

Studies on the Sediments of Vembanad Lake, Kerala State : Part I — Distribution of Organic Matter

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Sediment samples collected from different parts of the lake between Cochin and Alleppey have been studied for their organic matter content in relation to the distribution pattern of the sediments and the hydrographical features of the lake. The organic matter content varies from 0.1 to 6.0% (av. 2.55%). It follows broadly the distribution pattern of the sediments in that the fine-grained sediments (silty clays and clayey silts) have higher organic matter content than the sands and silty sands. While this is broadly so, the fine-grained sediments in the estuarine region have relatively higher organic matter content than their counterparts in the other parts of the lake. This has been traced to the differences in the hydrographical features and the organic production of the waters.

AMONG the numerous lagoons and estuaries that are present along the Kerala coast, Vembanad Lake, extending from Crangannore in the north to Alleppey in the south in the central part of the Kerala coast, is the largest. In recent years, considerable amount of work has been carried out on the waters of this lake between Cochin and Alleppey and a good amount of information is available on the physical, chemical and biological aspects of these waters. But no information is available on the nature of the bottom sediments, their mineralogy, and chemistry. Hence, a comprehensive study of the sediments of this lake between Cochin and Alleppey has been initiated and the present paper gives a brief account of the organic matter content of the sediments in relation to the distribution pattern of the sediments and the hydrographical factors.

Description of the Area

Vembanad Lake is a coastal lagoon bordered on its west by the Arabian Sea and separated from it by a barrier beach. In the area under study, it is about 65 km long and has an area of 20461 hectares. It has a permanent connection with the sea at Cochin. Three major rivers, viz. Pamba, Manimala and Achankoil, debouch into the lake at its southern end at different points (not shown in the map). Another major river Muvattipuzha with its branch Ittupuzha joins it midway between Cochin and Alleppey. Apart from these major rivers, a number of small rivers flow into the lake at different points. In the northern half of the lake (north of Vaikam), there are a number of subsidiary channels which are separated from one another by sand bars which have been described by Vaidyanathan¹ as ancient beach ridges. The barrier beach and these sand bars (ridges) have roughly the same trend—NNW-SSE.

The depth as well as the width of the lake varies from region to region. In the channels on either side of Willingdon Island on which the harbour is situated, a depth of about 12 m is maintained by

dredging for the passage of the ships. In all other areas of the lake, the depth varies between 1.5 and 6 m.

The presence of the harbour and the influence of land make the region around Willingdon Island highly polluted. In the south where the lake attains its maximum width, the eastern half has been reclaimed for irrigation purposes and bunds have been constructed. This region which appears as a single sheet of water in the map is now traversed by a network of canals passing through the different blocks of the reclaimed area. At Tannirmukham where the lake has its minimum width, a barrage is being constructed to prevent the incursion of salt water into the southern region so that more area could be brought under reclamation. Dredging is done at a number of places for the exploitation of subsurface shell deposits.

Methods

During November-December 1969, bottom sediment samples were collected from the different parts of the lake and Muvattipuzha and Ittupuzha rivers at close intervals using a Van Veen grab. In all about 2.50 samples were collected and the locations of the stations are shown in Fig. 1. Observations regarding colour, odour, etc., of the sediments were made immediately after collection.

In the laboratory, each sample was thoroughly mixed and representative sample taken and dried in the hot air oven around 70°C. Then a portion of the sample was taken for grain size analysis and the other portion pulverized for chemical analysis. The portion used for the chemical analysis was washed with distilled water repeatedly to remove salts.

All the samples collected were subjected to grain size analysis. After separating the samples into sand and silt-clay fractions, the former was sieved and the latter subjected to pipette analysis following the method of Krumbein and Pettijohn². From the data, cumulative frequency curves were drawn and the median diameter computed. The ratios

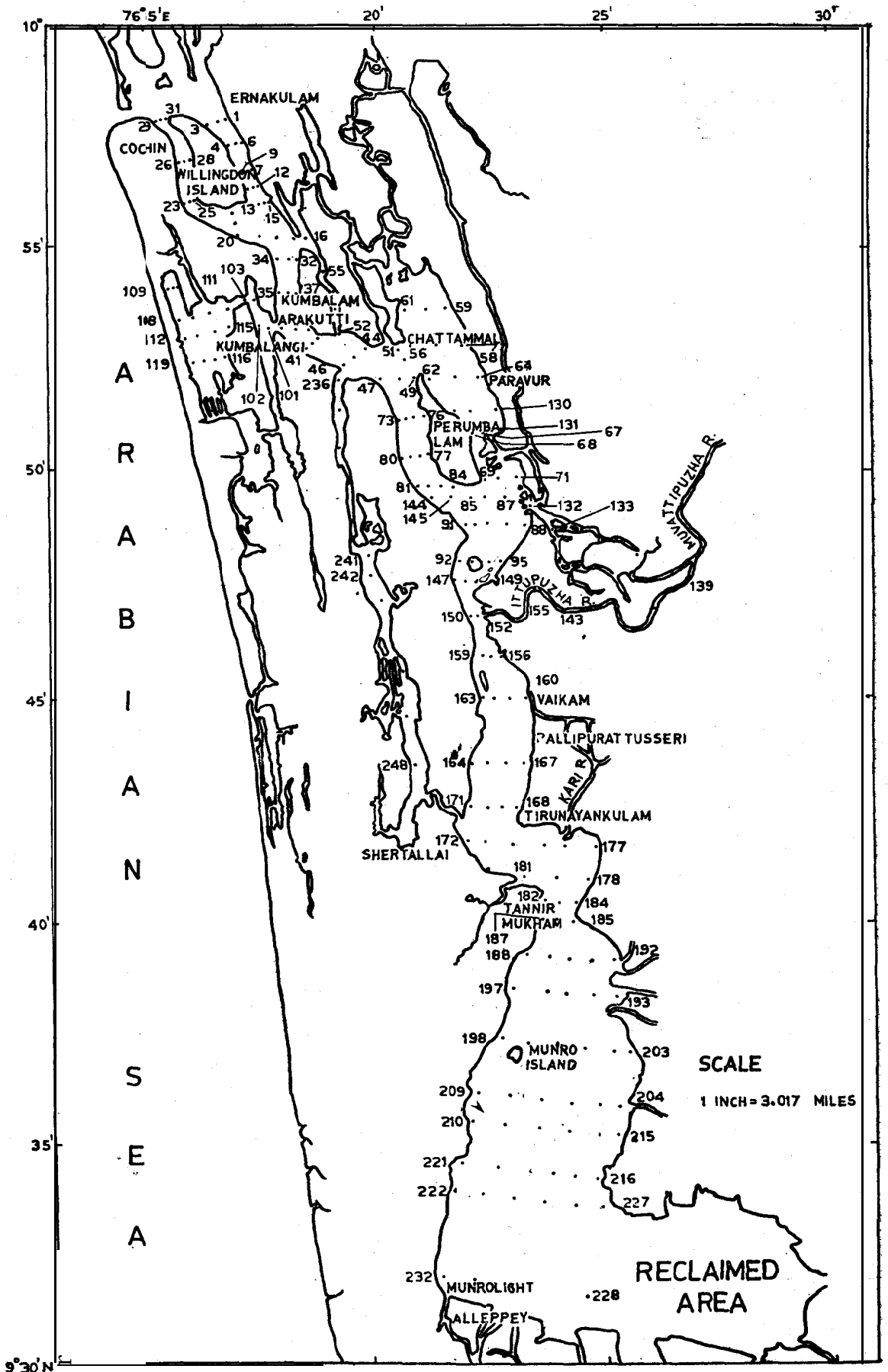


Fig. 1 — Sample locations in the area of study

of sand, silt and clay were calculated from the weight percentages and the texture of the sediments determined based on proportions of sand, silt and clay, as suggested by Shepard³.

Organic carbon was determined by the direct method of El Wakeel and Riley⁴ and the organic matter computed using a factor of 1.723.

Results and Discussion

Grain size and texture of the sediments — The median diameter of each sample as obtained from the cumulative weight frequency curve was plotted at the corresponding sample location on the chart and isopleths of 4 and 8 phi were drawn (Fig. 2). The median diameter ranges from coarser than 4 phi to finer than 8 phi. Sediments finer than 8 phi as their median diameter (clays) are met with in the channels on either side of Willingdon Island and there too they have little spread. Sediments having their median diameter in the silt range have a larger spreading. One zone starting from the southern end of the lake extends up to a little north of Munro Island. While this zone occupies the entire width of the lake at its southern end, towards north its width decreases and it is flanked on either side by a zone of sand. A second zone starting from Tirunayankulam extends northward up to Pallipurattuseri. This is also surrounded on all sides by a sand zone. The third zone occurs in the subsidiary channel west of Kumbalangi and occupies the entire channel except for a small portion on the eastern margin. Another zone is associated with the clay zone in the channels on either side of Willingdon Island and in the western half of the channel south of the Island. In the rest of the lake, the floor is carpeted by sediments having their median diameter in the sand range.

The areal extent of the different sediment units based on their texture is shown in Fig. 3. In terms of texture, sediments having a considerable spreading fall mainly under four categories, viz. sands, silty sands, silty clays and clayey silts. In the southern half of the lake, sands are confined to the western margin of the lake as a narrow band, running almost all along the length of the lake. In the northern half (north of Vaikam), starting from a little south of 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 this distribution of sands, silty sands occupy a greater area in 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. The last-named sediment unit has a considerable spread in the southern end of the lake and is surrounded by sandy silts. The other sediment units met with, namely sand-silt-clays, sandy silts and clayey sands, do not have any significant spreading. The factors giving rise to this pattern of distribution of sediments in the lake will be dealt with elaborately elsewhere.

Organic matter — The organic matter content of these sediments ranges from 0.10 to 6.00% (av. 2.55%). The range of values obtained for the four major sediment units, sands, silty sands, clayey silts and silty clays, are 0.10-2.80%, 1.38-4.28%, 2.90-6.00% and 3.30-6.00% respectively.

Although there is a certain amount of overlapping of values it can be seen that finer sediments have higher values than coarser sediments. In general, a decrease in median diameter was accompanied by an increase in the organic matter content. This is in agreement with the findings of several workers⁵. The average values of organic content for sands, silts and clays of this area are 1.42, 3.55 and 4.80% respectively while the average values reported for sand, silt and clay for the nearshore sediments of many parts of the world are 1, 2 and 4% respectively⁶.

Fig. 4 is an isopleth map of organic matter in the sediments of the lake. In Muvattipuzha and Ittupuzha rivers and some subsidiary channels where samples were collected from the centre only, the values of organic matter obtained are recorded at those station locations. It can be seen from this figure that in the northern half of the lake (north of Vaikam) values between 4 and 6% are confined to (i) the channels on either side of the Willingdon Island, (ii) the western half of the channel west of Kumbalangi. Values below 1% and between 1 and 2% are mostly confined to (i) Ittupuzha and Muvattipuzha rivers, (ii) all the subsidiary channels other than the one west of Kumbalangi, (iii) the region starting from a little south of Ittupuzha river and extending up to southern end of Kumbalam and (iv) western half of the lake east of Perumbalam Island. In the rest of the area, values between 2 and 4% occur with a little amount of overlapping. In the southern half of the lake values between 3 and 4% and 2 and 3% are mostly confined to the southern end of the lake. Values between 2 and 3% are also met with in the region starting from a little west of Kari river mouth and extending for a few miles northward. Values below 1% are confined to the sand zone running along the western margin of the lake north of Tanuirmukham. In the rest of the area, values between 1 and 2% occur. It should, however, be mentioned here that in the sand zone running along the western margin of the lake south of Tannirmukham also, values more than 1.50% are not recorded.

A comparison of Fig. 4 with Fig. 3 will show that the organic matter distribution of the lake sediments follows broadly the sediment distribution pattern in that the finer sediments, silty clays and clayey silts, have higher organic matter content and the sands have a lower organic content with the other types of sediments sharing values in between. While this is broadly so, a careful examination of the data shows that clayey silts in the northern region (around Willingdon Island) exhibit a higher content of organic matter than their counterparts in the southern end of the lake.

The organic matter content of the estuarine or lagoonal sediments is dependent upon sources like (i) from land through run off and (ii) from the overlying waters through organic productivity and the influence of the sea in the estuarine part. With the presence of several rivers joining at different points, the source from the land is evident. However, in order to understand the differences observed in the organic matter content of the fine-grained sediments in the estuarine region and their counterparts in the southern end of the lake, a discussion of the hydrographical and hydrobiological features of the lake is necessary. Our

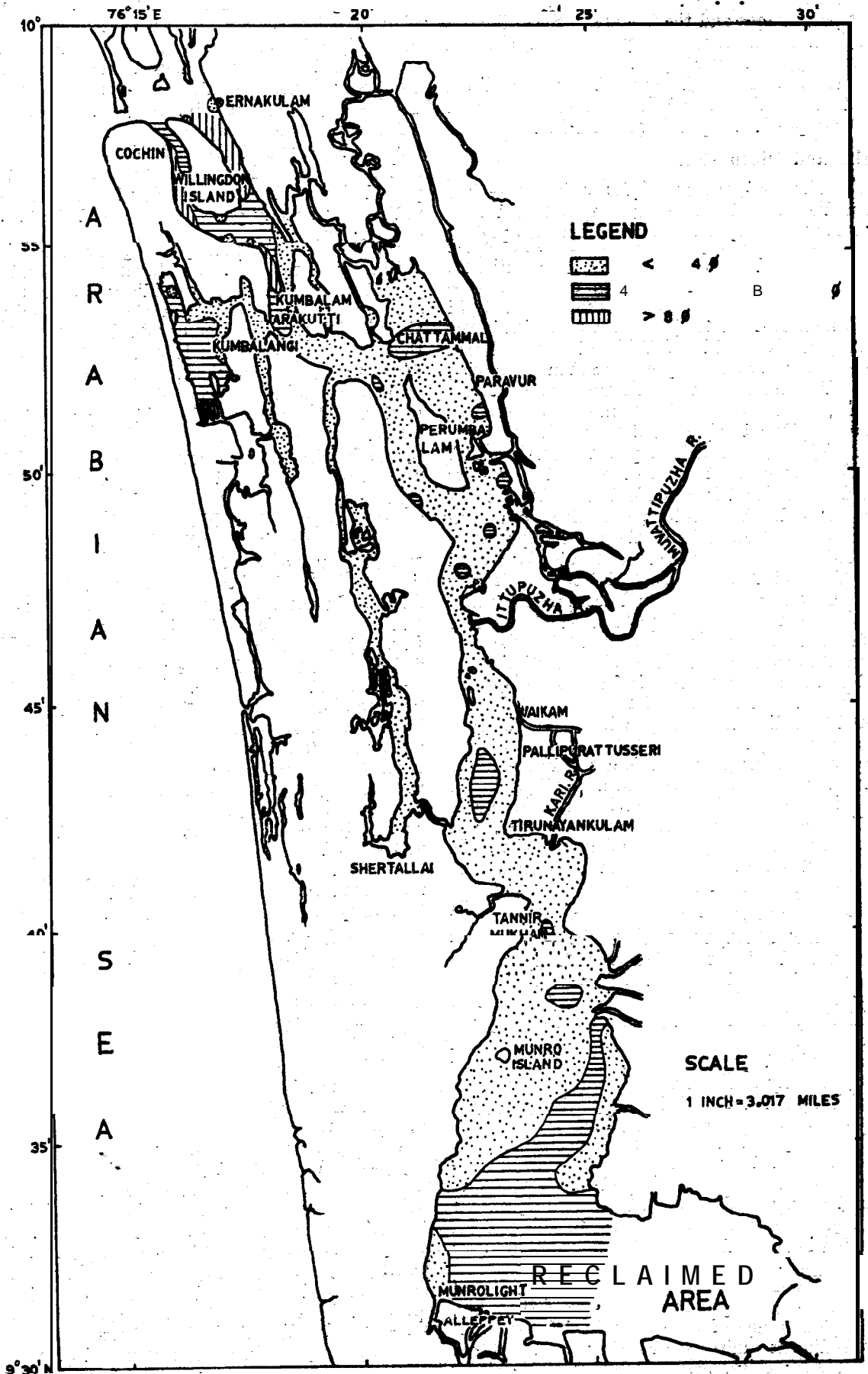


Fig. 2 — Distribution of phi median diameters in the lake

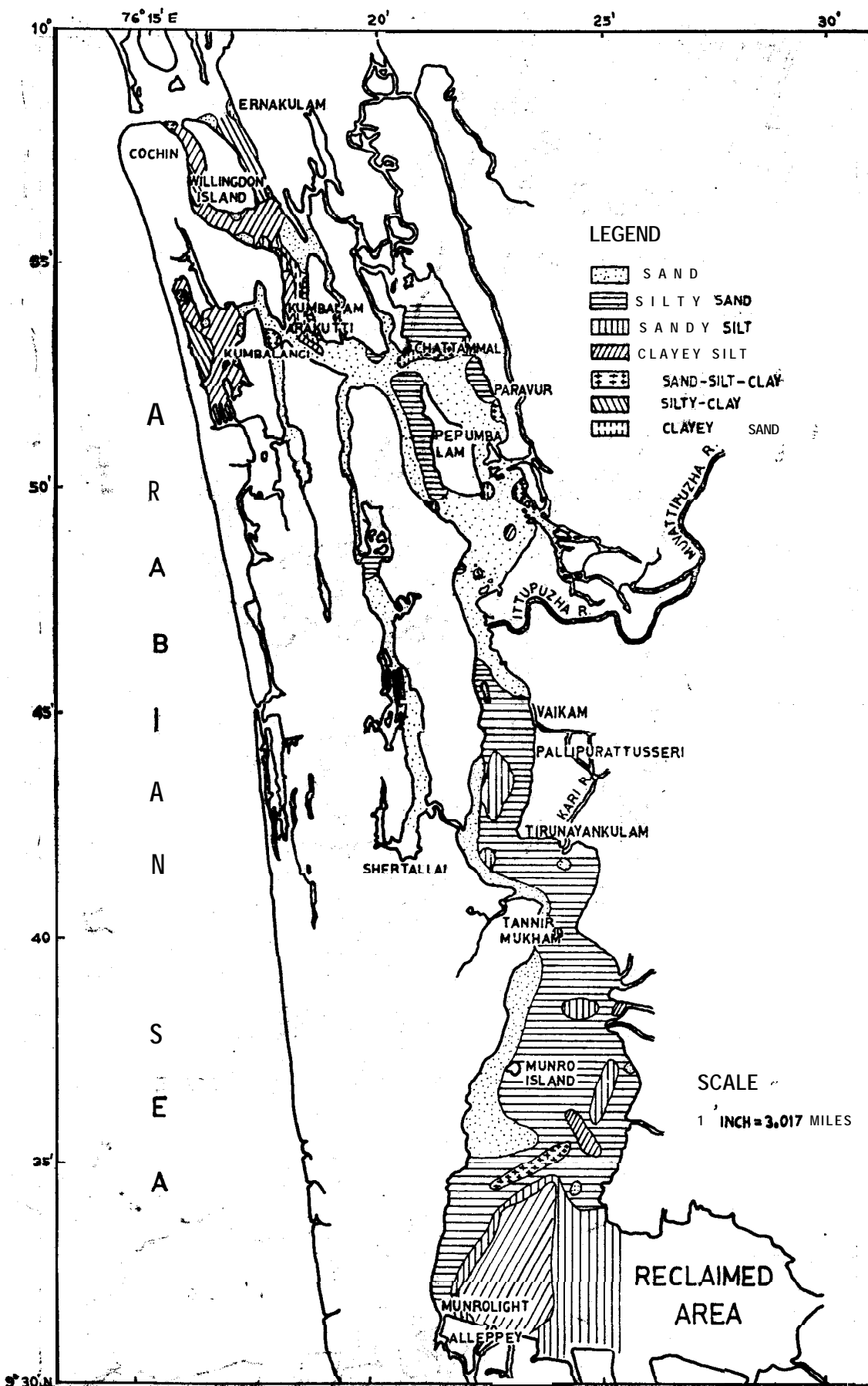


Fig. 3 — Distribution Of sediments based on sand, silt and clay content in the lake

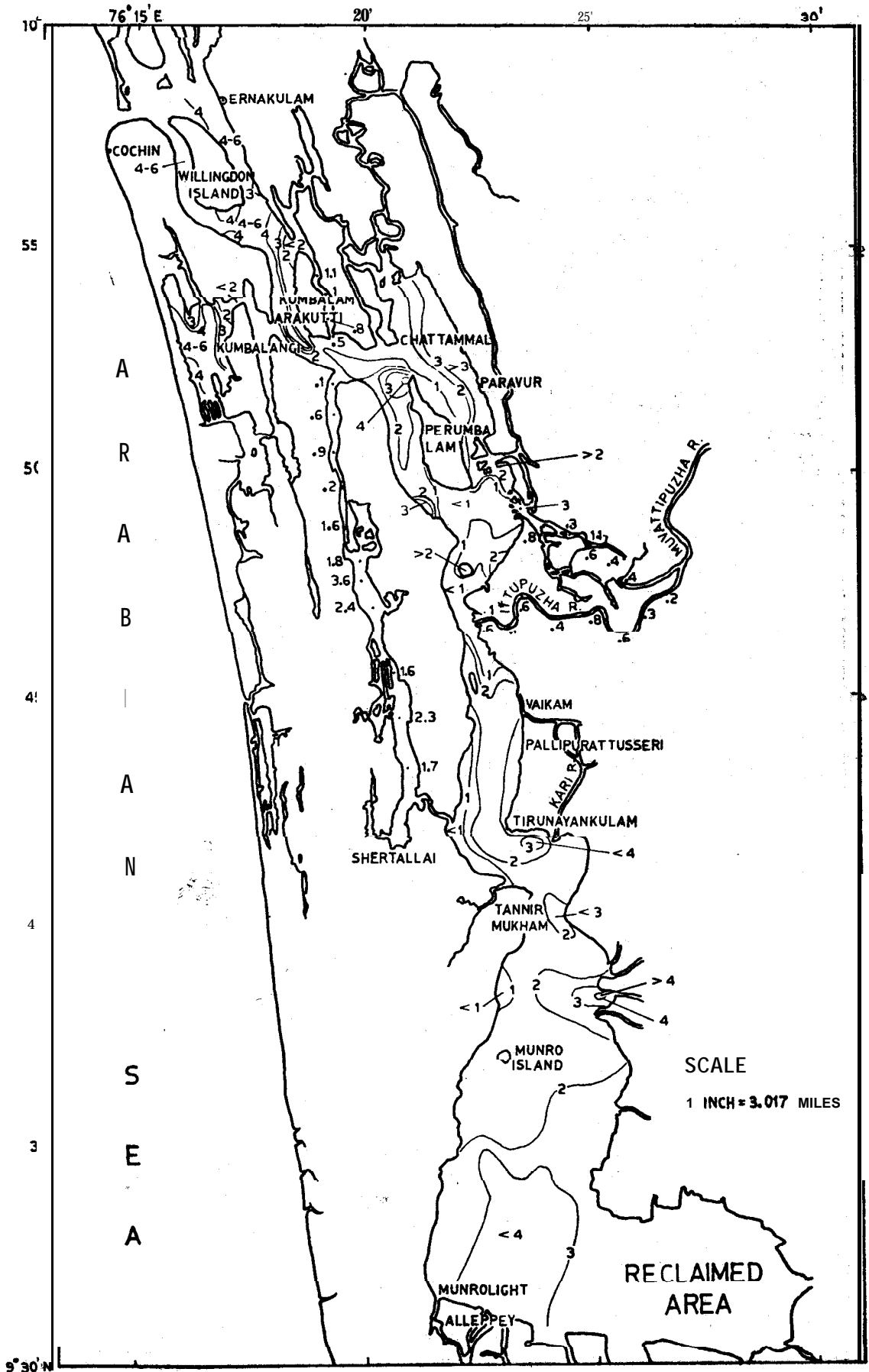


Fig. 4 — Distribution of organic matter in the lake

knowledge of the hydrographical features of the lake is mainly derived from the works of Ramamirtham and Jayaraman⁹, Murty¹⁰ and Sankaranarayanan and Qasim¹¹. While Murty carried out his studies up to the southern end of the lake, investigations carried out by other workers were confined to the estuarine part of the lake only, i.e. between Cochin Harbour entrance and Arakutti. These studies indicate that from January to April/May stable marine conditions exist in the estuarine area with practically no vertical gradients in the various parameters like salinity, temperature, oxygen etc. In the rest of the lake, there is a progressive increase in the salinity of waters both at surface and bottom from month to month; from January to April/May the conditions change from fresh water (in January) to marine even at the southern end of the lake. By April/May complete mixing takes place. With the onset of monsoon in May/June, in the estuarine part, fresh to brackish water conditions exist at the surface while marine conditions continue to prevail at the bottom with cold and dense high salinity water with low oxygen content being present. These bottom waters have been recognized by Ramamirtham and Jayaraman⁹ as up-welled waters from the Arabian Sea. In the rest of the lake, fresh water conditions exist at the bottom also. With the termination of the monsoon season (in October) and the decrease in the fresh water flow, marine conditions begin to develop quickly: in the estuarine part even at the surface and slowly in the rest of the lake. Productivity studies in the estuarine part indicate that phytoplankton production is uniform throughout the year and it far exceeds the zooplankton production¹². Typical marine conditions being present in the rest of the lake—for a month or two only, it is conceivable that the area may be much less productive than the estuarine region. Hydrobiological surveys conducted by Devassy and Gopinathan¹³ up to Alleppey before and during monsoon support this conclusion.

In view of the conditions mentioned above, it is understandable that the fine-grained sediments in the estuarine region have a higher content of organic matter. Although fine-grained sediments are also present in the southern end of the lake and there is a good supply of material from the land, the shallowness of the lake, the high dissolved oxygen content of the waters throughout the year and high water temperatures (27° to 32°C) of both the surface and bottom waters may aid in the destruction

of organic matter by oxidation rather than preservation of it in these sediments. The brown colour of these sediments in contrast to the greenish black colour of the estuarine sediments lends support to this conclusion.

A comparative study of the organic matter content of these sediments with that of the adjacent shelf and slope regions¹⁴ indicate that they compare favourably with them. A comparison made with the sediments of the Chilka Lake on the east coast of India shows that, in general, the sediments of Vembanad Lake have a higher percentage of organic matter than the sediments of Chilka Lake. The average organic matter content of Chilka Lake is 1.38% (ref. 15) which is much lower than the average for Vembanad Lake (2.55%).

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