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A Comparative Study of Physico-Chemical Investigation along Parangipettai and Cuddalore Coast

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Abstract: The present study was attempted on the physico chemical variability of two different environs along Parangipettai and Cuddalore coastal and estuarine waters of the Bay of Bengal. Comparative study was carried out to examine the level of contaminants affecting the coastal and estuarine environment namely Nitrite, Inorganic phosphate, Ammonia and other physico-chemical parameters. Distribution of nutrients has exhibited considerable seasonal and spatial variations. Station 3 and 4 (Cuddalore coast and Uppanar Estuary) registered higher concentration of nutrients than station 1 and 2 (Vellar estuary and Parangipettai coast).

Key words: Physico-chemical, temperature, salinity, pH, dissolved oxygen

INTRODUCTION

The rapid industrialization and aquaculture practices along the river systems and the coastal areas have brought considerable decline in the water quality of brackish waters and the estuaries. Coastal zones and estuaries are important ecological systems and a resource for a variety of uses. Such areas are subjected to a variety of socio-economic drivers, producing increased pressures and impacts, which can lead to environmental stress or even affect public health (Cave *et al*., 2003; Belzunce *et al*., 2004). With the sudden increase of population and rapid economic development, these areas are facing many ecological problems. Such problems have been assigned mostly to an excess of nutrients, associated with industrial and municipal wastewater (Balls, 1992) forestry and agriculture (Bell, 1991). The subsequent increase in nutrient loads produces an ecological impact over biological communities (Karlson *et al*., 2002), associated mostly with eutrophication processes (Wang *et al*., 1999; Hanninen *et al*., 2000).

The hydrobiological study is a pre-requisite in any aquatic system for the assessment of its potentialities and to understand the realities between its different trophic levels and food webs. Further, the environmental conditions such as topography, water movement, salinity, oxygen, temperature and nutrients characterizing a particular water mass also determine the composition of its biota. Thus, the nature and distribution of the flora and fauna in the aquatic system are mainly controlled by the fluctuations in the physical and chemical characteristics of the water body. In Indian estuaries and seas the physico-chemical characteristics had been carried out by many workers (Ramaraju *et al*., 1987; Gouda and Panigrahy, 1996; Satpathy, 1996; Vijayalakshmi, 1999; Rajasegar, 2003).

The present study has been carried out in variation of physico-chemical parameter in two different estuaries and coastal environments (Fig. 1). Among the two environments, Parangipettai coast is not polluted, receiving only the land drainage through the Vellar estuary Parangipettai situated along the southeast coast of India has a unique potential for marine and brackish water resources, being endowed with various aquatic biotopes viz., neritic, estuarine, backwaters and mangroves and it is

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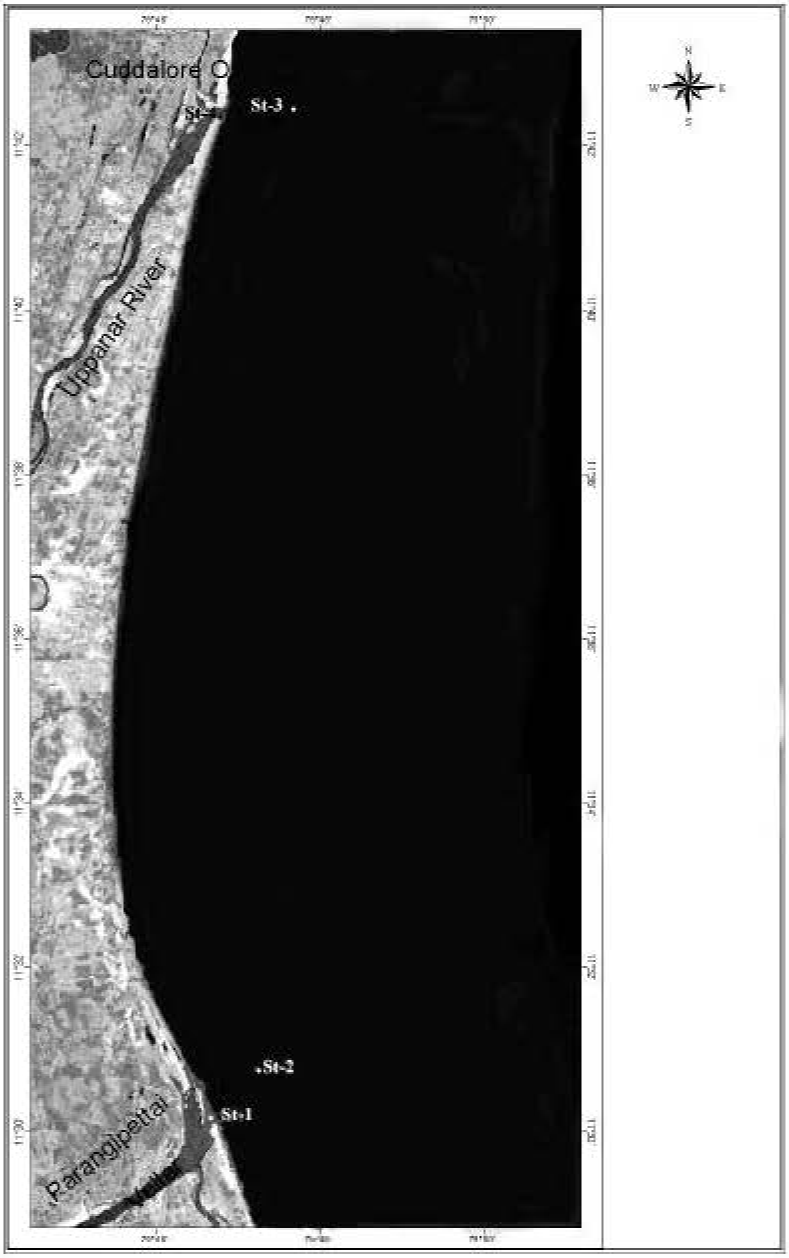

Fig. 1: The study area

connected to the Bay of Bengal at Parangipettai. While the Cuddalore coast is polluted due to mainly the industrial discharges in to the Uppanar estuary. Therefore, in the present investigations were carried out in both the estuarine and coastal environment of Cuddalore and Parangipettai waters for the period of two years to determine the level of nutrients and other Physico-chemical parameters in both the estuarine and coastal environment.

Station 1 (Lat. 11° 31' 07' N" and Long. 79° 46' 67" E) is located in the marine zone of Vellar estuary (mouth region), which is influenced by both neritic waters of Bay of Bengal and the fresh water flow of the river Vellar.

Station 2 (Lat. 11°30' 79" N and Long. 79°47' 92" E) is situated on the 5 fathom line in the near shore waters of the Bay of Bengal at Parangipettai and is about 2 km away from the mouth of Vellar estuary.

Station 3 (Lat. 11° 42' 31" N: Long. 79° 47' 80" E) is located on the 5 fathom line in the near shore waters of the Bay of Bengal at Cuddalore fishing harbour and is about 2 km away from the Cuddalore harbour.

Station 4 (Lat. 11° 42' 34" N: Long. 79° 46' 88" E) is located in the marine zone of Uppanar estuary the Gadilam estuary is also joined near this station and most of the industries are located near the station and hence selected for sampling (Fig. 1).

MATERIALS AND METHODS

Surface water samples were collected at monthly intervals from all the stations for a period of two years from October 2000 to September 2002 for the estimation of various physico-chemical parameters. Rainfall data for Parangipettai and Cuddalore coast were obtained from the meteorological department. Temperature of air and surface water was recorded by using a standard Centigrade thermometer. The hydrogen ion concentration (pH) was estimated by using Elico-model (L_1-10) pH meter. Salinity was measured by using hand Refractometer (Atago, Japan). Dissolved oxygen concentrations were analyzed immediately by adopting the Winkler's method as described by Strickland and Parsons (1972).

For the analysis of nutrients, surface water samples were collected in a clean polythene bottle and kept in an icebox and transported to the laboratory immediately. The water sample was then filtered using a Millipore filtration unit using 4.7 cm Whatman Glass Filter paper (GF/C) and analyzed for inorganic phosphate, nitrite, reactive silicate and ammonia adopting the standard methods described by Strickland and Parsons (1972) and are expressed in $\mu M\ L^{-1}$.

RESULTS

Monthly variations in meteorological and physico-chemical parameters viz. rainfall, air and surface water temperature, salinity, pH, dissolved oxygen, inorganic phosphate, nitrite, reactive silicate and ammonia in water were recorded for a period of two years from October 2000 to September 2002.

Rainfall

The total annual rainfall recorded from Parangipettai (station 1 and 2) was 870.5 (2000 to 2001) and 966.4 mm (2001 to 2002). Maximum (294.6 mm) rainfall was recorded during November 2000. The monthly mean rainfall was 77.5 mm, respectively. However at Cuddalore, the total annual rainfall recorded for the year 2000 to 2001 was 882.3 and 953.8 mm in 2001 to 2002. Maximum rainfall (296 mm) was recorded during November 2000. The monthly mean rainfall for the year 2000 to 2001 and 2001 to 2002 was 73.52 and 79.48 mm, respectively (Fig. 2).

Temperature

During the study period air temperature varied from 24.1 to 33.8°C. The minimum was recorded during monsoon season (October, 2001) at station 3 and maximum during the summer season (April, 2002) at station 1 (Fig. 3). In general, all the four stations showed similar seasonal changes. Surface water temperature showed similar trend to that of air temperature. The surface water

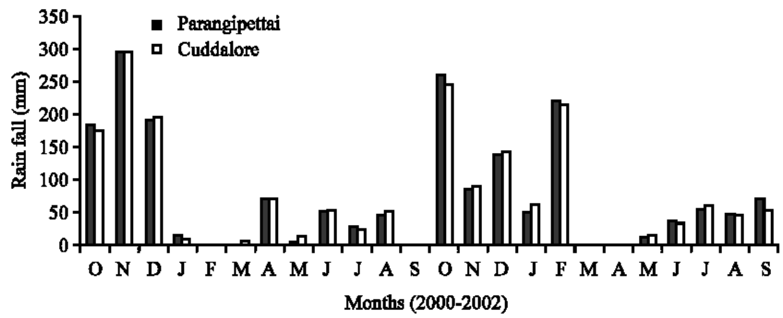

Fig. 2: Monthly variations in rainfall recorded during October 2000 to September 2002 from Parangipettai and Cuddalore

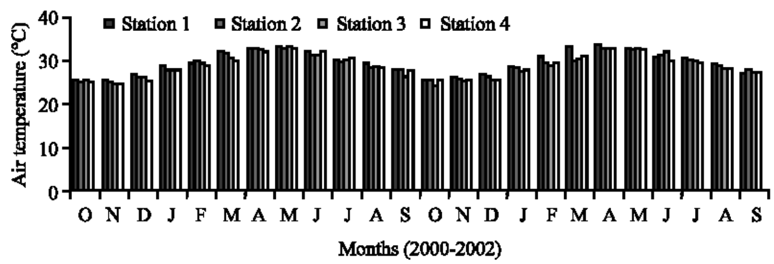

Fig. 3: Monthly variations in air temperature recorded during October 2000 to September 2002 from stations 1, 2, 3 and 4

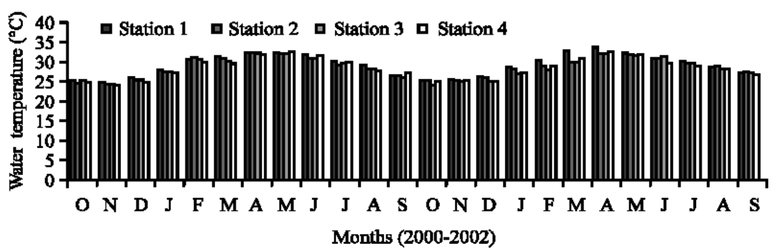

Fig. 4: Monthly variations in surface water temperature recorded during October 2000 to September 2002 from stations 1, 2, 3 and 4

temperature was varied from 24.5 to 34.2°C. The minimum surface water temperature was recorded during monsoon season (October, 2001) at station 2 and maximum was recorded during the summer season (April, 2002) at station 1 (Fig. 4). In general, all the four stations showed similar seasonal changes.

Salinity, pH and Dissolved oxygen

Salinity range was varied from 15.3 to 35.5‰. All the stations showed similar seasonal pattern in salinity distribution and registering low values during monsoon season and high values during the summer season (Fig. 5). Seasonal fluctuations in the pH followed the trend similar to that of salinity (Fig. 6). Dissolved oxygen concentration was varied from 3.14 to 7.02 ml L^{-1}. minimum was recorded in the premonsoon season at station 4 and the maximum during monsoon season at station 1 (Fig. 7).

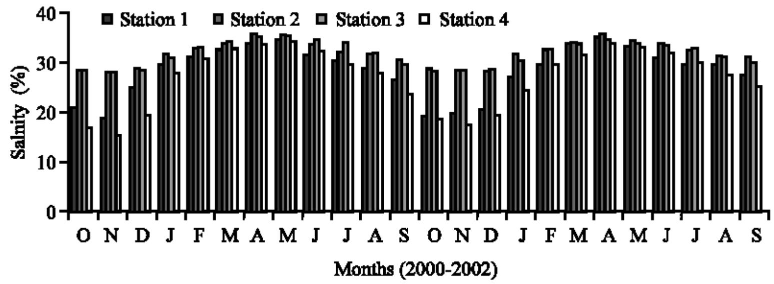

Fig. 5: Monthly variations in salinity recorded during October 2000 to September 2002 from stations 1, 2, 3 and 4

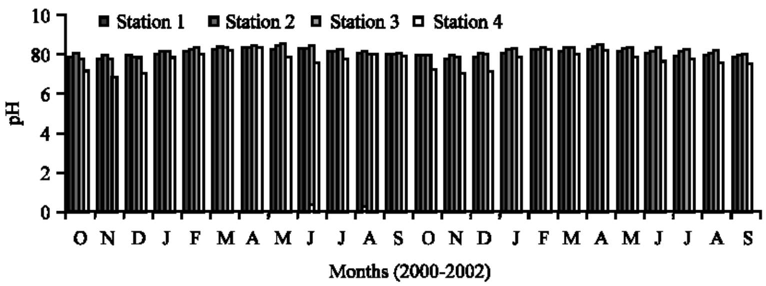

Fig. 6: Monthly variations in pH recorded during October 2000 to September 2002 from stations 1, 2, 3 and 4

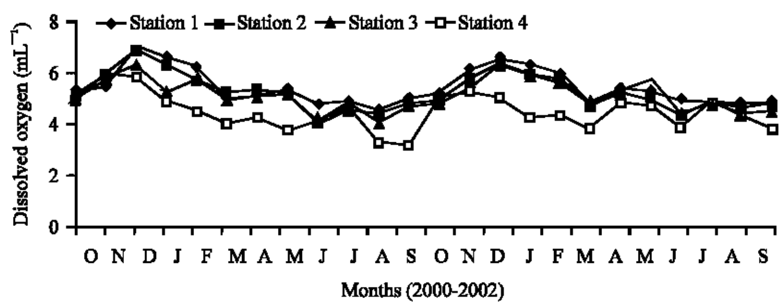

Fig. 7: Monthly variations in dissolved oxygen concentration recorded during October 2000 to September 2002 from stations 1, 2, 3 and 4

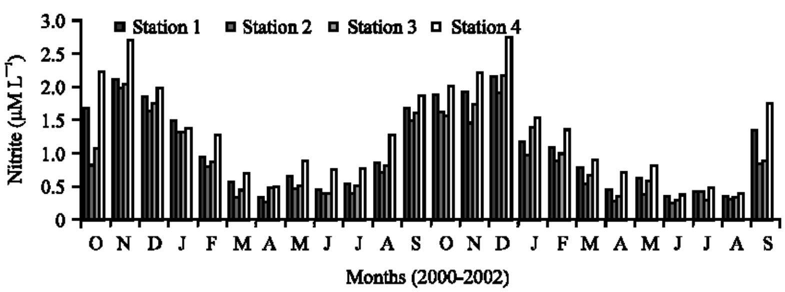

Fig. 8: Monthly variations in nitrite concentration during October 2000 to September 2002 from stations 1 2, 3 and 4

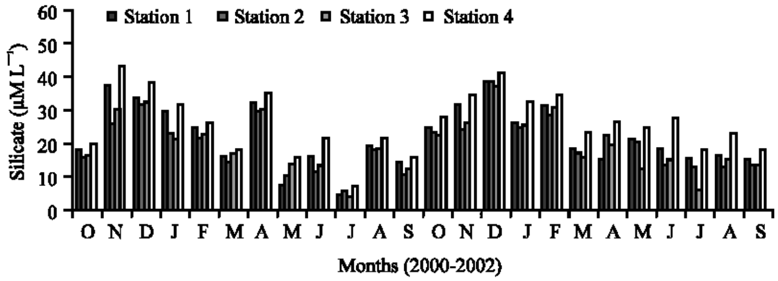

Fig. 9: Monthly variations in dissolved inorganic silicate concentration during October 2000 to September 2002 from stations 1, 2, 3 and 4

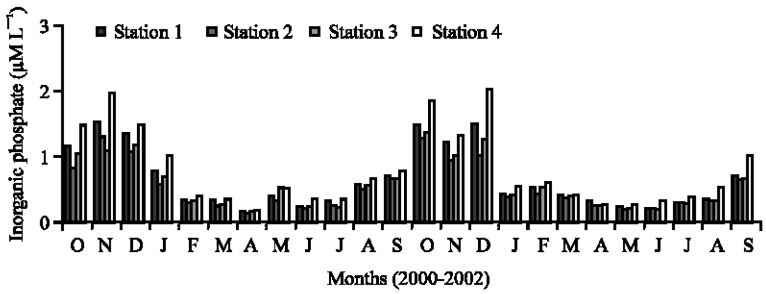

Fig. 10: Monthly variations in inorganic phosphate concentration during October 2000 to September 2002 from stations 1, 2, 3 and 4

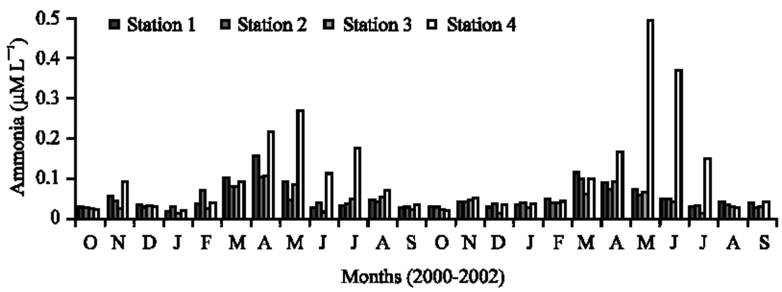

Fig . 11: Monthly variations in ammonia during October 2000 to September 2002 from stations 1, 2, 3 and 4

Nitrite, Silicate, Inorganic phosphate and Ammonia

The nitrite concentration was varied from 0.205 to 2.68 μM L^{-1}. Minimum was recorded during premonsoon season at station 2 and the maximum during monsoon season at station 4 (Fig. 8). Silicate values was ranged from 4.83 to 52.32 μM L^{-1} concentration it also shows the similar trend like nitrite minimum was recorded during premonsoon at station 3 and the maximum during the monsoon season at station 4 (Fig. 9). Inorganic phosphate concentration was varied from 0.186 to 2.48 μM L^{-1}. Minimum was recorded during the postmonsoon at station 2 and the maximum during the monsoon at station 4 (Fig. 10). Ammonia level was varied from 0.0111 to 0.461 μM L^{-1}. Minimum was recorded during premonsoon season at station 1 and the maximum during the summer season (Fig. 11).

DISCUSSION

The physico-chemical variables of the present study areas are subjected to wide spatial temporal variations. Rainfall is the most important cyclic phenomenon in tropical countries as it brings about important changes in the physical and chemical characteristics of the coastal and estuarine environments. In the present study, bulk quantities of rainfall were received during the monsoon months (November, 2000 and October, 2001) due to northeast monsoon.

Temperature variation is another important factor in the coastal and estuarine ecosystems, which influences the physico-chemical characters of coastal and estuarine waters to a greater extend triggering the breeding and spawning of marine fishes. Seasonal variations were observed in atmospheric and water temperature showed the distinct biomodel oscillations at all the three stations. The maximum temperature was recorded during the summer season and minimum was recorded monsoon could be ascribed to the effect of atmospheric cooling. In the present study temperature showed that atmospheric variation including insolation play major role governing temperature and water exchange between the sea and the estuary is of less significance. Similar conclusion has also been drawn from this estuary (Chandran and Ramamoorthy, 1984; Rajasegar, 2003).

Salinity is considered to be the prime factor among the environmental variables influencing the dynamic nature of the estuarine and coastal waters by the freshwater inflow and the prevailing temperature. Among the four stations, the salinity values ranged from 18.5 to 35.5‰ during the two years of study period. The maximum salinity was recorded at station 2 during the summer season (April, 2002) and the minimum at station 1 during the monsoon season (November, 2001). The higher values recorded in summer season could be attributed to the high degree of evaporation of surface water in the shallow areas and less wave and tidal action with decreased freshwater inflow and drainage. During the monsoon season, all the stations received bulk rainfall and the freshwater input in turn greatly reduces the salinity values. Moderate salinity values were observed during the pre and postmonsoon periods, which represent a transition period between monsoon and summer. Similar observations were made by Rajasegar (2003).

The hydrogen-ion concentration (pH) gets changed with time due to the changes in temperature, salinity and biological activity. The pH remained alkaline throughout the study period at all stations registering a maximum during summer season, which could be attributed to the high salinity of water. Most of the natural waters are generally alkaline due to the presence of sufficient quantities of carbonate. Higher value of pH was recorded at coastal stations (2 and 3) than in estuarine stations (1 and 4). pH was low during the monsoon (7.7 at station 1 and 3, 7.8 at station 2 and 7 at station 4) and this was associated with lesser salinity region. pH was also quite low during floods in the peak monsoon season due to the influence of freshwater influx, dilution of saline water, reduction of salinity and temperature and decomposition of organic matter, as suggested by several authors (Zingde *et al*., 1985).

Dissolved oxygen concentration shows a wide range of variation throughout the study period. Dissolved oxygen concentration was low during the premonsoon season but increased during summer and monsoon seasons. The low dissolved oxygen concentration observed during the premonsoon season could be attributed to the lesser input of freshwater into the study area. Higher value of dissolved oxygen concentration observed in the monsoon season was due to heavy rainfall and the result of freshwater mixing (Ramaraju *et al*., 1987; Zingdge *et al*., 1985)., Mitra *et al*., (1990); Nandan and Abdul Azis (1993) and Rajasegar (2003) have also opined that the monsoonal maximum of dissolved oxygen content was due to the consequent renewal of freshwater flow.

From the present study it is evident that relatively higher concentration of ammonia was recorded in water samples of Uppanar estuary, which receives the contaminants directly through the discharge of untreated domestic sewage from Cuddalore town area and the disposal of waste from well established industrial area. But along Parangipettai coast, at station 1 is apparently unpolluted due to limited inflow of domestic sewage and the absence of major industrial complex in the nearby areas. The main source of contaminants might be through the aquaculture activities.

Nitrite concentration was higher during the monsoon season and low during the summer season. The peak values of nitrite observed during the monsoon season could be attributed to the influence of seasonal floods. The higher concentration of nitrite and seasonal variation could also be attributed to the variation in phytoplankton excretion, oxidation of ammonia and reduction of nitrite (Kannan and Kannan, 1996). In addition to this increase in nitrite content at the surface water layer might also be due to denitrification and by air-sea interaction of exchange of chemical elements (Mathew and Pillai, 1990). Low values of NO_2 observed during the summer seasons might be due to the lesser amount of freshwater inflow and higher salinity. The observed increase in nitrite at station 1 and 4, may be due to the increased bacterial activity which is more in a silty-clayey substratum prevailing at station 1 and 4 rather than the sandy substratum at station 2 and 3 (Segar and Hariharan, 1989). Similarly maximum value in monsoon and minimum value in summer season were also recorded by Chandran and Ramamurthi (1984) from Vellar estuary, Edward and Ayyakkannu (1991) from Kollidam estuary, Kannan and Kannan (1996) from Palk Bay, Satpathy (1996) from coastal waters of Kalpakkam and Vijayalakshmi (1999) from Parangipettai and Cuddalore waters.

In the present investigation, the reactive silicate concentration was found to be much higher than inorganic phosphate and nitrite. Station 1 and 4 recorded more silicate concentration than the station 2 and 3. High silicate concentration recorded during monsoon season may be due to the addition of silica material by land run-off caused by flooding during the monsoon season. Further more silicate available at the bottom sediments might go into the upper water layers when the bottom is agitated by wind action during the monsoon season.

Low values of silicate recorded during the premonsoon season may be due to the sizeable reduction in the freshwater input and greater utilization of the nutrient by the abundantly available phytoplankton for their biological activity (Gouda and Panigrahy, 1992). In addition to phytoplankton uptake, some other processes like absorption and co-precipitation of soluble silicon might also govern the distribution of dissolved silicate in the marine environment (Choudhury and Panigrahy, 1991; Gouda and Panigrahy, 1992).

In the present study, the inorganic phosphate registered its peak values during the monsoon season and decreased concentration during the postmonsoon season. Inorganic phosphate concentration was high in both the estuary and coastal waters during the monsoon season due to heavy rainfall, input of domestic sewage and fertilizers from the agricultural discharges from the adjacent lands. Low concentration of inorganic phosphate observed during the postmonsoon seasons was due to the decreased land drainage, sewage and fertilizer disposal from the land drainage. Such monsoonal maximum and postmonsoonal minimum in the inorganic phosphate concentration was also reported from Arasalar and Kaveri estuary (Saraswathi, 1993), Tranquebar-Nagappattinam coast (Sampathkumar, 1992).

Station 1 and 4 registered more concentration of inorganic phosphate than the station 2 and 3. The high inorganic phosphate concentration is an important feature associated with sewage pollution in the estuarine environment and hence the inorganic phosphate concentration could be taken as an index to identify the extend of pollution in the estuarine environment and compare with coastal environment.

Higher concentration of ammonia was observed during the postmonsoon and summer seasons. Higher concentrations could be partly due to death and subsequent decomposition of phytoplankton. Further, the peak concentrations of ammonia during the postmonsoon and summer seasons coincided with the high zooplankton production that could be related to the excretion of ammonia by planktonic organisms (Segar and Hariharan, 1989).

The present observation on nutrients, agree well with the statement of Choudhury and Panigrahy (1991) as the distribution and behaviour of nutrient in the coastal environment particularly in the near shore water and estuaries may exhibit considerable seasonal variation depending upon the local condition like rainfall, quantum of freshwater inflow, tidal incursion and some biological activity like phytoplankton uptake and regeneration.

The Cuddalore coast and Uppanar estuary shows the higher concentration of nutrients when compared with The Vellar estuary and Parangipettai coastal waters. Particularly the less DO and pH values and higher ammonia level was observed in Uppanar estuary which may perhaps be due to the heavy discharge of industrial effluents from the SIPCOT industry causing the estuarine environment to become polluted one.

CONCLUSION

The physico-chemical status of the estuarine and coastal waters of Parangipettai, using this methodology, is good in general. However, in the Cuddalore coast, the Uppanar estuary, the water quality parameters are not good enough because of the discharges from the associated industry and municipal drainage.

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