Universal Impact Factor
2012:0.9285;
2013:1.2210

Index Copernicus Value
2011:5.09, 2012:6.42,
2013:15.8, 2014:89.16,
2015:78.30, 2016:91

NAAS Rating
2012:1.3; 2013-16: 2.69
2017-18: 3.98

SJIF
2012: 3.947, 2013:4.802

InfoBase Index
2015:4.56

Cosmos Impact Factor
2015: 4.366

Received on:
30rd March 2018
Revised on:
24th April 2018
Accepted on:
25th April 2018
Published on:
1st May 2018
Volume No.
Online & Print
99 (2018)
Page No.
22 to 21

Life Sciences Leaflets is an international open access print & e journal, peer reviewed, worldwide abstract listed, published every month with ISSN, RNI Free- membership, downloads and access.

SEASONAL VARIATIONS OF ZOOPLANKTON AND THEIR CORRELATION WITH PHYSICO-CHEMICAL PARAMETERS OF KANJIALAKE, NANDANKANAN ZOO, BHUBANESWAR

G.N.INDRESHA[1*], S.P.PARIDA[2] AND A.K.PATRA[3]

[1]REGIONAL MUSEUM OF NATURAL HISTORY, SIDDHARTHA NAGAR, MYSORE, KARNATAKA.

[2]REGIONAL MUSEUM OF NATURAL HISTORY, BHUBANESWAR, ODISHA.

[3]P. G. DEPARTMENT OF ZOOLOGY, UTKAL UNIVERSITY, BHUBANESWAR.

Corresponding author's e-mail: gnindresha@gmail.com

ABSTRACT:

Zooplankton plays an important role in fresh water ecosystems in transfer of energy at the secondary trophic level in an aquatic ecosystem. They are intermediate link between primary producers viz. phytoplankton with higher trophic level organisms. Zooplanktons are rich in essential amino and fatty acids and provide fish with nutrients and their study is necessary in fisheries and aquaculture and is considered as nature's water purifiers and respond quickly to the changes in the medium and are used as indicators of overall health of the aquatic ecosystem. Zooplankton is important in understanding the lake dynamics and the results of the study undertaken at Kanjia lake of Nandankanan sanctuary, are discussed in detail.The grab samples were collected from four different sites, enough to accurately represent the whole water body to assess their physical and chemical and biological parameters at monthly intervals in the middle of every month between 9:00- 11:00 am.To minimize the changes in the sample from collection to laboratory analysis, the sample was preserved soon after the collection by 5 % formalin.The preserved samples were brought to the laboratory for qualitative and quantitative analysis. Quantitative studies were made by using Sedgwick rafter cell. Different physicochemical parameters were measured in the field itself by physical methods or by using Systronics P-4

water analysis kit (E-Merck). Zooplanktons density ranged from 52 to 66.25 $nL^{-1}$with mean ± S.D. (58.765 ± 5.844) during winter season, 90.625 to 127 nL^{-1} with mean ± S.D. (104.609 ± 15.661) during summer season and 49.375 to 69.312 nL^{-1} with mean ± S.D. (58.656 ±8.324) during monsoon season.The variations across sites and over seasons were significant.The total densities of zooplankton were found to be maximum during summer and minimum during monsoon season. In the community structure and species diversity, protozoa found to be dominant group followed by rotifera, cladocera, copepoda and astracoda. Average of four years density also found to be minimum during monsoon and maximum during summer. In general higher zooplankton density was much more pronounced during the summer season than the monsoon and winter periods in the lake. During the present investigation, the water samples from four study sites have been analyzed for spatial and temporal distribution in density, diversity and percentage distribution of zooplankton. The study revealed the presence of 30 species, out of which 10 species of Protozoa, 9 species of Rotifera, 4 species of Cladocera, 3 species of Ostracoda, and 4 species Copopoda. The zooplankton assemblage of this lake consists primarily of protozoa followed by Rotifers. In the community structure and species diversity, out of 30 species recorded, the Protozoa were found to be dominant group consisting of 10 species ((33.33%) followed by Rotifera with 9 species (30%), Cladocera with 4 species (13.33%), Copepoda with 4 species (13.33%) and Ostracoda with 3 species(10%).

KEY WORDS: *KanjiaLake, zooplankton, seasonal variation, physico- chemical parameters.*

INTRODUCTION:

Phytoplankton constitutes an important source of food for fish. They also play an important role in fresh water ecosystems as bio-indicators. Algae are considered as excellent bio-indicators. In Indian aquatic eco-habitats, algal flora impacts luxuriant growth and hence most of the investigators handle them as important bio-indicators. Borse *et al*. (2003) highlighted the importance of algae as pollution indicators and their use for assessing the water quality. Phytoplankton found in various fresh water ecosystems plays a vital role in the food chain and food web of ecosystem. It is necessary to study population dynamics, community structure, species composition, species diversity of plankton while undertaking ecological investigations in aquatic ecosystems, particularly in fresh water resources. No long term and systematic study has been conducted on the phytoplankton of Kanjia Lake. Hence this research reports the seasonal variation of phytoplankton with physicochemical parameters.

Kanjia Lake like the jewel in crown has been the star of attraction for the visitors of Nandankanan zoo as well as Sanctuary. Kanjia lake spread over 75 hectares of area is popularly known as Nandankanan lake situated between 85° 48’ to 85° 50’ E longitudes and between 20° 23’ to 20° 25’ N latitudes. It is an important wetland lying to the south of the Mahanadi delta head within the boundary of Nandankanan Sanctuary.

MATERIALS AND METHODS:

Sampling sites for the water body/lake are selected to represent the water quality at different points and depth. Sampling points were decided by keeping in mind that the considered sampling points must include shallow and deep regions of the water body, points of inflow, and outflow of water in the lake and anthropogenic activities. The grab samples were collected from four different sites, enough to accurately represent the whole water body to assess their physical and chemical and biological parameters at monthly intervals in the middle of every month between 9:00- 11:00 am. From each station, two samples were collected in thoroughly cleaned 1L litre inert plastic containers, which were rinsed with distilled and lake/tank water before collection to avoid contamination for the analysis of physicochemical properties and phytoplankton. Water samples were collected in a sampling bottle avoiding floating materials. The closed bottle was dipped in the lake at the depth of 0.5M below the surface, and then a bottle was opened inside and was closed again to bring it out at the surface (Verma *et al.*, 2011).From the time of sample collection to the time of actual analyses, many physical, chemical and biochemical reactions would change the quality of the water sample. Therefore to minimize this change the sample were preserved soon after the collection by adding with 10ml of 1% Lugol's solution. The stoppers of the sample containers were closed properly to prevent outside contamination. The container was labelled describing the name of the water body, date, time, sampling point and conditions under which it was sampled.

Different physicochemical parameters such as colour of water, odour, taste, water depth, air temperature, water temperature, pH , dissolved oxygen, conductivity, transparency were measured in the field itself by physical methods or by using Systronics P-4 water analysis kit (E-Merck) whereas the analyses of remaining parameters like chlorides, nitrates, phosphates, total hardness, total alkalinity, turbidity, TDS and salinity were determined by in the laboratory by method suggested by Abbasi (1998), APHA- AWWA and WPCF (2005) and by using Systronics P-4 water analysis kit (E-Merck). The study was carried for a period of 4 years (November-2009 - to October- 2013).For qualitative analysis of phytoplankton;wet mounts were prepared by transferring 0.1ml sample to a glass slide and placing a cover slip over the sample. The phytoplankton were identified by using the key given in the book "The Fresh Water Algae" by Prescott (1970); Edmondson (1995) and Abbasi (1998). Quantitative analysis was done by using Sedgwick-Rafter (S-R) counting cell by taking 1ml of plankton concentrate in the cell. The sample is allowed to settle for about 5 minutes before the actual counting begins.The percentage composition of major group of phytoplankton was calculated using the formula (Abbasi,1998).

$$No/ml = \frac{C \times 1000\ mm^3}{L \times D \times W \times S}$$

Where

C= number of organisms counted

L= length of each strip(S-R cell length), mm

D= depth of strip(S-R cell depth) mm and

W= width of a strip (Whipple grid image width)

S= number of strips counted.

RESULT:

Zooplankton considered being the ecological indicators of water bodies. Factors such as light intensity, food availability, dissolved oxygen and predation effect the population dynamics of zooplankton. Low pH or higher salinity can reduce their diversity and density.

Monthly variations in zooplankton density (nL^{-1}) and various physicochemical parameters in the surface waters of the Kanjia Lake at different sampling sites were observed for four years. Seasonal variations over a period of four years of study were calculated from these data. Seasonal variations in physicochemical parameters, density, diversity and % distribution of zooplankton withtheir mean value recorded during the study period from four sites over a period of four years is given in **Table-1**. List of zooplanktons recorded during the study is given in **Table-2.**The correlation coefficient (r) of zooplanktons density with other water quality parameters during winter; summer and monsoon are given in **Table-3, 4 & 5**.

Zooplanktons density ranged from 52 to 66.25 $nL^{-1}$with mean ± S.D. (58.765 ± 5.844) during winter season, 90.625 to 127 nL^{-1} with mean ± S.D. (104.609 ± 15.661) during summer season and 49.375 to 69.312 nL^{-1} with mean ± S.D. (58.656 ±8.324) during monsoon season. The variations across sites and over seasons were significant.The total densities of zooplankton were found to be maximum during summer and minimum during monsoon season. In the community structure and species diversity, protozoa found to be dominant group followed by rotifera, cladocera, copepoda and astracoda.

DISCUSSION:

Zooplanktons also known as animal planktors, plays a key role in transfer of energy at the secondary trophic level in an aquatic ecosystem. Since the zooplankton in the aquatic food chain are consumed by variety of secondary consumers including economically important groups such as prawns, crabs and fishes, they play a key role in indicating the presence or absence of various species of such fresh water bodies (Shukla *et al*. (2012). They are intermediate link between primary producers viz. phytoplankton with higher trophic level organisms. Zooplanktons are rich in essential amino and fatty acids and provide fish with nutrients and their study is necessary in fisheries and aquaculture and is considered as nature's water purifiers (Farshad and Venkataramana, 2012). Zooplanktons respond quickly to the changes in the medium and are used as indicators of overall health of the aquatic

ecosystem (Younus *et al*., 2013). Vaishali *et al.* (2012) studied the occurrence of rotifers and its relation to the water quality during the bioremediation process in Lake Kacharali, Thane, Maharastra, India and recognized their role in cycling of organic material and constitute a large portion of the diet of larval fish. Therefore, the study of zooplankton is important in understanding the lake dynamics and the results of the study are discussed in detail.

In the present study the minimum density of zooplankton were observed during monsoon season. The maximum density of zooplankton was observed during summer season. Average of four years density also found to be minimum during monsoon and maximum during summer. In general higher zooplankton density was much more pronounced during the summer season than the monsoon and winter periods in the lake.

Mishra and Panigrahy (1996) and Joshi (2011) reported a peak in zooplankton density in summer followed by winter and the lowest density during monsoon season. According to Joshi (2011) the monsoon season is associated with lower population density due to dilution effect and decreased photosynthetic activity by the producers and maximum density during summer is due to high temperature, lower transparency and high standing crop of primary producers leading to greater availability of food. Shukla *et al. (*2012) observed quantitative decline in zooplankton population during monsoon and increase during post monsoon and pre-monsoon in Chando lake, Uttar Pradesh. Pandey *et al.* (2013) observed more zoo plankton density during summer season in the swamps of Purnia, Bihar with temporal and spatial variations depending on the limnological characters and their density in the decreasing order from summer > winter >Monsoon.

Srivastava (2013) in his studies on monthly variations in the occurrence of zooplankton in a freshwater body, Ramgarh Lake, Gorakhpur, Uttar Pradesh noticed the production of zooplankton in the lake was minimum during monsoon season and maximum during June-July months. The findings of the present investigation on zooplanktons density of Kanjia lake are similar to the findings of Mishra and Panigrahy (1996); Joshi (2011);Shukla *et al. (*2012); Srivastava, (2013) andPandey *et al.* (2013).

Fresh water zooplankton consists of mainly four major groups i.e. Protozoa, Rotifera, Cladocera and Copepoda. Rotifers are essential food source for Indian major carps and are excellent bio-indicators (Ahmed *et al*. (2011). Shyam (1991), Bais and Agrawal (1995) found that Protozoans, Rotifers, Cladocerans, Copepods and Ostracods constituted main groups of zooplankton in their study.

During the present investigation, the water samples from four study sites have been analyzed for spatial and temporal distribution in density, diversity and percentage distribution of zooplankton. The study revealed the presence of 30 species, out of which 10 species of Protozoa, 9 species of Rotifera, 4 species of Cladocera, 3 species of Ostracoda, and 4 species Copopoda. The zooplankton assemblage of this lake consists primarily of protozoa followed by Rotifers. In the community structure and species diversity, out of 30 species recorded, the Protozoa were found to be dominant group consisting of 10

species ((33.33%) followed by Rotifera with 9 species (30%), Cladocera with 4 species (13.33%), Copepoda with 4 species (13.33%) and Ostracoda with 3 species(10%). Rao *et al*. (1982) reported protozoan as dominant group among zooplanktons.

In the study on zooplankton diversity of three fresh water lakes with relation to trophic status, in Gulbarga district, Karnataka state, Rajashekhar *et al*. (2009) have reported occurrence of 39 species of different groups of zooplankton. Farshad and Venkataramana (2012) reported 25 species of fresh water with dominance of rotifers. Sharma and Singh (2012) recorded 20 species of zooplankton represented by Rotifers, Cladocera, Copepoda and Protozoa with dominance of Rotifers and were found maximum during summer followed by winter and minimum during monsoon. Shukla *et al.* (2012) reported 23 species with Rotifers (seven sp.), Cladocera and Copepoda (six sp.) and four species of Protozoa with dominance of Rotifera.

Younus *et al*. (2013) reported 28 species with Cladocera> Protozoa >Rotifera>Copepoda in the decreasing order of dominance. Pandey *et al*. (2013) recorded 26 zooplankton species belonging to Rotifera (17 sp.) Cladocera (5 sp.) and Copepoda (4 sp.) with dominance of Rotifers >Cladocera>Copepoda and population density was maximum in summer and minimum in monsoon season. In the present investigation on the density, diversity and percentage distribution of zooplankton, zooplankton were represented by Rotifera, Protozoa, Cladocera, Copepoda and Ostracoda and found to exhibit maximum density during summer and minimum during monsoon season contributing significantly to the secondary production of the lake. It agrees with the findings of Farshad and Venkataramana (2012); Sharma and Singh (2012); Shukla *et al.* (2012); Younus *et al*. (2013); and Pandey *et al*. (2013).

Choudhary *et al*. (1991) revealed direct relationship between water temperature and D.O. and inverse relationships between zooplankton density and water temperature.Sahib (2004) observed a direct correlation between dissolved oxygen level and zooplankton populations. Kumar *et al.* (2012) in their studies on phosphate in reference to zooplankton: a shortreview observed that the nutrient like phosphate and nitrate play a key role controlling the fluctuations and the important factor controlling production, growth and distribution of zooplankton in fresh water ecosystem.

The relation between zooplankton and physicochemical parameter were analyzed through Pearson's correlation co-efficient. The variations were insignificant during winter, summer and monsoon season but significant over the years during winter and summer season and insignificant during monsoon season (Table-3,4 & 5.Whereas average of four year shows significant variations across sites and over different seasons. This shows seasonal variation in the density and diversity of zooplanktons in the present study. The variations among different groups of zooplankton were found to be significant among the different groups and over the different sites during all the seasons. Correlation of zooplankton with phytoplankton and other physicochemical factors were also obtained. During

winter season correlation were positive with phytoplankton, phosphates, chlorides, total hardness, alkalinity, turbidity, salinity, pH, and dissolved oxygen, air and water temperature. Zooplanktons show positive correlation with phytoplankton, phosphates, turbidity and negative correlation with conductivity and alkalinity during summer season. During monsoon season zooplanktons showed positive correlation with phytoplankton, turbidity, pH, water and air temperature and negative correlation with conductivity and dissolved oxygen. Maximum density of zooplankton population during summer is related to higher temperature and higher production of phytoplankton leading to greater availability of food, and low population density during monsoon is due to dilution effect, decreased temperature and decreased phytoplankton production. The study thus revealed the seasonal variation in the density and diversity of zooplankton and is influenced by various physicochemical factors directly or indirectly.

ACKNOWLEDGEMENT:

Authors extend thanks to Head, P. G. Department of Zoology, Utkal University, Bhubaneswar, Director and & staff, NandankananZoo, Director, NMNH New Delhi, for granting necessary permission and support for carrying out the research work. Staff, RMNH, Bhubaneswar for their cooperation in the above study.

REFERENCES:

Abbasi, S. A. (1998) Water quality sampling and analysis, Discovery Publishing House, New Delhi

Ahmad, U., S. Parveen, A. A. Khan, H. A. Kabir, H. R. A. Mola and A. H. Ganai(2011) Zooplankton population in relation to physicochemical factors of a sewage fed pond of Aligarh (UP), India. *Biology and Medicine, 3(2) special Issue:* 336-341.

APHA-AWWA-WEF (2005) Standard Methods for the examination of water and wastewater. 21st Ed., Washington, D.C.

Bais, V. S. and N. C. Agrawal (1995) Comparative study of the zooplanktonic spectrum in the Sagar Lake and Military Engineering Lake.*J. Envron. Bio.*, 16(1): 27-32 .

Battish, S. K. (1992) Freshwater zooplankton of India.Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Choudhary, S. K., M. Nayak, R. B. Singh and P. Bannenee (1991) Diurnal variation in some physicochemical and biological parameters of two ponds at Bhagalpur (Bihar).*Natl. Acad. Sci. Lett.*, 14 (10): 403-407.

Dhanapathi, M. V. S. (2000) Taxonomic notes on the rotifers from India (from 1889-2000).Indian Association of Aquatic Biologists, Publ. No.10.

Farshad H. and G. V. Venkataramana (2012) Impact of physico-chemical parameters of water on zooplankton diversity in Nanjangud industrial area, India, *Int. Res. J. Environment Sci.*, 1(4): 37-42.

Joshi, P. S. (2011) Studies on zooplanktons of Rajura Lake of Buldhana district, Maharashtra, India. *Science Research Reporter* 1(3):132 -137.

Kumar, B., V. Sharma, K. S. Gaur and M. S. Sharma (2012) Studies on phosphate in reference to zooplankton: a short review. Bulletin of Environment, *Pharmacology and Life Sciences*, 1(5): 71-81.

Mishra, S. and R. C. Panigrahy (1996) Copepods of Bahuda estuary (Orissa), east coast of India. *Indian J. Marine Sci.,* 25(2): 98-102.

Pandey, B. N., R. Siddhartha, K. D. Tanti, and A. K. Thakur (2013) Seasonal variation in zooplanktonic community in Swamp of Purnia (Bihar), *India Aquatic Biology Research Sciknow Publications Ltd.* , 1(1): 1-9.

Pandey, B. N., R. Siddhartha, K. D. Tanti, and A. K. Thakur (2013) Seasonal variation in zooplanktonic community in Swamp of Purnia (Bihar), *India Aquatic Biology Research Sciknow Publications Ltd.* , 1(1): 1-9.

Rajashekhar, M., K. Vijaykumar and Z. Parveen (2009) Zooplankton diversity of three freshwater lakes with relation to trophic status, Gulbarga district, North-East Karnataka, South India. *International Journal of Systems Biology,* 1(2): 32-37.

Sahib, S. S. (2004) Physicochemical parameters and zooplankton of the Shendurniriver, Kerala. *Journal of Ecobiology,* 16(2): 159-160.

Sharma, D. K. and R. P. Singh, (2012) Seasonal variation in zooplankton diversity in Tighra reservoir, Gwalior (Madhya Pradesh), *Indian J. Sci. Res.*,3(2): 155-161.

Shukla, A. J. P. Shukla and M. Mishra (2012) Biotic Spectrum of Chandolake in context of ecological status and zooplankton diversity. *Current Research Journal of Biological Sciences*, 4(6): 690-695.

Shyam, R. (1991) Comparative dynamics of zoo plankton in a tropical freshwater swamp and in newly constructed ponds in swampy area. *J. Appl. Zoo. Res.,* 2 (2): 80-84.

Srivastava, S. K. (2013) Monthly variations in the occurance of zooplanktonin a freshwater body, Ramgarh Lake, Gorakhpur, U.P. International Journal of applied biosciences,1(2): 23-27.

Vaishali, S., Q. Goldin and P. K. Madhuri (2012) Occurrence of rotifers and its relation to the water quality during the bioremediation process in lakeKacharali, Thane, Maharastra, India ISCA *Journal of Biological Sciences,* 1(3): 54-58.

Verma, P. U., D. K. Chandawat and H. A. Solanki (2011) Seasonal variation in physicochemical and phytoplankton analysis of Kankaria Lake, *Life Sciences Leaflets, 19*: 842-854.

Younus, A., A. Hussain, G. Hussain, M. Tharani and M. Amine (2013)Diversity and seasonal variations of zooplanktons in Pahuj reservoir at Jhansi (U.P) India. *International Journal of Pharmaceutical & Biological Archives*; 4(1): 100-104.

Table 1: Seasonal variations in physicochemical parameters, density, and diversity and % distribution of phytoplankton recorded during three different seasons.

Season	Winter		Summer		Monsoon	
Parameters	MEAN	± S.D.	MEAN	± S.D.	MEAN	± S.D.
Air temp(^{0}C)	23.893	2.442	36.715	2.610	29.426	1.348
Water temp(^{0}C)	22.467	2.066	36.046	2.576	29.362	1.189
pH	7.233	0.555	8.012	0.678	6.801	0.769
D.O.(mgL^{-1})n	8.676	2.213	9.066	2.379	7.892	3.026
Conductivity-µS/cm	258.921	45.223	208.843	61.402	260.343	37.066
Salinity(ppt)	0.238	0.065	0.249	0.049	0.217	0.069
TDS(mgL^{-1})	103.950	19.157	90.062	21.080	104.166	7.943
Turbidity(NTU)	3.244	1.591	4.612	1.384	6.282	6.369
T.Alkalinity(mgL^{-1})	120.687	61.162	84.078	28.650	108.75	53.763
T.Hardness(mgL^{-1})	18.426	4.588	18.951	5.079	18.901	3.859
Chlorides(mgL^{-1})	8.686	0.760	15.152	0.730	3.029	1.461
Nitrates(mgL^{-1})	0.024	0.011	0.022	0.005	0.029	0.019
Phosphates(mgL^{-1})	2.295	1.41	2.122	1.263	2.715	1.835
Total P.plankton(nL^{-1})	3670.312	157.956	6269.475	383.297	3521.25	348.39
Chlorophyceae	1917.65 (52.21%)	173.8904	3464.314 (55.351)	258.1538	1843.165 (52.362%)	196.8091
Cyanophyceae	580.9125 (15.825%)	131.31333	1059.161 (16.8977%)	239.7178	529.4685 (14.9875%)	223.6787

Bascillariophyceae	1171.68 (31.9539%)	23.3224	1745.938 (27.75%)	298.041	1148.565 (32.6487%)	141.2635

Table – 2: List of phytoplankton species recorded from KanjiaLake.

Plankton Type				
Chlorophyceae	S1	S2	S3	S4
AnikistrodesmusfalcatusRalfs	+	+	+	+
Botryoccoccussp.	+	+	+	+
Clamudomonasglobosa Snow	+++	++	++	+++
Chlorella vulgarisBeij	++	++	+	+++
Cosmariumreniforme Arch	+	+	+	+
CosmariumbioculetumBerb	+	+	+	+
Cosmarium botrytis	+	+	+	+
ClosteriumlanceolatumKutz	++	++	++	+++
ClosteriumleibejiKutz	++	++	+	+++
Dictyosphaeriumpulchellum Wood	+	+	+	++
Euglena viridisEhrenb	++	++	-	+
Euglena elegansEhrenb	+	+	-	++
Euglena spirogyraEhrenb	+++	++	++	+++
Paridorinamorum Mull	++	++	+	+++
Pediastrum tetras Brown	+	+	+	+
PhacuspleuronectesOfmduj	+	+	+	+
Protococossp	+	+	+	+
Spirogyra variansKutz	++	++	+	+++
Spirogyra longataVauch	++	++	+	+++
ScenedesmusquadricaudaTurb	+	+	+	+
UlothrixzonataKutz	+	+	+	+
VolvoxglobatorEhrenb	+	+	+	+
Westellabtryoides West	++	++	+	+++
Zygnemasp	+	+	++	+++
Cyanophyceae				
Anabaena sp	+++	++	+	+++
LyngbyaspHarv.	++	+++	+	+++
MicrocystisaeroginosaKutz	+++	++	++	+++
NostocspVauch	++	++	++	+++
Oscillatoriasimplicissima	+++	++	+	+++

Oscillatoria princes	+++	++	+	+++
PhormidiumfavosumGom	+++	++	++	+++
Rivulariasp	++	++	+	+++
Bacillariophyceae				
Amphora ovalisKutz	+	-	-	+++
Cyclotella comateEhrenb	++	+	-	++
Cymbellanaviculiformis Auer	+	++	+	+++
FragillariabrevistriataGrun	+	+	+	++
GomphonemalanceolatumEhrenb	++	+	-	++
Melosira granulateRalfs	+	+	+	+++
NaviculaLaterostrataHust				
Navicula cuspidateKutz	+	+	+	++
NitzschiaclosterumEhrenb	++	++	+	+++
PinnulariaviridisEhrenb	++	+	-	+++
Synedra ulnaEhrenb	+	++	+	+++

-= Absent, +=Present, ++= moderately Abundant, +++= More abundant.

TABLE 3: CORRELATION COEFFICIENT VALUES AMONG DIFFERENT PHYSICOCHEMICAL PARAMETERS AND PLANKTON (PHYTOPLANKTON) DURING WINTER (2009-10 TO 2012-13)

0	Air Temp.	Water Temp.	pH	DO	EC	Sal.	TDS	Turb	T.Alk.	T. H	Cl	NO_3	PO_4	P. pl	Z.pl
Air temp	0														
Water temp	0.969**	0													
pH	0.347**	0.277*	0												
DO	0.074	0.061	0.435**	0											
EC	-0.106	-0.066	0.364**	0.626**	0										
Sal.	-0.187	-0.22	0.194	0.608**	0.462**	0									
TDS	-0.04	0.025	0.311*	0.401**	0.667**	0.316*	0								
Turb	-0.209	-0.193	0.067	0.733**	0.644**	0.761**	0.282*	0							
T.Alk.	-0.294*	-0.24	0.021	0.727**	0.674**	0.666**	0.417**	0.868**	0						
T. H	-0.079	-0.133	0.131	0.755**	0.255*	0.644**	-0.106	0.676**	0.591**	0					
Cl	0.347**	0.365**	0.065	0.046	-0.141	-0.05	-0.059	-0.037	-0.035	-0.16	0				
NO_3	-0.038	-0.006	-0.042	0.527**	0.36**	0.583**	0.202	0.59**	0.602**	0.469**	0.112	0			
PO_4	-0.235	-0.19	0.27*	0.643**	0.817**	0.63**	0.788**	0.707**	0.744**	0.26*	-0.034	0.417**	0		
P. pl	0.42**	0.421**	0.202	-0.051	-0.191	-0.145	-0.148	-0.137	-0.150	-0.219	0.664**	-0.06	-0.052	0	
Z.pl	0.27*	0.287*	0.423**	0.432**	0.182	0.259*	0.1	0.255*	0.254*	0.245	0.478**	0.182	0.285*	0.559**	0

TABLE 4: CORRELATION COEFFICIENT VALUES AMONG DIFFERENT PHYSICOCHEMICAL PARAMETERS AND PLANKTON (PHYTOPLANKTON) DURING SUMMER (2009-10 TO 2012-13)

0	Air Temp.	Water Temp.	pH	DO	EC	Sal.	TDS	Turb	T.Alk.	T. H	Cl	NO_3	PO_4	P. pl	Z.pl
Air temp	0														
Water temp	0.920**	0													
pH	0.254*	0.158	0												
DO	0.151	0.168	0.474**	0											
EC	-0.326**	-0.399**	0.048	-0.258*	0										
Sal.	0.373**	0.384**	0.163	0.083	-0.655**	0									
TDS	0.009	0.094	0.243	-0.093	0.082	0.057	0								
Turb	-0.155	-0.164	-0.443**	-0.22	-0.351**	0.291*	-0.221	0							
T.Alk.	-0.112	-0.104	-0.419**	-0.41**	0.366**	-0.16	-0.269*	-0.206	0						
T. H	0.333**	0.371**	0.338**	0.701**	-0.439**	0.361**	-0.383**	0.151	-0.362**	0					
Cl	0.55**	0.446**	0.183	0.128	-0.011	0.131	0.085	-0.303**	0.281*	-0.014	0				
NO_3	-0.192	-0.158	-0.367**	-0.409**	0.042	0.257*	0.154	0.373**	0.193	-0.252*	-0.301*	0			
PO_4	0.108	0.238	-0.19	0.036	-0.81**	0.701**	0.202	0.433**	-0.218	0.172	-0.094	0.221	0		
P. pl	-0.425**	-0.42**	0.052	0.153	0.163	-0.037	0.048	-0.076	-0.013	-0.196	0.008	0.025	-0.014	0	
Z.pl	-0.169	-0.143	-0.021	0.206	-0.381**	0.214	0.133	0.251*	-0.441**	-0.003	-0.02	0.094	0.355**	0.603**	0