

Studies on the Size Distribution and Physical Parameters of the Sediments of the Cochin Harbour

THOMAS CHERIAN

National Institute of Oceanography, Panji, Goa

ABSTRACT

The paper presents the results of the studies on the various physical parameters of the sediments in and around the Cochin Harbour as a prelude to the study of the problem of sedimentation in this Harbour. About 78 samples were analysed and their median size, coefficient of sorting, skewness and water content were determined. The studies show that the median size of the sediments of the backwaters varies between coarse clay and medium sand ranges. In general, the sediments of the Cochin backwaters are poorly or moderately sorted. The coarse sediments are better sorted than the fine sediments. All samples exhibit positive skewness, suggesting that coarser admixture predominates. The water content of the samples varies between 27% and 72%. More than 70% of the sediment samples has water content values higher than 50%. There exists an inverse relationship between the percentages of water content and sand fraction of the samples.

INTRODUCTION

The present study is based on the analyses of bottom sediment samples from 78 stations situated in the Cochin backwater and in the immediate vicinity of the Cochin harbour. The sampling was mainly confined to the northern part of the backwater system where presumably the greatest variations in the sediments may be expected.

In the central portion of the backwater, however, there is a channel which divides into two branch channels: Ernakulam channel and Mattancherry channel. The main channel extends westward outside the barmouth which is the approach channel to the Cochin Harbour. The average depth of these channels varies between 30 and 35 feet. The area under study along with the exact locations of stations is given in Fig. 1.

Trask (1930) appears to have been the first to recommend the preparation of maps showing the areal variations of sediments by means of the median grain diameters. Pratej (1932) suggested the regional statistical method to study the sediments by collecting the samples over an area by means of sampling grid to establish the relation between the sediments and their environment. More recently Krumbein and Aberdeen (1937) made use of isopleth maps for the study of the physical factors in the environment which control the deposit. No previous account has appeared representing the sediments of the Cochin Harbour statistically through isopleth maps. Recently some studies were made on size distribution and organic matter of the sediments of Vembanad Lake by P.S.N. Murty *et al.* (under publication).

COLLECTION OF DATA

The data was collected using the Institute's Research Vessel "NEENDA-KARA" which is equipped for work in shallow waters. The stations were numbered serially in the order of collection. The stations fall on a grid pattern which divides every square mile into quarters. Samples were collected from nearly every quarter, and on this basic pattern additional samples were collected when changes in the nature of samples were seen. Samples were collected using Van Veon grab from most of the stations where the depth was small and current speed was not high. At few stations especially outside the barmouth, the collection of the samples was made by operating the LaFond--Dietz snapper. The sample for the analysis was taken from the upper 5 cms of each sample for the study of areal distribution of the various statistical parameters of the sediments in the region. The data represents the conditions in the pre-monsoon period when the bottom deposits are least disturbed due to land drainage.

METHODS OF ANALYSIS

The standard pipette method by Krumbein and Pettijohn (1938) was used for the analysis of all samples except a few whose particle size lies entirely within the range of sieve sizes. The coarse sediments and the coarse fraction of the fine samples were analysed following the standard sieve method. The water content values were determined by drying a fixed quantity of each sample in a hot air oven for 15 minutes at 90°C.

GRAPHIC PRESENTATION AND STATISTICAL ANALYSIS OF THE DATA

The phi-scale was conveniently chosen to represent the data of the samples. The data is presented graphically using ϕ as an independent variable. The standard statistical parameters - such as Median ($Md\phi$), Quartile Deviation ($QD\phi$), Coefficient of sorting (So) and Skewness (Sk) were computed according to the methods of Krumbein and Pettijohn (1938) and Trask (1932). For statistical purposes the median is chosen as an average value, and the spread of the curve is expressed as the phi quartile deviation. These two values furnish data on the size and the degree of sorting, in connection with maps of the statistical values. The phi median and phi quartile deviations of the samples are presented as isopleth maps in Figs 2 and 3 respectively.

DISCUSSIONS

Isopleth maps for median ($Md\phi$) and quartile deviation ($QD\phi$) were prepared by plotting the values at each sampling point. (An isopleth may be defined as a line of equal abundance or magnitude (Krumbein 1936). The salient features of these two maps of sediment characteristics are discussed here.

(i) AREAL DISTRIBUTION OF SIZE, EXPRESSED AS $Md\phi$:

The phi median of each sample was plotted at its corresponding sampling point and isopleths representing one-half phi unit (one $\sqrt{2}$ class interval) were drawn as shown in Fig. 2.

The map gives the general distribution of sediments in the area. It can be seen that the median diameter of the sediments of the Ernakulam channel mostly lie between 3ϕ and 4ϕ which fall in the very fine sand ranges though there is a linear zone of coarse silt at the southern end of the channel. The isopleths follow a wavy pattern and show a gradation with the grain size decreasing slightly towards the eastern side of the channel.

The northern part of the Mattancherry channel shows a similar pattern regarding the nature of the bottom deposits as the $Md\phi$ values vary mostly only between 3.6 and 3.8 (very fine sand). But at the central part of the channel, the isopleths first show an increase in value towards east and thereafter towards west. South of this channel, the median size of the sediments increases gradually southwards as the isopleths show a decreasing tendency. The coarsest sediments in the backwaters are encountered at stations south of Mattancherry channel where $Md\phi$ has values around 2 (Medium-Fine Sand).

At one place outside the channel, between Ramantharathi island and Bolghaty island, the isopleths enclose a zone of fine sediments. Another zone of fine sediments

can be noticed between *Ramanthuruthi* island and *Vimanathiru* island where the finest sediments in the backwaters are observed, having median diameters about 8ϕ (coarse clay). A region of coarse sediments can be observed very near the Ernakulam shore opposite to the barmouth where the $Md\phi$ has values as low as 2.5 (fine sand). North of this, the region between the Ernakulam shore and *Bolghaty* island is characterized by coarse sediments, the median diameter varying between 2ϕ and 3ϕ (Fine to Very Fine sand). A similar region of coarse sediments can be seen between *Bolghaty* island and *Wallarpat* island where the median size of the sediments fall in the Fine or Very Fine sand ranges.

The sedimentary conditions outside the barmouth are quite clear from the isopleth map of the region. The median diameter shows a gradual decrease in size in the offshore direction. It varies from about 2ϕ (Fine sand) to 2.5ϕ (Fine sand) from station No. 67 near the barmouth to station No. 74 near the No. 3 buoy, over a distance of 1.5 nautical miles. Further west, in the region between stations 74 and 77, from No. 5 buoy to No. 1 buoy, the isopleths lie more close with values increasing from 2.5ϕ to 5.5ϕ (Fine sand to Medium silt) over an extent of about 0.7 nautical mile indicating a sharp decrease of sediment size offshore. Another feature is the decrease in the size of the sediments in the northward and southward directions from the approach channel. This decrease is more conspicuous towards north than towards south.

(ii) AREAL DISTRIBUTION OF $QD\phi$:

The phi quartile deviation is a measure of the average spread of the curves, expressed directly in Wentworth grades. The areal distribution of $QD\phi$ is shown in Fig. 3. Isopleths were drawn at intervals of 0.5 each of which represents an additional wentworth grade between the quartiles. The quartile deviation map seems to have resemblance to the phi median map. The general nature of sorting can be understood from Trask's coefficient of sorting, S_0 , calculated from $QD\phi$ values using the conversion chart. In general, the sediments of the Cochin backwaters are poorly or moderately sorted. The larger the value of $QD\phi$ the wider is the spread of the curve, and hence the poorer is the sorting of the sediments. This is particularly evidenced by comparing the $QD\phi$ values for the regions between *Ramanthuruthi* island and *Bolghaty* island and also between *Ramanthuruthi* island and *Vimanathiru* island where the sediments are poorly sorted. Another important aspect that can be inferred from the analysis of the data is that the well-sorted sediments with values of $QD\phi \leq 1.3$ are associated with the same general area of the sediments with $Md\phi \leq 3\phi$. Thus the coarsest sediments in the area under study are best sorted. Outside the barmouth it is specially noticeable that the average spread of the curves increases away from the coast indicating poorer sorting associated with finer sediments. Hence a definite relation appears to exist between the average size and 'degree of sorting' in the sediments of the Cochin backwaters.

(iii) SKEWNESS

Trask's skewness (S_k) has been determined for each sample. The skewness values vary between 0 and 1.1. One feature worth mentioning is that all samples exhibit positive skewness, suggesting predominance of coarser admixture in the samples.

(iv) WATER CONTENT

The water content of the sediments varies with the nature of the sediments. The analysis shows that in the Cochin backwaters the water content of the sediments varies between 27% and 72% approximately. On an average 70% of the samples from inside the barmouth has water content values higher than 50% and the rest shows values less than 50%. An examination of the analytical data also reveals that there exists an inverse relationship between the percentages of water content and sand fraction of the samples. Hence the water content is found to be low in well-sorted regions and high in poorly or moderately sorted regions of the backwaters as the degree of sorting is related to the average size of the sediments. Fig. 4 is a graph showing this relationship for representative stations.

CONCLUSIONS

1. In general, the sediments of Ernakulam channel and northern part of Mattancherry channel are mostly very fine sand. But the central part of Mattancherry channel has got comparatively finer sediments.
2. The coarsest sediments (Medium sand) of the area are observed south of Mattancherry channel, whereas the region between *Ramanthuruthi* island and *Vinnathira* island has the finest sediments (Coarse clay) of the backwaters.
3. Outside the barmouth, the median grain size decreases in the offshore direction. There is also a decrease in the sediment size in the northward and southward directions from the approach channel.
4. Over a greater part of the Cochin Harbour and the adjacent area, the sediments show poor or moderate sorting.
5. The coarsest sediments in the area are best sorted and the finer sediments are associated with poorly or moderately sorted areas.

6. Outside the barmouth there is a decrease in the degree of sorting in the offshore direction.

7. Most of the samples exhibit positive skewness showing the predominance of coarser admixture in the sediments.

8. Water content of the sediment varies between 27% and 72%. About 70% of the samples from inside the barmouth has water content values higher than 50% while only 30% shows values less than 50%.

9. There exists an inverse relationship between the percentages of water content and sand fraction in the sediment samples of the Cochin backwaters.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Dr. N.K. Panikkar, Director, National Institute of Oceanography (CSIR), for his keen interest and encouragement in the work. I am also thankful to Dr. V.V.R. Varadachari, Head of Physical Oceanography Division of N.I.O., for his valuable guidance and helpful suggestions.

REFERENCES

- KRUMBEIN, W.C., (1936).—“The use of Quartile Measures in describing and comparing sediments” *Amer. Jour. Science*, vol. 37, pp. 98-111.
- KRUMBEIN, W.C., and ABERDEIN ESTHER, (1937).—“The sediments of Barataria Bay” *Jour. of Sedimentary Petrology*, Vol. 7, pp. 3-17.
- KRUMBEIN, W.C., and PETTJOHN, F.J., (1938).—“Graphic presentation of Analytical Data” In ‘Manual of Sedimentary Petrography’, D. Appleton—Century Company Inc., N.Y.
- MURTHY, P.S.N. and VEERAYYA, M.—“Organic matter in the Sediments of Vembanad Lake” (Under publication).
- PRATH, O., (1932).—“Die Marinen Sedimente als Abbildung ihrer Umwelt and ihre Auswertung durch regional Statistische Methode” *Fortschritte der geol. u. Palaen.* Vol. 11, pp. 220-45.
- TRASK, P.D., (1930).—“Mechanical Analysis of Sediments by centrifuge” *Econ. Geol.*; Vol. 25, pp. 581-99.
- TRASK, P.D., (1932).—“Origin and Environment of source sediments of Petroleum”, Gulf Publishing Company, U.S.A., p. 67.