

Studies on the Sediments of Vembanad Lake, Kerala State: Part III—Distribution & Interpretation of Bottom Sediments

M. VEERAYYA & P. S. N. MURTY
National Institute of Oceanography, Panaji

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Percentage distributions of different size fractions and the grain size parameters of the sediments have been studied with a view to understanding the depositional processes operating in different parts of the lake. These studies have revealed that (i) in the southern half of the lake, coarser fractions are confined to the western margin of the lake and the finer fractions occupy the rest of the area while in the northern half, finer fractions are restricted to the estuarine region and the coarser fractions occupy the rest of the area including the rivers; (ii) well sorted and negatively skewed sediments are present in the Muvattipuzha and Ittupuzha rivers and in the neighbourhood of these river mouths and some of the subsidiary channels while poorly sorted and positively skewed sediments are present in the rest of the lake; and (iii) sediments deposited as bed load are confined to the Muvattipuzha and Ittupuzha rivers and to the subsidiary channel between Arakutti and Shertallai, those deposited as rolling and suspension population (with higher percentage of rolling population towards the western margin in the southern half) occupy the area between the southern end of Kumbalam Island and the southern end of the lake and those deposited as suspended load are restricted to the estuarine region. The presence of finer sediments in the southern half of the lake has been attributed to (i) the shallowness of the area, (ii) the presence of a number of big and small rivers that supply the finer material to the lake during the monsoon months, and (iii) the presence of fresh water conditions for the major part of the year, while the finer sediments in the estuarine region are due to the deposition of suspended load by flocculation during the post and premonsoon months and the supply of fine material from the sea through tidal currents during these months.

REGIONAL setting of the Vembanad Lake, Kerala State, and the distribution pattern of the different sediment units of the lake have been earlier described¹. In the present paper an attempt has been made to relate variations in different size fractions of the sediments that constitute the bulk samples and in the various grain size parameters to the depositional processes operating in different parts of the lake.

Methods

Locations of the stations from where the bottom sediment samples were collected are given earlier¹. From the sieving and pipette analysis data², sand, silt and clay proportions and grain size parameters such as phi deviation measure (σ_d) and phi skewness measure (α_d) based on the formulae of Inman³ were computed. A series of maps were then constructed showing the distribution of coarse sand, medium sand, fine sand, very fine sand, silt and clay by their weight in percentage. Also, maps were drawn showing the areal distribution of phi deviation measure, and the relationship of phi median diameter with phi deviation measure, of phi median diameter with phi skewness measure, of phi deviation measure with phi skewness measure and of median diameter with 1st percentile diameter (CM-diagram⁴) in μ . In the Muvattipuzha and Ittupuzha rivers and some of the subsidiary channels where samples were obtained only from the central portions and where no contouring is possible, the values of the parameters were recorded at the corresponding station locations in the respective distribution maps.

Results

Percentage Distributions of Different Size Fractions of Sediments

Coarse sand—Coarse sand distribution (Fig. 1) indicates that higher percentages of coarse sand occur only in the sediments of Muvattipuzha and Ittupuzha rivers. In the southern half of the lake (between Alleppey and Vaikam), largest amounts of coarse sand (5-20%) occur along the western margin of the lake while in the rest of the area, the values are below 5%. In the northern half of the lake (between Vaikam and Cochin), percentages in the range of 10-20 occur in a small area on the eastern margin of the lake north of the Ittupuzha river mouth and percentages in the range of 5-10 occur on the eastern margin of the lake between Ittupuzha and Muvattipuzha river mouths and at a few other isolated points. In the rest of the area, the values are below 5%.

Medium sand—Just as in the case of coarse sand, the medium sand also occurs in abundance in the sediments of the Muvattipuzha and Ittupuzha rivers (Fig. 2). In the southern half of the lake, higher percentages of medium sand (10-70%) are confined to the western margin of the lake while in the rest of the area it is below 10%. In the northern half of the lake, values in the range of 30-50% occur only at a few isolated places, viz. along the eastern margin of the lake between Muvattipuzha and Ittupuzha river mouths, at the south-eastern and northeastern corners of Perumbalam Island, at the northern end of the subsidiary channel

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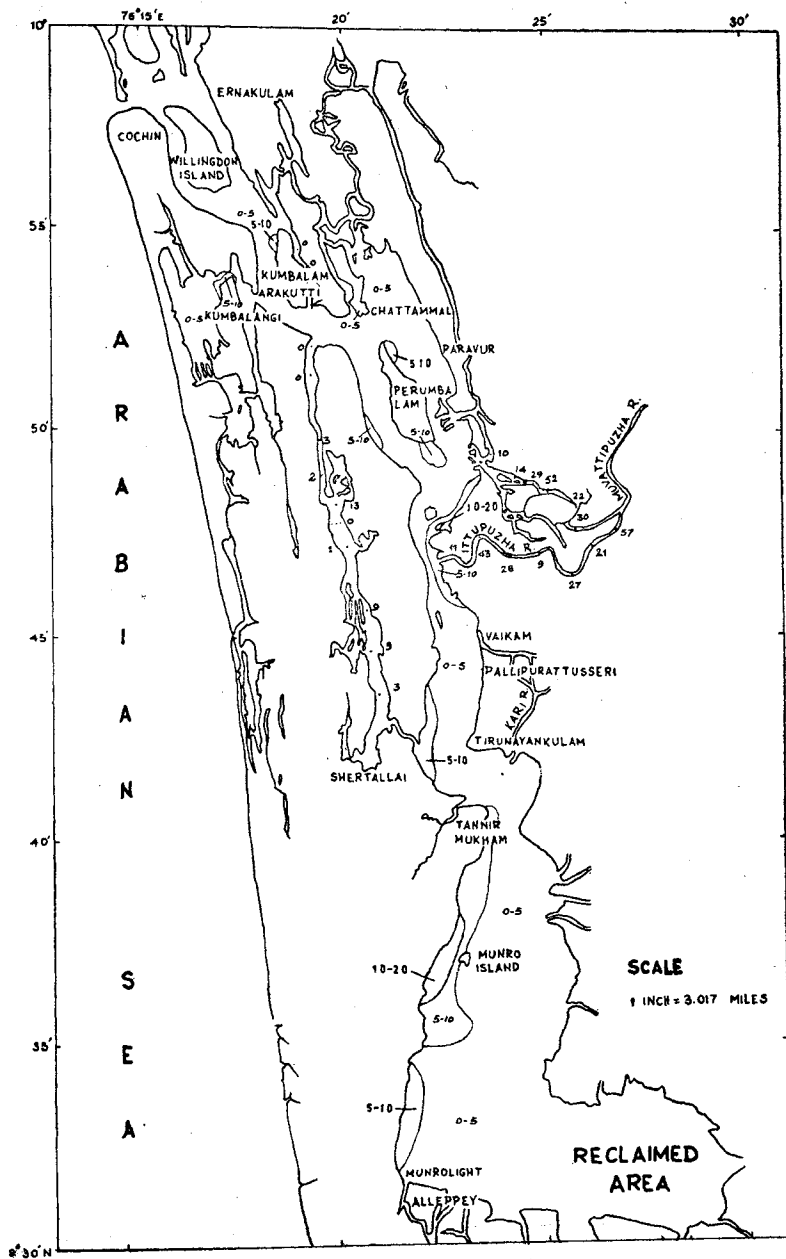


Fig. 1 — Percentage distribution of coarse sand

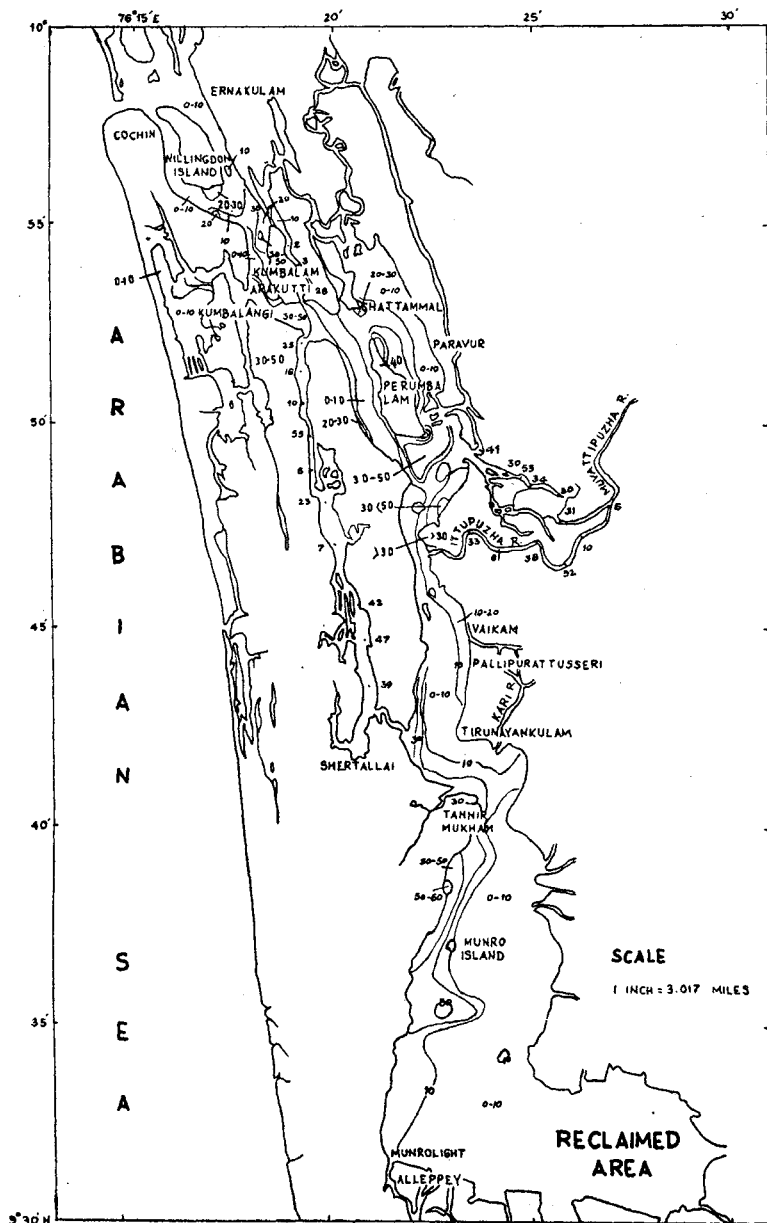


Fig. 2 — Percentage distribution of medium sand

running between Arakutti and Shertallai, at the northeastern corner of Kumbalam Island, etc.; values in the range 20-30% occur along the eastern margin of the lake between the river mouths of Muvattipuzha and Ittupuzha, along the eastern margin of Perumbalam Island and at a few isolated places such as at the southern end of Willingdon Island; values in the range of 10-20% are confined to the central half of the channel east of Perumbalam Island and eastern and western margins of the channel west of Perumbalam Island. In the rest of the area, values below 10% occur. In the subsidiary channel running between Arakutti and Shertallai, although values in all the ranges occur, most of them are confined to the higher ranges only.

Fine sand — Percentage distribution of fine sand in the lake (Fig. 3) shows that, by and large, the percentage values of fine sand in the sediments of Muvattipuzha and Ittupuzha rivers are relatively low in contrast to the values of coarse and medium sands. In the southern half of the lake, while values in the range of 30-50% occur all along the western margin of the lake, on the eastern margin of the lake, they occur only at a few isolated places. Values in the range of 20-30% occur as a narrow band along the western margin of the lake up to a little south of Tannirmukham and thereafter they occur along both the eastern and western margin of the lake up to Vaikam. Starting from the southern end of the lake at its western margin, values in the range of 10-20% run as a narrow band in the middle portion of the lake up to a little south of Tannirmukham. They also occur as a narrow elongated patch in the central portion of the lake between Tirunayankulam and Vaikam. Values in the range of 0-10% occur in a greater portion of the southern part of the lake and extend northward as a narrow band up to a little south of Tannirmukham, sandwiched between the higher values on either side. In the northern half of the lake, values in the range of 50-70% are confined only to a few isolated patches; values in the range of 30-50% occur in a greater part of the area between Ittupuzha river mouth and the southern end of Kumbalam Island, the subsidiary channel east of Kumbalam Island, the eastern margin of the subsidiary channel west of Kumbalangi, and also at a number of isolated spots; values in the ranges of 20-30 and 10-20% are confined to the middle portions of the channels on either side of Perumbalam Island, the eastern margin of the subsidiary channel west of Kumbalangi, the eastern margin of the channel to the east of Willingdon Island and the western margin of the channel west of Willingdon Island while values below 10% occur along the eastern margin of the channel east of Perumbalam Island, in the channels on either side of Willingdon Island and in the channels east of Kumbalam Island and west of Kumbalangi.

Very fine sand — Sediments of the Muvattipuzha and Ittupuzha rivers contain negligible amounts of very fine sand (Fig. 4). In the southern half of the lake, values in the range of 30-50% occur in a few isolated patches. Very fine sand in the range of 10-30% is characteristic of the southern half of the lake except at its southern end and in a narrow zone along the western margin where it ranges less than 10%. In the northern half of the lake, sediments with a very fine sand component of 30-50% occupy the eastern half of the channel east of Perum-

balam Island, the central part of the channel west of Perubalam Island, the subsidiary channel east of Kumbalam Island and a few isolated spots along the eastern margin of the channel east of Willingdon Island and the eastern margin of the lake opposite to the Ittupuzha river mouth. Values in the ranges of 10-30% are confined to the western half of the channel east of Perumbalam Island, the eastern and western margins of the channel west of Perumbalam Island, and a few isolated spots in the channels on either side of Willingdon Island. Values in the range of 0-10% are confined to the eastern half of the lake between the river mouths of Muvattipuzha and Ittupuzha, the channels on either side of Willingdon Island and to the channel west of Kumbalangi. In the subsidiary channel between Arakutti and Shertallai, the distribution is erratic.

Silt — Fig. 5 shows the percentage distribution of silt fraction of the sediments. It shows that the sediments of Muvattipuzha and Ittupuzha rivers contain little or no silt. In the southern half, higher percentages of silt (30-80) are confined to the eastern half of the lake while values in the range of 0-20% are confined to the western margin of the lake. In the northern half, values in the range of 50-70% are confined to the channels around Willingdon Island and the channel west of Kumbalangi. Values in the range of 30-50% occur in the eastern half of the channel east of Perumbalam Island, the central portion of the channel west of Perumbalam Island, the western half of the channel west of Kumbalam Island, the channels around Willingdon Island; values in the range of 20-30% occur in the central portion of the channel east of Perumbalam Island and in the channel west of it, in the channels around Willingdon Island and in the channel west of Kumbalangi. Values in the ranges 0-20% are confined to the rest of the area.

Clay — Fig. 6 shows the percentage distribution of clay fraction in the sediments. The clay content of the Muvattipuzha and Ittupuzha river sediments is practically nil. In the southern half, values in the range of 30-50% occur as a small patch at the southern end surrounded on either side by values in the ranges of 20-30 and 10-20%. To the north of this patch, values in the range of 0-10% occur in the eastern portion of the lake up to a little south of Tannirmukham and thereafter, these values are confined to the western margin of the lake while values in the range of 10-20% occur in the rest of the area. In northern half, values in the ranges of 30-70% are confined to the channels on either side of Willingdon Island, the western half of the channel west of Kumbalam Island, the channel west of Kumbalangi and to a few isolated spots at different parts of the lake; values in the range of 20-30% are confined to the eastern margin of the channel west of Kumbalam Island; values in the range of 10-20% are confined mostly to the channels on either side of Perumbalam Island while values in the range of 0-10% occur in the rest of the area.

Distribution of Grain Size Parameters

Phi deviation measure — Fig. 7 shows the regional variation in the phi deviation measure values of the sediments. It reveals that well sorted sediments occur in the Muvattipuzha and Ittupuzha rivers and near their mouths; in the area south of Perumbalam Island, in the subsidiary channel east of

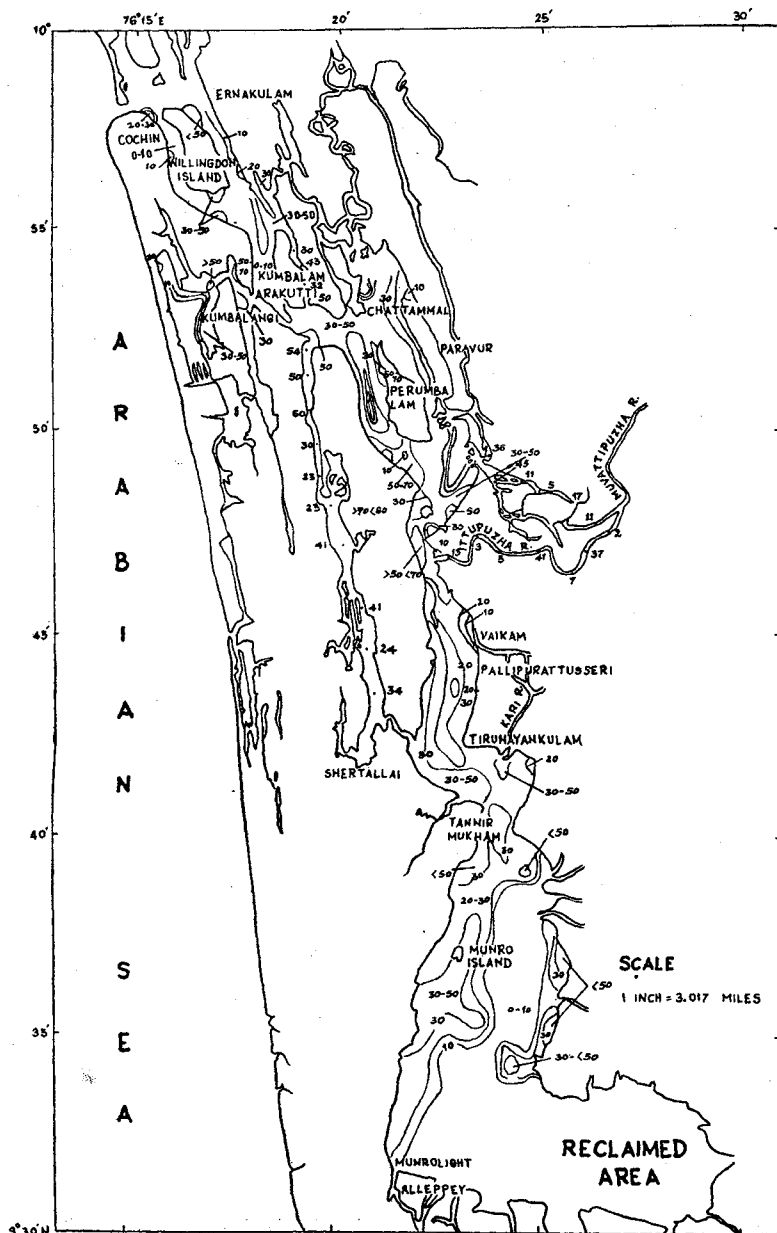


Fig. 3 — Percentage distribution of fine sand

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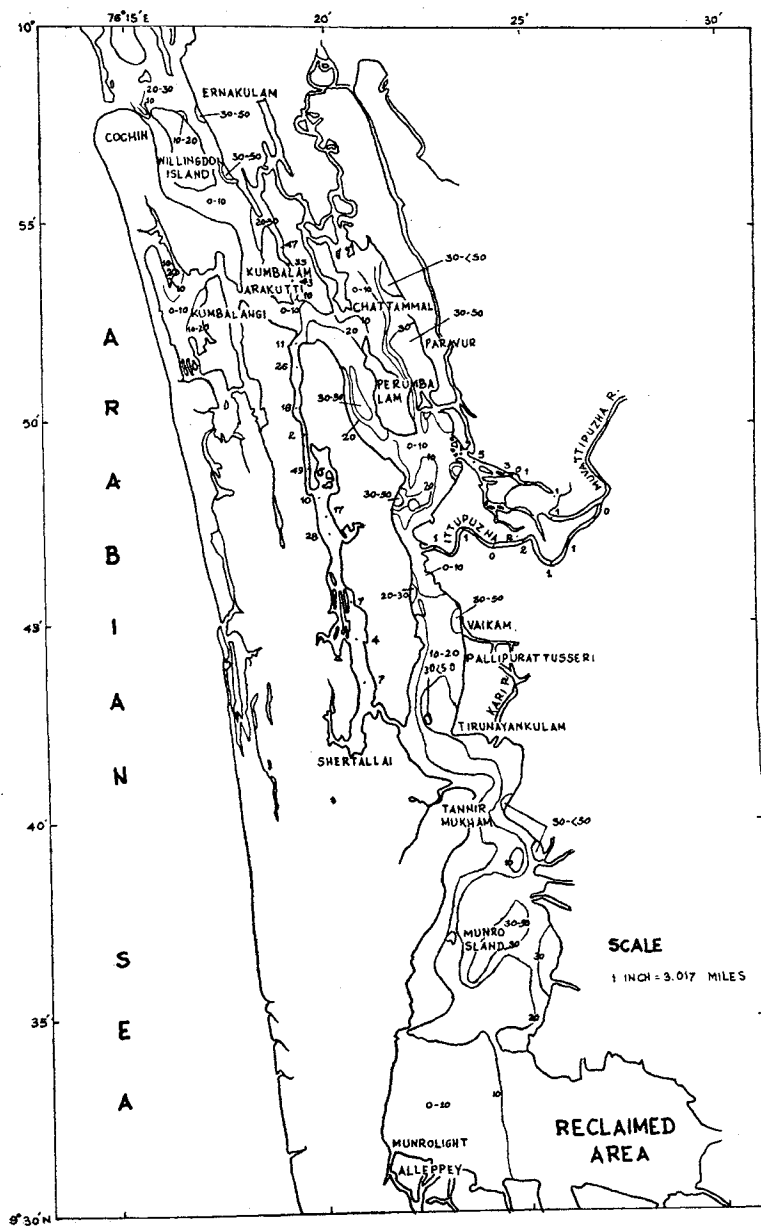


Fig. 4 — Percentage distribution of very fine sand

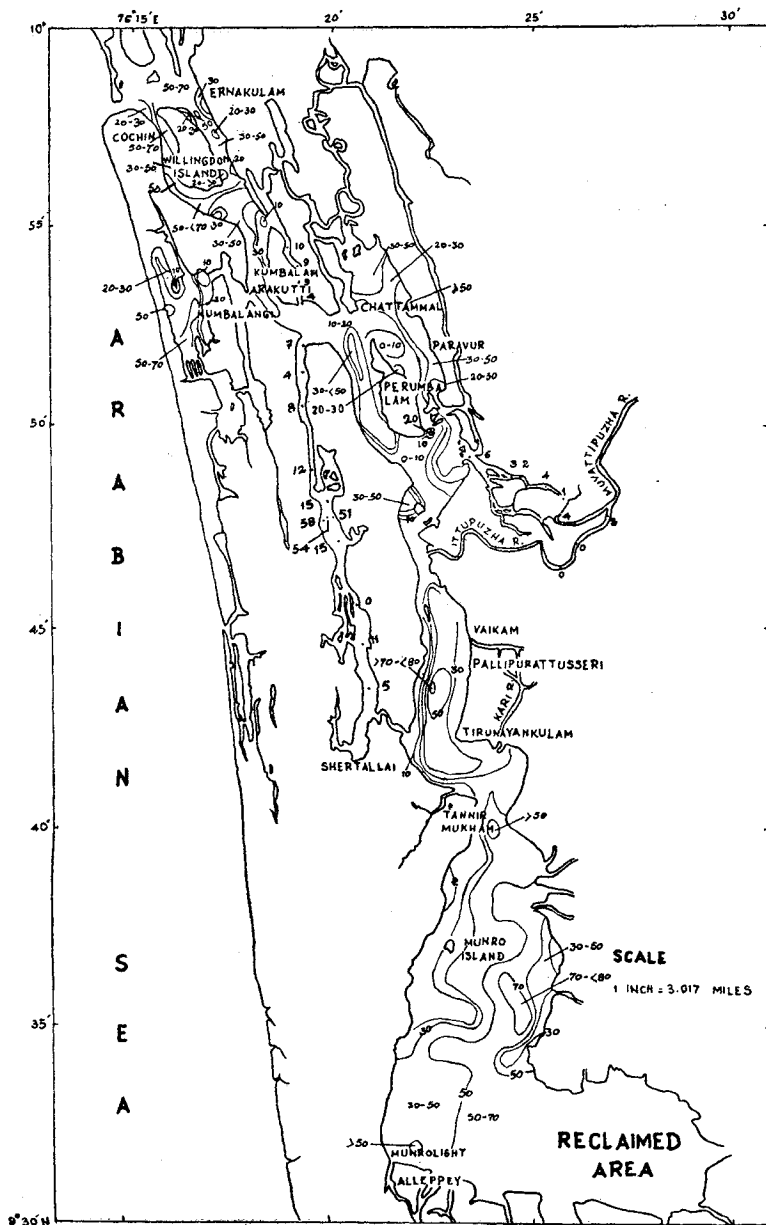


Fig. 5 — Percentage distribution of silt

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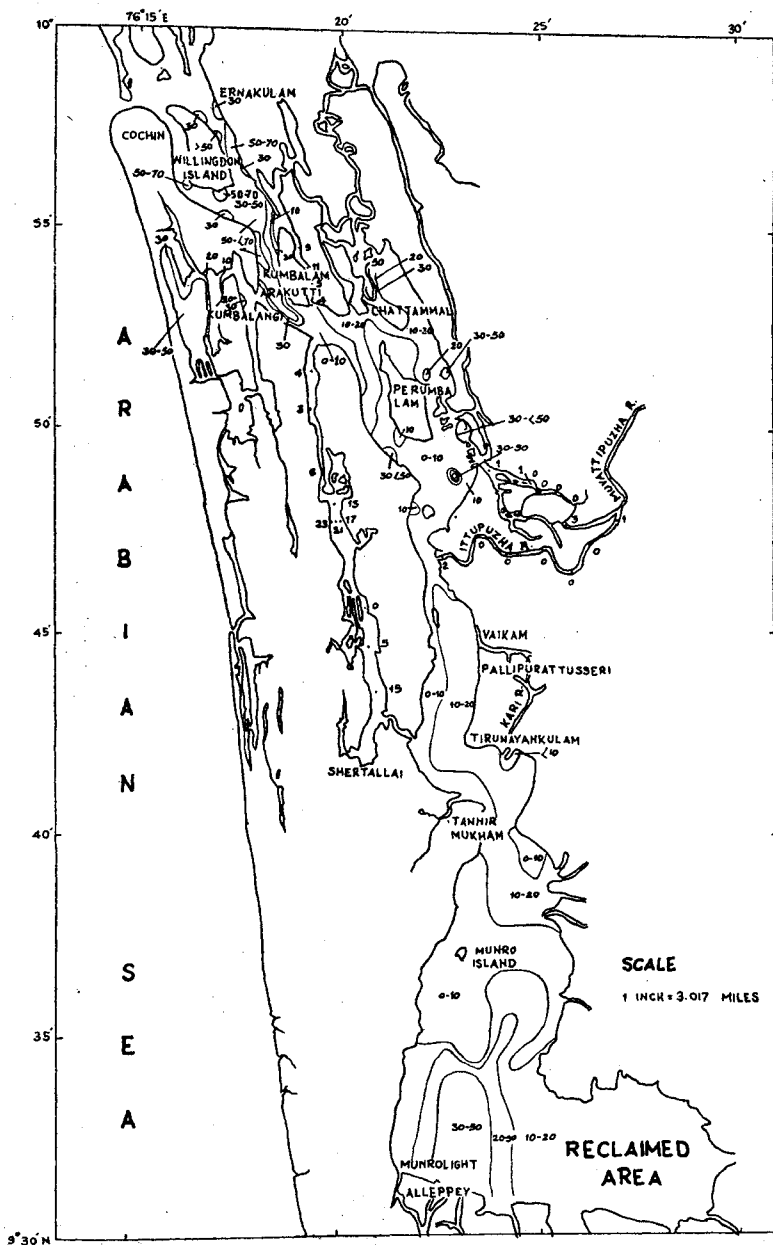


Fig. 6 — Percentage distribution of clay

Kumbalam Island, and in the major portion of the channel between Arakutti and Shertallai. In the rest of the lake (except in some samples, which were collected close to the banks), the sediments are poorly sorted.

The scatter plot between phi median diameter and phi deviation measure (Fig. 8) indicates that the sediments with median diameter mainly in the fine sand range have low standard deviation values and fall in well to moderately sorted class and the sediments show very poor sorting as the median diameter values increase beyond 3 phi.

Phi skewness measure—The values obtained reveal that the sediments of the Muvattipuzha and Ittupuzha rivers, and the region in front of these river mouths—extending up to the entrance channels east and west of Perumbalam Island in the north and up to a little south of Ittupuzha river mouth, and the estuarine region (partly) are negatively skewed while the sediments in the rest of the area are positively skewed.

The scatter plot between phi median diameter and phi skewness measure (Fig. 9) shows that the sediments with median diameter in fine sand range which are well sorted are either symmetrically distributed or slightly positively skewed or negatively skewed. Further, within this size range, a group of sediments which are poorly sorted attain positive skewness. The skewness values show a decreasing trend as the median diameter values increase.

The scatter plot between phi deviation measure and phi skewness measure (Fig. 10) indicates that the sediments having their phi deviation measure values in higher ranges are positively skewed while those having their phi deviation measure values in the lower ranges are characterized by negative skewness.

CM diagram—Fig. 11 shows the relationship between the median diameter and the 1st percentile diameter in μ of the sediments. It reveals that the sediments under study can be grouped into three categories in regard to their mode of depositions: (i) as bed load, (ii) as rolling and suspension population, and (iii) as suspended load. Sediments under the first category are confined to the Muvattipuzha and Ittupuzha rivers and to the subsidiary channel between Arakutti and Shertallai; sediments under the second category to (a) the southern half of the lake with higher percentages of rolling population along the western margin, and (b) the area between Ittupuzha river mouth and the southern end of Kumbalam Island; sediments under category three are restricted to the estuarine region.

Discussion

The sediment distribution pattern in a coastal lake depends on the sediment source, the texture of the sedimentary material supplied, the bottom topography of the lake and hydrographic features of the lake waters. A detailed description of the lake area under study has been given earlier¹. Ramamirtham and Jayaraman², Murty³ and Sanakaranarayanan and Qasim⁴ have described the hydrographic features of the lake waters. The area is under the influence of two monsoons, southwest and northeast. Of these, the southwest monsoon brings heavy rain fall (annual rain fall, 120 in.). The Pamba, Manimala and Achankoil rivers which join the lake at its southern end as well as the Muvat-

tipuzha and Ittupuzha rivers which enter the lake midway between Cochin and Alleppey flow through the precambrian formations in their upper reaches and through the recent alluvium in their lower reaches⁵. They together supply the sedimentary material to the lake during the monsoon months by way of bed load as well as suspended load.

Percentage distributions of different size fractions of the sediments broadly indicate the existence of a partition between the coarser and finer components of the sediments. In the southern half, higher percentages of coarse, medium and fine sand fractions are confined to the western margin of the lake (Figs. 1-3), while the finer fractions—very fine sand, silt and clay—occur in the rest of the lake (Figs. 4-6). In the northern half, higher percentages of coarse, medium and fine sand fractions are restricted to (i) Muvattipuzha and Ittupuzha rivers (especially the coarse sand fraction), (ii) region between their river mouths and the southern end of Kumbalam Island, and (iii) various subsidiary channels excluding the one west of Kumbalangi, while finer fractions of the sediments, particularly the silts and clays are confined to the estuarine region. One conspicuous feature in the northern half of the lake is that the coarse and medium sand fractions show a decreasing trend from the rivers to the estuarine region. On the other hand, the fine and very fine sands show an increasing trend towards the north up to the southern end of Kumbalam Island and thereafter they show an abrupt fall in their abundance. In terms of the texture of the sediments, sands are confined to the western margin in the southern half of the lake as a narrow band running almost all along the length of the lake. In the northern half, starting from a little south of the Ittupuzha river mouth, sands constitute the dominant sediment unit up to the southern end of Kumbalam Island. They also occupy all the subsidiary channels. In contrast to such distribution of sands, silty sands occupy a greater part of the southern half of the lake and have a restricted spread in the northern half. Silty clays are mostly confined to the channels on either side of Willingdon Island in association with the clayey silts while the clayey silts have considerable spread in the southern end of the lake¹. This distribution pattern broadly corresponds to the areal distribution of different size fractions of the sediments described above.

It is known that, normally, in the fresh water environment, mud occurs in the shoal areas and sand occurs in the channels. The shallowness of the area (depths varying from 2 to 3 m over a large area), the presence of a number of small rivers that join the lake along its eastern margin and the three major rivers at its southern end which supply a good amount of fine material and the presence of fresh water conditions for the major part of the year, may, perhaps, be responsible for the accumulation of the finer fractions of the sediments in the major portion of the lake in its southern half. Further, the existence of brackishwater conditions during the premonsoon period (mid January to mid May) may also help in the deposition of suspended materials through flocculation⁶. Although the western margin of the lake is not much deeper than the eastern side, the presence of coarser fractions of the sediments (sands in terms of texture) may be due to the presence of some type of currents(?) which

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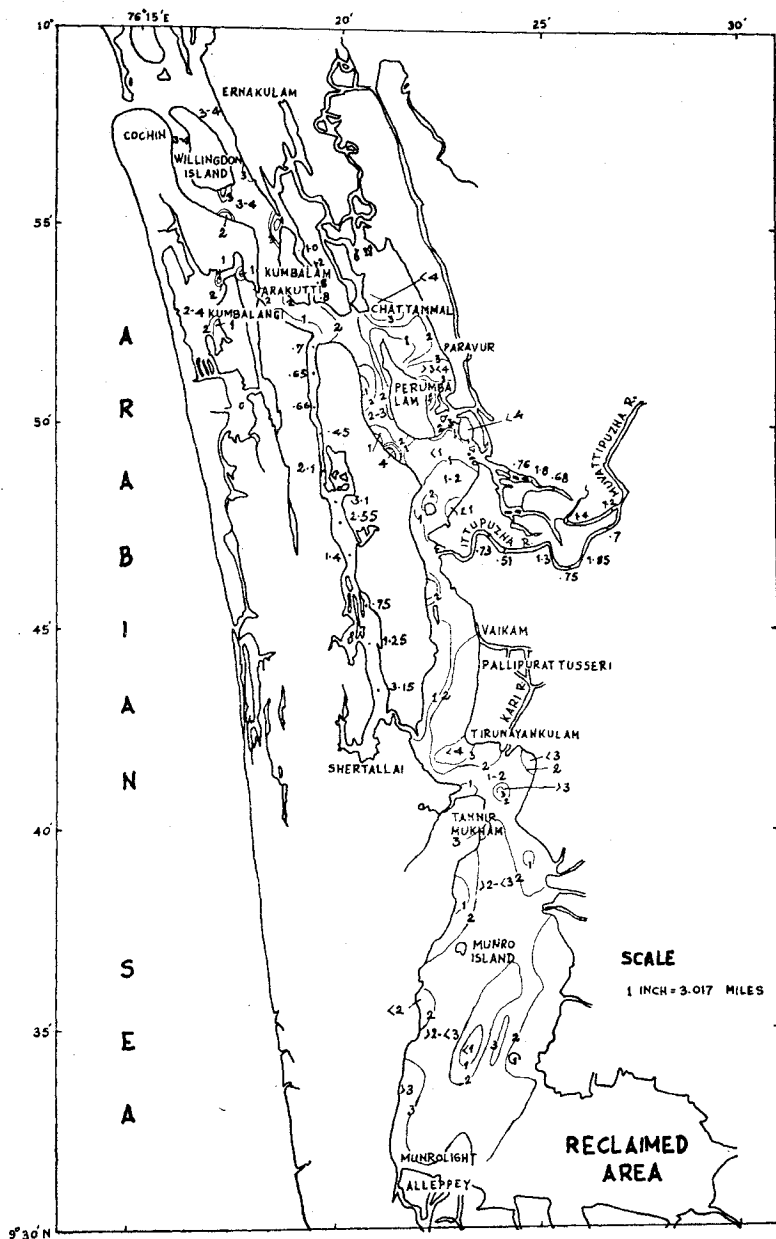


Fig. 7 — Distribution of phi deviation measure values

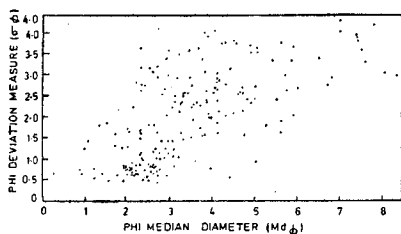


Fig. 8 — Scatter plot between phi median diameter and phi deviation measure

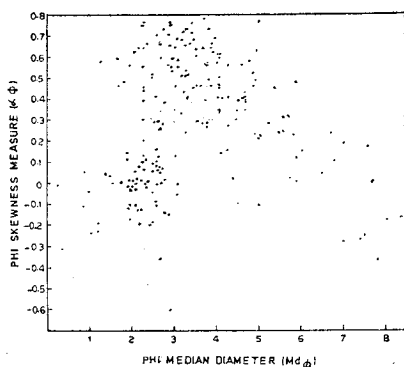


Fig. 9 — Scatter plot between phi median diameter and phi skewness measure

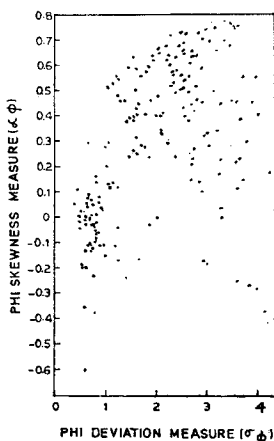


Fig. 10 — Scatter plot between phi deviation measure and phi skewness measure

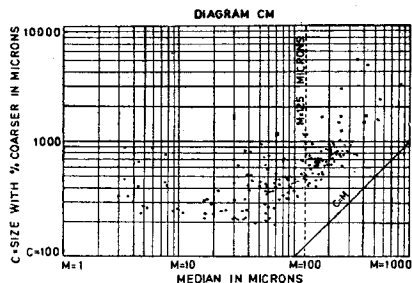


Fig. 11 — CM diagram of the sediments from the study area (●, Lake samples; points in right top square pertain to samples from the rivers and the channel between Arakutti and Shertalai]

may be preventing the deposition of finer fractions of the sediments. In the northern half, the presence of coarser fractions of the sediments (sands in terms of texture) in (i) Muvattipuzha and Ittupuzha rivers, (ii) area between the Ittupuzha river mouth and the southern end of Kumbalam Island, and (iii) subsidiary channels can be attributed to the influence of the Muvattipuzha and Ittupuzha rivers. The presence of predominantly finer fractions of the sediments, especially the silts and clays (silty clays and clayey silts in terms of texture) in the estuarine region is understandable as the sedimentary material enters the brackish to marine conditions it gets flocculated and settles to the bottom. Thus, while the settling of finer fractions of the sediments takes place during the postmonsoon and premonsoon months in the estuarine region, the conspicuous absence of the coarser fractions of the sediments can be attributed to the presence of saline water (salt wedge)¹⁰ at the bottom all through the year. Gopinathan and Qasim¹¹ have shown that silting in the estuarine area occurs during the pre and postmonsoon periods while the flushing of finer material from the estuarine region to the sea takes place during the monsoon period. Further, it may be mentioned here that the bottom sediments in the estuarine region comprise the sediment load brought from the rivers as well as the material transported from the sea into the estuary during the post and premonsoon months through tidal currents. The negative skewness values associated with some of the finer sediments of the estuarine region also indicated the continuous addition of fine material¹².

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