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Use of Algae as a Bioindicator to Determine Water Quality of River Mula from Pune City, Maharashtra (India)

Ayodhya D. Kshirsagar[1,2,*]

1. Department of Botany, University of Pune, Pune – 411 007, (M.S., India)
2. Department of Botany, C. T. Bora College, Shirur, Pune – 412 210, (M.S., India)

*** Corresponding author: drayodhya11@gmail.com**

Abstract:

The algal samples were collected monthly from selected three sampling stations of river Mula at Pune city from October 2007 to September 2008. Total of 162 species belong to 75 genera of algae were recorded from three sampling stations throughout the study period. In present study Palmer, (1969) Algal Genus Pollution Index and Algal Species Pollution Index were employed to study the water quality of river Mula. The total score of Algal Genus Pollution Index of station I, II and III were 19, 37 and 42 respectively. While total score from the Algal Species Pollution Index at station I- 9, station II – 31 while at station III- 34 recorded from river Mula, Pune. The total score of each station was greater than 20 indicating the confirmed high organic pollution. Considering all the water parameters and pollution index it was clearly shown that the sampling stations II and III were highly polluted than station I. The results of the present study revealed that the surface water quality was affected from domestic uses at the downstream of the river. Thus, algal communities were used as bioindicator of organic pollution of river Mula, Pune.

Keywords: Algae, bioindicator, Mula river, pollution, pollution index, Pune

1.0 Introduction:

Due to constant growth of population, technological and industrial progress the nature of aquatic environment undergoes numerous changes and deteriorating its quality. In urban area, water pollution problems always influence the biological imbalance are both qualitatively and quantitatively. Bioindicator are taxa or groups of organisms that show signs that they are affected with environmental pressure because of human activities or the destruction of biotic system (McGeoch, 1998 and Shahabuddin, 2003). The major groups of organisms that have been used as indicators of environmental pollution include bacteria, fungi, protozoa, algae, higher plants, macro invertebrates and fish. The presence or absence of the indicator organisms reflects aquatic environmental conditions. Therefore to conserve valuable resources from further deterioration there is a need for regular monitoring of the river.

Algae are involved in water pollution in a number of important ways. Due to the enrichment of inorganic phosphorous and nitrogen is responsible for the growth of algae in water bodies. Research in the freshwater ecology of algae related to water pollution is sparse, and it is necessary of detailed study for searching indicator species. The uses of algal communities correlating water pollution (Sonneman*et al.,* 2001). Algae are one of the most rapid bioindicator of water quality changes due to their short life spans, quick response to pollutants and easy to determine their numbers Plafkin*et al.,* (1989).

Mula is considered to be the lifeline of the Pune city. Recently there have been concerns over the water quality of the river Mula from Pune city. The Mula water is used for bathing, drinking, irrigation and industrial purposes. Due to increasing urban and industrial activity that influence on the water quality of Mula river. The issue is increased nutrients and the impacts of municipal waste water effluents on the biological community and water quality. The water quality assessment based on algae used as bioindicator, paying special attention to river Mula.

A great deal of research work has been done mainly with the growth of algae in polluted and

non polluted waters of river Mula from Pune city. Gunale and Balkrishanan (1981) carried out study on the freshwater ecology of algae related to water pollution and it is necessary of detailed study for searching indicator species were used for water quality studies on Pavana, Mula and Mutha river flowing through Pune city, indicating that certain algal group were indicative of level of organic enrichment. Gunale,(1982)emphasized mainly on Biomonitoring of eutrophication in Pavana, Mula and Mutha river flowing through Pune city.

In present study Palmer, (1969) Algal Genus Pollution Index and Algal Species Pollution Index were employed to study the water quality of river Mula from Pune city. A list of most pollution tolerant genera and species according to Palmers index were calculated for all sampling stations. A pollution index factor was assigned to each genus and species by determining the relative number of total points scored by each alga. The pollution status of sampling stations of river Mula was determined based on their index. This water pollution index is used for detection and evaluation of water pollution. The purpose of this study is to know the use of algae as bioindicator to determine the quality of river Mula.

2.0 Material and Methods:

2.1 Studied area:

Pune is located 560 m above MSL (18^0 31' N, 73^0 51' E) and on the western margin of the Deccan Plateau spread on the banks of the rivers Mula and Mutha. The river Mula originates along the Western Ghats, Maharashtra, India. The Mula enters in the Pune metropolitan's area near Wakad and it merges with the river Mutha in the Pune city.

2.2 Sampling stations:

For present study, Mula river water were collected from three sampling stations between upstream at Wakad and downstream at Dapodi in Pune city on the basis of drainage pattern and activities in its catchment (Figure 1), Station I (Wakad), Station II (Aundh) and Station III (Dapodi).

2.3 Collection and analysis of algal sample:

The water samples for algal analysis were collected monthly from October 2007- September 2008 at the selected sampling stations I, II and III. Palmer (1969) proposed a pollution index based on algal genus and species used in the rating water sample for high or low organic pollution. The pollution tolerant genera and species of algae were recorded from selected sampling stations. A list of most pollution tolerant genera and species according to Palmers index were calculated for all sampling stations. A pollution index factor was assigned to each genus and species by determining the relative number of total points scored by each alga. The pollution status of sampling stations of river Mula was determined based on their index as shown in Table 1 and Table 2. Identification were done using standard keys of algae by, Smith 1950; Prescott 1951; Desikachary 1959; Randhawa 1959; Ramnathan 1964; Sarode and Kamat 1984.

3.0 Result and Discussion:

Palmer, (1969) made the first attempt to identify and prepare a list of genera and species of algae tolerance to organic pollution. He prepares a list of 60 genera and 80 species tolerant to organic pollution. According to Palmer, scores of 20 or more are indication of high organic pollution. The pollution tolerant genera and species belonging to four groups of algae from three stations of Mulariver were recorded. Totally all 45 genera and 33 species are recorded in Table 3 and Table 4.

The use of algae as biological indicators of pollution has been studied by rating pollution tolerant algae in the rivers based on the report of Palmer, (1959).Total of 75 genera and 162 species of algae were recorded from three sampling stations of the river Mula(Kshirsagar*et al*., 2012). The algae from station II and station III were indicated the highest degree of organic pollution (Kshirsagar and Gunale, 2011; Kshirsagar*et al.,* 2012) shows the dominance of *Chlorella*, *Scenedesmus*, *Pediastrum*, *Oscillatoria*, *Melosira*, *Navicula*, *Nitzschia*, *Gomphonema*, *Euglena* etc throughout the study, which considered to be indicators of organic pollution. The similar observations were encountered by Hosmani and Bharti, (1980); Trivedi, (1988); More and Nandan, (2000). Palmer, (1980) stated *Scenedesmus* indicate eutrophic water.

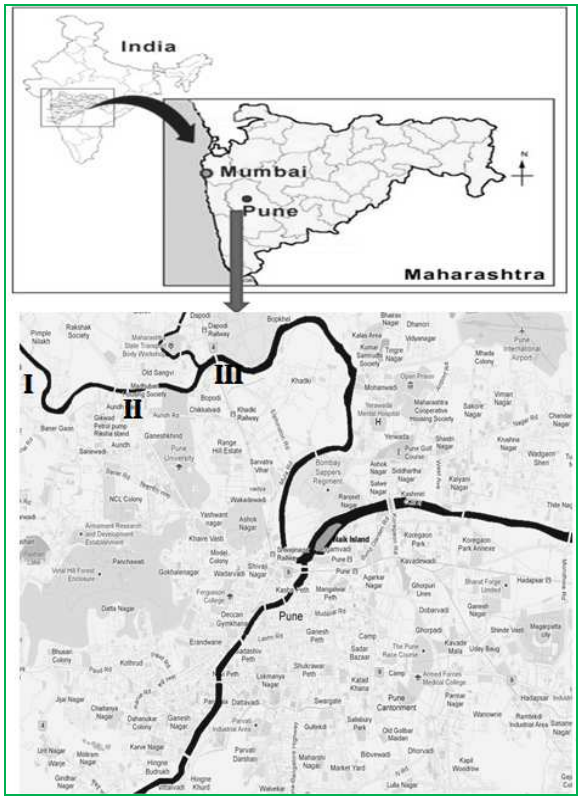

Figure 1: Map showing geographical localities of sampling stations (station I, II and III). Map is only representative and distances are not to the scale

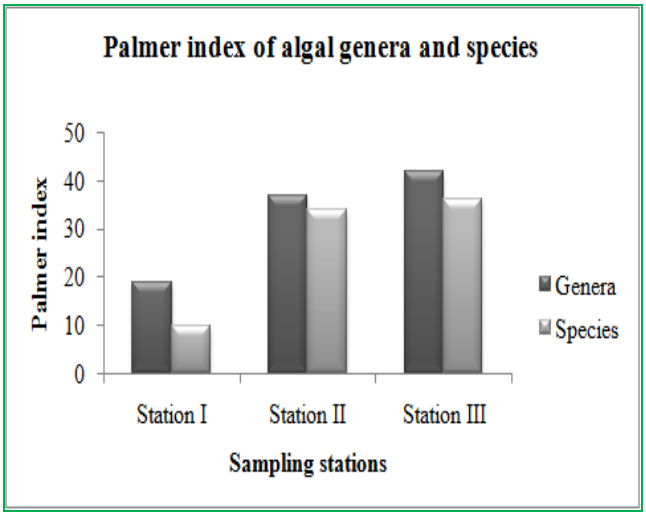

Figure 2: Pollution index score of algal genera and species at selected sampling station of Mula river for the period of October 2007 to September 2008.

Table 1: Algal genus pollution index (Palmer, 1969).

Genus	Pollution index	Genus	Pollution index
Anacystis	1	*Micractinium*	1
Ankistrodesmus	2	*Navicula*	3
Chlamydomonas	4	*Nitzschia*	3
Chlorella	3	*Oscillatoria*	5
Closterium	1	*Pandorina*	1
Cyclotella	1	*Phacus*	2
Euglena	5	*Phormidium*	1
Gomphonema	1	*Scenedesmus*	4
Lepocinclis	1	*Stigeocloniu m*	2
Melosira	1	*Synedra*	2

Following numerical values for pollution classification of Palmer (1969),
0-10= Lack of organic pollution
10-15= Moderate pollution
15-20= Probable high organic pollution
20 or more = Confirms high organic pollution.

By using Palmer's index of pollution for rating of water samples as high or low organically polluted at three stations of river Mula were tested. The present study showed 19 pollution tolerant genera were found at all sampling stations of river Mula of which Chlorophyceae comprised 8, Cyanophyceae 2, Bacillariophyceae 6 and Euglenophyceae 3 genera (Table 5). The total score of Algal Genus Pollution Index of station I, II and III were 19, 37 and 42 respectively (Table 5 and Figure 2). While total score from the Algal Species Pollution Index at station I- 9, station II – 31 while at station III- 34 recorded (Table-6 and Figure 2). Thus, it was observed that, the higher score for Palmer index at station II and III indicating high organic pollution. While the total scores of station I was less than 20 indicating probable moderate organic pollution.

Table 2: Algal species pollution index (Palmer, 1969).

Algal species	Pollution Index
Ankistrodesmusfalcatus	3
Arthrospirajenneri	2
Chlorella vulgaris	2
Cyclotellameneghiniana	2
Euglena gracilis	1
Euglena viridis	6
Gomphonemaparvulum	1
Melosiravarians	2
Naviculacrptocaphala	1
Nitzschiaacicularis	1
Nitzschiapalea	5
Oscillatoria chlorine	2
Oscillatorialimosa	4
Oscillatoriaprinceps	1
Oscillatoria putrid	1
Oscillatoriatenuis	4
Pandorinamorum	3
Scenedesmusquadricauda	4
Stigeocloniumtenue	3
Synedra ulna	3

Following numerical values for pollution classification of Palmer (1969),
0-10 suggests lack of organic pollution
11-15 indicated moderate pollution
16-20 indicates probable high organic pollution
21 or more confirm high organic pollution.

Palmer's (1969) has shown that the genera like *Oscillatoria*, *Euglena*,*Scenedesmus*,*Chlamydomonas*,*Navicula*, *Chlorella*,*Nitzschia* and *Ankistrodesmus*were found in organically polluted water supported by Ratnasabapathy, (1975) Gunale and Balakrishnan, (1981); Goel*et al*.,(1986); Jafari and Gunale, (2006); Sanap, (2007). Similar genera were recorded in the present study. The occurrence of *Oscillatoria*, *Euglena*, *Chlorella*,*Scenedesmus*,*Gomphonema* and *Melosira*were recorded repeatedly and consider as indicators of pollution in view of the results of Palmer pollution index. *Oscillatoria*was found to be the most active participant in all stations may be the good indicators of contaminated water bodies similar observation recorded by Das *et al*., 2007 and Rai*et al*., 2008. Palmer, (1969), the genus *Euglena* tops the list of his sixty most tolerant genera of pollution. *Crucigenia*,*Dictyosphaerium*,*Achnanthes*,*Golenkini a*recorded at station III. *Stigeocloniumtenue*,*Oscillatorialimosa*,*Oscillatoriat enuis*,*Nitzschiapalea*indicates highly eutrophicated water bodies (Patrick, 1972; Gunale and Balakrishnan, 1979).

The degree of organic pollution was increased at station II and III of Mulariver and it is confirmed by using Palmer's index. This index suggests eutrophic conditions in Mulariver. Algae encountered from the river Mula reflects the eutrophic condition and therefore, may be used as an indicator of water quality. The waters of Mulariver, showed number of genera and species like *Oscillatoria*, *Euglena*,*Scenedesmus*,*Pediastrum*, *Chlorella*,*Navicula*,*Nitzschia*,*Stigeoclonium*,*Synedra* and *Melosira*were recorded repeatedly and consider as indicators of pollution in view of the results of Palmer pollution index. Whereas *Oscillatoria*, *Euglena*,*Scenedesmus*, *Chlorella*,*Melosira*were dominant can be used as pollution tolerant algae. Patrick, (1965) concluded that *Euglena* and *Oscillatoria* are highly pollution tolerant genera and therefore, reliable indicators of Eutrophication.

Table 3: Pollution tolerant genera of algae from three stations of river Mula from Pune city in order of decreasing emphasis (Palmer, 1969).

Sr. No.	Name of algal Genera	Group	Total points	Stations		
				I	II	III
1.	*Euglena*	F	172	-	+	+
2.	*Oscillatoria*	B	161	+	+	+
3.	*Chlamydomonas*	F	115	-	-	+
4.	*Scenedesmus*	G	112	+	+	+
5.	*Chlorella*	G	103	+	+	+
6.	*Nitzschia*	D	98	-	+	+
7.	*Navicula*	D	92	+	+	+
8.	*Synedra*	D	58	-	+	+
9.	*Ankistrodesmus*	G	57	-	+	+
10.	*Phacus*	F	57	-	+	+
11.	*Phormidium*	B	52	-	+	-
12.	*Melosira*	D	50	+	+	+
13.	*Gomphonema*	D	48	+	+	+
14.	*Cyclotella*	D	47	-	+	+
15.	*Closterium*	G	45	+	+	+
16.	*Micractinium*	G	44	-	+	+
17.	*Pandorina*	F	42	+	+	+
18.	*Microcystis*	B	39	-	+	+
19.	*Lepocinclis*	F	38	-	+	+
20.	*Spirogyra*	G	37	+	+	-
21.	*Anabaena*	B	36	-	-	+
22.	*Pediastrum*	G	35	+	+	+
23.	*Arthrospira*	B	34	+	-	-
24.	*Trachelomonas*	F	34	+	+	-
25.	*Fragilaria*	D	33	+	+	+
26.	*Ulothrix*	G	33	-	-	+

27.	*Surirella*	D	33	-	+	+
28.	*Eudorina*	F	30	-	+	+
29.	*Lyngbya*	B	28	-	+	+
30.	*Oocystis*	G	28	-	-	+
31.	*Spirulina*	B	25	-	+	+
32.	*Cymbella*	D	24	+	+	+
33.	*Actinastrum*	G	24	+	+	-
34.	*Coelastrum*	G	24	+	+	+
35.	*Hantzschia*	D	23	-	+	+
36.	*Golenkinia*	G	19	-	-	+
37.	*Achnanthes*	D	19	-	-	+
38.	*Pinnularia*	D	18	-	+	+
39.	*Chlorococcum*	G	17	-	-	+
40.	*Asterionella*	D	17	-	+	-
41.	*Cocconeis*	D	17	+	-	-
42.	*Cosmarium*	G	17	+	+	+
43.	*Selenastrum*	G	15	-	+	+
44.	*Dictyosphaerium*	G	14	-	-	+
45.	*Crucigenia*	G	14	-	-	+

Key: + = present - = absent

Table 4: Pollution tolerant species of algae from three stations of river Mula from Pune city in order of decreasing emphasis (Palmer, 1969).

Sr. No.	Name of algal Species	Group	Total points	Stations		
				I	II	III
1.	*Nitzschiapalea*	D	69	-	+	+
2.	*Oscillatorialimosa*	B	42	-	+	+
3.	*Scenedesmusquadricauda*	G	41	-	+	+
4.	*Oscillatoriatenuis*	B	40	-	+	+
5.	*Stigeocloniumtenue*	G	34	-	-	+
6.	*Synedra ulna*	D	33	-	+	+
7.	*Ankistrodesmusfalcatus*	G	32	-	+	+
8.	*Pandorinamorum*	G	30	+	+	+
9.	*Chlorella vulgaris*	G	29	+	+	+
10.	*Cyclotellameneghiniana*	D	27	-	+	+
11.	*Oscillatoriaprinceps*	B	24	-	+	+
12.	*Hantschiaamphioxys*	D	23	-	+	+
13.	*Oscillatoriachalybea*	B	22	+	+	+
14.	*Euglena oxyuris*	F	21	-	-	+
15.	*Scenedesmusobliquas*	B	20	+	-	-
16.	*Chlorella pyrenoidosa*	G	20	-	+	+
17.	*Eudorinaelegans.*	F	20	-	-	+
18.	*Euglena acus*	F	20	-	+	+
19.	*Lepocinclis ovum*	F	19	-	+	+
20.	*Micractiniumpusillum*	G	18	-	+	+
21.	*Melosiragranulata*	D	18	+	+	+
22.	*Pediastrumboryanum*	G	18	-	+	+
23.	*Actinastrumhantzschii*	G	15	+	+	-
24.	*Synedraacus*	D	14	-	-	+
25.	*Cocconeisplacentula*	D	14	+	-	-
26.	*Coelastrummicroporum*	G	14	-	+	+
27.	*Achnanthesminutissima*	D	13	-	-	+
28.	*Scenedesmusdimorphus*	G	13	+	-	-
29.	*Navicula cuspidate*	D	12	-	+	+
30.	*Scenedesmusacuminatus*	G	12	+	-	+
31.	*Pediastrum duplex*	G	12	+	-	-
32.	*Trachelomonasvolvocina*	F	11	+	-	-
33.	*Dictyosphariumpulchellum*	G	9	-	-	+

Group: F: Flagellates, D : Diatoms, B : Blue greens, G : Greens.

Table 5: Pollution index of Algal genera according to Palmer, (1969) at three stations of Mulariver from Pune city.

Sr. No.	Algal genera	Pollution Index	Stations		
			I	II	III
	CHLOROPHYCEAE				
1	*Chlamydomonas*	4	-	-	4
2	*Pandorina*	1	1	1	1
3	*Chlorella*	3	3	3	3
4	*Ankistrodesmus*	2	-	2	2
5	*Scenedesmus*	4	4	4	4
6	*Micractinium*	1	-	1	1
7	*Closterium*	1	1	1	1
8	*Stigeoclonium*	2	-	-	2
	CYANOPHYCEAE				
9	*Oscillatoria*	5	5	5	5
10	*Phormidium*	1	-	1	-
	EUGLENOPHYCEAE				
11	*Euglena*	5	-	5	5
12	*Lepocinclis*	1	-	1	1
13	*Phacus*	2	-	2	2
	BACILLARIOPHYCEAE				
14	*Melosira*	1	1	1	1
15	*Cyclotella*	1	-	1	1
16	*Synedra*	2	-	2	2
17	*Navicula*	3	3	3	3
18	*Gomphonema*	1	1	1	1
19	*Nitzschia*	3	-	3	3
		Total Score	**19**	**37**	**42**

As a result we revealed algae sensitive to water pollution in the case of river Mula and these were; the algae from station II and III which were polluted water showed the dominance of *Scenedesmus quadricauda*, *Chlorella vulgaris*, *Oscillatoria limosa*and *Melosira granulate* throughout the year, which are considered to be indicators of organic pollution. Thus over all pollution index showed that at station II and III the river water showed confirms high organic pollution and station I suggests lack of organic pollution. It was supported by data of physico-chemical analysis of Mula river water during October 2007 to September 2008 (Kshirsagar and Gunale, 2011). Palmer, (1969) suggested that algae are reliable indicators of water pollution as it was true in present study.

Table 6: Pollution index of Algal species according to Palmer, (1969) at three stations of Mula river from Pune city.

Algal species	Pollution Index	Stations		
		I	II	III
Ankistrodesmus falcatus	3	-	3	3
Chlorella vulgaris	2	2	2	2
Cyclotella meneghiniana	2	-	2	2
Nitzschiapalea	5	-	5	5
Oscillatorialimosa	4	4	4	4
Oscillatoriaprinceps	1	-	1	1
Oscillatoriatenuis	4	-	4	4
Pandorinamorum	3	3	3	3
Scenedesmus quadricauda	4	-	4	4
Stigeoclonium tenue	3	-	-	3
Synedra ulna	3	-	3	3
	Total score	**9**	**31**	**34**

4.0 Conclusion:

Over all pollution index was showed that at station II and III the river water showed confirms high organic pollution and station I suggests lack of organic pollution. Palmer, (1969) suggested that algae are reliable indicators of water pollution as it was true in present study. Diversity change of algal communities (Palmer algal genus and species index) can be used to compare and classify the water quality of river Mula from Pune city. These pollution tolerant algae can be used for remediation of domestic wastewater.

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