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Original Research Paper

Diversity Index of Algal Flora in Wular Lake, Kashmir

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ABSTRACT

Shannon's diversity index of algal flora was calculated to analyse the algal community in Wular lake, Kashmir during March 2002-February 2004. All the selected five stations did not show any difference in the mean values of diversity index, but the values of each month showed slight variation. Diversity was correlated with physicochemical parameters. It showed positive correlation with Transparency and negative correlation with conductivity, carbon dioxide, hardness and nitrate. The ANOVA was highly significant with respect to site and season. Shannon's index may hold good index for determining the degree of pollution.

INTRODUCTION

To describe the structure of algal communities by Shannon's diversity index (H), attempts have been made by earlier workers like Margalef (1964), Sager & Hasler (1969), Meyer & McCormick (1971) and Eloranta (1976). In India little work has been carried on such aspects. Prasad & Singh (1982) studied species diversity of benthic diatoms in Gomati river. Species indices were used for evaluation of the degree of pollution by Patric & Riemer (1966), Wilhm (1967) and Woodwell (1970). In the present study, diversity index was used to analyse algal community structure in Wular lake. A multifactorial statistical analysis was made to study interrelationship of physicochemical parameters with Shannon's diversity index.

MATERIALS AND METHODS

The investigation was performed from March, 2002 to February 2004. Five study sites of Wular lake, through which River Jhelum traverses, were selected for collection of water and algal samples. Station 1: It represents inlet of Wular lake where the River Jhelum (the main feeding channel) enters the lake; Station 2: Laharwalpura; Station 3: Ashtingoo; Station 4: Wutlab; Station 5: Ningli, which represents the outlet of Wular lake (Fig. 1).

Analysis of water samples: Water temperature, transparency, dissolved oxygen, free carbon dioxide, total alkalinity, depth, conductivity and pH were measured in the field, while the remaining parameters were determined in laboratory within 24 hrs. The water samples for laboratory analysis were collected in 1-litre polythene bottles. The analysis was carried out following the methods of APHA (1998) and CSIR (1974).

Algal analysis: Algal samples were collected at monthly intervals during the course of investigation. Quantitative enumeration of algae was carried out by passing a known (1-5 litre) volume of lake water through the plankton net No. 25 (mesh size 64μm). The filtered samples were preserved by adding a few drops of Lugol's solution. The samples were then reduced to a known volume of 15, 30

mL in centrifuge. Enumeration of algae was done by taking 1 mL of sub-sample in a Sedgwick Rafter cell and counting its entire contents up to the statistical accuracy. The results are expressed as units per litre. The works of Heurck (1896), Smith (1950), Desikachary (1959), Randhawa (1959), Ramanathan (1964) and Philipose (1967) were considered for the identification of algae. Species diversity of algal community was calculated from the mathematical expressions suggested by Shannon & Weaver (1949). It was calculated and compared for all the stations studied. A multifactorial correlation analysis of data was made to study the interrelationship of various parameters of the waters. The relationship between the Shannon index of diversity and physicochemical parameters was also made. The relationship between Shannon's index of diversity (H) and the physicochemical parameters was also shown by correlation matrix. The range, means and standard deviation were calculated to show general statistical relationships.

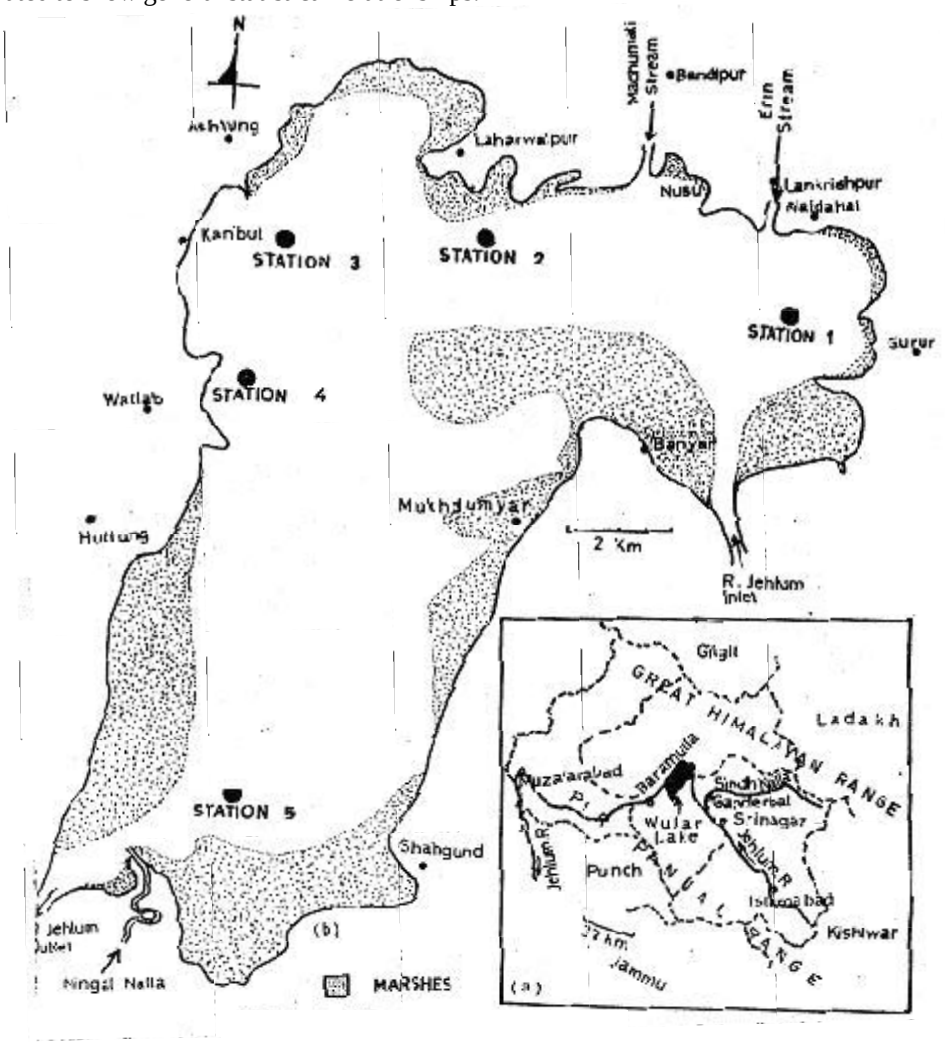

Fig. 1: (a) Map of Kashmir showing location of Wular lake. (b) Map of Wular lake.

RESULTS AND DISCUSSION

The algal species reported during the study period in lake Wular are given in Table 1, and the diversity index of algal species for each month at five stations in Table 2. Diversity index ranged from (0.053-0.66), (0.27-0.59), (0.39-0.57), (0.43-0.56) and (0.34-0.45) at sites 1, 2, 3, 4 and 5 respectively. The values of range, mean and standard deviation are shown in Table 3. The Table revealed that the mean values are very similar at all the stations but the standard deviation values vary. The diversity values showed seasonal and site variations. Seasonally the (H) value is more in spring as compared to other seasons. On the basis of site variations, the Shannon's index value is maximum at Site 1, and minimum at Site 5 (Table 4).

The mean monthly values of physicochemical parameters at five stations of the lake are shown in Table 5, and Figs. 2 and 3. The air temperature, water temperature and carbon dioxide depicted increase from spring to summer, but onwards it gets decreased. The site variations revealed that temperature and carbon dioxide were higher at Site 4 as compared to other sites on account of nearness to the township. The depth and transparency were lowest at Site 1 and highest at Site 5, while

Table 1: List of algal diversity reported in Wular lake.

Bacillariophyceae	*Pennularia sp.*	*P. simplex*
Amphiopleura pelicida	*Pleurosigma elongatum*	*P. tetras*
Amphora ovalis	*Rhophalodia gibba*	*Pithophora sp.*
Astronella Formosa	*Stauroneis acuta*	*Pleurotonium ehrenbergi*
Closteriopsis longissima	*S.anceps*	*P. trabeculae*
Coconies placetula	*Surirella biseriata*	*Senedesmus armatus*
Cyclotella sp.	*Surirella robusta*	*S. bijugatus*
Cymbella cistula	*Synedra ulna*	*S. indicus*
Cymbella tumida	*Tabellaria sp.*	*S. obliques*
Diatoma longissima	**Chlorophyceae**	*Scherioderia stigera*
Diatoma vulgare	*Chlorella sp.*	*Selenastrumgracile*
Epethemia sorex	*Cladophora sp.*	*Selenastrum muticum*
Epethemia turgida	*Closterium acutum*	*Spirogyra*
Eunotoa sp.	*C. gracile*	*Stigeoclonium sp.*
Fragellaria crotonensis	*C. monaliform*	*Ulothrix zonata*
Frustulia rhomboids	*C. probosideum*	*Volvox sp.*
Gomphonema augur	*Coelastrum microporum*	**Cyanophyceae**
Gomphonema constrictum	*Cosmarium circulare*	*Anabaenopsis sp.*
Gomphonema olevaceum	*C. gracile*	*Anabena sp.*
Hantzschia sp.	*C. ovale*	*Lyngbya limnetica*
Leimophora sp.	*Dactylococus sp.*	*Merismopedia sp.*
Longissima elongatum	*Dicellula germinatum*	*Nostoc sp.*
Melosira granulata	*Eaustrum germinatum*	*Oscillatoria sp.*
Meriodon circulara	*Gleocotheca sp.*	*Phormedium sp.*
Navicula cuspidata	*Goniochloris mutica*	*Scytonema sp.*
N. formosa	*Gonium pectorale*	*Spirulina sp.*
N. mutica	*Hydrodictyon reticulatum*	**Euglenophyceae**
N. oblonga	*Mougetia sp.*	*Euglena acus*
N. obtuse	*Oedogonium sp.*	*Phacus sp.*
N. radiosa	*Pandorina sp.,*	*Trachelomonas sp.*
N. smithi	*Pediastrum biradiatum*	**Dinophyceae**
Nitzschia accicularis	*P. duplex*	*Peredenium sp.*
N. epiculata	*P.muticum*	
N. sigmoides	*P.ovatum*	

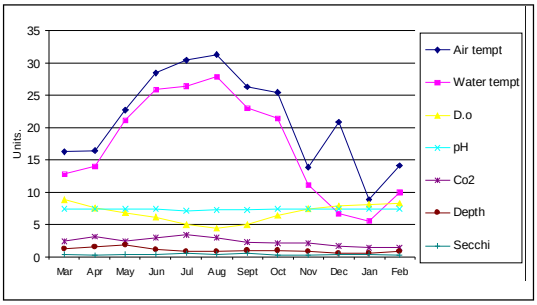

Fig. 2: Monthly variation in air temp., water temp., D.O., pH, CO_2, depth and transparency in Wular lake (2002-2004).

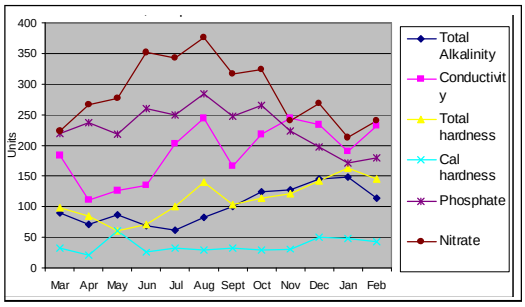

Fig. 3: Monthly variation in alkalinity, conductivity, total hardness, Ca-hardness, phosphate and nitrate in Wular lake (2002-2004).

seasonally depth was maximum in the month of May, and transparency in September. The hardness and conductivity depicted increasing trend during the period of investigation remaining maximum at Site 1, while water was more alkaline at Site 5 compared to other sites. The pH was slightly alkaline. Nitrate and phosphorus exhibited increasing trend from spring to summer, but summer onwards their concentration gets decreased.

The present study revealed that all the five stations of the Wular lake have difference in the site means and monthly means of (H) values. The lake depicted maximum (H) value at Site 1 (mean 0.090) and lowest at Site 5 (mean 0.048) on account of more anthropogenic pressure and more stagnation at Site 1, while more flushing rate and lotic nature of site 5 as compared to other sites. Seasonally it was maximum in spring for the fact that in spring season the pollution level gets increased due to more anthropogenic impact on account of agricultural intensification as most of the lake has been converted into agricultural land. Similar observations were also made by Prasad & Singh (1982) and Suresh & Raoji Bhai (1985).

Moreover, the lake is the lap of all domestic pollution because the main feeding channel of the lake is River Jhelum through which the domestic waste of whole Kashmir valley enters the lake. Shannon's diversity values depicted minor fluctuations with respect sites because there was no remarkable difference in the number of taxa composing dominant species at different sites of the lake.

Table 2: Shannon's index (H) of algal diversity in Wular lake (2002-2004).

~ Month	Station 1	Station 2	Index Station 3	~ Station 4	Station 5
March	0.66	0.51	0.52	0.48	0.40
April	0.55	0.46	0.48	0.49	0.37
May	0.56	0.46	0.50	0.53	0.36
June	0.65	0.41	0.39	0.52	0.39
July	0.65	0.45	0.43	0.53	0.37
August	0.56	0.47	0.52	0.52	0.34
September	0.63	0.50	0.47	0.49	0.42
October	0.64	0.51	0.48	0.52	0.35
November	0.65	0.27	0.54	0.55	0.43
December	0.60	0.47	0.54	0.56	0.39
January	0.65	0.59	0.57	0.43	0.38
February	0.53	0.57	0.53	0.56	0.45

Table 3: Mean values Shannon's algal diversity.

Station	Range	Mean	Standard deviation
1	(0.080-0.15)	0.090	0.35
2	(0.030-0.087)	0.057	0.82
3	(0.030-0.099)	0.067	0.23
4	(0.032-0.099)	0.068	0.25
5	(0.026-0.072)	0.048	0.21

This agrees with the observations of Yoshitake & Imahori (1980), however, the mean maximum values of (H) were observed at Site 1 with respect to other sites. This might be due to more pollution load at Site 1 compared to other sites. In most heavily polluted areas where the phytoplankton production is strongly inhibited, the biomass was decreased but the diversity was increased Eloranta (1976). Diversity index increased with the distance from toxic pollution as observed by Woodwell (1970). It was also true in the present investigation as Site 4, which depicted higher value of (H) with respect to other sites, lies away from the source of pollution (Table 4).

Statistical analysis revealed that the diversity index has highly positive correlation with transparency on account of shallow nature of the lake (Table 6). The index, however, is negatively correlated with hardness, carbon dioxide and conductivity which agrees with the observations of Suresh & Raoji Bhai (1985). The ANOVA showed significant variation of Shannon's index with respect to site and season on account of different pollution load at different sites in different seasons due to the variation in lake dynamics (Table 7).

Diversity index is a good index for assessing and ranking the water quality. Analysis of diversity of algal flora of the lake leads to conclusion that the mean values did not differ from each other

Table 4: Seasonal variation in Shannon's index (H) of algal diversity in Wular lake (2002-2004).

Season	Site1	Site2	Site3	Site4	Site5	Means
Spring	0.097	0.072	0.080	0.087	0.064	0.080
Summer	0.119	0.055	0.065	0.068	0.041	0.070
Autumn	0.052	0.034	0.040	0.043	0.031	0.040
Winter	0.091	0.066	0.080	0.074	0.057	0.074
Means	0.090	0.057	0.067	0.068	0.048	

Table 5: Mean monthly values of physico-chemical parameters (2002-2004).

Parameters ~	~ 1	2	Stations 3	~ 4	5
Water tempt (°C)	17	17.2	17.40	18	17.50
Depth (m)	0.7	0.87	1.03	0.94	1.28
Transparency (m)	0.27	0.40	0.35	0.38	0.61
Cond. (µS/cm 25°C).	253	157.7	162.2	194	193.8
pH (Units)	7.2	7.30	7.30	7.30	7.40
Alkalinity (mg/L)	95.63	104	91.750	97.37	120.96
D.Oxygen (mg/L)	6	6.80	6.70	6.50	7.60
Free CO_2 (mg/L)	3	2.20	2.40	2.50	1.90
Tot. Hardness (mg/L)	143.50	120	99.80	103	116.20
Ca. Hardness (mg/L)	42.63	26	29.60	33.80	34.30
Mg content (mg/L)	24.75	15.80	17	16.80	20
Chloride (mg/L)	20.29	17.80	20.50	21.2	17.50
Ammonia (µg/L)	88.34	76.30	80.70	81	79.80
Nitrate (µg/L)	325.7	282.80	272.60	312	233.40
Tot. phosphate (µg/L)	248.5	236.20	247.50	235	180.70

Table 6: Correlation of Shannon's index (H) of algal diversity with different physicochemical parameters.

Positive correlation	Negative correlation
Transparency** (0.422)	Conductivity** (-0.122) Carbon dioxide** (-0.275) Calcium hardness** (-0.172) Total hardness** (-0.200) Magnesium content** (-0.267) Nitrate** (-0.195) Total Alkalinity** (-0.278)

Table 7: Analysis of variance of Shannon's index (H) in Wular lake (2002-2004).

Independent variable	Dependent variable	DF	MS	F	P
Site	Shannon's index	4	0.0117	10.00	0.00
Season		3	0.0144	16.37	0.00
Site*Season		12	0.0039	1.11	N.S

remarkably at the stations in different seasons studied, which can be directly related to the eutrophic nature of the Wular lake.

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