

Effect of Organic Pollution on Some Hydrographic Features of Cochin Backwaters

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Some hydrographic features of Cochin backwaters were studied from September 1974 to August 1975 in 7 stations of which 6 receive sewage discharge in varying quantities and one is a 'clean' station near the barmouth. Thermal gradient of the waters was more largely dependent on the depth of the station than on the sewage discharge. Seasonal and tidal variations in salinity were more evident during monsoon than in pre- or postmonsoon periods. No significant change in salinity was noticed due to discharge of sewage. Significant seasonal and tidal fluctuations in the values of oxygen were observed. Lowest oxygen values were seen during premonsoon periods when temperature was 32.6°C at surface and 32°C at bottom. Dissolved oxygen content varied proportionately with sewage discharge. High temperature and rapid decomposition of organic waste during premonsoon accelerated pollution effect. BOD₅ varied with stations, season and tide. Oxygen consumption of the bottom waters of polluted areas was 12 to 13 times as high as that in barmouth. In polluted areas fluctuating increase of BOD₅ values was noticed with the commencement of premonsoon while a decreasingly fluctuating trend prevailed with monsoon. BOD₅ at low tide was higher than at high tide in the polluted area. High sulphide content reaching to a maximum of 4.92 mg/litre was observed at the bottom of polluted stations especially during low tide of premonsoon periods.

COCHIN backwaters receive either directly or indirectly the sullage waters and municipal sewage from the city. The total consumption of drinking water in this urban area is roughly 14 million gallons/day of which a high percentage joins the drainage and reaches the backwater system through a network of canals. Part of the sewage of the city is treated in a mechanically aerated and activated sludge process treatment plant maintained by the State Public Health Engineering Department. Capacity of this plant is only 1 million gallon per day. Rest of the sewage and sullage water mixed with domestic waste is carried along the 6 major canals and drained into the backwaters. These canals vary from 0.5 to 1.5 m in depth. The drainage contains turbid liquid with a considerable amount of putrescible organic material both dissolved and suspended of domestic origin. Hydro-biochemical studies of Cochin backwaters have been the subject of several investigations. However, except for the preliminary studies on organic pollution¹, there is no previous account on the effects of organic pollution on the hydrographic features of Cochin backwaters.

Materials and Methods

The general object of this study was to investigate the effect of organic pollution of the waters around Cochin harbour and adjacent areas. Observations were made round the seasons (premonsoon = January to April, monsoon = May to October and postmonsoon = November to December) at fortnightly intervals of which one was at low tide and the other at high tide, from September 1974 to August

1975. Five parameters, viz. temperature, salinity, dissolved oxygen of both surface and bottom waters, biochemical oxygen demand (BOD₅) and total sulphide content in bottom waters, were chosen. The location of sampling stations 1 to 7 is same as reported earlier¹. The depth (m) at these stations is as follows: 1, 1.2; 2, 1.5; 3, 7; 4, 4.5; 5, 4.5; 6, 6; and 7, 2.5. Of these station 3 which is 50 m away from the shore receives practically no sewage, while the others which are 200 m from the shore receive municipal sewage in varying quantity and quality, though remarkably low at station 6.

Water samples were collected with a plastic bucket for surface sampling while sampling was done with a Hytech water sampler from the bottom of each station according to their depths. Salinity was estimated by Mohr Knudsen method. Winkler procedure was used for the determination of dissolved oxygen. Biochemical oxygen demand and total sulphide were measured by standard procedure suggested by American Public Health Association². Total sulphide was determined as follows: Water samples were preserved using zinc acetate as zinc sulphide. From the precipitated sample hydrogen sulphide was generated using concentrated hydrochloric acid in an inert atmosphere of carbon dioxide. The evolved hydrogen sulphide was dissolved in distilled water and titrated against standard iodine solution using starch as indicator.

Results and Discussion

Temperature — Seasonal changes in the surface temperature are well marked in the backwaters. Values of seasonal changes in surface temperature

vary from 4° to 5.4°C, lowest being 25.8°C and highest being 32.6°C. As regards bottom temperature the values range between 3.7° and 5.7°C with 25.2° and 32.2°C being the lowest and highest temperatures. During premonsoon period the temperature is high at all stations and this situation prevailing during both high and low tides. Difference between the surface and bottom temperature of highly polluted areas (stations 1 and 2) vary between 0.1° and 0.3°C during high tide of March to May, and during low tide the temperature variation is between 0.1° and 0.9°C. At the 2 deeper areas (stations 3 and 6) the thermal gradients between surface and bottom are high because of greater depth (above 6 m). Sewage discharge to the backwaters does not seem to have any significant effect on the temperature. On the other hand, temperature has considerable effect on the oxygen content and BOD of the sewage receiving areas.

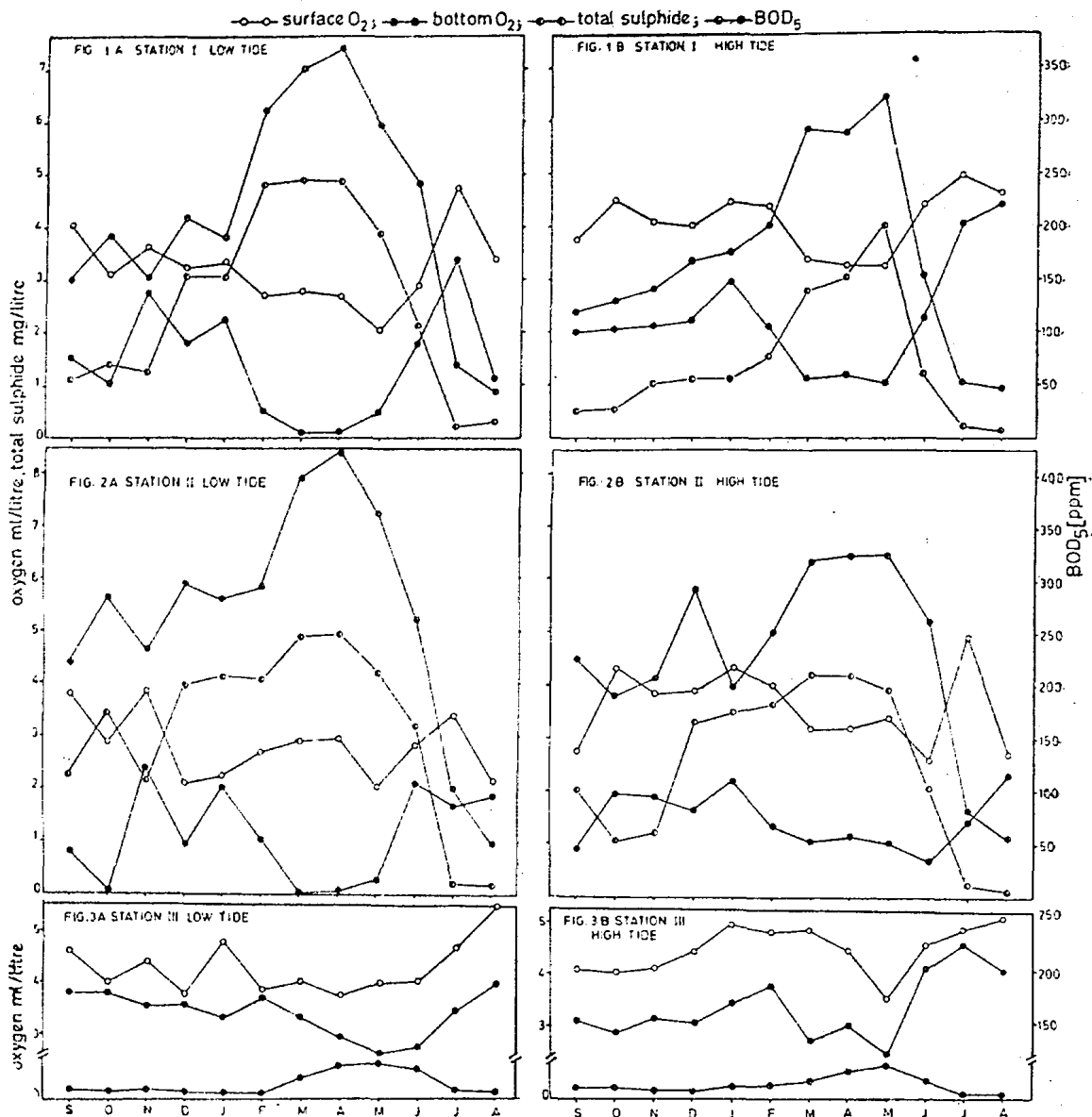
Salinity—Seasonal and tidal variations in the salinity are well pronounced during the year. The overall change in salinity at the bottom of station 3 from 34.31‰ in April to 1.11‰ in July clearly indicates the variations occurring near the mouth of backwater. Variations are more evident during monsoon than in pre- or postmonsoon periods. During monsoon heavy rainfall washes the sewage from the canals and deposits solid waste at the areas of sewage discharge. The sewage draining into the estuary mixes with the saline water from top to bottom during high tide and forms a homogeneous mixture. This is evident from the very little difference in salinity between surface and bottom at stations 1, 2, 4, 5 and 7. No significant change in salinity is noticed due to the discharge of sewage.

Dissolved oxygen—Concentration of dissolved oxygen was measured at the stations throughout the year. Significant seasonal and tidal fluctuations in the values of oxygen of both surface and bottom waters were seen with stations (Figs. 1 to 7). Lowest oxygen contents were usually found during premonsoon periods when the temperature reached 32.6°C at the surface and 32°C at the bottom. Dissolved oxygen content of both bottom and surface of the sewage receiving areas was always fluctuating due to the availability of decomposing materials such as detritus mixed with organic gyttja at the bottom and suspended decomposing material in the water column. Owing to the high temperature during premonsoon months (March-April) the process of decomposition is accelerated with the uptake of dissolved oxygen. It is stated that oxygen consumed by decomposition of organic matter is often reflected in the disappearance of oxygen from the deeper strata of the water body³. It is also known that the oxygen content is always low at the bottom waters⁴. In the Cochin estuary as observed from the 7 stations oxygen content was less than 0.05 ml/litre at the polluted stations 1 and 2 (Figs. 1 and 2) during March and April. Therefore, the worst of pollution effect is usually experienced during premonsoon periods when the combined effect of high temperature and rapid decomposition of organic material occurs. This agrees with the results reported for the premonsoon month at Visakapatnam

harbour⁵. With the commencement of monsoon the sewage gets diluted and considerable amounts of organic material are deposited in the canal opening areas. The suspended materials are washed away by the tides and flushing fresh water.

Biochemical oxygen demand—Importance of BOD₅ in the assessment of pollution effect of an environment has been stressed⁶⁻⁸. It is the dissolved or suspended organic material in the waste that gives biochemical oxygen demand to the polluted waters. BOD recorded in the present study (Figs. 1 to 7) varies with season and stations. Values obtained for stations 1 and 2 reveal (Figs. 1 and 2) that the oxygen consumption of the bottom waters is 12 to 13 times as high as those measured in bottom at the barmouth (Fig. 3). At barmouth (station 3), BOD₅ increases gradually with commencement of premonsoon and shows a decreasing trend with monsoon periods, while a similar but fluctuating trend exists with the other stations though the BOD₅ value at any of these stations is always higher than at the barmouth. Maximum uptake of oxygen is observed in the bottom where the organic wastes are decomposing. There are marked differences in the values of BOD₅ of different seasons in all the stations. With the onset of premonsoon, high temperature regime is initiated which lasts up to the beginning of monsoon. Consequent thermal effect accelerates the bacterial degradation process of the waste resulting in the multiplication of bacteria and uptake of dissolved oxygen. Subsequently monsoon waters wash the sewage with heavy organic matter which is deposited in the estuary while lighter particles are washed away with the fresh water outflow. Though the BOD₅ values tend to remain more or less the same during the early monsoon month (May) marked decreasing trend is seen from June onwards. Analysis of high and low tide BOD₅ values of sewage receiving areas reveals that BOD₅ at low tide is usually higher than at high tide while it is more or less the same in the barmouth. It is observed that BOD values fluctuate with station and time. The former variations are due to the quantity and quality of the sewage while the latter type of variations are usually due to monsoon and tidal effects. Highest BOD₅ values recorded are at stations 1, 2, 4, 5 and 7. At station 4, during premonsoon BOD₅ value is 11 to 12 times as high as that measured during monsoon periods in the same station (Fig. 4). This indicates the effect of monsoonal flow to a remarkable extent resulting in the dilution of the sewage at this station which is not far away from the barmouth. Similarly in station 2 the BOD₅ value reaches above 400 ppm during premonsoon month (April) while the value decreases to below 50 ppm during monsoon month (August) in low tide (Fig. 2A). Obviously the monsoonal run off is heavy to a noticeable extent of dilution of the polluted area.

Total sulphide—No measurable amount of sulphide is observed at the barmouth (station 3) while high total sulphide content is observed in the bottom waters of heavy sewage discharged areas, (stations 1 and 2) when the oxygen concentration is very low (Figs. 1 to 7). Reports⁹ are available on odour and colour of the mud samples as indicators



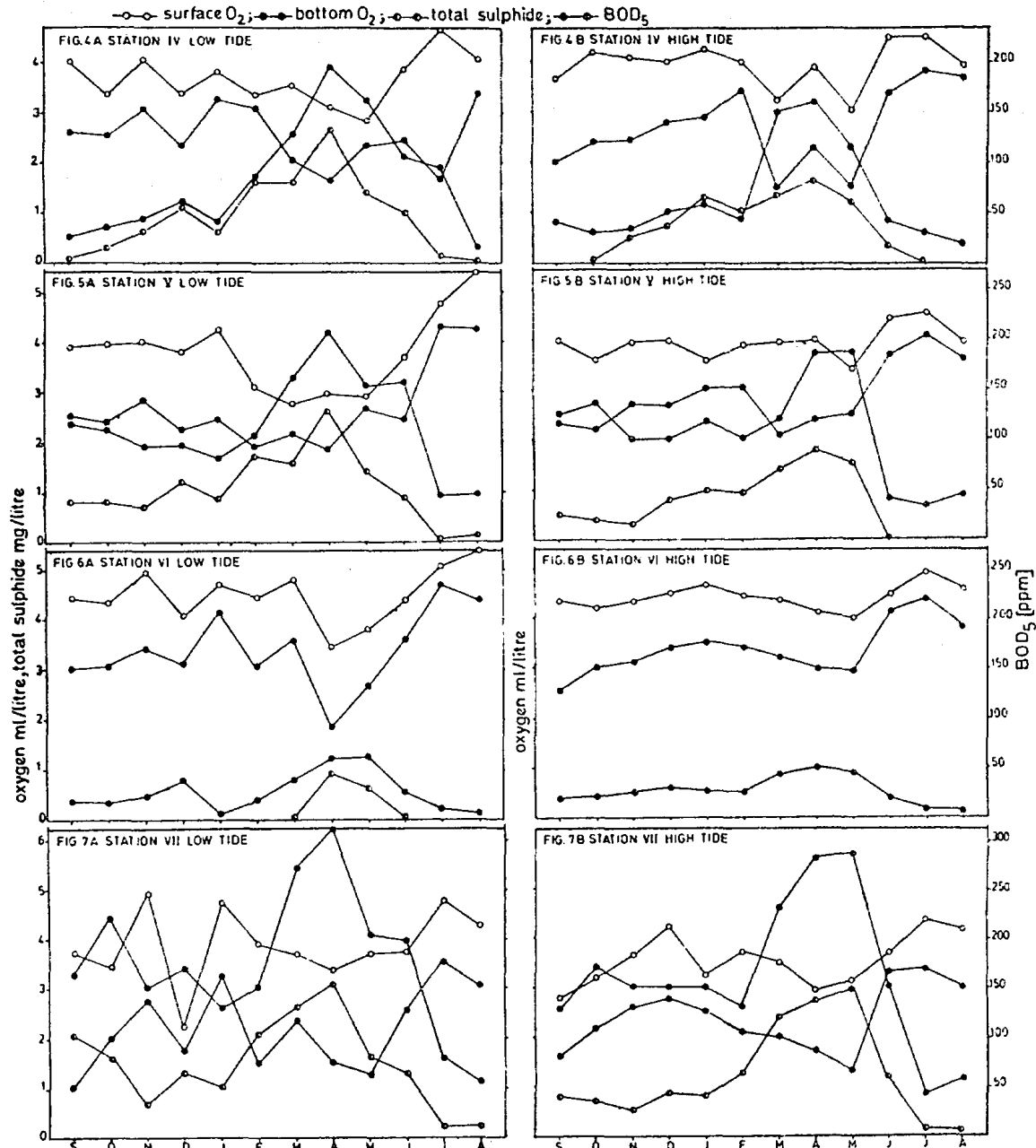
Figs. 1-3 — Distribution of O₂ (surface and bottom), BOD₅ (bottom) and sulphide (bottom) during low tide (A) and high tide (B) at stations I to III

of high sulphide content in polluted areas. The odour and colour of mud samples of sewage discharged areas in the present study also indicate presence of high sulphide content. Maximum value of sulphide recorded at these stations is 4.92 mg/litre during low tide. The sulphide concentrations in all stations except 3 (Fig. 3) and 6 (Fig. 5B) fluctuate in proportion to the availability of varying quantity of decomposing sewage. Only during pre-monsoon period at station 6 measurable amount of sulphide is noticed (0.86 mg/litre at low tide; Fig. 5A).

Comparing these sewage receiving and 'clean' stations, it is apparent that they differ in dissolved oxygen content and BOD. Bacterial oxygen consumption is significantly higher in the outfall stations like 1

and 2 than the 'clean' station as evidenced by high BOD values. The waters of polluted stations show high BOD₅ (420.6 ppm) and total sulphide (4.92 ppm) values and low oxygen (0.05 ml/litre) values during summer months. These values are remarkably different from even the standard values for effluents discharged into inland waters which are 30 ppm for BOD₅ and 2 ppm for sulphide. Initiated by the decomposing sewage, the anoxic conditions of the water just above the bottom are apparently confined to the small area for a short time and due to the tidal mixing the water never becomes depleted of oxygen permanently. However, this is indicative of localized pollution which is beyond the assimilative capacity and tolerance level of the estuary.

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Figs. 4-7 — Distribution of O₂ (surface and bottom), BOD₅ (bottom) and sulphide (bottom) during low tide (A) and high tide (B) at stations IV to VII

In stations 4 to 7 BOD values are not as high as in stations 1 and 2 and not as low as in station 3 indicating that they remain as partly polluted locations seasonally. It is observed that seasonal change in temperature of the water has very significant effect on dissolved oxygen and hence on BOD₅ values as well. This is more pronounced in premonsoon than in monsoon and postmonsoon periods. Most adverse conditions of pollution occur during premonsoon when the temperature is between 31° and 32-6°C. Depletion of dissolved oxygen

to a greater extent occurs in highly polluted areas (stations 1 and 2) during premonsoon period. Higher BOD₅ values occur during low tide than at high tide in the sewage polluted areas. Organic pollution has significant effects on D. Oxygen BOD₅ and sulphide content of the estuarine waters while the temperature and salinity are not significantly affected.

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