

constituent of polluted brackish or marine waters in Europe<sup>25</sup>.

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## Pollution Status of the Cochin Beach

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Indicator bacteria contributing to faecal pollution, and fresh or decaying *Salvinia molesta* debris contributing to biological pollution are identified. Both types of pollution are pronounced during

monsoon and postmonsoon months rendering the beach unsuitable for recreational and fishing activities. Premonsoon and late postmonsoon months are almost free of pollution. Qualitative and quantitative population of indicator bacteria and their possible correlation with certain environmental parameters, abundance of fresh or decaying salvinia debris and the overall pollution status of the beach are presented.

Beach as recreational centre is gaining importance. But due to environmental factors like sewage discharge and organic wastes, emanating from human and nonhuman sources, the beaches frequently get polluted and become unsuitable for human activity. Organic wastes such as decaying plant and animal matter, debris, etc. primarily contribute to environmental pollution by increasing the suspended load in water, depleting the oxygen and increasing the hydrogen sulphide and levels of biochemical oxygen demand. One of the most important beach pollutants is faecal contamination of sand and sea water as shown by 'indicator bacteria'. Studies pertaining to faecal pollution of beaches are comparatively few<sup>1-9</sup> and particularly so for Indian coasts<sup>11-13</sup>.

Present paper deals with faecal contamination and pollution due to salvinia debris (biological pollution) of Cochin beach.

*Study area*—Fort Cochin has a plain sandy beach (approx. 1 km long; long. 74°14-15'E, lat. 09°57-58'N) located about 13 km southwest from the town. The 1st transect for sampling is opposite to the tourist resort while the 2nd transect is opposite the cement platform. Fishing operation with castnets, shore nets, and Chinese shrimp nets (dip nets) along the beach is a regular feature.

Average beach expanse (m) at the sampling point was premonsoon, 30-35; postmonsoon, 20-25; and monsoon 5-10. Median diameter (mm) of sand grain at high tide mark was 0.134, mid tide mark 0.153 and low tide mark 0.179. There were no cusps formed and nearshore drift was not significant. Surf zone was shallow and without depressions. There were no rocks infringing into the water and sand dune flora was absent. Upper most part of supra littoral region was guarded with boulders throughout. Wave action was not strong, average wave height during fair season being about ½ m, and about 3 waves/min.

Collections of sand and water samples, processing of samples, transportation, preparation of media and techniques employed in plating, incubation and enumeration of indicator organisms were carried out as reported earlier<sup>13</sup>. Sampling was done fortnightly at about 25 m perpendicular from the coast for 1 yr (November 1976 to October 1977).

Biochemical oxygen demand (BOD<sub>5</sub>) was estimated<sup>14</sup>. Hydrogen sulphide (H<sub>2</sub>S) was determined using iodometric method. Mohr Khnudsen method

was used for salinity measurements. Dissolved oxygen was estimated employing Winkler's method (accuracy  $\pm 0.005$  ml/litre). Sediment load was estimated by the centrifuge method.

The bacterial counts, given in Table 1, are the average of pooled duplicate samples from transects 1 and 2 of both the fortnights in the month. In all a total of 288 samples of sand and 96 samples of surf beaten sea water were examined.

**Faecal contamination**—Indicator bacteria occurred in most of the months in sea water and in beach sand in both the transects (Table 1). No appreciable fortnightly variations of counts were recorded for beach sand and sea water. In general, higher counts were recorded in sand than in sea water, as reported for Cherai beach<sup>13</sup>. Monsoon months (June and July) registered higher population counts than other months. The highest incidence recorded in July 1977 was due to lowering of salinity with the monsoonal flow which provided suitable concentration for the survival of indicator organisms. This was in agreement with the trend of bacterial population in the closeby Cherai beach<sup>13</sup> also. However, the maximum counts observed in Fort Cochin beach (134 coliforms, 33 *E. coli* and 35 *S. faecalis*/g sand) were far above the counts encountered in Cherai beach<sup>13</sup> or from Colva beach, Goa<sup>11</sup>, while it was comparable to Siridaon beach, Goa<sup>12</sup>. Thus Siridaon beach and the beach under study, presented similar bacteriological status. Macrofaeces were not recorded throughout the course of investigation in sea water while they were often present in beach sand in certain months.

FC/FS ratio was worked out as suggested by Finstein<sup>15</sup> and is presented in Table 1. Nonhuman type (NH) occurred throughout the investigation except in January, March and July 1977 when it was human type (H type). The nonhuman type was contributed principally by dead animals washed ashore during that period.

Bacterial counts >100,000 colonies/g sand suggested a health hazard similarly 300 colonies of fungi in sand indicated risk of fungal infection. In a survey<sup>9</sup> of 40 bathing beaches around the English coast, known to be contaminated with sewage, only 4 cases of paratyphoid fever probably due to bathing were recorded. Greenburg<sup>16</sup> pointed out that enteric organisms can create health hazard. Berger *et al.*<sup>4</sup> in their review on coliform standard for recreational waters cited a number of cases where bathing in sewage polluted water caused suspected fever in Perth. Stevenson<sup>8</sup> showed when maximum permissible number (MPN) was 2,400 coliforms/100 ml there was no significant increase in the incidence of illness in swimmers. Maximum acceptable count in different countries for coliforms was 10,000/litre of water and

Table 1—Bacterial Counts at Cochin Beach during Different Months of Study

[Values are expressed in number/g sand or/ml water]

Month	Coliform	<i>E. coli</i>	<i>S. faecalis</i>	FC/FS ratio
1976				
Nov.				
S	17	10	13	1 NH
W	7	3	7	0.4 NH
Dec.				
S	8	2	6	0.3 NH
W	Nil	Nil	1	—
1977				
Jan.				
S	22	6	2	3 H
W	20	3	4	1 NH
Feb.				
S	27	5	5	1 NH
W	1	Nil	1	— NH
March				
S	20	7	10	1 NH
W	33	4	2	2 H
April				
S	14	4	5	1 NH
W	16	2	5	0.4 NH
May				
S	12	5	5	1 NH
W	14	1	7	0.1 NH
June				
S	38	11	9	1.2 NH
W	31	8	6	1.3 NH
July				
S	89	18	10	2 H
W	72	21	5	4 H
Aug.				
S	16	3	3	1 NH
W	5	Nil	2	— NH
Sept.				
S	21	3	5	1 NH
W	20	1	5	0.2 NH
Oct.				
S	22	5	4	1.2 NH
W	22	2	3	1 NH

S = sand; W = water; NH = nonhuman; H = human

the same for *S. faecalis* was 200/litre<sup>7</sup>. Stevenson<sup>8</sup>, reported that MPN > 2,400/100 ml of coliforms is often recommended as MPN for bathing beaches. In the present beach, maximum count registered was 45/ml in July (monsoon period) while during fair season (September to April) the average count ranged from 10-15/ml, which was much lower than the permissible limits. Therefore, based on the faecal coliform counts, it may be observed that the beach is not 'objectionable' for bathing or for other recreational activities during fair season. Even the *S. faecalis* counts were below the 'objectionable' level during fair season.

**Environmental parameters**—Dissolved oxygen, salinity, biochemical oxygen demand (BOD<sub>5</sub>),

SHORT COMMUNICATIONS

sediment load and hydrogen sulphide exhibited marked correlation with the bacterial population counts, while atmospheric temperature, water and sand temperature and pH did not affect the population since their variation was not significant (Table 2).

Salinity: During premonsoon and postmonsoon months, when the salinity values were higher, the counts of bacteria showed a declining trend. Higher counts were recorded in monsoon months (June and July) as dilution of sea water offers better survival chances for the microorganisms.

Biochemical oxygen demand: Indicator bacterial population and BOD<sub>5</sub> values showed a marked correlation. Months of high BOD<sub>5</sub> values registered high bacterial population while the inverse was true in months with low BOD values (Table 2). Excessive aggregation of decayed salvinia debris may principally be responsible for high BOD<sub>5</sub> values in the environment.

Sediment load: A well defined correlation existed between counts of bacteria and sediment load values. Monsoon months were characterised by high sediment load values and correspondingly high population of indicator organisms. Monsoon currents bring up the mud from the substratum which contributes to the sediment load. Bacteria may find suitable conditions for adhering on mud particle which offers better survival. However, inverse relationship was noticed during the premonsoon months.

Hydrogen sulphide: Direct correlation was noticed between bacterial population and H<sub>2</sub>S values. Low H<sub>2</sub>S values were followed by low bacterial counts

particularly in premonsoon months while it was reverse in monsoon months.

*Biological pollution*—Large quantities of African weed *Salvinia molesta* gets washed ashore during monsoon months. Quantitative abundance of the weed in the surf zone is so much that it practically clogs the entire area. The beach is virtually covered with the weed in various stages of decay during monsoon and postmonsoon months. During the late postmonsoon months due to wave action the weed gets covered with sand and embedded (>½ m) in the vertical axis. The hazardous effects of the weed may be summarised as follows:

(1) Quantitative abundance of the weed in varying stages of decay caused considerable damage to shore fishing operations (dip nets and cast nets) by clogging the nets.

(2) The weed interfered with swimming even during the postmonsoon months, since it harboured large numbers of fungi and bacteria causing considerable dermal irritation to swimmers<sup>17</sup>.

(3) Decayed debris of the weed caused depletion of oxygen enhancing the BOD<sub>5</sub> and H<sub>2</sub>S levels, thereby creating conditions not suitable for inshore fishes. This affected the shore seine fishery operations considerably.

(4) Large quantities of the weed in varying stages of decay contributed to the organic matter, discoloured the beach sand and presented an 'unhealthy' picture of the beach.

The weed completely disappeared by November/December and the beach was devoid of

Table 2—Environmental Parameters at Cochin Beach during the Study Period  
[Diss. Oxygen, sed. load, BOD and H<sub>2</sub>S are expressed in mg/litre]

	Temperature °C			Diss. oxygen	Salinity	pH	Sed. load	BOD	H <sub>2</sub> S	
	Atmos.	Sand	Water							
	1976									
Nov.	32.75	31.6	30.25	4.42	19.05	6.8	0.17	10.15	1.77	
Dec.	32	32.5	30.5	3.43	20.36	7.3	0.12	9.93	1.3	
	1977									
Jan.	31	31	29.5	6.33	27.35	7.2	0.001	8.7	0.85	
Feb.	31.9	30.25	29.75	5.74	30.35	7.35	0.001	5.44	0.01	
March	34.5	33.9	33.62	5.64	30.93	7.37	T	2.2	T	
April	32.5	32.87	32.1	5.74	31.55	7.65	0.007	T	0.2	
May	29.25	30.25	29.87	5.54	26.21	7.4	0.12	9.84	0.72	
June	25.27	26.9	25.2	3.62	18.56	7.1	0.2	10.94	1.23	
July	28.62	27.75	26	3.57	17.78	7	1.29	11.58	1.46	
Aug.	31.7	31.55	30.85	3.5	20.44	7.2	0.66	9.52	1.1	
Sept.	32.26	31.02	29.5	5.14	23.5	7.36	0.5	3.01	0.78	
Oct.	29	31.75	27.75	3.3	23.11	7.6	0.17	7.55	1.76	

T = traces

weed pollution during late postmonsoon and premonsoon months. It may be noted that the environment is free of biological pollutant during late postmonsoon and premonsoon months which coincided with 'unobjectionable' months referred for faecal contamination. Total absence of macrofaeces, disappearance of salvinia and improvement in the physico-chemical conditions of the environment during the late postmonsoon and premonsoon months offered a presentable status to this beach above the 'objectionable levels' of pollution.

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## Trace Metals in Zooplankton from the Bay of Bengal

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Zooplankton samples, collected during the 20th and 21st cruises of *RV Gaveshani* in the Bay of Bengal, were analysed for their trace element concentrations. The concentrations were comparable to the values obtained by other workers in different areas.

Determination of heavy metals in biological material of the sea has attained practical importance with the increased awareness of the dangers of marine pollution. So far little work<sup>1-6</sup> has been done on the multi-element determination in bulk collections of zooplankton.

Zooplankton are of much importance in the cycling process of elements in the oceans. Though the concentrations of metals in zooplankton vary because of many reasons, they do indicate possible environmental characteristics of a particular region. Moreover, being a major source of food for larger animals, their role in the transfer of metals to higher trophic levels is of much importance. The present study deals with the determination of Cu, Fe, Co, Ni, Pb, Mn and Zn in zooplankton from the Bay of Bengal. This work forms a part of the programme on monitoring different pollutants in the biological material from the Indian waters.

All collections were made during the 20th and 21st cruises of *RV Gaveshani*. Zooplankton samples were collected using an HT Net (mesh size 0.2 mm) from the stations shown in Fig. 1. The net was towed for 15 min while the ship was moving dead slow. The metal frame of the net was covered by a canvass sheet and a PVC bucket was used. On completion of the tow, the net was not washed with the ship's sea water supply<sup>7</sup>. The plankton cake was transferred to polythene bags directly from the bucket, with the help of a precleaned glass rod, after draining the water out. All samples were frozen at  $-5^{\circ}$  to  $-10^{\circ}$  C on board.

On reaching the shore laboratory, the samples were thawed and dried at  $60^{\circ}$  C in petri dishes. Dried material (1-2 g) was weighed accurately and then transferred to a 100 ml conical flask. The material was digested in conc.  $\text{HNO}_3$  (15-25 ml) followed by concentrated perchloric acid until a clean solution was obtained. Blanks were run along with the samples. The acid volume, reduced to 1-2 ml, was transferred to a 10 ml flask and made up to the mark with glass distilled water. The solutions were examined for trace metals

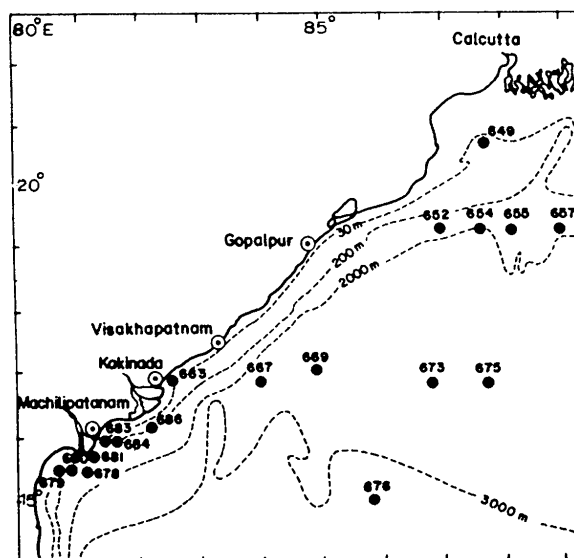


Fig. 1—Location of stations (Numbers refer to oceanographic station starting with cruise 1 of *RV Gaveshani*)