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Taxonomical study of Bacillariophyta as index of water quality in Khuzestan province (Iran)

Masoumeh Shams Kahrizsangi[1]*; Fahimeh Ebrahimi[2], Najmeh Ghorbani[2]

[1] Department of Biotechnology, Faculty of Biological Sciences and Technology, Shahid Ashrafi Esfahani University, Isfahan, Iran
[2,] Department of Biology, Faculty of Science, University of Isfahan, Isfahan, Islamic Republic of Iran.

[*1] Corresponding Author E-mail: dr.shams.algae@gmail.com
Tel: (+98) 09132322940
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Abstract

Diatoms were identified from 31 different stations in the Karun and Dez Rivers in Khuzestan, southwest Iran. A total of 68 species belonging to 32 genera were registered and the algal flora of water bodies shows the dominance diatoms like, *Asterionella formosa*, *Nitzschia palea, N. ovalis*, *Navicula radiosa*., *N. salinarum*,. *N. lanceolata*, *Cocconies placentula*., *C. pediculus*, *Gomphonema truncatum*., *Gomphonema olivaceum* var. *olivaceum*; *Cymbella affini, Ulnaria ulna*, *U. acus*., *Gyrosigma acuminatum*., *Diatoma hyemalis*. and *D. vulgaris*. As well as, results of the physical-chemical parameters show that temperature, COD and pH have effective role on the diatoms composition. *Navicula, pinnularia*, *Eudorina* and *Melosira* were found to be useful as indicators of some physico-chemical properties of water. It is now appropriate that the full potential of the use of diatoms in water quality assessments, and the information contained in the collection be developed and utilized in Iran Rivers.
Keywords: Diatoms, Water quality, Karun River, Iran.

Introduction:

Bacillariophyta are the most diverse and dominant group of algae in rivers, streams, lakes and wetlands forming the important component of the aquatic ecosystem (Stoermer & Smol, 1999), and used to detect change in water quality in a more integrated manner to assess the ecosystem integrity rather than traditional water monitoring, Because they are sensitive concerning pollution, acidification, and salinization, they are important bioindicators and are often used for routine water quality assessments in most ecosystems (Rott et al., 1998; Kelly et al., 1995; Szczepocka 2007, Torrisi et al., 2010; Shams et al., 2012; Atici & Shams 2017). Various species diversity indices respond differently to different environmental factors of biotic communities and therefore, recent investigations have been directed to species diversity indices. Biological assessment is a useful for measuring the ecological quality of aquatic ecosystems since biological communities integrate the environmental effects of water chemistry. Biological monitoring has advantages over chemical monitoring because it integrates responses to a range of pollutants occurring over different times (Juttner et al., 1996; Belore et al., 2002; Atici & Shams, 2017). Khuzestan province is located in the west southern of Iran with about 63633.6 Km^2 area. There are several Rivers and Lakes in this province. Supplier of water sources of this area are Karun, Dez, Maroon and Khirabad that Karun

River is 950 km long. It rises in the Zard Kuh mountains of the Bakhtiari district in the Zagros Range, receiving many tributaries, such as the Dez and the Kuhrang, before passing through the capital of the Khuzestan Province of Iran, the city of Ahvaz before emptying to its mouth into Arvand Rud. Karun continues toward the Persian Gulf, forking into two primary branches on its delta- the Bahmanshir and the Haffar - that join the Arvand Rud, emptying into the Persian Gulf. Water from the Karun provides irrigation to over 280,000 hectares of the surrounding plain and a further 100,000 hectares are planned to receive water. In addition, Karun River is important in terms of the whereabouts of merchant ships, the expansion of agriculture in Khuzestan, drinking water and irrigation source, and supply of electricity to surrounding cities, the boom in tourism in Khuzestan. The influx of industrial and agricultural effluents into the Karun River has caused severe pollution in this river. Also, the unauthorized operation of fish farms in different parts of the Karun River increases bio-pollution. Basir and Nabavi (2008) were studied on the water quality of Karun river in Ahvaz Bandaqir range using WQI index and GIS software; also, Hosseinian et al. (2006) researched about classification of quality of Karun and Dez rivers in the returns of Gotvand to Khorramshahr and Dezful Tabamadj using WQI index.

There have been a number of floristic investigations of diatoms in Iran, including of central and southeastern Iran (Compère 1981); central Iran (Moghadam, 1976; Afsharzadeh et al., 2003; Shams et al., 2012; Atici & Shams, 2017; Zarei-Darki, 2011; Kheiri et al., 2019; Naseri and Nooorzi, 2021); northern Iran (Ganjian et al., 1998; Jamaloo et al., 2006; Masoudi et al., 2012; Soltanpour-Gargari et al., 2011; Zarei-Darki, 2009), northwestern Iran (Nejadsattari, 2005); central and western Iran (Hirano 1973); southern Iran (Hulburt et al., 1981), Northwest Iran (Panahy-Mirzahasanlou et al., 2018) and large-scale surveys of Iran (Wasylik, 1975; Zarei-Darki, 2009, 2011). Compere (1981) reported 43 taxa from 21 localities in the central and southeastern parts of Iran. Although done some studied in some area in Iran, but no study was carried out on phytoplankton in the area of Khuzestan province, hence the study assessed some metals present in that region and diatoms composition for evaluation of water quality. The main objective of the study was to determine possible correlations among the water quality parameters, density and eventually to see if any of the diatoms significantly correlated with physico-chemical parameters can be used as an indicator of changes in water quality.

Materials and methods

Diatoms samples were collected as per standard methods (APHA 2005) from 31 sampling stations from June 2017 to December 2018 (Figure 1). In this study, the important factors such as pH, dissolved oxygen (DO), electrical conductivity (EC), temperature, biological oxygen demand (BOD) and chemical oxygen demand (COD) were analysed. Diatoms samples were taken with a plankton net (55 µm mesh size), and a drum from the water surface (Wetzel 2006). The collected samples were fixed in 4% formaldehyde and brought to laboratory, concentrated by centrifugation at 1500 rpm. Diatoms was cleaned using the method described by Patrick & Reimer (1975). Oxidation by hydrogen peroxide and potassium dichromate was done. Slides of diatoms for microscopic analysis were prepared, and identification were done according to identification keys (Cox 1996; Patrick & Reimer 1975; Prescott 1984, Wilson et al., 1996, Krammer 2002). The Diatoms were photographed with a Zeiss Axioster Plus research microscope. Temperature, DO, pH, EC, and turbidity were measured directly with multimeters WTW multi-3430, and BOD and COD were determined by (APHA 2005). In order to assessment of species diversity, Shannon-Weaver's index was calculated (Morgado et al., 2003)

H = - ∑Pi In Pi , Where, Pi = Ni/N represents the proportion of species in the community, Ni = number of individuals of a species i, N = total number of individuals.
Also, The Variance analysis (ANOVA) was done to see the variation of water parameters and diatoms with SPSS program. Also, the density of the most abundant species (cells ml^{-1}) was calculated. PCA analysis was performed to assess significant morphological variables using PC-ORD version 4.0.

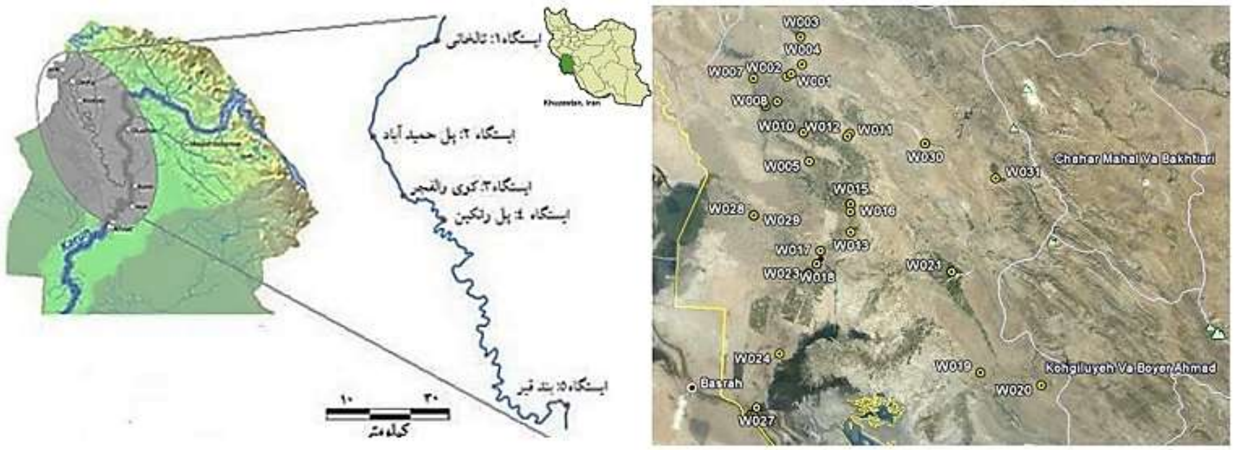

Figure 1.Map of studied sites in the Karun and Dez Rivers.

Results

Physical and chemical parameters

The physical-chemical factors were followed in the Karun River are shown in Table 1.
The water quality analysis of Khuzestan Rivers showed that 2, 5, 6, 9, 11, 29, 30, 31 stations were not unpolluted and 3, 13, 17, 27 stations were found to be highly polluted because of influx of industrial effluents, sewage and domestic wastes, and other stations were comparatively less polluted as compared to these stations especially in the 3, 13 and 27 stations. The highest number of COD and EC was obtained in down of the Hamidabad bridge and Khorramshahr Refinery, respectively.

Table 1. The physical-chemical factors in the Karun and Dez Rivers.

Value	Temperature °C	pH	DO mg L^{-1}	EC µS cm^{-1}	Turbidity NTU	BOD ppm	COD ppm
Karun River	21-30	7.94-8.21	7.58-9.13	515-2970	0.77-73.09	1.08-4.19	13.02-49.8
Dez River	18.3-31	7.4-8.19	4.4-9.24	499-4055	0.23-65.01	1.08-4.99	6.78-88.84

Taxonomy results

A total of 68 species and 32 genera of Diatoms were recorded and study indicated that dominant species were including of *Asterionella formosa* Hassal., *Gomphonema truncatum* Ehr., *Nitzschia palea* Kütz.,, *N. ovalis* Arnott, *Navicula radiosa* Kütz., *N. salinarum Grun,. N. lanceolata* (Agardh.) Kütz., *Cocconies placentula* (Ehr.) Cleve., *C. pediculus* Ehr., *Cymbella affinis* Kütz., *Ulnaria ulna* (Nitzsch) Compère, U. *acus* (Kütz.) M. Aboal., *Gyrosigma acuminatum* (Kütz.) Rabh. *Diatoma hyemalis* (Roth.) Heib., *D. vulgaris* Bory., Which pictures of some species are shown in Figure 2.

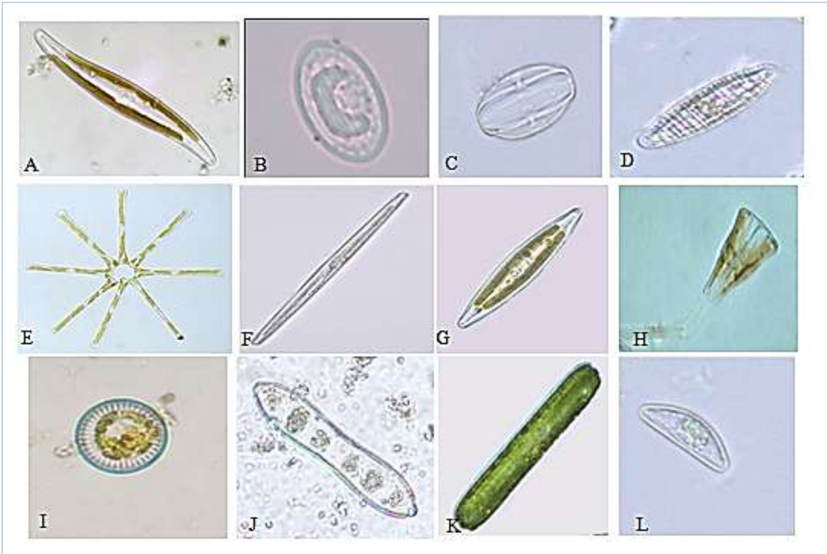

Figure 2. Pictures of some of the phytoplankton species in Karun and Dez Rivers (400 X).
A- *Gyrosigma acuminatum*, B- *Cocconies placentula*, C- *Amphora ovalis*, D- *Diatoma vulgare*, E- *Asterionella fragilis*, F- *Ulnaria ulna*, G- *Navicula radiosa*, H- *Gomphonema truncatum*, I- *Cyclotella meneghiniana*, J- *Cymatoplura solea*, K- *Pinnularia viridis*, L- *Cymbella affinis*

The scientific names of algae species were checked with the AlgaeBase website. *Nitzschia* and *Navicula* were the richest genera with 10 and 9 species, respectively. All sites contained diatom species characteristic of more alkaline and nutrient rich waters. The highest and lowest density were observed in Darkhovin Basin site (1562 Cellml^{-1}), Ramhormoz- Kamtoleh shaft (395 Cellml^{-1}), respectively. The greatest and lowest number of species was registered at 13 and 31 sites, respectively (Figure 3). Evidently in polluted zones, density of Bacillariophyta was high. Also, the highest and lowest Shannon diversity were obtained in Shosh shaft mix site (2.68) and upper of Dez Dam Lake (0.23) respectively (Figure 4).

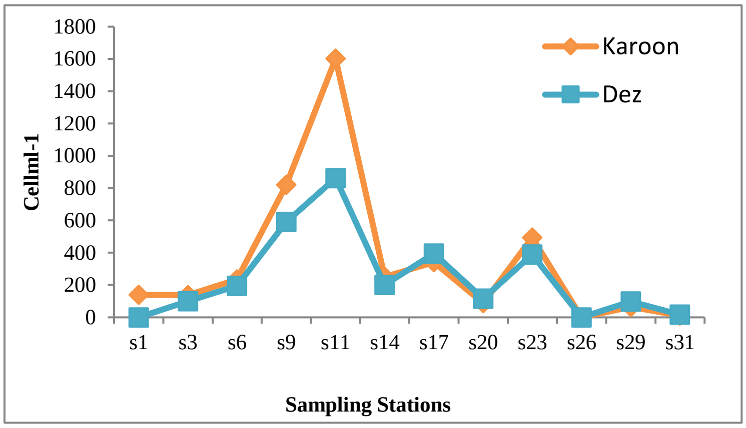

Figure 3. Density of diatoms communities in Karun and Dez Rivers.

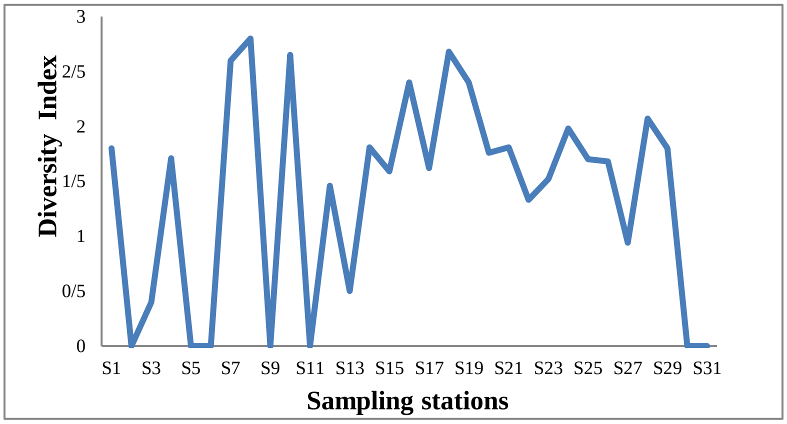

Figure 4. Species diversity of diatoms in different stations.

PCA plots (Figure 5) of the morphological characters separated centric diatoms from pinnate diatoms.

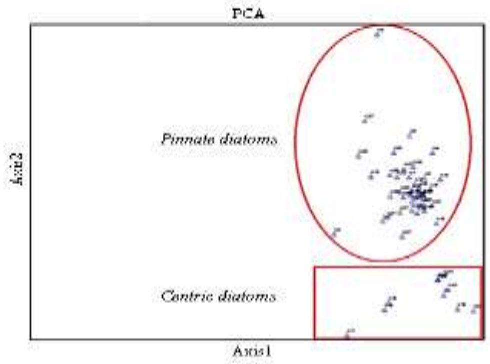

Figure 5. PCA plots of the morphological characters centric diatoms and pinnate diatoms

Conclusion

Bacillariophyta had the highest species number in different stations that Bacillariaceae showed the highest species richness that this result was similar to Nejadsattari et al (2007). *Cocconies pediculus* was the dominant diatom in all samples regardless of seasons. This is dominant species in less eutrophic environment. Observation was followed by the pennate diatom species *Nitzschia palea, Navicula salinarum, N. radiosa, Cymbella affinis, Gomphonema trunvatum, Gyrosigma acuminatum* and *Ulnaria ulna* that this data was resemble to Solak and Ács (2011) in Turkey river. The genera as *Navicula, pinnularia, Eudorina* and *Melosira* were observed in the present study as indicators of organic pollution-tolerant species. *Cymbella affinis, Nitzschia linearis, N. palea* and *Cyclotella meneghiana* are diatom species with medium tolerance to eutrophication (Lobo et al, 2004), also, *Ulnaria ulna* reported as diatom species with very low tolerance to eutrophication. The abundance of *Nitzschia*, and *Navicula* were high at Mollasani and Kote Amir Stations. The following taxa were also found in the present study: *Amphora ovalis, Cocconeis pediculus, Cyclotella meneghiniana, Cymbella helvetica, Diatoma vulgaris morphotype vulgaris, Nitzschia palea, Nitzschia sigmoidea*, which are reported by Shams et al., (2012). Sampling stations as 2, 5, 6, 9, 11, 29, 30, 31 were not unpolluted and 3, 13, 17, 27 stations were found to be highly polluted

because of influx of industrial effluents, sewage and domestic wastes, and other stations were comparatively less polluted as compared to these stations especially in the 3, 13 and 27 stations. Regarding the results of ANOVA, a significant difference was found between sampling stations in terms of diatoms density and turbidity that this result was similar to Shams et al., 2012..In general, taxa belonging to the genera *Nitzschia; Navicula* and *Cyclotella* are recorded as cosmopolitan, dominating impacted water bodies and thus are pollution tolerant taxa (Alakananda et al. 2011; Park et al., 2012). The genus *Nitzschia* is less understood because of the complexity in identification and its wide ecological preferences. Members of the genus *Nitzschia* are generally recognized as cosmopolitan in distribution and many have wide species tolerances to ionic concentrations and nutrient enriched aquatic ecosystems which this result is resemble to Shams and Afsharzadeh (2007). This index is based on the principle that in clean water, the species diversity is high while, in polluted water the diversity becomes low. Since the level of aquatic pollution are bound to increase overtime, through natural and artificial means, there is need to enforce existing industrial and environmental wastes discharges/recycling laws to ensure reduced, more efficient and planned waste discharge, especially into the aquatic ecosystem. Conductivity is useful in explaining diatom communities because it integrates several watershed processes as temperature, elevation and flow. It is also indicative of the relative levels of nutrients available to the communities in aquatic environments similar to results of Biggs (2000). PCA plots of the morphological parameters show that size, chloroplast shape, absent or present of groves, cell length are important characters on the diatoms differentiation. The dominance of certain species and frequency of the presence of these species are hence the characteristics of polluted waters. In other words, the diversity index of community is correlated in some cases with the degree of pollution (Wehr & Sheath, 2002). In general, the value of diversity index of community in less polluted waters will be higher which this results similar to Salam et al., 2004.
In conclusion, more ecological studies of diatom communities based on long-term data are necessary in order to get information about their specific ecological requirements, and to improve methods for water quality assessments. Determination of the relationship between diatom community composition and water quality variables shows that many species, notably *Navicula radiosa*, *Nitzschia palea* and *Ulnaria ulna* can act as indicators of some of the River water qualities. Future studies should focus particularly on sites in undisturbed, tropical environments, where sensitive species occur to be able to differentiate between unpolluted and polluted sites.

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