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Seasonal variations in physico-chemical parameters in Uppanar estuary, Cuddalore (southeast coast of India)

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Abstract

Seasonal variations of physico-chemical parameters such as rainfall, temperature, salinity, pH, dissolved oxygen and nutrients like nitrate, nitrite, inorganic phosphate and reactive silicate were studied from two different stations in Uppanar estuary, Cuddalore, southeast coast of India from April 2000 to March 2002. Atmospheric and surface water temperatures (°C) varied from 28 to 40.5 and 26 to 38 respectively. The salinity (‰), pH and dissolved oxygen (ml l^{-1}) ranges were: 6.0- 38.0; 7.1-8.2 and 2.4 to 4.5 respectively. Nutrient concentrations also varied considerably; nitrates: 8.15-25.66 µM, nitrites: 1.05-4.15 µM, phosphates: 0.17-2.96µM and reactive silicates: 27-168 µM. Nutrient concentrations were higher during monsoon season and low during summer.

Keywords: Physico-chemical parameters, nutrients, Uppanar estuary

Introduction

Many reports are available on the physico-chemical features of Indian estuaries (Murugan and Ayyakkannu, 1991; Govindasamy *et al*., 2000; Balasubramanian and Kannan, 2005; Paramasivam and Kannan, 2005; Rajaram *et al*., 2005; Ajithkumar *et al*., 2006; Sridhar *et al*., 2006; Asha and Diwakar, 2007). The Uppanar estuary is formed by the confluence of Gadilam and Paravanar rivers with Bay of Bengal. This open type estuary has an average depth of 2.5 m, width of 30 m near the mouth (11° 42' 14.42"N lat; 79° 47' 54.61"E long.) and 20 m in the upstream and the tidal effect extends up to 6 km upstream (Rajaram *et al*., 2005). It is one of the polluted estuaries along the southeast coast of India due to the discharges from the industries of the State Industries Promotion Corporation of Tamil Nadu (SIPCOT). This industrial complex is located on the western bank of Uppanar estuary covering an area of 520 acres with 44 industries, dealing with chemicals, petro-chemicals, fertilizers, pharmaceuticals, dyes, soap, detergents, packing materials, resins, beverages, pesticides, drugs, antibiotics etc. Most of the industries are wet process industries and they consume large quantity of water for their manufacturing process.

There is paucity of information on the environmental aspects of the estuary, though this region is a potential fishing ground with an annual average landing of about 2000 tonnes. The navigational activities of cargo ships and hundreds of indigenous fishing crafts, drainage of municipal and domestic sewages from Cuddalore, and wastes from coconut retting enter into this region. Moreover, drainage channels from the nearby agricultural lands also discharge water with synthetic contaminants like pesticides and fertilizers into the Cuddalore coastal area. The polluted Uppanar estuary is located adjacent to the Rasapettai boat jetty (11° 42' 03.75"N lat.; 79° 46' 28.49"E long.) (Fig. 1). The present study deals with the spatio-temporal variations of physico-chemical parameters in Uppanar estuary, Cuddalore, southeast coast of India.

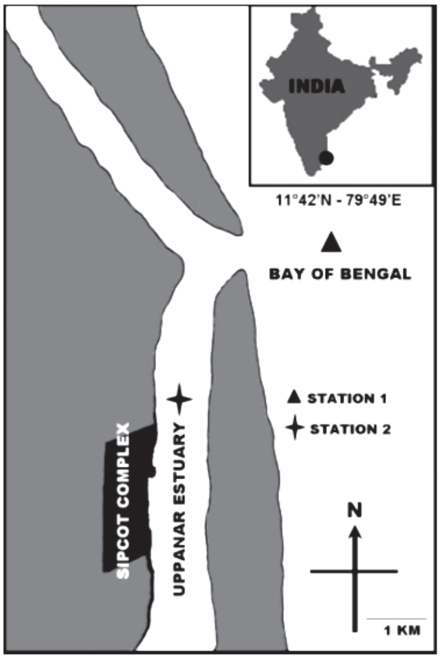

Fig. 1. Map showing location of sampling sites

Material and methods

Monthly water samples were collected in the forenoon from two stations during April 2000 – March 2002. Station 1 was near Cuddalore old town, 1 km away from the Uppanar-mouth where the depth is 5 m with sandy-bottom and salinity 31‰. Station 2 was located adjacent to the Rasapettai boat jetty in the polluted area with 2.5 m in depth, muddy bottom and salinity 25‰.

Monthly rainfall data for the study area were obtained from the Department of Statistics, Government of Tamil Nadu. A calendar year was divided into four seasons *viz.*, monsoon (October-December), postmonsoon (January-March), summer (April-June) and premonsoon (July-September), based on the northeast monsoon which prevails over the study area.

Temperature, salinity and pH were measured using standard instruments *viz.*, centigrade thermometer, Atago-hand refractometer of Japan and Elico pH meter (model LC-120), respectively. Dissolved oxygen and nutrients of water samples were analysed as per standard methods (Strickland and Parsons, 1972). Co-efficient of correlation (r) was worked out to understand the relationship between the various parameters.

Results and Discussion

Rainfall: The total rainfall during April, 2000 - March, 2001 was 989 mm. The monthly rainfall ranged between 15 and 222 mm and there was no rainfall from January to March, 2001. During April, 2001 - March, 2002 the total rainfall was 1348.1 mm. The monthly rainfall ranged from 38.8 to 280 mm and there was no rainfall during March, 2002 (Fig. 2). Rainfall is the most important cyclic phenomenon in tropical countries as it brings important changes in the hydrological characteristics of the coastal marine environments. In the present study, peak values of rainfall were recorded during monsoon in October. While the first year recorded deficient rainfall, the second year rainfall was normal.

Temperature: Atmospheric and surface water temperature (°C) ranges were 28-40.5 and 26-38 respectively (Fig. 2). Generally, the surface water temperature is influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters (Govindasamy *et al.,* 2000). The water temperature during November was low because of strong land breeze and precipitation and the recorded high value during summer could be attributed to high solar radiation (Sampathkumar and Kannan, 1998; Rajaram *et al*., 2005). The observed spatial variations in temperature could be due to the intensity of prevailing streams and the resulting mixing of waters. The estuary is covered with mangrove vegetation (Ashok Prabu *et al*., 2005). There was no relationship between the air and surface water temperatures, which could be due to different environmental situations (r = -0.611 at station 1 and r = -0.5620 at station 2).

Salinity: Salinity acts as a limiting factor in the distribution of living organisms and its variation caused by dilution and evaporation is most likely to influence the faunal distribution. In the present study, salinity at both the stations was high during

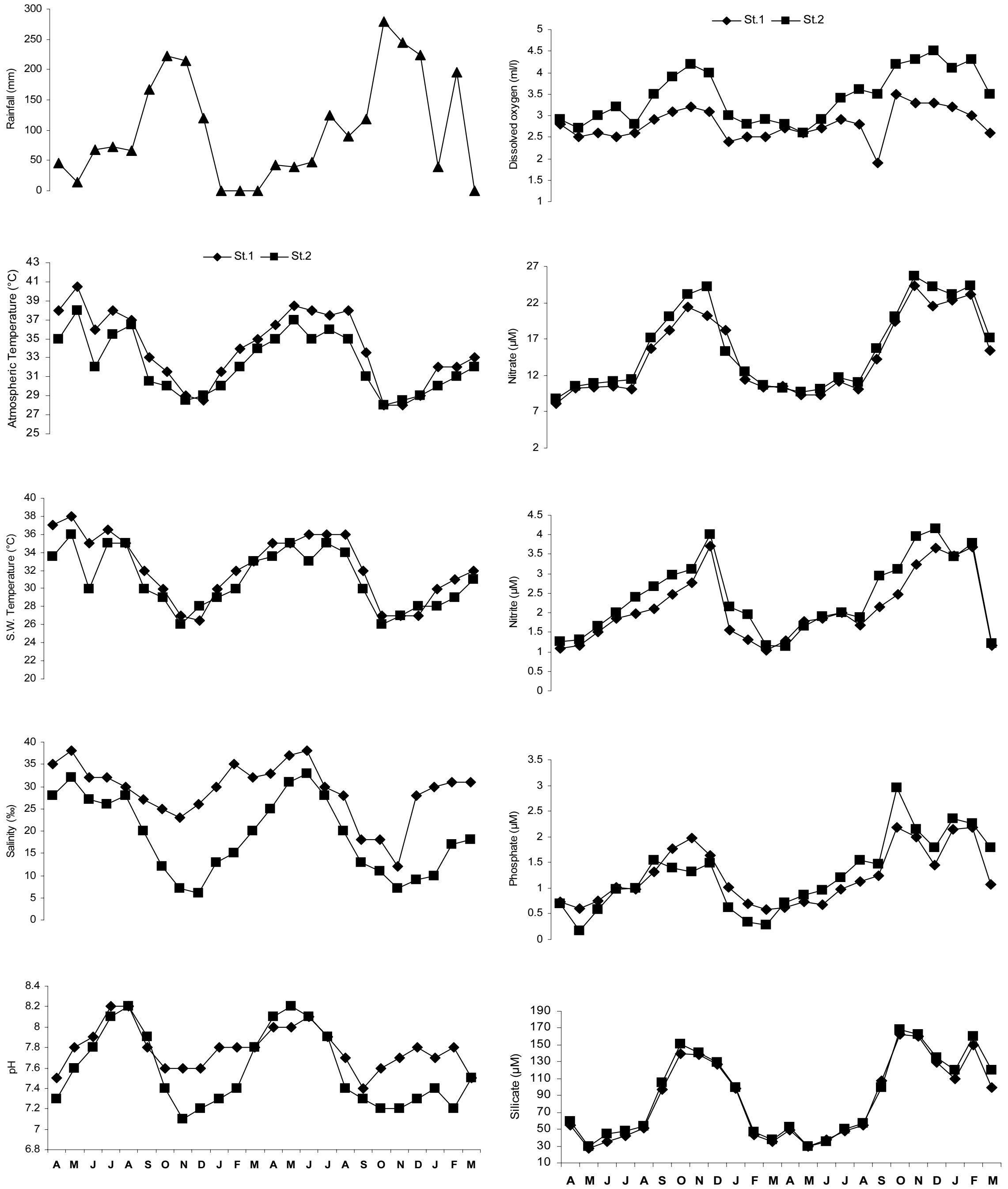

Fig. 2. Estimates of hydrographic parameters in Uppanar estuary, Cuddalore during April 2000 – March 2002

summer and low during the monsoon season (Fig. 2). The observed salinity variations could be related to the influx of freshwater from land runoff, caused by monsoon or tidal variations. This is evidenced by the negative correlation between salinity and rainfall (r = -0.700 at station 1 and r = -0.4761 at station 2). The higher salinity could also be due to the high temperatures as evidenced by the significant positive correlation between these two parameters. Higher summer values (38.0‰) may also be attributed to the low amount of rainfall, high degree of evaporation besides dominance of neritic water from the open sea (Sampathkumar and Kannan, 1998; Govindasamy *et al*., 2000; Rajasegar, 2003). On the other hand, during the monsoon season, the rainfall and the consequent freshwater inflow from the land in turn would have moderately reduced the salinity (6.0‰).

pH: Hydrogen ion concentration (pH) in surface waters remained alkaline throughout the study period at both the stations with the maximum (8.2) during summer and minimum (7.1) during monsoon (Fig. 2). Generally, temporal fluctuations in pH could be attributed to factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, low primary productivity, reduction of salinity and temperature besides decomposition of organic matter (Rajasegar, 2003; Paramasivam and Kannan, 2005). The recorded high summer pH values might be due to the influence of seawater penetration and high biological activity (Balasubramanian and Kannan, 2005) and also due to the occurrence of high photosynthetic activity (Sridhar *et al*., 2006).

Dissolved oxygen: Dissolved oxygen varied from 2.4 to 4.5 ml l^{-1} (Fig. 2). It is well known that salinity affects dissolution of oxygen in seawater (Govindasamy *et al*., 2000). In the present investigation, higher values of dissolved oxygen were recorded during monsoon season which might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing (Padmavathi and Satyanarayana, 1999; Govindasamy *et al*., 2000; Rajasegar, 2003). Paramasivam and Kannan (2005) attributed that seasonal variation of dissolved oxygen is mainly due to freshwater flow and terrigenous impact of sediments.

Nutrients: Nutrients are important parameters in the estuaries influencing growth, reproduction and metabolic activities of biotic components. Distribution of nutrients is mainly based on season, tidal conditions, freshwater inflow and land runoff, chemical, petrochemical, pharmaceutical effluents and flushing of fertilizer used in paddy fields. During the present study, all the four nutrients were found to be high during monsoon season and low during summer at both the stations (Fig. 2).

Nitrates: The recorded highest monsoonal nitrate value (25.66 µM) could be mainly due to the organic materials received from the catchment area during ebb tide (Kannan and Kannan, 1996; Rajasegar, 2003) (Fig. 2). The increased nitrate level may be also due to leaching of rocks, fertilizer, pharmaceutical industries, domestic and municipal sewage, fresh water inflow and mangrove litter-fall decomposition during northeast monsoon (Ashok Prabu *et al.,* 2005; Rajaram *et al*., 2005). Another possible way of nitrate input could be through oxidation of ammonia form of nitrogen to nitrite and then consequently to nitrate (Rajasegar, 2003). The recorded low values (8.15 µM) during non-monsoon period may be due to utilization by phytoplankton as evidenced by high photosynthetic activity and the dominance of neritic seawater having negligible amount of nitrate (Govindasamy *et al*., 2000; Rajaram *et al*., 2005).

Nitrites: The higher value of nitrite recorded during monsoon season (4.15 µM) could be due to variation in phytoplankton excretion, oxidation of ammonia and reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus (Asha and Diwakar, 2007) and also due to denitrification and air-sea interaction exchange of chemicals (Rajasegar, 2003) (Fig. 2). The recorded low value (1.05 µM) during summer and postmonsoon seasons could be related to less freshwater inflow and high salinity (Murugan and Ayyakkannu, 1991).

Inorganic phosphates: The high concentration of inorganic phosphates (2.96 µM) during monsoon season might be due to the monsoonal terrigenous input (Fig. 2). The low phosphates value (0.17 µM) during summer and postmonsoon seasons could be attributed to the limited flow of freshwater, high salinity and utilization of phosphate by phytoplankton (Senthilkumar *et al.,* 2002; Rajasegar, 2003). The variations may also be due to the processes like adsorption and desorption of phosphates and buffering action of sediment under varying environmental conditions (Rajasegar, 2003). Further, the recorded high monsoonal value may be due to heavy rainfall, land runoff, its autochthonous origin and weathering of rocks (in the upstream area) liberating soluble alkali metal phosphates, the bulk of which are carried into the estuaries (Govindasamy *et al*., 2000). The addition of super phosphates applied in the agricultural fields as fertilizers and alkyl phosphates used in households as detergents can be other sources of inorganic phosphates during the season (Senthilkumar *et al*., 2002; Ajithkumar *et al*., 2006).

Reactive silicates: The silicate content was higher than that of the other nutrients and the recorded high monsoon values (168 µM) could be due to heavy influx of freshwater derived from land drainage carrying silicate leached out from rocks and also from bottom sediments exchanging with overlying water due to the turbulent nature of water in the estuaries (Govindasamy and Kannan, 1996; Rajasegar, 2003). Besides, the dissolution of particulate silicon carried by the river, the removal of soluble silicates by adsorption and co-precipitation of soluble silicon with humic compounds and iron (Rajasegar, 2003) are some of the processes which might have caused the depletion of silicate in summer months.

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