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# THE ECOLOGICAL BASIS FOR SIMULATING PHYTOPLANKTON RESPONSES TO ENVIRONMENTAL CHANGES IN RIVER KUAKHAI AT BHUBANESWAR CITY, ODISHA

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## ABSTRACT

**The phytoplankton diversity of river Kuakhai at Bhubaneswar City, Odisha showed altogether 11 species of Bacillariophyceae, 10 species of Chlorophyceae and 12 species of Cyanophyceae. Bacillariophyceae imparted the dominant group followed by Chlorophyceae and then Cyanophyceae. The diversity index (Hs) ranged from 2.22 to 3.14 and the species equitability (j) ranged from 0.76 to 0.98 whereas species richness index (d) ranged from 3.12 to 7.3 at all the study stations. Seasonal plankton count revealed that the Chlorophyceae showed its peak during winter season in both the years whereas Bacillariophyceae and Cyanophyceae showed a bimodal peak.**

**KEYWORDS :** Ecology, phytoplankton response, River Kuakhai, Bhubaneswar city

Planktons are the microscopic aquatic forms which form the biotic community in aquatic ecosystem (Sharma and Mankodi, 2005). Phytoplankton is the primary producer and constitutes the first level in aquatic food chain for all aquatic organisms. The use of density and diversity of phytoplankton and their association as biological indicators in the assessment of water quality has been reported by several workers. Among biotic communities, phytoplankton constitutes the first stage in trophic level by virtue of its capacity to transduce radiant solar energy into biological energy through photosynthesis. Therefore these are also referred to as primary producers (Sakhare and Joshi, 2006). In order to understand the biological functioning of fresh water ecosystem and detect the changes over time, it is essential to investigate the development of the phytoplankton population as they are particularly sensitive to changes in nutrients, responding rapidly when levels rise (Thackeray et al., 2008). The growth and multiplication of phytoplankton is mainly dependent on temperature, solar illumination and availability of certain essential nutrients such as nitrates, silicates and phosphates (Butterwick et al., 2005). Study of planktons is essential to understand the basic nature of any ecosystem. Therefore, the present work reflects the species density, diversity and distribution of phytoplankton of river Kuakhai at Bhubaneswar city, Odisha.

## MATERIALS AND METHODS

The plankton samples were collected on monthly basis during the period from January 2011 to December 2012 from three sampling stations covering upper (S-I), middle (S-II) and downstream (S-III) of river Kuakhai at Bhubaneswar city of Odisha. Plankton samples were collected by net method in which bolting nylon materials of No.25 or 30 (pore size, 64μm and 51 μm respectively) are used for the construction of various types of nets for the collection of phytoplankton from the surface or at different depths of water bodies. Then samples were collected by filtering 50 litres of surface water through plankton net made up No. 25 (Mesh size 64μm) bolting silk net. The water sample thus collected was preserved by adding 2% neutralized formalin solution. Bottling and labelling was done immediately after preservation. The preserved samples were brought to the laboratory for qualitative as well as quantitative analysis. The water samples (A, B, C) were poured in a separating funnel allowed to stand for 48 hours, after which the filtrate water sample was collected in three separate containers. With the help of a pipette 1 ml. of sample was transferred to a Sedgwick-Rafter plankton counting cell for identification and count. The identification of the planktons was done with the help of methods described by Edmondson (1995) and Dhanapathi (2000). The total no. of planktons in a litre of water sample was calculated using the formula:

$$n = (a1000)\ c/l$$

where n - The number of phytoplankton per litre of water
a-The average number of planktons in 1ml. of sample
c-The ml. of phytoplankton concentration
l-The volume of original water samples in litres

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To study the community structure of the phytoplankton following indices were then calculated.

**A. Shannon and Weiner Index (Hs)**

The Shannon and Weiner diversity index is given by the equation,

$$Hs = \Sigma Pi \ln Pi$$

Where,

Hs = Diversity index

i = counts denoting the ith species ranging from 1- n

Pi = Proportion that the ith species represents in term of

**Table 1: List of Available Phytoplankton Species Recorded at Different Sampling Stations of River Kuakhai During 2011and 2012**

| | | 2011 | | | 2012 | | |
|---|---|---|---|---|---|---|---|
| | | S-I | S-II | S-III | S-I | S-II | S-III |
| CHLOROPHYCEAE | *Closterium lanceolatum* Kutz | + | + | + | + | ++ | + + |
| | *Microspora* | - | + | + | ++ | + | ++ |
| | *Mougeotia* | + | + | + | + | ++ | + + |
| | *Oedogonium* | ++ + | + | ++ | ++ + | ++ | +++ |
| | *Oocystis* | - | + | + | + | ++ | + + |
| | *Staurastrum* | ++ | + | - | + | ++ | + |
| | *Spirogyra varians* Kutz | +++ | +++ | +++ | +++ | ++ | +++ |
| | *Ulothrix zonata* Kutz | + + | + | + | + | ++ | ++ |
| | *Volvox globator* Ehrenb | +++ | ++ | +++ | ++ | + | ++ |
| | *Zygnema* Sp | +++ | ++ | +++ | +++ | ++ | +++ |
| BACILLARIOPHYCEAE | *Amphora Ovalis* Kutz | ++ | + | + | ++ | + | ++ |
| | *Diatoma Sp* | + + + | ++ | +++ | +++ | ++ | +++ |
| | *Fragillaria Sp* | - | + | + | ++ | ++ | ++ |
| | *Frustulia* | - | + | + | ++ | ++ | ++ |
| | *Gomphonema Lanceolatum* (Ehremb) | ++ | + | ++ | +++ | ++ | ++ |
| | *Gyrosigma* | + | - | + | ++ + | ++ | + |
| | *Melosira granulate* Ralfs | + | + | + | ++ | ++ | + |
| | *Navicula laterostrata* Hust | +++ | ++ | +++ | +++ | ++ | +++ |
| | *Nitzschia* Sp | + + + | ++ | +++ | +++ | ++ | ++ |
| | *Tabellaria* | + | + | + | +++ | ++ | ++ |
| | *Vaucheria* | ++ | + | + | ++ | ++ | ++ |
| CYANOPHYCEAE | *Anabaena* Sp | + | + | - | + | + | ++ |
| | *Ancysties* | ++ | + | + | ++ | + | + |
| | *Chlamydomonas* | - | + | - | + | + | ++ |
| | *Merismopoedia* | - | + | + | ++ | + | + |
| | *Nostoc* Sp Vauch | +++ | ++ | +++ | +++ | ++ | +++ |
| | *Osciliatoria Sp* | +++ | ++ | +++ | +++ | ++ | +++ |
| | *Phormidium favosum* Gom | + | + | - | ++ | + | + |
| | *Polycystis* | - | + | - | + | + | + |
| | *Rivularia* Sp | + | ++ | ++ | ++ | + | + |
| | *Scytonema* | - | + | - | ++ | + | ++ |
| | *Spirulina* | ++ | + | - | + | + | + |
| | *Trichomus* | - | + | + | + + | + | ++ |

**Table 2: Seasonal Variations in The Distribution ($nl^{-1}$) of Phytoplankton at Different Sampling Stations of the River Kuakhai**

| | Season | S - I | S - II | S - III |
|---|---|---|---|---|
| Chlorophyceae | Winter | 375.35 | 394.875 | 244.375 |
| | Summer | 747.25 | 685.5 | 665.875 |
| | Rainy | 60.625 | 39.875 | 51.25 |
| Cyanophyceae | Winter | 204 | 84.5 | 110.25 |
| | Summer | 103.12 | 73.62 | 129 |
| | Rain y | 88.87 | 93.75 | 99.5 |
| Bacillariophyceae | Winter | 981.5 | 922 | 846.25 |
| | Summer | 512.87 | 514.12 | 485.15 |
| | Rainy | 116.75 | 109.125 | 179.875 |

numbers of individuals with respect to the total no. of individuals in the sampling space as a whole.

**B. Pielou Species Equitability Index (j)**

Pielou's Species Equitability Index (j) is represented by the equation:

$$j = Hs / Log2\ S$$

Where,

j = Equitability Index

Hs = Shannon and Weiner Diversity index

S = Number of species in a population.

**C. Margalef Species Richness Index (d)**

The Margalef Species Richness Index (d), used to evaluate the community structure, is represented by the equation.

$$d = (S\ \ 1) / LogN$$

Where,

d = Species Richness Index

S = Number of species in a population

N = Total number of individuals in S species

## RESULTS

The phytoplankton population constituted of Bacillariophyceae, Chlorophyceae and Cyanophyceae. The phytoplankton diversity showed altogether 11 species of Bacillariophyceae, 10 species of Chlorophyceae and 12 species of Cyanophyceae (Table, 1). Among all the phytoplankton Bacillariophyceae was dominant followed by Chlorophyceae and then Cyanophyceae. The concentration of phytoplankton and percentage composition of different groups indicated that the Diatoms were the main components of the community being maximum in winter at S-I and minimum during the rainy season at S-II (Table, 2 and 3 and Figure, 1).

The present work concludes that among phytoplankton, Bacillariophyceae topped the list. It was

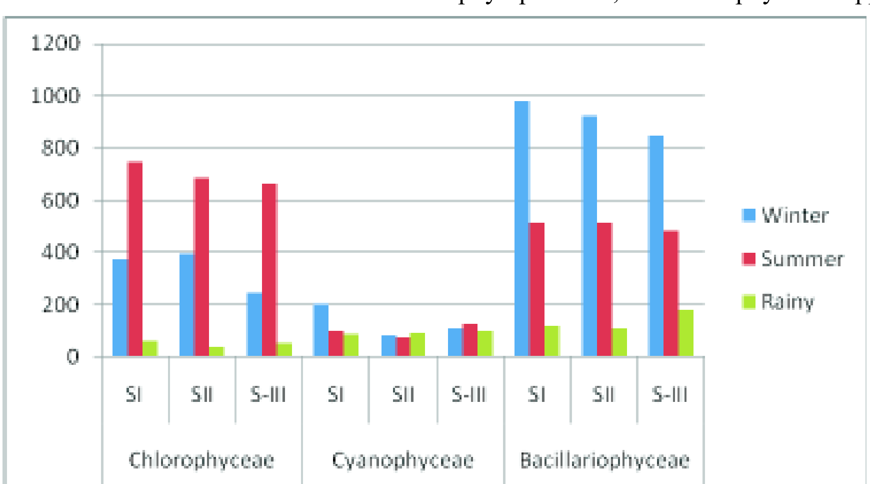


**Figure 1: Seasonal Variation of Different Species of Phytoplankton in Different Sampling Stations of River Kuakhai**

**Table 3 : Percentage of Phytoplankton Belonging To Various Taxonomic Groups In Different Sampling Sites of River Kuakhai**

| Species Groups | Year | S- I | S- II | S-III |
|---|---|---|---|---|
| Chlorophyceae | 2011 | 27.45 | 33.07 | 30.01 |
| | 2012 | 26.2 | 36.0 | 34.55 |
| Cyanophyceae | 2011 | 22.4 | 20.4 | 21.73 |
| | 2012 | 19.5 | 18.0 | 20.45 |
| Bacillariophyceae | 2011 | 50.15 | 46.53 | 48.26 |
| | 2012 | 54.3 | 44.0 | 45.0 |

recorded maximum in S-I (981.5/L) and least in S-II (109.12/L). Both Chlorophyceae and Cyanophyceae followed the same trend of being highest in number in S-I and lowest in S-II (Table, 2; Figure, 1).

The phytoplankton percentage was highest in S-I and least in S-II except Chlorophyceae which showed maximum value in S-II and minimum in S-I (Table-3). The percentage of Chlorophyceae among the phytoplankton was highest in S-II (36.0%) and lowest in S-I (26.2%). The percentage of Bacillariophyceae among the phytoplankton was highest in S-I (54.30%) and lowest in SII (44.0%). The Cyanophyceae count showed the highest percentage in S-I (22.4 %) and lowest was in SII (18.0%). All the groups of phytoplankton showed the minimum count during rainy season in both the years of the study in all the sampling stations. The present study showed that among 11 species of Bacillariophyceae, Diatom was dominant from all the sampling stations throughout the study. The species *Zygnema* dominated in the Chlorophyceae group and in case of Cyanophyceae group, Nostoc was the dominant species.

The Shannon and Weiner diversity index (Hs), Species equitability or evenness index (j) and Species richness index (d) of phytoplankton are presented in Table-4. The diversity index (Hs) ranged from 2.22 to 3.14. The maximum value of diversity index was recorded for S-I during rainy season, for S-II during summer season and for S-III during winter season. Minimum value of the diversity index (Hs) was recorded during winter for all the stations except S-III (rainy). Species equitability (j) ranged from 0.76 to 0.98 at all the stations. The maximum value of species equitability was recorded during rainy season while the minimum value was recorded during winter season. The species richness index (d) range from 3.12 to 7.3. The maximum value of the richness index was recorded for S-I during rainy season and for S-II & III during winter season. For all the stations the minimum value of species richness index was recorded during rainy season except S-I (summer)

## DISCUSSION

In the present work phytoplankton is represented by three major groups; Bacillariophyceae, Chlorophyceae and Cyanophyceae, which agrees with the findings of Sakhare and Joshi (2006) and Reynolds et al., (2012). Seasonal fluctuations were well observed in the present study. Among different groups of planktons, Bacillariophyceae occupied the first place which matches the findings of Suresh et al., (2011) in the river Pinder of Gharwal Himalayas.

The highest plankton population was observed in the winter samples when both the turbidity and velocity is low. Lowest count of plankton population occurred during rainy season when the river is highly turbid and also flooded. The minimal count of plankton during rainy season can also be resulted due to the cloudy weather which prevents light penetration into the water body.

The Chlorophyceae showed its peak during summer season in both the years, but Bacillariophyceae and Cyanophyceae showed a bimodal peak (Noges et al., 2010). The diatoms were recorded maximum during winter in all the sampling stations in 2011, while in 2012 the S-II & S-III showed the peak in summer and in S-I the peak value was recorded in winter. Similar trend was noticed in the case of Cyanophyceae. In 2011, S-II & III the BGA count was maximum in winter and in S-I it was maximum during the summer. Favourable environment conditions such as

**Table 4 : Shannon and Weiner Diversity Index (Hs), Pielou Species Equitability Index (j) and Margalef Species Richness Index (d) of Phytoplankton Community of River Kuakhai at Different Stations During The Study Period**

| | S-W diversity Index (Hs) | | | Equitability Index (j) | | | Richness Index (d) | | |
|---|---|---|---|---|---|---|---|---|---|
| | S-I | S-II | S-III | S-I | S-II | S-III | S-I | S-II | S-III |
| Jan | 2.52 | 7.83 | 2.81 | 0.76 | 0.87 | 0.91 | 4.83 | 5.03 | 4.6 |
| Feb | 2.96 | 3.05 | 2.80 | 0.88 | 0.90 | 0.91 | 5.33 | 6.03 | 5.3 |
| Mar | 2.56 | 3.14 | 2.80 | 0.81 | 0.93 | 0.93 | 4.36 | 5.46 | 4.52 |
| Apr | 2.77 | 3.05 | 2.81 | 0.88 | 0.91 | 0.92 | 4.50 | 5.78 | 4.44 |
| May | 2.94 | 2.97 | 2.95 | 0.90 | 0.90 | 0.9 | 4.97 | 5.65 | 5.27 |
| Jun | 2.84 | 3.01 | 2.75 | 0.90 | 0.95 | 0.93 | 4.48 | 5.56 | 4.41 |
| Jul | 2.81 | 2.46 | 2.64 | 0.93 | 0.95 | 0.97 | 5.02 | 3.65 | 4.25 |
| Aug | 3.03 | 2.41 | 2.51 | 0.97 | 0.96 | 0.98 | 6.03 | 3.45 | 3.89 |
| Sep | 2.34 | 2.58 | 2.22 | 0.96 | 0.97 | 0.96 | 3.37 | 4.27 | 3.26 |
| Oct | 2.97 | 2.46 | 2.34 | 0.89 | 0.95 | 0.94 | 7.30 | 3.58 | 3.12 |
| Nov | 2.81 | 3.00 | 3.05 | 0.91 | 0.93 | 0.92 | 4.70 | 5.63 | 5.56 |
| Dec | 2.78 | 2.80 | 3.00 | 0.87 | 0.91 | 0.90 | 4.48 | 4.41 | 5.01 |

moderate temperature, low flow, transparency during winter season favours the growth of phytoplankton in river Kuakhai. The increased phytoplankton density in post monsoon period may be due to the rich nutrients received through rain water (Clegg et al., 2003).

From the study it is therefore evident that out of the three study sites, S-II is the most polluted and S-I is the least affected site. The present work concludes that changes in algal assemblages can be linked to changes in water chemistry such as pH, phosphorus and nitrogen. The other factors responsible for variations in plankton population may be increased or decreased sunlight, altered flow regime as also reported by Park et al., 2004. There were also several species of Bacillariophyceae which were both positive and negative indicators of site condition i.e. they prefer high oxygen but also tolerate alkaline sediment. These species were not always associated with human disturbances (Fore and Graft, 2002). Among all the three groups of phytoplankton the Diatoms are used to assess the biological conditions of large rivers as reported by Fore and Graft (2002). Regarding the fluctuation in population of Diatoms it can be said that the number of taxa declines with extreme urbanization or contamination from sewage discharge.

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