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ORIGINAL ARTICLE

Phytoplankton Diversity and its relation to Season and some physicochemical Parameters in Karoon 4 Reservoir (Iran)

S.A.Mousavi[1]*, Mehdi Soltani[2], Abolghasem Kamali[3], Mehdi Shamsaei[3]
1*Department of Fisheries, Science and Research Branch, Islamic Azad University, Tehran, Iran.
E-mail: sm_mousavi792000@yahoo.com.
2. Department of Aquatic Animal Health, Tehran University, Tehran, Iran.
3. Department of Fisheries, Science and Research Branch, Islamic Azad University, Tehran, Iran.

ABSTRACT
This study was located at Karoon 4 reservoir,down-stream of Armand and Bazoft rivers (Southwest of Iran).Water samples were collected from March 2012 to February 2013 in three selected silts. Environmental parameters and chlorophyll a concentration were measured, as well as identification and abundance of phytoplankton communities were studied. According tothis study, 27 species were identified at four seasons. Most abundance was related to the phyla Bcillariphyta (17species), Cyanophyta (4species),Crysophyra and Chlorophyta(3) species,Dinophyta(2 species) and Crysophyte(1 species) respectively. The results showed, the maximum rate of chlorophyll a concentration was measured inthe warm and minimum of this, was measured in the cold months. According to this, minimum and maximum of the chlorophyll a concentration was observed in March (2.1 µg/L) and October (4.9 µg/L), respectively. The rate of chlorophyll a concentration shows an oligotrophic condition in the lake of karoon 4 dam (5). As the results, we have the positive significant correlate between the parameters include, COD,NO3,temperature, pH, turbidity, chlorophyll a and phytoplankton abundance(P< 0.01).Whereas, there is not significantly positively correlated between DO and another parameters(P> 0.05).The chlorophyll a concentration and phytoplankton community have a significant negative correlation with transparency (-P< 0.01).
Keywords: Phytoplankton, chlorophyll a, karoon4, identification, abundance

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INTRODUCTION

About 45.000 enormousdams >15 m in elevation had been built until the end of 2000, in more than 150 countries. While 160 to 320 new enormousdams are founded worldwide each year (34).Damming by supplying water, bridling floods, irrigating yields, transport facilitation and obtaining easy electric energy, have many interests all over the world for thousands of years(32). However damming have a several environment impacts,including make the physical, chemical and geomorphologic changes. because of blocking a river and varying the natural dispensation and schedule of stream flow. Among other impacts that enlace changes in primary producers of ecosystems, such as effects on river margin and littoral plant-life and on down- stream ecosystems such as wetlands(30).

Algae are important for aquatic environments. They belong to highly diverse group of producer organisms with chlorophyll *a* and unicellular reproductive structures. They ranged from 4 to 13 with as many as 24 classes and about 26,000 species. The algae are one of the important biological indicators in aquatic ecosystems. While In most ecosystems they play a role as the primary producers in the food chain,on the other hand some species by secret the toxic substances hepatotoxins or neurotoxins etc., can be harmful to human, fishes and other vertebrates into the water bodies (1). Reproduction of harmful especially species organisms should be monitored. Analysis of the phytoplankton biology and ecology are advantageous for monitoring the physico-chemical and biological factors of the water environment. Some groups of phytoplanktonsparticularly blue green algae can be inducement deoxygenation, when they bloom, may leading to fish death (31).

Algae widely occur in waterecosystems, such as fresh water, marineor brackish. However, they can also be found in almost every other environment on earth, such as some algae that grow in the snow of some mountains. In addition their function to provide the food source for heterotroph organisms.They also supply the oxygen necessary for the metabolism of the consumer organisms. Sometimes humans directly consume algae (10). but mainly these microorganisms are consumption by organisms such as zooplanktons. Algae are largely present in freshwater environments, such as lakes, reservoirsand rivers. They are typically present in these places as micro-organisms. These organisms are visible only with the aid of a light microscope. Nevertheless their microscopic size, they have a major impact in the freshwater ecosystems, both in terms of fundamental ecology and in relevance to human (5).

Algal bloom can be cause of some important environmental impacts worldwide, and it will reason a several problems such as toxin production,redolence, trash and possibly unsafe drinking water(22).Commonly,temporal and spatial occurrence ofalgal blooms is mainly controlled by several physical and chemical factors including temperature, nutrients, flowrate and rainfall (8 & 24). Nutrient access has oftenimportance than other factors and has been a mainqualifying factor to impress successions of phytoplankton species abundance (18).In general, proliferated N and P inputs instigate bloom of some algae species and increase phytoplankton biomass (33).Another factor that has a major affect in algal bloom is water temperature(11, 6 & 14).Also some hydrodynamics, include water flow and sedimentation,frequentlystimulatethe trophic replication in aquatic ecosystems (12).Somewhen,rainfall as an external factor plays an important role in algal community and species combination and their environments (18).

MATERIALS AND METHODS

Study area

This study was located at Karoon 4 reservoir.Down-stream of Armand and Bazoft rivers.The karoon 4 Dam was completed in 2012, is a greatest two archconcrete gravity dam in Iran, with 230 m height, 32 km2 catchment area and a storage volume of 2.2billion m3. The tree sampling stations where chosen.One near the dam crest 31° 36′21″ N. 50°28′38″E.second near the area of the Armand riverintake31°38′19″N.50°30′48″and tertiary near the Bazoftriver intake area 31°40′33″N. 50°29′39″E Fig 1.

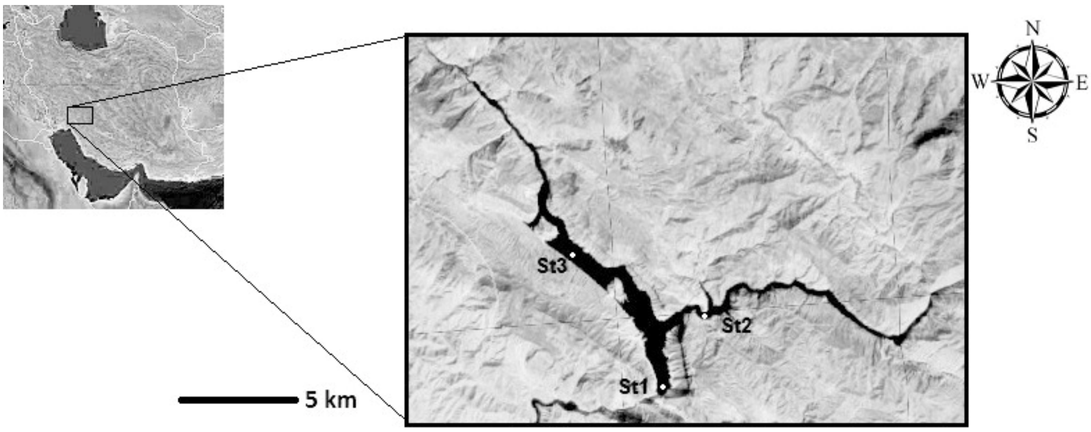

Fig 1. Study area of karoon 4 reservoir

Sampling

Water samples were collected by using a Ruttner sampler 6 liter per each station monthly from March 2012 to February 2013. Tree stations were chosento assessment chlorophyll *a*. phytoplankton numbering and identification and physicochemical parameters. Forevaluate phytoplankton the samples were fixedimmediately withacid Lugol's iodine solution. To preserving the samples with Lugol's solution, 0.7 ml Lugol's solution was added to 100ml samples and store in dark andfor measurement ofChlorophyll *a*concentration,samples were preserved immediately by 4% formaldehyde and maintenance in cold and dark condition (3).

Turbidity, Temperature, pH and Do were measured with multi meter and Transparency was determined by secchi disk. For measuring biological oxygen demand (BOD), chemical oxygen demand (COD),total dissolved solid (TDS), total suspended solid (TSS), ammonium, nitrate and phosphate, the water samples were preserved after sampling according to Standard Method(4).

Phytoplankton Analysis

Sedimentation was carried out by decanting the 100 ml sample into a measuring cylinder and allowing the cylinder tostabile for 24h for sedimentation the algae. Sedimentation was fulfilled in the dark and cold conditions. By siphoning 80 ml of surface liquid, concentration of phytoplankton was carried out. Counting was performed by using of Sedgwick–Rafter slide and optical invert microscope (OLYMPUS BH-2), at ×400 a magnification (5).

Environmental factors analysis

Dissolve oxygen (DO), pH, temperature, turbidity and EC were measured in situ by Multi meter and transparency was measured by secchi disk. For measuring another Physic-chemical parameters include phosphate,nitrate,biological oxygen demand (BOD), chemical oxygen demand (COD), and total dissolve solid (TDS), the water samples were filtered after sampling by glass-fiber filters (0.45-μm pore size)(15 & 26). Then analyzed by spectrophotometry Hach(DR 5000)(4).Measurement of chlorophyll *a*Concentration was carried out byspectrophotometric method described in (SEPB 2002).Hence, at first the samples were extracted from the filter for 24 h with 90% acetone (34 & 7).

Statistical analysis

Two tailed Pearson correlation was performed to identify relation amongphytoplankton abundance, chlorophyll *a* concentration and physicochemical factors (23). One-way ANOVA was used to test for differences in thephytoplankton abundance,chlorophyll *a* concentration and physiochemical factors among the sampling stations and the seasons (25 &28).

Results and Discussion

According tothis study, 27 species wereidentified at four seasons. Most abundance was related to the phyla Bcillariphyta (17species), Cyanophyta(4 species),Crysophyra and Chlorophyta(3) species,Dinophyta(2 species) and Crysophyte(1 species) respectively. Algal communities were shown the variation according to several seasons.Results were indicated that spring and winter by 19 species have been a most abundant between several seasons.While, the summer (17 species) and autumn (11 species) were located in latter levelsrespectively.

In the spring,*Synedraacus* and *Achnanthidiumminutissimum* by 21 and 20 cells/mL, were most abundant in study areas, respectively. While,*Cosmarium sp.* (44cells/mL) And *Cyclotellameneghiniana*(42 cells/mL) were most abundant in summerat several seasons. Also in the autumn and winter *losteriumacerosum*(21 species) and *Cymbellacesatii*(20 species) were most abundant, respectively. On the other hand, in the spring *Nitzschiapalea* by 75-100% of algal taxa was most abundant among the other species. But some species in summer had this feature,include *Achnanthidiumminutissimum, Cosmarium* sp., and*Peridiniumcinctum*. Also in the winter,*Dinobryonsertularia* and *Dinobryonsertularia*by 100% of phytoplankton taxa had themost abundant (Table1).

Analyses of physicochemical parameters were also performed in this study. Monitoring of study sites showed,the highest level of oxygen dissolve between different seasons was 9.37mg/L in March and lowest of this factor was 8.13mg/L in May.Whereas the oxygen variation between seasons was not considerable. Amount of phosphate 0.1> mg/L was very low and it can be as a limiting parameter. The highest range of temperature 27°Cwas recorded in the august and lowest was recorded in the march by 11 Degrees Celsius(Table 2).

The results showed, the maximum rate of chlorophyll *a* concentration was measured inthe warm and minimum of this, was measured in the cold months. According to this, the chlorophyll *a* concentration was decreased in the march to 2.1μg/L. It shows the lowest rate of photosynthetic activity. So this parameter was enhanced to 4.9 μg/L, in the October. Generally the rate of chlorophyll *a* shows an oligotrophic condition in the lake of karoon 4 reservoir (5) (Table 2).

The environmental parameters are presented in figure 2,showthe differentiations between the stations. As can be observed in figure 2, there are not significant differentiations between study sites.

The secchi disk visibility was used for transparency of the lake. According to the results this parameter was high between the study times (5.72-7.65 m),this represent, the oligotrophic condition in the lake (5) and it shows, as the water temperature increases, the transparency is reduced to 5.72 m (Table 2).

The analeysis of the environmental indexes include, Dominance, Diversity (measured by Shanon index), and Richness (measured by Margalef Index) was done.Based on the results, maximum and minimum of the richness(Margalef Index) wasobserved in the winter and summer respectively.(Fig 3).

According to the analyses, maximum and minimum of the dominance index was seen in the autumn and spring respectively. Whereas, the maximum of diversity (Shanonindex) was apperceived in the spring and minimum in the autumn (figure 3).

The Pearson correlation coefficients between the parameters show the positive significant correlate between the parameters include, COD,NO3,temperature, pH, turbidity, chlorophyll *a* and phytoplankton abundance ($P< 0.01$) (27,17 & 19). Whereas, there is not significantly positively correlated between DO and another parameters (2). The DO just correlated significantly negatively with temperature. It is because of decrease the potential of oxygenmaintenanceby increase the temperature (2 &16). The chlorophyll a concentration and phytoplankton community have a significant negative correlation with

transparency. Since by increase of the phytoplankton community and chlorophyll *a*concentrationreduced the visibility on secchi disk, it same to obtained result from (34).
According to statistical analysis, NO_3 has correlated significantly positively by chlorophyll *a* concentration that is unlike the same studies (34), it can be due to enhanced agricultural and aquaculture activities upstream the lake. the biological oxygen demand (BOD) shows the significant correlation with chlorophyll *a* concentration because of enhancement of the phytoplankton activity in the water body (17,19,13) (Table 3).
Analysis of variance (ANOVA) was used to analyze the differences between environmental parameter, phytoplankton abundance and chlorophyll *a* concentration and seasons .The results show the significant deference between several seasons and parameters except temperature (Table 4).
Analysis of variance (ANOVA) was used to analyze the differences between environmental parameter, phytoplankton abundance and chlorophyll *a* concentration and seasons .The results show the significant deference between several seasons and parameters except temperature (Table 4).
According to the results there is no significant differentiation between parameters of stations. All parameters include physicochemical factors; phytoplankton abundance and chlorophyll *a* concentration have not significant difference in stations. It shows that some factors such as floods can be affected to this condition (Table 5).
The presence of the some Bcilariophyta species such as Achnanthidiumminutissimum and cymbella sp., monitored to the oligo and mesotrophic condition (29). The Eulenophyta populations thrive under high nutrient levels and are, therefore, useful bio-indicators of such conditions (21). Absence of this phylum shows the non-eutrophic conditions. We observed some group of Cyanophyta but in cold condition of water (9). Some groups of Chlorophyta include Chlamydomonas and Chlorella usually occurs in eutrophic waters, in this study this species of phylum Chlorophyta were not found (20).Whereas, another species such as Cosmariumsp. and Coelastrum sp., that indicate the oligotrophic waters, were observed in the samples.

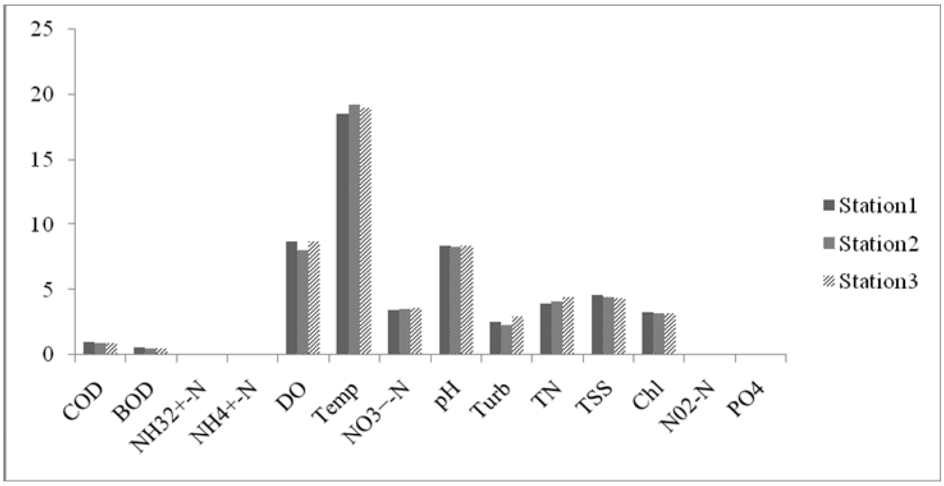

Fig 2.Environmental parameters.Chlorophyll *a* concentration in stations.

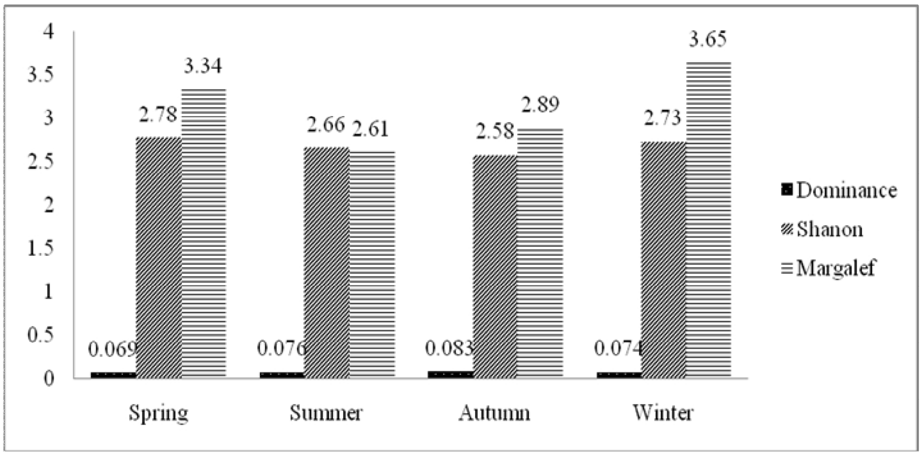

Fig 3.The change of environmental Indexes according to the seasons.

Table 1. List of phytoplankton species recorded from three stations according of seasons.

	spring	Summer	Autumn	Winter
Bacillariophyta				
*Achnanthidiumminutissimum*Kützing	++	+++		+
*Cocconiesplacentula*Her.	+	+++		++
*Cyclotellameneghiniana*Kützing	+	+++	+	+
*Cymbellaprostrata*Berkeley Brun		++	+	+++
*Cymbell*acesatiiRab. Grun.	++		++	++
*Fragilariacapucina*Desm	+	+++	+	+
*Gomphonematruncatum*Her.	++		++	++
*Gomphonemaolivaceum*Lyngb.		+++	+++	
*Naviculagracilis*Ehrenberg	++	+++		+
*Naviculatenelloides*Meist.	++		+++	+
*Naviculalanceolata*Agardh. Kutz.	+	+++	+	+
*Nitzschiadraveillensis*Coste&Ricard			++++	
*Nitzschiafrustulum*Kutz.	++		++	++
*Nitzschiagraciliformis*Lange-Bert.		+++	++	
*Nitzschiaacicularis*W. Sm.	++	++		++
*Nitzschiapalea*Kutz.&W.Sm.	+++	++		
*Synedraacus*Kützing	++	++	+	+
Chlorophyta				
*Closteriumacerosum*Schrank	+	++	+++	
Coelastrumsp	++	++		+
Cosmariumsp.	++	+++		
Chrysophyta				
DinobryonsertulariaEhr.				++++
Cyanophyta				
*Nostoc commune*Vaucher ex.			++	+++
*Scytonemaarenarium*Berkeley				++++
*Spirulinamajor*Kutz.			+++	+++
*Gomphosphaeriaaponina*Kützing	++		++	+
Dinophyta				
*Peridiniumcinctum*Muell.	++	+++		
*Ceratiumhirudinella*Muller	++	+++		

$^{+}$ 25% of samples; $^{++}$25-50% of samples; $^{+++}$ 50-75% of samples and $^{++++}$75-100% of samples.

Table 2. The environmental parameters, chlorophyll *a* concentration and phytoplankton abundance in several mounts.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
COD	0.83	0.17	1.13	1.47	1.47	1.4	1.13	0.9	0.7	0.63	0.63	0.63
BOD	0.42	0.23	0.6	0.6	0.73	0.67	0.6	0.5	0.43	0.33	0.33	0.32
DO	8.97	8.13	8.87	9.1	8.8	8.53	8.27	8.4	8.47	9	9	9.37
Temp	15.7	20.7	23.3	25.7	27.3	22.3	20	18	16	14.3	12.3	11
NO_3	1.57	1.97	2.33	6.63	5.97	4.7	4.1	3.8	3.47	2.33	4.1	1.27
EC	474	482	433	428	436	529	543	543	623	634	543	457
pH	8	7.67	8.63	9.03	9.03	8.63	8.37	8.4	8.13	8.37	8.37	7.77
Turb	2.67	3.33	4	3.33	4	3	2.67	2.7	1.67	1	1.33	1.33
TN	1.57	1.97	2.33	6.67	5.97	5.97	6.37	5.4	4.07	4.13	3.87	1.37
TSS	5.67	4	4.67	3.67	4.67	5.67	6.33	3.7	4.33	4.33	3.67	2.67
Trans	6.78	6.32	6.18	5.82	5.72	6.44	6.51	6.7	7.41	7.43	7.56	7.48
Chl	3.28	3.59	3.85	4.61	4.77	4.31	2.48	2.5	2.31	2.32	2.31	2.2
TA	223	242	260	403	412	389	141	145	142	144	143	127
PO_4	0.1>	0.1>	1.0>	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>
NH_4^+	0.13	0.14	0.17	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.13
NH_3^{2+}	1.1	1.8	2.3	6.6	5.9	6.4	5.8	4.8	2.4	3.9	4.3	1.5

COD: Chemical oxygen demand (mg/L);BOD: Biological oxygen demand (mg/L);NH_3^{2+}-N: Ammonia (mg/L); NH_4^+-N ammonium.(mg/L);DO: Dissolve oxygen (mg/L); Temp: temperature (◦C); NO_3—N: nitrate (mg/L); EC:Electrical conductivity(μ mohs/cm^2); Turb: turbidity (NTU);TN total nitrogen (mg/L); PO_4-P: phosphate (mg/L); TSS: Total suspended solid (mg/L);Trans: transparency (m);.Chl: chlorophyll *a* (mg/m^3); TA: total abundance (cells/ml).

Table 3.Pearson correlation coefficients between the parameters of the sampling sites.

	BOD	NO_3	DO	Temp	pH	Turb	Trans	Chl	TA
COD	.824**	.695**	-.159	.677**	.788**	.496**	-.584**	.619**	.667**
BOD		.593**	-.237	.647**	.606**	.550**	-.661**	.569**	.584**
NO_3			.141	.649**	.754**	.348*	-.501**	.544**	.631**
DO				-.320	-.062	-.365*	.229	-.114	-.012
Temp					.630**	.821**	-.885**	.866**	.829**
pH						.449**	-.506**	.578**	.613**
Turb							-.819**	.762**	.677**
Trans								-.843**	-.773**
Chl									.973**

$^*P < 0.05$; $^{**}P < 0.01$

COD: Chemical oxygen demand.(mg/L); BOD: Biological oxygen demand (mg/L); DO: Dissolve oxygen (mg/L); Temp: temperature (◦C); NO3—N: nitrate (mg/L); Turb: turbidity (NTU); Trans: transparency (cm); Chl: chlorophyll *a* (mg/m^3); TA: (total abundance (cells/ml)

Table 4.Analysis of variance (ANOVA) between the environment parameters, phytoplankton abundance and chlorophyll *a* concentration by season.

	Sum of Squares	Mean Square	F	Sig.
BOD	.574	.191	11.313	.000
NO3	76.285	25.428	38.399	.000
Temp	10.883	3.628	2.755	.059
DO	725.556	241.852	40.733	.000
pH	3.614	1.205	8.989	.000
Turb	28.972	9.657	22.430	.000
Trans	11.096	3.699	25.399	.000
Chl	30.852	10.284	207.729	.000
TA	411380.556	137126.852	480.760	.000

COD: Chemical oxygen demand.(mg/L); BOD: Biological oxygen demand (mg/L); DO: Dissolve oxygen (mg/L); Temp: temperature (◦C); NO3—N: nitrate (mg/L); Turb: turbidity (NTU); Trans: transparency (cm);.Chla: chlorophyll *a* (mg/m^3); TA: (total abundance (cells/ml).

Table 5.Analysis of variance (ANOVA) between environment parameters, phytoplankton abundance and chlorophyll *a* concentration by stations.

	Sum of Squares	Mean Square	F	Sig.
BOD	0.030417	0.015208	0.462735	0.633582
NO3	0.350556	0.175278	0.059553	0.942286
Temp	3.057222	1.528611	1.009657	0.375322
DO	4.388889	2.194444	0.079477	0.923776
pH	0.027222	0.013611	0.057031	0.944658
Turb	2.166667	1.083333	0.880903	0.423927
Trans	0.439717	0.219858	0.473685	0.626872
Chl	0.067917	0.033958	0.034621	0.966007
TA	1496.056	748.0278	0.058912	0.942888

COD: Chemical oxygen demand.(mg/L); BOD: Biological oxygen demand (mg/L); DO: Dissolve oxygen (mg/L); Temp: temperature (◦C); NO3—N: nitrate (mg/L); Turb: turbidity (NTU); Trans: transparency (cm);.Chl: chlorophyll *a* (mg/m^3); TA: (total abundance (cells/ml).

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