# Estimation of Organic Matter and Carbon Content in Lacustrine Sediments of Pulicat Lake, South East Coast of India

T. Lakshmi Prasad[1], M. Pramod Kumar[1*], K.Nagalakshmi[1], N.Jayaraju[2], B.Lakshmanna[2] and T.Siva prathap[1]

[1]Dept of Earth Sciences, Yogi Vemana university, Kadapa

[2]Dept of Geology, Yogi Vemana University, Kadapa

**Abstract:**

Pulicat Lake is one of the major important lakes in southern India is taken for the present study to monitor the health status of the lake by determining the Organic matter (OM) and carbon content (CC). A total of 9 sediment samples were collected from pulicat lake at random locations and co-ordinates of the sampling stations were recorded by using a hand held GPS. Ranges of sand, silt and clay are 11.8% to 93% (av. 61.1), 6.7% to 87.8 % (av. 31) and 0.3% to 47.8% (av. 12.2) respectively. More than 60% of the sand grains in this environment are mainly medium to fine grade and predominance of silty sand. The organic matter values ranges from 1.89 to 8.62% and controlled by grain size patterns. Silt clay and clay in the central part of the lagoon are having high carbonate content (range 0.5 to 3.2%). Like organic matter, the carbonate content is less in the coarse sediments and in fine sediments of the central parts of the lagoon is more. The average carbonate content of the Pulicat Lake sediments is 1.45%. The sediments were mostly transported by bottom suspension and rolling, graded suspension and uniform suspension mode.

**Keywords:** Pulicat Lake, Organic matter, Carbon content, Graded suspension.

## Introduction

Estuaries are the transitional zones between the fluvial and marine environs. Estuaries receives large amount of contamination from urban and industrial sites. In India estuarine ecosystems are deteriorating day by day through anthropogenic activities. Within estuarine ecosystems, bottom sediments have an important function as an efficient natural trap for diverse substances (including contaminants) and also as a natural regulator of the processes that occur in the lake floor (Ramesh et al., 2002). Bottom sediments act as sinks and sources of contaminants in aquatic systems because of their physical and chemical properties. The physical and chemical erosion of rocks from the catchment area, sediment detritus and soil particles are transported and deposited through the waterways and streams into the lake forming a depositional pattern on the lake floor. However, knowledge is scarce regarding the relative contributions from the catchment area, the distribution pattern of the sediment (Sathyanarayanana et al., 1985) Bottom sediments also store large amounts of organic matter and affect the oxygen content of bottom water. Bottom sediments also constitute a source of nutrients to the water column above them leading to benthic-pelagic coupling and influencing primary productivity (Ramesh et al., 2002). The primary source of organic matter and organic carbon in lake sediments is often thought to be from the particulate detritus of plant sand only a small percent is derived from the animals (Subba Rao, 1960)

Estimation organic matter and carbon content play a key role in carbon cycle and thus it is also important in terms of global climate change. Lakes and reservoirs and their sediments generally rich in organic matter which undergo complex processes like accumulation, export, degradation, heterotrophic utilization (Carter and Mitterer, 1978). In general organic matter consists of simple/ combined organic molecules like lipids carbohydrates and proteins which may further undergo mineralization and results in production of Green House Gasses (GHG) (Sheu and Presley, 1986).

Bottom sediments in aquatic environment consist of particles of varying sizes, shape and chemical composition, and are transported through different natural agencies and deposited according to their textural properties in different areas. The grain size, organic-matter and calcium carbonate content may be serious factors other than pollution that influence metal distributions in sediments. Most hydrophobic organic contaminants, metal composites, and nutrients, which enter into the water, become associated with particulate matter. Under certain situation the contaminants in the bottom sediments may be released back into the water or enter the food chain. These contaminants may pose a high risk to the ecosystem on a large scale and hence need to be monitored at regular intervals (Rao and Rao., 1969; Usha and Rajasekhar., 2016). Grain size analysis has recently been used in environmental studies, relating fine-grained samples to micro-contaminants in several environments. Lagoon sediments usually have high clay concentrations, which increase the particle–particle interface. Grain size parameters have been used to characterize the sediments in the shelf environment (Carranza et al., 2005); moreover, the bottom topography of any modern environment is affected by the distribution and transportation processes of the sediments present in the area. Analyses of textural parameters are indicators of the ecological condition as they are environmental sensitive (Krumbein and Pettijohn., 1938; Folk and Ward., 1957).

Pulicat lake which is one of the major important lake in southern India is taken for the present study and it is the second largest brackish water ecosystem on the east coast of India. The Lake is drained by three larger inflows and many minor inflows (Nagalakshmi et al., 2017). Pollution from sewage, pesticides, agricultural chemicals and industrial effluents are gradually becoming major threats. It is speculated that the Arani and Kalangi rivers draining into the lake bring in fertilizers and pesticides with the runoff from the agricultural field in the drainage basin. The domestic sewage forms a more diffuse input. Effluents and wastes from numerous fish processing units are also major sources of pollutions in the study area. The oil spills from the mechanized boats are always a potential hazard. Till date, there has, however, been little effort to either quantify the organic matter and carbon content or even identify their probable sources. Therefore, it is imperative to determine the organic matter and carbon content in water bodies coupled with grain size characteristic of Pulicat lake bottom sediments.

**Location and Hinterlad Geology:**

Pulicat Lake is dominated by sandy mud charged with organic matter and shell of mollusks, yellowish buff or dark clays and sands are brought down by the large rivers like Pennar, kalangi and Arni rirvers. The sand is widely exposed to surface, whereas the Nellore Schist and silica rich quartz veins and Quaternary alluvium and Laterites, Tertiary & Triassic sandstones and Precambrian Gneiss, Amphibolites, Quartzite shales are available as country rock situated much away from the study area (Nagalakshmi et al 2017& 2018).

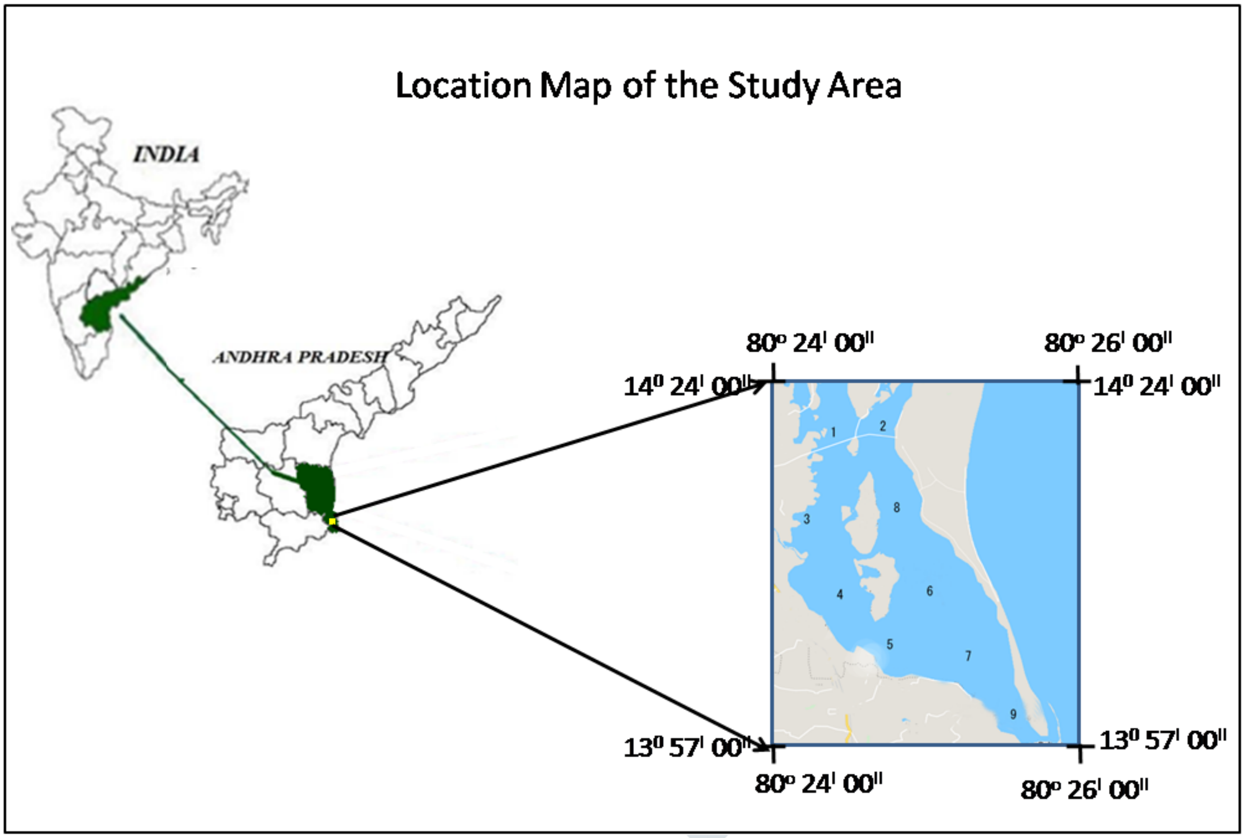


Figure. 1 Location Map of the Study Area

**Objectives:**

To determine the organic carbon, organic matter and carbon content in lake sediments.

To determine the sand, silt and clay percentages in the sediments.

To determine the granulometric characteristics of bottom sediments.

**Materials and Methods:**

A total of nine bottom sediment samples were collected by using Van Vein grab sampler on board hired fishing trawler. The sampling station locations were geo tagged by using the hand held Global Positioning System (GPS). Then the collected samples were transferred to pre-cleaned polyethylene bags, stored, labeled neatly, and dried for further analysis. The collected samples were taken to the laboratory and dried; 100gms of the sample was taken from the bulk sample by using coning and quartering method. Thus weighed 100gms sample thoroughly washed with distilled water for removing the salts and treated with 15% hydrogen peroxide ($H_2O_2$) and Hydro Chloric Acid (HCL) to dissolve the shell material and further 100gms of sample was transferred in to a 230 mesh ASTM sieve and washed thoroughly with water for separation of silt, clay from total sediment. Pipette analysis was carried out to compute sand, silt and clay fractions. The residual sand particles in the sieve will be subjected to sieving technique followed by analysis and interpretation of textural characteristics of sediments by using scatter plots and C-M Diagrams. For Total Organic Carbon (TOC) and Carbon content (CC) are determined by taking 0.4 gms and 0.5 gms of sediment samples by using against titration method and calculated TOC & CC in the sediments.

**Results and Discussion**

Percentages of Sand, silt and clay in sediment samples ranges from 11.8 to 92.3 (Avg61.1), 6.7 to 87.8 (Avg 31) and 0.3 to 47.8 (Avg 12.2) respectively (Table 1). More than 60% of the sand grains in this environment were falls in Medium to fine sand. According to Folk and Ward (1957) and Passega and byramjee (1969) classification various sediment types in the lake bed are muddy sand, silty sand, sandy silt, sandy clay and sand. Pulicat lake sediments show the predominance of silty sand.

| Sample No. | Sand% | Silt% | Clay% | Type of Sediment | % of O.C | % of O.M | % of CaCo3 |
|---|---|---|---|---|---|---|---|
| PL_1 | 88 | 11.6 | 0.4 | Silty Sand | 2.5 | 3.4 | 1.5 |
| PL_2 | 83.3 | 16.3 | 0.4 | Silty Sand | 3.3 | 4.2 | 0.5 |
| PL_3 | 86.2 | 13.4 | 0.4 | Silty Sand | 1.4 | 5.7 | 0.9 |
| PL_4 | 85.7 | 13.9 | 0.4 | Silty Sand | 2.3 | 2.4 | 1.5 |
| PL_5 | 51.7 | 19.1 | 29.2 | Muddy Sand | 4.3 | 4 | 0.8 |
| PL_6 | 11.8 | 87.8 | 0.3 | Sandy Silt | 3.6 | 7.5 | 2.5 |
| PL_7 | 36.6 | 56.8 | 6.6 | Sandy Silt | 4.2 | 6.8 | 3.2 |
| PL_8 | 31.1 | 21.1 | 47.8 | Sandy Clay | 5 | 1.9 | 0.8 |
| PL_9 | 93 | 6.7 | 0.3 | Sand | 5.9 | 8.6 | 0.6 |
| **minimum** | **11.8** | **6.7** | **0.3** | | **1.4** | **1.9** | **0.5** |
| **maximum** | **93** | **87.8** | **47.8** | | **5.9** | **8.6** | **3.2** |
| **Average** | **61.1** | **31** | **12.2** | | **3.61** | **4.94** | **1.45** |

Table 1 represents the percentages of sand, silt & clay and Organic Carbon, Organic Matter & Carbon Content in pulicat lake sediment samples.

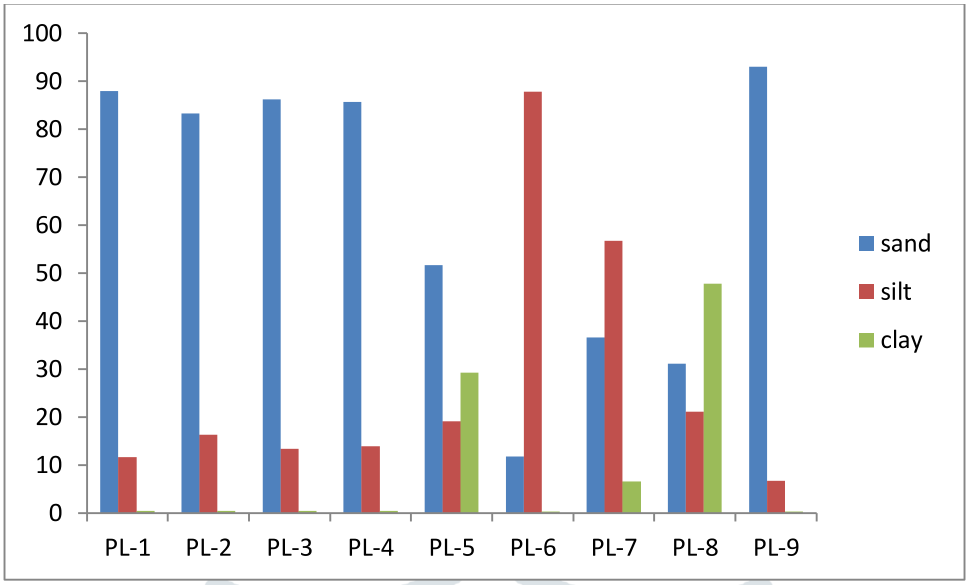

Figure 2 Sand, Silt and Clay fractions in the pulicat lake sediment samples

**Organic Matter**

Organic Carbon refers only to the carbon component of organic compounds, which comprises in a range from 1.3 to 5.9%. The organic carbon content is at $9^{th}$ sampling station and also at central part of the lagoon. The organic matter of the study area value ranges from 1.89 to 8.62. The abundance of organic matter depicts that the sediments are immature and appears to have been derived from marine sources. In addition to the above, other controlling factor may be rate of sedimentation, which is variable in different areas of the river. The high inorganic sedimentation will dilute the environment of organic matter in sediments and increase of organic matter with decreasing the grain size has been reported from many areas, all over the world, and is attributed to co sedimentation of particulate organic matter with clay and mineral particles (Carter and Mitterer., 1978; Bhatia and Cook., 1986; Sheu and Presley, 1986; Fralick and Kroberg., 1997; Seetharamiah and Swamy., 1999).

**Calcium Carbonate**

The Calcium carbonate content in the sediment samples ranges from 0.5 to 3.2%. The samples from central part of the lagoon show higher amount calcium carbonate values. Such an association in central part of the lagoons with higher calcium carbonate accompanied with finer sediments has been reported (Fralick and Kronberg., 1997; Seetharamaiah and Swamy., 1999). Average carbonate content of the Pulicat Lake sediments is 1.45%. Low carbonate content of the sediments in the vicinity of the river confluences indicates that no detrital carbonate is contributed by the river Kalangi. Shell fragments, tests of organisms and f ine-grained carbonate precipitated from the lagoon waters constitute the chief source of calcium carbonate in the lake sediments.

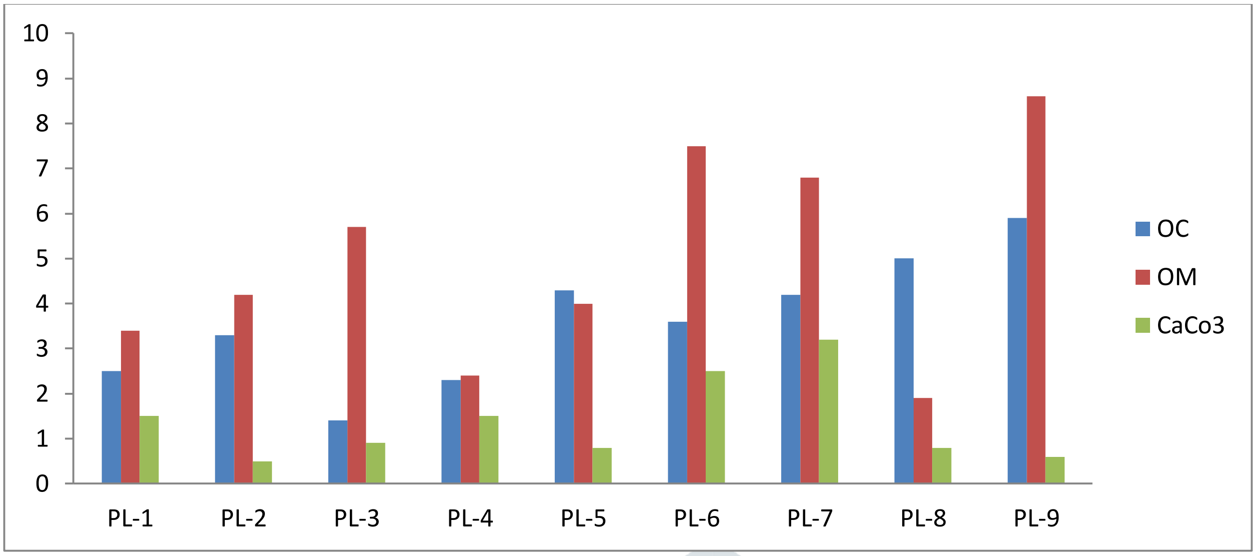


Figure. 3 Graphical representations of Organic Carbon, Organic Matter and Carbon Content in the sediment samples

### Grain size statistical analysis

Graphic mean (Mz) is a measure of central tendency, which is calculated by the formula φ 16 + φ 50 + φ 83 /3. The graphic standard deviation is the measure of sorting or uniformity of particles size distribution and it is calculated by the formula φ 84 - φ 16 / 4 + φ 95 - φ 5 / 6.6 (Inman,. 1952). The graphic mean and standard deviation values obtained ranges from 1.39 to 5.34 φ ( Avg 3.405) and 0.915 to 2.742φ (Avg 15.3) respectively. Most of samples are medium to fine and showing moderately to poorly sorting nature (Table-2). The graphic skewness measures the predominance of coarse or fine material in sediments. It is calculated by the formula φ 84 + φ 16 – 2 φ 50 / (φ 84 - φ 16) + φ 95 + φ 5 – 2 φ 50 / (φ 95 – 2 φ 5). The negative value denotes coarse skewed material, whereas, the positive value represents more material in the fine tail i.e. fine skewed (Krumbein., 1934). The skewness value ranged from -0.565 to +0.597 φ (Table-2) which indicates Gavel in size. The graphic kurtosis (KG) is the peakedness of the distribution and measures the ratio between the sorting in the tails and central portion of the curve. If the tails are better sorted than the central portions, then it is termed as platykurtic, whereas, leptokurtic, if the central portion is better sorted (Passega., 1957). If both are equally sorted then mesokurtic condition prevails. The values obtained ranges from 0.506 to 5.94 φ (Table-2). It indicates very platykurtic to very leptokurtic in nature.

| Sample No. | Mean | SD | Skewness | Kurtosis |
|---|---|---|---|---|
| PL_1 | 2.244 | 1.084 | 0.324 | 2.658 |
| PL_2 | 2.895 | 0.975 | 0.597 | 1.926 |
| PL_3 | 2.109 | 1.138 | 0.225 | 1.962 |
| PL_4 | 2.364 | 1.007 | 0.279 | 2.037 |
| PL_5 | 4.962 | 2.296 | 0.5 | 0.506 |
| PL_6 | 4.956 | 0.915 | -0.565 | 5.94 |
| PL_7 | 4.442 | 1.843 | -0.269 | 1.259 |
| PL_8 | 5.343 | 2.742 | -0.23 | 0.548 |
| PL_9 | 1.399 | 1.203 | 0.313 | 1.165 |
| **Minimum** | **1.399** | **0.915** | **-0.565** | **0.506** |

| | | | | |
|---|---|---|---|---|
| **Maximum** | **5.343** | **2.742** | **0.597** | **5.94** |
| **Average** | **3.405091** | **1.532727** | **0.109636** | **2.222455** |

Table. 2 Granulometric Parameters of the sediment samples

**Cumulative curves of Pulicat lake sediments**

The grain size is plotted on horizontal axis, and cumulative weight percent is plotted on the vertical axis with a scale running from 0 to 100%. An S-Shapes curve is produced when an arithmetic ordinate scale is used. Sediment with a normal distribution plots as a straight line when a probability ordinate scale is used to construct the cumulative curve, the cumulative curves (plotted on probability paper) commonly do not plot as straight lines. Such curves are thought by some to represent sediment composed of several distinct sub populations, each of which has a lognormal distribution and is related to different modes of transport (Figure-4).

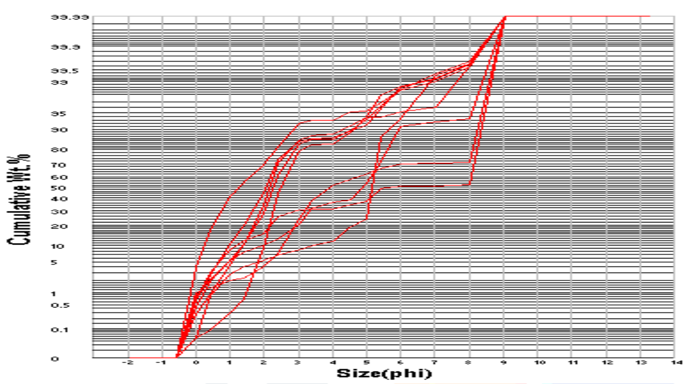


Figure. 4 Cumulative curves of Pulicat lake sediments

**CM-Pattern**

The CM pattern of the sedimentary environment helps in analyzing transportation mechanism, depositional environment with respect to size, range and energy level of transportation. It also determines process and segregates characteristic agents that are responsible for the formation of clastic deposits. In the present study an attempt has been made to identify the modes of deposition of the bottom sediments of the pulicat lake. Passega (1957&1964) interpreted the distinct patterns of CM plots in terms of different modes of transportation by plotting coarsest first percentile grain size (C) and the median size (M) of sediment samples on a double log paper. Visher (1969) explained the log normal sub populations within the total grain size distribution curve as representing suspension, saltation and surface creep or rolling modes of transportation mechanisms. The relation between C and M is the effect of sorting by bottom turbulence. The good correlation between C, determined by only one percent by weight of the sample, and M, which represents grain size as a whole, shows the precision of the control of sedimentation by bottom turbulence. The results have been plotted in CM diagram (Fig.5&6). Passega (1957&1964,) have used the grain size parameters and the plots of CM patterns to distinguish between the sediments of different environments. In the study area, CM pattern is sub divided into segments, namely, NO, OP, PQ, QR, and RS (Passega, 1957). The results of the CM diagram from the study shows that, sediment material is transported by bottom suspension & rolling, graded suspension, and uniform suspension modes (Fig.5) and moreover the sediment material is from beach and pelagic environs, carried into the lacustrine environment by means of tractive currents (Fig.6).

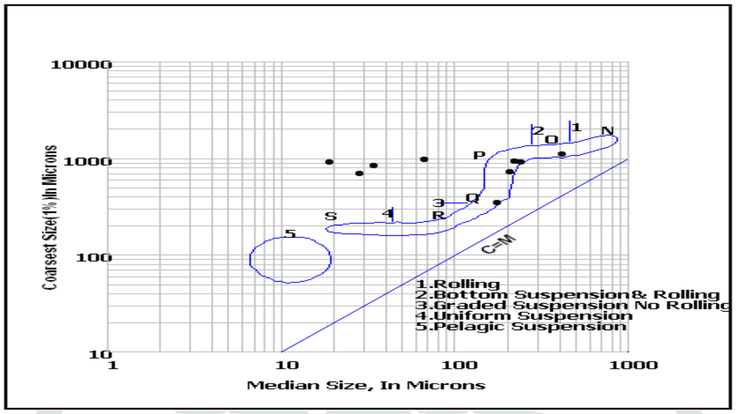


Figure. 5 CM-diagram showing mode of transportation of Pulicat lake sediments

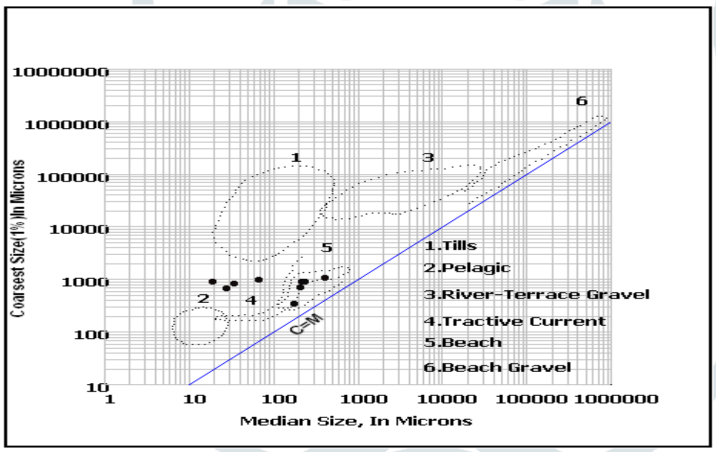


Figure. 6 CM diagram showing deposition environment of sediments

## Triangular diagram

Sediment logic datasets are typically large and compiled into tables or databases, but pure numerical information can be difficult to understand and interpret. Thus, scientists commonly use graphical representations to reduce complexities, recognize trends and patterns in the data, and develop hypotheses. Of the graphical techniques, one of the most common methods used by sedimentologists is to plot the sand, silt, and clay percentages on equilateral triangular diagrams. This means of presenting data is simple and facilitates rapid classification of sediments and comparison of samples (Poppe and Eliason, 2007). Further, sediment classification has been attempted by plotting the percentage of sand, silt and clay in a triangular diagram proposed by (Folk .,1957).In the study area most of the samples fall in sand region, and reaming samples fall in clayey sand, sandy silt, silt and sand-silt-clay respectively.(figure-7)

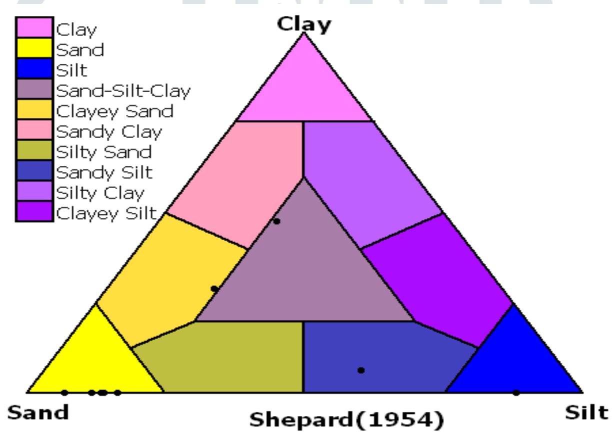


Figure. 7 Triangular (Shepard's) diagram showing distribution of study area sediment

## Conclusions

This study describes the sedimentary properties of sediments, mode of transportation, depositional processes along with estimation of organic carbon and organic matter in the pulicat lake. The organic matter in the Pulicat Lake ranges from 1.89% to 8.62%. It is mainly controlled by the grain size patterns; the main source of organic matter in the study area is due to high biological productivity. The major source of carbon content in these sediments is by worn type shell fragments. The graphic mean value indicates the dominance of medium to fine sand size particles (1.39 to 5.34 φ), show moderately to poorly sorting (0.915 to 2.742 φ), predominance of Coarse to very fine skewed (-0.565 to +0.597 φ), and very platykurtic to very leptokurtic in nature. The CM-pattern of sediment samples show modes of transportation of sediments into the lagoon by bottom suspension and rolling, graded suspension and by uniform suspension and deposited in tractive currents environment. Triangular plot shows the all the sediments are sand, clayey sand, sandy silt, silt and sand-silt-clay in nature. The present study helps for the quantification of parameters like organic matter, organic carbon & carbon content and warrants period monitoring of these parameters continually to know the effects ecological imbalances caused if any.

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