the shore sediments. Presence of zircon and rutile in the sediments indicates the acidic igneous rock as the source rock. Magnetite indicates the basic igneous rock. The garnet presence in the sediments suggests the provenance from metamorphic source. Based on the provenance it is inferred that the sediments might be originating from the catchment of the Cauvery River and its tributaries. The below samples are chosen because these samples showed more angularity and strongly coarsely skewed than the other sub samples. Distribution of the heavy minerals in the beach sediments are given in Table 4. The percentage of different heavy minerals is depicted in Fig. 6.

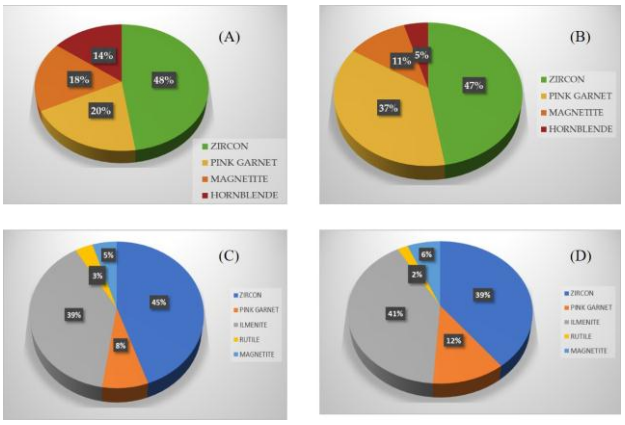

Fig. 6 Pie charts showing the percentage of corresponding heavy minerals present in (A) L1S5 (B) L1S6 (C) L2S2 (D) L2S3

Table 4 -Percentage of Heavy and Light minerals

Location	Sample No.	Weight % (g)	Heavy Minerals (g)	Light Minerals (g)
Vellapallam	L1S6	28.745	0.885	27.429
Vellapallam	L1S5	63.098	11.31	47.682
Kovilpathu	L2S2	36.734	2.443	34.291
Kovilpathu	L2S3	55.72	7.213	48.507

CONCLUSION

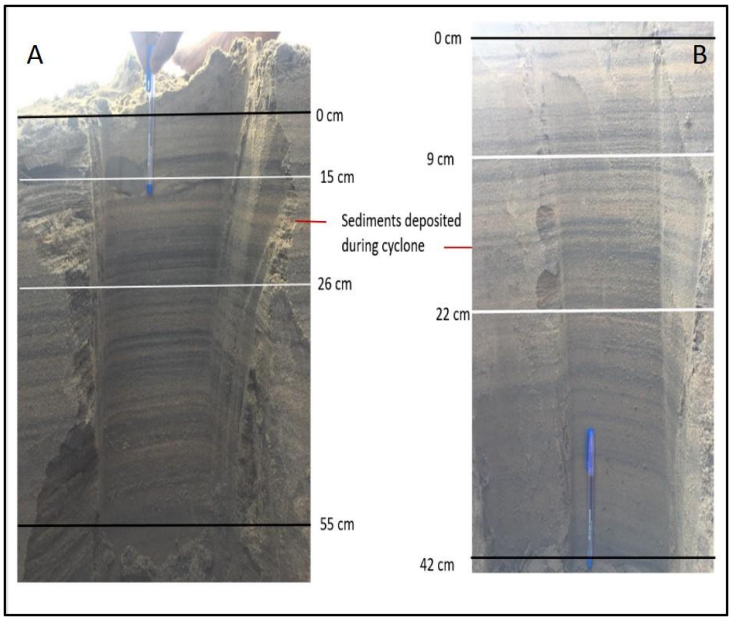

Fig. 7 Photograph taken in field showing the thickness of cyclone deposits in (A) Vellapallam (B) Kovilpathu

The sedimentological and heavy mineral studies were carried out at Vellapallam and Kovilpathu coast in order to find the sediment characteristics of Gaja cyclone sedimentsThe heavy minerals showed a high concentration than the usual deposits prevailing during normal conditions. In addition to these the sediments showed high angularity at certain depths confirming the deposition by high energy. It is found out that in the location one (Vellapallam coast) sample no. L1S5 and L1S6 and in location two (Kovilpathu) sample no. L2S2 and L2S3 show the characters of the cyclone sediments. In the first location, the cyclone sediments are deposited for a thickness of 11cm (i.e., from 15cm to 26cm) and in the second location the cyclone sediments are deposited for a thickness of 13cm (i.e., from 9cm to 22cm).

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