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Algal Indices as a Biomonitoring Tool to Assess Eutrophication in the Urban Ponds: a Case Study

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ABSTRACT: Eutrophication of the urban water bodies is one the biggest challenge causing severe ecological and economic loss. Urban ponds are more prone to eutrophication due to their small size and polluted catchment areas. Biomonitoring using phytoplankton provides cost-effective estimation of the level of eutrophication. Ten urban ponds in different areas of the Mumbai city were chosen to investigate the phytoplankton community structure, and level of eutrophication. We assessed the 3 algal indices *viz.* Shannon-Wiener indices, Palmer and Nygard's (Myxophycean and diatom) indices. Linear relationship of these indices was tested against Carlson trophic state indices in order to assess the effectiveness of these indices to measure the degree of eutrophication in urban lakes. All ten lakes were found to be eutrophic, of which two were very low eutrophic (TSI – 53.74-53.95), four were low-mid eutrophic (TSI – 55.18 – 57.5), and four lakes were mid eutrophic (TSI 61.4 – 62.2). Shannon-Wiener indices (r= -0.73) and Myxophycean indices (r= 0.77) showed strong correlation with TSI whereas Diatom indices (r= -0.12) and Palmer’s Algal Pollution Indices (r= - 0.47) showed weak correlation with TSI. Thus study found that Shannon-Wiener indices and Myxophycean indices are reliable and cost effective means to assess the eutrophication of urban ponds in Mumbai.

Keywords: Urbanization, Biomonitoring, phytoplankton, urban ponds, eutrophication.

INTRODUCTION

Freshwater is a most fundamental and irreplaceable natural resource. Sustainable management of freshwater resources is one of the greatest concerns for the world, particularly in developing countries. Freshwater ecosystems around the world are being severely damaged by anthropogenic activities (Alam et al., 2017; Brill et al., 2017; Oliver et al., 2019).Urban population are not directly dependent on the ponds for water supply and therefore, subject of apathy and neglect. Urban ponds provide ecological, social and economic services ranging from recharging groundwater, flood control, supporting biodiversity, microclimate regulation and asthetic etc. (Haase, 2013;Hill et al., 2017; McInnes & Everard, 2017). Eutrophication is major water quality challenges that diminish the ability of urban ponds to provide these services (Ferreira et al., 2011; Srinivasan et al., 2013; Usharani & Keerthi, 2020).

Regular water quality monitoring is essential step towards formulating conservation strategies for urban lakes (Murphy et al., 2019; Singh et al., 2018). Biomonitoring is reliable and economical means of water quality monitoring (Kohlmann et al., 2018; Pham, 2020). Phytoplankton due to their small size and

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ability to provide strong response to environmental changes are being routinely used for biomonitoring especially for trophic state of the water (Allende et al., 2019; Wu et al.,2017).Multiple algal indices have been developed to assess the water quality. For reliable results indices are required to be tested for ability to provide linear response for the water quality parameter to be monitor (Arab et al., 2019; Cupertino et al., 2019; Tang et al., 2013). We assessed the effectiveness of 3 algal indices *viz.* Shannon-Wiener indices, Palmer and Nygard's indices to assess the degree of eutrophication in term of tropic state of the pond water. Linear relationship of these indices was tested with Carlson trophic state indices.

MATERIALS AND METHODS

Mumbai is the financial capital of India located at the western coast of the country. It is one of the biggest cities in world in terms of population and population density (Sansare & Mhaske, 2020). Ten ponds were selected randomly and are located in the southern, eastern and western parts of the city. All are man-made ponds constructed to provide water in the city. Description of the ponds is provided in Table no. 1.

Table 1. Descriptions of the lakes selected for study.

Sr. No.	Name of Lake	Area (m^2)	Latitude	Longitude	Usage
1	Bandra	23664	19°3' 18.86" N	72° 49' 50.91" E	Recreational
2	Banganga	2386	18°56'43.72" N	72° 47' 37.24" E	Recreational
3	Powai	1636605	19°07'48.0" N	72°54'36.00" E	Recreational, irrigation, fishing
4	MNP lake	2861	19°03'10.84" N	72° 51' 48.52" E	Rain water harvesting, irrigation
5	Madh island	3436	19º08'24.35" N	72°47'31.63" E	Washing, Bathing, irrigation
6	Sheetal	10748	19º05'2.45" N	72º52'54.48" E	religious rituals, idol immersion
7	Sion	4831	19º02'50.38" N	72º51'57.65" E	Temple pond, religious rituals
8	Shyamnagar	4043	19º08'17.74" N	72º51'47.64" E	recreational
9	Paskal	4100	19º08'46.52" N	72º47'56.38" E	Washing, Bathing, irrigation
10	Arey pond	20426	19° 09' 40.90" N	72° 52' 17.63" E	Recreational, irrigation, fishing

Surface water samples were collected monthly during April 2016 – March 2018 at ten sampling stations. All sampling was done in the morning between 6-8 am and all ponds were covered in 2 consecutive days to reduce the impact of weather induced changes in samples. Eutrophication level was measured by following Carlson trophic state indices (1977). Physical-chemical analyses of water were done following standard methods as per American Public Health Association (APHA, 2005). Concentration of chlorophyll-a in water was measured by 90% acetone extraction method (Jeffrey et al., 1997). Secchi disks (SD) with 0.3 m diameter was used to measure water transparency was measured using Concentrations of total phosphorus (TP) and total nitrogen (TN) were determined colorimetric methods. Trophic state indices (TSIs) were calculated by averaging the four parameters. Phytoplankton samples were collected by filtering 60 l water collected from 5 different spots in the lake through plankton net with a mesh size of 25 μm. All samples were preserved in Lugol’s iodine solution and analysed using Sedgwick-Rafter cell counter (50 x 20 x 1 mm) as described by Eaton et al., (2005).From the qualitative and quantitative analysis of the plankton Nygaard’s indices, Palmer’s pollution indices and Shannon-Wiener indices were calculated to qualify the water quality of the water bodies.

RESULTS AND DISCUSSION

Seasonal change in the trophic state of pond water was determined by Carlson Trophic

State Indices (TSI). All the lakes were found to be eutrophicated in all the seasons. Arey (avg TSI- 53.74) and MNP (avg TSI- 53.95) ponds were low eutrophic four pond were low-mid eutrophic (avg TSI – 55.46 – 57.5), and four ponds were mid eutrophic (TSI 61.4 – 62.2). Powai lake was found to be the most eutrophicated lake. Degree of eutrophication was slightly higher in summer as compared to other seasons in most of the lakes (Fig 1).Degree of eutrophication was lower in monsoon season. Ray et al., (2020) and Yin (2002) has reported similar seasonal fluctuations in eutrophication level due to dilution and flushing of nutrients due to monsoon rains.

Shannon-Wiener indices (1949) are widely used tool to measure biodiversity and ecological health of habitat. Eutrophication reduces the diversity (Glibert et al., 2018). Therefore, it is routinely used for assessing water quality (Sakset & Chankaew, 2013). When the value of Shannon-Wiener indices is greater than 3 it indicates clean water, 1 to 3 is an indicator of the moderate level of pollution whereas less than 1 is considered as heavily polluted water body (Spellerberg et al., 2003; Ranjit, 2015).

Shannon diversity indices of all the lakes ranged between 0.98 (Powai lake) to 2.51 (MNP pond) indicating low to mid level of pollution. In most of the ponds (7 out of 10) phytoplankton diversity was highest in winter and summer season and least in monsoon season. Lowest Shannon values were reported from Powai lake in all the seasons (0.9 in monsoon, 1.13 in winter and 1.11 in summer) (Fig. 2). Strong negative correlation (r= -0.721) of Shannon diversity indices and TSI was recorded.

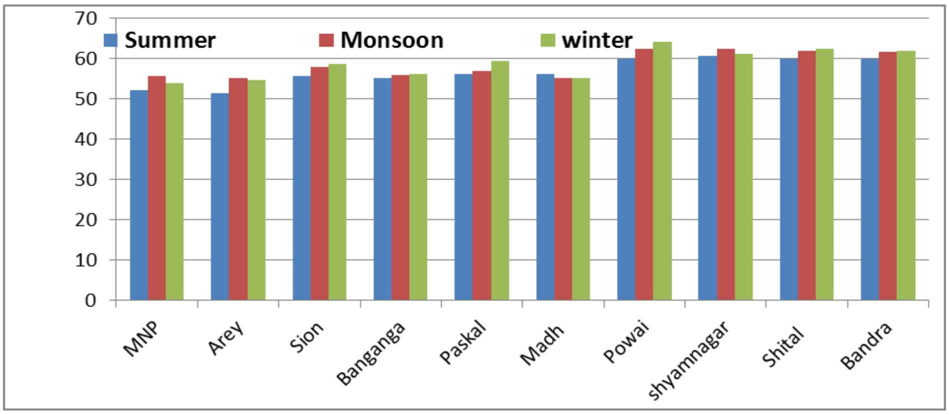

Fig. 1. Values of Carlson Trophic State Indices (TSI)

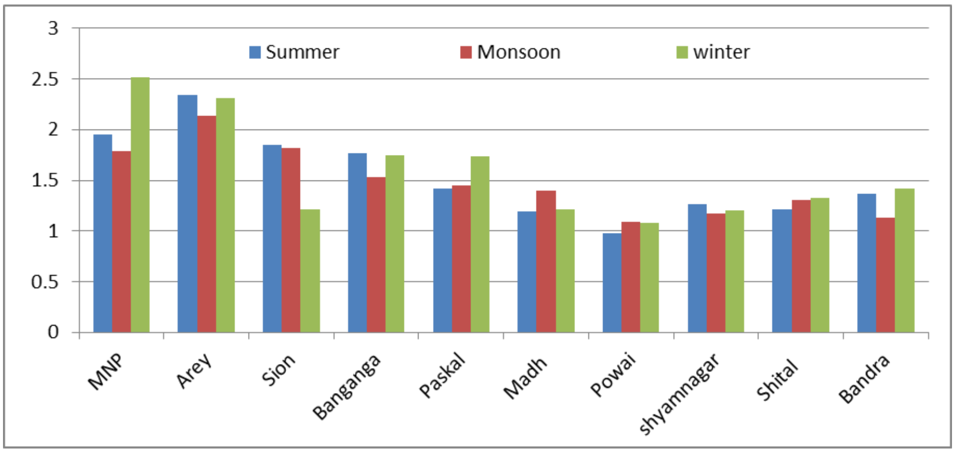

Fig. 2. Values of Shannon-Wiener indices for phytoplankton diversity.

Palmer (1969) and Nygard (1976) pollution indices based on algal genus and species that are tolerant to different level of organic pollution. These indices have been verified by researcher as useful analytical tools for assessing trophic conditions (Ajayanand & Ajit Kumar,2017;Çiçek & Yamuç, 2017;Ghaderpoori, 2018; Kar et al., 2018).When values of Palmer indices are 10-15 indicate moderate organic pollution, 15-20 moderate to high pollution and values above 20 indicate high organic pollution (Salem et al., 2017).

Palmers algal indices values ranged in between 17 to 23 indicating moderate to high eutrophication. The highest value was reported from Powai (23) lake in summer, whereas the lowest from Banganga (17) lake in winter (Fig 3). Insignificant correlation (r = -0.47) recorded between values of TSI and Palmer indices. Palmer's pollution (genera) indices were found to be a not useful bio indicator tool to assess the degree of eutrophication of urban lakes in Mumbai.

Nygaard indices are composed of five indices to evaluate the trophic status of lakes. It measures the ratios of indicator planktonic algal groups present in water. These indices are Chlorophycean indices, Cyanophycean or Myxophycean indices, Bacillariophyceaean indices, Euglenophycean indices and a combination of these indices is called compound coefficient indices (Chakraborty et al., 2010; Zębek & Napiórkowska-Krzebietke, 2016). Chlorophycean, Euglenophcean and compound indices were not calculated due to the absence of algae belonging to chlorococcales group in the samples.

Myxophycean indices ranged from 1.4 to 12, inferring eutrophicated status of all the lakes. Highest values were recorded from Powai Lake (12 in summer). Lowest values were recorded in Arey (1.2 in winter and monsoon) and MNP (1.3 in winters) ponds. Myxophycean indices values showed clear seasonal variation. Values were recorded higher in 9 out of 10 ponds (Fig. 4) Myxophycean indices values showed strong positive correlation (r= 0.76) with TSI. Values of diatom indices were found to inconsistencies with no clear trends (Fig 5). Values of diatom indices showed very weak correlation (r = - 0.12) with TSI. Hence diatom indices.

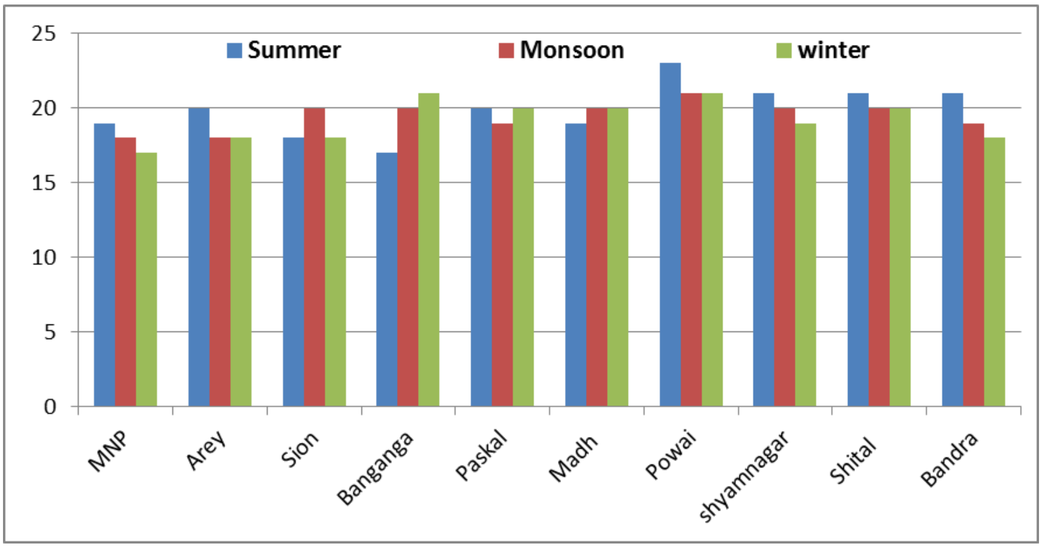

Fig. 3. Values of Palmer indices

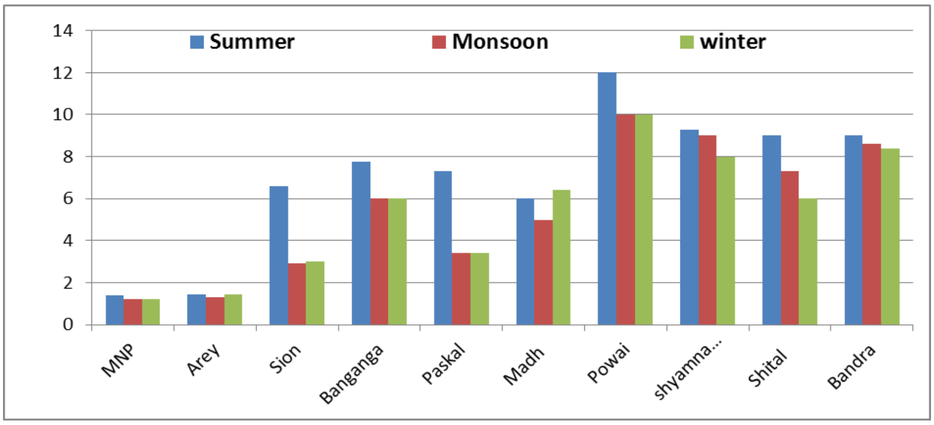

Fig. 4. Values of Myxophycean indices

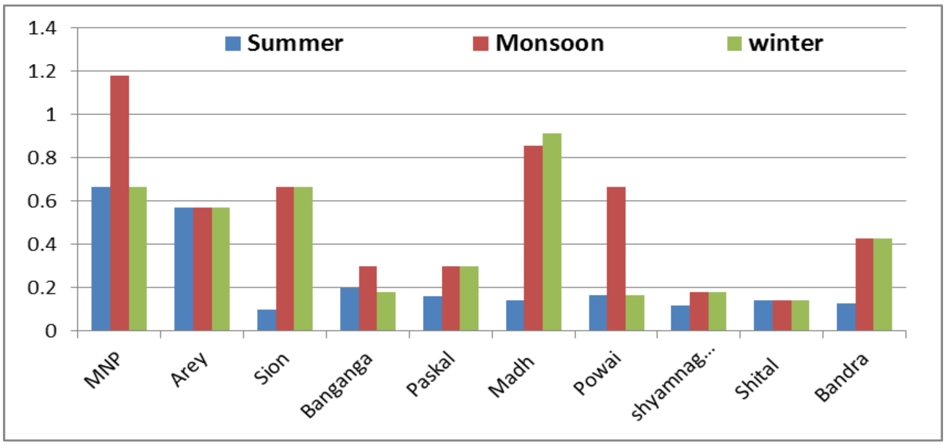

Fig. 5. Values of Diatom indices

CONCLUSION

Present study concludes that all the 10 ponds studied were eutrophicated in nature. Arey and MNP ponds were very low eutrophic, Sion, Banganga, Paskal and Madh ponds were low-mid eutrophic and Powai, Bandra, shyamnagar and Shital ponds were mid eutrophic. Shannon-Wiener indices and Myxophycean indices could be used as reliable biomonitoring tools for monitoring trophic status of urban ponds in Mumbai.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interests regarding the publication of this manuscript.

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The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. Also, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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