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Seasonal distribution of nitrate, nitrite, ammonia and plankton in effluent discharge area off Mangalore, west coast of India

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Distribution of NO_3-N, NO_2-N, NH_3-N and plankton has been studied at 9 stations situated along 4, 10 and 20 m depth off the point (Thannirbhavi, Mangalore) discharging nitrogenous effluents. Apparently there is no build up of any form of nitrogen studied during the present investigations. The stations at 4 m depth contour, particularly S_2 which is closest to the effluent discharge point show increased plankton production.

Seasonal distribution of various nutrients along the east and west coasts of India has been studied[1-3]. Though considerable work on the nutrient distribution in waters along Karnataka coast has been carried out[4-6], there is paucity of information on the influence of nutrients on plankton distribution along this coast. However, the general effect of industrial effluents on the biota off Mangalore has been studied[7]. This paper pertains to seasonal distribution of nitrate, nitrite and ammonia along with plankton in an area off Thannirbhavi, Mangalore where nitrogenous effluents are discharged.

Materials and Methods

Nine sampling stations (S_1, S_2 and S_3 along section H_1; S_4, S_5 and S_6 along section H_2 and S_7, S_8 and S_9 along section H_3) in relation to the Netravathi-Gurpur estuarine mouth and the effluent discharge point were selected (Fig.1). The two rivers Netravathi and Gurpur drain their waters into the Arabian Sea 5 km south of the above effluent discharge point. Regular monthly sampling was done from March 1981 to February 1982 excluding the monsoon period (June to August, 1981). Water samples, collected from the surface using a clean plastic bucket and from the nearbottom layers by means of a Nansen reversing water bottle, were analysed in the laboratory for nitrate, nitrite and ammonia following standard colorimeteric methods[8], using a Klett Summerson photoelectric colorimeter. Horizontal and vertical hauls of plankton were made using an Heron Tranter net. The length of the tow was found using the speedometer of the boat[9]. The volume of water filterd was calculated using standard methods[10]. Plankton samples fixed in 4% seawater-formalin were subjected later to quantitative analysis and the wet weights were determined and expressed in $mg.m^{-3}$.

Results and Discussion

Ammonia-nitrogen—Fig.2A represents the seasonal fluctuation of ammonia-nitrogen. The higher values recorded along section H_1 is perhaps due to its proximity to the point of discharge of effluents and to biodegradation of urea.

The subsurface variations closely followed those in the surface. Higher concentrations in the subsurface water particularly during September could be partly due to death and subsequent de-

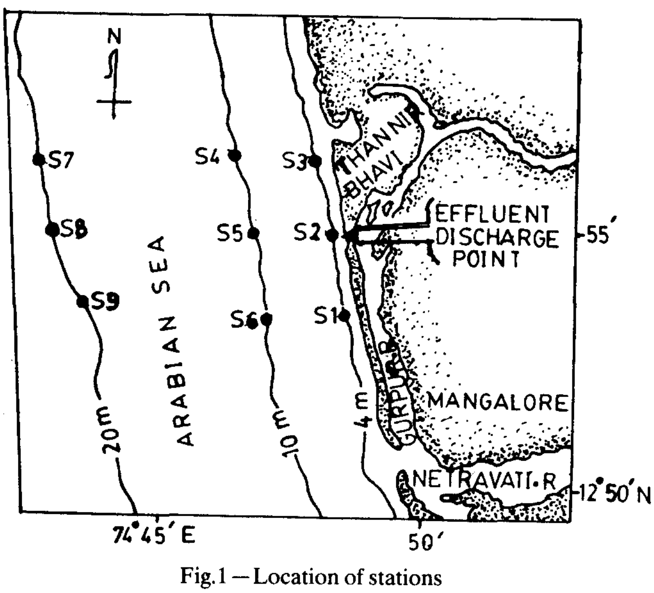

Fig.1 — Location of stations

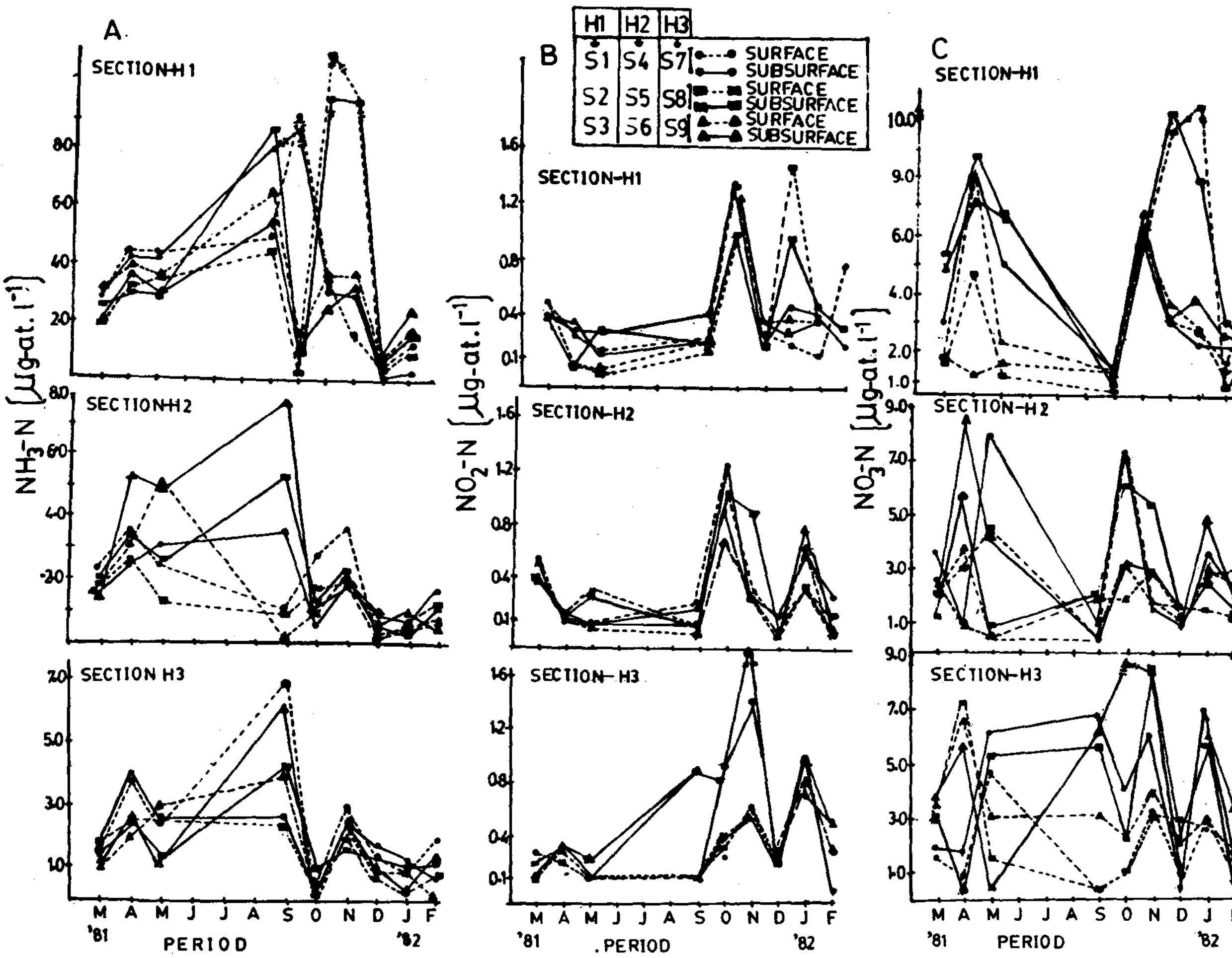

Fig. 2—Seasonal fluctuation of ammonia (A), nitrite (B) and nitrate (C)

composition ot phytoplankton which is reported to be abundant during the monsoon season along the west coast of India[11,12] and partly due to terrigenous input during this season.

The irregular monthly fluctuation of ammonia concentrations at the nearshore stations along section H_1, which is in contrast to that along sections H_2 and H_3, could be related to the proximity of the effluent discharge point and the variations of rate of discharge (av. 7200 $m^3 . d^{-1}$) of the effluents. Further, the pattern of circulation in this area might also be a factor as reported by earlier workers[13].

Phytoplankton production appears to influence the ammonia concentrations (Figs 2A and 3A). Thus the peak concentration of ammonia during November could be related to decomposition of plankton which was abundant during October. The less abundant phytoplankton during November (Fig.3A) and the resultant non-utilization of ammonia could have also contributed to the higher concentrations of ammonia. However, the high concentration of ammonia at st S_2 (located near the effluent discharge point) may be due to oxidation of ammonia which is reported to be slow in relatively polluted waters[14]. The peak concentrations of ammonia during April and September in the deeper stations (section H_3) coincided with the high zooplankton production and this could be related to the excretion by planktonic organisms (Fig.3B).

The annual range of concentration of ammonia in this area[13] (0.543 to 24.12 µg-at $N.l^{-1}$) is more or less similar to the range observed during the present study (traces to 27.19 µg-at $N.l^{-1}$). This shows that there is practically no build up of total ammonia. The gradual decrease of ammonia concentration in the offshore stations (section H_3) and the corresponding increase in nitrate concentration may be due to oxidation of ammonia to more stable forms of nitrogen.

Nitrite-nitrogen—High concentrations of nitrite-nitrogen are evident during October along section H_1, during October and November along section

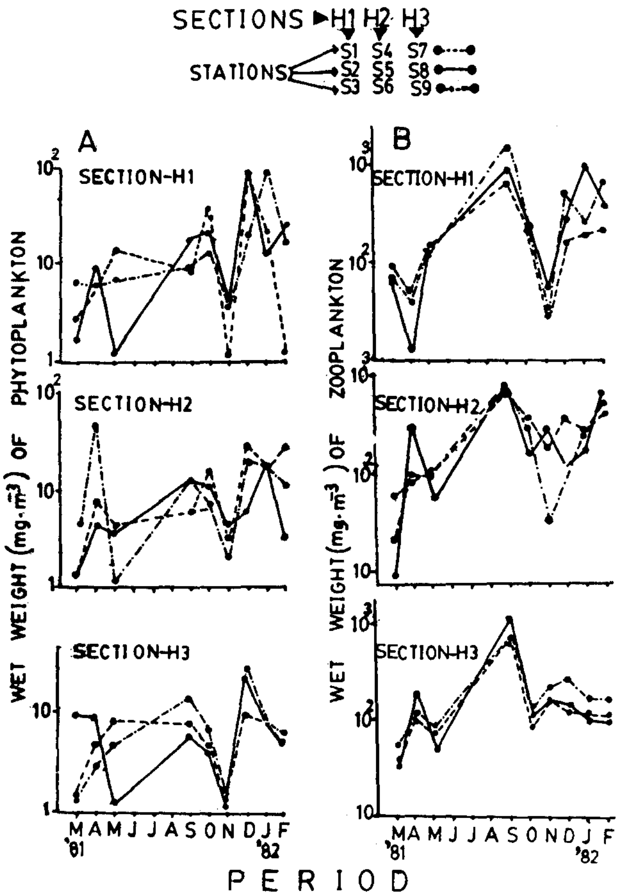

Fig. 3 — Seasonal abundance of phytoplankton (A) and zooplankton (B)

H_2 and during October, November and January along section H_3 (Fig.2B). The pattern of variations remained more or less similar at all sections. However, there was a gradual increase in the concentration of nitrite from section H_1 to H_3 and this may be attributed to the bacterial decomposition of planktonic detritus.

Variation in the concentration (μg-at $N.l^{-1}$) of nitrite in the present study (traces to 1.56 in the surface waters) was slightly less than that reported earlier[13,15] (traces to 3.8 and 0.1 to 5.9 respectively) in the same area. These variations are thought to be related to variations in the quantum of effluent discharged. The differences in seasonal variation may be contributed by the variation in the phytoplankton excretion, oxidation of ammonia and reduction of nitrate of which the latter is reported to be dominant[16].

High values of nitrite recorded at all stations during October may be the consequence of higher values of ammonia recorded during September. Similarly the isolated peak values of nitrite recorded during December may be due to the high concentration of ammonia during November. The peak values of nitrite during January at H_1 are believed to be due to the effluent discharge coupled with phytoplankton abundance during December (Fig.3A).

The higher subsurface nitrite concentration at almost all stations appeared to be due to the death and decay of plankton and due to the nitrifying bacteria[17,18]. However, increase of nitrite in the subsurface layers from section H_1 to H_3 could be due to the increased bacterial activity which is expected in a silty-clayey substratum compared to the sandy substrate near the coast.

Nitrate-nitrogen—Among the three inorganic forms of nitrogen, nitrate-nitrogen was the most abundant at all stations, perhaps due to the fact that nitrate is thermodynamically the most stable oxidation level of nitrogen in the presence of oxygen in seawater[18] and could accumulate if left unutilised.

Comparison of concentration range of nitrate in the present study with that reported earlier for the same area (Table 1) indicates deviations which may be due to fluctuations in the input of effluents. The increased values in the offshore region (section H_3) is due to oxidation of available ammonia.

Fig.2C indicates that the subsurface concentration of nitrate-nitrogen exceeded that of the surface layers at stations along sections H_1 and H_3. The concentration of nitrate is relatively more at section H_1 and H_3 compared to H_2. The increased concentration at H_1 appears to be due to the proximity of the effluent discharge point.

High values of nitrate at all stations during April/May could be attributed to oxidation of ammoniacal form of nitrogen to nitrite and subsequently to nitrate. While the peak values in H_1 was recorded during October, the same was recorded during October and January along H_2 and during October, November and January along H_3.

The peak nitrate values invariably recorded in October at all stations were preceeded by higher concentration of ammonia. The oxidation of ammonia to nitrite and then to nitrate may take place photochemically or chemically in a thin surface layer or biologically in and near the bottom[19]. The high values of nitrate-nitrogen might have been due to bacterial oxidation rather

Table 1 — Concentration of nitrate-nitrogen (μg-at $N.l^{-1}$) observed by various authors in Thannirbhavi area

Surface water	Subsurface water	Author
Traces to 28.30	Traces to 23.70	Reddy[11]
Traces to 16.63	0.78 to 11.31	Eknath[15]
0.45 to 15.25	0.32 to 13.25	Present study

than photochemical oxidation of the high level to ammonia.

Phytoplankton—The phytoplankton abundance progressively increased in the coastal stations and the highest value at station S_2 of section H_1 (Fig.3A) may be due to the effect of nitrogenous effluents discharged near this station. However nutrient requirement is known to differ with the phytoplankters and that high concentrations of nutrients alone may not be conducive for substantial increase in productivity[20]. Since the rate of regeneration of nitrogen is slower than that of phosphorus, the readily available ammoniacal form of nitrogen at st S_2 could have been responsible for high plankton production.

Seasonal abundance of phytoplankton was recorded during April/May, September/October and December/January at various stations. After a temporary shut down of effluent discharge during March, full discharge was resumed in April and this could be the reason for high production of phytoplankton during April/May. While the abundance of phytoplankton in September/October is believed to be a seasonal trend[13,15,21] the abundance of the same during December/January seems to be related to the increased nutrients contributed by the terrigenous sediments brought down through the Netravathi-Gurpur estuary during monsoon and postmonsoon season and carried by the generally prevailing northerly drift[22] during November/December.

Zooplankton—The coastal waters harboured more zooplankton than the waters at section H_3. A clear-cut abundance of zooplankton at all stations during April/May, September and December to February was observed (Fig.3B). The preponderence of zooplankton during April/May can be attributed, on the basis of earlier observations in the area[9], to relatively greater abundance of ctenophores, polychaetes, chaetognaths and lucifers. The higher values at all the stations during September is a regular seasonal occurrence in Thannirbhavi area[13,15,21]. The postmonsoon abundance exceeded that of the premonsoon abundance. While this could have been controlled by the meroplanktonic community as reported earlier[9], the abundance in December-February may be related to the abundance of copepods[9]. There is no clear-cut relationship discernible between phytoplankton and zooplankton. This may be due to the changing food habits of plankton in the coastal waters[20].

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