Identification of Algae as Pollution Bioindicators in Shakh-Kenar, Gavkhouni Wetland, Isfahan

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Abstract

Identification of algae of Shakh-Kenar, Gavkhouni Wetland, was studied from September 2017 to November 2018 at three stations with three replication. Totaly, 69 species and 43 genera belonging to six divisions were identified. Species were belonging to the Bacillariophyta, Chlorophyta, Cyanophyta, Euglenophyta, Dinophyta and Chrysophyta. The density variations of the algae were between 98 and 1597 cells/cm^3. The highest density was found at station 1 in autumn. According to the Shannon-Weaver Index, the highest and the lowest diversity were observed in autumn and winter, respectively. Bacillariophyta, especially pennate forms; such as *Navicula, Nitzschia*, *Cymbella,* and *Ulnaria* were semi dominant in the most stations. From Chlorophyta; *Pediastrum*, *Cladophora* and *Scenedesmus* were showed conspicuous increase in summer and early autumn. *Chroococcus disperses* (Keissl.) Lemn, *Merismopedia punctata* Meyen, *Oscillatoria* sp. were demonstrated more abundance in autumn. *Phacus* sp., *Euglena caudata* Hubner, *Trachelomonas playfair* Defl., *Glenodinium quadridense* (Stein.) Schiller, *Ceratium hirundinella* (OF. Muell.) Duj and *Peridinium cinctum* Muell., were observed in later summer and autumn. Regarding to taxa list, kind of pollution index algae and water quality index were recognized from Chlorophyta, Cyanophyta, Dinophyta and Euglenophyta, that they play important role modify water odor/taste, corrosion of tubes, methods, and production of toxins.

Keywords: Algae, Shakh-Kenar, Gavkhouni Wetland, Isfahan.

Introduction

Population growth and development of urbanization and industries resulted in precipitate consumption of water and problems in preparation of drinking water as a serious issue facing human-kind in current century. Agricultural development and industrial activities have led to the destruction and alteration of ponds and surface waters (David and Rajan, 2015; Rajmohan and Elango, 2005). Rivers and lakes are considered natural resources for drinking, agricultural, and industrial purposes (Vanitha et al., 2012). Therefore, conservation and sustainability of these

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ecosystems and proper use of surface water in countries like Iran which are considered arid and semi-arid climatologically, is important. Algae, in lakes play an important role in survival of other aquatic organs, production of oxygen, and the maintenance of ecosystem. The growth and development of algae are affected by many factors. Excessive emitting of organics and minerals has occasioned eutrophication and the development of algae specially diatoms and blue-green algae in aquatic environments altering and odorizing the taste of water, and also blocking water filters. Sometimes, algal bloom due to production of toxic compounds damages the growth of other aquatic organism. In addition, algae may be proposed as a prominent polluting organism in response to the change of nutrients. So, the number and their taxonomic combination indicates the change of lakes' and lagoon's waters. Zayandeh Rood river as the principle and sustainable source of water for Gavkhouni lagoon takes its source from the slopes of Zardkooh Bakhtiari located in Chaharmahal Va Bakhtiari, and flows through a 300-kilometer labyrinthine track toward the south eastern region of Isfahan, finally ends up in Gavkhouni lagoon. The quantity and quality of the Zayandeh Rood river through its track is affected by many factors in a way that the water ends up in Gavkhouni lagoon is fundamentally different to the one took its source from Zardkooh Bakhtiari slopes in terms of the grade of salinity and pollution rate. Shakh Kenar dam is the last deflecting dam built on the track of Zayandeh Rood river which plays an important role in meeting the aquatic needs of urban, rural, and agricultural regions of Isfahan Province. Therefore, studying of these algae is important in identifying its biodiversity and water quality control. In Iran, there are a little study related to algae especially phytoplankton, and most of the studies conducted until now have focused on the water chemistry. There has been no study related to the taxonomy and floristic identification of algae, specially the feature ones playing role in Shakh Kenar dam pollution index. Thus, identifying the present algae in Shakh Kenar is important for studying its biodiversity, and implementing the plans concerning observing the quality of Shakh Kenar water and consequently the Zayandeh Rood river one.

Materials and Methods

Shakh-Kenar Dam is located 16 km Varzaneh city and 10 km Gavkhouni Wetland of Isfahan. This dam is the latest deflective dam on the Zayandeh Rood river. There are two chanels which provide water for around farmlands. Algal samples were taken from three sampling stations from September 2017 to November 2018, seasonally in three repetitions (Figure 1). Samples were taken in plastic bottles (1.5 lit) and fixed with 4% Formaldehyde on the same day. The samples were concentrated by centrifugation at 1500 rpm. Taxonomic identifications were performed according to Cox (1996), Prescott (1970, 1984), Patrick and Reimer (1975), and Whitford and Schumacher (1984). Algal counting was done by Sedgewick-Rafter slide and they photographed with a Zeiss

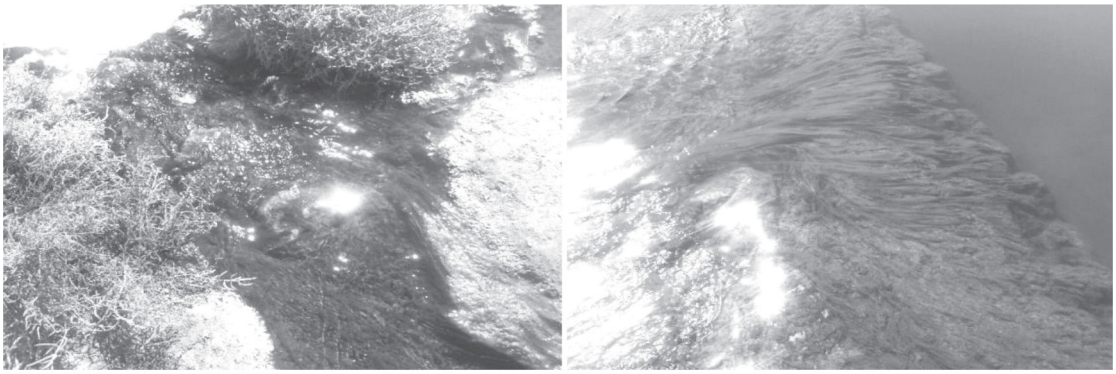

Fig. 1. Sampling stations in Shakh Kenar dam.

Axiostar plus research microscope. Graphs were determined with Excel. The diversity of algal communities was calculated and compared using the Shannon-Weaver Index. H′= -∑Pi log2 (Total number of individuals = N, Specifics abundance mean = Xi = ni/N = Pi) (Palmer, 1969).

Results

In this study, a total of 69 species and 43 genera belonging to 6 divisions were identified (Figure 2). A floristic list of collected algae is given in Table 1. The scientific names of algae species were checked with Algaebase website. Bacillariophyta comprised 35 genera (17 species) were showed the highest density and diversity, *Navicula, Nitzschia* and *Cymbella* (8, 5, 3 species, respectively) showed the high diversity along the Shakh-Kenar dam, afterward, *Pinnularia, Gomphonema, Diatoma, Cocconeis* and *Ulnaria* were demonstrated the highest species. From Chlorophyta, *Pediastrum* and *Scenedesmus* possessed the most abundant, and *Cladophora* got a high diversity in all stations. In addition, from Chrysophyta, *Dinobryon* (3 species) was observed. *Merismopedia* and *Oscillatoria* (3, 2 species, respectively), indicated a high diversity. In addition, *Euglena caudate* Hub., *Phacus* sp., *Trachelomonas playfairi* Defl., and *Lepocinclis* ovum (Ehr.) Lemn., constituted the most genera in Euglenophyta. Finally, *Glenodinium quadridense* (Stein.) Schiller, *Ceratium hirundinella* (OF. Muell.) Duj and *Peridinium cinctum* Muell., were observed with the highest abundance. In this study, the highest and the lowest density were observed between 1266 and 525 cells/cm^3 in autumn and winter respectively (Figure 3).

According to the Shannon-Weaver Index, the highest diversity was 2.16, at station 2 in November 2017, and the lowest value (1.84) was observed at station 1 in September 2016. Among the stations, H′ mean showed an increasing from site 1 to site 3 in Shakh-Kenar Dam. In other words, results showed that station 1 has more pollution than other stations. Also, regarding to results, diversity index of less than 2 is illustrator high pollution and number between 2-3 indicate moderate pollution, which regarding to results, station 1 relation to other sites has the lowest diversity

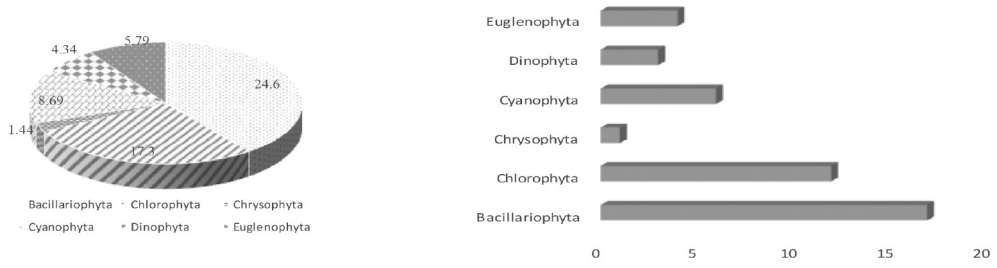

Fig. 2. Percentage and number of genera in the algae divisions in Shakh Kenar dam.

Table 1. Checklist of phytoplankton in Shakh kenar dam.

Bacillariophyta	*Amphora ovalis* Kutz.	*Gomphonema olivaceum* (Lyngb.) Kutz.
	Asterionella formosa Hassal.	*Nitzschia fossilis* Grun.
	Cocconies pediculus Ehr.	*Gomphonema truncatum* Ehr.
	Cocconies placentula (Ehr.) Cleve.	*Gyrosigma acuminatum* (Kutz.) Rabh.
	Cyclotella meneghiniana Kutz.	*Meridion circulare* (Greve.) Agard
	Cymatopleura solea (Breb.) W. Smith.	*Navicula angusta* Grun.
	Cymbella affinis Kutz.	*Navicula cryptocephala* Kutz.
	Cymbella cesatii (Rab.) Grun.	*Navicula cryptotenella* (Lange-Bert.).
	Cymbalia cistula (Ehr.) Kirch.	*Navicula lanceolata* (Agardh.) Kutz.
	Diatoma hyemalis (Roth.) Heib.	*Navicula radiosa* Kutz.
	Diatoma vulgaris Bory.	*Navicula salinarum* Grun.
	Fragilaria crotonensis Kitton.	*Navicula tenelloides* Meist.
Chloropyta	*Ankistrodesmus convolutes* Corda.	*Mougeotia* sp.
	Chlamydomonas angulosa Dill.	*Nephrocytium limneticum* M. Smith.
	Chlorella vulgaris Beye.	*Oocystis crassa* Wittock.
	Cladophora sp.	*Pediastrum braunii* Wartmann.
	Cosmarium sp.	*Pediastrum integrum* var. *priva* Printz.
Cyanophyta	*Anabaena* sp.	*Merismopedia elegans* A. Braun.
	Chroococcus dispersus (Keissl.) Lemm.	*Merismopedia glauca* Ehr.
	Lyngbya sp.	*Merismopedia punctata* Meyen.
Euglenophyta	*Euglena caudata* Hubner.	*Lepocinclis ovum* (Ehr.) Lemm.
		Trachelomonas playfairi Defl.
Dinophyta	*Ceratium hirundinella* (O. F. Muell.) Duj	*Glenodinium quadridens* (Stein.) Schiller.
Chrysophyta	*Dinobryon divergens* Imhof.	*Dinobryon cylindricum* Imhof.
	Navicula veneta Kutz.	
	Nitzschia fossilis Grun.	
	Nitzschia gracilis Hantzsch.	
	Nitzschia ovalis Arnott.	
	Nitzschia palea (Kutzing) W. Smith.	
	Nitzschia radicula Hust.	
	Pinnularia major Ehr.	
	Pinnularia sudetica (Hilse) Perag.	
	Stephanodiscus hantzschii Grun.	
	Surirella linearis W. Smith.	
	Ulnaria acus (Kützing) M. Aboal.	
	Ulnaria nana Meister.	
	Ulnaria ulna (Nitzsch) P. Compere	
	Pediastrum integrum var. *scutum* Raci.	
	Scenedesmus bijuga (Turp.) Lagerh.	
	Scenedesmus quadricauda	
	Spirogyra sp.	
	Zygnama pectinatum	
	Oscillatoria acuminuta	
	Oscillatoria formosa	
	Spirulina major Kutz.	
	Phacus sp.	
	Peridinium cinctum (Muell.)	
	Dinobryon sertularia Ehr.	

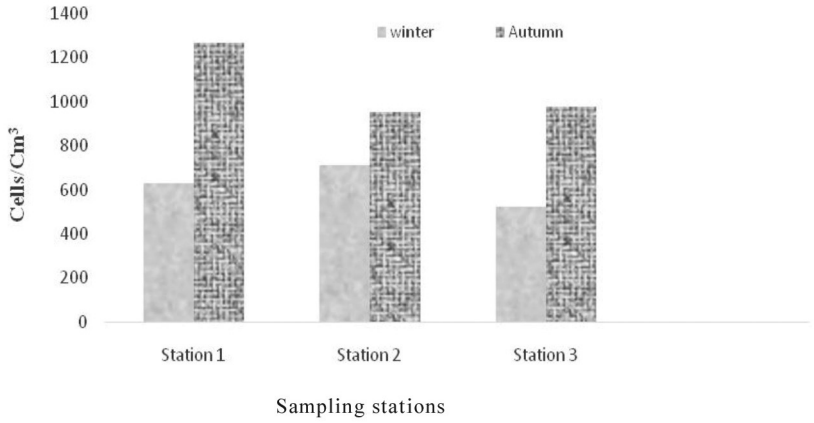

Fig. 3. Variations of phytoplankton density in the Shakh Kenar dam.

index and increasing pollution.

Discussion

In this research, totally 69 species belong to 43 genera placed in 6 divisions were identified. Bacillariophyta (35 species, 17 genera) were demonstrated the highest density and diversity among the algae, that the distribution pattern and diversity in different seaons were similar to (Descy and Gosselain, 1994; Karacaoglu et al., 2004; Atici and Shams, 2017; Shams et al., 2012; Atici and obali, 2010). Among the diatoms, pennate forms had the most species and genus diversity. Bacillariophyta are dominant algae in tropical and temperate regions. *Ulnaria ulna* (Nitz) P. Compere., *U. acus* (Kützing) M. Aboal., *U. nana* Meister., *Nitzschia gracilis* Hantzsch, *N. fossilis* Grun., *N. palea* (Kutzing) W. Smith., *N. ovalis* Arnott., *N. radicula* Hust., *Navicula salinarum* Grun., *N. rodiosa* Kutz., *N. Lanceolata* (Agardh.) Kutz. and *N. angusta* Grun. mostly present in different stations beside other genera. Also, *Fragilaria crotonensis* Kitton., and *Asterionella formosa* Hassal., were detected in higher density. These species are indicators of mesotrophic Lakes (Conulol, 2005). Moreover, *Asterionella formosa*, is usually indicator species of eutrophic structure (Yilmaz and Aykulu, 2010). *Cyclotella meneghiniana* Kutz., a centric diatom, was dominant diatom in all samples regardless of season, similar to (Kelly and Whitton, 1995; Naz and Turkman, 2005; Karacaoglu et al., 2004; Shams et al., 2012), and this species is indicator of oligo-mesotrophic lakes (Lei, 2005; Kilinc, 1998; Baykal et al., 2004). However, pennate diatom species as *Ulnaria ulna, Navicula salinarum, Nitzschia rodicula, Diatoma vulgaris Bory.,* and *Cymbella affinis* Kutz., widely distributed which this results also reported from other lakes (Cocquyt and Vyverman, 2005). Principally, *Nitzschia Palea* was the most observed species in the stations 1, 3 that was more polluted, which is in agreement with (Skcherbak and Rodkin 1994; Cox, 1996 and Moghadam,

1976). Generally, diatoms as water quality index, odor/taste index (*Asterionella, Ulnaria* and Filters blocking index (*Navicula, Cymbella, Fragilaria*) have an important role in lake ecosystems (Van Dam, 1993). Chlorophyta formed the second dominant group, with reasonably high species diversity (15 species) (Danilov, 2001; Conulol, 2005; Descy and Gosselain, 1994) including *Cladophora*, *Nephrocytium*, *Scenedesmus*, and *Pediastrum* which is consistent with the results reported by Semeneh et al., 1998; Karjalainen et al., 1996; Atici and Shams, 2017). Cyanophyta (9 species, 6 genera) were dominant species especially in summer and rarely in autumn which this issue is similar to Lei, 2005. *Oscillatoria, Merismopedia, Chroococcus* showed the most abundance in summer. *Spirulina* was observed in autumn in low-density populations, and *Anabaena* was rarely observed in fall and summer. The similar results was observed in Devegeçidi and Uluabat Lakes in Turkey by Karacaoglu et al., 2004, and Baykal et al. (2004), that in winter, they indicated low densities. *Anabaena* is considered as the index of smell and taste of water. Green-blue algae are dominating in eutrophic lakes, which they occasion algae dominance in the late spring and summer, and through forming blooms on the water, reduce the clarity of water, but in Shakh-Kenar dam, we observed less blooms formed.. The dominance of some Cyanophyta and Dinophyta, *Oscillatoria* and *Anabaena* are commonly observed in the polluted waters as reported by Zincke (2004), Nandan and Aher (2005), and also Shams et al., (2012). Studying Shakh-Kenar, abundance of *Oscillatoria* as epilitic algae, and also *Gomphonema* as a epiphythic algae were observed on the *Cladophora*. *Oscillatoria* genus is considered, and also was observed, frequently as the biological polluting factor and also the affecting one as far as the corrosion of metals and the production of poison is concerned specially in the first and third stations; this is compatible with the findings of Gadag et al., (2005). As far as Dinophyta including of *Peridnium cinctum, Glenodinium quadridens,* and *Ceratium hirundinella* were observed more frequently in the summer and early autumn. These algae were more frequently observed in different stations during a year except winter. Salmaso et al. (2003) reported the existence of *Peridnium cinctum* in Como Lake in Italy. Furthermore, *Ceratium hirundinella* is reported as a dominant genus in southern Africa and Golbasi lake in Turkey (Ginkel et al., 2005; Naz and Turkman, 2005). This species is dominant in eutrophic and Mesotrophic lakes. In addition, according to other studies, this species is observed in Mesotrophic lakes. In the present study, this algae, which produces poison and changes the taste and odor of water, was observed in the late autumn in Shakh-Kenar dam. Furthermore, it has been cited as one of the polluting factors in eutrophic waters (Ginkel et al., 2001). In this study, *Phacus* sp., *Lepocinclis ovum* and *Euglena proxima* (Euglenophyta) indicated quiet abundance in different stations especially in autumn. Also Rassashko et al. (1991) reported simi-

lar results. In Shakh-Kenar, these species are considered as the index of blocking filters. Generally, the frequency of Euglenophyta in lakes indicates the increasing of organic nutrition, water pollution, and eutrophication. Various species of *Lepocinclis* were counted in autumn, which Barone (1994) cited these species as resistant to stress and pollution like Dinophyta. *Dinobryon* was observed in all stations. Furthermore, Salmaso (2003), reported the existence of this genus in Iseo and Lugano lakes in Italy. According to the Palmer index (1969), identification and provision of a list of algae species resistant against pollution is done in this study. The Palmer index indicates that *Oscillatoria, Euglena, Scenedesmus, Navicula*, and *Nitzchia* are the polluting index. *Oscillatoria, Euglena,* and *Ankistrodesmus* are polluted by heavy metals (Patrik and Reimer, 1975), and *Scenedesmus, Pinullaria*, and *Anabaena* are resistant to organic pollutants which indicate a reduction from upstream to downstream. Regarding that Shakh Kenar is the last dam constructed on the river (the lagoon's inflow) to regulate the Zayandeh Rood river's flow for agricultural and milling purposes, and after Shakh Kenar, the River is ramified and the lagoon is formed, so there are similarities among some of algal genera and species of Shakh Kenar with other Iranian and international ecosystems. In terms of floristic and applicable studies, the investigated taxa of this ecosystem introduce as a part of the Iranian aquatic habitats. Therefore, taxonomic and floristic study of this habitat may improve the species richness and diversity of algae in Iran.

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