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Water quality and phytoplankton characteristics in the Palk Bay, southeast coast of India

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Abstract: *The present study was carried out to determine the water quality in terms of physicochemical characteristics and plankton distribution in the coastal waters of Kattumavadi, Palk Bay for a period of one year from April 2002 to March 2003. Air and surface water temperatures varied from 28ºC to 32.50ºC and from 27.5 to 32.0°C while light extinction coefficient (LEC) varied between 0.95 and 1.85. Salinity ranged from 26.0 to 34.5‰ and the pH ranged between 7.95 and 8.35. Variation in dissolved oxygen content was from 4.15 to 7.18 ml^{-1}, and the particulate organic carbon (POC) content varied between 0.49 and 2.28 $mgCl^{-1}$. Concentrations of nutrients viz. nitrate (2.15 to 8.28µM), nitrite (0.12 to 0.62µM), inorganic phosphate (1.28 to 2.15µM) and reactive silicate (5.15 to 12.52µM) also varied independently. Chlorophyll a content ranged from 0.28 to 1.48 mg m^{-3} and the primary productivity, from 4.19 to 16.08 $mgCm^{-3}hr^{-1}$. The present study recorded a total of 43 species of planktonic diatoms and two species of blue-green algae. Population density of phytoplankton varied from 18,000 to 34,000 cells l^{-1}. Percentage composition of the diatoms showed minimum values during the monsoon season and the maximum values during the premonsoon season.*

Key words: *Physicochemical characteristics, Water quality, Nutrients, Coastal waters, Phytoplankton.*

Introduction

In India, the Palk Bay has landmarks between the Point Calimere and Rameshwaram island as northern and southern borders, respectively. The eastern part of the bay is connected with Srilanka whereas the western part of the bay is the border of the Indian subcontinent. The plants and animals of this bay are dependent on various physicochemical factors including nutrients, which are responsible for the fertility of the water masses (Harvey, 1995).

The Palk Bay region has not been paid much attention when compared to the adjacent Gulf of Mannar and most of the available literature and studies do not indicate the present scenario of the bay. Jayaraman (1954) has studied the water quality parameters of inshore waters of the Mandapam region. Prasad and Nair (1960) have studied the distribution and occurrence of diatoms in the inshore waters of the Palk Bay. Murthy and Udaya Varma (1964) have studied the hydrographical features of the Palk Bay. After this, there is no work directly dealing with the water quality of the Palk Bay except that of Kannan and Kannan (1996) who have studied the physicochemical characteristics of the seaweed beds of the Katumavadi and Kottaipattinam regions of the Palk Bay. Some studies (Oswin and Rahman, 1997; Kannan *et al*., 2003) are available on the Muthupettai mangroves of this region. Though, considerable attention has been paid in the recent years to study the physicochemical parameters of the coastal waters around India in order to ascertain the water quality and productivity, very little information is available on these aspects of the Palk Bay. Hence, the present study was undertaken on the water quality and phytoplankton characteristics for a period of one year from April 2002 to March 2003 at Kattumavadi, a coastal region in the Palk Bay.

Materials and Methods

Kattumavadi (Lat. 10º4'N; Long. 79º12'E) is a coastal village in the Palk Bay region of the Pudukottai district of Tamilnadu state. The sea in this area appears calm during most of the months with lesser tidal influence. There are no major river discharges expect that of a small river, Narasinga Cauvery, which brings water only during the rainy season. Fishing activities are carried out on a small scale using wooden dug out canoes, rather than mechanized boats. This coast is dominated by luxuriant growth of seagrasses, seaweeds and is devoid of rocks, corals or any other similar substrates. Active aquaculture is noticed all along the Kattumavadi coast, discharging effluents directly in to the sea in many areas.

Seasonal collections were made to record the physicochemical and phytoplankton characteristics of the Kattumavadi coast. Weather data have been collected from the meteorological department, Chennai and given in Table 1. A calendar year was divided into four seasons viz. postmonsoon (January-March), summer (April-June), premonsoon (July-September) and monsoon (October-December) based on the northeast monsoon which is prevalent in the study area.

Atmospheric and surface water temperatures were measured using standard mercury filled centigrade thermometer. Light penetration in the water column was measured with the help of secchi disc and light extinction co-efficient (LEC) was calculated using Pool and Atkins (1929) formula. Salinity was estimated with the help of a hand refractometer (Atago, Japan) and pH was measured using a Elico pH meter (Model LC- 120). Dissolved oxygen was estimated by the modified Winkler's method, described by Strickland and Parsons (1972).

Table – 1: Variations in the total rainfall and wind speed.

Date	Rainfall (mm)	Windspeed (km/hr)
15 May 2002	102.66	6.66
10 August 2002	27.33	6.00
14 November 2002	189.96	Data not available
13 February 2003	8.50	Data not available

For the analysis of nutrients, surface water samples were collected in clean polythene bottles and kept in an ice box and transported immediately to the laboratory. The water samples were filtered using a millipore filtering system (MFS) and analyzed for dissolved inorganic phosphate, nitrate, nitrite and reactive silicate by adopting the standard methods described by Strickland and Parsons (1972). POC was estimated by filtering one litre of water sample using MFS through whatman glass filter paper (GF/C) coated with $NaSO_4$. POC was then determined by wet ashing the filter paper with the mixture of potassium dichromate and concentrated sulphuric acid. By measuring the decrease in the extinction of yellow dichromate solution, concentration of POC was determined using Spectronic 20D (Milton Roy, USA) (Parsons *et al*., 1984).

Phytoplankton samples were collected from the surface water by towing a plankton net (mouth diameter 0.35m), made of bolting silk (No. 30, mesh size: 48 µM) for half an hr. The collected samples were preserved in 4% neutralized formalin and used for qualitative analysis and were identified using the standard works. For the quantitative analysis of phytoplankton, the settling method described by Sukhanova (1978) was adopted. Numerical plankton analysis was carried out using Utermohl's inverted plankton microscope.

Chlorophyll-a concentration was estimated by following the method of Strickland and Parsons (1972). Primary production was estimated by adopting the light and dark bottle technique as described by Strickland and Parsons (1972) and the productivity has been expressed as $mgCm^{-3}hr^{-1}$. Simple correlation (r) was made for the statistical interpretation of the physicochemical and plankton characteristics.

Results and Discussion

Atmospheric temperature varied from 28ºC to 32.50ºC with the minimum (28.0ºC) during the monsoon season and the maximum (32.5ºC) during the summer season. The maximum surface water temperature (32.0ºC) was recorded during the summer season and the minimum (27.5ºC) was recorded during the monsoon season (Fig. 1). Light extinction co-efficient (LEC) varied from 0.95 to 1.85 with the maximum during the postmonsoon and minimum during the premonsoon seasons (Fig. 2). Salinity ranged between 26.0 and 34.5‰ recording the maximum during the premonsoon season and the minimum during the postmonsoon season. The maximum (8.35) hydrogen-ion concentration (pH) was recorded during the summer season and the minimum (7.95), during the monsoon season (Fig. 3).

Table – 2: List of phytoplankton species recorded from Kattumavadi, Palk Bay.

Bacillariophyceae (Diatoms)

1. *Achnanthes brevipes* Agardh
2. *Asterionella glacialis* Cast.
3. *Bacteriastrum delicatulum* Cleve
4. *Cerataulina bergonii* Peragallo
5. *C. indicus sp.nov.*
6. *C. orientalis* Schiller
7. *Climacosphenia elongata* Bailey.
8. *Coscinodiscus jonesianus* (Greville) Ostenfeld
9. *C. lineatus* Ehrenberg
10. *C. marginatus* Ehrenberg
11. *C. sub-lineatus* Grunow
12. *Fragilaria brevistriata* Grun.
13. *G. sphaerophorum* Ehrenberg
14. *Grammatophora undulata* Ehrenberg
15. *Gyrosigma balticum* (Ehrenberg) Rabenhorst
16. *G. disortum* (W.smith) Cleve
17. *Navicula cincta* (Ehr.) Kutz.
18. *N. cuspidata* Kutz.
19. *Nitzschia closterium* (Ehrenberg) W. Smith
20. *N. longissima*(Brebission) Ralfs
21. *N. sigma* (Kutzing) W.Smith
22. *Odontella heteroceros* Grunow.
23. *O. mobiliensis* Bailey
24. *O. pulchella* Gray
25. *Pinnularia acrosphaeria* Brebission
26. *Planktoniella sol* (wallich) Schutt
27. *P. aestuarii* (Brebission)
28 *P. angulatum* (Quekett) W. Smith
29. *P. elongatum* W. Smith.
30. *P. normanii* Ralfs
31. *Pyxidicula minuta* Grunow.
32. *Rhizosolenia alata* Brightwell
33. *R. crassispina* Schroeder
34. *R. cylindrus* Cleve
35. *Synedra ulna* (Nitz) Ehr.
36. *Tabellaria fenestrata*(Lyngb.) Kutz.
37. *Thallassionema nitzschioides* Grunow.
38. *T. lineatum* (Ostenfeld) Gran
39. *Thallassiothrix frauenfeldii* Grunow.
40. *T. longissima Grun.*
41. *T. favus* Ehrenberg
42. *T. reticulatum* Ehrenberg
43. *T. robertsianum* Greville

Cyanophyceae (Blue-green)

44. *Aphanocapsa conferta Richter.*
45. *Chroococcus indicus* Zeller.

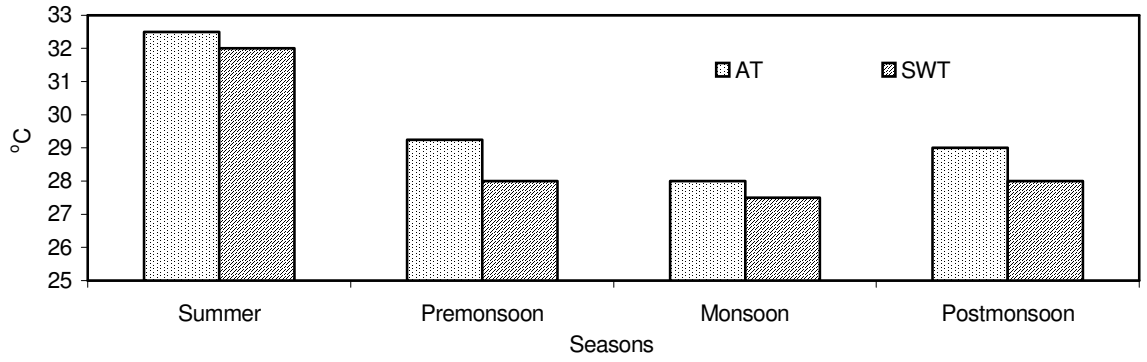

Fig. 1: Variations in air and surface water temperature.

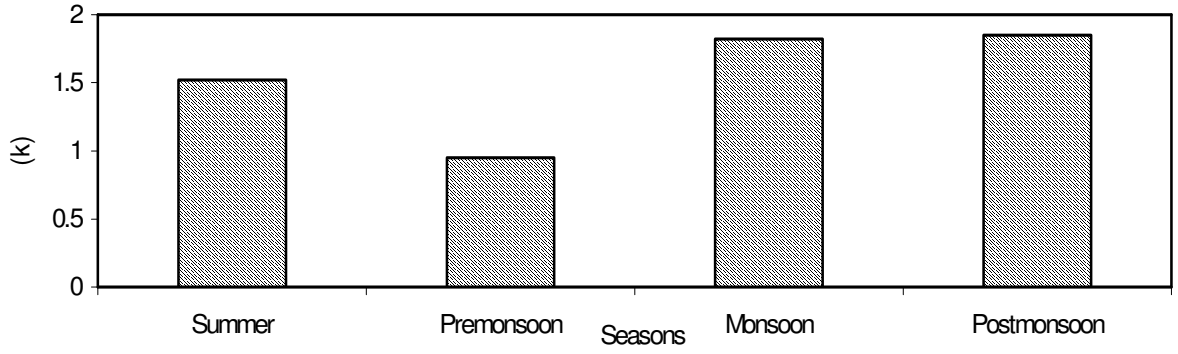

Fig. 2: Variations in the light extinction coefficient.

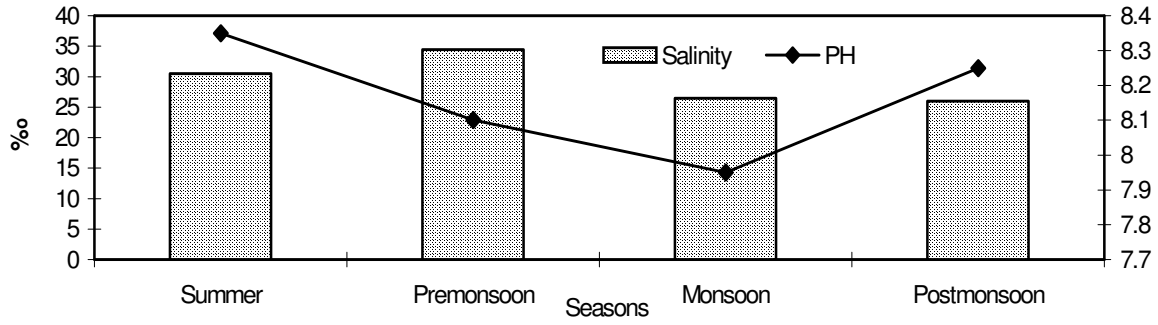

Fig. 3: Variations in the salinity and pH.

Dissolved oxygen content varied from 4.15 to 7.18 ml l^{-1} with the minimum during the summer season and the maximum during the postmonsoon season (Fig. 4). Particulate organic carbon (POC) content varied between 0.49 and 2.28 mg Cl^{-1}. The minimum was recorded during the summer season and the maximum was recoded during the monsoon season (Fig. 5).

Concentration of nutrients viz. nitrate (2.15 to 8.28µM), nitrite (0.12 to 0.62µM), inorganic phosphate (1.28 to 2.15µM) and reactive silicate (5.15 to 12.52µM) varied independently (Fig. 6). The minimum concentration of nitrate (2.15µM) was recorded during the postmonsoon season and the maximum (8.28µM), during the premonsoon season while the nitrite content recorded the minimum (0.12µM) during the summer season and the maximum (0.62µM) during the postmonsoon season. Inorganic phosphate concentration recorded the minimum (1.28µM) during the postmonsoon and the maximum (2.15µM), during the summer season. Reactive silicate concentration registered its maximum (12.52µM) during the summer and minimum (5.15µM), during the postmonsoon season. Chlorophyll content ranged from 0.28 to 1.48 mg m^{-3} with the minimum (0.28 mg m^{-3}) during the monsoon season and the maximum (1.48 mg m^{-3}), during the premonsoon season while the primary productivity varied from 4.19 to 16.08 mg C m^{-3} hr^{-1} with the minimum during the monsoon and the maximum during the summer season (Fig. 7).

During the present study period, a total of 43 species of planktonic diatoms and two species of blue-green algae were

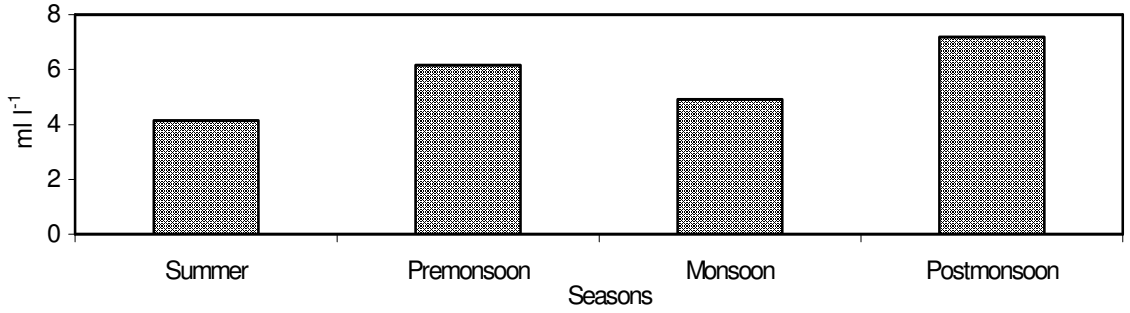

Fig. 4: Variations in dissolved oxygen content.

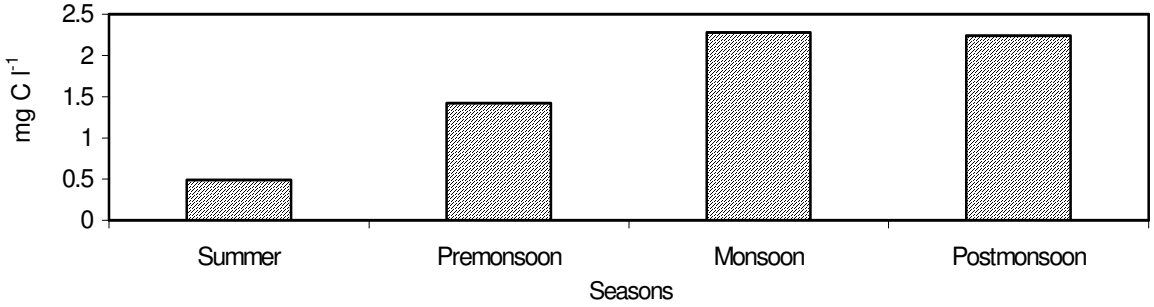

Fig. 5: Variations in the content of particulate organic carbon.

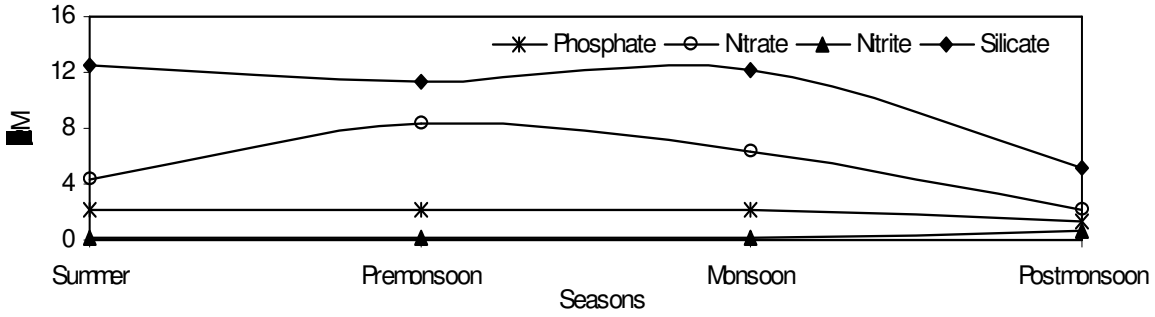

Fig. 6: Variations in nutrients concentrations.

recorded (Table 2). Population density of the phytoplankton varied from 18,000 to 34,000 cellsl^{-1}. The minimum density was recorded during the monsoon season and the maximum density was recorded during the summer season (Fig. 8). Percentage composition of planktonic diatoms recorded the minimum (75.0%) during the monsoon season and the maximum (99.99%) during the premonsoon season.

The present study has recorded several important factors that are influencing the coastal waters. In general, higher air and surface water temperatures were recorded during the summer season. The minimum temperature recorded during the monsoon season could be ascribed to the rainfall caused by the northeast monsoon at Kattumavadi. During the present study period, the surface water temperature was always lower than that of air temperature. This indicates that the water temperature was mainly influenced by air temperature, besides water currents. This is further confirmed by the significant positive correlation ($p<0.1\%$) obtained between atmospheric and surface water temperatures. Similar seasonal patterns were reported by Rajapandian *et al.* (1990) from the Tuticorin coast, Sampathkumar and Kannan (1998) from the Tranquebar-Nagapatinam coast and Subramanian and Kannan (1998) from Tuticorin region, all lying along the southeast coast of India including the present study area.

LEC is influenced by wave action, tides, wind agitation and freshwater discharges, by stirring up the bottom thereby resuspending the settled particles and fine sand or mud particles in shallow areas as that of the present study area. The monsoonal maximum of LEC could be attributed to the turbid nature of the coastal waters caused by the land runoff. This observation is in good agreement with the findings of Sampathkumar and Kannan (1998) from Tranquebar – Nagapattinam region and Kannan and Kannan (1996) from the Palk Bay.

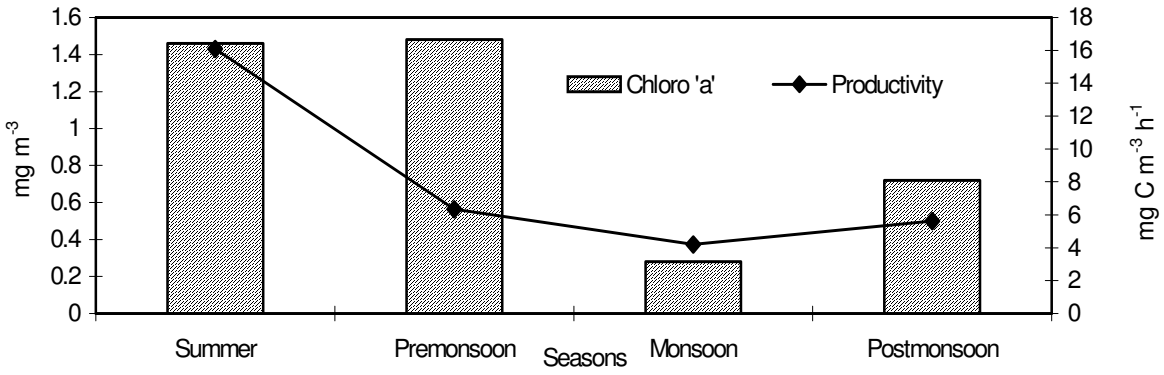

Fig. 7: Variations in chlorophyll a concentration and primary productivity

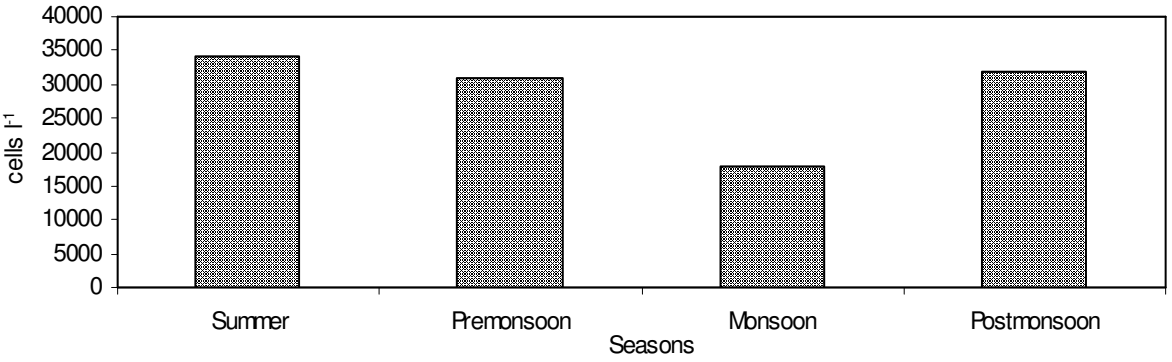

Fig. 8: Variations in phytoplankton population density .

Salinity is one of the important factors that influences the functional physiology and reproductive activity of the organisms (Kinne, 1971). In the present study, salinity was higher during the summer and premonsoon seasons. This could be due to the continuous evaporation of water from the study area especially during these seasons as also observed by Sampathkumar and Kannan (1998). Dissolved oxygen showed higher values during the postmonsoon season and lower values during the summer season. The latter could be due to the decrease in oxygen solubility because of increase in temperature and salinity of the water column during the summer season. This is well explained by the significant negative correlation ($p<5\%$) obtained between DO and air and surface water temperatures. Similar observations have been made by Padmavathi and Satyanarayana (1999) from the coastal waters of the Godavari.

During the present study period, higher POC content was recorded during the monsoon season and the lower content, during the summer season. The higher POC content recorded during the monsoon season could be due to the land runoff in the study area. POC showed significant negative correlation ($p<1\%$) with the water pH which indicates that the production of carbonic acid during the decomposition of organic matter would have altered the alkaline pH, as this station supports a good quantity of seaweed and seagrass biomass.

Nutrient concentrations showed distinct seasonal variations. Inorganic phosphate showed little fluctuation, recording the maximum during the summer season and the minimum during the postmonsoon season. The increased phosphate concentration observed during the monsoon season in the study area could be due to the land runoff from the irrigation channels and release of phosphate from the sediments due to high wind action during this season. The lower phosphate concentration during the postmonsoon season could be attributed to the utilization of the nutrient by the phytoplankton, which occurred in higher densities during the postmonsoon and summer seasons.

Higher and lower values of nitrate were recorded during the premonsoon and postmonsoon seasons respectively. Qasim and Reddy (1967) also observed a similar trend in the Cochin backwaters. Nitrite concentration showed a marginal difference in its seasonal distribution. Postmonsoon recorded higher concentration and monsoon season recorded lower concentration of nitrite. This seasonal difference in nitrite concentration could be attributed to the variations in phytoplankton excretion, oxidation of ammonia and reduction of nitrate. The latter is reported to be dominant, in addition to the bacterial decomposition of planktonic detrivores (Segar and Hariharan, 1989). Silicate concentration registered its maximum during the summer season and minimum during the

postmonsoon season. Sudden fall in the silicate concentration during the postmonsoon season could be attributed to the increased population density of phytoplankton.

Seasonal variation in the distribution of chlorophyll a in the surface water of the study area showed maximum during the summer and premonsoon seasons and minimum during the monsoon season. Chlorophyll concentration and primary productivity remained high during the summer months coinciding with the maximum population density. The negative correlation obtained between the nutrient and the phytoplankton population density indicates the utilization of nutrients by the phytoplankton. Though some nutrient load is expected to be there in the coastal waters by the release of aquaculture effluents, the levels of different nutrient were within the normal limits probably due to the utilization by the phytoplankton and other primary producers. However, if the nutrient levels increase beyond the normal limits, there is always the possibility for the initiation of harmful algal blooms.

From the present study, it is concluded that the water quality of the Palk Bay at Kattumavadi is in normal condition and there is no indication of any coastal pollution even after the development of aquaculture industry in this region at present.

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