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J. Environ. Biol.
33, 585-589 (2012)
ISSN: 0254-8704
CODEN: JEBIDP

Studies on phytoplankton characteristics in Ayyampattinam coast, India

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Publication Data

Paper received:
25 September 2010

Revised received:
09 June 2011

Re-revised received:
18 July 2011

Accepted:
21 September 2011

Abstract

Physico-chemical variables in the marine environment are subjected to wide spatio-temporal variations. The various physico-chemical parameters viz: temperature, salinity, pH, dissolved oxygen and nutrients of the environment are the factors which mainly influence the production and successful propagation of planktonic life in the coastal biotopes. The ranges of values of surface water temperature (0°C), salinity (‰), pH and dissolved oxygen (ml l^{-1}) were: 25.5 - 33.4; 23 - 35; 7.8 - 8.2; 3.6 - 5.2, respectively. The values (μg l^{-1}) of nutrients were: nitrate 3.21 - 6.34, nitrite 0.74 - 0.896, phosphate 0.22 and 1.16, silicate 24.85 - 61.92 and ammonia 0.05 - 0.32. The recorded values of primary productivity (mgcm^{-3}hr^{-1}) ranged between 16 – 116 and the chlorophyll "*a*" varied from 3.74 – 8.52. A total number of 51 species of phytoplankton representing different classes viz: Bacillariophyceae (40); Dinophyceae (8); Chlorophyceae (1) and Cyanophyceae (2) was recorded. Among the four classes, Bacillariophyceae appeared to be the dominant group in respect of total species and cell numbers. The population density of phytoplankton was high during summer season and quite low during monsoon season.

Key words

Physical parameters, Inorganic nutrients, Phytoplankton, Species diversity

Introduction

Phytoplankton is one of the initial biological components from which the energy is transferred to higher organisms through food chain (Tiwari and Chauhan, 2006; Tas and Gonulal, 2007; Shashi Shekher *et al.*, 2008). Phytoplankton are the microscopic single celled aquatic plants forming the prime component in the food chain of aquatic ecosystems. In any aquatic environment, phytoplankton constitute the most important group for the production of particulate material in the food web and also act as the first link in all marine food chains. Without phytoplankton there would be no life to speak of in the open sea. These microscopic unicellular plants form the base of the marine food web, fueling all of the higher organisms with the products of their photosynthesis (Sallie W. Chisholm, 1992). Phytoplankton are the important components in the energy exchange processes of the oceans. They reduce atmospheric carbon dioxide, and thus play a crucial role in controlling climatic changes and global warming. Phytoplanktons are food for a variety of predators and fuel food webs. Phytoplankton species distribution shows wide spatio-temporal variations due to the differential effect of hydrographical factors on individual species and they serve as good indicators of water quality including pollution (Liu *et al.*, 2004). Plankton is one of the important components of any aquatic ecosystem and which is obvious from the abundant occurrence of planktonivorous animals in the marine ecosystems. Among plankton, phytoplanktons are the primary source of food in the marine pelagic environment, initiating the food-chain which may culminate even in large mammals (Waniek and Holliday, 2006). Physico-chemical parameters, species composition and seasonal variation in phytoplankton abundance have been studied in other regions of Indian coastal waters (Saravanakumar *et al.*, 2008; Vengadesh Perumal *et al.*, 2009). Present study deals with

Fig.1: Study area - Ayyampattinam coast

the seasonal and temporal variation of phytoplankton in relation to hydrographical parameters from Ayyampattinam area of southeast coast of India.

Materials and Methods

The Ayyampattinam coast is a fishing hamlet (09° 5 4' N latitude 79°08' E longitude), situated 45 km north of Thondi (Fig.1). Here, herbivorous fishes and sea grasses are abundant. The average depth of the study area is 6.2 – 12.4 m and the bottom sediment constitutes sandy silt. The rivers, 'Kumarapayal' and 'Kottaipattinam' are joining with the Bangal Sea near Ayyampattinam.

Rainfall data were obtained from the meteorological unit of Manamelkudi, southeast coast of India. Monthly samplings were made during the full- moon phase from October 2007 to September 2008 to study the physico-chemical parameters and phytoplankton distribution.

Temperature was measured using a standard 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 (Strickland and Parsons, 1972).

Surface water samples were collected in clean polyethylene bottles and kept in an ice box, and then transported to the laboratory. The collected water samples were filtered by using a millipore filtering system and analyzed for dissolved inorganic nitrite, ammonia, reactive silicate and inorganic phosphate by adopting the standard methods described by Strickland and Parsons (1972).

The phytoplankton net with the mesh size of 48µm and mouth diameter of 0.35m was submerged in the water and towed horizontally from a mechanized boat. During this operation utmost care was taken to allow maximum amount of surface and sub-surface water to pass through the mouth of the net for better filtration and for more number of plankton to be retained. The collected samples were preserved in 5% neutralized formalin for further 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. Phytoplankton were identified using the standard works of Venkataraman (1939), Subrahmaniyan (1946), Prescott (1954), Steidinger and Williams (1970).

Biodiversity indices were calculated following the standard formulae of Shannon and Weaver (1949) for diversity index (H'), Gleason (1922) for richness (D); Pielou (1966) for evenness (J') , The sampling period of October 2007 to September 2008 (one calendar year) was divided into four seasons such as monsoon (October to December), post monsoon (January to March), summer (April to June) and premonsoon (July to September) based on the northeast monsoon pattern, which is prevalent in the study area. Pearson correlation co-efficient values (r) were calculated to understand the relationships between distribution, diversity of phytoplankton and hydrographical parameters.

Results and Discussion

Physico-chemical variables in the marine environment are subjected to wide temporal variations. Rainfall is the most important cyclic phenomenon in tropical countries as it brings about important changes in the physical and chemical characteristics of the coastal environment. The rainfall in India is largely influenced by two monsoons viz., southeast monsoon on the west coast and northeast monsoon on the east coast (Perumal, 1993).

The total rainfall recorded was 1708.1 mm at Ayyampattinam from October 2007 to September 2008. It varied from 7 mm to 468.2 mm. In the present study, the peak values of rainfall were recorded during the monsoon month of October.

The remarkable variations were noticed in salinity and temperature patterns. The surface water temperature varied from 25.5 to 33.4°C (Table.1). The observed high value of temperature in May was due to the intensity of solar radiation and evaporation freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters. The observed low value of October was due to strong land sea breeze and precipitation (Senthilkumar *et al.*, 2002; Santhanam and Perumal, 2003). The salinity varied from 23 to 35 ppt (Table.1) and it was high during summer season and low during the monsoon season. 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 coastal ecosystems (Balasubramanian and Kannan, 2005; Sridhar *et al.*, 2006). The minimum salinity was recorded during the monsoon season and the maximum was recorded during summer season as reported earlier by Sundaramanickam *et al.* (2008).

The range of hydrogen ion concentration (pH) was 7.8 – 8.2 (Table.1), and in surface waters it remained alkaline throughout the study period. Generally, its seasonal variation 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 matter (Paramasivam and Kannan, 2005). The recorded high summer pH might be due to the influence of seawater penetration and high biological activity (Das *et al.*, 1997) and due to the occurrence of high photosynthetic activity (Subramanian and Mahadevan, 1999).

The dissolved oxygen varied from 3.6 to 5.2 ml l^{-1} (Table.1) and higher values of dissolved oxygen were recorded during monsoon months. The observed high monsoonal values might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing as suggested by Das *et al.* (1997). Mitra *et al.* (1990) have mainly attributed seasonal variation of dissolved oxygen to freshwater flow and terrigenous impact of sediments.

Noticeable changes were observed in nutrients concentrations (Table.1). Nitrates and nitrite values ranged between 3.21 and 6.34 µg l^{-1} and from 0.74 to 0.896 µg l^{-1} while phosphates ranged between 0.22 and 1.16. µg l^{-1}, reactive silicate 24.85 - 61.92. µg l^{-1} and ammonia 0.05 - 0.32 µg l^{-1} respectively.

Nutrients are considered as one of the most important parameters in the estuarine environment which influences the growth, reproduction and metabolic activities of living beings. Distribution of nutrients is mainly based on the season, tidal conditions and freshwater flow from land source. Presently recorded high monsoonal values could be mainly due to the organic materials received from the catchment area during ebb tide (Das *et al.*, 1997). 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; Santhanam and Perumal, 2003). The recorded low values of nitrate may be due to its utilization by phytoplankton as evidenced by high photosynthetic activity and also due to the neritic water dominance, which contained only negligible amount of nitrate (Govindasamy *et al.*, 2000).

The recorded high nitrite values could be due to the increased phytoplankton excretion, oxidation of ammonia and reduction of nitrate and by recycling of nitrogen and also due to bacterial decomposition of planktonic detritus present in the environment (Govindasamy *et al.*, 2000). The recorded low nitrite values during summer season may be due to less freshwater inflow and high salinity (Mani and Krishnamurthy, 1989; Murugan and Ayyakkannu, 1991).

The recorded high concentration of inorganic phosphates during monsoon season might possibly be due to intrusion of upwelling seawater into the creek, which in turn increased the level of phosphate (Nair *et al.*, 1984). Low summer values could be attributed to the limited flow of freshwater, high salinity and utilization of phosphate by phytoplankton (Senthilkumar *et al.*, 2002). The variation may also be due to the processes like adsorption and desorption of phosphates and buffering action of sediment under varying environmental conditions (Rajasegar, 2003).

The recorded high concentration of inorganic silicate content was higher than the other nutrients (NO_3, NO_2 and PO_4) and higher value was noticed during monsoonal season when the salinity was very low which may be due to heavy influx of fresh water (Rajaseger, 2003). The low value of silicate recorded during post-monsoonal season could be attributed to uptake of silicates by phytoplankton for their biological activity (Mishra *et al.*, 1993). Higher concentration of ammonia was observed during monsoon season which could be partially due to the death and subsequent decomposition of phytoplankton and also due to the excretion of ammonia by planktonic organisms (Segar and Hariharan, 1989).

Higher primary productivity (mg cm^{-3} hr^{-1}) was observed during the summer season (May), and low productivity during monsoon season (Fig.2). The high population density of phytoplankton and this higher density could also be due to neritic element domination, higher salinity and surface water temperature,

Table 1 : Physico-chemical characteristics of Ayyampattinam coast water (October 2007 – September 2008)

Parameters	Oct-07	Nov	Dec	Jan-08	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Temperature (0°C)	25.6	26	29	27	29	26.9	31	33.4	29.6	26.2	28.3	27
Salinity (‰)	28	28.6	30	32	33	33.6	35	34	35	32	33	32
pH	8	7.9	7.8	8.1	8.2	7.9	8.1	8	7.9	8.2	8.1	7.9
DO (ml l^{-1})	3.8	4.1	4	4.3	4.9	5.1	3.9	4.8	5.2	4.2	3.6	4.2
Nitrate (ml l^{-1})	4.499	4.151	3.435	3.231	3.21	3.128	4.723	4.049	3.558	3.313	6.34	2.454
Phosphate (ml l^{-1})	0.362	1.167	0.394	0.249	0.226	0.875	1.149	0.405	0.383	0.432	0.562	0.381
Ammonia (ml l^{-1})	0.156	0.213	0.204	0.322	0.093	0.171	0.187	0.272	0.057	0.119	0.208	0.156
Nitrite (ml l^{-1})	0.467	0.565	0.74	0.724	0.682	0.836	0.896	0.818	0.389	0.643	0.487	0.467
Silicate (ml l^{-1})	59.957	55.69	56.37	58.84	61.15	57.31	61.922	61.836	39.46	49.79	48.26	24.85

clear water conditions besides availability of nutrients (Thillai Rajasekar *et al.*, 2005). The recorded low primary productivity during monsoon could be related to the wash of the phytoplankton to the neritic region by the monsoonal flood besides reduction of salinity, which could have affected the phytoplankton population (Rajasegar *et al.*, 2000).

The Chl *a* values ranged between 3.74 and 8.52 mg m^{-3}. A higher value of Chl *a* was recorded during summer and the low value was observed during monsoon season. The recorded low monsoonal values could be due to freshwater discharges from the rivers (dilution), causing turbidity and less availability of light (Kawabata *et al.*, 1993; Godhantaraman, 2002; Thillai Rajasekar *et al.*, 2005).

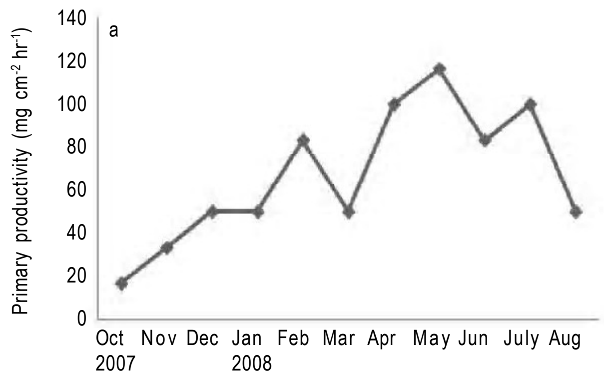

Fig.2: Primary production of phytoplankton at Ayyampattinam coastal region during October 2007 to August 2008.

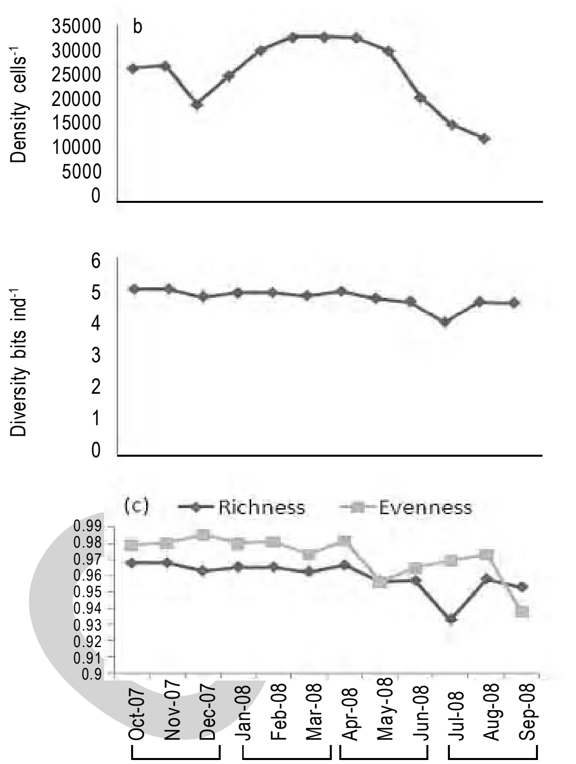

Fig.3 : Seasonal variations of phytoplankton population (a) density, (b) diversity, (c) richness and evenness recorded during 2007 to 2008 at Ayyampattinam coast.

Out of 51 species, 40 species of diatoms (Bacillariophyceae), 8 species of dinoflagellates (Dinophyceae), 1 species of green alga (Chlorophyceae) and 2 species of blue greens (Cyanophyceae) were recorded. The phytoplankton population density ranged between 12713 and 32618 cells l^{-1} (Fig. 3). The abundance of phytoplankton was lowest during monsoon season, when the water column was remarkably stratified to a large extent because of heavy rainfall, high turbidity caused by run-off, reduced salinity, decreased temperature and pH, overcast sky and cool conditions. However, during this season, freshwater algal forms like *Oscillatoria* sp and *Chlorella* sp were noticed and their population density was found to be higher in summer season as reported in other regions (Senthilkumar *et al.*, 2002). Thillai Rajasekar *et al.* (2005) reported the increase in number of phytoplankton species which increased consistently towards the outer region of the Bay of Bengal, where the salinity was high.

Phytoplankton population density and the maximum richness values were recorded during the postmonsoon season. Higher and lower species richness recorded during postmonsoon and monsoon seasons, respectively, which could be correlated with the recorded lower and higher salinity values, as reported by Mani (1992). The low density was recorded during the monsoon season. There was a positive correlation between phytoplankton species density and hydrographical parameters like dissolved oxygen(r=0.573), primary productivity(r=0.506), Chl *a* (r=0.81 2), nitrite (0.503) and silicate (r=0.649). The values of maximum species diversity, richness and evenness were 4.04, 0.96 and 0.98, respectively.

Totally 16 phytoplankton species were dominant, 15 species were moderate and 20 species were rare during observation. The present baseline data on the physico-chemical parameters in relation to phytoplankton distribution and abundance would form a useful tool for further ecological assessment and monitoring of coastal ecosystems of Ayyampattinam coast in future.

Acknowledgements

The first author is grateful to Dr. T. Balasubramanian**,** Director and Dean, CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai - 608 502, for providing the requisite facilities and to the authorities of Sethusamudram Ship Channel Project for providing fellowship.

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