

# Short Communications

## Siltation in the Outer Channel of Cochin Harbour

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Received 23 October 1976; revised received 4 May 1977

Considerable amount of siltation has been observed off 1800 m from the harbour mouth, with decreasing tendency beyond 6000 m. Tidal streams and long-shore currents appear to be prominent agencies for siltation in the outer channel. Statistical analysis of data shows that there is no significant difference in the annual variation of the silt amount near the entrance channel. No significant difference has been observed in the siltation of the northern and southern regions of the channel.

THE Cochin Harbour outer channel has been made navigable by cutting the sand bar present across the channel. Because of the high amount of siltation in the outer channel, access to the harbour has been maintained through constant annual dredging. During the past several years, in order to understand the processes of siltation in the harbour channels and to reduce the cost of dredging, some investigations have been made. Of these, the radio tracer studies made by Gole and Tarapore<sup>1</sup> and Sundara Ramam<sup>2</sup> followed by the silt estimation method of Gopinathan and Qasim<sup>3</sup> need particular mentioning.

The present study was carried out to analyse the significance of variation in the siltation rates during the different years at several sections of the outer channel. Relative influences of waves, tidal currents, the shifting of dumping ground of the dredged material, etc., on the rates of siltation in the area were also studied.

Sounding data for 6 yr, before and after dredging, from the outer channel, obtained from the Cochin Port Trust were used. The soundings before dredging were taken during November-December and the soundings after dredging were taken during April-May, every year.

For the analysis of data, the outer channel having a uniform width of 140 m and rectangular shape was divided breadth-wise into 2 equal regions, i.e. northern and southern regions (Fig. 1). These 2 regions were further divided length-wise into 24 sectors, each having 300 m length. The standard depth of the channel was taken as 12 m at the high water level. Taking this as the standard height the cross-sectional area of the channel in the northern and southern regions were measured with a planimeter. Finally, the total volume of the silt dredged from each sector in the northern and southern regions was determined by multiplying the areas of cross sections before and after dredging with the length of the sector (300 m) and taking the difference between the resulting volumes (before dredging minus after dredging).

Annual sectional variations of the total volume of silt in cubic meters are given in Fig. 2. More siltation takes place beyond 1800 m west-wards of the coast (sections 6 to 24) than the regions of the channel up to 1800 m from the coast (sections 1 to 5). Annual values for the total volume of the dredged silt for the sectors 1 to 5 and 6 to 24 are given in Table 1. It is quite obvious that the amount of siltation recorded for the sectors 6 to 24 for the years 1968, 1969 and 1971 is almost equal whereas the years 1967, 1970 and 1972 record slightly different values. Higher value of siltation in 1967 may be the after effect of December 1965 storm which deposited a large amount of clay to the coast just north of the entrance channel<sup>3</sup>. Davis and Fox<sup>4</sup> have observed that with the reversal of the wind direction and subsequent increase in the barometric pressure after a cyclonic storm crosses the coast, there will be a reversal of longshore current resulting in the sediment movement. After the storm in Dec. 1965, the clay deposit was washed offshore during the subsequent monsoon months, as revealed by the echograms of Nov.-Dec. 1966.

To study the variation in the volume of the dredged material in the outer channel, with almost rectangular shape and similar bottom topography, the data were subjected to statistical analysis

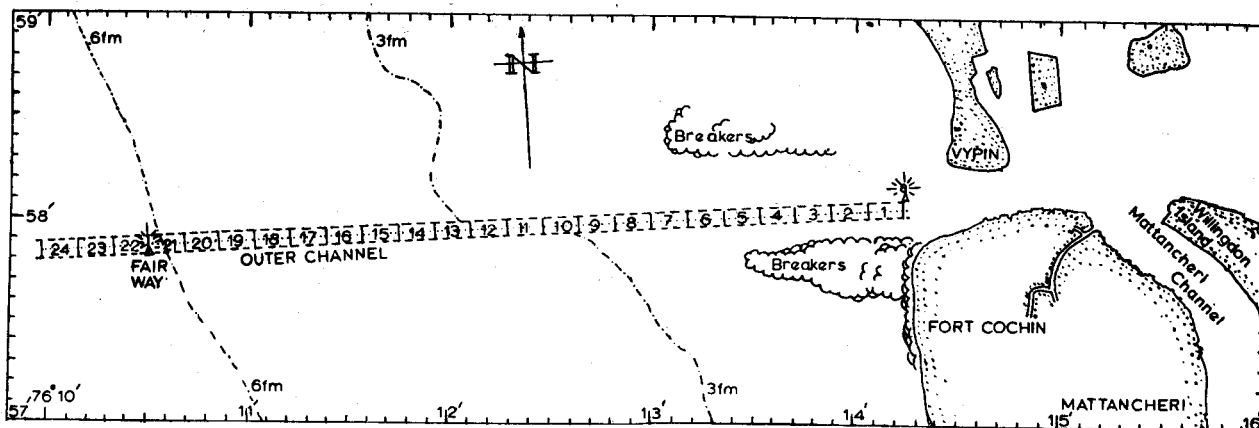


Fig. 1 — Station location map

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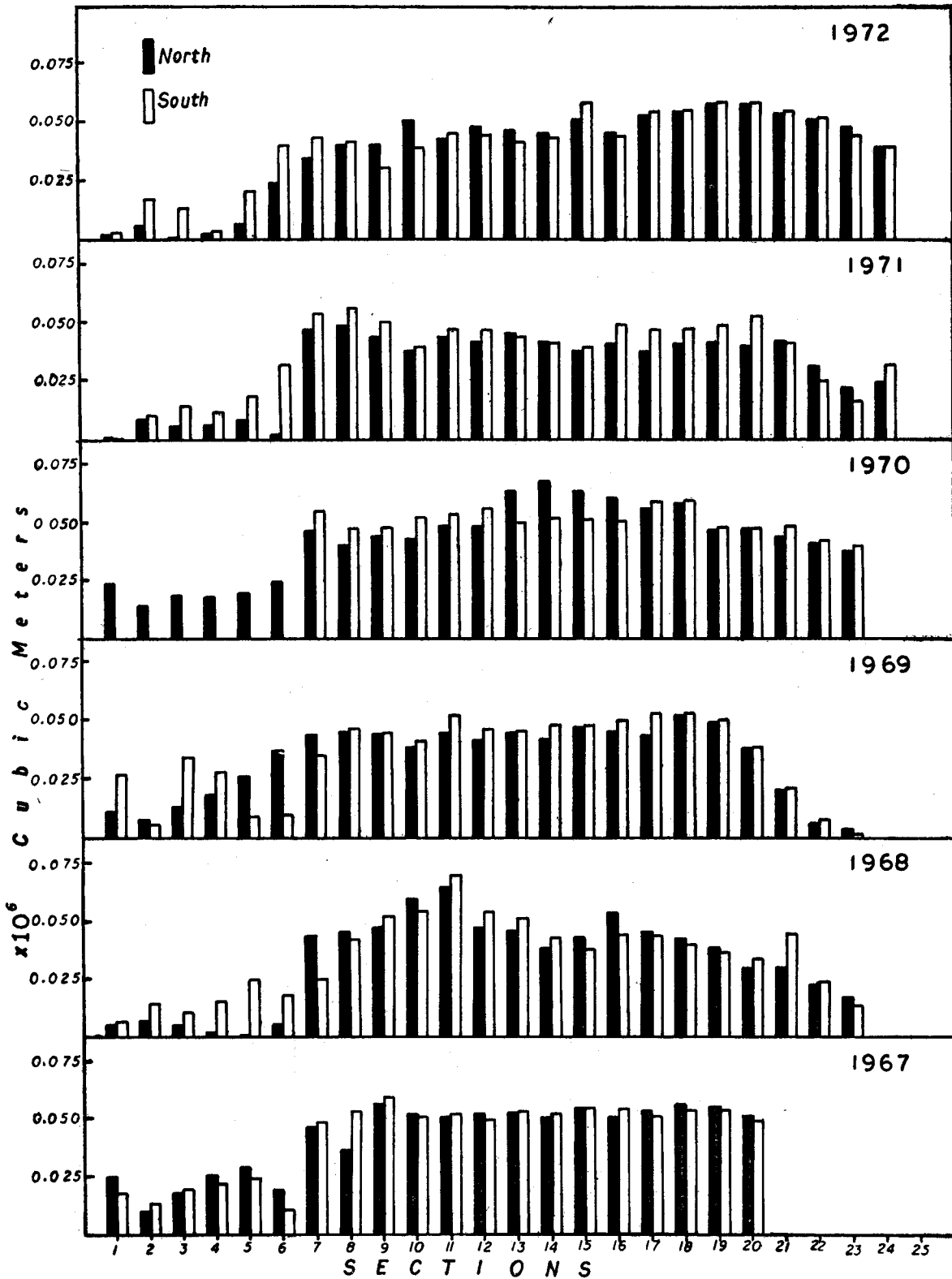


Fig. 2 — Total volume of sediments in north and south sections of the outer channel for different years

TABLE 1 — AREAWISE DISTRIBUTION OF DREDGED SILT IN THE OUTER CHANNEL OF COCHIN HARBOUR

Year	Sections 1 to 5 m <sup>3</sup> × 10 <sup>6</sup>	Sections 6 to 24 m <sup>3</sup> × 10 <sup>6</sup>	Sections 1 to 24 m <sup>3</sup> × 10 <sup>6</sup>
1967	0.18	1.47	1.65
1968	0.08	1.29	1.37
1969	0.18	1.33	1.51
1970	0.22	1.48	1.7
1971	0.08	1.31	1.39
1972	0.07	1.39	1.46

using analysis of variance technique. Table 2 gives the results of analysis of variance of the dredged silt amount as the variations between years, between north and south regions and between sectors. Variations in the dredged volume of silt between regions is not significant, indicating that the volume of dredged silt from these 2 regions is almost the same. However, variations between years ( $P \leq 0.05$ ) and between sections ( $P \leq 0.01$ ) are significant. The data were also analysed region-wise to test the significance of variations between sections within each region. Variation of dredged silt amount between sections is highly significant ( $P \leq 0.01$ ).

Tidal currents are generally recognized for their effect of sediment transport. Since the tidal streams do not result in a net transport of water, residual currents are generally observed to be responsible for their sediment transportation. For net sediment transport to occur, it is necessary to have either a residual current associated with the tidal streams or an asymmetry in the speed and directions of the tidal streams. However, sediment transport by tidal streams can occur with or without accompanying the residual currents<sup>5</sup>.

The Cochin Harbour outer channel is characterized by a mixed type of predominantly semi-diurnal tide<sup>6,7</sup> and the tidal streams during the ebb currents have longer duration and higher speed as compared with the flood current. It is quite probable, therefore, that the comparatively stronger ebb currents carry the suspended material considerably off the coast through the narrow barmouth. This process is well supported by the observed higher amount of siltation off 1800 m. The main source of silt in the outer channel is the backwaters and the offshore regions. During premonsoon months the waters around this region have relatively low amount of suspended material. During monsoon months, stratification is high due to the intrusion of salt wedge through the bottom of the channel with the overlying less saline water rich in suspended material. This stratification causes a mixing at the interface of the 2 layers resulting in the flocculation of the finer grains of the suspended material. Within the region of salinity intrusion, variation in the horizontal velocity with depth exhibits a net seaward flow near the surface and net landward flow at the bottom. Since the material in suspension tends to flocculate in saline environment, the floccules settle towards the bottom and

TABLE 2 — ANALYSIS OF VARIANCE OF THE DREDGED SILT AMOUNT (i) BETWEEN YEARS AND SECTIONS, (ii) IN THE NORTHERN REGION OF OUTER CHANNEL AND (iii) IN THE SOUTHERN REGION OF THE OUTER CHANNEL

Sources	SS	DF	MS	F
(i) BETWEEN YEARS AND SECTIONS				
Total	75.3622	167	—	—
Sections	33.8465	23	1.4715	9.2*
Years	3.2262	5	0.6452	4.03†
Regions	0.2645	1	0.2645	1.65
Error	38.025	238	0.16	—
(ii) IN THE NORTHERN REGION OF OUTER CHANNEL				
Total	27.4348	136	—	—
Sections	16.1092	23	0.7004	7.55*
Years	1.302	5	0.2604	2.81†
Error	10.0236	108	0.0928	—
(iii) IN THE SOUTHERN REGION OF OUTER CHANNEL				
Total	47.6627	130	—	—
Sections	19.1489	23	0.8325	3.16*
Years	1.6387	5	0.3277	1.24†
Error	26.8751	102	0.2634	—

Significant at: \*1% level; †5% level.

are carried in the landward direction to ultimately form shoals<sup>8</sup>. However, because of the strong tidal currents and flushing action near the narrow barmouth of the channel, the settling of silt in the sections 1 to 5 is considerably lower than that at sections 6 to 24.

In the offshore regions, the longshore currents form the major agents for siltation in the channel. The directions of wave approach are from north for the period November to March, north-west in April and, from west during May to September<sup>9</sup>. The northerly and north-westerly waves cause the southerly alongshore transport of the sediments, as the orientation of the Kerala coast is favourable for it. Moreover, the southerly surface currents from February to September may also favour the southerly alongshore transport. Similarly the southerly waves though not prominently observed in the study region during the postmonsoon season, coupled with the northerly surface current from October to January also favour a northerly sediment transport along this coast. Even though the statistical analysis does not show much variations in siltations between north and south regions as a whole, some of the sections of the southern region experience slightly higher rates of siltation, compared to that at the sections in northern region. This may be due to the fact that the south-westerly waves are long swells which have more efficiency in transporting sediments to the outer channel. However, the sediment transport into the outer-channel takes place from both sides of the channel. A similar conclusion has been arrived at by Das *et al.*<sup>10</sup> through their wave refraction studies in relation to sediment transport for this part of the coast. Also the radio-active tracer studies<sup>1</sup> conducted in this region have shown that the dredged material dumped north or south of the channel have ultimately found its way into the channel.

However, the tracer studies<sup>1</sup> conducted during the monsoon months of 1970 have shown that the material dumped at an area, 2 km north of the channel and 5 km west of the coast does not find its way back to the channel. Present studies also show that beyond sector 20 there is a falling tendency (Fig. 2) for siltation confirming that sediment transport is comparatively very negligible beyond this sector. Hence any dredged material dumped beyond offshore of this sector is not likely to find its way back to the channel.

The authors are thankful to Dr S. Z. Qasim, Director, and Dr V. V. R. Varadachari, Head, Physical Oceanography Division, for their interest in the work. Thanks are due to Shri V. S. Rama Raju, Scientist, for his valuable suggestions. Thanks are also due to the authorities of the Cochin Port Trust, especially to the senior marine surveyor, for providing the data on the soundings of the Cochin Harbour Outer Channel, for the period 1967 to 1972.

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### Distribution & Seasonal Abundance of *Oscillatoria nigroviridis* Thwaites ex. Gomont in the Waters of Visakhapatnam Harbour

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Received 23 October 1976; revised received 3 January 1977

*O. nigroviridis* and other blue-green algae are abundant in the waters of harbour area indicating the polluted nature of the Visakhapatnam harbour. In the surface waters of 4 stations, standing crop of *O. nigroviridis* varies in all months of the year with 2 peaks, a primary peak between September and December and a secondary peak between January and April. Production of *O. nigroviridis* is higher in the sewage polluted waters of station I than in the waters of other 3 stations, which are relatively less polluted.

WATERS of Visakhapatnam harbour are polluted by town sewage, effluents of industries like Caltex Oil Refinery and Coramandel Fertilizers and

also by the loading and unloading operations carried out in different channels. During the course of studies to assess the effects of polluted sea water of the harbour on the growth of marine algae, data have been collected on the species composition and abundance of phytoplankton of the harbour area. Results obtained on the distribution and seasonal abundance of *Oscillatoria nigroviridis* Thwaites ex. Gomont during 1975 are presented in this paper.

Four stations were selected in different channels of the Visakhapatnam harbour. Station I is located near the town sewage canal where it joins the Southern Lighter Canal and Station II is about 900 m away from the outfall area. Stations III and IV are situated in the northern arm and the western arm of the harbour. For phytoplankton analysis, 2 l of surface water were collected once in a month from each station between 1800 and 1900 hrs, brought to the laboratory and centrifuged. After a preliminary examination of the live plankton, the samples were fixed in 5% formalin. These samples were diluted further to a known volume and stained in Lugol's solution. While analysing the plankton samples, filaments, fragments and hormogonia of *O. nigroviridis* present in 1 cc of the subsample were counted separately, using a Sedgewick-Rafter cell. From an average value of 2 counts of the subsample, total number of filaments per litre of sea water was estimated.

*O. nigroviridis* is very abundant in the phytoplankton of Visakhapatnam harbour associated with many diatoms, dinoflagellates, green algae and blue green algae like *Arthrospira*, *Spirulina*, *Microcystis*, *Merismopedia* and it also grows as thin mats on harbour walls and other substrata in the mid-littoral zone in the harbour area.

Fig. 1 shows the seasonal abundance of *O. nigroviridis* in the 4 stations selected. Data could not be collected for March 1975, during the study. Standing crop of *O. nigroviridis* varied markedly in all months of the year with 2 peaks, a major peak between September and December and a minor peak between January and April. Peak periods varied slightly from one station to the other. In waters of station I the number of filaments per litre ranged from 4800 to 2437500 with a small peak in February and a primary peak in December. In station II counts per litre varied from 262 to 60063 with a secondary peak in February and primary peak in October. In station III, although 2 peaks were found with values ranging from 150 to 12900 filaments/litre, major peak was observed in February and minor peak in October, not coinciding with the seasonal periodicity of the plankton samples of the other stations. In station IV, number of filaments varied from 187 to 7938 with primary and secondary peaks in the month of October and April respectively. Low values observed in stations I to III in the month of November (Fig. 1) were not obtained in this station. In all these stations *O. nigroviridis* occurred sparsely between May and August.

Though there was no regular pattern in the occurrence of fragments or hormogonia, the percentage frequency values were higher during or