

## Hydrographic Features & Water Quality of Cochin Backwaters in Relation to Industrial Pollution

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Impact of industrial effluents on quality of receiving waters as assessed by COD, suspended solids, and some hydrographic features has been studied over an year at 4 stations in Cochin backwaters. The effect of effluents is considerable in the vicinity of the main discharge site (st 2) in nonmonsoon months. The monsoonal floods provide adequate dilution and mask the effects. No serious oxygen depletion is noticed at any of the stations. An attempt has been made to correlate the relative abundance of benthic fauna at the stations with the water characteristics like ammonia content and organic matter.

Pollution studies on Cochin backwaters have been initiated recently<sup>1</sup>. Impact of organic pollution on the hydrography of the estuary around Willingdon Island has been reported<sup>2</sup>. Incidence of fish mortality from industrial pollution in the upper reaches of the backwaters is also reported<sup>3,4</sup>. The effluents discharged into the backwater system from various industrial establishments, located in Eloor (Udyogamandal), constitute some of the major pollutants in the estuary. The industrial belt extends to nearly 5 km from Varapuzha to Alwaye along the upper reaches of the backwaters. A study has been undertaken during 1976-77 to understand the effect of industrial pollution in the estuarine environment. Results of the study are reported in this paper.

### Materials and Methods

Monthly samples at fixed locations were collected from 4 stations (Fig. 1), viz. Kalamassery (st 1), Udyogamandal (st 2), Elamakkara (st 3) and Barmouth (st 4).

Water samples were collected from the surface using a clean plastic bucket. Meyer-type sampler was used for bottom sampling. Bottom sediments were collected using a van Veen grab. Chlorinity was estimated by Mohr-Knudsen method<sup>5</sup>, dissolved oxygen by Winkler method<sup>6</sup> and chemical oxygen demand (COD) by refluxing the sample with potassium dichromate<sup>7</sup>. Chloride corrections were made<sup>8</sup> by multiplying the corresponding chloride values for salinity by a factor of 0.225. This factor was arrived at by estimating chloride interference for a series of sodium chloride solutions with known chloride contents ranging from 710 to 28400 mg/litre. Suspended solids were determined by filtering the

water sample through a Millipore filter (pore size 0.45  $\mu\text{m}$ ) and drying the residue to constant weight at 80-90°C.

Effluent samples collected from the discharge points were also analysed for COD by oxidation with permanganate<sup>9</sup>. Alkalinity was estimated by adding

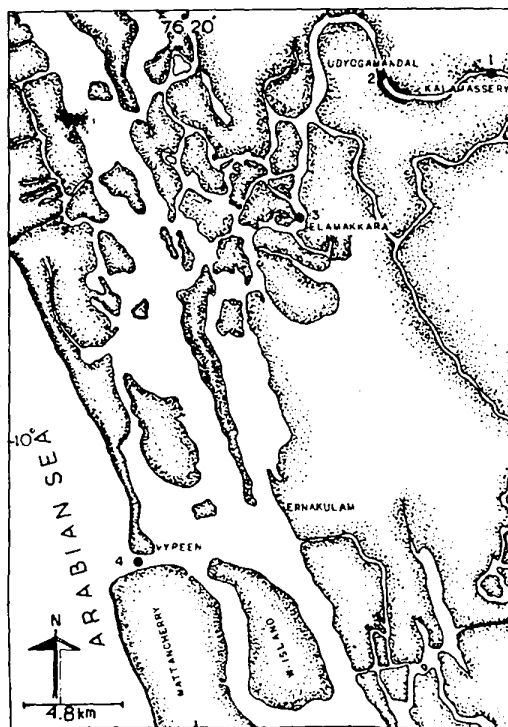


Fig. 1—Location of observation stations in Cochin backwaters

excess  $H_2SO_4$  and titrating the excess acid<sup>7</sup>. Ammonia was determined colorimetrically by indophenol blue method<sup>10</sup>. A seeded dilution method<sup>7</sup> was used in the estimation of  $BOD_5$ .

Temperature and pH for all water samples were noted at the time of collection. Qualitative observations on benthic fauna were also made from the grab samples.

### Results and Discussion

Variations in different parameters during the period of observation are shown in Fig. 2. Monsoonal floods influenced the water quality and hydrographic features at all stations considerably. For the presentation of results the year is divided into 3 seasons: premonsoon (January-May), monsoon (June-October) and postmonsoon (November-December).

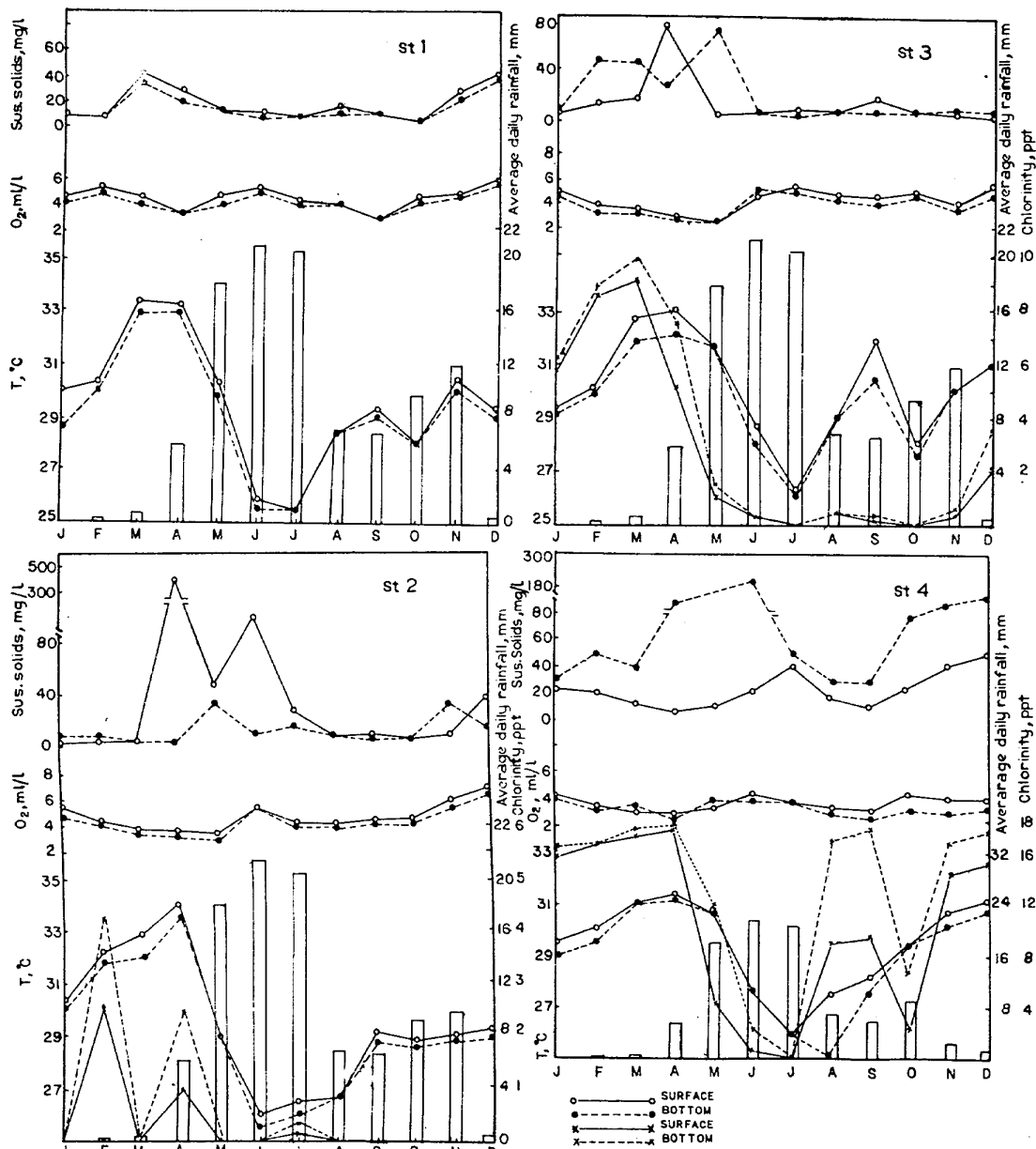


Fig. 2—Temperature, chlorinity, oxygen, suspended solids and rainfall at different stations

**Temperature**—Annual ranges in temperature were 25.5-33.2, 25.5-34.1, 26.3-33 and 26-31.5 at stations 1 to 4 respectively. St 2 in general showed higher temperature except during monsoon when the river was in spate. The higher ranges in temperature at sts 1-3 can be attributed partly to their shallow nature and absence of strong tidal influence which facilitates water exchange and nullifies localised thermal excursions.

**Chlorinity**—Sts 1 and 2 had fresh water regime round the year. St 2, however, had higher levels of chlorinity. This station also experienced sporadic increases in chlorinity during the premonsoon season (Fig. 2), presumably due to the release of chlorides through effluents. Analytical data of Jayapalan *et al.*<sup>3</sup> also show wide variations in chloride content during the period of observation (1968-71). They have also reported considerable fluctuations in the chloride content of the effluents. Sts 3 and 4 were subject to more pronounced seasonal variations in chlorinity. The variations at st 3 were from ~ 0-9.2 and at st 4 from almost fresh water to marine conditions. Chlorinity at all stations, like temperature showed inverse relationship with rainfall (Fig. 2).

**pH**—pH values ranged from 6-7, 5.5-8, 6-7.5 and 6.5-7.5 respectively at sts 1 to 4. St 2 showed erratic fluctuations during the nonmonsoon months probably due to localised influence of effluents.

**Dissolved oxygen**—Dissolved oxygen values were higher during the monsoon at all stations, and were low during the premonsoon months. Surface values in general remained higher (Fig. 2). There was no indication of an oxygen gradient, except at st 4 during the monsoon months. This gradient which disappeared with the re-establishment of marine conditions has been reported previously<sup>11</sup>. The absence of a gradient at sts 1-3 may be due to their shallow nature. The annual ranges in values for oxygen were 3-6, 3-5.8, 3-5.5 and 2-4.2 ml/litre respectively for sts 1 to 4. There was no indication of any serious depletion of oxygen at any of the stations.

**Suspended solids**—Patterns of distribution of suspended solids were different in the 4 stations (Fig. 2). St 1 had lower quantities of suspended solids (4-40 mg/litre) as compared to sts 2 to 4 (4-408, 3-75 and 4-260 mg/litre for sts 2 to 4 respectively). St 1 had higher values in pre and post monsoons, which came down during the monsoon. St 2 showed wide fluctuations in suspended load, the surface values being generally higher and subject to wider variations (Fig. 2). St 3 had higher values during premonsoon months which came down in the monsoon months. Higher values in premonsoon may partly be due to the local disturbances caused by a small time fishery of the estuarine clam *Villorita cyprinoides*. Sts 1, 2 and 3 had comparable values during the monsoon season indicating the influence of high river discharge. However, st 2 showed a high value in June presumably derived from the effluents. At st 4 the suspended solids showed higher values, with very high values during monsoon (Fig. 2). Gopinathan and Qasim<sup>12</sup> have attributed the higher level of suspended solids to resuspension of sediment material by fresh water runoff and strong tidal action.

**Chemical oxygen demand**—Table 1 gives the average values and ranges of COD for the 4 stations. In calculating the average values and ranges, figures too close to the calculated chloride-interference have been discarded as unreliable. COD values were low and quite comparable at sts 1 to 3 during monsoon. Values at st 4 were higher compared to the other stations. The higher average values at st 4 were due to high values (1216 mg/litre at surface and 2237 mg/litre at bottom) in June. The values for the rest of the monsoon season were considerably lower. High values in June may be due to the added load of organic matter brought down with the land drainage following the first monsoonal showers. Premonsoon values were higher at all stations indicating a build up of organic load. St 2 had fairly high values during this season, but showed considerable range of variations (Table 1) indicating fluctuating COD load. The oxygen assets of the

Table 1—Chemical Oxygen Demand (mg/litre) of Water

Station	Depth (m)		Premonsoon		Monsoon		Postmonsoon	
			Range	Average	Range	Average	Range	Average
1	2-2.5	S	20-65	35	5-15	12	28-40	34
		B	15-62	37	8-15	13	5-36	21
2	2-2.5	S	93-322	200	15-25	20	16-27	23
		B	25-307	203	10-22	18	20-29	25
3	2-2.5	S	78-192	110	27-70	30	33-43	38
		B	15-1043	367	30-60	30	15-107	61
4	6-7	S	197-3797	1882	184-1217	653	300-1020	560
		B	312-2795	1706	192-2237	447	380-970	675

S=surface and B=bottom

Table 2—Characteristics of Effluents on Entering the River (February 1977)

Source of effluent	Temp. (°C)	Chlorinity (ppm)	pH	Dis. oxygen (ml/l)	Alkalinity (mg CaCO <sub>3</sub> /l)	Susp. solids (mg/l)	Perman-ganate consumed (mg/l)	COD (dichromate; mg/l)	BOD <sub>5</sub> (mg/l)	Ammonia (ppm)	Colour of effluents
Periyar Chem. Catalysts & Chem.	33.9	200	8	1.8	117	264	51.3	4400	51.3	0.12	Orange
India Ltd	43.9	310	6	1.4	16.4	184	7.67	20	14.3	2.76	Brown
Cominco Binani Zinc Smelters (1)	35.5	300	2	<0.05	195.8	8	11.93	50	1.3	0.15	Colourless
Bleach " (2)	32.2	50	2	4.5	157.7	16	6.67	10	—	1.1	do
Indian Rare Earths Ltd	36	50	6	4.2	10.8	15	12.67	20	6.3	1.86	do
FACT	30.2	50	6	4.4	16.3	12.5	14	30	5.3	3	Light grey
TCC	31	150	7	4.3	16.4	50	14.67	190	—	0.18	Colourless
Water Sample Upstream	29.5	50	6.5	6.9	18	8	5.3	20	9	0.03	do

receiving waters at this station, however, did not show any serious depletion (Fig. 2). St 4 had consistently higher values throughout the period of observation, probably due to domestic sewage and other particulate wastes discharged into the harbour area. Previous studies<sup>1,2</sup> have also shown appreciable degree of organic pollution in the harbour area.

It is to be stressed that the COD by dichromate reflux method has the disadvantage of high background noise due to chloride interference in saline waters. The oxidisability of chlorides in dissimilar systems containing organic and non-organic matter is reported to be different<sup>13</sup>. Hence, the present data may be treated as an index of the order of magnitude of organic load.

Some characteristics of the effluents discharged at st 2 are listed in Table 2. They all had higher temperature than ambient temperature, varying pH and alkalinity, and ranged from well oxygenated to poorly oxygenated (<0.05 ml/litre). The oxygen demand was generally low except in one instance where COD was 4400 mg/litre (Table 2). This effluent came from an organic chemical factory. Suspended solids were generally high and foam and oil slicks could be noticed on many occasions at the discharge area. Ammonia levels varied from 0.1-3 ppm, which in 2 instances surpassed the acceptable value<sup>14</sup> of 2.5 ppm. Jayapalan *et al.*<sup>3</sup> have also reported high ammonia values for some effluents from the same area. BOD<sub>5</sub> values were quite variable probably due to the relative toxic effects on the bacterial flora. Only one effluent had appreciable BOD<sub>5</sub> value (Table 2), and 2 showed oxygen depletion lesser than the seed sample. Values for BOD<sub>5</sub> were in most cases well above those for natural waters, though the highest value recorded was only 1/6-1/10th of that for domestic sewage<sup>15</sup>.

Data on the oxygen demand characteristics of the effluents and different stations do not reveal appreciable organic loads at sts 1 and 2 and the effluents, except in one case (Tables 1 and 2). Although st 2 experienced sporadic high oxygen demand during premonsoon it failed to show significant influence on the oxygen assets of the station. St 4, however, showed consistently higher oxygen demand (Table 2). Comparison of these 2 areas and analytical data on the effluents suggest that the pollution load at st 2 is not principally organic and that the organic load does not seriously deplete the oxygen.

Observations on the qualitative aspects of benthic life showed that sts 1, 3 and 4 supported benthic life. St 1 had 2 species of mussels, *Lamelliden marginalis* and *Batissa* sp. throughout the year. The estuarine clam *Villorita cyprinoides* of different size groups was present at st 3 at all times, indicating a thriving population. St 3 also supports a small time fishery. In the higher saline periods (premonsoon) gammarid amphipods were common at this station. St 4 had a fairly diverse benthic life as reported<sup>16</sup>. Higher organic load at this station failed to show any deleterious effects on aquatic life.

Examination of the discharge area from a biological point of view would indicate that the stresses at st 2 are varied and intermittent (Tables 1 and 2). The present investigation and available information<sup>3,4</sup>, show the presence of high ammonia, a potent toxin, in the effluents and at times in the water. Higher loads of suspended material, higher temperature and variable pH along with the occasional high chloride and COD levels especially in the dry months seem to make this environment hazardous. A gradient of stress which diminishes away from st 2 towards both upstream and downstream is apparent.

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