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Seasonal variations in physico-chemical characteristics of Pichavaram mangroves, southeast coast of India

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Abstract: *All the physico-chemical parameters such as temperature, salinity, pH, dissolved oxygen and nutrients like nitrate, nitrite, inorganic phosphate and reactive silicate were studied in Pichavaram mangroves, southeast coast of India, for a period of two years (April 2000-March 2002). Air and surface water temperatures varied from 27°C to 38°C and from 26°C to 37°C. Salinity varied from 3.0‰ to 33.0‰ and the pH ranged between 7.2 and 8.2. Variation in dissolved oxygen content was from 2.4 to 5.0 ml l^{-1}. Concentrations of nutrients viz. nitrates (9.50 to 32.12 µM), nitrites (1.07 to 5.99 µM), phosphates (0.73 to 2.36 µM) and reactive silicates (22.1 to 89.8 µM) also varied independently.*

Kew words: *Physico-chemical characteristics, Nutrients, Pichavaram mangroves*
PDF of full length paper is available with author ***(*arunachalashivamdr@yahoo.com)***

Introduction

Mangrove ecosystem acts as a buffer between transitional nearshore and lagoonal or estuarine environments with respect to their influence on freshwater discharge, salinity regime and the adjacent aquatic system in general (Ramanathan, 1997). The study of mangrove regions is necessary as they are highly productive and play an important role as breeding and nursery grounds for many commercially important finfishes and crustaceans (Kathiresan and Bingham, 2001). Investigation on the distribution and seasonal variations of nutrients is a prerequisite for assessing the biological economy of an estuarine milieu (Robertson and Blabber, 1992). Distribution of nutrients determines the fertility of a potential water mass (Panda *et al*., 1989; Bragadeeswaran *et al.,* 2007). The regular and periodic changes in the climate synchronized with season are ultimately reflected in the environmental parameters also, which in turn have a direct or indirect influence on the planktonic population. The seasonal variations of abiotic and biotic processes affect the nutrient cycle of different coastal environments (Choudhury and Panigrahy, 1991). The magnitude and periodicity of forces such as tides, nutrients, hydro-period and stresses such as cyclones, drought, salt accumulation and frost may largely determine the 'energy signature' in mangrove realm and in its floristic and faunistic composition (GUIDE, 2000).

For confirming the good quality of water resources large number of physico-chemical parameters, extent and source of any pollutional load must be known for which monitoring of physico-chemical parameters and pollutants is essential (Reddi *et al*., 1993). Assessment of water resource quality from any region is an important aspect for the developmental activities of the region, because the rivers, lakes and reservoirs are used for water supply to domestic, industrial, agricultural and fish culture (Jakher and Rawat, 2003). Fertility and healthiness of mangrove environment is reflected through productivity of the phytoplankton and zooplankton as primary and secondary producers. They are playing vital role in controlling food web relationships in mangrove waters. Larval retention and high productivity in mangrove-lined estuaries have generally been attributed to the abundant food supply in comparison to adjacent marine areas (Robertson *et al*., 1992; Robertson and Blabber, 1992). Organic material originated from decaying mangrove leaves are used as primary food source, sustaining larval and juvenile stocks. Influence of physical, chemical and biological changes on planktonic communities in mangrove waters are more pronounced than in the near shore coastal environment, resulting in seasonal changes of planktonic species and densities (Kannan and Vasantha, 1992). A number of authors have studied the physical and chemical characteristics of some Indian estuaries and mangroves (Sai Sastry and Chandramohan, 1990; Reddi *et al*., 1993; Kannan and Kannan, 1996; Sampathkumar and Kannan, 1998; Subramanian and Mahadevan, 1999 ; Rajasegar, 2003 ; Rajasekar *et al.,* 2005; Sridhar *et al.,* 2006; Ajithkumar *et al.,* 2006; Anilakumari *et al.,* 2007; Asha and Divakar, 2007). Hence, the present study deals with the spatio-temporal variations of physico-chemical parameters of Pichavaram mangroves, southeast coast of India.

Materials and Methods

The mangrove forest at Pichavaram, (Lat. 11° 29' N: Long. 79° 46' E) is located along the southeast coast of India, about 250 km south of Chennai city and 10 km south of Parangipettai in the Tamil Nadu State (Fig. 1). It is one of the typical mangrove swamps of the Vellar-Coleroon estuarine complex, covering an area of ca. 1100 ha and consisting of 51 islets ranging in size from 10 m^2 to 2 km^2 (Kathiresan, 2000 ; Godhantaraman, 2002). Of the total area, 50% is covered by the forest, 40% by the waterways and the remaining 10% by the sand and mud flats (Godhantaraman, 2002). It is highly productive with about 8 tones of organic plant detritus ha/

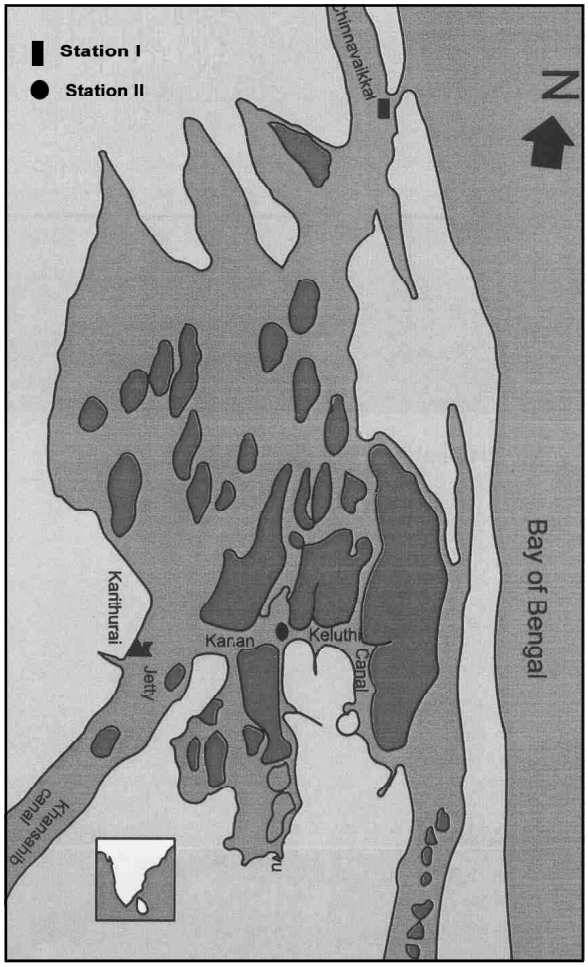

Fig. 1: Map showing the study area

year (Kathiresan and Bingham, 2001 ; Rajendran and Kathiresan, 2004). The channels in the mangroves are lined by a luxuriant vegetation of small salt marsh plants, trees, shrubs and thickets totaling about 30 species, of which 20 species are woody plants. The dominant trees belong to *Rhizophora apiculata* Blume, *Avicennia marina* (Forsk.) Vierh. and *Excoecaria agallocha* L. and the salt marsh plants are *Salicornia brachiata* Roxb., *Suaeda maritima* (L.) Dumort and *Sesuvium portulacastrum* (L.) (Godhantaraman, 2002).

Two different sampling sites were chosen and the distance between the stations was about 1 km (Fig. 1). Station 1, received neritic water from the adjacent Bay of Bengal through a mouth called 'Chinnavaikal' (marine zone) and the depth of the water column was about 2 m, (now this has been closed due to the recent Tsunami); Station 2, Kanankeluthi canal, is located near the old cottage of Tamil Nadu Tourism Corporation. During extreme low tides of certain months, the muddy bottom is exposed. Depth of this station is about 0.5 m during the high tide. The major freshwater source to this station is the Khan Sahib canal during monsoon and the excess drainage water is received through the irrigation canals from paddy fields. A dense vegetation of mangroves of *Rhizophora apiculata* Blume, *R. mucronata* Poir, *Avicennia marina* (Forsk.) Vierh., *A. officinalis* L., *Bruguiera cylindrica* L. (Bl.) and *Ceriops decandra* (Griff.) Ding Hou is found in this area. The tides are semi-diurnal and vary in amplitude from about 15 to 100 cm in different regions during different seasons, reaching a maximum during monsoon and post-monsoon and a minimum during summer (Kathiresan, 2000). The rise and fall of the tidal waters is through a direct connection with the sea at the Chinnavaikkal mouth and also through the two adjacent estuaries. The depth of the water-ways ranges from about 0.3 to 3 m (Kathiresan, 2000).

Samplings were made during different seasons to record the physico-chemical characteristics of the Pichavaram mangroves. Rainfall data was obtained from meteorological unit of Government of India located at Marine Biological Station at Parangipettai. A calendar year was divided into four seasons *viz.* monsoon (October to December), post monsoon (January to March), summer (April to June) and premonsoon (July to September) based on the northeast monsoon which is prevalent in the study area.

Field data like temperature, salinity, dissolved oxygen, pH and other nutrients were collected during morning to noon. Atmospheric and surface water temperatures were measured using standard mercury filled centigrade thermometer. Salinity was estimated with the help of a hand refractometer (Atago, Japan) and pH was measured using Elico pH meter (Model LC- 120). Dissolved oxygen was estimated by the modified Winkler's method, described by Strickland and Parsons (1972). For the analysis of nutrients, surface water samples were collected in clean polythene bottles and kept in an ice box and transported immediately to the laboratory. The water samples were filtered using a Millipore filtering system (MFS) and analyzed for dissolved inorganic phosphate, nitrate, nitrite and reactive silicate by adopting the standard methods described by Strickland and Parsons (1972). Simple correlation (r) was made for the statistical interpretation of the physico-chemical characteristics.

Results and Discussion

Rainfall: Total rainfall recorded during April, 2000 to March, 2001 was 936.6 mm. Rainfall ranged between 10 mm and 297.6 mm and rain did not occur during two months (February and March, 2001). Total rainfall of 1408 mm was recorded during April, 2001 to March, 2002. Rainfall varied from 50 mm to 260 mm and rain did not occur in the months of May and March (Fig. 2). Rainfall is the most important cyclic phenomenon in tropical countries as it brings important changes in the hydrographical characteristics of the marine and estuarine environments. In the present study, the peak values of rainfall were recorded during the monsoon month of November. The rainfall in India is largely influenced by two monsoons *viz.*, southwest monsoon on the west coast, northern and northeastern India and by the northeast monsoon on the southeast coast (Perumal, 1993). February, March and May 2001 and March 2002 were practically rainless.

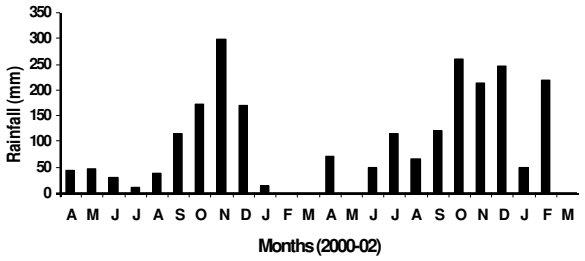

Fig. 2: Rainfall recorded during 2000 to 2002 in the study area

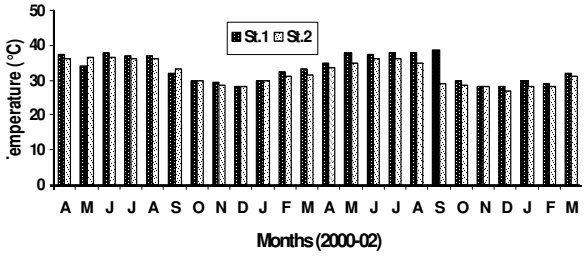

Fig. 3: Seasonal variation in air temperature during 2000 to 2002 at stations 1 and 2

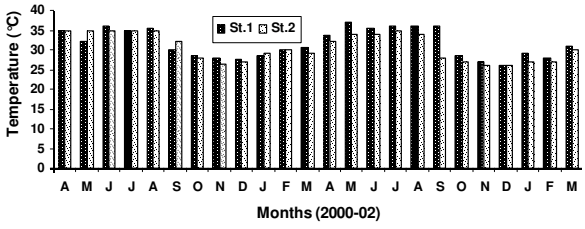

Fig. 4: Seasonal changes in surface water temperature during 2000 to 2002 at stations 1 and 2

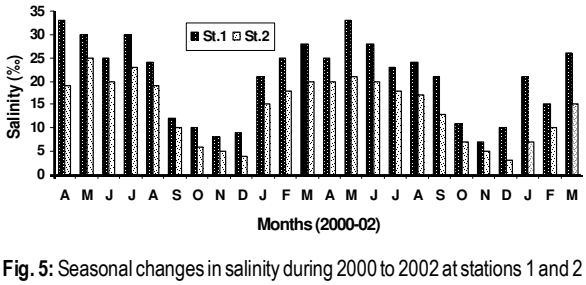

Fig. 5: Seasonal changes in salinity during 2000 to 2002 at stations 1 and 2

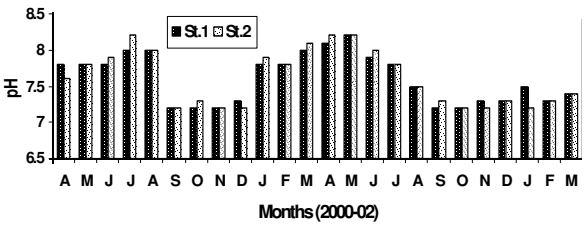

Fig. 6: Seasonal changes in pH during 2000 to 2002 at stations 1 and 2

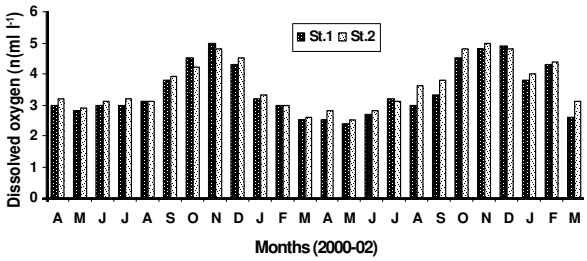

Fig. 7: Seasonal changes in dissolved oxygen during 2000 to 2002 at stations 1 and 2

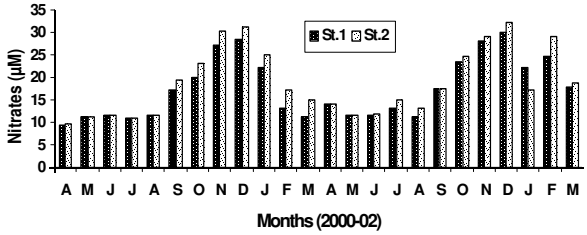

Fig. 8: Seasonal changes in nitrates during 2000 to 2002 at stations 1 and 2

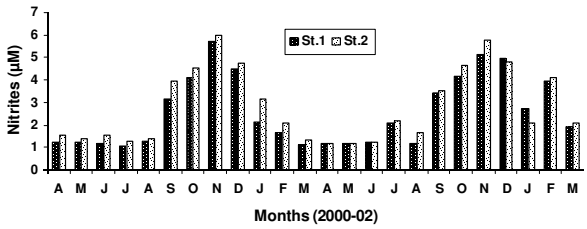

Fig. 9: Seasonal changes in nitrites during 2000 to 2002 at stations 1 and 2

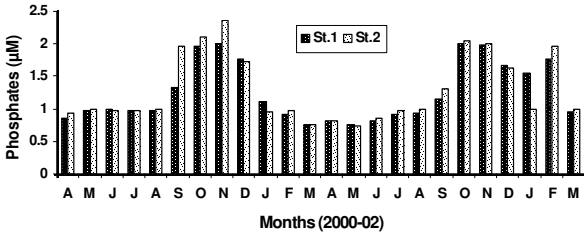

Fig. 10: Seasonal changes in phosphates during 2000 to 2002 at stations 1 and 2

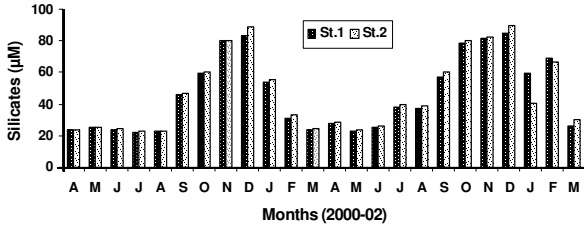

Fig. 11: Seasonal changes in silicates during 2000 to 2002 at stations 1 and 2

Surface water temperature: Air and surface water temperatures varied from 27°C to 38°C and from 26°C to 37°C (Fig. 3, 4). Generally, 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. The water temperature during December was low because of strong land sea breeze and precipitation and the recorded high value during summer could be attributed to high solar radiation (Das *et al*., 1997; Karuppasamy and Perumal, 2000; Senthilkumar *et al*., 2002 ; Santhanam and Perumal, 2003). The spatial variation observed in temperature could be due to the viable intensity of prevailing streams and the resulting mixing of water (Reddi *et al*., 1993). Statistical analysis showed a negative correlation (r=-0.5367 at Station 1 and r = -0.5660 at Station 2) between air and surface water temperature for both stations.

Salinity: The 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 fauna in the intertidal zone (Gibson, 1982). Generally, changes in the salinity in the brackishwater habitats such as estuaries, backwaters and mangrove are due to the influx of freshwater from land run off, caused by monsoon or by tidal variations. This is further evidenced by the negative correlation (r=-0.4761 at Station 1 and r=-0.7898 at Station 2) obtained between salinity and rainfall. Salinity showed a significant positive correlation with temperature. In the present study, salinity at both the stations was high during summer season and low during the monsoon season (Fig. 5). Higher values (33.0‰) during summer could be attributed to the low amount of rainfall, higher rate of evaporation and also due to neritic water dominance in the study area (Sampathkumar and Kannan, 1998; Govindasamy *et al*., 2000; Gowda *et al.,* 2001 ; Rajasegar, 2003). During the monsoon season (3.0‰), the rainfall and the freshwater inflow from the land in turn moderately reduced the salinity : Sai Sastry and Chandramohan (1990) in the Godavari estuary; Mitra *et al.* (1990) in the Bay of Bengal and coastal waters of Kalpakkam (Satpathy, 1996).

pH: Hydrogen ion concentration (pH) in surface waters remained alkaline throughout the study period at all the stations with maximum value (8.2) during the summer seasons and minimum values (7.2) during monsoon (Fig. 6). Generally, fluctuations in pH values during different seasons of the year is 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 and decomposition of organic materials as stated by Karuppasamy and Perumal, 2000; Rajasegar, 2003. High pH was recorded during summer seasons, which might be due to the influence of seawater penetration and high biological activity (Das *et al*., 1997) and due to the presence of high photosynthetic activity (Subramanian and Mahadevan, 1999). The statistical analysis also revealed that salinity show highly significant negative correlation with rainfall.

Dissolved oxygen: Variation in dissolved oxygen content was from 2.4 to 5.0 ml l^{-1} (Fig. 7). It is well known that the temperature and salinity affect the dissolution of oxygen (Vijayakumar *et al*., 2000). In the present investigation, higher values of dissolved oxygen were recorded during monsoon months at all the stations. Higher dissolved oxygen concentration observed during the monsoon season might be due to the cumulative effect of higher wind velocity joined with heavy rainfall and the resultant freshwater mixing (Das *et al.,* 1997). Mitra *et al*. (1990) mainly attributed seasonal variation of dissolved oxygen to freshwater flow and terrigenous impact of sediments. Further, significant inverse relationship between rainfall and nutrients indicated that freshwater flow constituted the main source of the nutrients in the mangroves.

Nutrients :

Nitrates: The recorded highest nitrates value (32.12 µM) during monsoon season could be mainly due to the organic materials received from the catchment area during ebb tide (Das *et al*., 1997) (Fig. 8). The increased nitrates level was due to fresh water inflow, mangrove leaves litter fall decomposition and terrestrial run-off during the monsoon season (Karuppasamy and Perumal, 2000). Another possible way of nitrates entry is through oxidation of ammonia form of nitrogen to nitrite formation (Rajasegar, 2003). The low values (9.50 µM) recorded during non-monsoon period may be due to its utilization by phytoplankton as evidenced by high photosynthetic activity and also due to the neritic water dominance, which contained negligible amount of nitrate (Rajashree Gouda and Panigrahy, 1995; Das *et al*., 1997; Govindasamy *et al*., 2000).

Nitrites: The recorded higher monsoonal values (5.99 µM) could be due to the increased phytoplankton excretion, oxidation of ammonia and reduction of nitrate and by recycling of nitrogen and bacterial decomposition of planktonic detritus present in the environment (Swami *et al*., 1996; Govindasamy *et al*., 2000). Further, the denitrification and air-sea interaction exchange of chemicals are also responsible for this increased values (Mathew and Pillai, 1990 ; Choudhury and Panigrahy, 1991) (Fig. 9). The recorded low value (1.07 µM) during summer and pre-monsoon seasons may be due to less freshwater inflow and high salinity (Mani and Krishnamurthy, 1989; Murugan and Ayyakkannu, 1991).

Inorganic phosphates: Nutrients are considered as one of the most important parameters in the mangrove environment influencing growth, reproduction and metabolic activities of living being. Distribution of nutrients is mainly based on the season, tidal conditions and freshwater flow from land source. High concentration of inorganic phosphates (2.36 µM) observed during monsoon season might possibly be due to intrusion of upwelling seawater into the creek, which increased the level of phosphate (Nair *et al*., 1984) (Fig. 10). The recorded low phosphates value (0.73 µM) during summer could be attributed to the limited flow of freshwater, high salinity and utilization of phosphate by phytoplankton (Senthilkumar *et al.,* 2002; Rajasegar, 2003). The variation may be due to the various processes like adsorption and desorption of phosphates and buffering action of sediment under varying environmental conditions (Rajasegar,

2003). Further, high value of phosphates noticed during monsoon season can also be related to the weathering of rocks soluble alkali metal phosphates, the bulk of which are carried into the mangroves. 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 (Tiwari and Nair, 1993).

Reactive silicates: The silicate content was higher than that of the other nutrients (NO_3, NO_2 and PO_4) and the recorded high monsoon values (89.8 µM) may be due to heavy inflow of monsoonal freshwater derived from land drainage carrying silicate leached out from rocks. Moreover, due to the turbulent nature of water, the silicate from the bottom sediment might have been exchanged with overlying water in this mangrove environment (Govindasamy and Kannan, 1996; Rajasegar, 2003) (Fig. 11). Besides this, the dissolution of particulate silicon carried by the river, the removal of silicates by adsorption and co-precipitation of soluble silicate silicon with humic compounds and iron (Rajasegar, 2003). The low concentration (22.1µM) during post-monsoon season could be attributed to uptake of the silicates by phytoplankton for their biological activity (Mishra *et al*., 1993; Ramakrishnan *et al.,* 1999).

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