Study on Physico-Chemical Parameters in Different Mangrove Regions, Southeast Coast of India

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Abstract
A study was undertaken to determine the physico-chemical parameters of water in different mangrove regions of Indian coast. Flora and faunas are living in that regions and it can provide wild life places for living and foraging. Physico-chemical parameters are influence the species diversity, pattern of diversity, spawning, breeding and metabolic activities. The temperature, pH, salinity, dissolved oxygen and nutrients are the major master factors of coastal water ecosystem. These parameters are occurring optimum level for the survival of species and poor water quality can influence the species activities and patterns of behavior. However, the base line physico-chemical data is toward the further study of ecological and conservation of economically and they are living species diversity patterns.

Keywords: Physico-chemical; Parameters; Influence; Organisms; Mangrove region

Introduction
The physico-chemical characteristics are said to play a significant role in the distribution of organisms such as reproduction, feeding etc. Various physico-chemical and biological processes in the mangals make it a habitat for vast array of organisms, leading to rich biodiversity [1] but seasonal variation and anthropogenic pressures bring about a lot of changes in physical-chemical characteristics, which affect the biotic elements of the mangals system. The most important variables which influence the mangrove are temperature, salinity, tides, rainfall and wind. Survival and development of regeneration and recruitment classes depend on salinity and solar radiation [2]. Temperature and salinity determine the species composition, distribution and zonation. Tidal amplitude with topography structure regulates the landward extension of the mangroves. Many studies related to hydro biological parameters were carried out in Indian coastal waters. Of which, Menon et al. [3] studied the hydrobiology of the Cochin backwaters, south west coast of India. The physico chemical characteristics of Pichavaram mangroves, south east coast of India by Rajendran [4] and Kathiresan [2,5]. Information on various physico-chemical and biological process, which controlling the prevailing environmental conditions of the region, will eventually helps to evaluate the ecological changes. Studies on hydrography of backwaters and mangroves of east coast of India [6] are limited when compared to the mangroves of west coast. Sundarban, [7], Bithor Kanika [7,8], Krishna and Godavari delta [9] in east coast, Pichavaram [10,11]. Physico-chemical parameters are most serious problems of aquatic organisms. It can affect the species diversity, presence and absence of species and pattern of distribution such as directly or indirectly and totally change the species behavior of inhabitants regions. The aim of the present study was to determine whether the physical and chemical parameters of monthly variability in different coastal environment.

Materials and Methods
Surface water samples were collected at monthly interval at two different stations, Station I- Muthupettai and Station II-Pointcalimere for a period of one year from October 2006 to September 2007 to analyze various physico-chemical parameters (Figure 1). Rainfall data for the study area was collected from the meteorological unit. The atmospheric and water temperature were measured using a digital centigrade thermometer. Salinity was estimated with the help of a hand refractometer (ERMA, Japan) and pH was measured using an ELICO Grip pH meter. Dissolved oxygen was estimated by the modified Winkler’s method [12].

For the analysis of nutrients, surface water samples were collected in clean polythene bottles and kept immediately in an icebox and transported to the laboratory. The water samples were then filtered using a millipore filtering system and analyzed for dissolved inorganic phosphate, total phosphorus, total Nitrogen, nitrate, nitrite, ammonia and reactive silicate by adopting standard procedure of [12].

Results
Rainfall
Rainfall in the southeast coast of India is largely influenced by the northeast monsoon, while, the southwest monsoon serves the coast.

Figure 1: Map showing the study area.

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Based on the cyclic phenomena of meteorological events, four seasons are broadly indicated in a calendar year they are: (1). Post monsoon (January to March) (2) Summer (April to June) (3) Pre monsoon (July to September) and (4) Monsoon (October to December).

The Rainfall at Point Calimere varied from 15.8 mm to 747 mm (Figure 2). Maximum (747 mm) was recorded during monsoon (Nov. 2006) and minimum (15.8 mm) was recorded during summer (Jun. 2007). In Muthupettai, it was varied between 302 mm and 30.2 mm (Figure 2). Maximum (302 mm) was recorded during monsoon (Oct. 2006) and in minimum (30.2 mm) was recorded during post-monsoon (Feb. 2007).

Atmosphere Temperature

The Atmosphere temperature at Point Calimere varied from 25.0°C to 29.9°C (Figure 3) Maximum (29.9°C) was recorded during post monsoon (Mar. 2007) and in minimum (25.0°C) was observed during pre-monsoon (Dec. 2006). At Muthupettai, it was ranged from 21 to 32.8 (Figure 3). Maximum (32.8°C) was recorded during summer (May 2007) and minimum (21.0°C) was recorded during monsoon (Dec. 2007). The two-ways ANOVA showed non-significant variations between the two stations and seasons (Table 1). The dissolved oxygen values between the two stations are positively correlated (r=0.344; p>0.10).

Water temperature

The water temperature at Point Calimere varied from 26.0°C to 30.2°C (Figure 4). Maximum (30.2°C) was recorded during monsoon (Nov. 2006) and in the minimum (26.0°C) was observed in post monsoon (Jan. 2007). The water temperature at Muthupettai varied from 23.0°C to 30.0°C (Figure 4). Maximum (30.0°C) was recorded during summer (May 2007) and in the minimum (23.0°C) was observed during monsoon (Dec. 2006). The two-ways ANOVA showed non-significant variations between the seasons and stations (Table 2). The dissolved oxygen values between the two stations are positively correlated (r=0.344; p<0.01).

Salinity

The values of salinity varied from 24.0 ppt to 34.0 ppt (Figure 5). Minimum (24.0 ppt) was recorded during monsoon (Dec. 2006) and the maximum (34.0 ppt) was recorded during pre-monsoon (Aug. 2007) in Point Calimere. The Muthupettai, it was varied from 24.0 ppt to 34ppt (Figure 5) Maximum (34ppt) was recorded during summer (May 2006) and minimum (24) was recorded during Monsoon (Dec. 2006). The two ways ANOVA showed non-significant variations between the seasons and stations (Table 3). The dissolved oxygen values between the two stations are positively correlated (r=0.926; p>0.001).

Dissolved Oxygen

At Point Calimere, it was varied from 3.92 mg/l to 5.22 mg/l (Figure 7). The maximum (5.22 mg/l) was recorded in post monsoon (Mar. 2007) and the minimum (3.92 mg/L) was recorded during monsoon (Oct. 2006). In Muthupettai, the dissolved oxygen was varied from 3.97 mg/l to 5.33 mg/l (Figure 7). The maximum (5.33 mg/l) was recorded during summer (May 2007) and minimum (3.97 mg/l) was recorded during Monsoon (Nov. 2006). The two-way ANOVA showed non-significant variations between the seasons and significant variations between stations (p<0.05) in (Table 4). The dissolved oxygen values between the two stations are positively correlated (r=0.982; p < 0.001).

Turbidity

The Turbidity at Point Calimere varied from 43.0 NTU to 260.0 NTU (Figure 8). Maximum (260.0 NTU) was recorded during pre-monsoon (July 2006) and minimum (43.0 NTU) was recorded during summer (May 2007). At Muthupettai varied from 40.0 NTU to 792 NTU (Figure 8). The maximum (792 NTU) was recorded during summer (May 2006) and in the minimum (40.0 NTU) was recorded...
1506.4 mg/l (Figure 9). The maximum (1506.4 mg/l) was recorded during summer (May 2007) and the minimum (82.1 mg/l) was observed during post-monsoon (Jan. 2007). The two-ways ANOVA showed non-significant variations between the seasons and stations (Table 7). The dissolved oxygen values between the two stations are positively correlated (r=-0.115; p>0.001).

**Water nutrients**

**Inorganic phosphate:** The value of inorganic phosphate was ranged during post monsoon (Jan. 2007). The two-ways ANOVA showed non-significant variations between the seasons and stations (Table 6). The dissolved oxygen values between the two stations are positively correlated (r=-0.048; p>0.001).

**Total suspended solids**

The total suspended solids at Point Calimere varied from 82.0 mg/l to 522.0 mg/l (Figure 9). Maximum (522.0 mg/l) was recorded during pre-monsoon (July 2007). Minimum (82.0 mg/l) was recorded during summer (May 2007). In Muthupettai, it was varied from 82.1 mg/l to 1506.4 mg/l (Figure 9). The maximum (1506.4 mg/l) was recorded during summer (May 2007) and the minimum (82.1 mg/l) was observed during post-monsoon (Jan. 2007). The two-ways ANOVA showed non-significant variations between the seasons and stations (Table 7). The dissolved oxygen values between the two stations are positively correlated (r=-0.115; p>0.001).
The dissolved oxygen values between the two stations are positively correlated ($r=0.926116; p>0.001$).

**Total phosphorus:** The Total phosphorus at Point Calimere varied from 1.32 μmol/l to 2.893 μmol/l (Figure 11). Minimum (1.32 μmol/l) was recorded during post monsoon (Jan. 2007) and in maximum (2.893 μmol/l) was recorded during pre monsoon (September 2007). At Muthupettai, it was varied from 1.29 μmol/l to 3.425 μmol/l (Figure 11). The minimum (1.29 μmol/l) was recorded during summer (Jun 2007) and the maximum (3.425 μmol/l) was recorded during monsoon (Nov. 2006). The two-way ANOVA showed significant variations between the seasons ($p<0.05$) and stations ($p<0.05$) in (Table 9). The dissolved oxygen values between the two stations are positively correlated ($r=0.926116; p>0.001$).

**Total Nitrogen:** The Total nitrogen at Point Calimere varied from 5.123 μmol/l to 38.916 μmol/l (Figure 12). Maximum (38.916 μmol/l) was recorded during post monsoon (Mar. 2007) and in minimum (0.550 μmol/l) was observed in monsoon (Nov. 2006). The inorganic phosphate at Muthupettai varied from 0.470 μmol/l to 2.620 μmol/l (Figure 10). The maximum (2.620 μmol/l) was recorded during post monsoon (Dec. 2006) and in minimum (0.470 μmol/l) was observed in post monsoon (Jan. 2007). The two-way ANOVA showed significant variations between the seasons ($p<0.05$) and stations ($p<0.05$) (Table 7).
was recorded during monsoon (Oct. 2006) and in minimum (5.123 μmol/l) was recorded during summer (May 2007). The total nitrogen at Muthupettai varied from 5.436 μmol/l to 37.382 μmol/l (Figure 12). Maximum (37.382 μmol/l) was recorded during monsoon (Oct. 2006). Minimum (5.436 μmol/l) was recorded during summer (May 2007). The two-way ANOVA showed non-significant variations between the seasons and stations (Table 10). The dissolved oxygen values between the two stations are positively correlated (r=0.926116; p>0.001).

Ammonia: The Ammonia at Point Calimere varied from 0.120 μmol/l to 0.698 μmol/l (Figure 13). Maximum (0.698 μmol/l) was recorded during monsoon (Dec. 2006). Minimum (0.0.120 μmol/l) was recorded during post monsoon (Feb. 2007). The two-ways ANOVA showed non-significant variations between the seasons and stations (Table 11). The dissolved oxygen values between the two stations are positively correlated (r=0.926116; p>0.001).

Nitrite: The nitrite at Point Calimere varied from 0.082 μmol/l to 1.957 μmol/l (Figure 14). Maximum (1.957 μmol/l) was recorded during pre monsoon (Sep. 2007) and minimum (0.082 μmol/l) was recorded during post monsoon (Feb. 2007). At Muthupettai, it was varied from 0.060 μmol/l to 2.082 μmol/l. Maximum (2.082 μmol/l) was recorded during monsoon (Nov. 2006) and minimum (0.06 μmol/l) was recorded during summer (May 2007). The two-way ANOVA showed significant variations between the seasons (p<0.05) and stations (p<0.05), (Table 12). The dissolved oxygen values between the two stations are positively correlated (r=0.926116; p>0.001).

Nitrate: The nitrate at Point Calimere varied from 0.639 μmol/l to 7.088 μmol/l (Figure 15). Maximum (7.088 μmol/l) was recorded during monsoon (Dec. 2006). Minimum (0.639 μmol/l) was recorded during summer (May 2007). The nitrite at Muthupettai varied from 0.911 μmol/l to 7.675 μmol/l (Figure 15). Maximum (7.675 μmol/l) was recorded during pre monsoon (Aug. 2006). Minimum (0.911μmol/l) was recorded during post monsoon (Feb. 2007). The two-way ANOVA showed non-significant variations between the seasons and stations (Table 13). The dissolved oxygen values between the two stations are positively correlated (r=0.926116; p>0.001).
fresh water discharge factors are governing light penetration capability of the entering stream and the sea together with tidal states. The water pH recorded during the present study fluctuated in alkaline range with low range of 7.2 at Point Calimere and the maximum of 8.5 were recorded in Point Calimere. The uptake of CO₂ by the photosynthetic organisms especially phytoplankton in the Muthupettai and Point Calimere waters could have increased the pH levels. Similar range of pH has also been reported by earlier researchers from this study area [15,16,18]. Knowledge of nutrients, pertaining to their contributory sources, utilization levels, mechanism and rates of their release will be of great value to assess the productivity of an estuary. There are several instants to show that river contribute nutrients in a significant measure to the estuary and there are also estuarine waters. Considering the above fact turbidity of water column of mangrove environment may be the reason for the low surface water temperature in the mangrove sites of the Muthupettai.

The sediment temperature also showed similar trend as that of surface water temperature. In general, the surface water and sediment temperatures were lower than atmospheric temperature in two stations. This might be due to shallow (0.5 m) nature of the environment, while the minimum temperature of 21.00°C was recorded at Point Calimere. This might be due to higher average of the station (5.0 m).

Salinity is one of the important key factors which determine the composition of biological component in the marine environment. The fluctuations in salinity affect the biological characteristics of the environment. Paramasivam and Kannan [18] Stated that the salinity at any point in an estuary will be depended on the topography of the estuary, the state of tide (high or low, and spring or neap), the time of the year controlling rainfall etc., and the extent of freshwaters flow. Present study was recorded high salinity values could be attributed to the high degree of evaporation and also due to neritic water dominance from sea. The lower salinity values of 24.0 ppt were recorded in the Muthupettai might be due to the continuous inflow of freshwater into the estuary through the six rivers (Branchlets of Cauvery River) during this part of the year. Paramasivam and Kannan [18] have recorded 2-29.5 ppt.

The water pH recorded during the present study fluctuated in alkaline range with low range of 7.2 at Point Calimere and the maximum of 8.5 were recorded in Point Calimere. The uptake of CO₂ by the photosynthetic organisms especially phytoplankton in the Muthupettai and Point Calimere waters could have increased the pH levels. Similar range of pH has also been reported by earlier researchers from this study area [15,16,18]. Knowledge of nutrients, pertaining to their contributory sources, utilization levels, mechanism and rates of their release will be of great value to assess the productivity of an estuary. There are several instants to show that river contribute nutrients in a significant measure to the estuary and there are also

![Figure 15: Monthly variations in nitrate.](image-url)

| Source of Variation | SS    | df | MS   | F      | F crit | P-value |
|---------------------|-------|----|------|--------|--------|---------|
| Seasons             | 2.0028| 1  | 2.0028| 0.6667 | 4.8443 | NS      |
| Stations            | 114.7987| 10 | 11.4362| 3.4743| 2.8179 | NS      |
| Error               | 33.0423| 11 | 3.0038|        |        |         |
| Total               | 149.8437| 23 |       |        |        |         |

Table 13: The two-way ANOVA between the stations and seasons.

**Reactive Silicate**

The reactive silicate at Point Calimere varied from 16.163 μmol/l to 96.813 μmol/l (Figure 16). Maximum (96.813 μmol/l) was recorded during monsoon (Nov.2006). Minimum (16.163 μmol/l) was recorded during post monsoon (Mar. 2007). The reactive silicate at Muthupettai varied from 32.214 μmol/l to 102.210 μmol/l (Figure 16). Maximum (102.210 μmol/l) was recorded during monsoon (Oct.2006). Minimum (32.214 μmol/l) was recorded during summer (May 2007). The two-way ANOVA showed non-significant variations between the seasons and stations (Table 14). The dissolved oxygen values between the two stations are positively correlated (r=0.926116; p>0.001).

**Discussion**

Adequate information on coastal wetlands such as estuaries, mudflats, coral reefs, mangroves etc., of Indian is available, and is having different characteristic behaviors in the physico-chemical and biological condition. Understanding such variations in the physico-chemical aspects of these ecosystems will help understand the functioning of these fragile ecosystems and thereby help protecting not only the ecosystems but also the human population from water borne diseases. In general, the surface water temperature is influenced by sun shine; evaporation, cooled freshwater influx and admixture ebb and flow from the adjoining neritic waters. Reid GK [13] remarked “The temperature of estuary, therefore, primarily is a function of temperature of the entering stream and the sea together with tidal states”. The maximum surface water temperature of 30.4°C was recorded in the Muthupettai and minimum water temperature of 25.0°C was recorded at the Muthupettai. Kannan et al. [14] also reported minimum temperature values at shrimp pond drainage sites of Muthupettai. However, Sankar [15], Oswin and Rahman [16], Ajith et al. [17] have reported lower temperature from mangrove area. This might be due to their nature of study, which they have compared only Point Calimere and Muthupettai further outpouring by land runoff discharges from shrimp farms, wave action, wind action, fresh water discharge factors are governing light penetration capability

![Figure 16: Monthly variations in silicate.](image-url)

| Source of Variation | SS    | df | MS   | F      | F crit | P-value |
|---------------------|-------|----|------|--------|--------|---------|
| Seasons             | 119.4656| 1  | 119.4656| 0.3018 | 4.8443 | NS      |
| Stations            | 5497.4244| 11 | 499.7659| 1.2627| 2.8179 | NS      |
| Error               | 4353.8635| 11 | 395.8058|        |        |         |
| Total               | 9970.7535| 23 |       |        |        |         |

Table 14: The two-way ANOVA between the stations and seasons.
number of instances to point out that the contribution is more from neritic end.

Nutrients are considered as one of the most important parameters in the marine environment. The distribution of nutrients is mainly based on the season’s tidal conditions and river flow. Silicate is different from nitrogen and phosphate in some ways and in the strictest sense it is not considered as a nutrient but its usefulness in the formation of skeleton of diatoms and radiolarians is very high. The concentration of reactive silicate was found to be much higher than other nutrients. In the present study, lower silicate values 32.214 µmol/l was recorded from the Muthupettai, while high values 102.210 µmol/l of the silicate observed in Point Calimere. This can be attributed to the influx aquaculture water during water exchange with silicate. However, Kannan et al. [14] reported a lower range of silicate (0.6 to 21.72 µmol/l) from this environment. Paramasivam and Kannan [18] have reported even more silicate level upto (115.632 µmol/l) from this mangrove environment. High concentration of Ammonia 0.544 µmol/l was observed in Muthupettai and less concentration of Ammonia 0.030 µmol/l was observed in Point Calimere. Further, the decomposition of plankton also contributed to the higher concentration of Ammonia [19,20].

The higher phosphate value 0.821 µmol/l was recorded from Muthupettai might be influenced by the freshwater inflow and lower value (0.670 µmol/l) from the open sea might be due to utilization of phytoplankton. Nair et al. [21] have opined that the demised river discharge and utilization for biological productivity also cause low phosphate in the environment. However, the present range of phosphate level is very low when compared to Physico-chemical characteristics of Muthupettai mangrove Environment [14,18].

Nitrite concentration was recorded during the present study showed optimum values at all the two stations. Nitrite concentration was found to be much lower than that of nitrate; however the same trend of fluctuation was noticed in both the cases during the present study. Maximum (1.957 µmol/l) was recorded at Point Calimere and minimum concentration (0.082 µmol/l) was recorded at Point Calimere. The decomposition of phytoplankton, reduction of nitrate and oxidation of ammonia combined together or individually contribute to the concentration of nitrite in the environment [22,23]. However earlier reports [15,17,18] found even higher concentration of nitrite from this mangrove environment.

Higher concentration of nitrate could be possible due to heavy rainfall, land drainage and agricultural discharge. Anbazhagan [22] suggested that the addition of nitrogenous nutrients mainly through freshwater and terrestrial runoff in the lagoon definitely increased the level of nitrate. Lower concentration of nitrate was recorded at open sea may be due to utilization of nitrate by the benthic algae and phytoplankton. High rainfall in forests [14,18,23] have reported higher concentration of nitrate (0.12-14.17; 0.15-14.17; 0.96-6.90; µmol/l respectively) from this mangrove environment.

Total Nitrogen concentration was maximum 38.916 µmol/l at Point Calimere and the same region minimum value were recorded 5.123 µmol/l [14] recorded the same value in Muthupettai mangroves and [11] also recorded comparable value of total nitrogen in Pitchavaram mangroves. Here it can conclude that, the physical and chemical properties of marine ecosystems are representative of the climatic and pollution conditions, sewage basin and biological formation.
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