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# Seasonal and diurnal variation of hydrobiological characters of coastal water of Chennai (Madras), Bay of Bengal

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Seasonal and diurnal variations in the hydrobiological characters of coastal water of southern Chennai, Bay of Bengal were studied. Parameters such as current, *p*H, salinity, inorganic nutrients, ($NH_4$, $NO_2$, $NO_3$, $PO_4$, $SiO_3$-$SiO_2$) and heavy metals exhibited unimodal oscillation and temperature, dissolved oxygen (DO), biological oxygen demand (BOD) and suspended solids exhibited bimodal oscillation. Particulate organic carbon (POC) was positively correlated with suspended solids. Chlorophyll-*a* (chl-*a*) and phytoplankton density showed two maxima; one in summer and another in southwest monsoon season and minimum value during the northeast monsoon. Productivity was low in northeast monsoon compared with other seasons. Temperature, dissolved oxygen (DO), chlorophyll-*a* (chl-*a*) and productivity increased in the day time and *vice versa* for inorganic nutrients. Low tide brought more nutrients and less saline water from the estuarine region; high tide brought more chl-*a* from the offshore water. All the parameters were highly influenced by monsoonal rain, littoral drift and land drainage in a season but diurnal variation was due to the combination of more than one factors.

Information on the coastal hydrography of Chennai (Madras) coast is essential in the context of coastal pollution and consequent productivity of the Bay. The Chennai coast is mainly influenced by a variety of pollutants from industries, harbour, domestic sewage etc. Rao & Valsaraj[1] found that DO in the waters of Chennai coast, near Marina, was low at high temperature (30°C) and high salinity (34.5‰). Sivaswamy & Prasad[2] indicated changes in water due to variation in different physico-chemical parameters and the phytoplankton population fluctuated at different seasons in the coastal waters. Prabu *et al.*[3] studied the occurrence of heterotrophic bacteria in the water and sediment samples collected from the Chennai coast and found that limited fluctuation in heterotrophic bacteria occurred throughout the year on both water and sediments. According to Prabhu *et al.*[4], the distribution of fungi in the water and sediment of Chennai coast was not well pronounced in different seasons. Diel cycles of biological and related parameters in the ocean are primarily a manifestation of the relation between sunlight and the marine biota[5]. Variations in biological parameters over 24 h at stations of Bombay coast were investigated by Bhattathiri & Devassy[6].

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Since Chennai is one of the main fishing centers of India, it is essential to know the hydrographical characters of the coast. For, this would provide valuable information on the nature of the coastal water. The physico-chemical and biological characters of coastal water of south Chennai, were studied from July 1992 to June 1993 and diel variation in the hydrobiological parameters during 1995, and the results are presented in this communication.

## Materials and Methods

For seasonal studies, five sampling stations (Fig. 1) were fixed along the 50 km distance of south Chennai coast at different intervals. Surface water samples were collected once in a month at 50m distance from the coastline in plastic containers and for diel study, water samples were collected during the northeast monsoon season at a distance of 1 km from the shore at 2 hourly interval from 0060 hrs till 0060 hrs the following day. The samples were kept at 1-4°C during transit to the laboratory and analyzed immediately

Both *p*H and temperature were measured and DO[7] was fixed in the field immediately after collection. Salinity, inorganic nutrients, primary productivity, pigments[8], POC[9], BOD[10], heavy metals (Cu, Zn and Cd) by atomic absorption spectrophotometry[11]

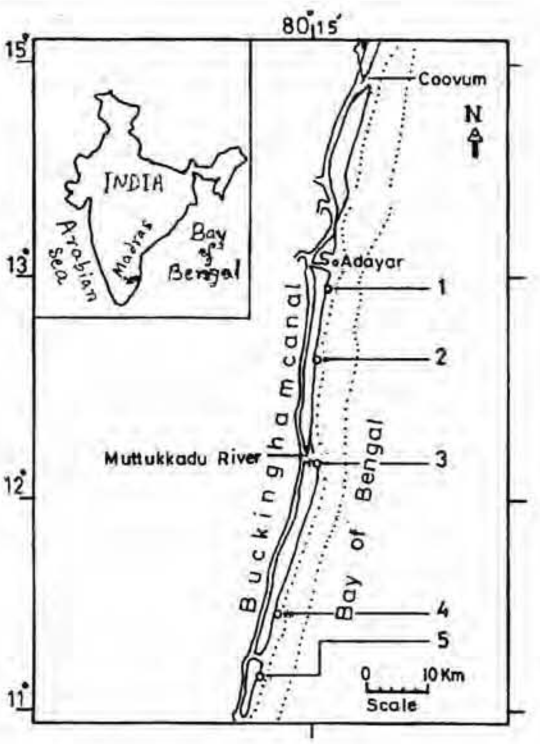


Fig. 1—Diagrammatic representation of study area— 1. Thiruvanmiyur; 2. V.G.P. Coast; 3. Kovelang; 4. Mamallapuram; 5. Kalpakkam.

(Varian, Model-1475) were measured in the laboratory. For diel study, the primary productivity was measured in the field. Dry weight of suspended solids was determined by filtering the seawater through dried and preweighed 0.45 µm pore size Millipore membrane filter, washed with distilled water and dried to a constant weight. Phytoplankton density was counted in a haemocytometer ("Neubauer", Fein Optik, Germany). The data from both study were given separately but for seasonal studies, the data from 5 stations were pooled; the average value was taken for the whole of south Chennai and statistically analyzed[12].

**Results and Discussion**

The Chennai coast received more rain from the northeast monsoon (October to December) than from the southwest monsoon (July to August). The littoral drift was from south to north, from January to middle of October and reversed its direction from north to south until January[13]. The water temperature ranged from 26.9 to 30.3°C, and exhibited a bimodal oscillation during the year (Fig. 2A). The salinity varied from 25.2 to $35.2\times10^{-3}$ and was positively correlated with temperature. Low values were recorded in December at the end of northeast monsoon season due to heavy freshwater discharge by the monsoon rain. The low *p*H was recorded in the northeast monsoon months due to heavy floods from the rivers[2, 14] and high values in summer season due to high photosynthesis[15] (Fig. 2B).

The DO was negatively correlated with salinity ($r = -0.746$, $p<0.001$ level), ranged from 5.8 to 7 mg $l^{-1}$ and showed high values in the middle of southwest and northeast monsoon seasons (Fig. 2B). The phytoplankton blooms might be responsible for the first peak of DO and freshwater flow by anti-clockwise current for the second peak of DO[16]. Decline in DO up to 5.8 mg $l^{-1}$ generally occurred with the rise in temperature and salinity[17] in other seasons.

Inorganic nutrients and heavy metals were high in the samples collected in northeast monsoon season compared with other seasons (Fig. 2C-F) This is ostensibly due to the influx of land run-off of freshwater inputs through the rivers Cooum and Adyar carried by anti-clockwise current[2, 18, 19] and release from sediments by the turbulence following strong winds[20]. The low values of nutrients in summer and southwest monsoon season might be due to the reduction of river flow and utilization by phytoplankton[18,20]. The increase of metals and nutrient concentrations followed by decrease of salinity can be attributed to the land run-off of fresh water inputs in the coastal region[21]. The prevalence of trace metals in the coastal waters is affected by several factors such as land drainage, flocculation, incorporation into phytoplankton and adsorption/desorption on/from suspended matter[22,23]. Effluents containing metals are from metal processing industries and harbour, especially from the paints of ships anchored in the Chennai commercial and fishing harbour. The hierarchy of metal level was Zn> Cu> Cd.

The monthly variation of BOD varied from 1.2 to 2.7 mg $O_2$ $l^{-1}$ (Fig. 2G) and was negatively correlated with salinity. High values were recorded in August (2.6 mg) and December (2.7 mg) and this may be due to phytoplankton blooms in August and land drained organic wastes in December. Suspended solids exhibited a bimodal oscillation in their distribution. A peak of 80 mg $l^{-1}$ was recorded during southwest monsoon and another during northeast monsoon (109 mg $l^{-1}$) (Fig. 2G). The POC level varied from 0.84 to 5.19 mg C $l^{-1}$ (Fig. 2H) and exhibited positive correlation with suspended solids[24] and negatively correlated with salinity (r =-0493, $p < 0.01$ level). These two maxima were due to resuspension of bottom sediments by turbulence caused by wind and land drainage[25].

Chlorophyll-*a* was positively correlated with salinity and minimum in northeast monsoon months (Fig. 2H) during which more nutrients were available. Microbial population also remained high during this season as reported by Prabu *et al.*[26], and Anbazhagan[27] in Kodiakkarai coastal water found similar relationship of high values in summer and southwest monsoon and low values in northeast monsoon season. This may be due to the outburst of phytoplankton bloom as a result of high nutrient availability. The reduction in chl-*a* in northeast monsoon season may be the result of freshwater discharges from the rivers, causing turbidity and less availability of light[27]. The phytoplankton counts were high during southwest monsoon season (Fig. 2I) as reported by some of the studies in Bay of Bengal[17, 27].

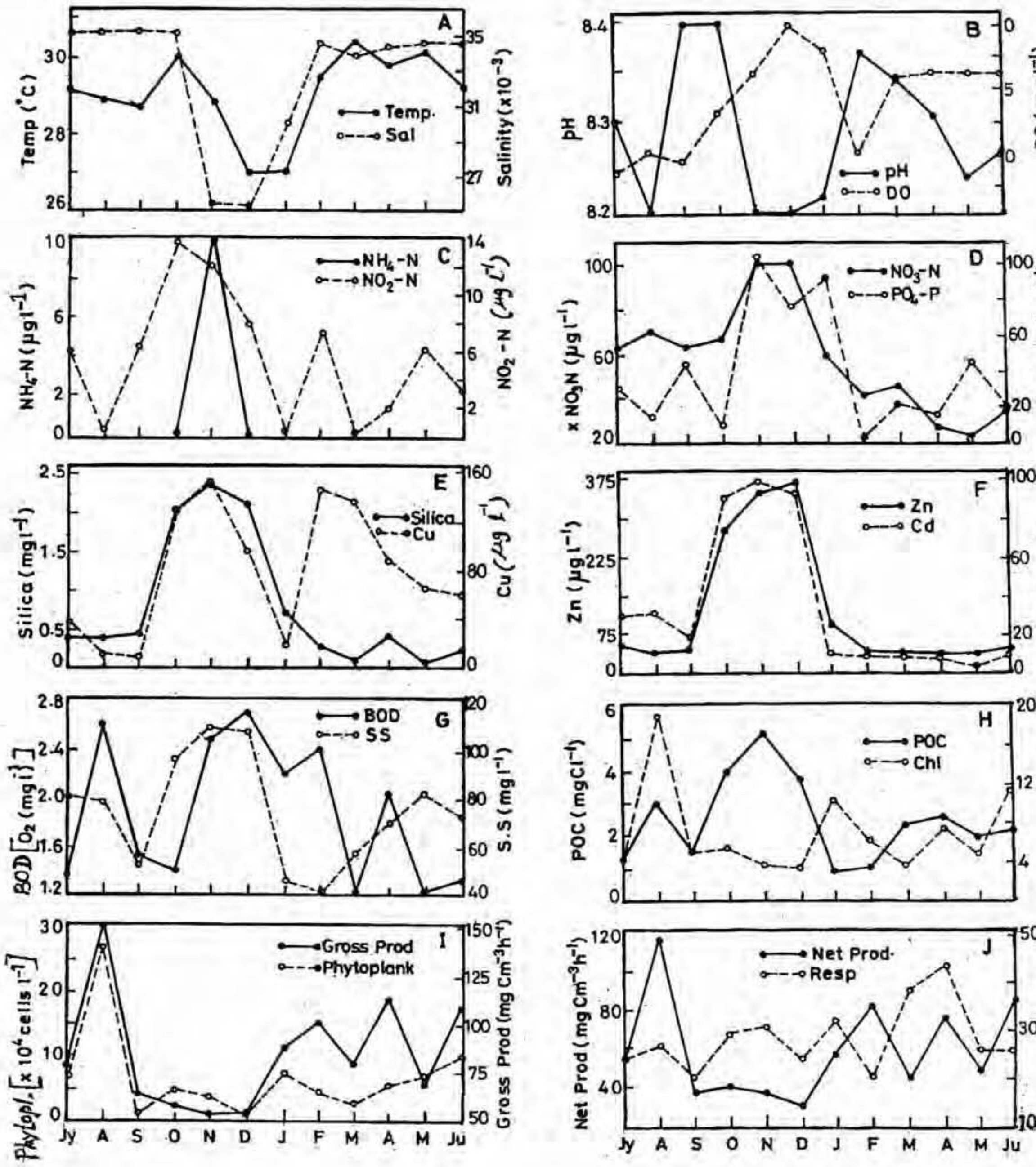


Fig. 2—Seasonal variations of hydrobiological characters of seawater-South Chennai.

Both gross and net productivity were low in the northeast monsoon season. Net productivity was positively correlated with salinity (Fig. 2J). The high productivity during summer and southwest monsoon season may be due to increased radiation[28]. The increase in respiration in the samples collected from northeast monsoon season may be due to the mixing of land drainage, which carries a lot of organic substances, resulting in the possibility of biological oxidation.

In diel study, the maximum temperature (30°C), *p*H and DO (6.1 mg $l^{-1}$) (Fig. 3A, B) in day time were due to the high solar radiation and photosynthesis. Maximum and minimum values of temperature of surface coincided with peak solar radiation and the temperature of water was essentially influenced by the atmosphere[30]. During day time, the photosynthetic oxygen production exceeded the oxygen consumption for respiration and *vice versa* in the night[30]. The reduction in salinity ($25 \times 10^{-3}$) (Fig. 3A) during low tide was due to the influence of fresh water from the river Adyar. Salinity level was always tide dependent[29, 30]. The decrease of nutrients in day time and the increase in night time indicated that they might have been consumed by phytoplankton during photosynthesis[31] as seen in high productivity in day time (Fig. 3C, D).

Increase in chl-*a* in the morning hours and decrease as the solar radiation increases (Fig. 3E) can be explained by pigment bleaching during high light [32, 33] and breakdown of cellular nitrogen compounds[33]. The downward migration of phytoplankton during day time is another possibility[34]. During night, the decrease in chlorophyll was more than compensated by increase in biomass[33]. The pigments are produced for only a few hours starting at the beginning of the light period and remained constant thereafter[35]. High value of chl-*a* during high tide compared to low tide may be due to the intrusion of phytoplankton cells from the offshore waters during the flood tide[35]. The

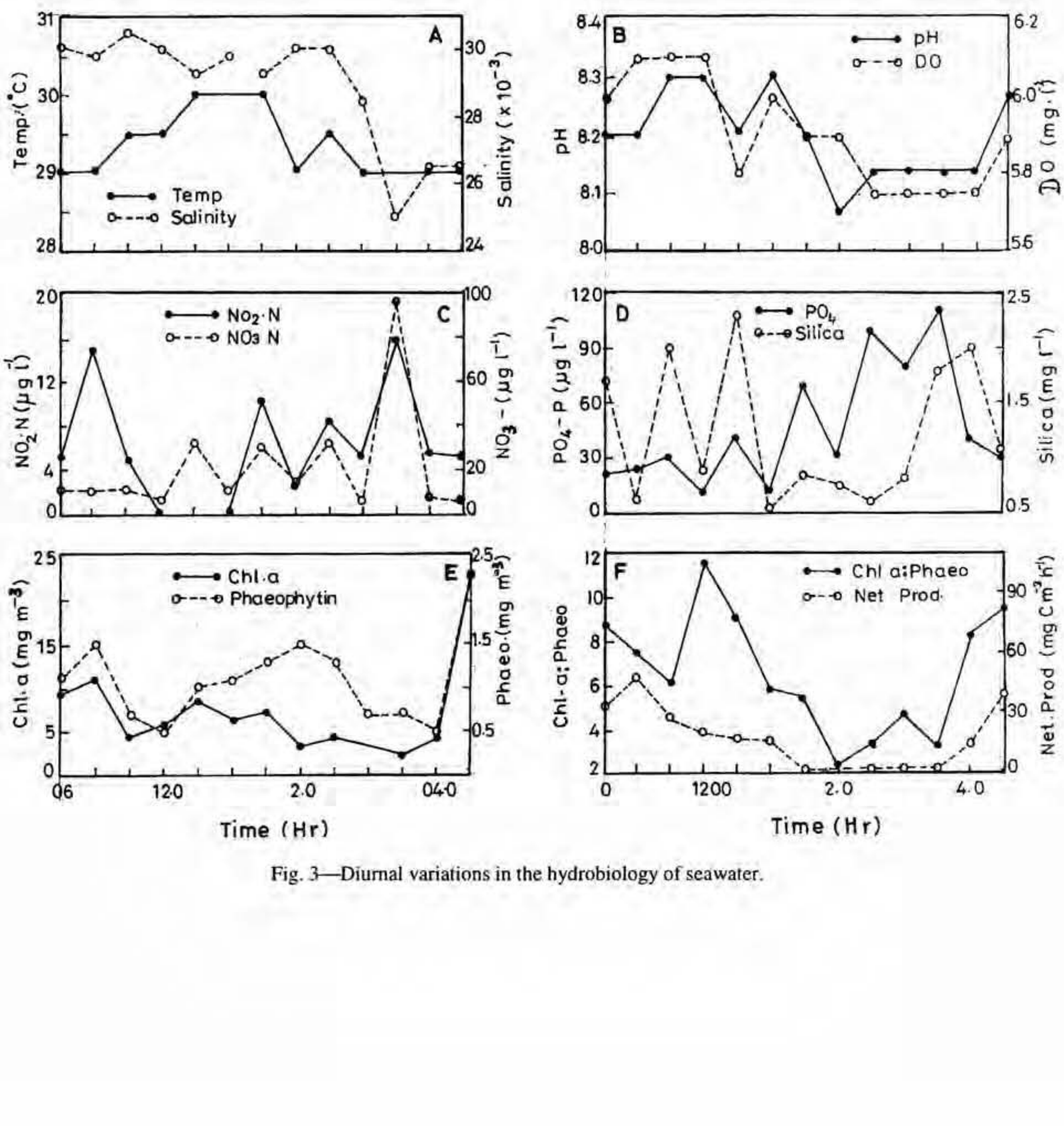


Fig. 3—Diurnal variations in the hydrobiology of seawater.

increase in chl-*a*/phaeopigment ratio during day time and high tide compared with night time and low tide (Fig. 3F) respectively may be due to the increased rate of zooplankton grazing during night time[31]. The intrusion of dead chlorophyll from the river Adyar during low tide might have increased the phaeopigment content.

Productivity level closely followed chl-*a* level. The increased value of gross and net productivity during morning hours (Fig. 3F) could not be wholly due to favourable exogenous factors like light and nutrient levels prevailing during that period[31]. Also population in the morning has a preponderance of young photosynthetically active cells[37]. The decrease in productivity after mid-day can be due to photoinhibition[31], their downward migration[38] and augmentation[37]. Clearly the polluted river Adyar exerts some influence on the seawater during low tide.

In general, the physico-chemical and biological parameters of the coastal water are highly influenced by monsoon rains, littoral drift and drainage from the rivers Cooum and Adyar.

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