The Effects of Physico-Chemical Parameters on the Phytoplankton Population of Shahrchai Dam Reservoir (Uramia- Northwest) Iran

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Abstract

The effects of water physico- chemical factors on phytoplankton communities of Shahrchai dam reservoir were studied. 6 sampling sites were chosen along Shahrchai dam and surface and deep layers were sampled during 3 seasons in 2015-2016. In this study, phytoplankton samples were fixed with 4% formalin and transferred to laboratory. Identification and enumeration of the phytoplankton were performed by inverted microscope equipped with 5 ml counting chamber. Totally 34 species of phytoplankton belonged to Green algae, Diatomes, Cyanobacteria and Euglenophyta were determined. Statistical analysis was carried out by PCA and UPGMA methods. The analysis of data by PCA showed that first and second axis created 99% of changes alone. There were 3 completely distinct groups of samples regarding the sampling seasons. The most effective physico- chemical factors influenced the phytoplankton communities were water transparency, EC and water temperature.

Keywords: Shahrchai reservoir, Physico-Chemical factors, Phytoplankton.

Introduction

Beside the social and economic importance, lentic water resources such as dam reservoirs are considered as valuable environmental and ecological resources. Due to high volume of soluble nutrients and load of organic maters from the basin, dam reservoirs are one of the fertilized systems providing nutrients to various plant communities. Phytoplankton are a group of photosynthesized floating algae in the water that play a key role in providing the nutrients, and oxygen to other live organisms, fixation of waste nitrogenous products, and the carbon dioxide fixation. These organisms are primary producers in aquatic ecosystems and were used to determine water pollution level. Algae are very powerful to identify and interpretation of water ecological conditions (Reynolds, 2006; Barone and Naselli, 1994; Stoermer and Smol, 1999).

Therefore, composition and abundance of algal communities are commonly used as a water quality index and trophic status of dam reservoirs and rivers (Mohebbi, 2012; Wetzel, 1983; Trinova, 1998; Reynolds et al., 2002; Mohsenpour et al., 2011; Yerli et al., 2012).

Human activities has increased the algal bloom and accelerated eutrophication of water bodies that has been observed in water systems all over the world (Ma et al., 2014). The over growth of

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cyanobacteria algae has a harmful effects on the use of urban water, industrial, fisheries and recreational activities (Dokulil and Teubner, 2000). Shahrchai dam reservoir was constructed on Shahrchai River, which flows through Uramia city and enters into the lake Uramia. The reservoir provides the drinking water of more than 860000 population of Uramia city and agricultural water of Uramia plain. In spite of high importance of this reservoir, its phytoplankton populations and related water quality indices has not yet been studied. Regarding to growing water shortage and reduced percipitation in recent years, determination of Shahrchai water quality status by phytoplankton population changes is a useful tool to manage water quality.

In Iran, some studies on phytoplankton populations of reservoir dams and rivers were made earlier (Mohebbi et al., 2012; Mohsenpour et al., 2011; Shams et al., 2012). These studies are mostly carried on one water ecosystem by phytoplankton population changes and water quality status. Also, internationally various work has done on determination of water quality using algae and related ecological variables (Wetzel, 1983; Trifonova, 1998; Reynolds et al., 2002; Mohsenpour et al., 2011; Yerli et al., 2012).

Materials and Methods

Water samplings were performed by a rottener type sampler. Two samples were taken from each site (surface and 1m depth). All samples immediately were fixed by logul solution. After transferring to laboratory, the samples were kept in dark and cool place. Identification and counting of phytoplankton were performed by a TS100 Nikon inverted microscope with resolution 400 and 5ml count chamber by Utermöhl (1958) method. In each sample, at least 50 field of view or 100 individuals from most abundant phytoplankton were counted (Venrick, 1978). In this study the identification keys such as Bellinger (1992); Tiffany and Britton (1971); Prescott (1962) were used to determine phytoplankton taxa. Water temperature, Dissolved Oxygen (DO), EC, pH and water transparency

Fig. 1. Study area and sampling sites in Shahrchai dam reservoir

Fig. 1. Study arca and sampling sitcs in Shahrcha

were measured by Oxymeter WTW320, EC meter WTWLF320, pH meter Teso320, and Secchi disc, respectively. PO_4^{3-}, NO_3^-, Total Nitrogen (TN) were determined with Spectrophotometer PG T80⁺ according to Greenberg et al. (1992).

Multivariate statistical analysis

Multivariate statistical analysis such as Principal Component Analysis (PCA) are techniques that shows the relationships between each taxon in a population or between population structure and ecological variables. The PCA method is used for decreasing phytoplankton data to limited number of taxon's that statistically significant and their distribution pattern is the cause of total variance of data (Beaver et al., 2013).

In this study grouping was made by dividing to basic components and then the role of studied factors were determined by biplot. Also, PCA analysis and the role of environmental factors were illustrated in PCA loading Table and Figures 1-7. Unweight Pair Group Method with Arithmetic Mean (UPGMA) is a simple hierarchical clustering method. This method is one of the most common techniques in ecology to classify the sampling units based on the amount of similarity of reciprocal pairs in prescribed variants (such as species composition). Algorithm UPGMA confirms a dendrogram that reflexes a shown structure in a similar or non-similar matrix. UPGMA is the simplest method to form a tree. This method basically was performed to make taxonomic phonograms. UPGMA use a consecutive clustering algorithm that in it localized topologic relations were determined based on the rate of similarity and similarity tree was constructed step by step. Two- way clustering method were done between physico-chemical and biological variables and among sites and sampling seasons to determine similarities and dissimilarities among these factors.

Tow- way Clustering Analysis of data were done using UPGMA method based on environmental variables. Before analysis, all data were standardized (Mean= 0, Variance = 1). Euclidian distance among studied samples were determined based on standardized obtained data. Matrix of obtained distance was used to make clustering UPGMA tree. PCA and Tow-Way Clustering were analyzed by Paleontological Statistics (PAST) version 3.04 (Hammer et al., 2001).

Results

Table 1 shows the complete list of phytoplankton taxa identified in Shahrchai dam reservoir. Totally, in this study, 34 taxa were identified in Shahrchai dam reservoir of which Bacillariophyta, Chlorophyta, Cyanobacteria and Euglenophyta with 16, 14, 3 and 1 taxa had the highest number of taxa respectively.

Some physicochemical parameters of shahrchai dam reservoir water in the study period are indicated in Table 2. Total nitrogen (TN) as an indicator of water trophy state ranges between 0.83 to 1.45mg/l.

In spring as well as autumn, the mean of phytoplankton density in depth samples were less than surface ones (Figs 2, 3). Cyanobacteria only occurred in summer and early autumn with 7.3×10^6 cell/l and 8.9×10^6 cell/l respectively (Fig .4). The density of chlorophyta in spring, summer and autumn were 64.3, 5.3 and 4.3 $\times 10^6$ cell/l respectively. In early spring, the highest algal density was nearly 8.5×10^6 cell/l was related to site 2 – surface and the lowest density 1.462×10^6 cell/l was related to site 6 (Fig. 3).

The analysis of basic components revealed that first and second axis were responsible for more than 99% of changes (Table 3). PCA showed three distinct groups which were completely met the sampling periods (Figs 6, 7 and 8).

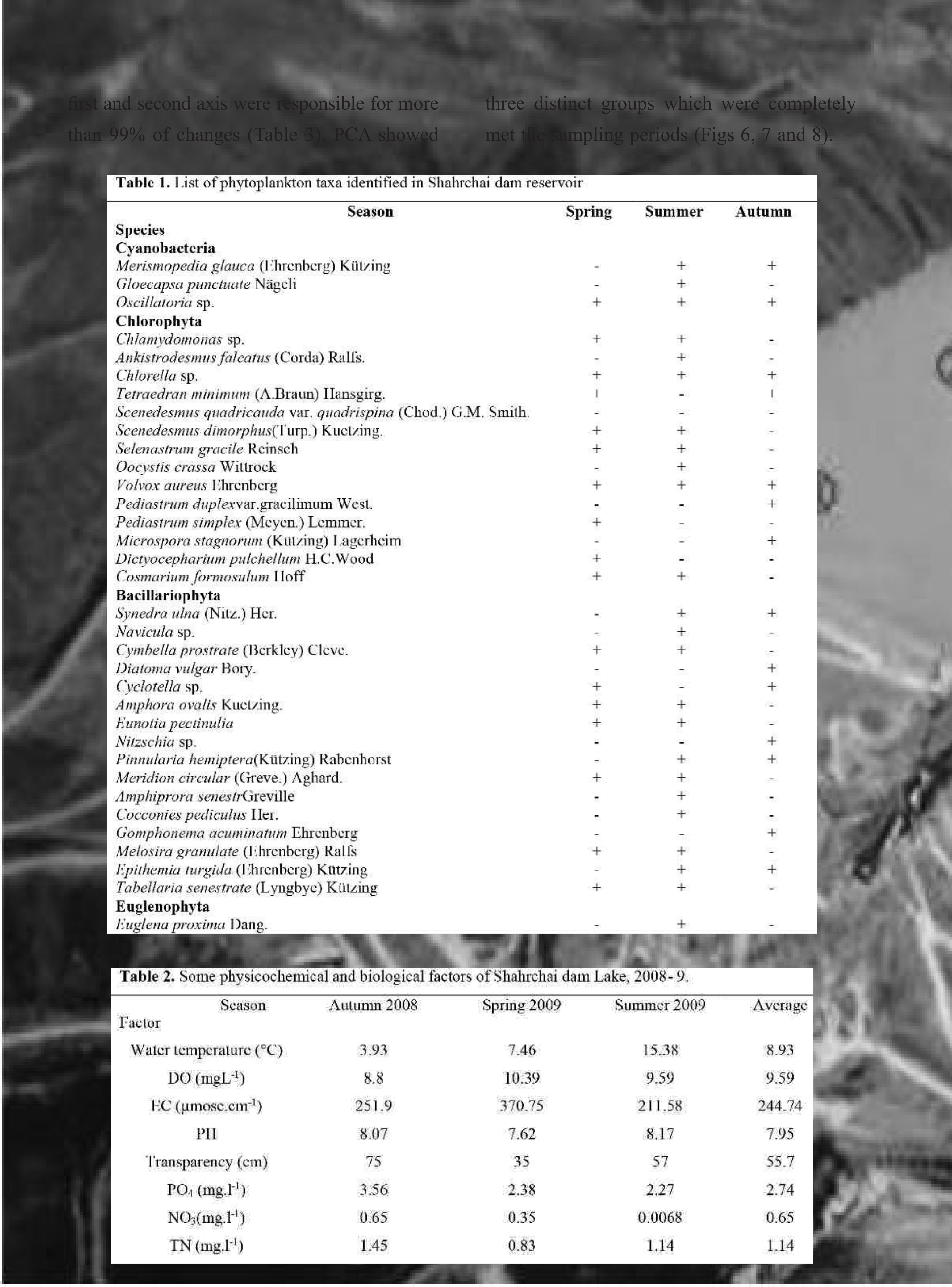

Table 1. List of phytoplankton taxa identified in Shahrchai dam reservoir

Season Species	Spring	Summer	Autumn
Cyanobacteria			
Merismopedia glauca (Ehrenberg) Kützing	-	+	+
Gloecapsa punctuate Nägeli	-	+	-
Oscillatoria sp.	+	+	+
Chlorophyta			
Chlamydomonas sp.	+	+	-
Ankistrodesmus falcatus (Corda) Ralfs.	-	+	-
Chlorella sp.	+	+	+
Tetraedran minimum (A.Braun) Hansgirg.	I	-	I
Scenedesmus quadricauda var. *quadrispina* (Chod.) G.M. Smith.	-	-	-
Scenedesmus dimorphus(Turp.) Kuetzing.	+	+	-
Selenastrum gracile Reinsch	+	+	-
Oocystis crassa Wittrock	-	+	-
Volvox aureus Ehrenberg	+	+	+
*Pediastrum duplex*var.gracilimum West.	-	-	+
Pediastrum simplex (Meyen.) Lemmer.	+	-	-
Microspora stagnorum (Kützing) Lagerheim	-	-	+
Dictyocepharium pulchellum H.C.Wood	+	-	-
Cosmarium formosulum Hoff	+	+	-
Bacillariophyta			
Synedra ulna (Nitz.) Her.	-	+	+
Navicula sp.	-	+	-
Cymbella prostrate (Berkley) Cleve.	+	+	-
Diatoma vulgar Bory.	-	-	+
Cyclotella sp.	+	-	+
Amphora ovalis Kuetzing.	+	+	-
Eunotia pectinulia	+	+	-
Nitzschia sp.	-	-	+
Pinnularia hemiptera(Kützing) Rabenhorst	-	+	+
Meridion circular (Greve.) Aghard.	+	+	-
*Amphiprora senestr*Greville	-	+	-
Cocconies pediculus Her.	-	+	-
Gomphonema acuminatum Ehrenberg	-	-	+
Melosira granulate (Ehrenberg) Ralfs	+	+	-
Epithemia turgida (Ehrenberg) Kützing	-	+	+
Tabellaria senestrate (Lyngbye) Kützing	+	+	-
Euglenophyta			
Euglena proxima Dang.	-	+	-

Table 2. Some physicochemical and biological factors of Shahrchai dam Lake, 2008-9.

Season Factor	Autumn 2008	Spring 2009	Summer 2009	Average
Water temperature (°C)	3.93	7.46	15.38	8.93
DO (mgL^{-1})	8.8	10.39	9.59	9.59
EC ($\mu mosc.cm^{-1}$)	251.9	370.75	211.58	244.74
PH	8.07	7.62	8.17	7.95
Transparency (cm)	75	35	57	55.7
PO_4 ($mg.l^{-1}$)	3.56	2.38	2.27	2.74
NO_3($mg.l^{-1}$)	0.65	0.35	0.0068	0.65
TN ($mg.l^{-1}$)	1.45	0.83	1.14	1.14

Fig. 1. Study area and sampling sites in Shahrcha

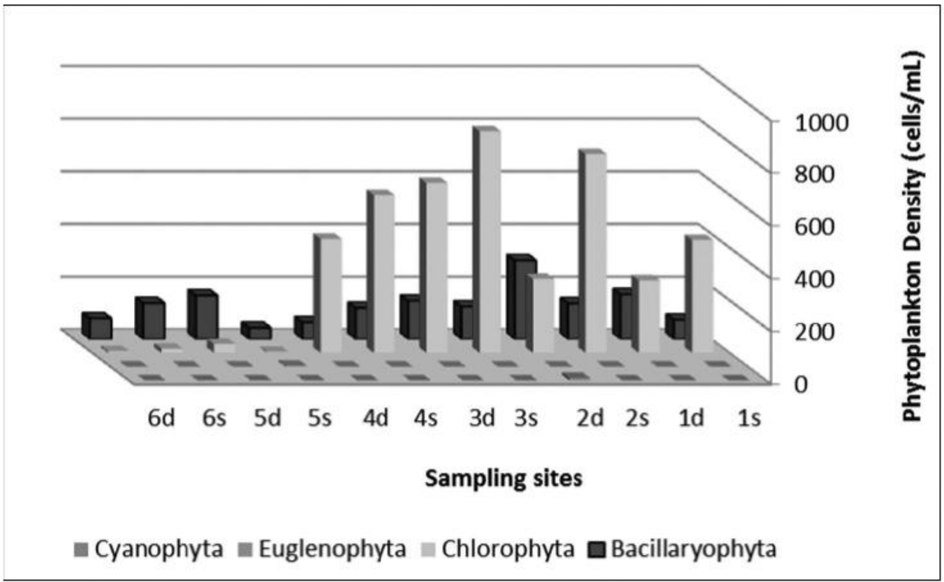

Fig. 2. The density of phytoplankton groups in Shahrchai reservoir in autumn 2008

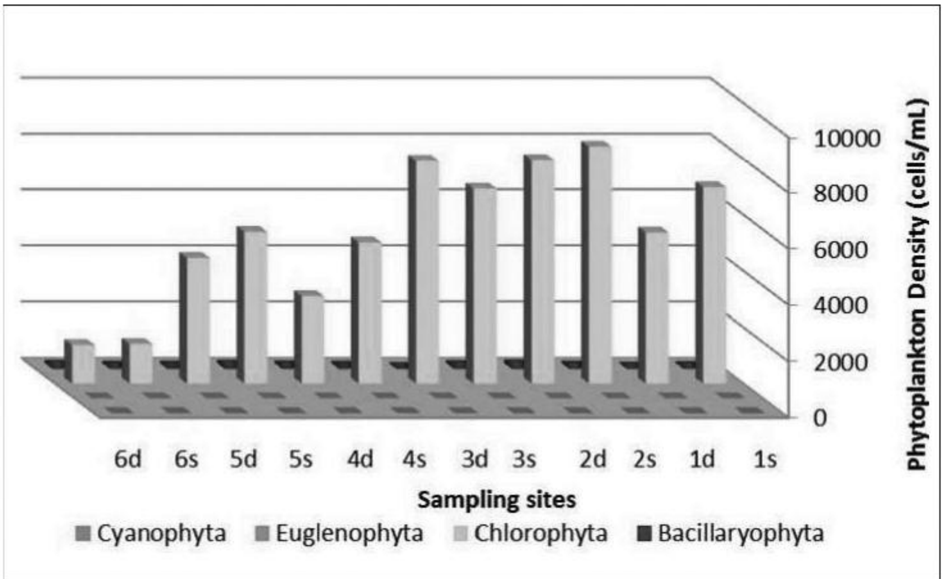

Fig. 3 The density of phytoplankton groups in Shahrchai reservoir in spring 2009

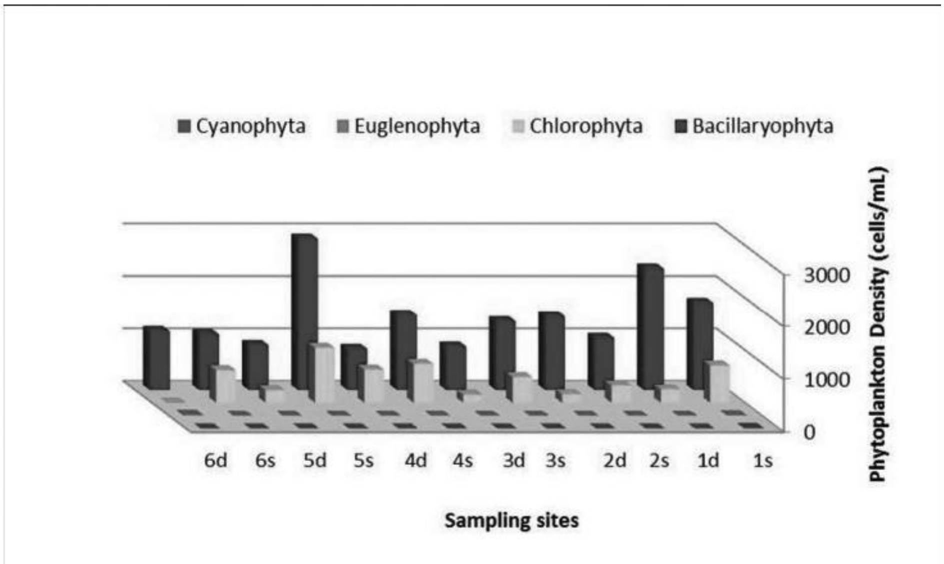

Fig. 4. The density of phytoplankton groups in Shahrchai reservoir in summer 2009

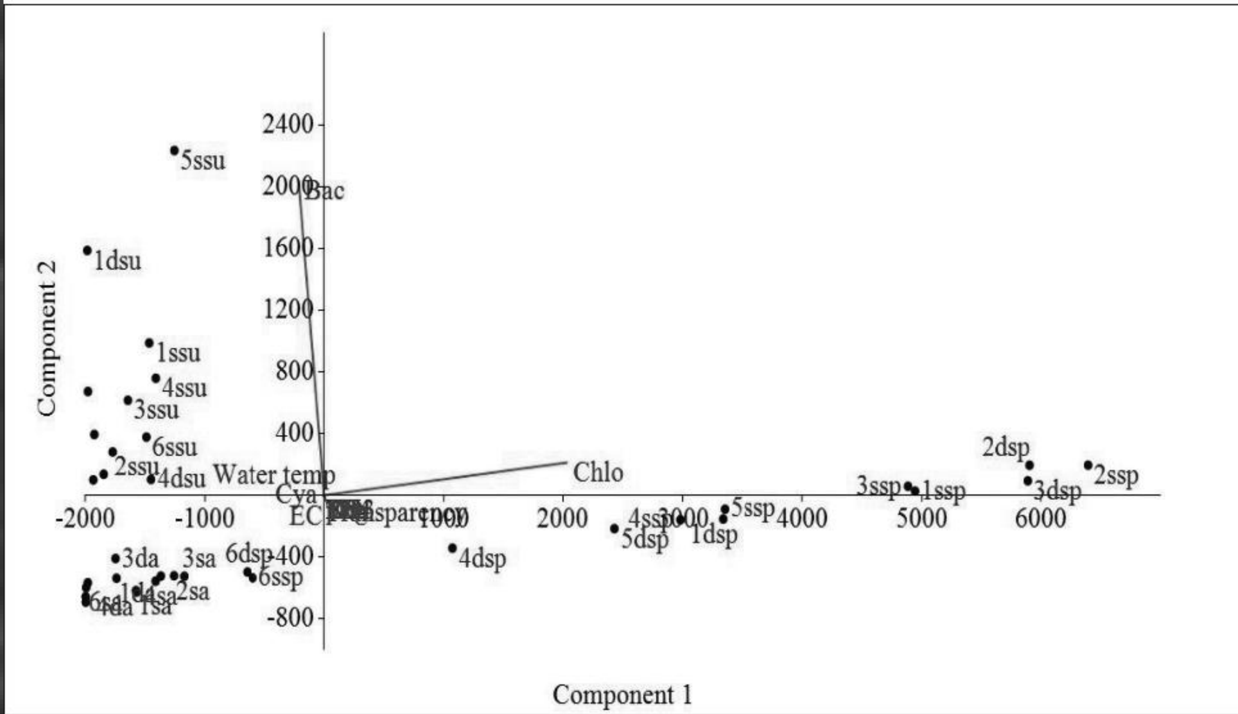

Fig. 5. Principal Component Analysis (PCA) of phytoplankton groups, physicochemical factors, sampling sites and seasons in Shahrchai reservoir

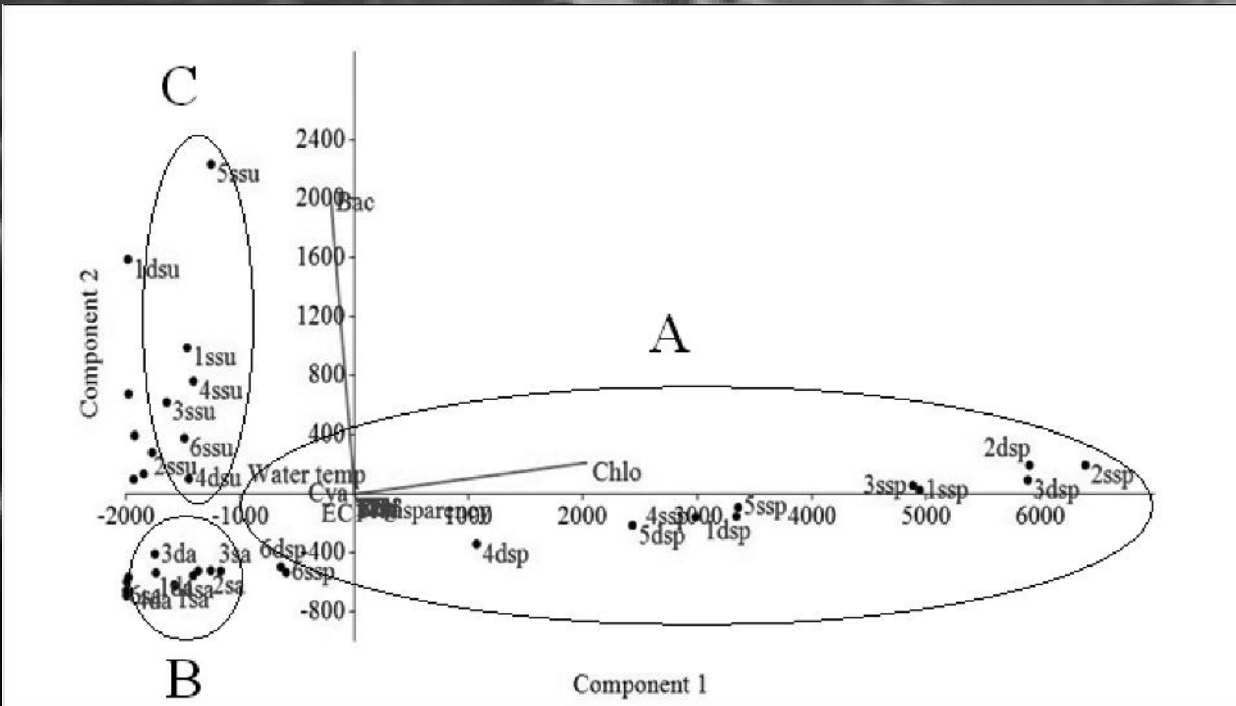

Fig. 6. Principal Component Analysis (PCA) of phytoplankton groups, physicochemical factors, sampling sites and seasons in Shahrchai reservoir (note to the grouping based on the seasons: A- spring, B- autumn, C- summer)

Fig. 1. Study area and sampling sites in Shahrcha

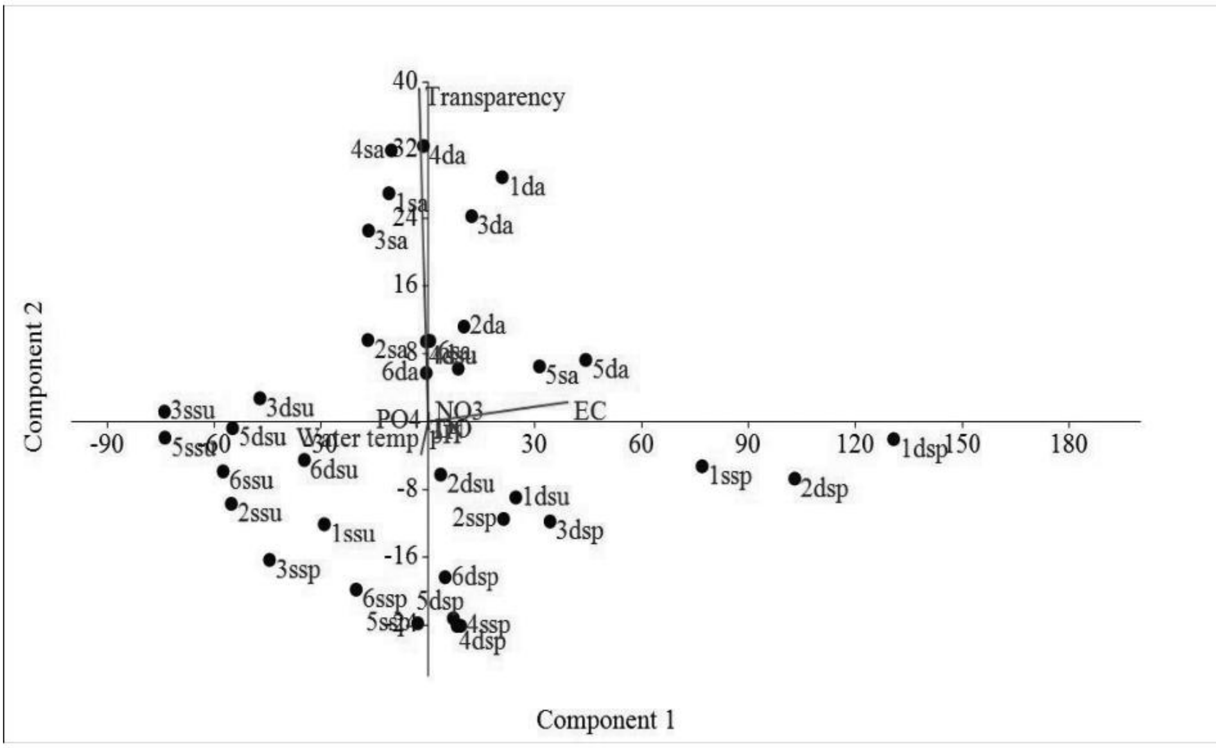

Fig. 7. Principal Component Analysis (PCA) of physicochemical factors, sampling sites and seasons in Shahrchai reservoir

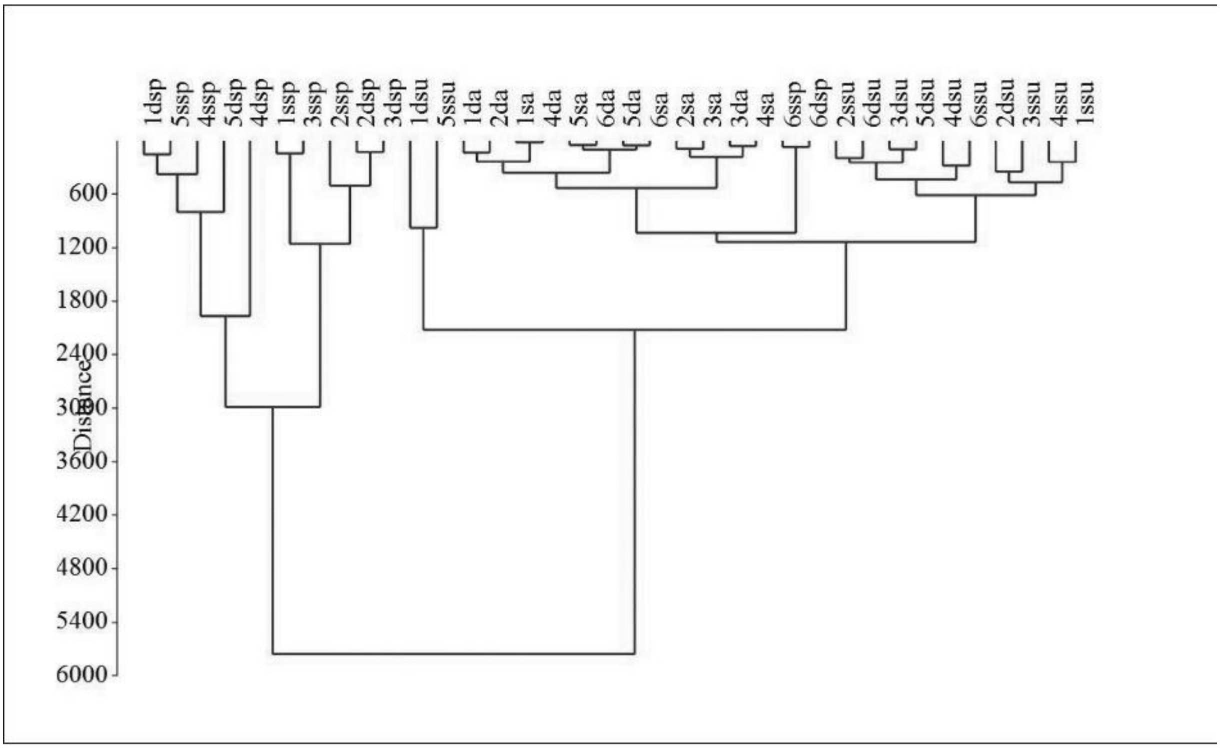

Fig. 8. Clustering analysis of sampling sites and seasons in Shahrchai reservoir by UPGMA method

Table 3. Total components factor loadings in PCA of Shahrchai reservoir limnological parameters

Component	Eigenvalue	Variance (%)
1	7.6×10^6	94.6
2	432031	5.375
3	1316.15	0.016375
4	163.785	0.0020277
5	7.62473	9.4862×10^{-5}
6	7.50029	9.3314×10^{-5}
7	4.27768	5.322×10^{-5}
8	0.389737	4.8488×10^{-6}
9	0.169695	2.1112×10^{-6}
10	0.14498	0.14498×10^{-6}
11	0.0912185	0.0912185×10^{-6}
12	0.065562	8.1568×10^{-7}

Discussion

The phytoplankton are the base of food chain and constitutes the bulk of primary producers in all water bodies. The ecology of phytoplankton has a principal importance because strongly depics the water quality and also reflects the average ecological condition (Tyagi and Nalik, 2017). In our study, Chlorophyta was the most abundant algal group followed by Bacillariophyta and Cyanobacteria. Similar findings were reported by Tyagi and Malik (2017) and Mishra et al. (2010). Martinel et al. (2016) studied the phytoplankton and trophic state of a nearly impounded reservoir. They concluded that phytoplankton structure may be a suitable indicator to follow the trophic status of a young reservoir. Shahrchai reservoir is a relatively new reservoir (impounded in 2005). So, our study shows an appropriate approach that might be recommended to follow ecological condition of the reservoir in the future studies.

In spring as well as autumn, the mean of phytoplankton density in depth samples were less than surface ones. That shows phytoplankton density is largely related to sun light and its depth of penetration in the water. Cyanobacteria only occurred in summer and early autumn with 7.3×10^6 cell/l and 8.9×10^6 cell/l respectively, which indicates oligotrophic status of Shahrchai reservoir. Low level of cyanobacteria indicated the non- contamination or low contamination in all sampling sites. Year round high density of chlorophyta indicated low levels of contamination in the reservoir. In this study *Chlorella* as a green alga showed a high abundance in all samples in both spring and autumn. Also in early spring the algae bloom in the Shahrchai Lake was related to *Chlorella*. In early spring, the highest algal density was nearly 8.5×10^6 cell/l was related to site 2 surface and the lowest density 1.462×10^6 cell/l was related to site 6. The low density of phytoplankton at site 6 can be attributed to increase in water depth at this site due to rainfalls that caused to increase water level at that time. The analysis of basic components revealed that first and second axis were responsible for more than 99% of changes (Table 2). The results showed 3 completely distinct groups related to sampling seasons (Fig. 7). The most important physicochemical variables affecting this classification were water transparency, EC and water temperature (Fig. 7).

Wassie and Melese (2017) studied the effects of physicochemical factors on phytoplankton structure in Selameko reservoir in Ethiopia. Their results confirmed that anthropogenic activities can influence the phytoplankton population by changing the phosphorus concentration. Mohebbi et al. (2015) showed that agricultural activities and urbanization were the most important factors in eutrophication of Aras reservoir. Water quality and trophic structure of the Shahrchai reservoir may be negatively af-

Fig. 1. Study area and sampling sites in Shahrcha

fected by agricultural and livestock activities (Mutlu and Kutlu, 2017) performed around the dam in the future. Therefore, to avoid such disturbances in the Shahrchai reservoir, basin and reservoir management plans are strongly recommended. In conclusion, Shahrchai reservoir is an important fresh water source fed by Shahrchai river and snow waters and contains noticeable freshwater potential. Besides, its eutrophication status was not exceeded the limits recommended for Lakes, ponds and dams. Therefore, the reservoir management should be streamed toward integrated approaches to let the condition goes well.

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