

Physical Factors Related to the Marine Disposal of Industrial Effluents off Pondicherry

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Field studies were carried out during February and April, 1981 to collect the environmental data on the physical characteristics of the coastal waters and the sea bottom off Pondicherry, required for the planning and design of marine outfalls for the effluents from two chemical factories. Tides and currents were recorded and the advective and diffusive behaviour of the surface waters was evaluated. The tidal oscillations were noted to be moderate along the Pondicherry coast and the currents were generally weak. The contribution of wind on the surface drift was considerable. The bathymetry of the area was supplemented by delineating the seabed sediment distribution. A silty/clayey belt between 8-m and 12-m contours was identified. Otherwise the nearshore bed was mostly composed of sand. Dye-diffusion studies showed that the waters off Pondicherry Proper were less turbulent than those off Pilliarkuppam. The results are discussed in the context of locating effluent outlets.

INTRODUCTION

Rapid industrialisation of the Union Territory of Pondicherry has resulted in the more and more utilization of the adjoining coastal waters in recent years. In particular, two factories situated along the Pondicherry coast, one producing industrial alcohol and the other paper pulp, have already contemplated discharge of their wastewater into the sea, through submarine pipelines at suitable sites, after adequate treatment as per specified standards. The studies reported here were carried out to collect the environmental data on the physical characteristics of the coastal waters and the sea bottom off Pondicherry, for planning and designing of marine outfalls. Considering the nature of the area and the requirement, the surveys were conducted during February and April, 1981.

AREA OF STUDY

The Coromandel Coast (which Pondicherry is a part of) is sandy and exposed, for most part of the year, to very heavy surf (Figure 1). Anchoring of ships and landing by boats are difficult in Pondicherry waters (Bay of Bengal Pilot, 1962). The period between October and December is associated with rough weather. The north-east monsoon blows from October to the end of January and the sea is very rough during this period. For the rest of the year the wind is generally off the land (from westward) in the morning,

but there is usually a stiff breeze from southeastward in the afternoon, which makes the sea very choppy. The currents are irregular, having speeds from 1 to 1.5 Kt and varying in speed and direction during different seasons. A detailed account of the currents off Coromandel Coast can be seen elsewhere (Bay of Bengal Pilot, 1962).

METHOD OF STUDY

Tides were measured with the help of graduated staff set at Pondicherry Pier. The observations covered spring and neap tidal conditions. The levels were referred to Chart Datum and were compared with the tides at the nearest standard port (Nagapattinam) (Figure 2). A summary of the tidal information is given in table 1.

Table 1. *Tidal Information (Pondicherry) (11°56' N, 79°50' E)*

Level	Height above chart datum, m
MHWS	1.31
MLWS	0.49
MHWN	1.07
MLWN	0.73
MSL	0.76

Note : (i) Average tidal range ratio (w. r. t.) Nagapattinam) = 2.14
(ii) Average tidal lag (w. r. t. Nagapattinam) = 1 hr 45 min

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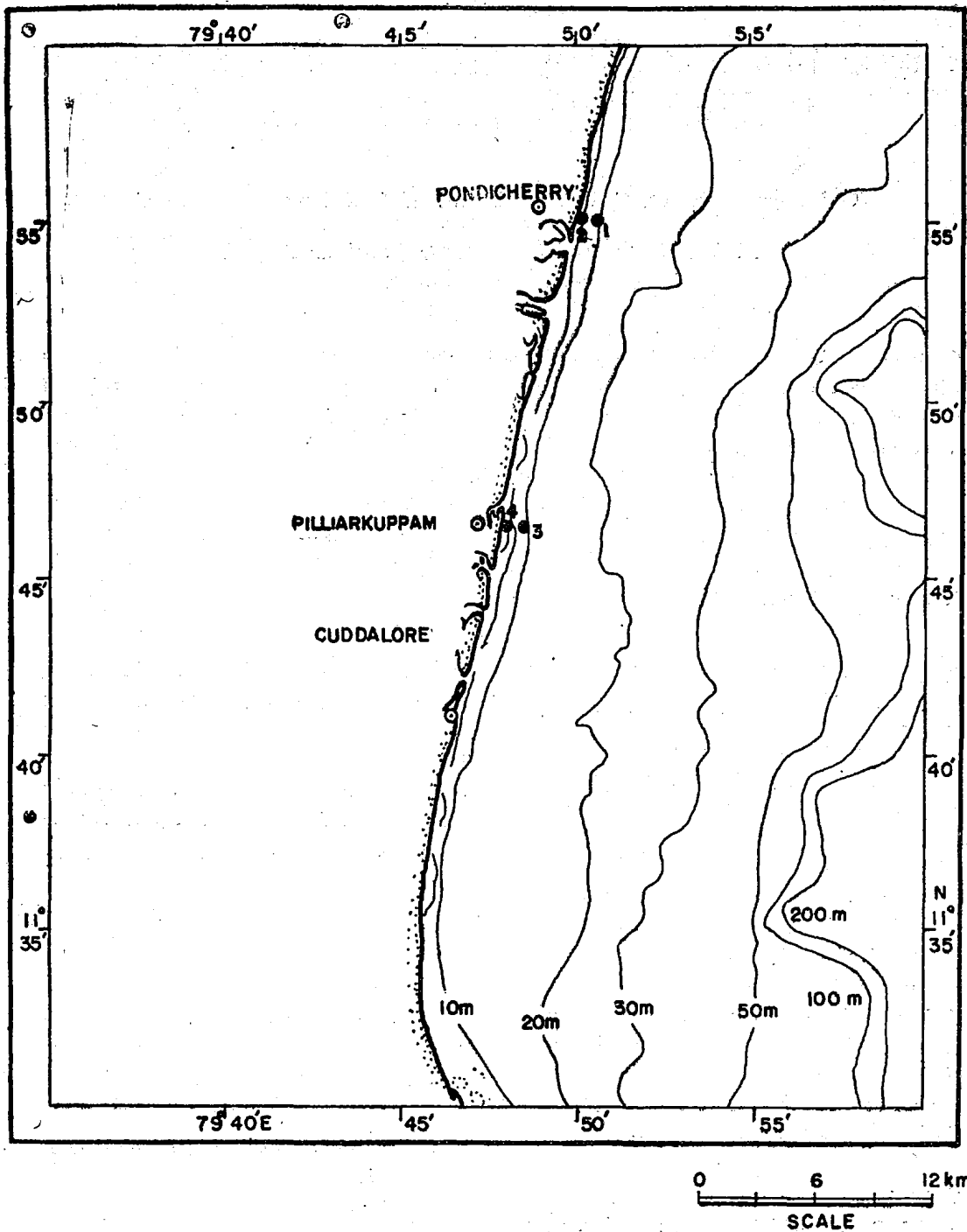


Figure 1. *Location map*
 (The current meter stations are shown by dots)

The current values were obtained by NIO rotor current meter at the surface (1 m below the sea surface), mid-depth and bottom (1 m above bed) covering spring and neap tidal conditions. Current velocity was measured at two stations (5 and 8 m deep) along a transect off Pondicherry Proper and off Pilliarkuppam (Figure 1). The componential currents (north-south

and east-west) were computed and are shown along with the related environmental parameters in figures 3, 4, 5, and 6. The advection of the surface waters was estimated by tracking the trajectories of vane-float assembly released at selected points. A shallow-water echosounder was used for charting the bottom topography. The bathymetry of the regions

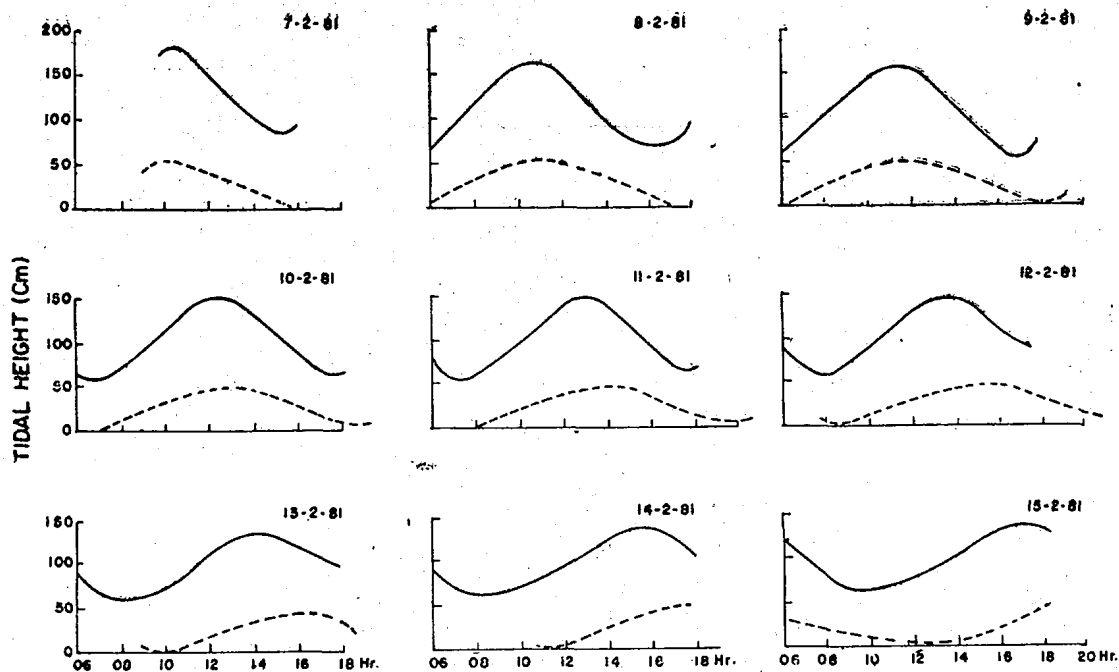


Figure 2. Observed tides at Pondicherry (———) with predicted tides at Nagapattinam (- - - -)

off Pondicherry Proper and Piliarkuppam is shown in figure 7 and 8 respectively after appropriate tidal corrections.

The bottom sediments were collected with van Veen grab

at a depth interval of 1-3 m along perpendicular transects off Pondicherry and Piliarkuppam. The samples were analysed for the grain-size distribution, following the standard method (Buchanan and Kain, 1971). The results are given in tables 2 and 3.

Table 2. Bottom sediment size distribution off Pondicherry Proper during February and April, 1981

Station depth, m	Composition, %							
	Coarse sand		Fine sand		Silt		Clay	
	F	A	F	A	F	A	F	A
3	8.9	6.5	87.8	78.4	3.1	15.1	0.2	0.1
6	4.7		82.5		11.4		1.4	
7		2.8		62.4			33.5	1.3
8		1.6		45.4			40.5	12.5
9	5.9		20.2		64.3		9.5	
10		4.6		31.7			58.1	5.6
12		7.8		40.6			40.2	11.5
13	91.8		5.3		2.1		0.8	
15	95.7	31.6	3.7	28.6	0.6	33.1	0.1	6.7
16		85.7		11.8		2.4		0.1

F - February; A - April

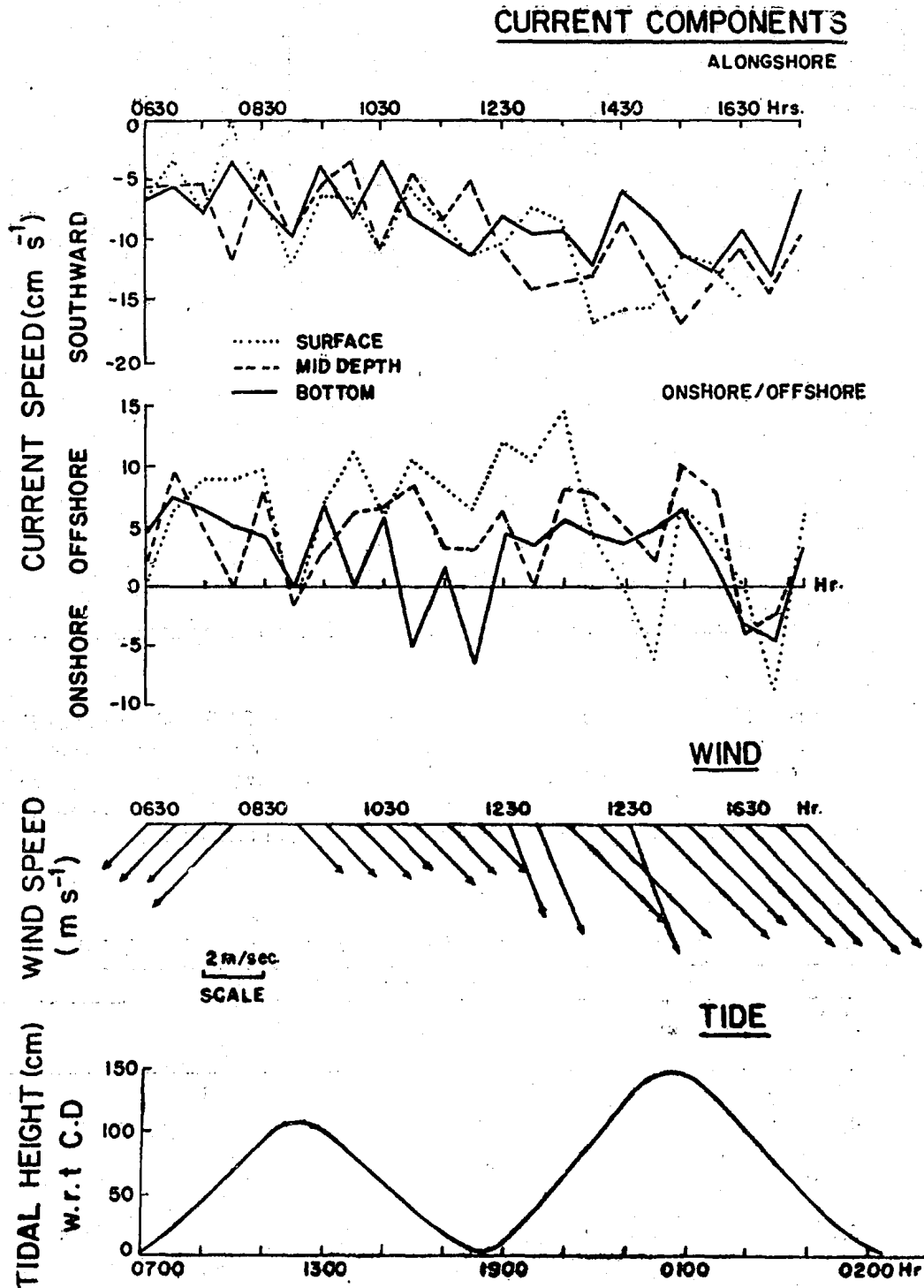


Figure 3. Componental currents with related parameters off Pandicherry Proper on February 7, 1981 (Station 1)

Dispersion of a pollutant patch was simulated with limited success, by injecting an artificial fluorescent dye (Rhodamine-B) at probable discharge points. Dyed sea water samples were collected from the surface

periodically over space and time to determine the instantaneous dye concentration photometrically. The number of times a given pollutant would get diluted in relation to progressive diffusion time for a small

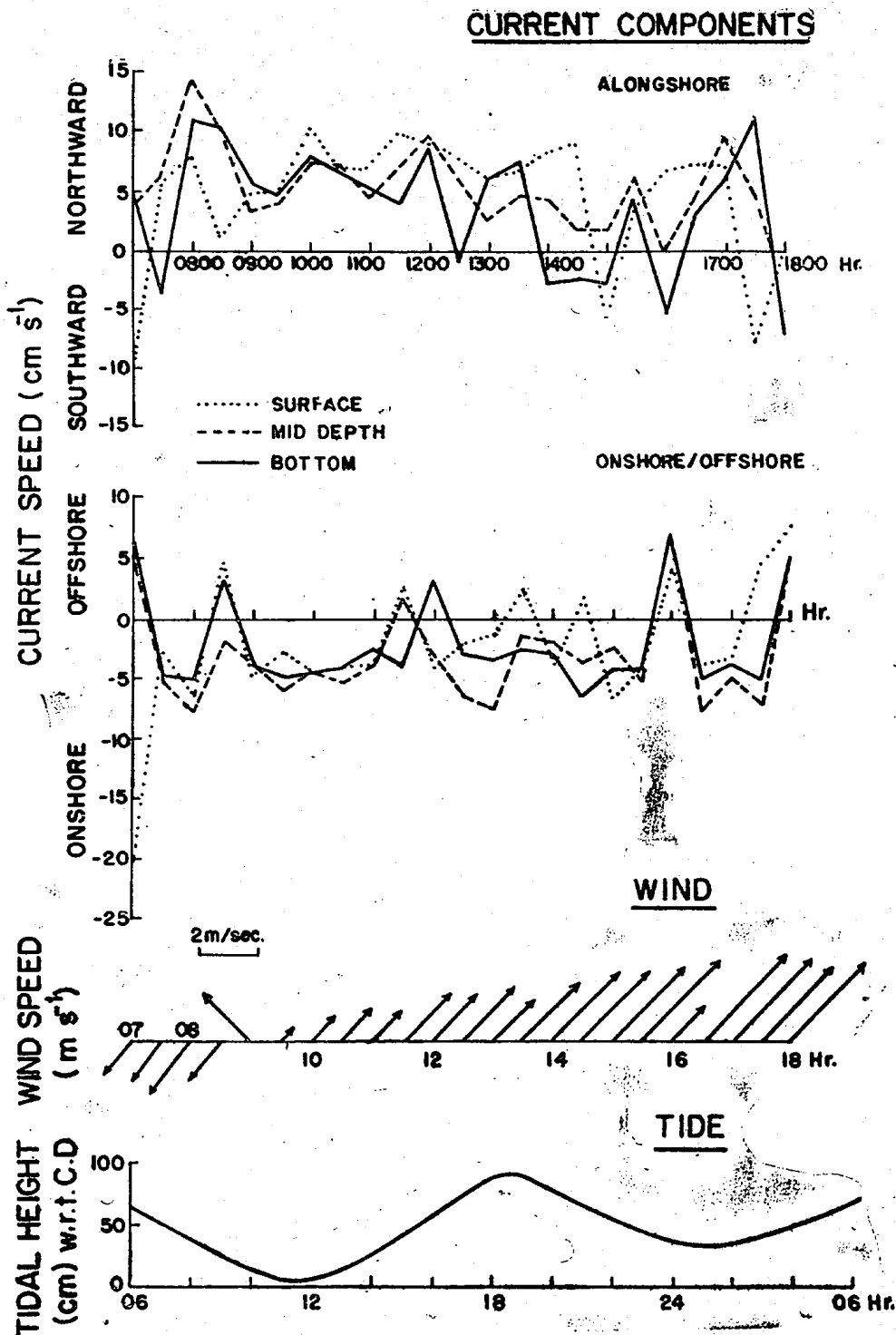


Figure 4. Componential currents with related parameters off Pondicherry Proper on February 13, 1981 (Station 2)

instantaneous dye release was thus estimated (Table 4). The wind velocity was measured with a portable wind meter, in conjunction with current observations. Additional wind data were obtained

from the nearest meteorological observatory. The wave characteristics of the grid encompassing Pondicherry coast (10° - 15° N and 79° - 85° E) have been considered here (NIO Report, 1982).

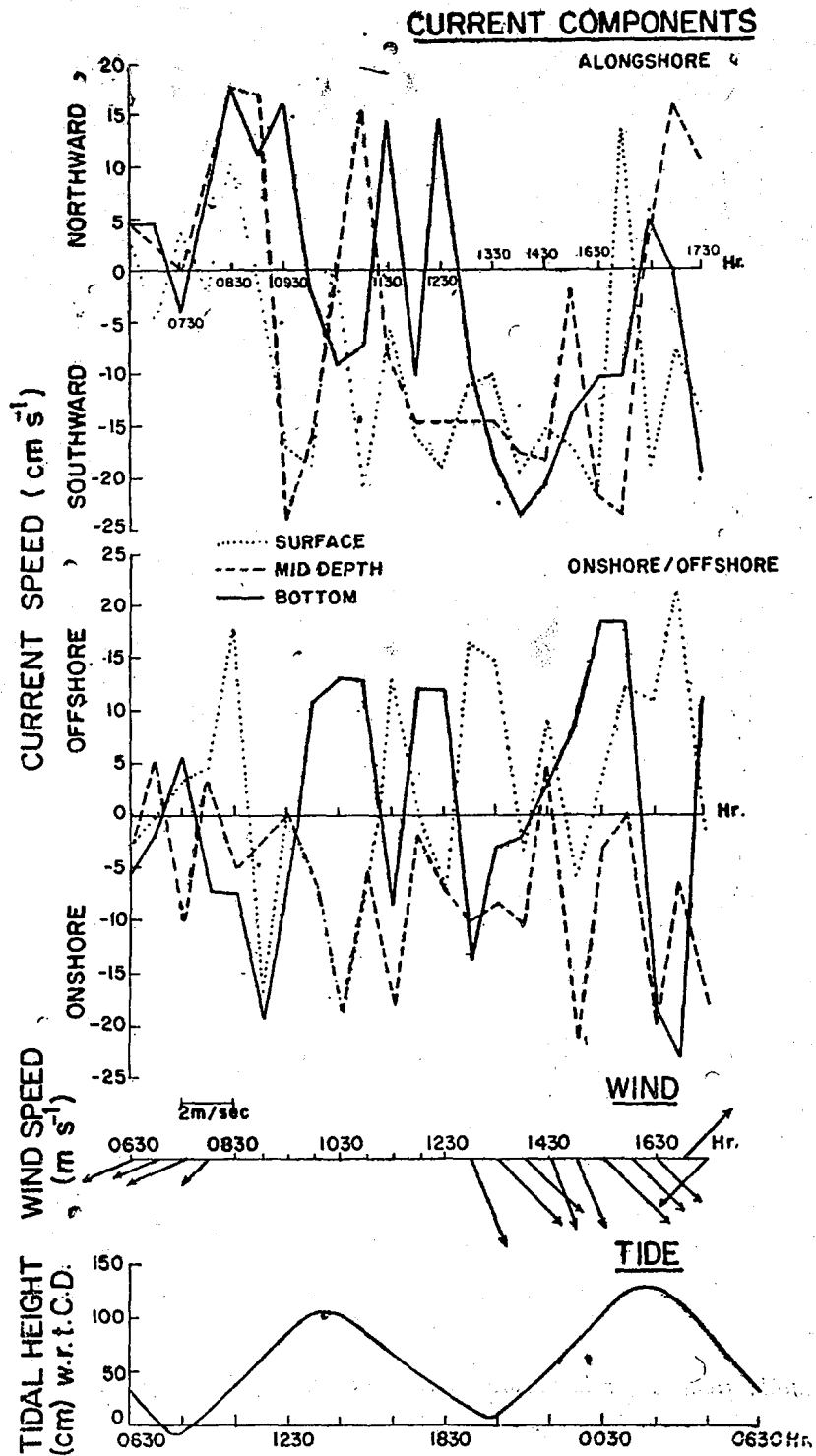


Figure 5. Componential currents with related parameters off Pilliarkuppam on February 9, 1981 (Station 3)

Table 3. Bottom sediment distribution off Pilliarkuppam during February and April, 1981

Station depth, m	Composition, %							
	Coarse sand		Fine sand		Silt		Clay	
	F	A	F	A	F	A	F	A
3		44.6		53.7		1.5		0.2
5	8.7		88.8		2.3		0.2	
6		7.2		83.7		8.5		0.5
8	2.2	5.2	61.7	60.0	26.6	26.2	9.5	8.5
10	11.4	6.7	45.3	57.0	34.9	30.2	8.5	6.1
12	33.0	15.6	44.5	58.3	13.0	20.0	9.5	6.0
14	66.8		30.6		2.3		0.2	
15		75.2		23.2		1.4		0.2

F - February; A - April

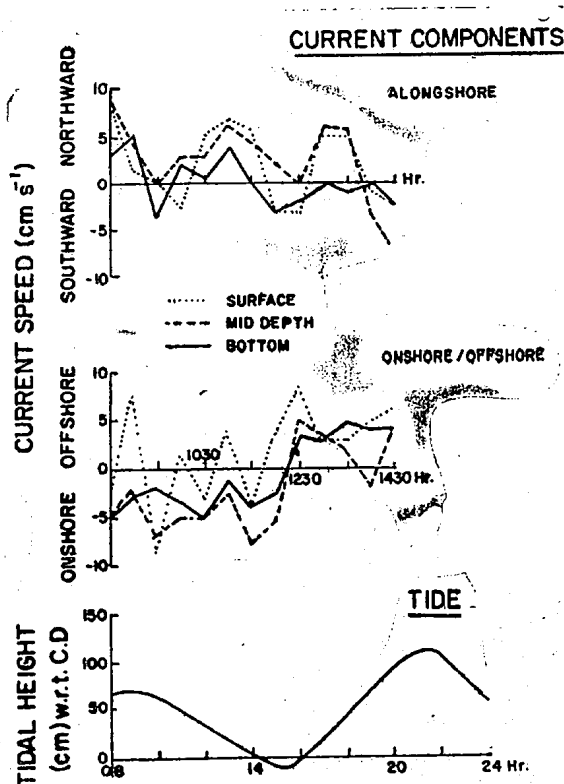


Figure 6. Componential currents with related parameters off Pilliarkuppam on February 16, 1981 (Station 4)

Table 4. Ambient dilution off Pondicherry coast

Region	Diffusion time, min	Dilution factor	
		Standard depth-6m	Standard depth-9m
Pondicherry Proper	15	1	1
	30	4	4
	60	6	6
	120	8	9
Pilliarkuppam	15	8	-
	30	18	26
	60	31	51
	120	43	75

RESULT AND DISCUSSION

Tidal oscillations are moderate in this area and consequently form one of the significant process-mechanisms for pollutant dispersion (Figure 2 and Table 1). However, the tidal currents are generally weak. The contribution of wind currents is considerable (Figures 3, 4, 5 and 6). The spring-to-neap variation is very marginal. The general circulation along the Coromandel Coast renders the coastal currents a strong directional bias. The maximum current speed observed off Pondicherry is about 25 cm/sec during January/

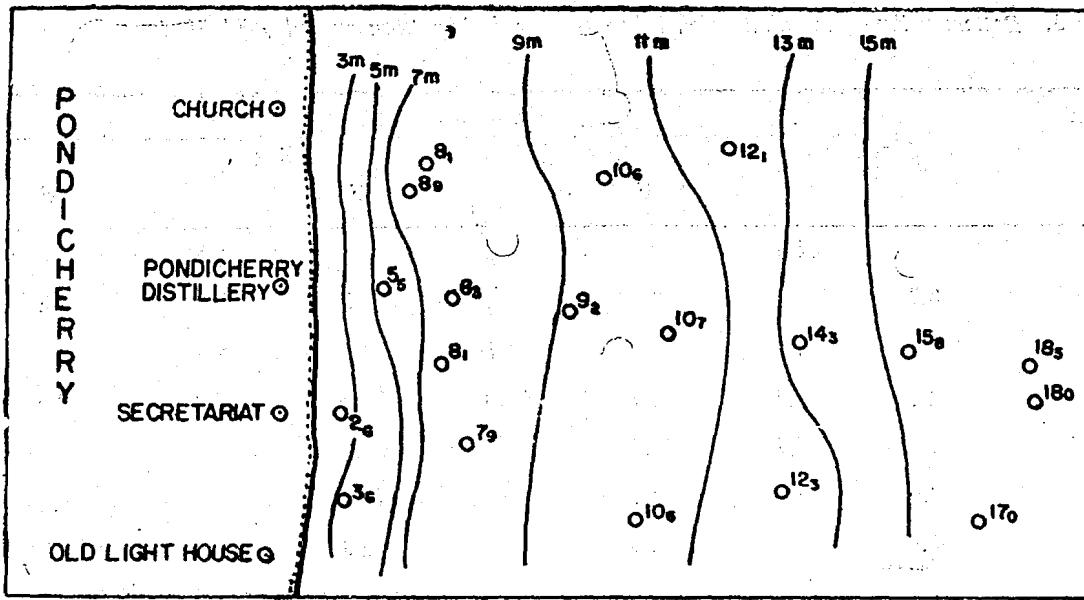


Figure 7. Bathymetry off Pondicherry Proper on February 14, 1981 (scale is given in Figure 8)

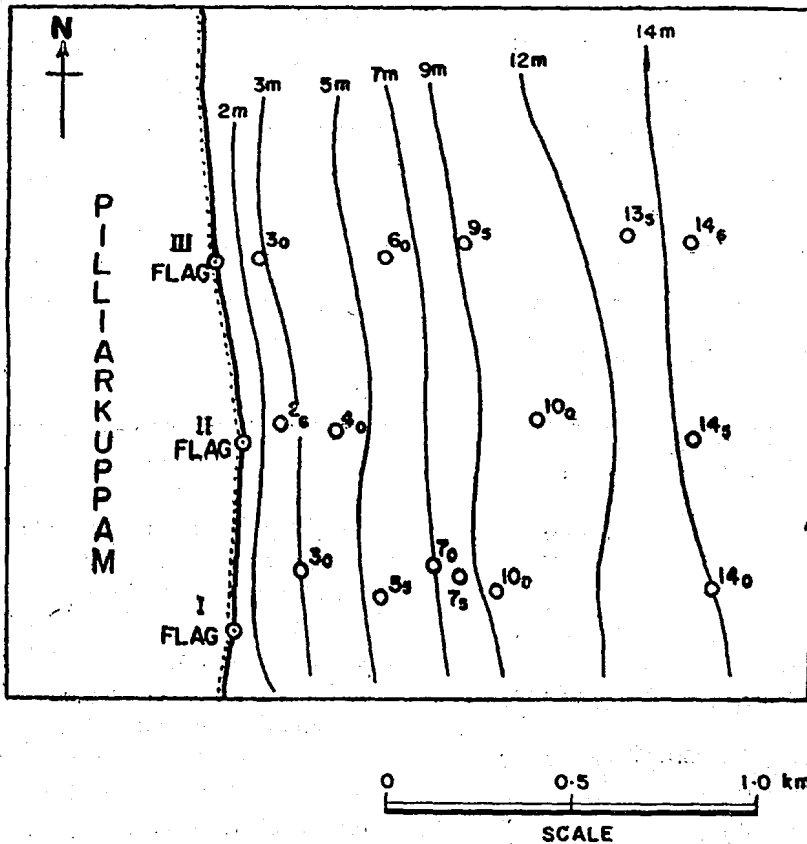


Figure 8. Bathymetry off Pillarkuppam on February 11, 1981

April 1981. The componential currents further reveal the extent to which onshore-offshore tendency of the currents prevails (Figures 3, 4, 5 and 6). The behaviour of the surface waters under the influence of the prevalent wind regime could be made out from the trajectories of the floats. The floats released at different locations within 1 km from the shore travelled with an average speed of 20 cm/sec. towards the shore, and finally got grounded.

The directions of the waves off Pondicherry coast characteristically shift, in response to the north-east and south-west monsoons in November and May respectively. Waves of height over 6 m have been reported offshore (NIO Report, 1982). Calm conditions prevail mostly during the early part of the year. The bathymetry of the nearshore reaches of Pondicherry and Piliarkuppam is generally uniform and the contours run almost parallel to the shoreline (Figure 7). The continental shelf is steep and considerable water depths are available not very far from the shoreline (Figure 7). The beaches of Pondicherry are known to be vulnerable to periodic erosion. It is likely that the beach sand is moved in the offshore-onshore directions as well as in the alongshore direction, so that seasonal changes in the nearshore topography are noticeable. However, historic data on the bathymetry of this region were not immediately available.

In general the sea bottom between the shore and 6 m depth contour is fine sandy in texture. A coarse bottom prevails beyond 14 m depth (tables 2 and 3). The results of the sediment analysis clearly revealed a clayey/silty belt between 8 and 12 m contours. A lot of significance as to fisheries has been attached to this belt by the local fishermen. The black colour of the sediments at certain region off Pondicherry is attributed to the influence of some sewage runoff. Dye-dispersion studies show that the waters off Piliarkuppam are more turbulent than those off Pondicherry Proper. Dilutions of the order of 4 to 6 times will be available in 1/2 to 1 hr, if the effluents are released in the surface waters within the offshore distances of 250 m (station depth 6 m) and 700 m (station depth 9 m) off Pondicherry Proper. Off Piliarkuppam, dilutions of 18 and 50 times will be available in 1/2 to 1 hr respectively if the effluents are discharged at 400 m (station depth 6 m) and 700 m

(station depth 9 m) respectively. At both the places the surface and as well as the bottom currents have a tendency to move towards the shore occasionally. In case the effluents are caught up in this current having speeds upto 20 cm/sec, the contaminants will reach the shore within 1/2 hr if released at a distance of 250 m and in 1 hr if released at 500 m off the shores. It may be noted that while the length of the wastewater pipeline has direct bearing on the advective mixing of contaminants off both Pondicherry and Piliarkuppam, it has limited contribution towards ambient diffusion off Pondicherry comparatively.

These physical factors are very important in the determination of the location of the marine outfalls. The fishery-rich silty zone off Pondicherry coast should also be considered while locating the outlets. Since the advective diffusion rates in these water bodies are rather low, near-field initial dilution may have to be augmented by the use of properly designed diffuser system. Also since the area is under the influence of strong wind and wave regimes, and the nearshore sea bed composed predominantly of fine sand is vulnerable to topographic changes, the effluent pipelines should be adequately protected.

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