

Organic Pollution in Cochin Backwaters*

R. V. UNNITHAN, M. VIJAYAN & K. N. REMANI

Regional Centre, National Institute of Oceanography, Cochin 682018

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As part of the investigations on pollution in Cochin backwaters, hydrography, bottom and fauna of Cochin Harbour area were studied from 6 polluted (sewage and particulate matter) and one 'clean' station during August to October 1974. Increase in organic content and bacterial activity in both bottom water and sediment, as indicated by high BOD, values (6.21 to 280.40 mg/litre), low and fluctuating oxygen values (<0.05 to 3.81 ml O_2 /litre) in the bottom water, high hydrogen sulphide content in the bottom water of the sewage affected stations, and the difference (quality, quantity and distribution) in macrofaunal communities as opposed to those seen in the 'clean' area, indicated the influence of sewage discharge on the environmental factors and fauna of the area.

LOCATED along $9^{\circ}58'N$ and $76^{\circ}15'E$ on the south-west coast of India the Cochin backwater system forms a tropical positive estuary¹ which provides excellent conditions for rich animal life. Considerable work has been done on the hydrography and productivity of this estuary¹⁻¹¹. The Cochin Corporation sewage system empties its municipal waste and other particulate organic matter into the estuary through major canals (Fig. 1), viz. Padiyathukulam canal (station 1), canal from Ernakulam market (station 2), Kalvathi canal from Fort Cochin. (station 4), Rameswaram canal from Mattancherry (station 5), Pulimuttu canal from Palluruthy (station 6) and Thevara canal (station 7). The present paper, while initiating pollution studies in Cochin backwaters, presents briefly an account of the localized effect on the environmental factors and bottom fauna that may be of importance for the assessment of the extent of pollution in the estuary consequent on sewage discharge.

Materials and Methods

Area of the backwater system between Aroor and the barmouth was selected for the present study. The sites where each canal referred above opens into this portion of the backwater system was fixed as a collecting station with an additional site (station 3) near the barmouth for the study of hydrography, bottom and benthic fauna. Stations 1, 2, 4 to 7 receive sewage effluents in varying proportions into the backwater system through the network of canals while station 3 is relatively free and unaffected by sewage discharge. Sewage discharge at station 6 is comparatively low keeping the area more or less clean as regards organic pollution. Both surface and bottom samples and bottom fauna were collected at fortnightly intervals from each station. A plastic bucket was used for collecting water samples from the surface. As the bottom

was shallow enough water samples from the bottom were collected using a Meyer type water sampler. Salinity was determined by Mohr Knudsen method. Winklers method (accuracy ± 0.05 ml O_2 /litre) was used for the estimation of dissolved oxygen. Biochemical oxygen demand was determined in accordance with the procedure of American Public Health Association¹² and iodometric method was used for the estimation of hydrogen sulphide. Bottom sampling with the van Veen Grab (0.05 m²) was made at each station for bottom fauna. Some preliminary sieving was made on board the

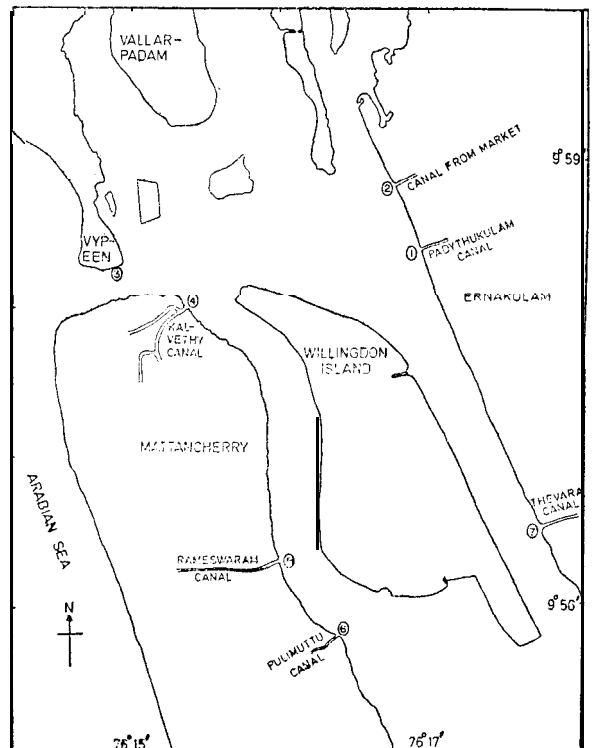


Fig. 1 -Location of stations 1 to 7 in Cochin backwaters

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work boat. All organisms which were retained by a 0.5 mm mesh sieve were collected and analysed numerically groupwise.

Data collected during August to October 1974 were analysed and discussed.

Results and Discussion

Sewage from the town consists of waste water and domestic sewage. It is generally, fresh water contaminated by dissolved and particulate matter in varying degrees.

Temperature — Temperature (Table 1) is more or less uniform at all stations during the period of observation, ranging between 26.1° and 31.2°C at the surface and 24.6° and 31.1°C at the bottom. Temperature gradients between the surface and the

bottom water of the sewage affected areas are low while in the station 3 the range is high. It may be due to the homogeneous mixing of sewage water and estuarine water in sewage affected areas.

Salinity- The time of observation (August to October) is the end of monsoon and usually the salinity is low. During the peak of the south-west monsoon low salinity value <1‰ in the entire estuary was observed⁵. Sewage water draining into the estuary is rapidly mixed with extra estuarine water entering the canal during high tide. In the Cochin backwaters the tides are of mixed semi-diurnal type and varicus environmental features are greatly influenced by the tidal rhythm¹³. Salinity (Table 1) of stations 1, 2, 5 and 7 is mainly influenced by the quantity of sewage water dis-

TABLE 1 — SURFACE AND BOTTOM PARAMETERS AT 7 FIXED STATIONS

Station*	Surface parameters.			Bottom parameters.				
	Temp °C	Salinity ‰	O ₂ ml/l	Temp. °C	Salinity ‰	O ₂ ml/l	BOD, mg/l	H ₂ S mg/l
2-g-1974 (TIDE: HIGH)								
1	26.4	0.39	3.07	26.3	0.37	2.08	56.37	0.22
2	26.4	0.39	3.23	26.2	0.11	2.01	75.32	0.31
3	26.1	0.75	3.61	24.6	19.52	3.37	6.21	nil
4	26.5	0.57	3.52	26.4	0.75	2.75	21.22	nil
5	27.1	0.39	4.12	26.9	0.39	2.70	41.23	0.20
6	26.9	0.39	4.01	26.8	0.39	3.00	12.18	nil
7	26.9	0.39	3.81	26.7	0.39	2.05	70.31	0.22
10-9-1974 (TIDE: LOW)								
1	29.6	7.32	4.01	29.5	7.83	1.50	150.7	1.12
2	29.7	7.02	3.82	29.6	8.77	0.80	220.6	2.25
3	28.4	12.90	4.51	25.8	31.67	3.80	9.72	nil
4	29.3	12.72	4.00	29.1	13.84	2.61	25.81	0.04
5	30.2	9.52	3.91	29.8	11.62	2.52	120.7	0.83
6	30.5	7.32	4.46	29.9	20.70	3.01	18.51	nil
7	30.6	6.04	3.72	30.3	7.32	1.05	180.21	2.06
26-9-1974 (TIDE: HIGH)								
1	28.8	1.37	3.75	28.1	1.37	2.01	118.8	0.5
2	28.1	0.54	2.76	26.2	0.54	0.88	225.4	2.03
3	26.3	2.74	4.08	25.2	19.54	3.31	8.41	nil
4	27.1	0.55	3.64	26.9	1.69	2.00	40.42	0.05
5	28.2	0.54	4.02	27.9	1.11	1.32	150.1	1.81
6	28.0	1.37	4.36	27.8	1.02	2.54	18.21	nil
7	27.9	0.70	2.76	27.5	0.90	0.66	232.4	1.78
g-10-1974 (TIDE: LOW)								
1	29.0	2.74	3.12	28.9	2.74	1.06	192.5	1.40
2	30.0	2.56	2.92	29.8	2.56	to.05	280.4	3.41
3	28.3	4.54	4.01	28.1	5.81	3.81	6.84	nil
4	30.0	4.36	3.36	29.1	4.72	2.56	35.41	0.30
5	29.7	4.18	3.98	29.5	4.22	2.40	120.1	0.81
6	30.0	4.21	4.36	27.5	4.47	3.04	18.12	nil
7	30.4	1.47	3.44	30.1	1.84	2.01	220.16	1.58
29-10-1974 (TIDE: HIGH)								
1	30.5	8.69	4.52	30.3	9.42	2.08	129.1	0.53
2	30.5	8.87	4.34	30.1	12.85	1.98	192.2	1.06
3	28.4	20.25	4.01	27.9	27.29	2.93	9.12	nil
4	29.1	16.09	4.19	28.4	22.23	2.42	28.11	nil
5	30.3	13.03	3.63	29.9	20.79	2.20	89.5	0.42
6	30.4	11.94	4.21	29.8	12.30	3.01	20.5	nil
7	31.2	4.36	3.18	31.1	5.26	2.18	170.6	0.68

*Depth (m) at station 1, 1.2; 2, 1.5; 3, 7.0; 4, 4.5; 5, 4.5; 6, 6.0; 7, 2.5.

charged. Though enormous sewage is discharged at station 4 the salinity is not much affected because of the influence of the high saline water always available near the barmouth. The extension of high saline water at the barmouth has also been commented on elsewhere¹⁰. During low tide, the sewage water flushes and spreads into the estuary resulting in localized low saline conditions, except for areas very near the barmouth.

Oxygen — Oxygen content of bottom waters of stations 1, 2, 5 and 7 is dependent largely on the quantity of sewage and tidal rhythm (Table 1). Tidal mixing stirs the waste considerably into the water from top to bottom during high tide and the tidal current regularly sweeps away the suspended wastes, as observed at station 4 where enormous amount of organic waste is discharged through Kalvathi canal but the oxygen deficiency is remarkably reduced by the influence of tidal flow and current effects.

Effect of sewage discharge at stations 1, 2, 5 and 7 is clearly seen from the oxygen content, colour and nature of the substratum. During low tide the oxygen value reaches to <0.05 ml O_2 /litre at station 2 because of high content of decomposing organic matter discharged from the market.

Heavy load of settled organic matter together with dissolved organic substances will reduce the amount of oxygen available especially at stations 1, 2 and 7.

Lowest oxygen values are usually found at the sewage canal opening areas, presumably due to pollution and to high natural deposition of organic wastes. It has been observed¹⁴ that the influx of waste from forest industry may reduce the dissolved oxygen content of the water. Similarly due to the decomposition of municipal waste deposited at the bottom, the oxygen content may be reduced, affecting adversely the living resources at the sewage opening stations.

Biochemical oxygen demand — High content of domestic sewage discharged at stations 1, 2, 4, 5 and 7 may settle at the bottom and undergo decomposition causing oxygen depletion. The rapid degradation of organic material is indicated by the high biochemical oxygen demand (BOD₅) in the bottom water of sewage affected areas. A high BOD₅ indicates large bacterial populations consuming the available oxygen. Highest BOD₅ values are seen at stations 1, 2, 5 and 7. The highest value

recorded during the observation is 280.4 ppm at station 2.

Correlation coefficient calculated between the mean oxygen (ml/litre) and mean BOD₅ (mg/litre) is -0.9586, which is significant at 0.1% level indicating that BOD₅ and oxygen are very highly negatively correlated.

Low values of oxygen and high values of BOD₅ at stations 1, 2, 5 and 7 are suggestive of organic pollution to a more remarkable extent at these areas than in stations 4 and 6 where the values are greater indicating a marginal zone of pollution. Maximum values of oxygen is shown at station 3. This is a more or less pollution free zone near the barmouth.

Hydrogen sulphide — Organic wastes discharged may undergo decomposition using the available oxygen resulting in anaerobic condition and formation of hydrogen sulphide in and near the bottom. Measurable amounts of hydrogen sulphide are observed in the bottom waters of the stations 1, 2, 4, 5 and 7. Highest values obtained are 3.41 and 2.25 mg/litre at stations 2 and 7 respectively. Stations 3 and 6 are devoid of hydrogen sulphide (Table 1).

Data for dissolved oxygen and hydrogen sulphide show a relationship, i.e. lower oxygen values, high BOD, and higher values of hydrogen sulphide indicate the effect of sewage discharge. Heavy impact of sewage pollution is observed at stations 1, 2 and 7.

Fauna — Bottom fauna from 7 stations show considerable quantitative and qualitative variation as illustrated by the polychaetes, crustaceans and molluscs collected (Table 2). It is observed that benthic animals reflect not only the conditions at the time of sampling but also those earlier¹⁵. There is an enormous increase in the total number of animals mostly polychaetes and crustaceans, in station 3 as compared to other stations. This region may therefore be considered unaffected according to faunal patterns. It is apparent (Table 2) that the least numbers of animals were found in stations 1 and 2. This decrease in the number of animals at these 2 stations should be attributed to the increase of sewage inflow and may be considered as polluted zones. Stations 4, 5 and 6 should be included under marginal zones as they show sufficient representations of the fauna but not the maximum. Maximum BOD₅ value, high hydrogen

TABLE -- DISTRIBUTION OF BOTTOM FAUNA AT SEVEN FIXED STATIONS

Station Number of observations	Polychaeta			Crustacea			Mollusca		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
1	5			0		60	0	60	12
2	5	120	190-220	0	300-80	16	20	40	16
3		20							56
4	5	1000	220-450	11(20)	30: 40	8316	0	260	12
5	5	80	6520	60	120	32	20	40	16
6						32	0	0	0
7	5	90-120	280-1720	20	20-100	88	20	120	56

sulphide and minimum oxygen value reflect the characteristics of a polluted zone. High value of BOD_5 in station 2 indicates an increase in organic content and bacterial activity and consequent decrease of oxygen content and hence decrease in the number of animals. A respective decrease in BOD_5 values in the healthy zone, i.e. station 3 shows considerable increase in the number of animals.

Qualitatively too the benthic animals indicate level of pollution. Polychaetes being a considerably tolerant group of animals are present in all the stations. The mean value of polychaetes in the healthy zone, i.e. station 3 is found to be much less when compared to that of a strictly marginal zone such as station 5. This area being unpolluted, animals other than polychaetes successfully join the struggle for survival and reduce the number of polychaetes. Polychaetes dominate in number in the polluted zones as they form the most suitable tolerant group of benthic animals of the area. With the increase in pollution level, even the most tolerant benthic animals like polychaetes may be wiped off completely from the polluted zone due to anaerobic conditions. However, the prevalence of effective environmental factors such as tidal rhythm and monsoonal inflow are discouraging to such a situation in the Cochin backwaters. These factors should maintain to a considerable extent the pollution level to tolerant condition for the minimum indicator organisms to survive. Crustaceans and molluscs are few or absent in the marginal and polluted zones as compared to the healthy zone mainly because the pollutants of the sewage inflow may promote the disappearance of representatives of the fauna which have occurred here earlier and stimulated the development and growth of new fauna afresh.

Quantitative variations in the composition of animals may be correlated with the distribution of detritus carried by the sewage discharge; crustaceans being heterophagous in feeding habits, consume the polluted detritus available resulting in accelerated growth rate. However, accumulation of pollutants beyond the tolerance level affects the survival of the species and consequent reduction in total number is noticed. The presence of more crustaceans in the healthy zone (station 3) than in polluted and marginal zones may reasonably be attributed to this phenomenon. An enormous increase in the number of polychaetes is noticed in the marginal zones. The inflow of sewage into the backwaters, as stated for heated effluents¹⁶, may lead to an increase of initial growth rate and precocious maturity, resulting in shortening of life cycles and consequent increase in the number of animals. This increase in number can also partly be due to the greater tolerant capacity as against other groups of animals which would have disappeared from these areas due to the effect of pollution. Here a relationship between disappearance and mess development of organisms is indicated.

In the polluted and marginal zones bivalves are lesser in number than those of the healthy zones. Molluscs being mostly filter feeding in habit, concentrate more pollutants than other animals. Hence in the polluted zones they are not able to tolerate

the increase of pollutants beyond a level, and a consequent decrease in number results.

The demarcation of polluted, unpolluted and marginal zones based on different parameters studied in the present investigation is provisional and may be open to criticism in their being too 'loose'. With more intensive collection and analysis of data around the season, this classification of convenience should prove realistic and useful for effective control operations to follow.

From the present study it may be concluded that organic pollution to a considerable extent exists in the Cochin backwater, especially in areas where the Padiyathukulam canal (station 1) and the canal from market (station 2) join the backwater. The extent of pollution in these areas is well above tolerance level of the estuarine fauna. Continued discharge of sewage effluents at the present rate may affect the ecosystem and estuarine life of the harbour and the harmful effects may extend to the neighbouring inshore waters as well. Hence control operations are necessitated. Distal areas near the bar-mouth remain more or less free from pollution due to effective dilution by the open sea water especially during high tide. A marginal zone of pollution is also suggestive in the proximal areas of the harbour. Collection and analysis of data round the season should provide a more effective picture on organic pollution in the harbour.

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