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Studies on the ecology and distribution of phytoplankton biomass in Kadalur coastal zone Tamil nadu, India

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ABSTRACT

The present investigation is an attempt to ascertain the nature of the environment at Kadalur, a coastal village of Tamil Nadu. Pytoplankton of the palk Bay was studied during June 2009 to July 2010. For the present study three sampling Stations were fixed viz., Station 1 (Palar river), Station 2 (Palar estuary) and Station 3 (Kadalur sea coast). The percentage contribution of each group of phytoplankton was in the decreasing order of Myxophyceae > Chlorophyceae > Bacillariophyceae > Eugleninae at Station 1 and Diatoms > Dianoflagellates > Bluegreens > Greens > Others at Stations 2 and 3. However, Station 2 recorded more percentage of diatoms and dinoflagellates than Station 1 and 3. Phytoplankton population density and species diversity were high during the summer season. Phytoplankton species were invariably sparse during the monsoon season at all the stations. The density of phytoplankton population, as observed in the present study, was more or less equal with compared to the densities reported by earlier workers from various other marine environs of the South East Coast of India. It showed an inverse relationship with the nutrients concentrations. Species richness and evenness of phytoplankton showed an inverse relationship with the dominance index and the dominance index showed significant spatial variation. Distribution of chlorophyll **'a'** concentration closely followed the pattern of the fluctuation in phytoplankton population and it also varied seasonally. Phytoplankton chlorophyll **'a'** concentration increased with increasing phytoplankton standing crop and gross primary productivity. In general, Station 2 recorded more species composition, population density, gross primary productivity, and chlorophyll **'a'** concentration than Stations 1 and 3, which may be due to the occurrence autochthonous particulate food matter in freshwater. The diversity of coastal marine species may have been associated with the allochthonous species from the estuary.

Introduction

Plankton is one of the important components of any aquatic ecosystem. This is obvious from 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).

More than 95% of the primary production in the oceanic waters is contributed by only phytoplank on (Lewis, 1974). However, the shallow neritic zones of the coastal areas are comparably more productive due to the comoined production of unicellular algae, macro-algae, symbiotic algae of coral reefs and the seagrasses. Among all, the drifting micro-algal (phytoplankton) population plays a major in determining the productivity of the coastal and marine environment.

Phytoplankton species composition, richness, population density, and primary productivity will vary from coast to coast and sea to sea depending upon the varying hydro biological features. It is worth mentioning that Reynolds (1993) has stated that changes in species composition and dominance of phytoplankton can be mediated by a variety of mechanisms including ambient temperature, light penetration, nutrient supply, and removal by zooplankton *etc.* However, such information on phytoplankton of the Palk Bay is very much limited. Banse *et. al,* (1996) studied the possible causes of the seasonal phytoplankton blooms along the southeast coast of India and reported that the seasonal increase of nutrient supply primarily increased the growth rate of the phytoplankton. Krishnamoorthy and Subramanian (1999) reported that the west coast current and conglomeration of open ocean influenced the highest species diversity of meroplankton in the Palk Bay and Gulf of Mannar. Sridhar *et. al.* (2006) reported the seasonal behavior of distribution of phytoplankton in the Palk Bay region. This has necessitated the present attempt to study the phytoplankton community structure in the Palk Bay with reference to the ambient water quality.

The present work was carried out to study the Kadalur is a coastal village of Tamil Nadu, that located in the neighborhood of the estuarine region Palar river to assess the quantitative distribution of Zoo plankton from the three stations 1 (Palar river), station 2 (Palar esturary) and station 3 (Kadalur sea coast)

Materials and Methods

Phytoplankton samples were collected at monthly intervals from the waters of the study area by towing a plankton net (0.35 µm mouth diameter) made up of bolting silk (No. 30, mesh size 48 µm and No. 10, mesh size 158 µm, respectively for phytoplankton) for half an hour. These samples were preserved in 4% neutralized formalin and used for 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.

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For the sake of convenience, the phytoplankton were assigned to some major groups viz. diatoms, dinoflagellates, bluegreens, greens and others for phytoplankton. Species diversity index (H'), species richness (SR), evenness index (J') and dominant index (δ) were calculated using the formulae of Shannon and Weaver (1949), Gleason (1922), Pielou (1966) and Ignatiades and Mimicos (1977), respectively. Primary productivity was estimated by adopting the light and dark bottle technique of parson et. al., (1989).

Shonon and Weavers formula is

$$H' = \left[-\sum_{i=1}^{s} Pi \log_2 Pi...... \right]$$

Where H' = species diversity in the bits of information per individual and Pi = Propotion of

the sample belong to the species.

Species richness (SR) was calculated as described by Gleason (1922).

$$SR = \left[\frac{S-1}{\log_e N} \right]$$

Where,

S = the number of species of particular sample and

N = the natural logarithm of the total number of individuals of all the species in the sample.

Evenness index (J') (equitability) was calculated by the formula of Pielou (1966).

$$J' = \left[\frac{H'}{\log_2 S} \right]$$

Where H' = Species diversity in the bits of information per individual and

S = Number of species

Dominant index (δ) was calculated using the formula of Mc Naughton (1967) as described by Ignatiades and Minicos (1977).

$$\delta = \left[100 \, \frac{(n_1 + n_2)}{N} \right]$$

Where,

δ = Dominance index, equal to the percentage of total standing crop contributed by the two most important species

n_1 and n_2 = Percentage of total population of total phytoplankton standing crop in the same series of sample.

Primary productivity was estimated by adopting the light and dark bottle technique (Strickland and Parsons, 1972) and the productivity has been expressed as gCm^{-3} $hour^{-1}$. Gross primary productivity alone was calculated.

Phytoplankton were identified using the standard works of Hustedt (1930 - 1966), Venkataraman (1939), Cupp (1943), Subrahmanyan (1946), Prescott (1954), Desikachary (1959, 1987 and 1988), Handey (1964), Steidinger and Williams (1970), Taylor (1976) and Anand *et. al.,* (1986).

Results and Discussion

The result on phytoplankton diversity observed during the different seasons, Station 1 (Palar river), Station 2 (Palar estuary) and Station 3 (Kadalur sea coast), during the present study (July 2009 to June 2010) is given in Table 1, Table 2 and Table 3.

The percentage compositions of phytoplankton at different stations of the present study area according to the descending order are Station 1: Myxophyceae > Chlorophyceaqe > Bacillariophycae > Euglininae > Others, Station 2 &3:Diatoms > Dianoflagellates > Bluegreens > Greens > others. In general, at ali the stations minimum and maximum percentage compositions were recorded during monsoon and summer seasons.

At Station 1, phytoplankton population density varied from 8,800 to 41,440 minimum (8,800 $cellsl^{-1}$) was recorded during monsoon (December) season the maximum (41,440 $cellsl^{-1}$) during the summer (May) season. At Station 2, phytoplankton population density varied from 18,640 to 56,630$cellsl^{-1}$. Minimum 18,640 $cellsl^{-1}$) was recorded during monsoon (October) season and the maximum 56,630 $cellsl^{-1}$) during summer (April) season. At Station 3, minimum (11,400 $cellsl^{-1}$) was recorded during monsoon (December) season and the maximum 48.160 $cellsl^{-1}$) during summer (May) season. In general, minimum phytoplankton population density was recorded during monsoon season and the maximum during summer season at all the stations.

At Station 1, minimum (2.54 bits/ind.) phytoplankton diversity index (H') was recorded during premonsoon season and the maximum (3.93 bits/ind.) during summer (June) season. At Station 2, minimum (1.56 bits/ind.) diversity index recorded during post monsoon (February) season and the maximum 3.38 bits/ind.) during the summer (June) season. At Station 3, minimum diversity index (2.96 bits/ind.) was recorded during the monsoon (October) season and maximum (3.08 bits/ind.) during the summer (June) season. In general, summer season recorded maximum values of phytoplankton per diversity at all the stations.

Minimum (0.93) and maximum (2.06) values of phytoplankton species richness were recorded during monsoon (November) and summer (May) seasons respectively at Station 1. Minimum (1.56) and maximum (3.38) species richness values were recorded during post monsoon (February) and summer (June) seasons Station 2. Minimum (1.23) and maximum (2.96) species richness values were recorded during monsoon (October) and summer (June) seasons at Station 3. In general, summer season recorded maximum value of phytoplankton richness at all the stations.

Station 1 registered minimum (0.48) species evenness during monsoon December) and the maximum (0.66) during the summer (June) season. Station 2 registered minimum (1.19) species evenness during premonsoon (September) and the maximum (0.93) during the summer (May) season. Station 3 registered minimum (0.62) species evenness during monsoon (November) season and the maximum (0.81) during the post monsoon (March) season.

Phytoplankton species dominance index was minimum (6.82) during summer (May) season and the maximum (18.02) during premonsoon (July) season at Station 1. Phytoplankton species dominance index was minimum (10.82) during summer (April) season and the maximum (39.08) during post monsoon (January) season at Station 2. Phytoplankton species dominance index was minimum (8.22) during summer (May) season and the maximum (23.23) during post monsoon February) season at Station 3. In general, all the stations recorded minimum values of phytopiankton species dominance index during summer season.

Minimum (0.17 $gCm^{-3} hr^{-1}$) GPP was recorded during summer (May) season and the maximum (0.88 gCm^{-3} hr^{-1}) during premonsoon (September) season Station 1. Minimum (0.18

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gCm^{-3} hr^{-1}) GPP value was recorded during monsoon (November) season and the maximum (1.26 gCm^{-3} hr^{-1}) during summer (may) season at Station 2. Minimum (0.06 gCm^{-3} hr^{-1}) GPP values was recorded during post monsoon (march) season and the maximum (1.21 gCm^{-3} hr^{-1}) GPP was recorded during summer (April) season at Station 3.

In the marine environment, phytoplankton acts as primary producers using radiant energy. They initiate the marine food chain and the secondary (zooplankton) and tertiary (nektons like finfish and others) producers which depends on zooplankton directly or indirectly for food. Phytoplankton species undergo spatio – temporal changes in their distribution due to the differential effects of changing physical, chemical and biological factors on individual species. Of the marine biotic components, phytoplankton can be used as bioindicators since they reflect even the subtle changes taking place in their immediate environment by changing their species composition, biomass, community structure, chlorophyll content and productivity. Moreover, productivity of the estuarine and marine ecosystems is largely determined by their physoplankton population (supate and Gaykar, 1992 and Gandhiyappan, 1999).

At station 1, minimum and maximum values were observed during monsoon and summer seasons respectively. Similar observations were also made by Anilchauhan (1991), Baruah et al., (1997), Gujarathi and Kanhere (1998) and Iyyappan (2000). Among stations 2 and 3, the percentage composition was dominated b diatoms and dianoflagellates and this group executed more percentage at station 2.

In the present study, diatoms formed the dominant group followed by dianoflagellates, bluegreens, greens and others at stations 2 and 3. Percentage composition of each group of Phytoplankton was thus in the decreasing order, as indicated below:

Station 1 : Myxophyceae > Chlorophyceae > BacillarioPhceae > Eugleninae > Others

Station 2 & 3 : Diatoms > Dianoflagellates > Bluegreens > Greens > others

Station 2 recorded more percentage of diatoms and dianflagellates than Stations 1 and 3. Similar observations of diatoms domination accommodates various groups of phytoplanktons as reported by Ananthan (1991 & 1995) from the parangipettai and Cuddalore and Pondicherry marine environs, Edward and Ayyakkannu (1991) from the Kollidam estuary, Vasantha (1989), Kannan (1992) and Mani (1992 & 1994) from the Pitchavaram mangroves, Govindasamy (1992) and Govindasamy et. al., (1997) from the coromandel Coast, Sampathkumar (1992) from the Tranquebar – Nagapattinam Coast and Murugan and Ayyakkannu (1991) from the Cuddaore – Uppanar backwaters.

High phytoplankton population density and species diversity were observed during the summer season at all the stations. During this season diatoms dominated the phytoplankton community. The maximal phytoplankton population density during the summer could be attributed to the increased salinity, pH, temperature, DO and more intensity of light prevailed during this season. Evidently these parameters showed a positive correlation with population density, chlorophyll 'a' and gross primary productivity. Further, phytoplankton population density exhibited a negative correlation with the nutrients (PO_4, NO_2, NO_3 and SiO_2). Occurrence of higher density during the summer season especially coincided with the lower nutrients concentration and this might be during the utilization by the phytoplankton, similar observations were also made by Ananthan (1995) from Pondicherry coastal environs.

The phytoplankton species were invariably sparse during the monsoon season. Minimum population density during monsoon season may be due to the combined effect of physico chemical parameters such as heavy rainfall, increased turbidity and reduced salinity, temperature and pH and flushing of population by monsoon floods as reported by Kawabata et. al., (1993) from Vellar estuary. It is worth mentioning here that the phytoplankton population and their growth depend on several environmental factors which are variable in different seasons and different regions (EI – Gindy and Dorgham, 1992). Edward and Ayyakkannu (1991) recorded maximum and minimum density of diatoms, dianoflagellates, bluegreens, greens and silicoflagellate from the Kollidam estuary during the summer and monsoon seasons. Vasantha (1989), Kannan (1992) and Mani (1994) have also recorded the occurrenc3e of maximum density during the summer season and the minimum during the monsoon season from the Pitchavaram mangrove waters.

In general, the population density observed during the present investigation was lesser than the densitites reported earlier from various other marine environs (Ananthan, 1991 and 1995; Edward and Ayyakkannu, 1991; Govindasamy, 1992; Saraswathy, 1993; De et al., 1994 and Mani, 1994). At all the stations maximum species diversities (3.93 bits / individual at station 1; 3.38 bits / individual at Station 2 and 2.96 bits/ individual at Station 3) were observed during the summer season and minimum diversity (2.54 bits / individual at Station 1, 1.56 bits / individual at Station 3) was observed during the monsoon season. The species diversity values reported in this study are similar to the values obtained by Edward and Ayyakkannu (1991) from Kollidam estuary. Several other workers Sampathkumar (1992), Ananthan et.al., (1992), Govindasamy et. al. (1997), Govindasamy and Kannan (1998), Rajasegar (1998) and Gandhiyappan (1999) pertaining to the phytoplankton species diversity carried out along the South East Coast, where the present study area is also located, recorded lesser values due to the higher value of population density and less species diversity than that of the present study area, where higher diversity was noticed though population density was low.

Species richness was maximal during summer and minimal during the monsoon season at all the stations. These values were comparatively lesser than the values reported earlier by Edward and Ayyakkannu (1991) from Kollidam estuary and Saraswathi (1993) from the Arasalar and Kaveri estuaries. The occurrence of low species richness during monsoon season and high values during other seasons could be correlated with lower and higher salinity values respectively as suggested by mani (1992).

Chlorophyll 'a' is the principle photosynthetic pigment responsible for the primary production in the aquatic realms. Hih concentrations of chlorophyll 'a' would result in high values of productivity and reflect on high phytoplankton biomass. In the present study, chlorophyll 'a' concentration was low during the monsoon season and high during summer season, coinciding with lower (monsoon season) and higher (summer season) population density and gross primary productivity (GPP), respectively. In general, distribution of chlorophyll 'a' closely followed the phytoplankton cell counts and the maximum values was obtained during the peak phytoplankton population density as reported by Gounda and Panigraghy (1993) and Akpan and Offen (1993). Similar observations have been also made by Sathyanaranayana et. al., (1990 a & b) from the Visakhapatnam horbour, Verlencar and Dhargalkar (1992) from the Goa sea and Ananthan (1995) from the Pondicherry Coast.

Chlorophyll 'a' concentrations recorded during the present study period were comparable to the concentrations reported by earlier workers (Raman, 1995) from Visakhapatnam Harbour, Santhanam et. al., (1994) from Tuticorin Bay, Mani (1992 & 1994) from Pitchavaram waters and Mishra and Panigraphy (1995) from Bahuda estuary. Verlecar and Dhargalkar (1992) found that chlorophyll 'a' concentration in the surface waters varied between 0.73 and 6.30 mg m^{-3} in the Goa reigon. Selvaraj et. al., (1990) reported that the chlorophyll 'a' concentration in the oceaic waters of the South East Coast of India ranged from 0.04 to 3.2 mg m^{-3}.

Gross primary productivity values showed a vide range of fluctuations in the present study as reported by Gpinanthan et. al., (1994) from Tuticorin waters, Govindasamy (1992) and Govindasamy et. al., (1997) from the Coromandel Coast, Sampathkumar (1992) from Tranquebar – Nagapattinam Coast. In the present study, maximum value of grass productivity was recorded during the summer season. This is more or less similar to the value (1.113 gCm^{-3} hr^{-1}) reported earlier by Valsaraj and Raj (1994) from the Madras Coast. Likewise, in Arabian Gulf and Gulf of Oman, high primary productivity was observed during the post monsoon and summer seasons when there was high surface water, while low productivity was noticed during the monsoon season when low surface water temperature and low salinity were observed (El – Gindy et. al., 1992).

Of the three stations investigated, Station 2 recorded more species composition, population density, gross primary productivity and chlorophyll 'a' concentration than Stations 1 and 3, probably owing to its autochthonus species in addition to the allochthonus estuarine species.

Recently, choudhury Pal, (2010) also recorded such dominance of diatoms from the Bay of Bengal region. Perumal et. al., 2009 have reported that higher concentration of chlorophyll 'a' recorded in the present study, in the coral reef waters may affect the coral health by decreasing the light availability to zooxanthallae. Duyl et. al., (2002) have also opined that enhanced nutrient supply might trigger the size increase in cells, which would ultimately increases the chlorophyll 'a' concentration.

In general, open coasts, estuaries, mangroves and backwaters are well studied for their planktonic community structure and only little is known about the plankton community of the coral reef waters (Duyl et. al., 2002) and the information is very much lacking in the case of seagrass ecosystems. Panigrahi et. al. (2004) have reported that the abundance and diversity of diatoms in the neritic zone of the Bay of Bengal are common features. Dominance of diatoms in reef waters has also been reported by Kannan et. al., (1998) from the Gulf of Mannar region and Sorokin (1990) from the Great Barrier Reef.

Table 1 Phytoplankton observed during July 2009 – June 2010 at station 1

Parameters	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Annual Average
Zoo. Density	20080	10620	14060	6800	4680	844	0	0	0	0	19990	26260	19.749
Sp. diversity	3	3.24	2.96	2.62	2.85	2.76	0	0	0	0	3.07	2.79	1.94
Sp. Richness	1.04	0.95	0.88	0.62	0.57	0.44	0	0	0	0	1.82	1.26	0.632
Sp. Evenness	0.76	0.8	0.64	0.83	0.88	0.92	0	0	0	0	0.96	1	0.565
Dom. Index	12.84	16.06	14.14	20.64	24.42	18.98	0	0	0	0	6.22	10.04	10278

Table 2 Phytoplankton observed during July 2009 – June 2010 at station 2

Parameters	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Annual Average
Zoo. Density	46080	32560	24980	18900	16440	11260	23230	19.870	36640	49470	38980	53250	30.971
Sp. diversity	4.68	4.26	5	4.11	3.74	3.89	4.6	3.61	4.92	5	5.26	5.17	4.276
Sp. Richness	2.84	2.32	1.82	0.79	1.06	1.66	2.22	3	2.465	3.36	2.76	2.91	2.266
Sp. Evenness	0.87	0.84	0.9	0.870	0.92	0.9	0.93	0.95	0.94	0.98	1	0.96	0.921
Dom. Index	24.22	16.18	10.66	14.96	17.78	21.12	26.39	22.96	20.66	34.89	28.2	30.16	22.348

Table 3 Phytoplankton observed during July 2009 – June 2010 at Station 3

Parameters	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Annual Average
Zoo. Density	24400	26600	20860	12000	6840	10400	14800	16660	27900	30300	36420	28300	21.04
Sp. diversity	3.22	3.09	3.68	3.06	3.24	4	4.39	4.12	3.89	3.64	3.42	3.6	3.612
Sp. Richness	1.84	1.68	1.04	1.23	1.13	0.63	1.46	1.89	2	2.76	2.22	1.98	1.644
Sp. Evenness	0.82	0.9	0.86	0.8	0.94	0.83	0.8	0.86	0.76	0.98	0.94	1	0.874
Dom. Index	17.67	14.96	21.12	22.22	27.61	20.22	32.06	28.95	24.06	10.95	8.47	12.06	20.029

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