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Water Quality Based Physico-Chemical Characteristics In The Man-Made Mangroves Region of Vellar Estuary

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ABSTRACT

This study investigated the physico-chemical parameters of different man-made mangroves in the vellar estuary. The variations in the meteorological and hydro biological parameters such as rainfall, wind speed, temperature, salinity, pH, dissolved oxygen and nutrients were recorded for three stations of artificial mangroves in the vellar estuary during the year of 2015 and 2016. Monthly mean data were obtained for rainfall and wind velocity from the meteorological centre, Parangipettai. Highest rainfall was observed in the month of December 2015 (monsoon) with 185.48 mm and showed fluctuations among the different seasons. Atmospheric temperature was recorded in the study area varied from 22 °C to 36 °C. The physico-chemical parameters in the man-made mangroves of vellar estuary found to be considered with good water quality as they possess normal range of nutrient concentrations, which has to be protected and conserved.

KEYWORDS: Mangroves; Physico-chemical; Nutrients; Vellar; Estuary.

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INTRODUCTION

Mangrove ecosystem referred to as tidal forest, coastal woodland which is more productive found in the tropical and subtropical regions. Mangroves in India estimated to be 6740 km^2 which accounts for about 7% of the world's total mangrove vegetation. It has been invariably controlled by the abiotic factors which are important for all biochemical reaction and functioning of ecosystem, which make them structurally unique. It has also been reported that the mangroves are often influenced by the five important variables, namely temperature, salinity, tides, rainfall. The salinity determines the composition, distribution and zonation of the mangrove species, whereas the tidal amplitude determines the landward extension of mangroves. Mangrove ecosystem act as a buffer between near-shore and lagoon or estuarine waters which influence the freshwater discharge results in the salinity variations. Sediments in the mangrove regions might be originated due to soil erosion, decomposition of plants and animals within the estuarine ecosystem and plays a major role in the global cycle of carbon, nitrogen as well as sulphur[1].

The quality of water and sediments in the mangrove ecosystem depends on the physiochemical parameters, the magnitude and source of pollution load[2]. Reports are available on the physio-chemical characteristics of some Indian estuaries and mangroves[3,4,5] viz., Sundarbans[6], Bitherkanika[7] Krishna and Godawari delta[8] in east coast, Pitchavaram[9]. Information on various physico-chemical and biological process controlling environmental conditions of the region will eventually help to evaluate the ecological changes. Studies on hydrography of backwaters and mangroves of east coast of India are limited when compared to the mangroves of west coast[10]. However such studies have not been attempted so far in the man-made mangrove regions of Vellar estuary. Hence, the present study delineated to understand the physico-chemical characteristics of water in the man-made mangrove creeks along Vellar estuary.

MATERIALS AND METHODS

Surface water samples in the mangrove regions were collected at monthly intervals at three different stations for a period of three years to analyse the physico-chemical parameters. The rainfall data for the study area were obtained from the meterological unit, Parangipettai. Atmospheric temperature and water temperature was measured using digital thermometer. Salinity was determined using hand held refractometer (ERMA, Japan), whereas pH was measured using EuTech Grip pH meter. Dissolved oxygen was estimated by the modified Winkler's method[11]. For nutrient analysis, the surface water samples were collected in a polythene bottles, transported to the laboratory. The

collected samples were then filtered using a millipore filtering system for further analyses (inorganic phosphate, nitrate and nitrate) [11].

RESULTS

The variations in the meteorological and hydrobiological parameters such as rainfall, wind speed, temperature, salinity, pH, dissolved oxygen and nutrients were recorded for three stations of artificial mangroves in the Vellar estuary during the year of 2015 and 2016. Monthly mean data were obtained for rainfall and wind velocity from the meteorological centre, Parangipettai.

Rainfall and Wind Velocity

The highest rainfall was observed in the month of December 2015 (monsoon) with 185.48 mm and showed fluctuations among the different seasons. It was found that the rainfall recorded to be lower in the year of 2016 than 2015. Post-monsoon season recorded with no rainfall in both the years and most of the rainfall occurred as downpour confined to 7-16 days during the month of November and December 2015

Wind velocity was found to be higher in the pre-monsoon (8.935 km/hr) and monsoon (8.581 km/hr) season for the year 2015. Comparatively, the wind velocity was higher in 2015 than 2016 and the lower wind speed was recorded in the post-monsoon season for both the years (Figure.1).

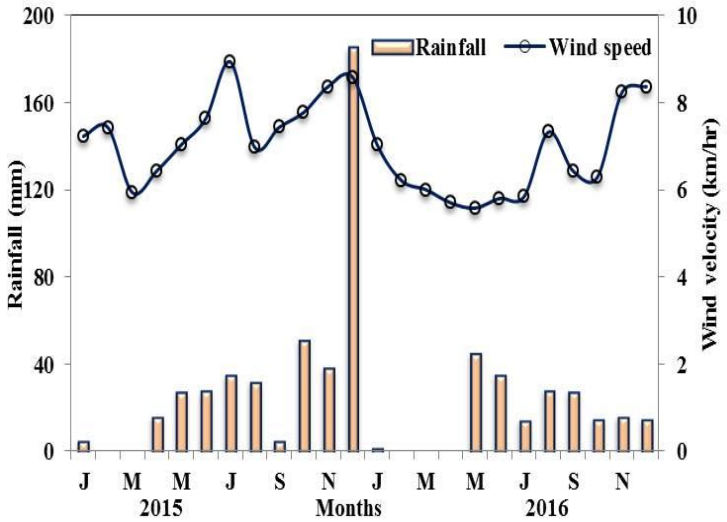

Figure 1. Wind velocity and rainfall recorded during the study period Atmospheric temperature

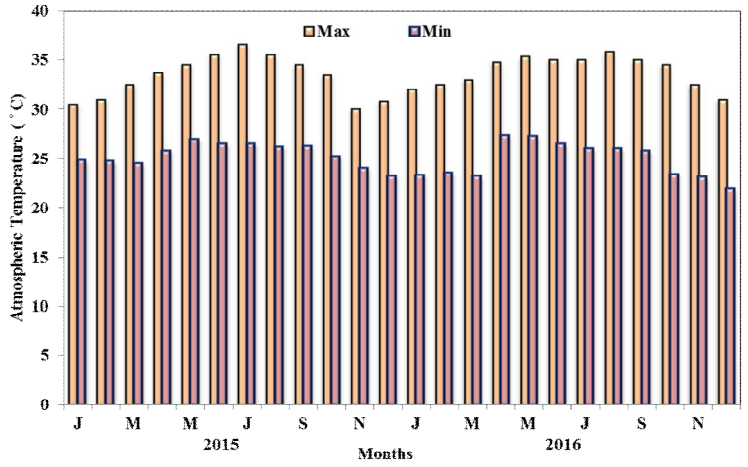

Figure 2. Atmospheric temperature recorded during the study period (2015-2016)

The atmospheric temperature was recorded in the study area varied from 22 °C to 36 °C. The maximum temperature observed during the pre-monsoon season with 36 °C in 2015 and 35.8 °C in 2016. It was found that monsoon and post-monsoon season registered minimum temperature of 22 °C in December 2016 and 24.5°C in March 2015 (Figure.2).

Humidity

The level of humidity was recorded to be higher in the monsoon season with 89% in 2015 and less during summer (70.5%) in 2016. The percentage of humidity fluctuated between the seasons and among the stations in the mangrove regions of Vellar estuary (Figure.3).

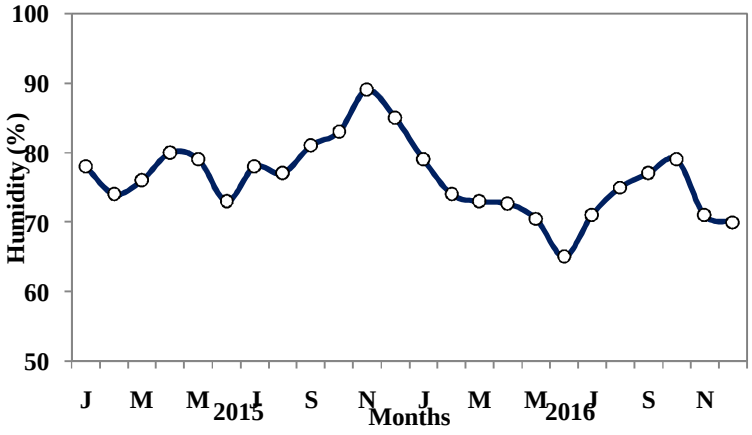

Figure 3. Humidity recorded during the study period (2015-2016)

Water temperature

The variations in the water temperature were recorded between the station I, II and III. The maximum temperature was recorded in the station II with 30°C (summer), followed by station I of 29 °C (post-monsoon) and Station III with 28.7 °C (summer) during the year of 2015. Slight variations were observed in the water temperature among the stations for both the years with a mean of 27.58±0.38 °C in station I, 27.52±0.39 °C in station II and 27.4±0.38 °C in station III. The lower temperature was recorded as 24 °C (Station I) during monsoon season (Figure. 4).

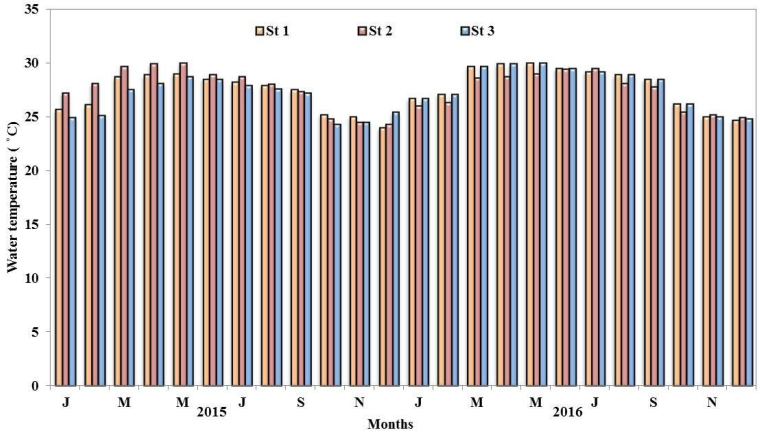

Figure 4. Water temperature recorded during the study period (2015-2016)

Salinity

In station I, the salinity ranged from 23 psu (post-monsoon) to 30 psu (summer) in 2015, whereas in station II, it ranged from 24 psu (monsoon) to 31 psu (summer), while it was found to be 23 psu (monsoon), 29 psu (summer) in sation III. In general the maximum value was recorded during the summer and minimum during the monsoon season in all the stations (Figure. 5). The mean values were found to be 26.9±0.47 psu in station I, 27.9±0.44 psu in station II and 26.1±0.47 psu in station III.

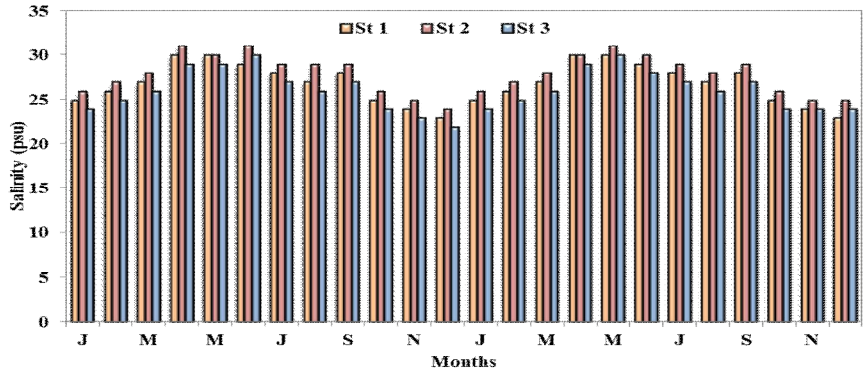

Figure 5. Salinity recorded during the study period (2015-2016)

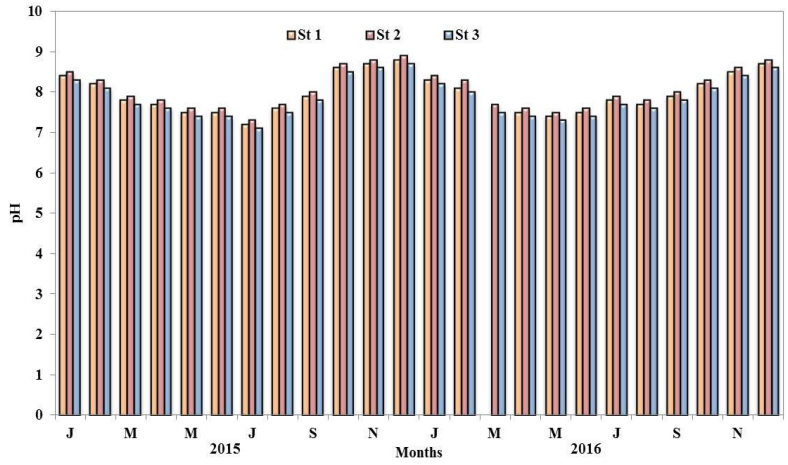

Figure 6. Hydrogen ion concentration recorded during the study period (2015-2016)

pH

The hydrogen ion concentration fluctuated on a monthly basis and ranged from 7.2 (May, 2015) to 8.8 (December, 2016) in station I with a mean pH of 7.9±0.19. In station II, it was found to be 7.2 (November, 2016) to 8.8 (July, 2015), whereas in station III, it was recorded to be 7.1 to 8.2 1 (October, 2015) with a mean pH of 8.06±0.20, while 7.1(May, 2015) to 8.7 (December, 2015) were observed in station III with a mean pH of 7.8±0.26 (Figure. 6).

Dissolved oxygen (DO)

The concentration of DO fluctuated among the stations of mangrove regions in the Vellar estuary. The DO concentration varied from 5.3 (May, 2015) to 7.8 (December, 2016) mg/L in station I, whereas in station II the concentration was found to be 5.7 (April, 2015) to 8.2 (November 2016), while 5.2 (May 2015) to 7.5 (December, 2016). It was found that the higher concentration of DO were recorded during the monsoon 2015 and lowered in summer 2015 (Figure. 7).

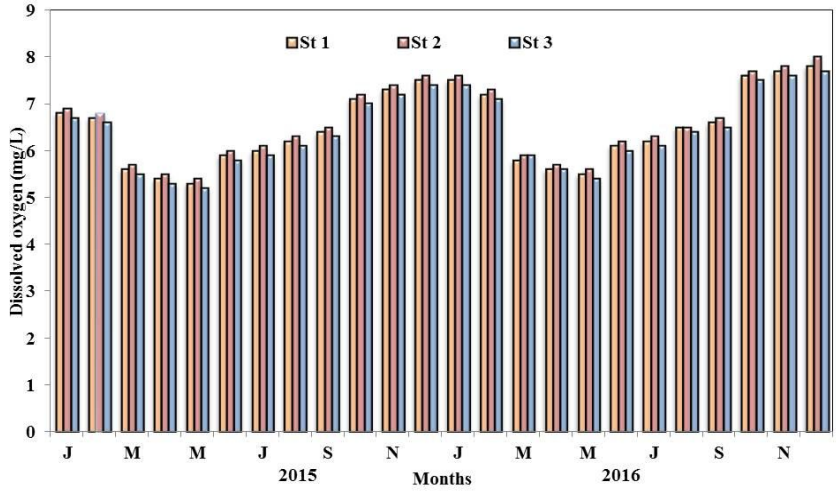

Figure 7. Dissolved oxygen concentration recorded during the study period (2015-2016)

Nitrate

Nitrate concentration ranged from 1.33 (February, 2016) to 7.35 (May, 2015) µmol/L; 1.03 (November 2015) to 7.16 (May, 2105) and 0.47 (July, 2015) - 7.50 (May, 2015) µmol/L in the station I, Station II and Station III (Figure 8). The two-way ANOVA showed no significant variations between the seasons and station ($P<0.05$; Table. 1). The maximum nitrate concentration was recorded in summer (May 2015) and minimum during monsoon (November, 2015 & 2016) and premonsoon (July, 2015).

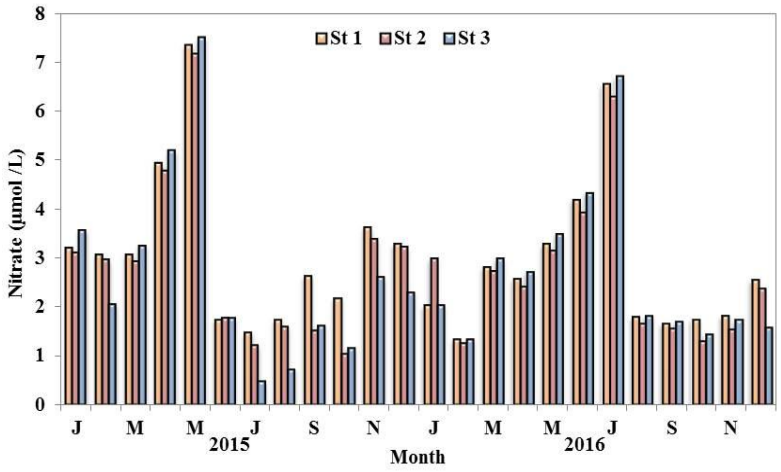

Figure 8. Seasonal variations of nitrate concentration in the study area

Table 1. Two-way ANOVA for nitrate concentration among stations and seasons

Source of Variation	SS	df	MS	F	P-value
Seasons	123.7267	22	5.623943	40.83412	4.12E-13
Stations	0.108139	1	0.108139	0.785173	0.385147
Error	3.029984	22	0.137727		
Total	126.8649	45			

Nitrite

The concentration of nitrite varied from 1.14 µmol/L (January, 2015) to 2.42 µmol/L (October, 2016); 1.11 µmol/L (February, 2015) to 2.30 µmol/L (September, 2105) and 1.26 µmol/L (December, 2016) to 2.54 µmol/L (October, 2015) in station I, station II and station III respectively (Figure. 9). Seasonally, the higher nitrite concentration was found in the monsoon season (October) and less during pre-monsoon and postmonsoon. The nitrite concentration showed significant variations between the stations ($p<0.05$) and less significance was observed between seasons (Table. 2).

Table 2. Two-way ANOVA for nitrite concentration between seasons and stations

Source of Variation	SS	Df	MS	F	P-value	F crit
Seasons	2.670587	22	0.12139	1.897503	0.070381	2.04777
Stations	1.086628	1	1.086628	16.98554	0.000449	4.30095
Error	1.407422	22	0.063974			
Total	5.164637	45				

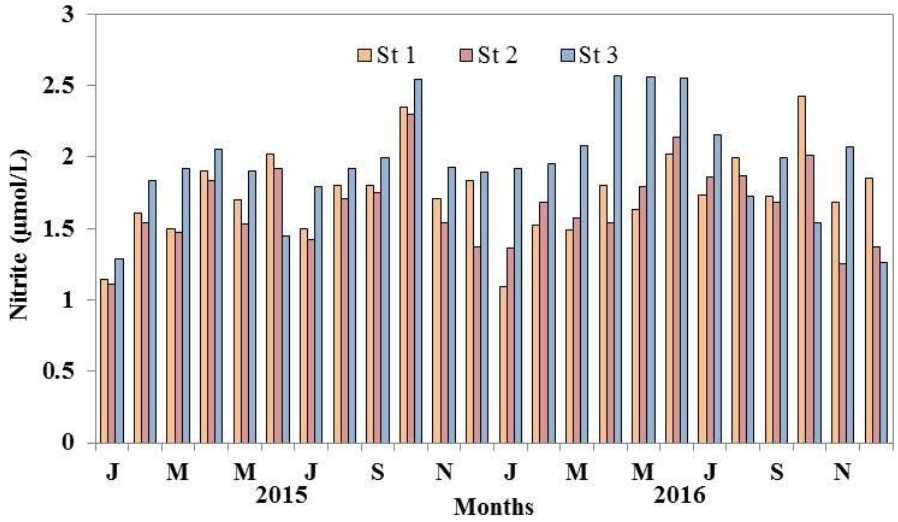

Figure 9. Seasonal variations of nitrite concentration during the study period (2015-2016)

Reactive Silicate

The maximum silicate concentration in station I was recorded as 12.49 µmol/L during monsoon season and minimum during pre-monsoon (1.87 µmol/L), whereas in station II the maximum concentration was found to be 12.18 µmol/L (monsoon) and minimum 1.05 µmol/L (pre-monsoon). In station III the silicate concentration was found to be maximum during monsoon (12.62 µmol/L) and minimum in pre-monsoon (2.08 µmol/L). There were no significant variation between the seasons and stations during the study period (P>0.05; Table 3). The maximum concentration for all the stations was observed during monsoon season of the years (Figure 10).

Table 3. Two-way ANOVA of reactive silicate between the seasons and stations

Source of Variation	SS	df	MS	F	P-value	F crit
Seasons	411.626	22	18.7103	229.998	3.39206E-21	2.04777
Stations	1.84801	1	1.84801	22.7169	9.29351E-05	4.30095
Error	1.78969	22	0.08135			
Total	415.264	45				

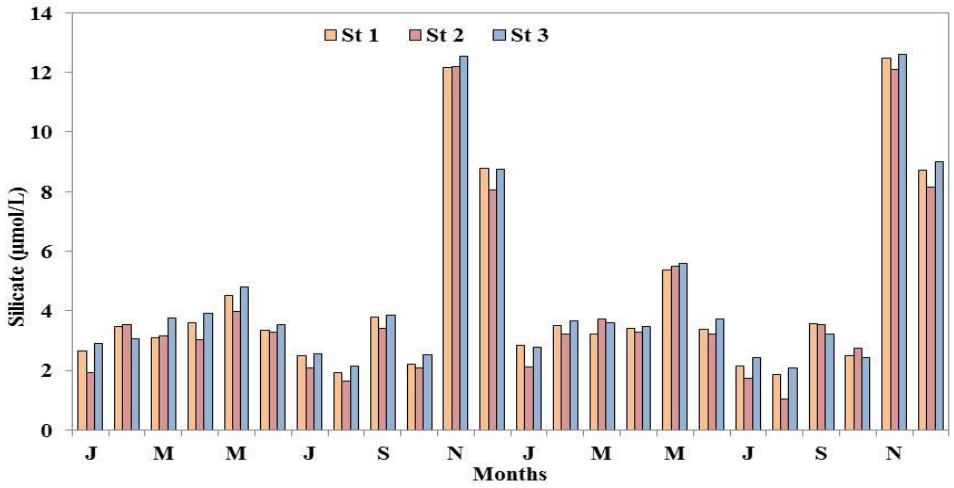

Figure 10. Seasonal variations of silicate concentration during study period

Inorganic phosphate

In station I, the concentration of inorganic phosphate were ranged from 1.119 µmol/L (January, 2016) to 2.88 µmol/L (September, 2015), whereas in station II the concentration varied between 1.12 µmol/L (January, 2016) and 2.88 µmol/L (September, 2016). In station III it ranges was found as 1.41 µmol/L (July, 2016) and 2.95 µmol/L (December, 2015). The higher concentration of inorganic phosphate was found in pre-monsoon and monsoon season while the lower concentration in post-monsoon season was noted (Figure. 11). Analysis of Variance showed significant variation ($P<0.05$; Table. 4) between stations in the both years (2015, 2016), whereas, no significant variation was observed between seasons. Inorganic phosphate concentration found to be significantly varied among the seasons and the stations ($P<0.05$; Table. 4).

Table 4. Two-way ANOVA for inorganic phosphate in the study area

Source of Variation	SS	Df	MS	F	P-value	F crit
Seasons	10.7862	21	0.51363	28.1865	5.5E-11	2.08419
Stations	0.29602	1	0.29602	16.2448	0.0006	4.32479
Error	0.38267	21	0.01822			
Total	11.4649	43				

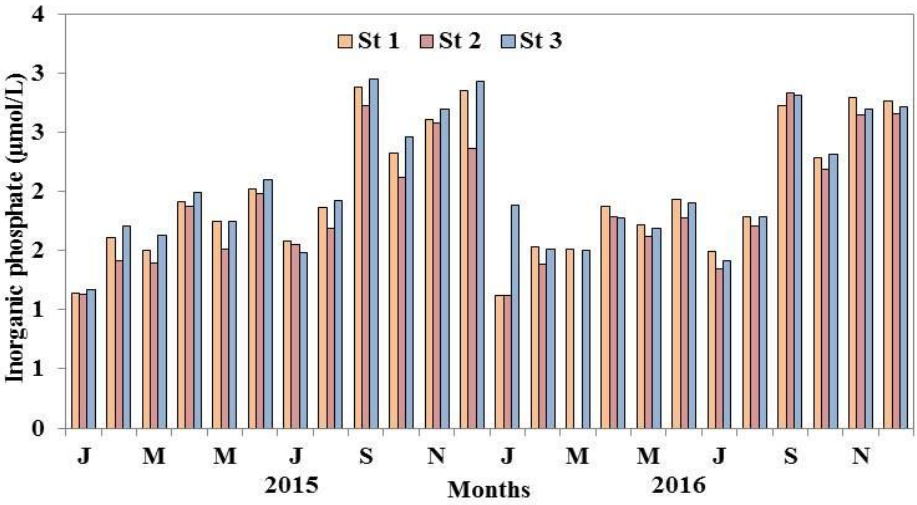

Figure 11. Seasonal variations of inorganic phosphate during the study period

DISCUSSION

The hydro geographical characteristics of the marine and estuarine environment have been influenced by rainfall and are the most important cyclic phenomenon in the tropical countries. In the present study, peak values of the rainfall were recorded during monsoon month of December 2015. The rainfall conditions are more significant for the distribution of mangroves in different zones of the tidal regions. The rain water leaches down the saline soil or sand particles within the soil strata more effectively and the salt water inundates the land surface during the successive tidal flow. In India, the rainfall is largely influenced by the two monsoons viz., northeast monsoon on the southeast coast and by the southwest monsoon on the west coast, northern and north eastern India. It has been reported that the monsoon rainfall varies from 3600 mm along the Kerala coast and decreases further towards Gujarat coast in the north to bare minimum of 400-600 mm and the major precipitation is experienced from September to December along the east coast. The Gulf of Mannar receives less than 90 mm which has been gradually increased towards the north of Portonova upto 1500 mm, whereas the rainfall reaches up to 1908 mm in Sunderbans. Andaman and Nicobar Islands experience heavy rainfall up to 3200 mm every year. Rainfall and Wind velocity found to be correlated in the mangrove environment which has been found higher in the pre-monsoon (8.935 km/hr) and monsoon (8.581 km/hr) season for both 2015 than 2016. The high speed wind activity are often influenced by the friction, increase in the ionic strength of the mangrove water, less river water inputs via estuaries owing to the construction of dams.

Analysis of physico-chemical parameters is most important to comprehend the biological conditions of the mangrove environment. Temperature play a major role in mangrove ecosystem, it

helps to understand the function of fragile ecosystem. In common the surface water temperature is influenced by the evaporation, cooled fresh water influx and admixture ebb flow from the neritic waters. In the present study, the surface water temperature ranged between 24 °C and 30°C between the station I, II and III. The minimum temperature recorded might be due to the disposal of shrimp pond drainage wastes in the station I of mangrove environment. It has also been reported that the minimum temperature recorded in the Muthupettai mangroves could be due to the shrimp pond drainage sites[12,13]. However, Oswin and Rahman[14], Sankar[15] and Ajith et al.[16] have reported the lower temperature in the mangrove area which might be due to the nature of study, as they have compared only using point calimere and further outpouring by land run off, wave actions, wind actions, light penetration capability in the estuarine waters. Considering the above facts, the turbidity of the water column of mangrove environment may be the reason for low surface water temperature in the mangrove sites along Parangipettai region. Generally, surface water temperature is often influenced by the intensity of solar radiation, evaporation, insolation, freshwater influx, cooling and mix up with ebb. The sediment temperature also showed similar trend as that of surface water temperature.

Salinity acts as a limiting factor in determining the distribution of biological components in the marine environments and its variation are often influenced by the fauna in the intertidal zone. The changes in the salinity in brackish water habitats such as estuaries, back waters and mangroves are due to the freshwater influx from land run off or tidal variations which affects the biological characteristics of the environment. The salinity at any point in an estuary will be depended on the topography of the estuary, state of tide, time of the year controlling rainfall etc., and the extent of freshwater flow[17]. In the present study, the salinity fluctuated between 23 psu to 31 psu among all stations. The higher salinity was recorded during the summer which could be attributed to the high degree of evaporation in the study area, whereas, the lower salinity recorded during monsoon season which might be due to the freshwater inflow towards the study area. The present study resembles with the earlier reports of in the Gulf of Kachchh[18].

The pH recorded during the study period remained alkaline during the entire study period. The CO2 uptake by the photosynthetic organisms in the Vellar estuary could have increased the pH values and the similar range of pH has also been reported by Sankar[15] in the Muthupettai mangrove environments. The fluctuations of the pH during different seasons in 2015 and 2016 could also be attributed to the factors like freshwater influx, reduced salinity and temperature, decomposition of organic matters[19,20].

Dissolved oxygen in the marine environment is often influenced by the temperature and salinity. The DO concentration fluctuated among the stations of mangrove regions in the Vellar

estuary and was ranged from 5.3 (May, 2015) to 7.8 (December, 2016) mg/L in station I, whereas in station II the concentration was found to be 5.7 (April, 2015) to 8.2 (November 2016), while 5.2 (May 2015) to 7.5 (December, 2016). Higher concentration of DO recorded during the monsoon season which might be due to the effect of wind velocity coupled with heavy rainfall and the resultant freshwater mixing. The seasonal variations of dissolved oxygen to the fresh water influx and impact of sediments was reported by De Souza and Sen Gupta[21].

Nutrients are considered as one of the most important parameters in the marine environments and their distribution is mainly based on the season's tidal conditions and river flow from land sources. The concentrations of nutrients are often influence the growth, reproduction and metabolic activities of the biotic components. In the present study, nitrate, nitrite, silicate and Inorganic phosphate concentrations was found to be higher in the monsoon season and less during the summer, premonsoon and post monsoon season for all the stations during the study period. High concentration of inorganic phosphate observed during the monsoon might be due to intrusion of upwelled seawater into the creek that increased level of phosphate[22]. Regeneration and mixing of phosphorous from the bottom mud into the water column by turbulence and mixing also attributed to higher values during monsoon season. Similar to that the monsoonal elevation and summer reduction seem to bring both cyclic factors like freshwater runoff, influx from oceanic waters high salinity and biotic factors like utilization by the benthic algae. Phytoplankton could also be one of the reasons for increased concentration of nitrate, nitrite and silicate[23]. The addition of nitrogenous nutrients mainly through fresh water and terrestrial runoff in the lagoon might increase the concentration of nitrate, whereas less concentration may be due to the utilization of nitrate by the benthic algae and phytoplankton. The decomposition of phytoplankton, reduction of nitrate and oxidation of ammonia combined together or individually contribute the concentration of nitrite in the mangrove environment[24,25].

CONCLUSION

The physico-chemical parameters in the man-made mangroves of vellar estuary found to be considered with good water quality as they possess normal range of nutrient concentrations, which has to be protected and conserved. The present baseline information on the physicochemical characteristics of water in the manmade mangroves will be helpful for the further ecological assessment and monitoring along the vellar estuary.

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