Biological Indices to Depict the Water Quality Status

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Abstract

Biological entities form the major component of the ecosystem. The biotic and abiotic factors are closely related with each other and the change in one system immediately affects the other. Many researchers have proven this association and such studies are very useful in depicting the status of the ecosystem and also help in future planning.

The present work is about the plankton which are the chief constituent of aquatic ecosystem and are closely associated with the variation in the water quality.

Phytoplankton are the one with the ability of synthesizing own food with the help of photosynthetic pigments and zooplankton are heterotrophic planktonic animals which constitute an important food source for many species of aquatic organism. Both are very sensitive and their population varies according to the variation in surrounding temperature, pollution load and other disturbances. The present study was undertaken to evaluate the seasonal variation in the planktonic diversity of River Gadhi and its Reservoir Deharang and thus the water quality.

The sample was collected from 7 different sites from the water body which were selected according to the pollution load. The samples were analyzed for the physicochemical as well as biological parameters and the data was evaluated for the study of seasonal variation of the plankton. It has been found that the diversity is more in the premonsoon owing to the increased temperature, pollution load and stagnancy in the water body. The indices also helped in depicting pollution status as well as trophic status of the water body.

KEYWORDS- Hill's No., Shannon Index, Simpson index, Margalef's index, anthropogenic activity, sewage, temperature

Introduction

Plankton are feebly swimming organisms found in both fresh and marine water. They play a vital as an important member of food chain. They are broadly categorized as phytoplankton and zooplankton. Phytoplankton constitutes the basis of nutrient cycle of an ecosystem. Being primary producers they play an important role in maintaining the equilibrium between living organisms and abiotic factors. They are affected by physical, chemical and biological factors, making them valuable tool in monitoring programmes. They form good indicators of water quality as they have rapid turn-over time and are sensitive indicators of environmental stresses. On the basis of this, many workers have emphasized that algal communities as a whole serve as reliable indicators of pollution (Patrick, 1950; Palmer, 1969; Nandan and Patel, 1985). Phytoplankton was used for assessing the degree of pollution or as indicator of water pollution of different water bodies (Trivedy, 1986; Sudhaker et al., 1994; Dwivediand Pandey, 2002).

Zooplankton rank next to the phytoplankton in the nutrient cycle. They are also widely used as a water quality indicator. A change in the physico-chemical aspect of a water body brings about a corresponding change in the relative composition and abundance of the organisms in that water. Biomonitoring (biological surveillance) is the systematic use of living organisms or their responses to determine the quality of the environment (Rosenberg and Resh 1993).

The present study is about monitoring the seasonal variation in planktonic diversities of River Gadhi and Dehrang Reservoir using various diversity indices. The said water bodies runs outskirts of Panvel town (longitude $18^{o}58'$ N and latitude $73^{o}12'$ E). It has a stretch of 16 km and during its course it runs through many villages and Panvel town receiving anthropogenic load.

Topographically, the climate is not very hot and is typically coastal sultry type. The temperature ranges between 30.3 °C -22.6 ^{o}C. It receives average rainfall of 2177 mm. There are virtually two distinct periods, rainy and dry period. Dry period comprises winter and summer (www.maharashtra.gov.in).

During the present study, seven sites (Fig. 1) were selected on the Reservoir and the River. The river starts from a reservoir, which is located at the bottom of mountain hills. The reservoir collects water from natural springs and the water runoff that flows down the mountains during the rainy season. This was referred as S1 in the present study. The site S2 is just 2 km downstream to the reservoir and has no much human hindrance. Site S3 is 5 km downward to the reservoir. It has comparatively more anthropogenic activities than earlier sites. As we move the downstream, sites S4, S5, S6, S7 are located at the distance of one to two km from the earlier sites and every site receives sewage except S7 which receives cremation ash.

Materials and Methods

Phytoplankton

Using a wide mouth container, 500 ml of surface water sample was collected from different spots at every site from near the boundaries of the river and the reservoir. The samples from every station were preserved in separate container for phytoplankton. For immediate fixation, Lugol's Iodine solution made in formalin was used in the field and later 4% formaldehyde was used for long term preservation.

The phytoplankton were concentrated by allowing them to settle for about 15 to 20 days and then the upper water was decanted by using a rubber tube. The phytoplankton were identified by using standard identification keys (Fritsch, 1979; Sarode and Kamat, 1984; Bellinger, 1992).

For quantitative estimation, the counting was done by using Lackey's Drop method (APHA 1985). Density of phytoplankton (units/lit.) was calculated using following formula.

$$\text{Phytoplankton Units/l} = \frac{R \times At \times 10^3}{As \times S \times V} \times \frac{1}{C}$$

Where,

R = Number of organisms counted per subsample

At = Area of coverslip, mm2

As = Area of one strip, mm2

S = Number of strips counted, and

V = Volume of sample under the coverslip, ml

C = Concentration factor

$$\text{Concentration Factor (C)} = \frac{\text{Total Volume of Water concentrated}}{\text{Final volume made after concentration}}$$

Zooplankton

The sample collection, for the quantitative study of zooplankton was done by using a wide mouth container. 40 ltrs of water was collected from different spots from every site from the boundaries of the bank of the river and reservoir was filtered using net of mesh size 45 µm. The filtered samples were preserved separately for each site with 4% Lugol's Iodine made in formalin in a separate container.

Identification of zooplankton was done with the help of standard keys (Ward and Whipple, 1958; Battish, 1992; Pennak, 1995; and Dhanapathi, 2000).

The density count of zooplankton was done by observing subsamples under compound microscope and the number was calculated in units per liter by using following formula.

$$\text{Zooplankton per liter} = \frac{\text{No. of zooplankton/ml} \times \text{Dilution factor} \times \text{Volume of the concentrate (ml)} \times 1000}{\text{Total volume of water filtered}}$$

Diversity Indices

1. Hills number:

I. NO- This is the simplest of all the indices and indicates the total number of species occurring at a location in a sample.

II. N1- is the number of abundant species in a sample and in calculated by the formula

N1= e H 1 where, H is the Shannon's index

III. N2- is the number of most abundant species in a sample calculated using the formula

N2 = 1/ λ, where λ is the Simpson's index

All the above three i.e. NO, N1 and N2 are also called as Hill's number.

2. Simpson's index (λ):

It varies between 0 to1. It gives the probability that two individual drawn at random from a population belong to the same species. In simple words, if the probability is high that both individuals belong to the same species then the diversity of the community sample is low.

Simpson's index is calculated by using formula

$$\lambda = \sum_{i=1} \frac{ni\,(ni-1)}{n\,(n-1)}$$

Where, n is the total number of individuals,

ni is number of individuals of the I th species,

3. Shannon's index (H):

It measures the degree of uncertainty for S number of species and N number of individuals of the species. The index comes to zero when there is only one species in the community and it is maximum when all species are in equal number. This index is calculated as,

H' = - ∑ (pi* ln pi) (Shannon, 1949)

Where,

Pi = ni/N

ni = total number of individuals of a species

N = total number of individual of all species.

4. The indices of Richness (R1, R2, R3)

There are three richness indices

$$R1 = \frac{S-1}{\text{Log } N} \quad \text{(Margalef 1958)}$$

$$R2 = \frac{S}{\sqrt{N}} \quad \text{(Mehinicks 1964)}$$

R3 = Species per 1000 individuals (Odum 1971)

Where,

S is number of species

N is the total number of individual

All the indices were calculated monthly and the data was pulled seasonally as premonsoon, monsoon and postmonsoon.

Results and Discussions

NO

'NO' indicates the number of species. In case of phytoplankton, the seasonal trend shows more number of species in premonsoon season at S2 and minima at S1 during monsoon. The clear water, decreased flow, availability of sunlight favoured the growth of variety of organisms in this period at S2. However, increased turbidity, less transparency and dilution could be the factors showing few kinds at S1.

In case of zooplankton, S1 and S5 had shown more kinds of organisms in postmonsoon indicating availability of food and decreased resistance in this period. The decreased values at S2 in monsoon, indicates dilution and increased resistance.

N1

This is the number of species that one might see during leisure walk. The higher number ultimately indicates the healthy ecosystem. The present study reveals that the number of phytoplankton species encountered during premonsoon and postmonsoon is almost same than that of monsoon (Table 2). The maxima were at S4 in postmonsoon and minima at S6 in monsoon (Table 1).

The average N1 for zooplankton was same in all the season. However, very few groups were seen at S6 during monsoon. The controversial views are given from zooplankton and phytoplankton N1 number where N1 of phytoplankton indicates the site to be fairly richer whereas that of zooplankton indicate it to be poor in variety. The fall in monsoon season at especially S6 (Table 2) can be correlated with the facts that there might be washing of zooplankton from this site as the site receives direct sewage which had heavy flow during this season. The quantitative evaluation indicated S6 having only rotifers and copepods in this season (Gurav 2009).

N2

This can be interpreted as the number of species one might see with a quick walk through the community. More the number of species, healthier the system is. The present study reveals that S2 had greater N2 in premonsoon period. Comparatively, lesser N2 is seen at S4 in monsoon period (Table 2). The site S2 was always clear and had steady flow because of which the variety of phytoplankton is seen at this site.

For zooplankton also the site is showing good variety. The overall observations indicated that the upstream sites i.e. S1 to S3 have fair number of species than the downstream sites, S4 to S7 (Table 1). However, zooplankton had shown less variety in monsoon period at S6.The reason for N1 is also applicable here. The average N2 of all sites showed little lesser number in postmonsoon period at downstream site.

Simpson Index

The number indicates the chances of two species picked up randomly belong to the same category. The higher number indicates that two species picked are equally abundant. More the number, less is the diversity and vice versa. The present study indicates, forphytoplankton, the λ was minimum at S4 in post monsoon period and maximum at S7 in the same period. The maxima of S7 for phytoplankton in postmonsoon may indicate the water rich in nutrients and having few kinds of organisms frequently. The comparison of above indices of S4 also indicated that the diversity is good at this site in postmonsoon period. This is due stagnancy of water and clear sky.

In case of zooplankton, minima was at S7 in monsoon and the maxima was in premonsoon but at S3 (Table 1).Minima at S7 indicates is due to the varieties those were available in the month of July before the water was completely diluted (Gurav 2009)

Shannon index

It is a measurement that accounts for the richness and the percent of each species from a biodiversity sample within a local aquatic community. The index assumes that the proportion of individual in an area indicate their importance to diversity. It is heavily weighted towards the most abundant species in the sample which being less sensitive to species richness.H’ less than 3 and more than 1 indicates moderate pollution and value less than 1 indicates severe pollution.

The present study indicates the values between 1 and 2 for phytoplankton in all seasons indicating moderate pollution. The minima of 0.99 were seen at S2 in monsoon period (Table 1). Though it is so, the site cannot be said as polluted as the lesser number or evenness is due to increased flow of water and dilution in monsoon.The quantitative studies also revealed the same fact for the site. The maxima were 2.06 at S4 in postmonsoon. All the above indices have shown the better diversity at this site in post monsoon which is the outcome of decreased flow, availability of plenty of light and nutrient.

In case of zooplankton, the minimum index was 0.41 at S6 in monsoon period and maxima was 1.29at S2 in the pre and post monsoon(Table 1) where the water always had been clear and suitable for the growth of plankton during these periods. The reasons stated for S6 are applicable here also.

Species Richness Indices

Margalef’ index (d1)

This index standardizes the number of species encountered against total number of individuals encountered.

The fall in the value of the index shows rise in the level of pollution (Goel, 2006).

The minimum values for phytoplankton was 0.87 at S1 in monsoon and the maximum of 3.07 at S4 in postmonsoon period. The higher value of 3.07 was at S4 with reason of reduced flow and availability of nutrients.

For zooplankton, the minimum of 0.26 was at S6 in monsoon and maxima 1.39 at S1 in postmonsoon. The increased intensity of light with elevated temperature must have stimulated the reproduction in zooplankton. The overall look indicated that S6 had comparatively lesser values of diversity in all seasons (Table 3).The monsoon period has shown overall fall in the index.

Menhinick's index (d2)

Similar to Margalef's Index, the Menhinick's Index weight tries to standardize the number of species by the number of individuals encountered. The minima of 0.01 for phytoplankton was seen at S5, S6 and S7 in premosoon indicating dominance of pollution tolerant species (Table 1). The maxima of 0.07 were at S1 in post monsoon similar to Margalef's index and S3 in monsoon.

For zooplankton, the minima of 0.01 were seen at S4 in premonsoon again indicating the dominance of few organisms. The qualitative study has indicated very high number of rotifers at S1 in the month of April (Gurav 2009).). The maxima were 0.1 at S2 and S3 in monsoon. The qualitative ananlysis also indicates variety of groups of organisms in this season which could be due to less pollution and decreased feeding pressure. Though rainy, as the sights are not slopy, the water flow is tranquil which allowed the plankton to grow without having resistance caused due to waterflow.

Odum's index (d3)

It gives the idea regarding number of species per thousand litres. For phytoplankton, the minima of 0.01 were again at S5, S6 and S7 (Table 2). The maximum 1.57 was at S2in premonsoon indicating more variety.

For zooplankton, minima of 0.07 were at S4 in premonsoon. The maxima 3.17 at S2 in monsoon (Table 3). As stated the condition for d1, the conditions are applied here also.

Conclusion

All the indices were found to be more reliable indicating the water quality. From the summary of all indices it is concluded that the S2 is more clear and diverse whereas S6 is less diverse and polluted. Some controversial observations must be justified with the situations. The river is good and productive. It should be preserved and managed properly.

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