SPECIES DIVERSITY AND SEASONAL VARIATIONS IN PHYTOPLANKTON COMMUNITIES WITHIN HARIKE WETLAND – A RAMSAR SITE.

Prabha* and Anish Dua
Research fellow, Professor
Department of Zoology
Guru Nanak Dev University, Amritsar-143005, Punjab, India

Abstract: Phytoplankton play important role in primary production. Their short life span and ability to respond quickly to environment make them good indicator of water quality of lentic and lotic ecosystem. Their diverse occurrence serves as a useful tool in determining the fish assemblage. Present investigation aims at phytoplankton diversity and effect of seasonal variations in their occurrence. 46 species of phytoplankton were collected and identified. Shannon diversity index (H'), Simpson diversity index (1-D), Margalef's index and Berger-Parker's index for dominance (D) and Evenness index (e^H/S) were calculated. Maximum value for diversity indices was observed during spring season and minimum during rains. This study gives an indication about season prevalence in phytoplankton diversity and the possibilities of using them in biomonitoring studies to determine the quality of water body.

Key words: Berger Parker index, Hairke wetland, Margalef's index, phytoplankton, Shannon diversity index

Introduction

An ecosystem is emphatically affected by biodiversity prevailing in it. Biodiversity enhances resistance of an ecosystem by minimizing negative responses to environmental changes (Schabhuttl et al. 2013). Planktons are the most complex and diverse component of ecosystem. Amongst all types of planktons, phytoplankton are the most important as they are basic unit of aquatic food web. They liberate oxygen during photosynthesis and thus act as vital component of an aquatic ecosystem (Khan, 2003). Phytoplankton are acknowledged as excellent bioindicators as they respond quickly to changing environmental conditions. They are known to increase stability and resource efficiency of an ecosystem in freshwater and brackish habitats (Ptacnik et al. 2008). Previous investigations (Biswas, 1949, Das and Srivastva, 1959, Carr, 1966) indicated that different water bodies have high fluctuations in plankton species and their seasonality. According to Sommer et al. (1993) comparison of large no of phytoplankton species by using diversity indices summarizes the community structure as these diversity estimations could be used to elucidate ecological system (Figueredo and Giani, 2001). Present study is focussed on phytoplankton dominance, richness, diversity, evenness and seasonal variations within Harike wetland - A Ramsar site.

Material and methods

Study area

Figure 1: Harike Wetland Satellite Imagery

Harike wetland is a freshwater ecosystem with an international importance. It is the largest man made wetland of North-India that came into existence in 1952. This wetland has diverse ecological conditions and flora & fauna due to both lentic and lotic type of environment (Moza and Mishra, 2008). Harike wetland was declared "Ramsar site" by IUCN (1990) for its importance in Biodiversity. This wetland is situated at meeting point of three districts- Amritsar, Ferozpur and Kapurthala (31°08'30.15 N; 75°03'44.18 N; 210 msl). The main water inflow in the wetland comes from River Beas and Sutlej (Figure 1).

Physio-chemical Analysis

Water samples were collected from surface during four seasons. Samples were collected in pre-treated clean plastic bottles of 1L capacity and brought to laboratory for further analysis following manual of APHA/ AWWA/WEF (2005). Water temperature (WT °C), Electrical conductivity (EC µS/cm), pH, Dissolved oxygen (DO mg/L) and Total dissolved solids (TDS mg/L) were measured at the sampling using Hach DR 1900 multiprobe Kit. Five day Biochemical oxygen demand (BOD_5) was measured with Oxitop measuring system (thermostat TS 606-G/2-i). Turbidity of the water (TD) was measured using NTU turbiditimeter at the sampling site. Total hardness (TH mg/L) and Magnesium (Mg mg/L) were analysed in laboratory as protocol given by Trivedy and Goel (1986). Phosphate (P mg/L) and Sulphate (SO_4 mg/L) were analyzed using Merck cell test kits on UV/VIS spectrophotometer (Spectroquant® Pharo 300).

Phytoplankton collection

Sampling was done for four seasons (spring, summer, rains and winter) for two years (2014 April-2015 December) from the euphotic zone (0-1.0 m). Samples were collected, fixed with Lugol's solution in clean plastic bottles and were brought to laboratory and identified upto species level with the help of the standard literatures (Needham and Needham, 1972, Ward & Whipple, 1992, APHA, 1995). Phytoplankton were calculated as protocol given by Nannnette Huber (2012).
Seasonal variations in phytoplankton diversity and number of phytoplankton among various seasons were calculated using various diversity indices i.e. Shannon diversity index, Simpson diversity index, Margalef's index (species richness), Berger Parker's index and evenness index in ecology. Statistical computations were done using Microsoft Excel version 2010 and Past Version 3.

Results and Discussion

Physico-chemical variables

Average values for various seasonal fluctuations in water quality variables for two years are given in table 1. Minimum value of DO was recorded in rains (5.63 mg/L) and maximum value during winter season (11.09 mg/L). Lower concentration of DO is an indicator of eutrophic nature of a water body (Sheela et al. 2011). Higher value of DO (11.09 mg/L) and lower value of BOD_5 (1.50 mg/L) calculated in winter season depicts an inverse relationship of two variables. Maximum temperature was recorded during summer season was 31.0 °C and minimum temperature was recorded in winter season i.e. 15.50 °C. Temperature fluctuations play important role in phytoplankton diversity (Schabhuttl et al. 2013). Phosphate is important nutrient for phytoplankton growth. Maximum concentration of phosphates was found during winter and minimum conc. during summer season (0.13±0.01 mg/L). Decreased conc. of phosphates in summer season was also noticed by Nassar et al. (2014) while studying seasonal fluctuations of phytoplankton community. Conductivity possibly affects phosphorus availability in the water column as increased conductivity allows more anion binding to phosphorus in the form of phosphate, resulting in a decreased concentration of total available phosphorus and this chemical interaction would prevent phytoplankton from accessing phosphorus, resulting in decreased phytoplankton populations (Chouyyok et al. 2010, Lopez-Flores et al. 2014). In present investigation average fluctuations in EC during various seasons were recorded as 180.5±3.75 (summer), 184.8±2.88 (winter), 260.4±11.70 (spring) and 276.1±19.80 (rains).

Table 1 mean variations in physico-chemical variables among all seasons (2014-2015).

Variables	Spring (mean±S.E.)	Summer (mean±S.E.)	Rains (mean±S.E.)	Winter (mean±S.E.)
DO (mg/L)	8.45±0.20	8.53± 0.14	7.14±0.13	9.90±0.21
EC (µS/cm)	260.4±11.70	180.5± 3.75	276.1±19.80	184.8±2.88
pH	7.86±0.14	7.36±0.10	7.19±0.05	6.94±0.03
TD (NTU)	16.47±2.13	6.24±1.11	26.84±4.02	35.04 ±8.57
WT (°C)	24.76±0.56	27.70±0.48	23.42±0.60	16.66±0.85
TH (mg/L)	111.4±3.94	72.18±3.95	94.64±4.46	93.78±2.93
Mg (mg/L)	7.60±0.76	5.79±0.35	18.72±1.32	5.27±0.43
TDS (mg/L)	137.4±9.71	87.61±2.04	98.30±14.90	122.10±9.58
BOD (mg/L)	7.960±1.08	1.15±0.66	1.96±0.34	3.61±0.56
P (mg/L)	0.149±0.04	0.13±0.01	0.39±0.06	0.49±0.09
SO_4 (mg/L)	28.88±1.46	35.94±0.77	40.59±7.39	24.67±1.02

Phytoplankton diversity

At Harike wetland 46 species of phytoplankton were reported belonging to 7 families. Frequency of occurrence, abundance and seasonality are given in table 2. Among the 7 families Bacillariophyceae had maximum no. of species (45.65%) followed by Chlorophyceae (35.56%), Cynophyceae (6.52%), Zygnematophyceae (6.52%), Chrysophyceae (2.17%). Ulvophyceae (2.17%) and Xanthophyceae (2.17%) (Figure 2). Dominance of Bacillariophyceae family was also reported in previous studies (Ramesha and Sophia, 2013, Thakur et al, 2013, Nassar et al, 2015). Present study is in contrast with Sbhashshree and Patra (2013) and Ekpo et al. (2015) who reported Chlorophyceae as highest occurring family. Bacillariophyceae included *Aulacoseira granulate*, *Cocconies* sp., *Coccus tetrad*, *Cyclotella meneghiana*, *Cyclotella* sp., *Cymatopleura solea*, *Cymbella affinis*, *Diatom* sp., *Fragilaria construens*, *Fragilaria crotonensis*, *Gomphonema gracile*, *Gomphonema grovei*, *Gyrosigma acuminatum*, *Navicula cryptocephala*, *Navicula cuspidate*, *Nitzschia angustata*, *Nitzschia closterium*, *Pinnularia* sp., *Synedra acus*, *Synedra ulna* and *Synedra affinis*. Chlorophyceaea included *Actinastrum hantzschii*, *Chlorella vulgaris*, *Hydrodictyon* sp, *Pediastrum duplex*, *Pediastrum simplex*, *Netrium* spp, *Scenedesmus dimorphus*, *Scenedesmus longispina*, *Scenedesmus longus*, *Scenedesmus obliquus*, *Scenedesmus platydiscus*, *Scenedesmus quadricauda*, *Sphaeroplea* sp., *Spirogyra* sp., *Tetrahedron* sp. and *Zygnemopsis* sp. Cynophyceae included *Spirulina* sp., *Lyngyba* sp. and *Botrycoccus* sp. Zygnematophyceae had three members *Closterium setaceum, Cosmarium globosum* and *Straustrum* sp. Chryophyceae, Ulvophyceae and Xanthophyceae had only one species each i.e. *Dinobryon sertularia*, *Cladophora* sp. and *Ophiocytium parvulum* respectively.

A remarkable seasonal variation in phytoplankton occurrence was observed. *Cyclotella meneghiana* and Diatom spp. were present throughout all the sampling seasons. *Synedra acus* was occurred in all the seasons except rains. *Cymbella affinis, Nitzschia angustata* and *Pediastrum duplex* were observed during summer season and rains. Three species of genus *Scenedesmus* were observed during spring season and rains viz. *S. dimorphus*, *S. longus* and *S. platydiscus*. *Fragilaria crotonensis* and *Cosmarium globosum* were seen during spring and winter season. *Fragilaria construens* and *Pinnularia* spp were common during spring and summer season. *Cyclotella* spp was found in both summer and winter season. *Straustrum* spp and *Cladophora* spp were seen in rains and winter season. *Cocconies* spp, *Coccus tetrad*, *Navicula cryptocephala*, *Navicula cuspidate*, *Hydrodictyon* spp, *Spirogyra* Spp, *Tetrahedron* Spp, *Lyngyba* spp. and *Botrycoccus* spp. were confined to spring season only. *Aulacoseira granulate*, *Gomphonema gracile*, *G. grovei*, *Nitzschia closterium, Synedra affinis, S. ulna*, *Actinastrum hentzshii*, *Chlorella vulgaris, Pediastrum simplex, Netrium* spp. *Scenedesmus longus* and *Dinobryon sertularia* were seen only during summer season. *Cyclotella* spp, *Scenedesmus obliquus*, *S. quadricauda*, *Zygnemopsis* spp. and *Spirulina* spp. were observed during rains only indicating that these species are habituated to low temperature. *Gyrosigma acuminatum* and *Closterium setaceum* were seen in winter season only. Seasonal prevalence of phytoplankton species may be possibly related to species specific environmental conditions (Rajasekar et al, 2010).

Table 2. Phytoplankton species, frequency of appearance, abundance and seasonality in Harike Wetland during 2014-2015.

	Phytoplankton species	*Frequency*	*Abundance*	*Seasonality*
Bacillariophyceae				
1.	*Aulacoseira granulata*	F	+++	SU
2.	*Cocconies* sp.	C	+	SP
3.	*Coccus tetrad*	R	+	SP
4.	*Cyclotella meneghiana*	C	+	SP-SU-R-W
5.	*Cyclotella* sp.	C	+	SU-W
6.	*Cymatopleura solea*	R	+	R
7.	*Cymbella affinis*	C	++	SU-R
8.	*Diatom* sp.	F	++	SP-SU-R-W
9.	*Fragilaria construens*	C	+++	SP-SU
10.	*Fragilaria crotonensis*	C	+++	SP-W
11.	*Gomphonema gracile*	R	+	SU
12.	*Gomphonema grovei*	R	+	SU
13.	*Gyrosigma acuminatum*	R	+	W
14.	*Navicula cryptocephala*	C	++	SP
15.	*Navicula cuspidate*	C	+	SP
16.	*Nitzschia angustata*	C	++	SU-R
17.	*Nitzschia closterium*	C	+	SU
18.	*Pinnularia* sp.	C	++	SP-SU
19.	*Synedra acus*	C	+++	SP-SU-W
20.	*Synedra ulna*	C	++	SU
21.	*Synedra affinis*	C	+	SU
Chlorophyceae				

22.	*Actinastrum hantzschii*	C	+	SU
23.	*Chlorella vulgaris*	C	+	SU
24.	*Hydrodictyon* sp.	C	++	SP
25.	*Pediastrum duplex*	C	++	SU-R
26.	*Pediastrum simplex*	R	+	SU
27.	*Netrium* sp.	R	+	SU
28.	*Scenedesmus dimorphus*	C	++	SP-R
29.	*Scenedesmus longispina*	C	++	SP-R
30.	*Scenedesmus longus*	C	++	SU
31.	*Scenedesmus obliquus*	C	++	R
32.	*Scenedesmus platydiscus*	C	++	SP-R
33.	*Scenedesmus quadricauda*	F	+++	R
34.	*Sphaeroplea* sp.	C	+	SP
35.	*Spirogyra* sp.	C	+	SP
36.	*Tetrahedron* sp.	C	+	SP
37.	*Zygnemopsis* sp.	R	+	R
Chrysophyceae				
38.	*Dinobryon sertularia*	R	+	SU
Cynophyceae				
39.	*Spirulina* sp.	C	+	R
40.	*Lyngyba* sp.	C	++	SP
41.	*Botrycoccus* sp.	C	+	SP
Ulvophyceae				
42.	*Cladophora* sp.	C	+	R-W
Xanthophyceae				
43.	*Ophiocytium parvulum*	R	+	W
Zygnematophyceae				
44.	*Closterium setaceum*	F	+++	W
45.	*Cosmarium globosum*	C	+	SP-W
46.	*Straustrum* sp.	C	+++	R-W

Note: C common, R rare, F frequent; SP spring, SU summer, R rains, W winter; - absent, + present, ++ abundant, +++ highly abundant.

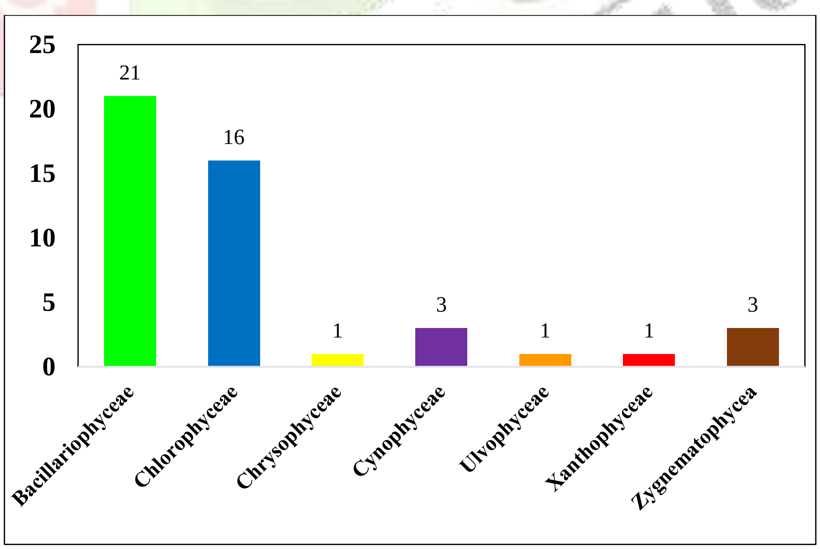

Figure 2: Number of Phytoplankton species of different families.

Diversity indices are useful tool for understanding community structure in terms of rarity and commonness of species occurring therein. Sigee (2004) has classified these bioindices of species diversity into three main classes viz. Margalef index (species richness), Simpson index (evenness/dominance) and Shannon-Weiner index (combination of richness and dominance). Possible range of values for Simpson index varies from 0 to 1, indicating least and most evenly distributed species respectively. Comparison of various diversity indices for spring, summer, rains and winter seasons is given in table 3. For present study Shannon diversity index (H') ranged from 2.874-1.558 among four seasons. Maximum value for H' was calculated for spring season and minimum value for rains. Hassan et al. (2010) also noticed decreased phytoplankton density in monsoon. Calculated value of Simpson index (1-D) ranged between 0.939 (spring) to 0.700 (rains). Evenness (e^H/S) had maximum value during spring season (0.885) and minimum value during rains (0.432). Berger-Parker's dominance index (D) clearly indicates about the dominance of a species. Increased value of this index indicates increased diversity and decreased dominance. Species dominance in terms of Berger-Parker dominance was found maximum for rains (0.467) and minimum for spring season (0.089). Margalef's index based on species richness had maximum value for summer season (2.293) and minimum value for rains (1.141). Decreased value of bioindices were recorded in rains as compare to other seasons. This could be possibly due to highly stratified water column because of heavy rainfall, high turbidity and decreased pH (Rajasekar et al. 2010). Similar observations were made by Rajasegar et al. (2000) who reported phytoplankton diversity associated with the shrimp farm development in Vellar estuary, South India.

Table 3: Comparison of Diversity indices for spring, summer, rains and winter seasons.

Seasons / Indices	Spring	Summer	Rains	Winter
Shannon (H')	2.874	2.457	1.558	2.464
Simpson (1-D)	0.939	0.875	0.700	0.906
Evenness (e^H/S)	0.885	0.530	0.432	0.839
Margalef	2.061	2.293	1.141	1.447
Berger-Parker	0.089	0.232	0.467	0.125

Conclusion

Harike wetland is contemplated as oligotrophic and healthy without being affected by anthropogenic and tourism activities. Low phytoplankton counts due to lower concentrations of nutrients and moderate values of diversity were observed. Also seasonal variations in phytoplankton diversity were observed that indicates season based fluctuation in their diversity. These bioindicators thus are reliable tool to estimate health status of an aquatic ecosystem and thus could be taken into consideration in future for water quality biomonitoring studies.

Acknowledgement

Authors give sincere thanks to faculty of Guru Nanak Dev University for providing lab facilities and University Grant Commission (UGC) under University with Potential of Excellence (UPE) scheme and Special Assistance Programme (SAP) for financial assistance.

References

APHA/AWWA/WEF. 2005. Standard methods for examination of water and wastewater. Vol. 21, American Public Health Association, American Water Works Association, Washington, USA.

Biswas, K. 1949. Common fresh and brackish algal flora of India and Burma. Records Botanical Survey of India, 15: 1–169.

Carr, J. L. 1966. Fresh water phytoplankton and phytonekton from Lake Rotoiti. TAN E, 12:13 -36.

Chouyyok, W., Wiacek, R.J., Pattamakomsan, K., Sangavanich, T., Grudzein, R.M. and Fryxell, G.M. 2010. Phosphate Removal by Anion Binding on Functionalized Nanoporous Sorbents. Environmental Science & Technology, 44: 3073-3078.

Das, S. M. and Srivatsava, V. K. 1959. Studies on freshwater plankton III. Qualitative composition and seasonal fluctuations in plankton components. Proceedings of National Academy of Science, India, 29B, 174–189.

Ekpo, I.E., Essien-Ibok, M.A. and Duncan, A.O. 2015. Densities, spatial distribution and community structure of plankton of Odot Stream. Journal of Ecology and Natural Environment, 7: 180-187.

Figueredo, C.C. and Giani, A. 2001. Seasonal variation in the diversity and species richness of phytoplankton in a tropical eutrophic reservoir. Hydrobiologia, 445: 165-174.

Hassan, F.M., Taylor, M., Mayson, M.S., Taee, Al. and Hassan, J.J. 2010. Phytoplankton composition of Euphrates River in Al-Hindiya barrage and Kifil city region of Iraq. Journal of Environmental Biology, 31: 343-350.

Khan, T.A. 2003. Limnology of four saline lakes in western Victoria, Australia. Limnolog, 33: 327-339.

LOpez-Flores, R., Quintana, X.D., RomanI, A.M., Baneras, Ll., Ruiz-Rueda, O., Compte, J., Green, A.J. and Egozcue, J.J. 2014. A Compositional Analysis Approach to Phytoplankton Composition in Coastal Mediterranean Wetlands: Influence of Salinity and Nutrient Availability. Estuarine, Coastal and Shelf Science, 136: 72-81.

Nassar, M.Z., El-Din., N.G.S. and Gharib, S.M. 2015. Phytoplankton variability in relation to some environmental factors in the eastern coast of Suez Gulf, Egypt. Environmental Monitoring and Assessment, 187: 648, DOI 10.1007/s10661-015-4874-y.

Moza, U. and Mishra, D.N. 2008. Current status of Harike Wetland and Visa Visa its Ecology and Fishery. Proceedings of Taal 2007: The 12th World Lake Conference, 1470-1476.

Nannette, H. (2012). Estuaries-Phytoplankton protocol. pp-1-8.

Nassar, M.Z., Mohamed, H.R., Khiray, H.M. and Rashedy, S.H. 2014. Seasonal fluctuations of phytoplankton community and physico-chemical parameters of the north western part of the Red Sea, Egypt. Egyptian Journal of Aquatic Research, 40: 395–403.

Needham, J.G. and Needham, P.R. 1962. A Guide to the Study of Freshwater Biology. 2nd Edn, Holden-Day INC., San Franciso, C. A.

Ptacnik, R., Solimini, A.G., Timo Tamminen, T.A., Brettum, P., Lepisto, L., Willen, E., Rekolainen, S. 2008. Diversity predicts stability and resource use efficiency in natural phytoplankton communities. Proceedings of the National Academy of Sciences of the United States of America, 105: 5134–5138.

Rajasegar M, Srinivasan M, Rajaram R. 2000. Phytoplankton diversity associated with the shrimp farm development in Vellar estuary, south India. Seaweed Research and Utilization, 22: 125–131.

Rajasekar K.T., Rajkumar M., SUN, J., Prabu, A.V. and Perumal P. 2010. Seasonal variations of phytoplankton diversity in the Coleroon coastal waters, southeast coast of India. Acta Oceanologica Sinica, 29: 97-108.

Ramesha, M.M. and Spphia, S. 2013. Species composition and Diversity of Plankton in the River Seeta at Seetanadi, the Western Ghats, India. Advanced Biotech, 2319-6750.

Schabhuttl, S., Hingsamer, P., Weigelhofer, G., Hein, T., Weigert, A. and Striebel, M. 2013. Temperature and species richness effects in phytoplankton communities. Oecologia, 171: 527–536.

Sheela, A. M., Letha, J., & Joseph, S. (2011). Environmental status of a tropical lake system. Environmental Monitoring and Assessment, 180: 427–449.

Sigee, D.C. 2004. Freshwater microbiology: diversity and dynamic interactions of microorganisms in the aquatic environment. Chichester, UK: Wiley.

Sommer, U. 1993. Disturbance-diversity relationships in two lakes of similar nutrient chemistry but contrasting disturbance regimes. Hydrobiologia, 249: 59-65.

Subhashree, P. and Patra, A.K. 2013. Studies on seasonal variations in phytoplankton diversity of River Mahanadi, cuttack city, Odioha, India. Indian Journal of Science and Natural Resources, 4: 211-217.

Thakur, R.K., Jindal, R., Singh, U.B. and Ahluwalia, A.S. 2013. Plankton diversity and water quality assessment of three freshwater lakes of Mandi (Himachal Pradesh, India) with special reference to planktonic indicators. Environmental Monitoring and Assessment, 185: 8355–8373.

Trivedi, R.K. and Goel, P.K. 1986. Chemical and Biological Methods for Water Pollution Studies. Environmental Publications, Karad, India.

Ward, H.B. and Whipple, G.C. 1959. Freshwater Biology. John Wiley & Sons Inc. USA.