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Phytoplankton in Relation to Pollution in Uppanar Estuary Southeast Coast of India

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Abstract: Impact of industrial pollution on water quality and phytoplankton population was done for a period of one year in Uppanar estuary at three location (Ia, Ib and Ic) and open sea. Water quality and phytoplankton diversity and distribution patterns indicated that, the water quality of this environment was highly polluted. Higher levels of nutrients, heavy metals, primary productivity, chlorophyll a and total carotenoid content in station Ia indicated a possibility for eutrophication, which also confirmed by the dominance of phytoplankton *Asterionella japonica* and *Thalassiothrix frauenfeldii*. In addition to that the species diversity was also very low when compared to open sea.

Key words: Phytoplankton, eutrophication, chlorophyll a, nutrients

INTRODUCTION

Rapid industrialization and human aggregation on earth have resulted in the production and disposal of enormous quantities of wastes into adjacent rivers and bays, which adversely affecting the water quality and the biota. Inadequate disposal of untreated industrial effluents and domestic sewage into shallow seawater off large coastal dwellings is a common practice. This has resulted not only in significant degradation of quality of seawater but also affected the biotic life (Khan *et al*., 1988). In marine environment phytoplankton occupy the functional and basic significance in the overall food web (Kalavati *et al*., 1997). Due to the pollution, plankton population is affected and leading to drastic changes in the food chain of the marine environment (Verloecar and D´Silva, 1977). Some phytoplankton species are often used as good indicators of water quality and pollution. Reports of previous studies revealed that, outburst of *Skeletonema costatum* as a result of pollution in Visakhapatanam harbour (Ganapati and Raman, 1979). The phytoplankton community was stressed by the large and continues outflow from El-Umoum effluents (Dorgham, 1997). Only limited studies were conducted in Indian waters regarding the relation ship between phytoplankton and pollutants. Hence the present study was undertaken in Uppanar estuary to evaluate the state of phytoplankton population, chlorophyll a, total carotenoid, primary production, phytoplankton diversity and distribution in relation to pollution and physiochemical parameters.

MATERIALS AND METHODS

Uppanar estuary located on the south east coast of India 11°42'284" N 79°46'471"E. Four stations (Ia, Ib, Ic) were selected for sampling, where the industries discharging their effluents and station IIa at open sea was chosen for the study (Fig. 1). Surface water samples were collected during low tide at fortnight intervals for one year (April, 2004 to March, 2005). The physicochemical

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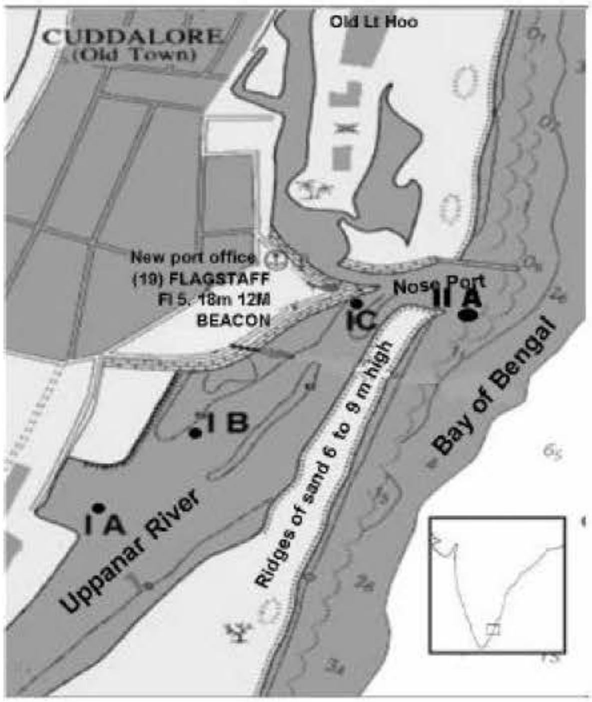

Fig. 1: Map showing the study area

parameters investigated were temperature, transparency, salinity, pH, dissolved oxygen, inorganic nutrients and heavy metals. In addition, primary production, phytoplankton pigments (chlorophyll a and total carotenoid) were also estimated. All the chemical analysis was completed on the same day of collection adopting the standard methods (Strickland and Parson, 1968) and heavy metal lead, cadmium and mercury were estimated in water sample by Atomic Absorption Spectroscopic (AAS) observation. For pigment analysis, 1 L of water sample was filtered through glass fiber filter paper (Whatmann GF/C) the chlorophyll-a (chl-a) and total carotenoid contents were estimated spectrophotometerically (HITACHI-U-2010). Primary productivity was estimated by light and dark bottle method (Strickland and Parson, 1968). For qualitative and quantitative enumerations of phytoplankton, a litre of water sample was fixed with 1% Lugol's iodine solution and then preserved with 3% neutralized formaldehyde. The phytoplankton were allowed to settle in a measuring jar, the supernatant was carefully siphoned out and the residual material was made up to 100 or 250 mL depending on phytoplankton concentration. This aliquot containing phytoplankton (1 mL) was transferred to a Sedgewick rafter cell counter (counting chamber) with the help of a microscope counting was done and the results were expressed as number of organisms/mL.

RESULTS AND DISCUSSION

In present the study, marked differences in the water quality and phytoplankton composition were observed (Table 1) between the Uppanar estuary (Stations Ia, Ib and Ic) a highly polluted one and the open sea environment (IIa), which was comparatively free from pollution.

In Uppanar estuary, during time of the low tide the effect of pollution was high due to the industrial discharges. Results obtained regarding physio-chemical parameters revealed that, overall range of temperature (23.6-36.2°C), turbidity (1-100 ppm), transparency (0.3-1.2 m), salinity

Table 1: Physico-chemical, heavy metal and biological characteristics of surface waters

Parameters	Ia	Ib	Ic	IIa
Temperature (°C)	23.6-34.2 (29.8)	24.3-33.6 (28.6)	25.6-31.8 (28.1)	22.1-28.3 (26.5)
Transparency (m)	ND-1.3 (0.5)	ND-2.1 (0.8)	0.3-3.2 (1.2)	3.2-6.9 (4.2)
Turbidity (ppm)	1.0-100 (20.0)	4.0-20.0 (10.0)	2.0-20.0 (8.0)	ND
Salinity (x 10^{-3})	5.9-28.3 (25.6)	6.1-29.8 (26.5)	9.8-32.6 (28.6)	32.4-34.87 (33.28)
PH	6.6-8.9 (7.6)	6.1-8.7 (7.2)	6.3-8.8 (7.2)	7.5-8.1 (7.7)
Dissolved Oxygen (mg L^{-1})	1.5-12.8 (8.1)	4.2-11.2 (8.3)	4.6-11.2 (6.8)	4.3-7.1 (4.6)
NO_2-N (mg L^{-1})	0.01-1.02 (0.18)	0.011-0.72 (0.07)	0.013-0.46 (0.04)	0.093-0.2266(0.016)
NO_3-N (mg L^{-1})	0.018-0.12 (0.02)	0.011-0.09 (0.03)	ND-0.05 (0.02)	0.002-0.015 (0.008)
SiO_4-Si (mg L^{-1})	0.31-22.61 (4.86)	0.28-6.24 (1.12)	0.18-3.13 (0.92)	0.32-0.82 (0.56)
PO_4-P (mg L^{-1})	0.82-3.12 (2.31)	0.41-3.62 (2.12)	0.028-2.86 (1.82)	0.082-0.96 (0.62)
Pb (mg L^{-1})	1.81-12.02 (6.82)	1.93-10.12 (5.2)	1.83-6.12 (4.3)	1.83-3.2 (2.8)
Cd (mg L^{-1})	1.23-10.32 (7.4)	0.96-5.72 (4.9)	0.98-5.35 (3.8)	0.82-4.12 (1.9)
Hg (mg L^{-1})	0.15-1.92 (1.32)	0.18-1.01 (0.91)	0.17-0.91 (0.72)	0.08-0.52 (0.31)
Primary productivity	32.31-1812.62 (1120.41)	122.16-1210.42 (810.26)	86.42-782.62 (180.21)	142.61-466.12 (340.22)
Chlorophyll -a	8.0-869.28 (32.622)	1.01-42.62 (21.63)	1.52-38.62 (11.21)	0.023-6.22 (3.12)
Total carotenoid	0.2-11.22 (5.262)	0.4-3.86 (2.921)	0.76-4.21 (2.821)	0.412-3.131 (1.812)
Phytoplankton No. of species	26	21	34	48
Abundance (No. mL^{-1})	110-519603 (186000)	180-213290 (28500)	168-136910 (68200)	86-5044 (1420)
Dominant species	*Asterionella japonica Thalassiothrix frauenfeldii*	*Chaetoceros affinis Asterionella japonica Thalassiothrix frauenfeldii*	*Thalassiothrix frauenfeldii Leptocylindrus danicus* and *Chaetoceros coarcatus*	*Rhizosolenia alata Chaetoceros affinis Thalassiothrix frauenfeldii*

(5.9 to 32.6×10^{-3}), pH (6.1-8.8), dissolved oxygen (1.5-12.8 mg L^{-1}), a high proportions of inorganic nitrogen (NO_2 0.013-1.02 mg L^{-1}, NO_3 0.011-0.12 mg L^{-1}), ammonia (NH_4 0.05-3.48 mg L^{-1}), silicate (SiO_3 0.18-22.61 mg L^{-1}), total phosphorus (0.028-3.62 mg L^{-1}) indicating a severe eutrophication in this area. However, the linkage of patterns between community structure and physical/chemical parameters within such an observational study cannot infer causality to (only) a few select abiotic parameters (Clarke and Gorley, 2001). These problems are particularly pronounced in geographic locales where coastal waters are influenced by extensive urbanization and agricultural activities associated with the demands of a growing human population (Aumen, 1995; Steinman *et al*., 2001). The heavy metal concentrations showed that lead (Pb) 1.81-12.02 mg L^{-1}, cadmium (Cd) 0.96-10.32 mg L^{-1} and mercury (Hg) 0.15-1.92 mg L^{-1}. These metals caused the growth of algae, which leads to the problems of metalloenzyme synthesis. The primary production was very high and it was in the range of 32.31-1812.62 mg C m^{-3} h^{-1}. The concentration of phytoplankton pigments, Chl-a ranged between 1.01-869.28 mg m^{-3}; total carotenoid concentration (0.2-11.22 mg m^{-3}) was very high and indicating the abundance of phytoplankton population. In the case of open sea (Station IIa) area where normal condition were observed, (i.e.,) the water transparency was more (4.2 m), turbidity negligible, salinity (32, 45-34.87×10^{-3}), pH (7.5-8.1) and dissolved oxygen (4.3-7.1 mg L^{-1}), fairly stable and the concentration of nutrients were low, the median values were of NO_2-0.016 mg L^{-1}, NO_3-0.008 mg L^{-1}, SiO_3-0.56 mg L^{-1} and PO_4-0.62 mg L^{-1}. Primary production, chlorophyll-a and total carotenoid contents were in the range of 142.61-466.12 mg C m^{-3} h^{-1}, 0.023-6.22 mg m^{-3} and 0.412-3.131 mg m^{-3}, respectively. The phytoplankton species composition revealed that, a sum of 58 species belongs to 16 genera and 12 families, notably Bacillariophyceae, Dinophysceae, Cryptophyceae and Euglenophyceae were recorded.

Station Ia, which is located in the immediate vicinity of industrial discharge where, 26 species of phytoplankton were recorded. The average abundance of phytoplankton number in this area was 186000 No. mL^{-1}. The species dominance was showen by *Asterionella japonica* (226580 No. mL^{-1})

from the total number of 519603 No. mL^{-1} followed by *Thalassiothrix franeufeldii* (185520 No. mL^{-1}) to form a bloom proportions. The salinity was decreased to 20.8×10^{-3} due to the dilution by industrial discharge. In the present study, in this station very high concentration of nitrite, nitrate and silicate were observed. The primary production, chlorophyll a and total carotenoid mean values were in the range of 1120.41 mg C m^{-3} h^{-1}, 32.62 mg m^{-3} and 5.262 mg m^{-3}. The *Asterionella formosa* bloom has established that fall in silicate concentration was principally responsible for bloom termination (Choudhury and Panigrahy, 1989). Phytoplankton blooms stimulated by elevated nutrient loading preceded and spatially corresponded with extensive hypoxia and anoxia within salinity-stratified waters, except during periods when reduced water residence times (resulting from sustained discharge) did not allow for bloom development (Tester *et al*., 2003).

Although there is an increase in phosphate and nitrate concentration, a rapid decrease in silicate. Chlorophyll a, cell counts and column production were generally low. The results obtained in heavy metal concentration in the study area revealed the presence of, lead, cadmium and mercury and their mean values were in the range of 6.82, 7.4 and 1.32 (mg L^{-1}), respectively. The high concentration of heavy metals induces an enzymatic mechanism in phytoplankton, (i.e., phytochelatin synthesis. In *Phaeodactylum tricornatum* phytochelation synthesis was observed within minutes of exposure to cadmium or lead. Because of the accumulation of heavy metals in side the cells, which leads the to metal-phytochelatin complex accumulation in the cells (Morelli and Scarano, 2000). In the present study the phytoplankton density study revealed that, *Asterionella japonica* (226580 No. mL^{-1}), *Thalassiothrix frauenfeldii* (185520 No. mL^{-1}),*Chaetoceros coarctatus* (85000 No. mL^{-1}), *Thalassionema nitzschioides* (6200 No. mL^{-1}) *Odentella sinensis* (2850 No. mL^{-1}). This area supported a rich population of Ciliates notably *Tetrahymena* sp. *Stylonychia* sp. *Holophorya* sp., *Metopus* sp. and *Vorticella* sp. known for their preference to organically rich area.

At station Ib totally 28 species of phytoplankton were reordered and represented by average no/mL. *Chaetoceros coarctatus* (84250 No. mL^{-1}), *Asterionella japonica* (62500 `mL), *Thalassiothrix frauenfeldii* (48120 No. mL^{-1}), *Ceratium macroceros* (4760 No. mL^{-1}) and *Dinophysis tripos* (3450 No. mL^{-1}). The above important species in this area on account of their high frequency of occurrence and total abundance indiscriminated that, disposal of sewage and industrial wastes have been a major cause for the nutrient enrichment in coastal wasters resulting in a decrease in diversity and an increase in biomass by promoting some opportunistic algal species to dominate and suppress others (Dederen, 1998). The subsequent re-establishment of compositional/biomass patterns to pre-discharge conditions would be expected to be relatively short (days to weeks) and dependent upon the time of year, rainfall magnitude and frequency and tidal cycles (Tester *et al*., 2003).

At station Ic located towards sea, the total number of phytoplankton species encountered were 34. The diatom, *Leptocylindrus danicus* (average No. 16510 mL^{-1}), contributed 65% of the total population found at this station. Here, *L. danicus* occurred with overwhelming dominance on three occasions (2005 March -31252, May-21625 and October-65450 No. mL^{-1}). Chlorophyll a contents of that occasion was 28.62, 21.65 and 38.62 mg L^{-1}, respectively. Similar observation of increasing nutrients in the interior creek areas of Bombay was reported by Nealam (1998) and said that stimulation of excessive growth of a few tolerant phytoplankters leading to generally higher values of chlorophyll a. This station was influenced by domestic sewage and harbour wastes through Kadilam river, hence the nutrient concentrations were very high (i.e., NO_2, 0.46 mg L^{-1}, NO_3 0.05 mg L^{-1}, SiO_4 3.13 mg L^{-1} and PO_4 2.86 mg m^{-3}. The phytoplankton species found were *Chaetoceros coarchatus* (3850 No. mL^{-1}), *Chaetoceros brevis* (3610 No. mL^{-1}), *Rhizosolenia alata* (3120 No. mL^{-1}), *Asterionella japonica* (2950 No. mL^{-1}) and *Biddulphia* sp. (1850 No. mL^{-1}).

Station IIa supported different variety of phytoplankton community, where 48 species of phytoplankton were recorded mostly represented by diatoms and dinoflagellates. The diatoms were represented by *Rhizosolenia alata* (618 No. mL^{-1}), *Chaetoceros affinis* (352 No. mL^{-1}), *Thalassiothrix fraunfeldii* (310 No. mL^{-1}), *Skeletonema costatum* (220 No. mL^{-1}) and *Rhizosolenia styliformis* (210 No. mL^{-1}) were the most important species. The nutrients and other factor were in normal range (Table 1).

The numerical abundance of phytoplankton was high but the species diversity was low in the Uppanar estuary, because the organic load was high when compared to open sea. Nealam (1998) also reported such a rapid proliferation of this species in nutrient rich areas due to the input of organic wastes. Lower diversity indices in Thana, region compared to those from relatively pollution free areas as reported elsewhere also suggested that deterioration of water quality in this study area. From this study, it is possible to suggest that pollutants from the SIPCOT industries have an impact on phytoplankton diversity and other organisms. There were no reports available regarding the impact of pollutants on phytoplankton in this area this is the first report.

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REFERENCES

Aumen, N.G., 1995. The history of human impacts, lake management and limnological research on Lake Okeechobee, Florida, USA. Archive fu¨r Hydrobiologie, Ergebnisse der Limnologie, 45: 1-16.

Choudhury, S.B. and R.C. Panigrahy, 1989. Occurrence of bloom of diatom *Asterionella glcialis* in nearshore waters of Gopalpur, Bay of Bengal. Ind. J. Mar. Sci., 18: 204-206.

Clarke, K.R. and R.N. Gorley, 2001. PRIMER v5: User Manual/Tutorial. Primer-E, Plymouth, United Kingdom, pp: 91.

Dederen, L.H.T., 1992. In: Marine Coastal Eutrophication, Vollenweider, R.A., R. Marchetti and R. Viciani (Eds.), University of Bologna, Italy, pp: 663.

Dorgham, M.M., 1997. Phytoplankton dynamics and ecology in a polluted area on Alexandria Coast, Egypt, Proc. 3rd Int. MEDCOAST Conference, Qawra (Malta), pp: 151-159.

Ganapati, P.N. and A.V. Raman., 1979. Phytoplankton in relation to pollution in Visakhapatnam harbour, East Coast of India. Ind. J. Mar. Sci., 3: 184.

Kalavati, C., A.V. Raman, J. Vaidehi and V. Ratna Bharathi., 1997. Effects of pollution on planktonic ciliates in Visakhapatnam harbour. Ind. J. Mar. Sci. 26: 68-73.

Khan, S.H. and M.A. Saleem, 1988. Preliminary Study of Pollution in Karachi Harbour. In: Marine Science of the Arabian Sea. Thompson, M.F. and N.M. Tirmizi (Eds.), American Institute of Biological Sciences, Washington D.C., pp: 539-547.

Morelli, E. and G. Scarano, 2001. Synthesis and stability of phytochelatins induced by cadmium and lead in the marine diatom *Phaeodactylum tricornutum*. Mar. Environ. Res., 52: 383-395.

Neelam, R. and N. Ramaiah, 1998. Phytoplankton characteristics in apolluted Bombay harbour-Thana-Bassein creek estuarine complex. Ind. J. Mar. Sci., 27: 281-285.

Srrickland, J.D.H. and T.R. Parsons, 1968. A practical hand book of sea water analysis (Fisheries Research Board of Canada, Bull NO. 167), pp: 311.

Steinman, A.D., K.E. Havens, H.J. Carrick and R. VanZee, 2001. The Past, Present and Future Hydrology and Ecology of Lake Okeechobee and its Watersheds. In: The Everglades, Florida Bay and Coral Reefs of the Florida Keys. Porter, K. and J. Porter (Eds.), An Ecosystem Handbook. CRC Publications, Boca Raton, Florida, pp: 19-37.

Tester, P.A., S.M. Varnum, M.E. Culver, D.L. Eslinger, R.P. Stumpf, R.N. Swift, J.K. Yungel, M.D. Black, R.W. Litaker, 2003. Airborne detection of ecosystem response to an extreme event: phytoplankton displacement and abundance after hurricane induced flooding in the PamLicoeAlbermarle Sound system, North Carolina. Estuaries, 26: 1353-1364.

Verloencar, X.N. and C. D´Silva, 1977. Plankton in relation to coastal pollution at Ennore, Madras coast. Ind. J. Mar. Sci., 6: 111.