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Biomonitoring the Health of Lake Mansar (Jammu), Using Phytoplankton

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Abstract: Phytoplankton investigation of a sub-tropical Lake Mansar has revealed a total of 92 species belonging to Chlorophyceae (57 spp.), Bacillariophyceae (20 spp.), Cyanophyceae (11 spp.), Dinophyceae (2spp.) and Euglenophyceae (2 spp.). Perennial Chlorophyceae was recorded to be the most occurred group throughout the study period. Palmer algal genus and species pollution index was used to monitor the health of Mansar Lake. The total scores of 36 for algal genus and 16 for algal species have shown organic pollution of the lake. Thus, phytoplankton can be considered as good bio-indicator for assessing the health of the Lake. Present observations showed that the lake is a highly productive water body, facing pollution problems and is approaching towards eutrophication due to the presence of high number of pollution indicator species of algae. Conservation strategies of the lake must take cognizance to protect it from further deterioration.

Keywords: Palmer Index • Bioindicators • Organic Pollution • Eutrophication • Conservation

Introduction

Geometric increase in human population coupled with rapid urbanization, industrialization, technological advancement and agricultural development has deteriorated the pristine nature of inland water bodies viz. lakes, wetlands, rivers etc. (Ibrahim and Nafi, 2017). Water pollution problems always impact the biological setup of water body both qualitatively and quantitatively. Bioindicators are taxa or groups of organisms that depict the environmental health due to human activities or the disturbances of its biotic system (Singh and Sharma, 2003; Bisht et al. 2019). The important groups of organisms that have been used as environmental pollution indicators include bacteria, fungi, algae, protozoa, higher plants, macro-invertebrates and fish. The presence and absence of the indicator organisms reflects the conditions of aquatic environment. Algae are one of the excellent bioindicators of water quality changes due to their short life spans and quick response to conditions (Plafkin *et al.*, 1993 and Singh and Sharma, 2018). Phytoplankton community is highly dynamic and has long been used as effective bioindicators of eutrophic water that is sensitive to environmental changes (Palmer, 1969; Chekryzheva, 2014 and Singh and Sharma, 2018). Species diversity and composition of the phytoplankton are used to assess the biological integrity of a water body (Sanet *et al.*, 2006). Phytoplankton use as bioindicators of pollution has been studied by rating pollution tolerant algae in a water body by Palmer, (1969) who attempted to identify and prepare a list of genera and species of algae tolerant to organic pollution. He made a list of 60 genera and 80 species tolerant to organic pollution and formulated the pollution index scale for assessment of organic pollution. Palmer pollution index (Palmer, 1969) score of 20 or more represents the high organic pollution. Biomonitoring is therefore a useful alternative tool for assessing the ecological quality of aquatic ecosystems. No sincere effort has been made by earlier workers to study role of algae as indicators in the Mansar lake. Therefore, it was felt worthwhile to undertake study on the monitoring phytoplankton as bioindicator for determination of environmental health of Mansar wetland of Jammu, in Himalaya foothills.

Materials and Methods

Study Area

Mansar lake (75^0 23′ 12″ E and 32^0 48′ 58″ N; elevation 666amsl) is heart shaped sub-oval, non-drainage type of fault basin is located in the Mansar village about 55Km east of Jammu city in District Samba (Fig. 1). Lake has surface area of about 0.58 km^2, circumference of 3.294 km and maximum depth, length and width of 38.25 m, 1204m and 645m, respectively (NIH, 1999; Chandrakiran and Sharma, 2011). Mansar lake is a closed basin situated in the hilly terrain surrounded by pine forest having cultivated fields and crematorium ground on the western bank, Nag temple, higher secondary school, bathing ghats and small market area towards the north-western side, pumping station and bus stand towards eastern side, habitation, guest house and market area towards south-eastern side and, Nag temple and Surinsar-Mansar Wildlife Sanctuary towards the southern side.

The present study on algal taxa was conducted from January 2014 to December 2015. Water samples from the littoral zone were collected on monthly basis from the Lake Mansar. 20 liters of water were filtered with the help of plankton net through a 55mm mesh size bolting silk and was allowed to settle down. The samples were preserved with 4% formaldehyde solution and 1 ml of lugol's solution. The phytoplankton analysis was performed with an inverted microscope (Sr. Biological Olympus Microscope CH 20i) using 10× 15× 40× and 100× objectives. The identification of phytoplankton species has been done by consulting standard literature in the form of keys, books and works (Prescott, 1956; Edmondson, 1992; Needham and Needham, 1962; APHA, 2005 and Bellinger and Sigee, 2010).

Palmer (1969) proposed a pollution index based on algal genus and species used for rating the water sample as low or high organically polluted. The pollution tolerant genera and species of algae were recorded from the lake. A list of most tolerant genera and species as per the Palmer index (1969) were calculated. A pollution index factor was assigned to each genus and species to determine the pollution index status of the Mansar Lake.

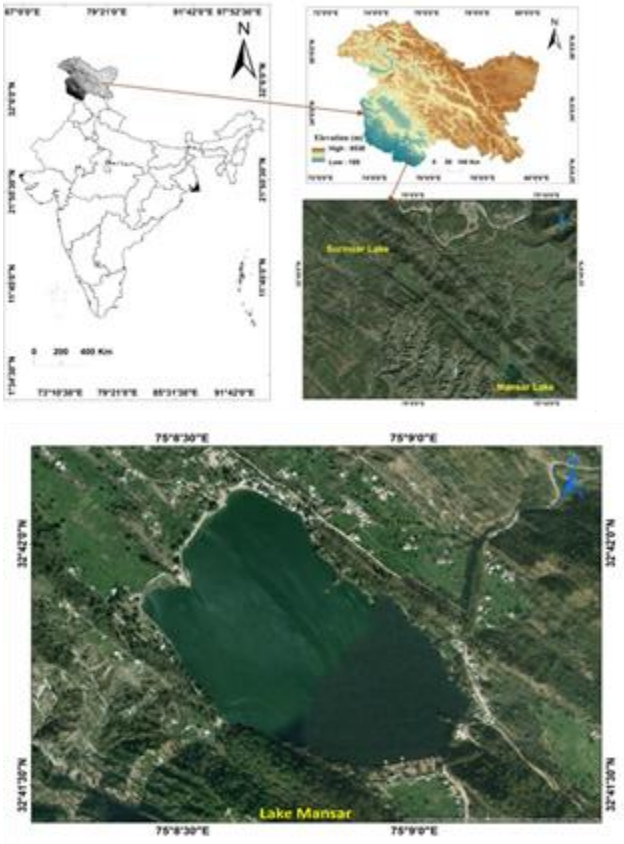

Fig. 1: Showing the location of the study area- lake Mansar

Results and Discussion

Qualitative composition

The present study recorded 59 genera belonging to 92 species from Lake Mansar (Fig.2 & Table-1). Qualitatively, among various classes, Chlorophyceae is represented by 57 species belonging to 32 genera, Bacillariophyceae 20 species belonging to 15 genera, Cyanophyceae by 11 species belonging to 9 genera, Euglenophyceae by 2 species of 2 genera and Dinophyceae by 2 species belonging to same genus.

Among the earlier studies carried out on this subtropical lake Mansar, Zutshi *et al.* (1980) reported 19 microphytic species belonging to Bacillariophyceae (9 spp.), Chlorophyceae (6 spp.), Cyanophyceae (3 spp.) and Dinophyceae (01 sp.); Sharma *et al.* (2007) reported 202 phytoplankton species belonging to

Chlorophyceae (131 spp.), Bacillariophyceae and Cyanophyceae (each 31 spp.), Euglenophyceae (7 spp.) and Dinophyceae (02 spp.) and Chandrakiran *et al.* (2014) reported 33 microphytic species belonging to Chlorophyceae (13 spp.), Cyanophyceae (11 spp.) and Bacillariophyceae (09 spp.).

The qualitative distribution of phytoplankton in Lake Mansar during the present investigation revealed that the lake is approaching towards eutrophication due to the presence of high number of phytoplanktonic species belonging to Class Chlorophyceae, Bacillariophyceae and Cyanophyceae. Such dominance in normal conditions in lentic water bodies in tropics and subtropics has been reported by Kant (1985), Sharma *et al.* (2007) and Chandrakiran *et al.* (2014).

The qualitative variations of phytoplankton classes in Mansar Lake indicated that these are richly manifested with phytoplankton. Seasonally, spring and post-monsoon phytoplankton high record may be attributed to high photoperiod and increase in water temperature. Whereas, short photoperiod and low temperature during winter may explain winter phytoplanktonic decline. Similar type of bimodal pattern in phytoplanktonic distribution have been recorded by Verma and Sharma (2009), Chandrakiran, *et al.* (2014) and Jindal *et al.* (2015). The qualitative studies from the littoral zones of Mansar lake reflect the idea that the waters in this wetlands is mesotrophic or between mesotrophic to eutrophic.

Table-1: Showing qualitative composition of phytoplankton taxa from Lake Mansar

Class Chlorophyceae			**Order Zygnematales**
S.No.	**Name**		
	Order Chlorococcales		
1	*Ankistrodesmus convolutus* Corda.	34	*Closterium acerosum* (Schr.) Ehr.
		35	*Closterium lenceolatum* Kutz.
		36	*Cosmarium awadhensis* Prasad & Mehrotra
2	*Ankistrodesmus falcatus* (Corda.) Rays	37	*Cosmarium obtusatum* Schmidle
3	*Actinastrum aciculare* Playfair	38	*Cosmarium phaselous* Breb.
4	*Chlorella conglomerata* (Artari) Oltmanns	39	*Cosmarium subcranatum* Nordst.
5	*Coelastrum microporum* Naegalii	40	*Cosmarium subtumidum* Nordst..
6	*Coelastrum phaselous* Berb	41	*Cosmarium ovatum* Nordst..
7	*Crucigenia quadrata* Morren	42	*Cosmarium undulatum* var. *minutum* Corda.
8	*Crucigenia triangularis* (Cord.) Schmidie	43	*Plueraotacnium trabecula* Naegalii
9	*Dictyosphaerium chlorelloides* Naegalii	44	*Penium minutum Cleve.*
10	*Golenkinia radiata* Chodat	45	*Staurastrum natator* W. & West
11	*Hydrodictiyon reticulatum* (Linn.) Legesh	46	*Staurastrum chaetoceras* (Schröder) G.M.
12	*Oocystis naegelii* A.Braun	47	*Spondylosium palnum* (Wolle) West
13	*Pediastrum duplex* Meyen	48	*Mougeotia recurva* (Hassael) De-toni
14	*Pediastrum ovatum* (Ehr.) A. Braun	49	*Mougeotia viridis* (Kurtz) Wittrock
15	*Pediastrum simplex* Mayen	50	*Mougeotia floridana* Trans
16	*Scenedesmus acuminatus* (Lagerh.) Chodat	51	*Spirogyra plena* (West) Czurda
17	*Scenedesmus armatus* (Cbod) Chodat	52	*Spirogyra reticulina* Randhawa
18	*Scenedesmus bijugatus* (Turpin) Kuetzing	53	*Spirogyra rivularis* (Hassall) Rabenh.
19	*Scenedesmus dimorphus* (Turpin) Kuetzing	54	*Sirocladium kumaoense* Randhawa
20	*Scenedesmus periforatus* Lemm. var. major Turner	55	*Sirogonium sticticum* Kutz.
21	*Scenedesmus prismaticus* Bruhl & Biswas	56	*Zygnema melanosporum* Lagerh.

22	*Scenedesmus platydiscus* (G.M. Smith) Chodat	57	*Zygnema indicum* Misra
23	*Schroederia indica* (Schroder) Lemmermann	**Class Bacillariophyceae**	
24	*Tetraedron incus* (Teiling) G.M. Smith		**Order Pennales**
	Order Chaetophorales	58	*Achnanthes lanceolata* (Breb.) Grun.
25	*Coleochaete soluta* (Breb.) Pringsch	59	*Amphora maharashtrensis* Sorde & Kamat
26	*Stigeoclonium farctum* Breth	60	*Amphora ovalis var. gracilis* V. Hureck
	Order Cladophorales	61	*Cocconeis placentula* Ehr.
27	*Cladophora glomerata (*L.) Kutz.	62	*Cymbella bengalensis* Grun.
	Order Oedogoniales	63	*Cymbella tumida* Breb.
28	*Bulbochaete gigantea* Pringsch	64	*Diatoma vulgaris* Bory
29	*Oedogonium nodulosum* Wittr.	65	*Fragilaria construens* (Ehr.) Grun.
	Order Ulotrichales	66	*Gomphonema constrictum* Ehr.
30	*Ulothrix elongatum* Hodgetts	67	*Gomphonema lanceolatum* (Her) F. Turris
31	*Ulothrix zonata (*Weber and Mohr) Kutz.	68	*Gyrosigma acuminatum* (Kutz.) Rabh.
	Order Volvocales	69	*Navicula cryptocephaloides* Hustedt.
32	*Pandorina morum (*Mull.) Bory	70	*Navicula similis* Krasske.
33	*Volvox globator* (L.) Ehr.	82	*Chroococcus turgidus var. maximus* Nygaard
71	*Nitzschia ovalis* Arnott	83	*Lyngbya aestuarii* Liebm.
72	*Nitzschia palea* Kutz.	84	*Merismopedia tenuissima* Lemm.
73	*Pinnularia subcapitata* Greg.	85	*Microcystis aeruginosa* Kutz.
74	*Surirella linearis* W. Smith var. festechi Pant	86	*Nostoc calcicola* Breb. ex Born et Flah
75	*Synedra acus var. radians* (Kutz.) Hustedt	87	*Oscillatoria curviceps* Ag. ex Gomont
	Order Centrales	88	*Spirulina gigantea* Schmidle
76	*Cyclotella meneghiniana* Kutz.	**Class Euglenophyceae**	
77	*Melosira varians* Ag.	89	*Euglena viridis* Kelbs.
Class Cyanophyceae		90	*Phacus curvicauda* Swire
78	*Anabaena circinalis* Rabneh ex Born et Flah	**Class Dinophyceae**	
79	*Anabaena oryzae* Fritsch	91	*Glenodinium cinctum* Ehr.
80	*Calothrix fusca (*Kutz.) Born et Flah	92	*Glenodinium kulezrynski (*Wolsz.) Schiller
81	*Chroococcus cohaerens* (Breb.) Nag.		

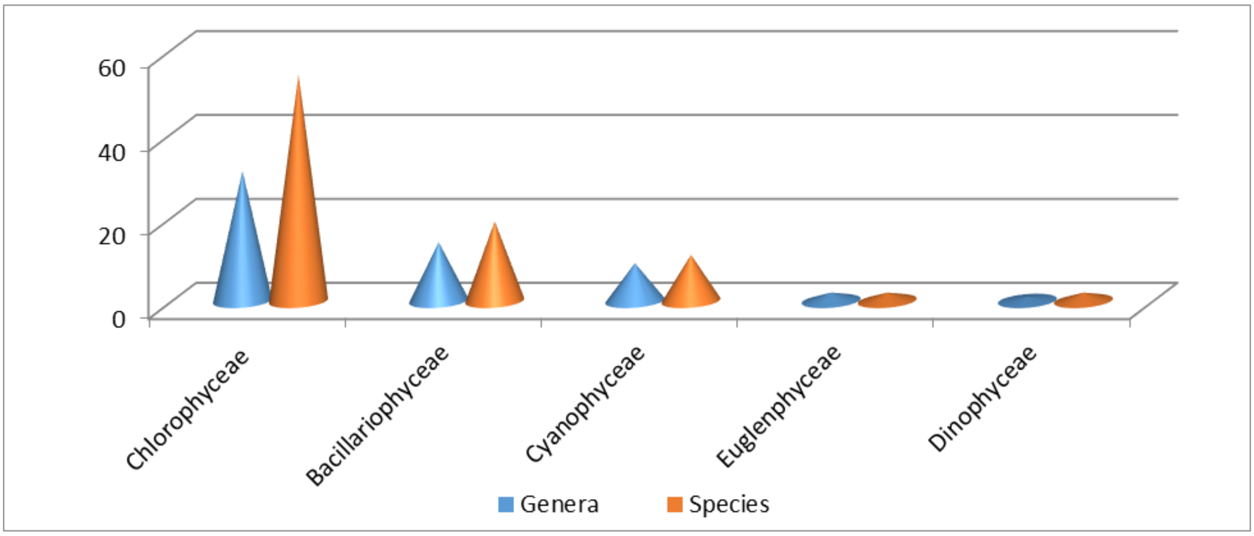

Fig.2: Graphical representation of various taxa in Lake Mansar.

Palmer's organic pollution indices

Palmer (1969) developed two algal pollution indices (genus and species) for use in rating of water samples with high pollution load. Two lists of organic pollution tolerant forms were prepared- one containing 60 genera, the other 80 species. In the present study, both algal genus and species pollution index have been used to determine the status of Mansar lake. The calculated index has been compared with the algal pollution index scale for assessment of organic pollution of the water body (Table-2).

Table-2. Algal pollution index scale for assessment of organic pollution of the water body (Palmer, 1969)

S. No.	Pollution index	Pollution status
1	0-10	Lack of organic pollution
2	10-15	Moderate pollution
3	15-19	Probable high organic pollution
4	≥ 20	Confirms high organic pollution

Among the total algal genera reported as indicators of organic pollution by Palmer (1969), about 15 phytoplankton genera from the Lake Mansar have been recorded during the present study. The total algal genus pollution index score for Lake Mansar has been recorded as 36 which confirms high organic pollution of the lake (Table-3a). Among the algal species tolerant to organic pollution (Palmer, 1969) about 6 phytoplankton species from Lake Mansar have been recorded. The total algal species pollution index score for Mansar lake have been recorded as 16 indicating probable high organic pollution of the lake (Table-3b).

Patrick (1965) also documented the pollution tolerant status of genera *Euglena* and *Oscillatoria* and denoted them as indicators of eutrophication of the aquatic ecosystem. Presence of genus *Scenedesmus* indicates the eutrophic nature of the water body (Palmer, 1980). Algal genera viz. *Chlorella*, *Scenedesmus*, *Pediastrum*, *Oscillatoria*, *Melosira*, *Navicula*, *Nitzschia*, *Gomphonema*, *Euglena* indicates organic pollution of water body (Kshirsagar *et al.*, 2012; Ganai and Parveen, 2014 and Jindal *et al.*, 2014). Changes in algal diversity can be used to classify the quality of water (Kumar *et al.*, 2012 and Kshirsagar (2013). Palmer (1969) reported that algae are important indicators of water pollution as it was evident during the present investigation.

Table-3. Algal genus and species pollution index scale for Mansar lake (Palmer, 1969)

(a) Algal Genus pollution index			**(b)-Algal species pollution index**		
Algal genus	Pollution index (Palmer, 1969)	Lake Mansar (2014-15)	Algal species	Pollution index (Palmer, 1969)	Lake Mansar (2014-15)
Anacystis	1	2	*Ankistrodesmus falcatus*	3	3
Ankistrodesmus	2	-	*Arthrospira junneri*	3	-
Chlamydomonas	4	-	*Chlorella vulgaris*	2	-
Chlorella	3	3	*Cyclotella meneghianiana*	2	-
Closterium	1	1	*Euglena viridis*	1	1
Cyclotella	1	1	*E. acus*	6	-
Euglena	5	5	*Gomphonema parculum*	1	-
Gomphonema	1	1	*Melosira varians*	2	-
Lepocinclis	1	-	*Navicula cryptocephala*	1	1
Melosira	1	1	*Nitzschiza acicularis*	1	-
Micractinium	1	-	*Nitzschia palea*	5	5
Navicula	3	3	*Oscillatoria chlorine*	2	-
Nitzschia	3	3	*O. limosa*	4	-
Oscillatoria	5	5	*O. putrid*	1	-
Pandorina	1	1	*O. princeps*	1	-
Phacus	2	2	*O. tenuis*	4	-
Phormidium	1	-	*Pandorina morum*	3	3
Scenedesmus	4	4	*Scenedesmus quadricauda*	4	-
Stigeoclonium	2	2	*Stigeoclonium tenue*	3	-
Synedra	2	2	*Synedra ulna*	3	3
Total	***44***	***36***	***Total***	***52***	***16***

Conclusion

Thus it can be concluded from the present study that palmer pollution index has shown high organic pollution in the Lake Mansar as algae are reliable indicators of water pollution. Algal genus pollution index score for Lake Mansar has been found as 36 which confirms high organic pollution of the lake and algal species pollution index score for Mansar lake have been recorded as 16 indicating probable high organic pollution of the lake. Change in diversity of algal communities can be used to determine and classify the water quality of lake. The study recommends the formulation of sustainable management plan and its implementation in order to preserve Mansar lake. Therefore to conserve it from further deterioration there is a need for regular monitoring.

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