Research Article

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A comparative Study of Diatom Flora of the Taleghan River in Iran with Other Studies Around the World

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Abstract

It is important to compare the flora of different parts of the world which have the various environmental condition. The flora of Taleghan dam and River was identified from November 2017 to October 2018 and the result is compared with 15 regions of recent studies in different continents. The flora of Africa with 66 percent common taxa was the highest similar to our study. Based on the comparison the *Ulnaria ulna* (Nitzsch) Compère, *Navicula cryptotenella* Lange-Bertalot, *Gomphonema acuminatum* Ehrenberg and *Nitzschia palea* (Kützinger) W Smith was the cosmopolitan species and *Achnanthes eutrophilum* (Lange-Bertalot) Lange-Bertalot, *Frustulia tugelae* Cholnoky, *Nitzschia acula* (Kützinger) Kützinger in Rabenhors, and some other species were rare taxon. 45 out of 203 diagnosed species and genus *Seminavis* D.G.Mann is new record for diatoms flora of Iran. Also, the species *Cymbella pernodensis* Maillard, *Cymbella novazeelandiana* Krammer and *Achnanthes druettii* Rimet & Couté were new records for Asia.

Keywords: Diatom; Cosmopolitan; Flora; Sefid Rud; Iran

Introduction

The changeability of different organisms including the diatoms in various habitats shows the biodiversity comprising species, genetic, and ecosystem diversity. It is necessary to understand the biodiversity to utilize the natural resources for human applications. There is a mutual relation between biodiversity and environment as the alteration in the physicochemical variables, impacts on the diversity of organisms and frequently are responsible for fluctuations the species assemblages. The diatoms are widespread organisms that occurred in various environments like soil, marine, freshwater, and even in extreme conditions. Mann [1] estimated their species number between 30,000 and 200,000 as of the most species-rich in the algal group. They prefer special environmental conditions, such as many other organisms which besides their fast reproduction and their resistant siliceous cell wall (useful for the rebuilding of previous environments) make them a good candidate as bioindicator. Therefore, it is important to study the flora of diatom communities that are influenced by the environmental condition and land-water interactions [2].

It is feasible to evaluate the environment in the aquatic ecosystem with the help of species diversity. Also, the diversity of species is an effective factor in ecosystem functioning, food chain, integrity, and process. The environmental condition such as temperature, humidity, geology, physicochemical elements, substrates (stone, sands, plants, and etc.), anthropogenic factors, water velocity and light intensity influences on the diatom community and their species richness [3,4]. According to the phylogenetic tree the epiphytic and epilithic lifestyle is an ancestral character in which many planktonic diatom species have been evolved from their lineage [5]. The major evolution (lifestyle, morphology, and ecology) of different diatom classes have occurred in the benthic lifestyle. The majority of diatom species live in benthic communities due to their heavy silicified frustule.

Comparing the present flora with the previous studies can reflect climate change and anthropogenic influences on the earth. Iran with 1.6 million km² has a diverse climate and the Zagros

Mountains from South part to North and Alborz Mountain from East to West [6]. Outstanding studies on the flora of algae in Iran were performed by [7,8]. Compère [9] has mentioned that Rabenhorst [10] has published the list of freshwater diatoms from South Persia. Leonard has collected some samples from Dašt-e Kavir, Dašt-e Lut and Jazmuriyān in 1972 and Compère [9] has identified 300 algae species and varieties which 99% of them belonged to Bacillariophyceae [9]. New records of species including *Nitzschia curvata* Compère, *Nitzschia iranica* Compère and *Navicula egregia* Hust. fa. *elongata* Compère was introduced.

During the five kilometers long sampling area of Taleghan River, 203 Taxa were identified which reflects the rich diatom flora of Iran. Compared to other floristic studies in Iran and other areas (in the same conditions such as: the time of study, sampling substrates, stations number, and etc.), the Taleghan area has the highest diatom diversity. The purpose of the present study was to compare the diatom flora of Taleghan River and Taleghan Dam with 15 other floristic studies in the world.

Material and Methods

Taleghan River is one of the main tributaries of Sefid Rud, the second-longest river in Iran with approximately 670 km length. It rises in the Alborz Mountain in the northwest of Iran and flows into the Caspian Sea. Taleghan River begins in the Kahar and Kandovan

mountains located in the western part of the Alborz domain. It is one of the longest rivers in the center of Iran with 180 km length; they form the Shah Roud River after joining to Alamut River. This study was carried out at eight sites on the Taleghan River and Taleghan Dam from November 2017 to October 2018 (Table 1, Figure 1). The number of sediments were 160 ml, collected from each station in three replicates. The sediment samples were fixed with a 4% formaldehyde solution in the sampling field and then transferred to the laboratory. Ten ml of suspension was prepared from the samples based on the protocol Van der Werff [11].

The samples were treated with 25 ml of hydrogen peroxide (H_2O_2) (1.5 h at 100 °C) and then 10 ml hydrochloric acid (HCl) (2 h at 120 °C) to remove organic matters. The oxidized by-products were removed by recurrent and settling with distilled water. To neutralize electrostatic charges on the suspended particles, one drop of 10% NH_4CL was added for every 10 mL of suspension [12]. Coverslips were prepared with diatom suspension and installed on slides in Naphrax glue. The Olympus microscope (Model CX31) via 100x oil immersion was used to investigate the diatom cells. Finally, the Canon camera (Model EOS 5D Mark III) was used to capture the images. The slides were examined to evaluate the abundance of species based on 300 valves counts for each site. Each month, three permanent slides were prepared for eight stations (Table 1, Figure 1).

Figure 1: The map of Iran, and locations of sampling sites.

Table 1: Sampling sites along the Taleghan River.

Site	Elevation (m)	Latitude & Longitude
1	1788	36°10.1'N, 50°42.65' E
2	1791	36°10.9'N, 50°42.8' E
3	1794	36°10.1'N, 50°8' E
4	1795	36°10'N, 50° 44.5' E
5	1797	36°10'N, 50°44' E
6	1817	36°10.2'N, 50°46' E
7 & 8	1832	36°10.3'N, 50°46.6' E

Physicochemical Analysis

To analyze physicochemical parameters, 120 ml of water from each station were collected. The parameters (cations, anions, SiO_2 , salinity, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), turbidity (nephelometric turbidity unit (NTU), PO_4^{2-} , NO_3^{2-} , and Mg^{2+}) were examined in the laboratory of the Mabna company (Karaj) according to American Public Health Association [13], and the electrical conductivity (EC), temperature (T), dissolved oxygen (DO) and oxidation-reduction potential (ORP) were measured in situ at station sites [14]. COD was measured by the optical method device, and with Hach Dr 5000. The local temperature, pH and DO, were measured via the Hach HQ30 analyzer, Nitrate, and phosphate parameters via the Hach Dr 2800 spectrophotometer, and the turbidity was measured by Wagtech turbidity detector.

Results and Discussion

Table 3 shows the physicochemical parameters of the water of stations. In the Taleghan stations, 203 taxa were identified which belong to 25 families and 49 genera (Table 2). The percentage of each class of diatoms is as below: Bacillariophyceae with 88%, Cosinodiscophyceae with 8%, and Mediophyceae with 4%. The percentage of the diatoms family included Bacillariaceae 21% (6 genera, 42 species), Navicullaceae 17% (4 genera, 34 species), Gomphonemataceae 11% (4 genera, 24 species), Cymbellaceae 10% (4 genera, 21 species), Achnanthidiaceae 5% (2 genera, 10 species), each of Catenulaceae, Fragillariaceae, Tabellariaceae, and Surirellaceae had 1, 2, 4 genera and 8 to 9 species (each of them 4%) respectively, and each of the nineteen other families less than 3% species accounted for them (Figure 2). *Nitzschia* 17% (32 spp.) was the most represented genus, being *Navicula*, with 26 species (14%) in the second.

Figure 2: The numbers of species, genera of family.

Table 2: Lists and comparison of the taxa of the Taleghan Dam and River in comparison with 15 regions.

Taxa Taleghan River (Iran)	B. A. I	K. R. I	A. F. I	A. F. I r	S. R	L. N. I	S. D. F	V. E	C. R. C	T. M. S. M	E. C. R	N. U. S	S. B	P. B	S. A
Bacillariophyceae															
Achnanthidiaceae															
<i>Achnanthidium affine</i> (Grunow) Czarnecki					p							p			p
<i>Achnanthidium crassum</i> (Hustedt) Potapova & Ponader *							p								p
<i>A. druartii</i> Rimet & Couté**							p								
<i>A. eutrophilum</i> (Lange-Bertalot) Lange-Bertalot*							p					p			p
<i>A. macrocephalum</i> (Hustedt) Round & Bukhtiyarova*															p
<i>A. minutissimum</i> (Kützing) Czarnecki		P			p			p	p	p	p	p	p	p	p
<i>A. saprophilum</i> (H.Kobayashi & Mayama) Round & Bukhtiyarova*					p							p	p		p
<i>Achnanthidium standeri</i> (Cholnoky) J.C.Taylor, E.Morales & L.Ector															p
<i>Achnanthidium</i> sp.															
<i>Planothidium frequentissimum</i> (Lange-Bertalot) Lange-Bertalot	P				p				p			p	p		p
<i>P. rhombiculum</i> Lange-Bertalot*											p				
Asterionellopsidaceae															
<i>Psammothidium pseudoswazii</i> (J.R.Carter) L.Bukhtiyarova & Round*															p
Amphipleuraceae															
<i>Frustulia tugelae</i> Cholnoky*															p
<i>F. vulgaris</i> (Thwaites) De Toni		P	p		p				p		p	p			p
Bacillariaceae															
<i>Bacillaria paxillifera</i> (O.F.Müller) T.Marsson			p	p				p				p			p
<i>Denticula kuetzingii</i> Grunow		p			p							p			p
<i>D. subtilis</i> Grunow	p			p								p			p
<i>Denticula sundayensis</i> Archibald*															p
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow	P	p	p	p	p						p	p	p	p	p
<i>Hantzschia</i> sp.															
<i>Mayamaea permitis</i> (Hustedt) Bruner & Medlin											p	p			p
<i>Nitzschia.acicularis</i> (Kützing) W. Smith			p	p	p	P					p	p			p
<i>Nitzschia acula</i> (Kützing) Kützing in Rabenhorst*												p			
<i>N. amphibia</i> Grunow.	P	p	p		p				P	P		p			p
<i>N. capitellata</i> Hustedt in Pascher			p		p							p			p
<i>N. clausii</i> Hantzsch			p	p	p				P			p			p
<i>N. communis</i> Rabenhorst			p		p							p			p
<i>N. dissipata</i> (Kützing) Rabenhorst	P	p	p	p	p				P	P	p	p			p
<i>N. dissipata</i> var. <i>media</i> (Kützing) Grunow		p			p										p
<i>N. draveillensis</i> Coste & Ricard *							p					p			p
<i>N. filiformis</i> (W. Smith) Van Heurck			p	p	p			p				p			p

<i>N. frustulum</i> (Kützing) Grunow	p		P	p	p							p			p
<i>N. gracilis</i> Hantzsch,			p	p	p			p				p			p
<i>N. heufleriana</i> Grunow	p		P	p	p							p			p
<i>N. iremissa</i> Cholnoky*															p
<i>N. linearis</i> (Agardh) W. Smith	p	p	P		p			P	P	p	p				p
<i>N. littorea</i> Grunow*												p			p
<i>N. microcephala</i> Grunow					p				P			p			p
<i>N. media</i> Hantzsch		P			P										P
<i>Nitzschia oligotraphenta</i> (Lange-Bertalot) Lange-Bertalot*															
<i>N. palea</i> (Kützing) W. Smith	p		P	p	p	p		p	P	P		p	p		p
<i>N. pura</i> Hustedt*					p							p			p
<i>N. pusilla</i> Grunow	p		P	p	p							p			p
<i>Nitzschia recta</i> Hantzsch ex Rabenhorst		p	p	p	p			P				p			p
<i>N. sigma</i> (Kützing) W. Smith			p	p	p							p			p
<i>N. sigmoidea</i> (Nitzsch) W. Smith	p			p	p							p			
<i>N. sublinearis</i> Hustedt			p												p
<i>N. subtilis</i> Grunow		p													
<i>N. tenuis</i> W. Smith*															
<i>N. tsarenkoi</i> Lange-Bertalot*															p
<i>N. umbonata</i> (Ehrenberg) Lange-Bertalot			p	p	p				P			p			p
<i>N. vermicularis</i> (Kützing) Hantzsch	P		P	p	p							p			
<i>Tryblionella apiculata</i> W. Gregory	p				p							p			p
<i>T. angustata</i> W. Smith			P	P							P	P			P
<i>T. calida</i> (Grunow) D.G. Mann	p				p							p			p
<i>T. hungarica</i> (Grunow) Frenguelli	p				p							p			p
Catenulaceae															
<i>Amphora copulata</i> (Kützing) Schoeman & R.E.M. Archibald	p			p								p			p
<i>A. inariensis</i> Krammer*												p			
<i>A. minutissima</i> W. Smith															
<i>A. ovalis</i> (Kützing) Kützing	p	p	P	p	p			p				p			p
<i>A. pediculus</i> (Kützing) Grunow		p	p	p	p			p		p	p	p			p
<i>A. veneta</i> (Kützing) Levkov		p	p	p	p	P		p				p			p
<i>Amphora</i> sp1															
<i>Amphora</i> sp2															
Cocconeidaceae															
<i>Cocconeis placentula</i> var. <i>euglypta</i> (Ehrenberg) Grunow			p	p	p			p	p			p			p
<i>C. pediculus</i> Ehrenberg	p	p	p	p	p					p		p			p
<i>C. placentula</i> Ehrenberg	p		p	p	p	p				p	p				p
<i>C. lineata</i> Ehrenberg		p	p		p			p				p	p		p
Cymbellales incertae sedis (Family)															
<i>Gomphonella olivacea</i> (Hornemann) Rabenhorst.			p		p										p
Cymbellaceae															
<i>Cymbella affinis</i> Krammer		p										p			

<i>C.cf. excisa</i> Kützing		p			p							p			p
<i>C.cf. neocistula</i> Krammer		P										p			p
<i>C.cistula</i> (Ehrenberg) O. Kirchner	P		p	p	p	p									p
<i>C.compacta</i> Østrup		p													
<i>C. diversistigmata</i> Krammer*															
<i>C. excisiformis</i> Krammer												p			
<i>C.langebertainii</i> Krammer		P					p								
<i>C.novazeelandiana</i> Krammer**															
<i>C.pernodensis</i> Maillard **															
<i>C.stigmaphora</i> Østrup*												p			
<i>C.subleptoceros</i> Krammer*															p
<i>C. turgidula</i> Grun.			p												p
<i>Cymboppleura amphicephala</i> (Nägeli ex Kützing) Krammer		p	p		p							p			p
<i>C. frequens</i> Schmidt*												p			
<i>C. langeBertainii</i> Krammer *															
<i>C.maggiæ</i> Bahls**															
<i>Cymboppleura naviculiformis</i> (Auerswald ex Heiberg) Krammer,															
<i>Cymboppleura</i> sp.															
<i>Didymosphenia geminata</i> (Lyngbye) Mart.Schmidt		p		p	p							p			
<i>Navicymbula pusilla</i> (Grunow) Krammer*															p
Diadesmidaceae															
<i>Luticola cf. ventricosa</i> (Kützing) D.G. Mann															
Diploneidaceae															
<i>Diploneis elliptica</i> (Kützing) Cleve*				p	p			p		p		p			p
<i>D. oblongella</i> (Nag.) Cl.Euler			p	p				p				p			p
<i>D. smithii</i> (Brebisson) Cleve				p								p			p
<i>Diploneis</i> sp.															
Eunotiaceae															
<i>Eunotia minor</i> (Kützing.) Grunow			p		p						p	p		P	p
Fragilariaceae															
<i>Fragilaria capucina</i> Desmazières Meso	p		p	p	p			p	p			p		P	p
<i>F. capucina</i> var. <i>rumpens</i> (Kutz.) Lange-Bertalot			p	p	p			p							p
<i>F. capucina</i> var. <i>rumpens</i> (Kutz.) Lange-Bertalot			p	p	p			p				p			p
<i>Fragilaria tenera</i> var. <i>nanana</i> (Lange-Bertalot) Lange-Bertalot & S. Ulrich				p	p										p
<i>F. tenera</i> (W. Sm.) Lange-Bertalot	P													P	p
<i>Fragilaria</i> sp1.															
<i>Odontidium hyemale</i> (Roth) Kützing*															
<i>O. mesodon</i> (Ehrenberg) Kützing	p	P													
Gomphonemataceae															
<i>Encyonema caesepitosum</i> Kützing		p	p	p	p										p
<i>E. mesianum</i> (Cholnoky) DG Mann					p										p
<i>E. minutum</i> (Hilse)D.G. Mann		P			p			p		p	p	p			p
<i>E. silesiacum</i> (Bleisch) D.G. Mann	p	P						p				p		P	p

<i>E. ventricosum</i> (C. Agardh) Grunow		P										p			p
<i>Encyonema</i> sp.															
<i>Encyonopsis minuta</i> Krammer & E. Reichardt		P	p					p				p			p
<i>E. subminuta</i> Krammer & Reichardt		P						p				p		P	p
<i>Gomphonema acuminatum</i> Ehrenberg	p		p	p	p	P		p	p	p	p	p			p
<i>G. caperatum</i> Ponader & Potapova*															
<i>G. capitatum</i> Ehrenberg		P						p				p			p
<i>G. insigne</i> W.Gregory					p							p			
<i>G. louisiananum</i> Kalinsky*															
<i>G. minutum</i> (C. Agardh) C. Agardh		P			p			p				p			p
<i>G. olivaceoides</i> Hustedt					p							p			
<i>G. parvulus</i> (Lange-Bertalot & E.Reichardt) Lange-Bertalot & E.Reichardt *												p			p
<i>G. parvulum</i> (Kützing) Kützing	p		p	p	p	P			p	p	p	p			p
<i>G. pumilum</i> var. <i>rigidum</i> Reichardt & Lange-Bertalot		P			p			p				p	p		p
<i>G. tergestinum</i> (Grunow) Fricke		P	p	p	p										
<i>G. venusta</i> passy*															
<i>Reimeria sinuata</i> (Gregory) Kociolek & Stoermer		P			p			P	p	p	p	p			p
<i>R. uniseriata</i> sala Guerrero and Ferrario*							p				p				p
Naviculaceae															
<i>Caloneis aequatorialis</i> Hustedt*															p
<i>C.bacillum</i> (Grun.) Cleve.			P	p	p			p				p			p
<i>C.silicula</i> (Ehrenberg) Cleve.		P	p	p	p							p			p
<i>Gyrosigma acuminatum</i> (Kützing) Rabenhorst	p		P	p	p							p			p
<i>G. attenuatum</i> (Kutz.) Rabenh.			P	p	p										p
<i>G. rautenbachiae</i> Chohnoky*															p
<i>G. scalproides</i> (Rabenhorst) Cleve			P	p	p							p			p
<i>Navicula amphiceropsis</i> Lange-Bertalot & U. Rumrich*												p			
<i>N. antonii</i> Lange-Bertalot		P									p	p			p
<i>N. capitatoradiata</i> H. Germain ex Gasse	p	P	p		p			P	p						p
<i>N. cincta</i> (Ehrenberg) Ralfs	p	P	p	p	p							p			p
<i>N. cryptotenella</i> Lange-Bertalot		P	p		p			p	P	p	p	p	p	p	p
<i>N. erifuga</i> Lange-Bertalot	p		p									p			p
<i>N. escambia</i> (R.M. Patrick) Metzeltin & Lange-Bertalot*												p			
<i>N. germainii</i> J.H. Wallace*												p			p
<i>N. gregaria</i> Donkin	p		p	p	p			P		p	p				p
<i>N. notha</i> J.H.Wallace															
<i>N. metareichardtiana</i> Lange-Bertalot & Kusber	P	P										P			P
<i>N. novaesiberica</i> Lange-Bertalot*												p			
<i>N. pseudolanceolata</i> Lange-Bertalot															
<i>N. radiosa</i> Kützing			p	p	p	P				p	p	p			p
<i>N. recens</i> (Lange-Bertalot) Lange-Bertalot	p				p							p			p
<i>N. rostellata</i> Kützing					p			P				p			p
<i>N. simulata</i> Manguin*												p			

<i>N. subrhynchocephala</i> Hustedt*																p
<i>N. tripunctata</i> (O.F. Müller) Bory de Saint-Vincent	p	P	p	p	p			p		P	p	p				p
<i>N. trivialis</i> Lange-Bertalot	p	p		p					P			p				p
<i>N. vandamii</i> Schoeman&Archibald*												p				p
<i>N. veneta</i> Kützing		p	p		p							p		p		p
<i>N. weberi</i> L.L. Bahls																
<i>N. zanonii</i> Hust.			p	p								p				p
<i>Navicula</i> sp 1																
<i>Navicula</i> sp2																
<i>Seminavis strigosa</i> (Hustedt) D. & E. Amilli*																p
Neidiaceae																
<i>Neidium dubium</i> (Ehrenberg) Cleve			P		p							p				p
<i>Neidium</i> sp.																
Pinnulariaceae																
<i>Pinnularia acrosphaeria</i> W. Smith			p	p	p							p				p
<i>P. brebissonii</i> (Kützing) Rabenhorst			p		p						p					
<i>P. lundii</i> var. <i>linearis</i> Krammer											p	p				
Rhoicospheniaceae																
<i>Rhoicosphenia abbreviata</i> (C. Agardh) Lange-Bertalot	p	p	p		p			p	P	p	p	p				p
Sellaphoraceae																
<i>Fallacia pygmaea</i> (Kützing) Stickle & D.G. Mann	p	p			p							p				p
<i>Sellaphora pupula</i> (Kützing) Mereschkovsky		p			p				P	p	p	p				p
<i>S. stroemii</i> (Hustedt) Kobayasi		p														p
Stauroneidaceae																
<i>Craticula buderi</i> (Hustedt) DG Mann												p				p
<i>C. buderi</i> (Hustedt) Lange-Bertalot												p				p
<i>C. halophila</i> (Grunow) DG Mann												p				p
<i>Stauroneis smithi</i> Grun.			p		p						p	p				p
Staurosiraceae																
<i>Pseudostaurosira parasitica</i> (W. Smith) Morales		p	p													
Surirellaceae																
<i>Campylodiscus</i> sp.																
<i>Surirella angusta</i> Kützing	p	p	p		p				P	p	p					p
<i>S. atomus</i> Turpin*												p				
<i>S. lacrimula</i> J.D. English in English & Potapova*																
<i>S. librile</i> (Ehrenberg) Ehrenberg	p			p	p	P					p	p				p
<i>S. minuta</i> Brébisson ex Kützing	p	p	p		p						p	p				
<i>S. ovalis</i> Brébisson Eutroph	p		p	p	p	p					p	p				p
<i>S. tenera</i> W. Gregory			p	p								p				
<i>Surirella</i> sp.																
Tabellariaceae																
<i>Asterionella formosa</i> Hassall		p	p		p						p					p
<i>Diatoma moniliformis</i> (Kützing) D.M. Williams	p	p			p							p				
<i>D. tenuis</i> C. Agardh	p		p	p	p							p				

<i>D. vulgaris</i> Bory.	p	P	p	p		P						p			p
<i>D. vulgaris</i> var. <i>breve</i> Grun	p	P	p	p	p										p
<i>Meridion constrictum</i> Ralfs *		p			p							p	p		
<i>Oxyneis binalis</i> (Ehrenberg) Round	p														
Ulnariaceae															
<i>Hannaea arcus</i> (Ehrenberg) Patrick	p	P		p	p							p	p		
<i>Ulnaria biceps</i> (Kützinger) P. Compère		p	p	p	p							p			p
<i>U. ulna</i> (Nitzsch) Compère	P	p	p	p		P		p	P	p		p	p	P	p
Cosinodiscophyceae															
Aulacoseiraceae															
<i>Aulacoseira granulata</i> (Ehrenberg) Simonsen			p							p		p	p		p
<i>Aulacoseira</i> sp1.															
<i>Aulacoseira</i> sp2.															
Melosiraceae															
<i>Melosira varians</i> C. Agardh	p	P	p	p				p	p	p	p				p
Mediophyceae															
Stephanodiscaceae															
<i>Cyclotella atomus</i> Hustedt*												p			p
<i>Cyclotella meneghiniana</i> Kützinger	p		p		p		p		p		p	p	P	p	p
<i>Pantocsekiella ocellata</i> (Pantocsek) K.T. Kiss & Ács		p	p				p					p			p
<i>Pantocsekiella rossi</i> (H. Håkansson) K.T. Kiss & E. Ács		p													

Notes: P stand for presence, B.A.I for Balikhli River Northwest Iran; K.R.I: Karaj River in Iran, A.F.I: Algal flora Iran; N.L.I: Neure Lake Iran; A.f.Ir: Algal flora Iraq; S.R: Southern of the Russian; S.d.f: Serbian diatom flora; V.E: Valenciana España; C.R.C: Cali River Colombia; T.M.S.M: tropical mountain streams of Mexico; E.C. R: Elbsandsteingebirge Czech Republic; N.U. S: Northwestern United States; S.B: southeastern Brazil; P.B: Paraná state Brazil, & S.A: South Africa. The new records for the flora of Iran are marked by an asterisk and new records to the flora of Asia by two asterisks.

The percentage of other genera are mentioned as: Each of *Cymbella* and *Gomphonema*, had 13 species (each of them 7%), each of *Amphora*, *Surirella*, and *Achnanthisdium* with 8 species (4%), each of the *Fragilaria*, *Cymboplectra*, *Encyonema*, and *Diatoma*, had 5 to 6 species (3%), *Tryblionella*, *Caloneis*, *Denticula*, *Craticula*, *Aulacoseira*, *Gyrosigma*, *Cocconeis*, and *Pinnularia*, had 3 to 4 species (2%), 29 other genera had 1 to 2 species (1%) of the identified taxa (Figure 2). Forty-five out of 203 diagnosed species are new records for the diatom flora of Iran which are marked with an asterisk in Table 2. Also, the genus *Seminavis* D.G., is new record for Iran. As well, three species were recognized as the new report for Asia including *Cymbella novazeelandiana* Krammer: [71,166; pl.47; pl.51] [15]. *Cymbella pernodensis* Maillard ex Lange-Bertalot & Moser [16]: [79; pl. 20; pl.25], and *Achnanthisdium druartii* Rimet & Couté [17]: (47572: 188, pls. I-III (Figures 3a-f). Due to their low frequency (R: <1.5%) in the samples, we cannot provide any better pictures. *Cymbella novazeelandiana* Kramme (Figure 3a&b), has only been reported in New Zealand and Australia [18]. It is also a new record for the diatom flora of Asia (Figure 2).

In this study some research of diatom flora was chosen which were representative of continents (Asia, Europe, Africa, America). The study of Brazil diatoms was conducted to increase

the biodiversity and ecology of tropical diatoms. In the Czech Republic study, the region includes pristine habitat with clean and unpolluted waters. The sampling in the Serbian study was done from different substrates including epiphyte and epilithic which two genera (*Microfissurata* and *Fistulifera*) were new for their flora. The sampling stations in Iraq and its geographical position were highly diverse from cold to hot and mountains to deserts areas which make it special. The characteristics of the sampling area in the United States were diverse regarding pH, temperature, salinity, nutrient, and a vast area which can be the reason for the diversity of diatom species.

Based on the comparison study the *Cymbella pernodensis* Maillard, has not been reported in Iran [19-30]. It is a freshwater taxon which occurred only in stations 5 & 6, in all months except spring with the following environmental conditions: alkaline pH (8.71), moderate to high conductivity (502- 834 $\mu\text{S}\cdot\text{cm}^{-1}$), oligotrophic to eutrophic conditions, temperature (4.9 – 19.9 °C), TDS (164 -335 $\text{mg}\cdot\text{l}^{-1}$), BOD (< 8 $\text{mg}\cdot\text{l}^{-1}$), DO (< 10 $\text{mg}\cdot\text{l}^{-1}$), ORP (102), Salinity (< 0. 2 g. l⁻¹), NTU (< 44), COD< 18 $\text{mg}\cdot\text{l}^{-1}$), PO_4^{2-} (0. 3 – 4 $\text{mg}\cdot\text{l}^{-1}$), NO_3^{2-} (< 3 $\text{mg}\cdot\text{l}^{-1}$), Si (2.9- 5.1 $\text{mg}\cdot\text{l}^{-1}$), & Mg^{2+} (4.8 – 16.3 $\text{mg}\cdot\text{l}^{-1}$) (Table 3).

Table 3: Seasonal mean and standard deviation of physicochemical parameters from sampling stations.

Parameters	Station	Spring	Autumn	Summer	Winter
*TDS (mg/l ⁻¹)	1	190±26.9072	187.4± 7.73821	157±7.9372	232.34± 59.8776
	2	204±19.1572	270.6667±21.7865	229.33±91.5277	243.67± 55.0121
	3	174.34±21.4553	269.5333±24.662	220±75.7825	328.33± 33.8575
	4	176.67±22.8108	317±9.5393	212±73.3212	335.33± 40.2036
	5	117.34±18.8237	276±22.33830	212±69.3974	244.33± 70.5147
	6	185.67±25.4230	323.34±10.6926	211±73.7360	334.67± 27.2274
	7	150±17.0880	301±44.9777	205.33±73.3303	355± 55.4616
	8	190.67±24.1729	320.6±15.14375	218.33±56.3589	382.66±57.9511
*DO (mg/l ⁻¹)	1	9.22±0.3576	6.367±0.0723	8.83±0.5843	8.56±0.2410
	2	8.8±1.1857	7.24±0.0655	7.56±0.2650	8.63±0.900
	3	9.67±0.4974	9.87±0.5351	8.29±0.7011	9.96±0.4454
	4	9.2334±0.1457	9.12±1.0484	8.543±0.444	9.83±0.6357
	5	8.79±0.4214	9.17±0.8155	8.043±0.6230	9.73±0.3450
	6	8.9±0.1058	9.37±1.3150	8.01±0.5708	9.54±0.3260
	7	8.67±0.3066	8.81±0.9103	7.98±0.4119	9.33±0.1563
	8	7.64±0.9544	9.65±0.4948	6.56±0.4636	8.23±0.583 8
pH	1	8.3±0.1011	8.3±0.1890	8.4±0.1365	8.4±0.3774
	2	7.9±0.1921	7.5±0.1059	8.4±0.0754	8.1±0.0500
	3	8.2±0.0346	8.4±0.0608	8.4±0.2007	8.5±0.1193
	4	8.2±0.0665	8.4±0.0953	8.5±0.3827	9.5±0.94
	5	8.75±0.8231	8.6±0.1550	8.5±0.1975	8.6±0.0263
	6	8.2±0.0321	8.4±0.028	8.3±0.1379	8.5±0.0251
	7	8.2±0.2757	8.0±0.5257	8.4±0.3659	8.4±0.1357
	8	7.64±0.4063	7.6±0.3957	7.9±0.3280	7.8±0.1248
*EC(μs.cm ⁻¹)	1	474.33±68.090	380±70.5053	412±20.7846	578±151.0860
	2	509±47.947	448.66±54.0030	597.66±152.454	616±129.5723
	3	435.33±54.500	558±227.3477	544.66±131.062	820.33±85.2310
	4	441.33±56.888	610±170.6135	608.33±106.7817	836±100.5385
	5	291.66±46.285	565.66±91.0842	553 ±218.2750	609.33±175.819
	6	461±64.280	619.66±185.9740	620.66±162.6571	833.33±67.869
	7	476±61.991	627.33±179.3804	595±.01952	785 ±155.9647
	8	810±153.948	627±449.5631	840.33±95.5527	995.33±91.664
T (°C)	1	13.26±3.3501	17.16±5.2519	24.1±1.1532	6.77±2.7024
	2	12.43±4.5544	14.83±3.9803	19.57±2.1361	7.8±1.3856
	3	9.46±3.0599	12.8±7.9680	18.03±1.0503	4.53±1.5695
	4	10.86±3.4063	13.3±8.2054	17.5±0.50	5.33±1.3316
	5	11.26±2.6388	12.3±7.0760	18.57±0.9814	5.87±0.9073
	6	11.56±2.8867	11.97±6.6108	19±0.7937	5.8±0.5291
	7	11.53±2.1939	11.97±6.1451	17.4±2.2052	6.43±0.4163
	8	13.26±3.2254	13.8±3.9038	16.67±1.0263	11.2±1.1135
	1	81.9±1.1	84.2±9.9141	92.17±10.5396	75.67±6.8244
	2	63.07±14.9887	52.53±29.0993	75.9±18.1033	64.67±6.9873
	3	78.5±2.3579	89.83±3.1973	82.73±4.1004	88.33±13.4767
	4	78.43±2.6857	87.53±2.9194	83.67±4.9328	87.3±11.9954

*ORP	5	81.63±4.1052	92.43±2.9737	89.8±5.0318	93.2±11.5723
	6	78.9±2.4248	85.67±3.2393	87.83±6.7884	87.17±15.4997
	7	76.13±5.7933	84.33±2.0305	84.37±7.2665	82±6.7201
	8	49.1±12.7106	58.47±1.3316	50.83±4.4814	45.93±14.3060
	1	24.8±21.9063	217.7863±0.133	12.11±4.2353	172.44±172.485
	2	160.17±135.991	249.4±5.5912	103.77±131.848	87.82±105.262
*NTU	3	208.83±228.211	7.873±5.4337	58.77±91.9923	100.57±88.7924
	4	207.23±194.208	7.28±4.1371	65.29±98.4728	74.83±101.8168
	5	64.37±29.6473	5.27±6.3918	36.65±43.6044	28.05±23.8778
	6	199.53±178.643	7.873±1.5305	48.98±70.1596	124.12±183.469
	7	194.07±204.784	2.15±4.0501	42.2±59.5838	112.17±180.115
	8	45.67±29.67	5.63±3.1923	41.72±68.6556	10.63±15.1046
	1	0.23±0.1527	1.65±2.1250	0.27±0.0577	0.67±1.0653
	2	0.45±0.3400	2.62±3.8804	0.38±0.2804	0.35±0.4763
	3	0.42±0.5054	1.41±2.1564	0.22±0.0529	0.73±0.5507
PO ₄ ²⁻	4	0.62±0.5647	1.28±1.4907	0.26±0.01	0.40±0.5169
	5	0.63±0.4250	2.25±1.5173	0.37±0.0208	0.97±0.2886
	6	0.18±0.1106	1.63±2.4866	0.31±0.0854	0.63±0.3900
	7	0.16±0.060	2.16±3.1525	0.48±0.2818	0.47±0.5485
	8	0.15±0.0873	2.17±3.2347	0.31±0.0230	0.41±0.5169
	1	2.91±1.4705	2.2±0.7810	1.76±0.4927	1.4±0.6000
	2	3.9±1.5099	3.7±2.8583	2.43±0.4932	1.83±0.5507
	3	3.7±1.1532	3.05±0.6500	3.02±0.6353	2.4±1.1357
NO ₃ ²⁻	4	3.09±0.6407	2.6±0.1732	3.1±0.3605	2.06±1.0016
	5	3.27±0.3511	2.27±0.3055	2.85±1.2020	2.16±0.7094
	6	3.47±0.3511	1.6±1.0392	2.22±0.5688	2.93±0.9018
	7	3.4±0.1732	2±0.8185	2.16±0.4613	2.8±1.3
	8	4.65±1.0819	2.12±0.6932	2.55±1.8183	3.03±0.4725
	1	2.71±0.4517	2.067±0.327	2.07±0.3271	3.05±0.8760
	2	3.28±1.1001	4.83±1.0272	4.83±1.0272	3.42±0.8145
Si(mg.l ⁻¹)	3	4.12±0.7441	4.91±0.5884	4.91±0.5884	5.34±2.4282
	4	3.87±0.54500	4.88±0.5129	4.88±0.5129	5.45±2.3696
	5	3.88±0.2893	5±0.4689	5±0.4689	5.51±2.6681
	6	3.85±0.5023	4.87±0.5089	4.88±0.5089	5.54±2.2360
	7	3.70±0.466	5.10±0.6942	5.10±0.6942	5.77±2.9021
	8	4.15±0.2753	5.22±0.7448	5.22±0.7448	5.85±2.7319
	1	14.88±7.467	13.16±0.5919	10.85±2.7484	10.21±3.0571
	2	9.92±2.4159	23.09±0.8013	9.54±1.6185	16±2.9328
	3	13.12±3.6345	14.57±1.6667	9.81±1.2932	17.6±2.2170
Mg ²⁺ (mg/l ⁻¹)	4	7.36±3.8797	13.75±3.1005	8.33±2.4179	18.88±9.8057
	5	7.04±2.4159	12.96±0.8313	8.86±0.7034	12.8±4.8318
	6	7.68±1.92	15.34±0.9657	6.38±2.0082	13.76±5.2872
	7	7.91±1.0450	13.7±1.7776	8.43±1.7953	14.37±2.4946
	8	13.44±3.4613	18.71±0.4801	14.38±3.9607	16.32±1.92

*TDS: Total dissolved solids; DO: Disolved oxygen; EC: Electrical conductivity, ORP: Oxidation reduction potential; NTU: Nephelometric turbidity unit

Achnantheidium druartii Rimet & Couté [17], have been reported from France and Spain Germany, Netherlands, Serbia: Jovac stream and Đetinja River, and Bulgaria [17,31-34]. This species is considered aggressive and has been invading the rivers of Europe [17]. It has been reported in North America only from rivers in Kentucky and Virginia [35]. This epilithic taxon usually lives on stones, however. Unlike the Rimet's results in the present study it occurred in sediment, so this taxon can be considered as epipelagic and epilithic taxon [17]. This taxon has special characters such as a longer valve, lower striae density, and lanceolate shape with subrostrated apices which make it distinguishable from other species like *A. convergens* Kobayasi, *A. deflexum* (Reimer) Kingston, and *A. japonicum* Kobayasi.

Frustulia tugelae Chohnoky, Ref identify [28], (plate. 44), L: 20-26 µm, W: 4.5-5 µm, it has dimensions: Valve length 17-26 µm, Valve breadth 4-5 µm, and Striae density >40 .10 µm (i.e., not visible in

LM). The type species (holotype) is *Frustulia saxonica* Rabenhorst and no synonym is currently included in Algae Base. This taxon is a freshwater species (www.algaebase.org) or associated with weakly acidic waters [28]. It has a restrict ecological range, only reported from the eastern mountainous regions of South Africa, and Tasmania [28,36].

A very small diatom linear shape and other individual characteristics with strongly concave valve margins, poorly elongated, rounded to sub-capitate apices and if not focused on, it may not be observed by diatomists in microscopic investigation. In our samples, it occurred in slightly alkaline pH (7.25), moderate electrolyte to high electrolyte content with conductivity (309- 890 µs cm⁻¹) and eutrophic conditions, with DO (7. 25 -9.74 mg.l⁻¹), ORP (-32.2- to -101.6), NO₃²⁻ (1.7-7 mg.l⁻¹), Si (2.23-8.57 mg.l⁻¹) & Mg²⁺ (11.48-24 mg.l⁻¹). It was observed only in winter and autumn (temperature 4.3-19.7°C) (Figure 3, Table 2).

Figure 3: a & b *Cymbella novazeelandiana*; c & d *Cymbella pernodensis* and e & f *Achnantheidium druartii* are new records for diatoms flora of Asia. Images were taken by Olympus optical microscope with a magnification of 100 (10µm scale bar).

The *Seminavis strigosa* (Hustedt) Danieleidis & Economou-Amilli in Danieleidis & Mann: it has been reported in New Zealand, North America: NW USA, German, Tasmania, Netherlands, Middle East (Egypt), South-west Asia (India), Spain, North America (Florida), Mexico, and Africa (Ivory Coast) [18,23,31,32,36-39,41-43]. The *Ulnaria ulna* (Nitzsch) Compère is the most frequent species which has been occurred in 12 out of 15 compared studies. Following this species in frequency is *Navicula cryptotenella* Lange Bertalot, *Gomphonema acuminatum* Ehrenberg, and *Nitzschia palea* (Kützing) W Smith, which were common in 11 studies. So, it can be concluded that these species are cosmopolitan and probably they can be seen in the normal environment of whole the world.

Some taxa were only reported from Iran's rivers, but not present in other compared regions, such as *Nitzschia subtilis* (Kützing) Grunow, *N. oligotraphenta* Lange Bertalot, *A. minutissima* W. Smith. *Cymbella compacta* Østrup, *C. diversistigmata* Krammer, *Gomphonema venusta* Passy, *Navicula notha* Wallace. So, they may be, found in special geographical regions. The other objective was to compare the flora of Taleghan River with other studies in Iran and the other 15 areas in the world (Table 2). The highest and the lowest similarity was between Africa's rivers (66%) and Serbia's diatoms (3%) respectively.

Medlin & Kaczmarzka and Medlin have classified the Bacillariophyta to three classes Coscinodiscophyceae, Mediophyceae, and Bacillariophyceae which it is supported by

the molecular analysis, however, we have used the Guiry & Guiry diatoms classification [44-46] (Figure 4, Table 3). Probably the high diversity of the Taleghan River can be related to the presence of 10 mines in the upstream which release the inorganic elements.

The assembly of ecosystems and species diversity is affected by anthropogenic activities such as destroying habitats, organic, and inorganic pollution.

Figure 4: Comparison between taxa similarity between 15 reigns in the world and Taleghan River and Taleghan Dam. Notes: S.A stand for South Africa; N.U.S: Northwestern United States; S.R: Southern of the Russian; A.F.I: Algal flora Iran; A.F.Ir: Algal flora Iraq; K.R.I: Karaj River in Iran; B.A.I: Balikhli River, Northwest Iran; E.C.R: Elbsandsteingebirge Czech Republic; C.R.C: Cali River Colombia; T.M.S.M: tropical mountain streams of Mexico; V.E: Valenciana España; N.L.I: Neure Lake Iran; P.S.B: Paraná state Brazil; S.B: southeastern Brazil and, S.D.F: Serbian diatom flora. Flora of South Africa and the USA are the most similar and the flora of Serbian diatom is the least similar with Taleghan River.

Conclusion

Based on the performed comparison, the *Ulnaria ulna*, *Navicula cryptotenella*, *Gomphonema acuminatum* and *Nitzschia palea* was the cosmopolitan species and *Achnanthisdium standeri*, *Frustulia tugelae*, *Nitzschia acula*, and some other species were rare taxon. Sixty-four species and two genera were new records for diatoms flora of Iran and for Asia the species *Cymbella pernodensis*, *Cymbella novazeelandiana*, and *Achnanthisdium druartii* were new recorded. According to the comparison of Taleghan diatom flora with 15 other environments, it can be concluded that the flora of Africa and the USA are the most similar and the flora of Serbia is the least similar to the Taleghan River. Also, the rare and cosmopolitan species was visible in Table 2.

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