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Research Article

Comparative spatial assessment of phytoplankton and productivity in coastal fresh water Pond, Estuary and Neritic water of Palk Bay, South East India

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Abstract

Spatial distribution of phytoplankton, hydrobiological parameters and productivity were investigated in coastal fresh water pond, estuary and neritic water of Palk bay, India. The temperature of the study area varied from 30.8°C to 38.1°C. Salinity of the study area ranged from 0.57 ppt to 34.28 ppt. *p*H during study ranged from 7.5 to 8.2. Dissolved Oxygen (DO) concentration of the study area ranged from 3.36 mg/l to 4.75 mg/l. A total of 103 species of phytoplankton were identified, among them, eighty three species were recorded from diatom, four species from blue green algae and sixteen species from dinoflagellate. The highest phytoplankton density in coastal fresh water pond, estuary and neritic waters of Palk bay were 112000, 388750, 296800 cells l^{-1} respectively. Net primary productivity recorded was high in the neritic waters (148 mg.C/m^3/hr) followed by estuarine water (138 mg.C/m^3/hr) and low in the coastal fresh water pond (28 mg.C/m^3/hr).

Keywords: Phytoplankton, primary productivity, Pappankanniar estuary, diversity and Canonical Correspondence Analysis.

Introduction

Phytoplankton are microscopic drifting plant groups found in abundance in near shore coastal areas typically within the upper 50 m (160 ft) of the water column. Each group exhibits a tremendous variety of cell shapes, intricate designs made up of calcareous and silica structures. They may act as excellent food for a variety of organisms, including zooplankton (microscopic animals), bivalve molluscan shellfish (mussels, oysters, scallops, and clams), and small fish (such as anchovies and sardines) which inturn act as ideal food for other marine organisms through food chain. Carbon sequestration efficiency of the oceans increased by phytoplankton, adding of micrometre-sized iron particles in the form of either hematite (iron oxide) or melanterite (iron sulfate) usually made available via upwelling along the continental shelves, inflows from rivers and streams, as well as deposition of dust suspended in the atmosphere. Rapid cell division in phytoplankton can produce millions of cells per liter of seawater through 5,000 known species of marine phytoplankton in world wide. Although, Physical processes of ocean system can play a significant role in the distribution of phytoplankton species. As they are called as primary producers, productivity of the any ecosystem in coastal and marine arena, depends on phytoplankton density. Hence the study on phytoplankton inevitable and the present study has aimed to investigate the distribution and community structure of phytoplankton with its ecological role in the coastal waters, estuary ecosystem and near shore fresh water pond system to understand the spatial relationship.

Materials and Methods

The study was carried out in coastal fresh water pond (beside to Pappankanniar estuary), Pappankanniar estuary (Mixing to Palk bay) and neritic waters of Palk bay, India (Fig. 1). Three core sampling points were located by GPS and other subordinate points were fixed around the core sampling points. The water samples were collected during full moon high tide for the estimation of temperature, salinity, oxygen, *p*H and phytoplankton. Temperature was measured by standard centigrade laboratory thermometer. The salinity was determined by Mohr's titration method (Strickland and Parsons 1968). The dissolved oxygen was estimated by the standard Wrinkler's method as given by Strickland and Parsons (1968). The *p*H was assessed by *p*H pen (made by Eutech instruments). Phytoplankton samples were collected at all sampling points from the water surface by towing plankton net (mouth diameter 0.35µm) made of bolting silk (No 30, Mesh size–48 µm) for ten minutes in each sampling point. These samples were preserved in 5% neutralized formalin and used for qualitative analysis. For the quantitative analysis of phytoplankton, the settlement method described by Sukhanova (1978) was adopted. Numerical plankton analysis was carried out using Utermohl's inverted plankton microscope and expressed in no/litre. Phytoplankton was identified using the standard works of Hustedt (1930), Venkataraman (1939), Cupp (1943), Subrahmanyan (1946), Desikachary (1959 and 1987), Hendey (1964), Stedinger and Williams (1970), Taylor (1976) and Anand *et al.*, (1986).The primary productivity was measured in the surface water following the light and dark bottle method (Strickland and Parsons, 1968) using the following formula.

Gross Primary Productivity (mg.C/m^3/hr)

$$\frac{O_2L_b - O_2D_b}{T} \times \frac{0.375}{PQ}\ 1000$$

Net Primary Productivity (mg.C/m^3/hr)

$$\frac{O_2L_b - O_2I_b}{T} \times \frac{0.375}{PQ}\ 1000$$

Where O_2 = Oxygen ml/lit
$O_2\ L_b$ = Oxygen dissolved in light bottle (mg/l).
$O_2\ D_b$ = Oxygen dissolved in dark bottle (mg/l).
$O_2\ I_b$ = Oxygen dissolve initial bottle (mg/l).
PQ = Oxygen synthetic Quotient (1, 2)
T = Hours of incubation (3 hours)

Shannon – Wiener Diversity (H')

To assess the planktonic diversity indices, the following formulas of Shannon and Wiener (1949) were used.

$$H' = -\sum_{i=1} pi \log pi$$

Which can be rewritten as

$$H' = \frac{3.3219\,(N \log N - -\sum ni \log ni)}{N}$$

where H' = Species diversity
ni = Number of individuals of the ith species
N = Total number of individuals in the collection
and $\sum$ = Sum

Simpson Index (D')

Species richness was calculated using the following formula given by Simpson (D)

$D = 1-C$
where, $C = \sum Pi\ 2$
$Pi = ni/N$
ni=Number of individuals of $i_{1,\ i2}$ *etc* and
N= Total number of individuals

Pielou's Evenness (J')

Evenness or equality (J), in the distribution of individuals among various species was calculated, using the formula of Pielou (1966).

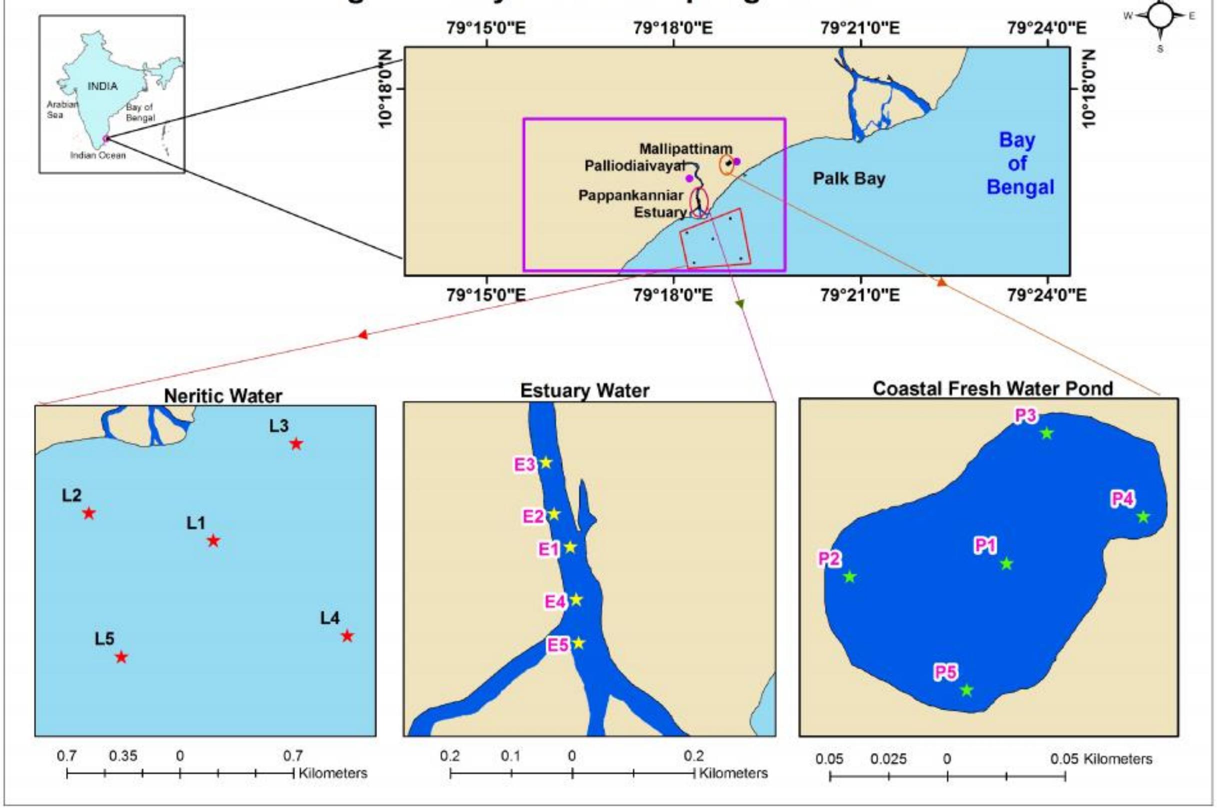
$$J' = \frac{H'}{\log S} \text{ or } \frac{H'}{\log 2s}$$

Where, J' = Evenness

H' = Species diversity and

S = Total number of species

Fig: 1. Study Area - Sampling Points



Results

Spatial distribution of phytoplankton, hydrobiological parameters and productivity were investigated in coastal fresh water pond, estuary and neritic water of Palk bay, India. The temperature of the study area varied from 30.8°C (neritic water - L3) to 38.1°C (Coastal fresh water pond - P1) (Fig. 2) and the mean temperature of 34.3°C. In coastal fresh water pond, the minimum temperature of 37.8°C (Station - P4) to maximum of 38.1°C (Station - P1) with mean temperature of 37.9°C was noticed. In estuary water, the temperature fluctuated between 33.7 °C (Station - E3) to 34.2°C (Station - E2) with mean temperature of 34°C. Temperature in neritic water, fluctuated between 30.8°C (Station - L3) to 31.1°C (Station - L2) with mean temperature of 31°C. Salinity of the study area ranged from 0.57 ppt (Coastal Fresh Water Pond - P4) to 34.28 ppt (neritic water - L2) (Fig. 3) with mean salinity of 21.75 ppt. In coastal fresh water Pond, the salinity recorded between 0.57 ppt (Station - P4) to 0.63 ppt (Station - P1) with mean salinity of 0.60 ppt. In estuary water, the salinity deviated from 30.34 ppt (Station - E3) to 30.41 ppt (Station - E2) with mean salinity of 30.41 ppt. In neritic water, the salinity recorded between 34.19 ppt (Station - L3) to 34.28 ppt

(Station - L2) with mean salinity of 34.23 ppt. *p*H during study ranged from 7.5 (Coastal Fresh Water Pond - P3 and P4) to 8.2 (neritic water - L1) (Fig. 4) and mean *p*H of 7.9. In coastal fresh water pond, the *pH* was recorded to be lower 7.5 (Station - P3 and P4) whereas higher value of 7.7 (Station - P1) with mean *p*H of 7.6. In estuary water, the *p*H noticed to be lower value of 7.9 (Station - E3) while higher value of 8.1 (Station - E1 and E2) with mean *p*H of 8. In neritic water, the *pH* was recorded to be less of 8 (Station - L3 and L4) whereas high of 8.2 (Station - L1) with mean *p*H of 8.1. Dissolved Oxygen (DO) concentration of the study area ranged from 3.36 mg/l (Coastal Fresh water Pond - P3) to 4.75 mg/l (neritic water - L4) (Fig. 4) and mean DO of 4.10 mg/l. In coastal fresh water pond, the low concentration of Dissolved Oxygen was noticed (3.36 mg/l) at station P3 whereas high concentration was observed (3.41 mg/l) at station P5 with mean DO of 3.39 mg/l. In Estuary water, the Dissolved Oxygen was low (4.15 mg/l) at station E4 while high (4.3 mg/l) at station E3 with mean DO of 4.22 mg/l. In neritic water, the low concentration of Dissolved Oxygen was noticed (4.65 mg/l) at station L2 whereas high concentration was observed (4.75 mg/l) at station L4 with mean DO of 4.7 mg/l.

During the study, a total of 103 species of phytoplankton were identified from the coastal fresh water pond, estuary and neritic waters of Palk bay.

The checklist for phytoplankton in all the stations are given in the table, 1. Among them, eighty three species were recorded from diatom, four species from blue green algae and sixteen species from dinoflagellate. *Coscinodiscus* sp., *Biddulphia* sp., *Triceratium* sp., *Thalasiothrix* sp., *Chaetoceros affinis*, *C. compressus*, *C. diversus*, *Coscinodiscus jonesianus*, *C. gigas*, *C. radiatos*, *Cyclotella striata*, *Ditylum brightwelli*, *Leptocylindrus danicus*, *Navicula granulate*, *Nitzschia longissimi*, *N. filiformis*, *N. striata*, *O. heteroceros*, *O. mobiliensis*, *O. sinensis*, *Planktoniella sol*, *Pleurosigma elongatum*, *P. normanii*, *P. sulcatum*, *Rhizosolenia alata*, *R. cylindrus*, *R. styliformis*, *Skeletonema costatum*, *Thalassiothrix longissimi*, *Thalassinonema nitzschioides* and *Triceratium inflatum* are diatoms represented in 10 sampling stations (both estuary and neritic waters). *Trichodesmium* sp, *Ocillatoria limosa*, *Trichodesmium erythraea* are Blue green algae and *Ceratium* sp, *Ceratium breve*, *C. macroceros*, *C. tripos*, *Dinophysis* sp, *Gymnodinium* sp are dinoflagellates represented in 10 sampling stations. 96 species were recorded in estuarine water (E1) and low number of 6 species in coastal fresh water pond (P1 to P5, all five stations) (Fig. 5). The percentage composition among the phytoplankton group of 103 species, the most dominant one was diatoms (80%) followed by dinoflagellate (16%) and blue green algae (4%) (Fig. 6).

Fig. 2 Temperature (°C)

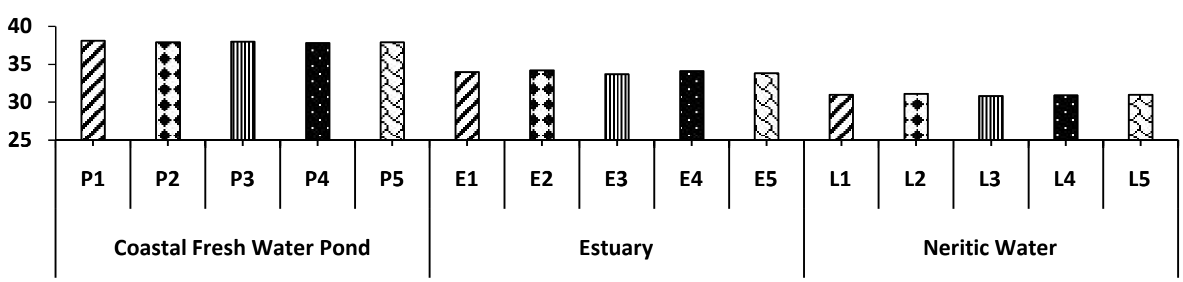


Fig. 3 Salinity (ppt)

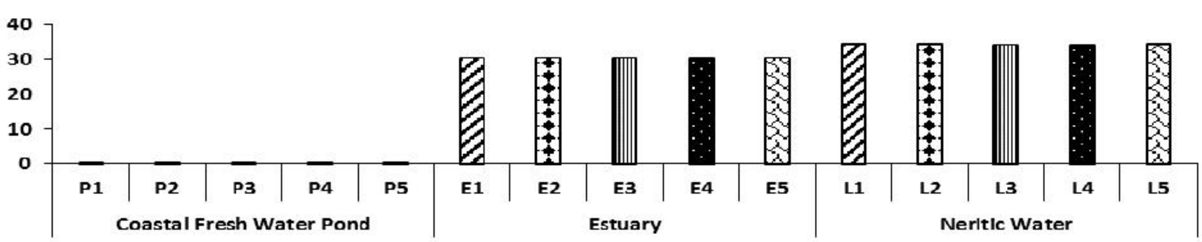


Fig. 4 pH

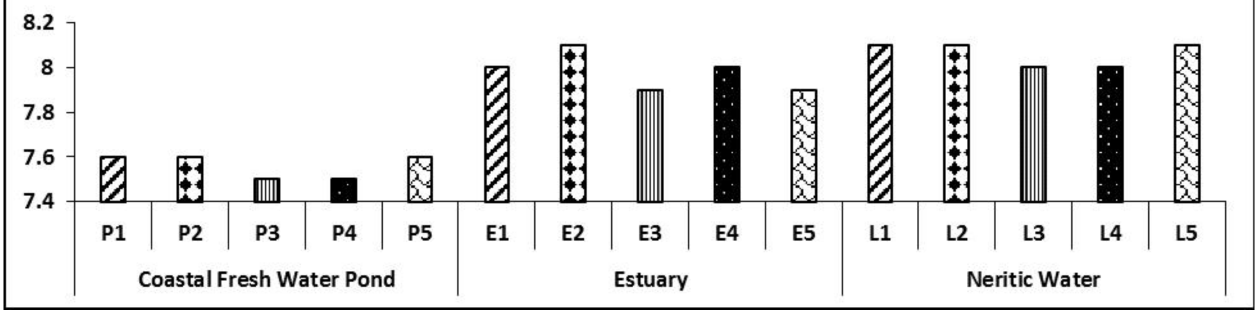


Fig. 5 Dissolved Oxygen (mg/l)

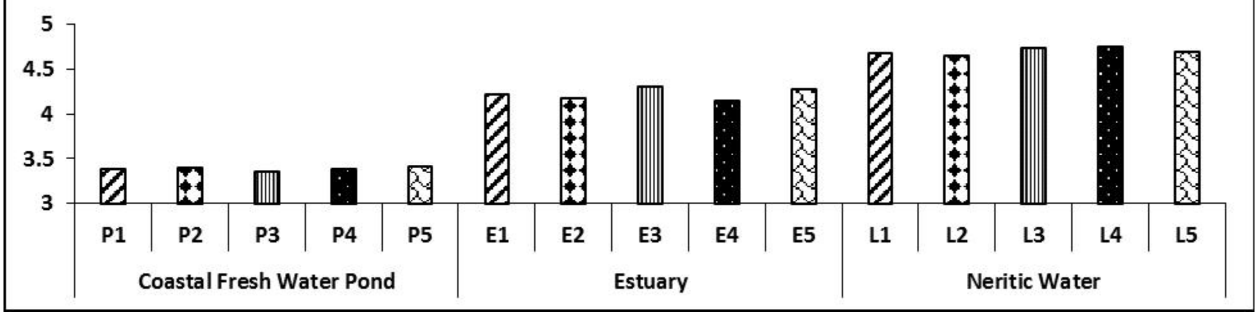


Fig. 5 Species Occurance in different stations

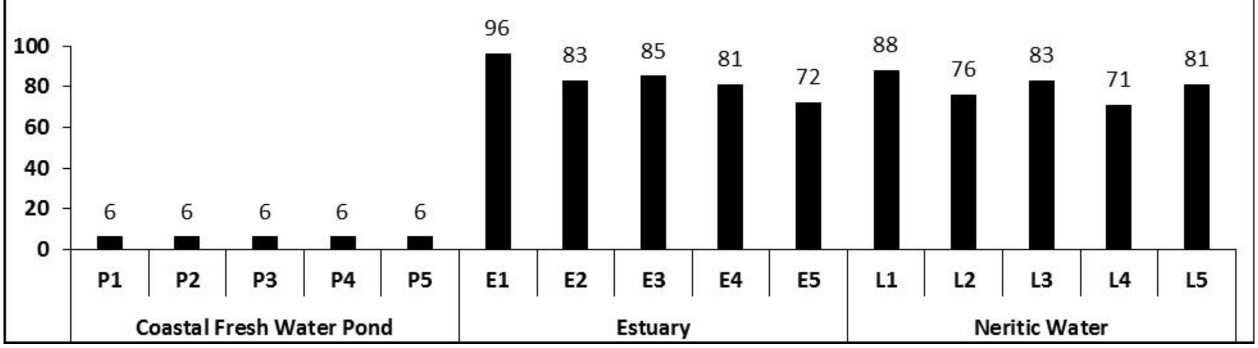


Fig. 6 Percentage Composition among Phytoplankton groups

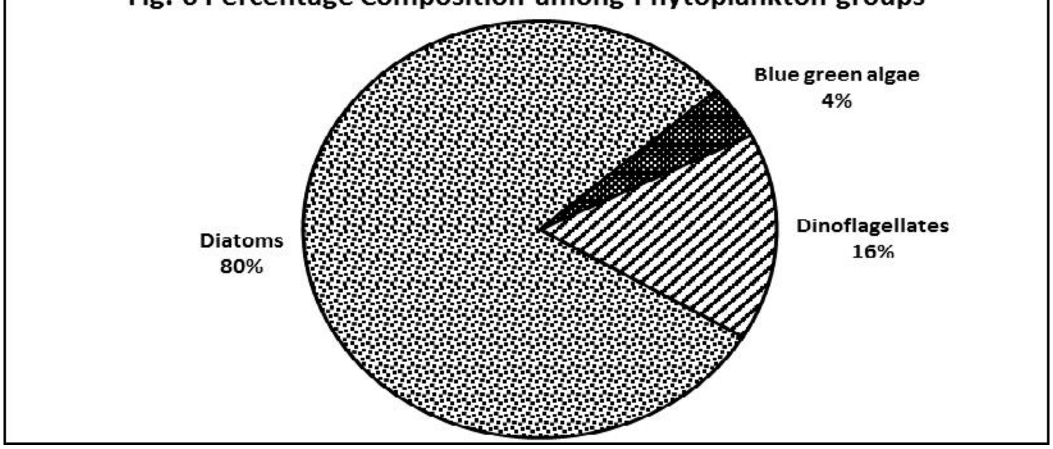


Table. 1 Checklist of Phytoplankton from Coastal Fresh Water Pond, Estuary water and Neritic water

Phytoplankton group	Phytoplankton Species	Coastal Fresh Water Pond					Estuary					Neritic water				
		P 1	P 2	P 3	P 4	P 5	E 1	E 2	E 3	E 4	E 5	L 1	L 2	L 3	L 4	L 5
	Spirulina sp	*	*	*	*	*										
	Anabaena sp	*	*	*	*	*										
	Pediastrum sp	*	*	*	*	*										
	Scenedesmus	*	*	*	*	*										
	Volvox colony	*	*	*	*	*										
	Coscinodiscus sp.						*	*	*	*	*	*	*	*	*	*
	Biddulphia sp						*	*	*	*	*	*	*	*	*	*
	Triceratium sp						*	*	*	*	*	*	*	*	*	*
	Thalasiothrix sp						*	*	*	*	*	*	*	*	*	*
	Tabellaria sp						*	*	*	*	*					
	Cerataulina sp.						*		*	*		*	*			*
	Chaetoceros affinis						*	*	*	*	*	*	*	*	*	*
	C. coarctatus						*	*			*	*	*		*	*
	C. compressus						*	*	*	*	*	*	*	*	*	*
	C. curvisetus						*		*	*	*	*	*		*	
	C. decipiens						*	*	*	*		*	*	*		*
	C. densum						*	*	*	*		*	*	*	*	*
	C. diversus						*	*	*	*	*	*	*	*	*	*
Diatom	*C. lauderi*						*	*	*	*		*	*	*		*
	C. lorenzianus						*		*	*	*	*		*	*	*
	C. peruvianus						*		*		*	*	*			*
	C. didymus						*	*			*			*		*
	Climacodium frauenfeldii						*	*	*			*		*	*	*
	Climacosphenia sp.						*	*	*			*		*	*	*
	C. elongate						*		*			*		*	*	*
	C. moniligera						*	*	*			*				*
	Closteridium lunula						*	*	*	*		*	*	*		*
	Coscinodiscus jonesianus						*	*	*	*	*	*	*	*	*	*
	C. eccentricus						*	*	*	*		*		*	*	*
	C. gigas						*	*	*	*	*	*	*	*	*	*
	C. densum						*	*		*		*	*	*	*	*
	C. radiatos						*	*	*	*	*	*	*	*	*	*
	Cyclotella striata						*	*	*	*	*	*	*	*	*	*
	Ditylum brightwelli						*	*	*	*	*	*	*	*	*	*
	Fragileria oceanica						*			*	*	*	*	*	*	*
	Gyrosigma balticum						*		*			*		*	*	*
	Hemidiscus hardmanianus						*	*	*	*		*	*	*	*	*

	Hyalodiscus steliger						*	*	*			*		*	*	*
	Isthmia enervis						*	*			*			*		*
	Lauderia annulata						*	*	*	*		*	*	*		*
	Leptocylindrus danicus						*	*	*	*	*	*	*	*	*	*
	Limcophora sp						*	*	*			*		*	*	*
	Limcophora abbreviate						*	*	*			*		*	*	*
	Lithodesmium undulatum						*			*		*	*		*	
	Melosira sulcata						*	*	*		*	*	*	*	*	*
	Navicula granulate						*	*	*	*	*	*	*	*	*	*
	Nitzschia longissima						*	*	*	*	*	*	*	*	*	*
	N. closterium						*	*	*	*	*	*		*	*	*
	N. filiformis						*	*	*	*	*	*	*	*	*	*
	N. panduriformis						*	*	*	*	*	*	*	*		
	N. paradoxa						*	*	*	*		*	*	*	*	*
	N. striata						*	*	*	*	*	*	*	*	*	*
	Odentella pulchella						*		*	*	*	*	*			*
	O. heteroceros						*	*	*	*	*	*	*	*	*	*
	O. mobiliensis						*	*	*	*	*	*	*	*	*	*
	O. regida						*	*	*		*	*			*	*
	O. sinensis						*	*	*	*	*	*	*	*	*	*
	O. aurita						*	*	*	*	*	*	*		*	*
	Planktoniella sol						*	*	*	*	*	*	*	*	*	*
	Pleurosigma elongatum						*	*	*	*	*	*	*	*	*	*
	P. normanii						*	*	*	*	*	*	*	*	*	*
	P. destuarii						*	*	*	*	*	*	*	*		
	P. carinatum						*	*	*	*		*	*	*		*
	P. sulcatum						*	*	*	*	*	*	*	*	*	*
	Rhizosolenia alata						*	*	*	*	*	*	*	*	*	*
	R. castracanei						*			*	*	*	*	*	*	*
	R. cylindrus						*	*	*	*	*	*	*	*	*	*
	R. hebetate						*	*	*	*	*	*			*	*
	R. styliformis						*	*	*	*	*	*	*	*	*	*
	R. shrubsolei						*	*	*	*	*	*	*			*
	R. stolterforthii						*	*	*	*		*	*	*		
	Schroederella delicatula						*	*	*	*	*			*	*	*
	Skeletonema costatum						*	*	*	*	*	*	*	*	*	*
	S. turris									*	*	*	*	*	*	
	Sphaerozosma vertebratum						*				*	*	*	*		
	Stephanodiscus sp						*	*	*	*	*		*	*		

	Stephanopyxis palmeriana						*	*	*	*	*	*	*	*		
	S. turris						*	*	*				*	*		
	Thalassiothrix longissima						*	*	*	*	*	*	*	*	*	*
	T. lohmanni						*	*	*	*	*	*	*	*		
	T. favenfeldii						*	*	*	*	*	*	*	*		
	Thalassinonema nitzschioides						*	*	*	*	*	*	*	*	*	*
	Triceratium inflatum						*	*	*	*	*	*	*	*	*	*
Blue Green Algae	*Merismopebia*	*	*	*	*	*										
	Trichodesmium sp						*	*	*	*	*	*	*	*	*	*
	Ocillatoria limosa						*	*	*	*	*	*	*	*	*	*
	Trichodesmium erythraea						*	*	*	*	*	*	*	*	*	*
Dinoflagellate	*Ceratium* sp						*	*	*	*	*	*	*	*	*	*
	Ceratium breve						*	*	*	*	*	*	*	*	*	*
	C. extensum						*	*	*	*		*		*	*	*
	C. furca						*	*	*	*	*	*	*	*		*
	C. fusus						*	*	*	*	*	*	*	*		
	C. inflatum						*	*	*	*			*	*	*	*
	C. macroceros						*	*	*	*	*	*	*	*	*	*
	C. setaceum						*	*	*	*	*			*	*	*
	C. trichoceros						*	*		*		*	*		*	*
	C. tripos						*	*	*	*	*	*	*	*	*	*
	Dinophysis miles						*	*	*	*	*			*	*	*
	Dinophysis sp						*	*	*	*	*	*	*	*	*	*
	Gymnodinium breve						*	*	*	*	*	*			*	*
	Gymnodinium sp						*	*	*	*	*	*	*	*	*	*
	Prorocentrum micans						*			*	*	*	*	*		
	Protoperidinium conicum						*			*	*	*	*	*		

The highest phytoplankton density in coastal fresh water pond, estuary and neritic waters of Palk bay were 112000, 388750, 296800 cells l^{-1} respectively (P5, E1 and L1) and low density were 84000, 271250, 202800 cells l^{-1} at St. P1, E5 and L5 respectively. The diversity of the phytoplankton population varied from 1.705 (L1) to 1.778 (P5). Evenness of the phytoplankton differentiated from 0.364 (E2 and E4) to 0.382 (P5). Richness varied from 1.5 (E5) to 1.8 (P5).

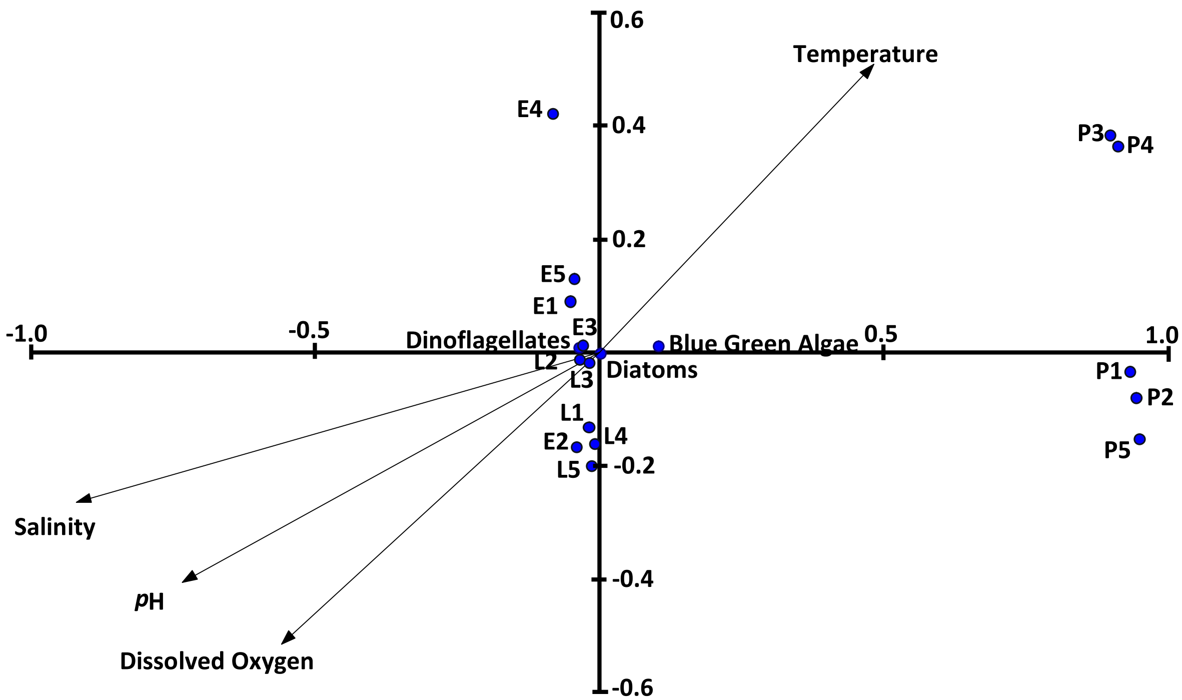
The variations in gross and net primary productivity in the surface water of coastal fresh water pond, estuary and neritic water during the study period are shown in table 2. In the present study, the highest gross primary productivity of 330 mg.C/m^3/hr was estimated in the neritic water followed by 140 mg.C/m^3/hr in estuarine water and lowest gross primary productivity of 40 mg.C/m^3/hr in coastal fresh water pond. Similarly, net primary productivity recorded was high in the neritic waters (148 mg.C/m^3/hr) followed by estuarine water (138 mg.C/m^3/hr) and low in the coastal fresh water pond (28 mg.C/m^3/hr).

Table. 2 Primary productivity in Coastal fresh water pond, estuary water and neritic waters

Sampling Stations	Primary Productivity (mg.C/m^3/hr)	
	Gross Primary Productivity	Net Primary Productivity
Coastal fresh water Pond	40	28
Estuary water	169	138
Neritic waters	330	148

The statistical results of the multivariate analysis (CCA) occurrence for phytoplankton species with respective to physicochemical parameter and stations were analyzed. Fig.7 showed that the first CCA axis separated Blue green algae along with temperature and stations P3 and P4. The second CCA axis separated Diatoms along with stations of P1, P2 and P5. The third CCA axis separated Salinity, *p*H and Dissolved Oxygen along with stations of L1, L2, L3, L5 and E2. Finally, the fourth axis separated Dinoflagellates along with stations E1, E3, E4 and E5.

Fig.7 Canonical Correspondence Analysis of Phytoplankton species between Physicochemical Parameter and Stations



Discussion

Comparative spatial assessment on phytoplankton at coastal fresh water pond, estuary water and neritic waters of Palk bay showed significant variations. A number of factors define phytoplankton proliferation and primary productivity such as salinity, temperature, light (influenced by turbidity), nutrients and dissolved oxygen. Temperature influences the biogeochemistry of the freshwater and marine environment (Prasad, 1969). Water temperature recorded as high in fresh water pond followed by estuarine waters and less in neritic water. Similar temperature range were observed by Sundaraj and Krishnamoorthy (1975) in Vellar estuary, Durgaprasad Rao and Poornachandra Rao (1975) in Pulicat Lake and Ashok Prabhu *et al.,* (2008) in Pichavaram mangroves Temperature was a controlling factor for the distribution of phytoplankton. Less density noticed in coastal fresh water pond might be the reason of elevated temperature. Krishnapillai (1986) stated that phytoplankton growth depend on temperature as they need light in the form of temperature for photosynthesis. Salinity also found to be crucial factor on the distribution of phytoplankton during the present study. Minimum salinity recorded in coastal fresh water pond followed by estuarine waters and maximum in neritic waters. Coastal fresh water pond had less salt concentration might have limited the species distribution rather than estuarine and sea water (table 1). Salinity and *p*H of water affected by the tidal rise and fall and a mixture of fresh water bodies particularly in rainy season (Radhakrishnan 1978). *p*H of water also depends upon relative contents of free CO_2, carbonates, bicarbonates and calcium (Ana Paula P. Carvalho *et al.,* 2010) and the water tends to be more alkaline when it possesses carbonates, but lesser alkaline when it supports more bicarbonates, free CO_2 and calcium. Hydrogen ion concentration (*p*H) in the present investigation showed that all sampling points remained alkaline at all sites, which lie adjacent to the sea and influenced by influx of neritic waters during tidal cycle (Bragadeeswaran *et al.,* 2007 and Prabhahar *et al.,* 2011) and high salinity (Mannikannan *et al.,* 2011). Low *p*H recorded in coastal fresh water pond followed by estuarine water and neritic water. Similar concentration values were observed in Sunderban’s Area (Volunteer Estuary Monitoring, 2006). The *p*H value of present study agreed with the Ramanathapuram estuary (Evengeline, 1975); Vellar estuary (Sundharaj and Krishna moorthy, 1975); Mandovi Cumderjia canal and Zuari estuary (Parulekar *et al.,* 1973). High *p*H in estuary and neritic water might be high biological activity (Das *et al.,* 1997, Ashok Prabhu *et al.,* 2008) and photosynthetic activity (Subramanian and Mahadevan, 1999; Srinivasan *et al.,* 2013). All the aquatic organism including plankton depends on the dissolved oxygen for respiration. Solubility of oxygen depends on salinity and temperature, therefore, increases in salinity and temperature, decreases the solubility of the oxygen. In the present study, the dissolved oxygen recorded as lesser in coastal fresh water pond followed by estuarine water and high in neritic water. Less DO concentration in pond resulted with high temperature (Ashok Prabu, *et al.,* 2008 and Priyanka Yadav, 2013) and it is due to lesser solubility of gas when temperature is high (Ayyanna and Narayudu, 2013). The surface water of marine and estuarine readily permits oxygen enrichment through atmospheric exchange, and sufficient light can penetrate surface waters to allow the oxygen releasing process of photosynthesis to occur (CCME, 1999 and Akbar John, 2011) which might be one of the reason of high DO concentration in estuarine and neritic water during study.

The phytoplankton inevitably needed for biological treatment of organic wastes loaded in coastal waters during monsoon seasons. They also exhibit complex variability in terms of diversity and dynamics, as they change within a short period of time. Hence, proper assessment by microscopic identification and quantification (Utermohl, 1958; Hillebrand, *et al.,* 1999) are necessary. In the present investigation, diatoms were dominated all the stations, followed by blue green algae and dinoflagellates. Diatoms always prefers to inhabit and dominates the phytoplankton community in shallow, turbulent and upwelling region *i.e.,* coastal region (Stowe, 1996). Moreover, adequate amount of nutrients and sun light in this shallow zone facilitate these microscopic autotrophs to photosynthesis and reproduce vigorously. Various studies proved that diatoms were found to be dominant in near coastal and estuarine waters (De *et al.,* 1994; Gouda and Panigrahy, 1996; Sawant and Madhupratap, 1996; Tiwari and Nair, 1998; Ramaiah and Ramaiah, 1998; Gopinathan *et al.,* 2001; Gowda *et al.,* 2001 Sarojini and Sharma, 2001 and Gouri Sahu *et al.,* 2012). In nutrient rich turbulent environments, non-motile fast growing diatoms could be favoured (Margaleff, 1978) by fast division rates (Kiorbe, 1993). Dinoflagellates are thought to have lower photosynthetic rates (Furnas, 1990; Tang, 1995) and higher metabolic process (Smayda, 1997). Vertical migration, mixotrophy, chemically-regulated interspecific competition, and anti-predation defenses have all been suggested as possible adaptations that might allow dinoflagellates to offset these physiological disadvantages and enable them to compete successfully with diatoms. Marine and estuarine living phytoplankton were higher in qualitatively and quantitatively. Present revealed that dinoflagellates can survive only in estuary and neritic water. They were absent in pond water showing their tolerance only to salt water and elevated *p*H. The salinity acts as a limiting factor in the distribution of planktons (Gopinath *et al.,* 2013). *p*H is also a factor that influences plankton density. The higher pH (alkaline pH) is favorable for the growth of phytoplankton Unni (1984) and Hujare, (2005). The high pH value increases the growth of algae (Kant and Kachroo (1971) and George (1961) and Agale *et al.,* (2013)). The statistical analysis of CCA explains that physicochemical parameters plays major role in phytoplankton *i.e.,* dinoflagellates represented in estuarine and Neritic waters which conform restricted niche and blue green algae need temperature for photosynthesis that can be clearly concluded from CCA graph. Phytoplankton numbers were more in estuarine water (3,88,750 cells l^{-1}) followed by neritic water (2,96,800 cells l^{-1}) and less in coastal fresh water pond (1,12,000 cells l^{-1}). Coastal Fresh water pond showed lesser species diversity and richness than other biotopes (estuary and neritic waters). Species evenness was higher in pond might elucidated that estuary and neritic waters were more productive.

The primary productivity depend on the phytoplankton cell numbers. It is an index for healthy biodiversity, biomass and carrying capacity of that system (Sarma *et al.,* 2006). The gross primary productivity in coastal fresh water pond, estuarine water and neritic water were 40 mg.C/m^3/hr, 169 mg.C/m^3/hr, and 330 mg.C/m^3/hr respectively. Similarly the net primary productivity were 28 mg.C/m^3/hr, 138 mg.C/m^3/hr and 148 mg.C/m^3/hr respectively. High density of phytoplankton and optimum salinity and some extends on temperature resulted high primary productivity in neritic and estuarine waters (Venugopalan, (1967) in Vellar estuary, Rajesh *et al.,* (2002) in Nethravathi estuary and Ramadhas, (1977) in Porto Nova waters). Primary productivity also depend on availability of nutrients (Thillai Rajasekar *et al.,* 2005). True to this, estuary and coastal waters receive more terrigenious nutrients in monsoon seasons than fresh water pond.

Rey *et al.,* (2004) and Abuzer and Okan, (2007) explained that phytoplankton can act as a useful indicators of water quality. The species composition, biomass, relative abundance, spatial and temporal distribution are the expression of an environmental health or biological integrity of a particular water body (Khattak *et al.,* 2005). As phytoplankton species composition determines the health of the food chain, our result depicts a healthy condition prevailed in the study area. Though the dominance of diatom without any bloom can be treated as a stable healthy condition. Also, phytoplankton composition influences various processes such as nutrient recycling, grazing, particle sinking and food webs (Cetinic *et al.,* 2006). Phytoplankton can be considered as an index of fertility (Prasad 1969) and the fish catches are directly proportionate to the quantity of phytoplankton availability and distribution (Chidambaram and Menon 1945).

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References

Abuzer C., K. Okan. 2007. On relationship between ecology and phytoplankton composition in a karstic spring (Cepni, Bolu) Ecol. Ind., 7 (2007), pp. 497–503

Agale, M. C., J. V. Patil and N.G. Patel. 2013. Study of seasonal variations of Phytoplankton and their correlation with physicochemical parameters of Budaki Medium Irrigation Tank, Shirpur. Dist.Dhule (M.S.) India. European Journal of Zoological Research, 2 (3):8-16.

Akbar John, B., B.Y. Kamaruzzaman, K.C.A. Jalal and K. Zaleha. 2011. Hydrology of the Horseshoe Crab Nesting Grounds at Pahang Coast, Malaysia. Oriental Journal of Chemistry. Vol. 27, No. (4): Pg. 1475-1483.

Ana Paula P. Carvalho, Tang Zhonghua, Maria Marlucia F. Correia and Jose Policarpo C. Neto. 2010. Study of Physical-Chemical Variables and Primary Productivity in Bacanga River Estuary Dam, Sao Luis, Maranhao, Brazil. Researcher; 2(2).

Anand, N., E. Mohan, R.S.S. Hopper and T.D. Subramanian. 1986. Taxonomic studies on blue green algae from certain marine environments. *Seaweed Res. Utln.,* 9, pp. 49-56.

Ashok Prabu, V., M. Rajkumar and P. Perumal, 2008. Seasonal variations in Physico-chemical characteristics of Pichavaram mangroves, southeast coast of India. *J. Environ. Biol.*29: 945- 950.

Ayyanna, Y. and Y. Narayudu. 2013. Hydrological Study of Fresh Water Pond at Kakinada Rural

Village, P. Venkatapuram, E.G. District, Andhra Pradesh. IOSR Journal of Applied Chemistry (IOSR-JAC). Volume 3, Issue 6, PP 01-05

Bragadeeswaran, S., M. Rajasegar, M. Srinivasan and U. Kanaga Rajan. 2007. Sediment texture and nutrients of Arasalar estuary, Karaikkal, Southeast coast of India. *J. Environ. Biol.*, 28, 237-240.

CCME. 1999. Canadian Water Quality Guidelines or the protection of aquatic life: Dissolved Oxygen (Marine) Publication (1299). Canadian Council of Ministers of the Environment.

Cetinic, I., Z. Vilicic, Z. Buric, G. Olujic. 2006. Phytoplankton seasonality in a highly stratified karstic estuary (Krak, Adriatic Sea). *Hydrobiologia,* 555 (2006), pp. 31–40.

Chidambaram, K. and M.D. Menon. 1945. The correlation of the West Coast fisheries with plankton and certain oceanographical factors. *Proc.Indian Acad .Sci* 822: 355-367.

Cupp, E.E. 1943. Marine plankton diatoms of the west coast of North America. *Bull. Scripps Inst. Oceanogr.,* 5, pp. 237.

Das, J., S.N. Das and R.K. Sahoo. 1997. Semidiurnal variation of some physicochemical parameters in the Mahanadi estuary, east coast of India. *Ind. J. Mar. Sci.,* 26, 323-326.

De. T.K., A. Choudhary and T.K. Jana. 1994. Phytoplankton community organization and species diversity in the Hoogly estuary, north east coast of India. Indian J. Mar.Sci., 23, pp. 152-156.

Desikachary, T.V. 1959. Cyanophyta. Indian Council of Agricultural Research, New Delhi. p. 686.

Desikachary, T.V. 1987. Atlas of diatoms. Monographs fasicle II, III and IV. Madras Science Foundation, Madras. p. 80.

Durgaprasad Rao. N.V. and M. Poornachandra Rao. 1975. Aqueous environment in the Pulicate Lake, East coast of India: Recent Research in Estuarine Biology. R.Natarajan (ed) p.p.109-122

Evengeline, G. 1975. Hydrobiology of the estuaries and back water Ramnad in Estuarine Biology. R.Natarajan(ed). Recents Researchers in Esuarine Biology,P.P. 1-20.

Furnas, M., 1990. In situ growth rates of marine phytoplankton: Approaches to measurement, community and species growth rates. J. Plankt. Res., 12(6): pp. 1117-1151

George, M.G. 1961. Diurnal variations in two shallow ponds in Delhi, India. Hydrobiology., 18(3): pp. 265-273.

Gopinath, M., S. Jayasudha, P. Umamageswari and P. Sampathkumar. 2013. Physico-biochemical variations in Parangipettai and Nagapattinam Coastal waters, Southeast coast of India. International Journal of Research in Biological Sciences; 3(4): pp. 149-156.

Gopinathan, C.P., R. Gireesh, K.S. Smitha. 2001. Distribution of chlorophyll a and b in the eastern Arabian Sea (West coast of India) in relation to nutrients during premonsoon season. J.Mar.Biol.Ass.India, 43, pp. 21-30

Gouda, Rajashree and R.C. Panigrahy. 1996. Ecology of phytoplankton in coastal waters off Gopalpur, east coast of India. Ind. J. Mar. Sci., 2, pp. 13-18.

Gouri Sahu, K.K. Satpathy, A.K. Mohanty and S.K. Sarkar. 2012. Indian Journal of Geo-Marine Sciences. Vol. 4(3). Pp. 223-241.

Gowda, G., T.R.C. Gupta, K.M. Rajesh, H. Gowda, C. Lingadhal and A.M. Ramesh. 2001. Seasonal distribution of phytoplankton in Nethravathi estuary, Mangalore. *J. Mar. Biol. Ass. India*, 43, pp. 31-40.

Hendey, N.Y. 1964. Bacillariophyceae (Diatoms). In: An Introductory Account of the Smaller Algal of British Coastal Waters. *Fishery Inves. Sem*., IV. London. p. 317.

Hillebrand, H., C.D. Durselen, D. Kirschtel, U. Pollingher, and T. Zohary. 1999. Biovolurne calculation of pelagic and benthic microalgae. *J. Phycol*, 35: 403-424.

Hujare, M.S. 2005. Hydrobiological studies on some water reservoirs of Hatkanangale Tahsil (M.S.) Ph.D Thesis. Shivaji University, Kolhapur.

Hustedt, Fr. 1930. Bacillariophyta (Diatomee) in A. Pascher’s Die Susswasser-Flora Mitteleuropa. Heft 10.

Kant, S. and Kachroo. 1971. Phytoplankton population dynamics and distribution in two adjoining lakes in Srinagar. I. Macroflora in relation to phytoplankton. Proc.Indian Natn. Sci. Acad. B 37(4): pp. 163-188.

Khattak, T.M., N. Bhatti, G. Murtaza. 2005. Evaluation of algae from the effluent of Dandot Cement Company, Dandot, Pakistan. *J. Appl. Sci. Environ. Manage*., 9, pp. 147–149

Kiorbe, T., 1993. Turbulence, phytoplankton cell size, and the structure of pelagic food webs. *Adv. Mar. Biol.* 29: pp. 1-72.

Krishnapillai, N. 1986. Introduction to planktonology Himalaya publishing house Giragaon, Bombay.

Manikannan Ramalingam, Subramanian Asokan and Abdul Hameed Mohamed Samsoor Ali. 2011. Seasonal variations of physico-chemical properties of the Great Vedaranyam Swamp, Point Calimere Wildlife Sanctuary, South-east coast of India. African Journal of Environmental Science and Technology Vol. 5(9), pp. 673-681.

Margaleff, R., 1978. Life forms of phytoplankton as survival alternatives in an unstable environment. *Oceanol. Acta.* 1: 493-510.

Parulekar, A.H. S. N. Dwivedi and A.K. Dhargealkar. 1973. Ecology of clam beds in Mandovi Cumderjia canal and Zuari estuary system of Goa. Indian J. Mar. Sci., 2: 122-126

Pielou, E.C. 1966. The measurement of diversity in different types of biological collection. *J. Theoret. Biol.,* 13, 144.

Prabhahar, C., K. Saleshrani and R. Enbarasan. 2011. Seasonal Variations In Physico – Chemical Parameters of Kadalur Coastal Zone, Tamil Nadu, India. *International Journal of Recent Scientific Research* Vol. 2, Issue, 1, pp. 22-28.

Prasad, R.R. 1969. The charactyeristics of marine plankton at an in shore station in the Gulf of Mannar near Mandapam. *Indian J. Fish.*1:1.36.

Priyanka Yadav, V. K. Yadav, A.K. Yadav and P.K. Khare. 2013. Physico-Chemical Characteristics of a Fresh Water Pond of Orai, U. P., Central India. *Octa. J. Biosci.* Vol. 1(2): 177-184.

Radhakrishnan, N.S. 1978. Hydrological studies in the in-shore water of Mangalore during 1964-1973. Indian J. Fish 25(1-2) pp.222-227.

Rajesh, K.M., G. Gowda and Mridula R. Mendon. 2002. Primary productivity of the brackishwater impoundments along Nethravathi estuary, Mangalore in relation to some physico-chemical parameters. *Fish. Technol.,* 39, 85-87.

Ramadhas, V. 1977. Studies on phytoplankton nutrients and some trace elements and some trace element in Proto Nova water. Ph.D. Thesis Annamalai University India. pp.135

Ramaiah, N. and N. Ramaiah. 1998. Phytoplankton characteristics in a polluted Bombay harbour, Thana-Bassein creek estuarine complex. Ind. J. Mar. Sci., 27, 281-285.

Rey, P.A., J.C. Taylor, A. Laas, L. Rensburg, A. Vosloo. 2004. Determining the possible application value of diatoms as indicators of general water quality: a comparison with SASS 5. Water SA, 30, pp. 325–332.

Sarma, V.V., Y. Sadhuram, N.A. Sravanthi, S.C. Tripathy. 2006. Role of physical processes in the distribution of chlorophyll-a in the Northwest Bay of Bengal during pre- and post-monsoon seasons. Curr. Sci., 91, pp. 1133–1134

Sarojini, Y. and N.S. Sarma. 2001. Vertical distribution of phytoplankton around Andaman and Nicobar Islands, Bay of Bengal. Indian J. Mar.Sci., 30, pp. 65-69.

Sawant, S. and M. Madhupratap. 1996 Seasonality and composition of phytoplankton in the Arabian Sea; Curr. Sci. 71(11). 869–873.

Shannon, C.E. and W. Wiener, 1949. The Mathematical Theory of Communication. Urbana, IL: University of Illinois Press.

Smayda, T.J., 1997. Harmful algal blooms: Their ecophysiologr and general relevance to phytoplankton blooms in the sea. *Limnol. Oceanogr*. 42(5):1137- 1 153.

Srinivasan Viswanathan, Usha Natesan and Anitha Parthasarathy. 2013. Seasonal Variability of Coastal Water Quality in Bay of Bengal and Palk Strait, Tamilnadu, Southeast Coast of India. *Braz. Arch. Biol. Technol.* v.56 n.5: pp: 875-884.

Steidinger, K.A. and J. Williams. 1970. Dinoflagellates. Mem. Hourglass Cruises. Vol. 2, pp. 1-251.

Stowe, K. 1996. Exploring Ocean Science**.** John Wiley and Sons Inc., p. 426.

Strickland, J.D.H and T.R Parsons. 1968. A practical Hand book of Sea water Analysis. Bull. Fish. Res. Bd. Canada, 167, 311 pp

Subrahmanyan, R. 1946. The diatoms of the Madras coast. *Proc. Indian, Acad. Sci.,* 24: 85-197.

Subramanian, B. and A. Mahadevan. 1999. Seasonal and diurnal variations of hydrobiological characters of coastal waters of Chennai (Madras) Bay of Bengal. Ind. J. Mar. Sci., 28, 429-433.

Sukhanova, I.N., 1978. Settling without Inverted Microscope. In: Phytoplankton Manual, Sourina, A. (Ed.). UNESCO, Paris, France, ISBN-13: 9789231015724, pp: 97-110.

Sundharaj, V. and Krishna moorthy, K. 1975. Nutrients and plankton, back water and mangroves. R. Natrajan (ed) recent researchers in estuarine biology.pp.273

Tang, Y., 1995. The allometry of algal growth rates. *J. Plank. Res.,* 17(6): 1325-1335.

Taylor, F.J.R. 1976. Dinoflagellates from the International Indian Ocean Expedition. A report on material collected by the R.V "Anton Bruun" 1963-1964. *Bibiliotheca Botanica.* Left, 132: pp. 1-226.

Thillai Rajsekar, K., P. Perumal and P. Santhanam. 2005. Phytoplankton diversity in the Coleroon estuary, southeast coast of India. *J. Mar. Biol. Ass India*. 47, 127-132.

Tiwari, L.R. and V.R. Nair: 1998. Ecology of phytoplankton from Dharamtar creek, west coast of India. *Indian J. Mar. Sci.* 27, 302-309.

Unni. K.S. 1984. Limnology of sewage polluted pond in central India. *Int.Revue. Ges. Hydrobiol.* Berlin. 69(4): 553-566

Utermohl, H., 1958. Zur Vervollkomnung der quantitativen phytoplankton methodik. Mitteilungen der Internationale Vereiningung fur Theoretische und Angewandte. *Limnologie,* 9:1-38.

Venkataraman, G., 1939. A systematic account of some south Indian diatoms. Proc. Ind. Acad. Sci., 10: 293-368.

Venugopalan, K. K.1967, Primary production in the estuarine and inshore waters at Porto Novo. 11°29'N-79"49'E). *International Indian Ocean Expdn.* (Abstract) 47-48.

Volunteer Estuary Monitoring. A Methods Manual. March 2006. EPA-842-B-06-003.