Diatom Diversity in The Spring and Spring-fed River of Tizab Region (Central Alborz), Iran

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Received: 2019-07-03 Revised and accepted: 2019-10-15

Abstract

Diatoms are the most diverse algae in aquatic ecosystems and springs are valuable as the biodiversity conservative habit and a crucial source of drinking water for mankind. Therefore, study of springs' algal flora biodiversity leads us to know more about conservation process. In this research, the diatom biodiversity of Tizab Spring and the spring-fed river was studied in summer and autumn 2017 for the first time. Thirty-three species were identified from which two species (*Achnanthidium pyrenicum* (Hustedt) H. Kobayasi and *Caloneis aerophila* W. Bock) are new records for diatom flora of Iran. The data revealed the flora is much similar to Karaj River flora. This similarity can be due to close geographical locations, as both rivers are located in the Central Alborz region. The distribution pattern of species was studied in Iran based on present references on Iranian aquatic ecosystems. This study presented that two-third of diatom species had a widespread distribution. Iranian flora data in comparison with European and American database showed that most species are the elements of the northern hemisphere. Diatom biodiversity studies in Central Alborz region is in its first steps. Therefore, much research is needed to reveal the diatom biodiversity and the potentiality of new species in this region.

Keywords: Central Alborz, Diatom, Distribution, Tizab Spring.

Introduction

Iran is a vast country (1.6 million km^2) possessing two mountainous ranges, Alborz and Zagros which serve as the origin of 350 mineral springs (Ghafouri, 2003). Mineral springs are freshwater ecosystems and ecologically valuable source of biodiversity and endemism, moreover supply of drinking water and therapeutic properties (Cantonati, 2012, Ghafouri, 2003, Lai et al., 2019).

Despite the importance and usefulness of springs, there is not efficient data about biota of springs in Iran especially diatoms. Studies on diatom assemblages in springs are limited to Wasylik (1975), Compere (1981) and Zarei-Darki (2011b). Moreover, the diatom study of lotic and lentic ecosystems in Iran is also recieved little attention as a few ref-

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erences are already present (Hirano, 1973; Moghadam, 1975; Synder et al., 2001; Nejadsattari, 2005; Jamaloo et al., 2006; Atazadeh et al., 2007; Witkowski et al., 2007; Shariatmadari et al., 2007; Zarei-Darki, 2009a; Zarei-Darki, 2009b; Khosravi-Rineh et al., 2011; Masoudi et al., 2011; Soltanpour Gargari et al., 2011; Shams et al., 2012; Cheraghpour et al., 2013; Kheiri et al., 2013; Zarei-Darki, 2011a; Zarei-Darki 2011b; Kheiri et al., 2018a; Kheiri et al., 2018b; Panahy Mirzahasanlou et al., 2018; Kheiri, 2019). Therefore, database about the diatom diversity in springs and in larger scale, aquatic ecosystems of Iran is limited.

The Tizab Spring is one of the main springs of Tizab valley located in the Central Alborz region. This spring is known for its healing properties for gastrointestinal and skin diseases. The spring is also the origin of Tizab, one of the tributaries of Damavand which is used for agriculture in Damavand region (Amidi et al., 2013). Based on lithological data from the geological map of Damavand region (1:100000, Jamshidi et al., 1997), Tizab area is composed of green tuff and andesitic, basaltic rocks.

There is no data previously on diatom diversity of springs in this region. The objective of this research was to reveal the diatom assemblage of the spring and river of Tizab and study the distribution of diatoms.

Materials and Methods

Location and description of the sampled spring and the spring-fed river

The Tizab Spring is located in the valley of Tizab, two kilometers far from the city of Damavand, in Central Alborz mountainous area. The spring, turns into the Tizab River and flows through the Tizab valley and continues its path along the gardens of Damavand region, irrigating them and terminates into the Damavand River (Amidi et al., 2013). People in this area also use spring for therapeutic purposes.

Diatom Analysis

Eight samples were collected from two stations, station 1: the spring (35° 45′45.0″N, 52°04 56′.9″E) with the elevation of 2331m and station 2: the spring-fed river (35°45′08.3″N, 52°05′10.6″E) with the elevation of 2256m during September and October 2017 (Figure 1). Temperature was measured in situ and water samples were transported to the laboratory for further analysis. The epilithic diatoms were brushed from the surface of the submerged stones. Samples were boiled with H_2O_2 and HCl to remove the organic material. After repeated washing with distilled water, the material was air-dried on cover slips and mounted in Naphrax. Light microscope observations were conducted using an Olympus BX53. Micrographs were taken with an Olympus DP72 camera. Diatoms were identified according to Krammer and Lange-Bertalot (1986–1991b), Lange-Bertalot and Krammer (1989), Krammer (1997a, b), Krammer (2003), Lange-Bertalot (2001), Lange-Bertalot et al. (2003), Levkov (2009), Hofmann et al. (2011) and Van de Vijver et al. (2011). The size (length and breadth) of species was measured using Image J software (Schneider

et al., 2012). Temperature was measured in situ and water samples were transported to the laboratory for further analysis, with results summarized in Table 1.

Results

Totally 33 species belonging to 15 genera were identified based on the observation of benthic diatom samples in Tizab Spring and River. Among the species, *Achnanthidium pyrenicum* (Hustedt) H.Kobayasi and *Caloneis aerophila* W.Bock are new records. One taxon was centric. Pennate diatoms included one araphid, six monoraphid and 25

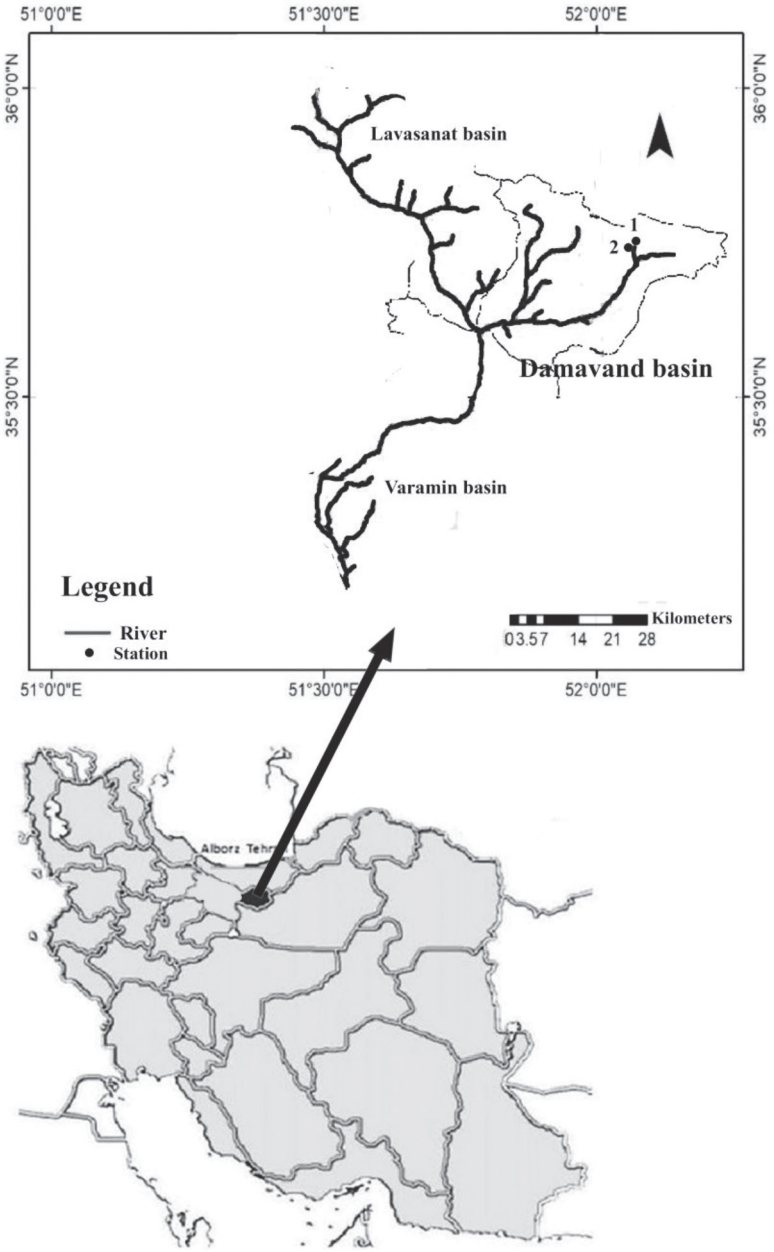


Fig. 1. Map of sampling sites.

biraphid species. Most species belong to *Nitzschia* (six species). *Navicula, Gomphonema, Achnanthidium* and *Encyonopsis* with three species were the most diverse genera. The new record species are marked by an asterisk.

The physicochemical parameters presented the pH range of 6.7-6.9 for the Tizab spring that was neutral and the pH of 7.5-7.7 for the Tizab River which was slightly alkaline. Therefore, the range of pH fluctuates slightly as the water flows down from the spring site to the river site in both sampling months.

Two sites based on chemicals concentration of calcium, magnesium, nitrate and sulfate did not show much differences. However, the concentration of sodium, chloride and potassium decreased slightly along the spring and the river site adjacent to the spring. Electric conductivity also reduced from 0.6 dS/m to 0.3 dS/m in spring site toward the river.

Regarding the sampling months, chloride concentration reduced greatly in October at the sampling sites. There was also a slight reduction in the concentration of the magnesium and sodium and a slight rise in the potassium content in October comparing with the content in September (Table 1).

Description of the taxa

**Achnanthidium pyrenicum* (Hustedt) H. Kobayasi, Fig. 23

Ref: Hoffman et al. 2011 (p.85, pl: 22, 62-70).

Dimension: 18.13µm long, 3.88 µm wide, 20 striae in 10 µm.

Distribution in Iran: This taxon is a new record for diatom flora of Iran.

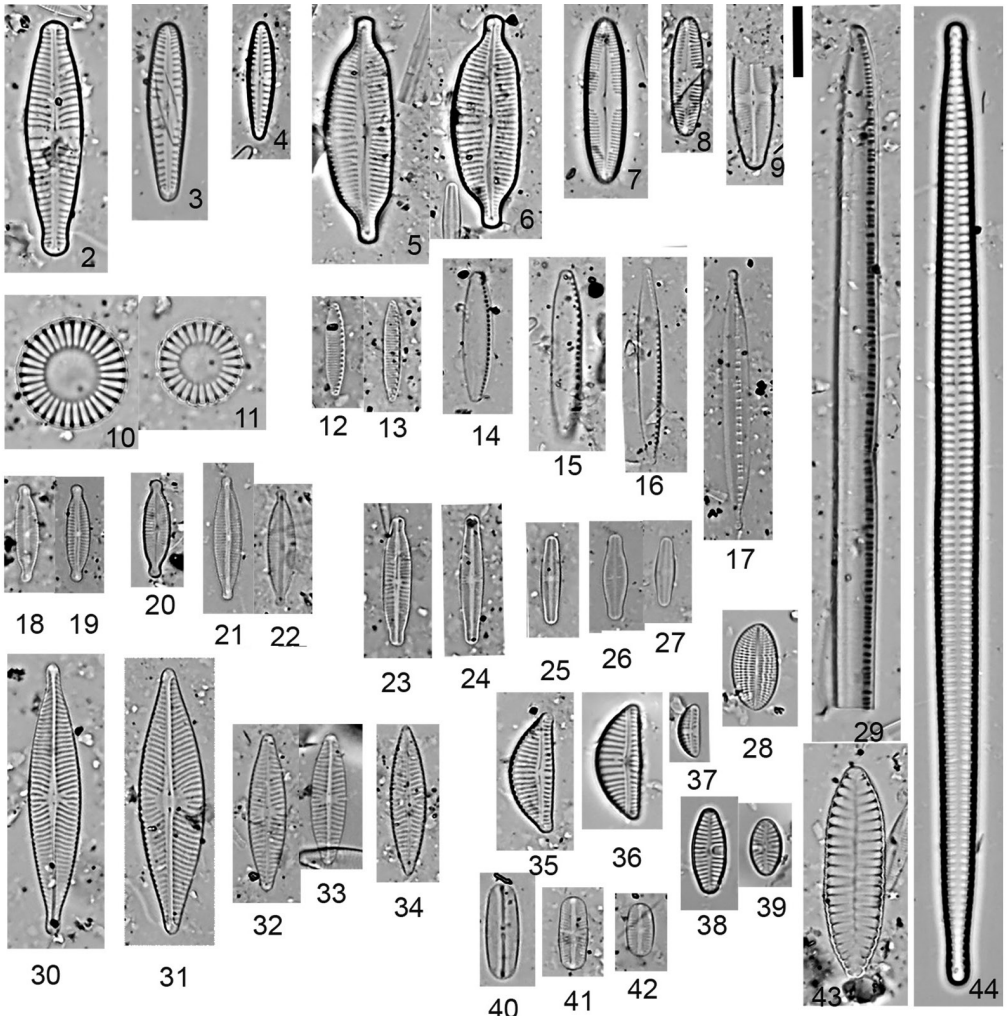
Achnanthidium lineare W. Smith, Fig. 25

Ref: Van de Vijver et al., 2011.

Dimensions: 9.36 µm long, 2.10 µm wide, striae are not visible in LM.

Table 1. Physical and chemical parameters recorded from the Tizab spring and river in September and Octobor 2017.

	September		October	
	Station			
Parameter	1	2	1	2
Temperature (°C)	14	15	13	15
pH	6.9	7.5	6.7	7.7
EC (dS/m)	0.6	0.3	0.6	0.3
Ca^{+2} (mg/L)	0	0	0	0
Mg^{+2} (mg/L)	14	14.6	11.6	8.8
Na^{+} (mg/L)	7.1	4.3	5.6	4.8
K^{+} (mg/L)	1.9	1.2	2.2	1.3
NO_3^{-} (mg/L)	2.1	2.1	1.5	1.1
SO_4^{-2} (mg/L)	48.4	50.5	54.7	52.6
Cl^{-} (mg/L)	150.9	133.1	8.9	26.6



Figs 2-44. Light micrograph of diatom species. **Fig. 2.** *Gomphonema micropus.* **Fig. 3.** *Gomphonema lateripunctatum.* **Fig. 4.** *Gomphonema pumilum* var. *rigidum.* **Fig. 5-6.** *Cymbopleura amphicephala.* **Figs. 7-8.** *Caloneis aerophila.* **Fig. 9.** *Staurophora tackei.* **Figs. 10-11.** *Cyclotella meneghiniana.* **Figs. 12-13.** *Nitzschia frustulum.* **Fig. 14**. *Nitzschia pusilla.* **Fig. 15** *Nitzschia communis.* **Fig. 16.** *Nitzschia palea.* **Fig. 17**. *Nitzschia dissipata* var. *media.* **Figs. 18-19**. *Encyonopsis minuta.* **Fig. 20.** *Encyonopsis microcephala.* **Figs. 21-22.** *Encyonopsis subminuta*. **Fig. 23.** *Achnanthidium pyrenicum*. **Figs. 24.** *Achnanthidium minutissimum.* **Fig. 25.** *Achnanthidium lineare.* **Figs. 26-27.** *Achnanthidium* cf. *minutissimum* var. *jackii.* **Fig. 28.** *Cocconeis placentula* var. *euglypta.* **Fig. 29.** *Nitzschia linearis.* **Figs. 30-31.** *Navicula capitatoradiata.* **Figs. 32-33.** *Navicula veneta.* **Fig. 34.** *Navicula cryptotenella.* **Fig. 35.** *Encyonema ventricosum.* **Fig. 36.** *Encyonema Lange-Bertalotii* morphotype 2. **Fig. 37.** *Amphora pediculus.* **Figs. 38-39.** *Planothidium frequentissimum.* **Fig. 40.** *Fallacia subhamulata.* **Figs. 41-42.** *Sellaphora stroemii.* **Fig. 42.** *Achnanthidium* sp. **43.** *Surirella angusta.* **Fig. 44.** *Ulnaria ulna*. Scale bar: 10 μm.

Distribution in Iran: Compere, 1981; Jamaloo et al., 2006; Zarei-Darki, 2011b

Achnanthidium cf. *minutissimum* var. *jackii* (Rabenhorst) Lange-Bertalot, Figs 26-27

Ref: Hoffman et al., 2011 (p. 84, pl. 23: 22-29).

Dimension: 9.54-12.59 µm long, 2.79-3.33 µm wide, striae are not visible in LM.

Distribution in Iran: This taxon is only recorded from northern Iran (Soltanpour-Gargari et al., 2011).

Achnanthidium minutissimum (Kützing) Czarnecki, Fig. 24

Ref: Hoffman et al. 2011 (p.83, pl. 23:15-21).

Dimension: 17.65 µm long, 3.21 µm wide, striae are not visible in LM.

Distribution in Iran: This taxon is widespread in Iran (Jamaloo et al., 2006; Moghadam, 1975; Witkowski et al., 2007; Compere, 1981; Kheiri et al., 2018a; Wasylik, 1975; Shariatmadari et al., 2007; Zarei-Darki, 2011b; Khosravi-Rineh et al., 2011).

Amphora pedicus (Kützing) Grunow in A.W.F. Schmidt, Fig. 37

Ref: Krammer and Lange-Bertalot 1986 (p.346, pl. 150: 8-13); Levkov 2009 (p. 101, pl. 55: 31-34, 78: 40-47).

Dimension: 7.49 µm long, 2.82 µm wide, 16 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Moghadam, 1975; Soltanpour-Gargari et al., 2011; Atazadeh et al., 2007; Synder et al., 2001; Witkowski et al., 2007; Nejadsattari, 2005; Compere, 1981; Panahy-Mirzahasanlou et al., 2018; Kheiri et al., 2018a; Zarei-Darki, 2011b).

**Caloneis aerophila* W.Bock, Figs 7-8

Ref: Hoffman et al. 2011 (p.115, pl.67: 20-22)

Dimension: 16.48-22.69 µm long, 4.26-5.10 µm wide, 10 striae in 10 µm.

This taxon is a new record for diatom flora of Iran.

Cocconeis placentula var. *euglypta* (Ehrenberg) Grunow, Fig. 28

Ref: Krammer and Lange-Bertalot 1991b (p.86, pl. 53: 1-19)

Dimension: 6.94 µm long, 2.63 µm wide, 26 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran. (Moghadam, 1975;Wasylik, 1975; Soltanpour-Gargari et al., 2011; Compere, 1981; Nejadsattari, 2005; Zarei-Darki, 2011b).

Cyclotella meneghiniana Kützing, Figs 10-11

Ref: Krammer and Lange-Bertalot 1991a p.44, pl. 44:1-10

Dimension: 11.81-15.19 µm in diameter, 12-14 costae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Moghadam, 1975; Soltanpour-Gargari et al., 2011; Atazadeh et al., 2007; Witkowski-et al., 2007; Shams et al., 2012; Nejadsattari, 2005; Cheraghpour et al., 2013; Zarei-Darki, 2009a; Compere, 1981; Panahy-Mirzahasanlou et al., 2018; Shariatmadari et al., 2007; Zarei-Darki, 2011b).

Cymbopleura amphicephala (Nageli) Krammer, Figs 5-6

Ref: Krammer 2003 (p. 70, pl. 91: 1-18, 93:2-8)

Dimension: 29.53-31.48 µm long, 9.25-9.90 µm wide, 14-16 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Moghadam, 1975; Synder et al., 2001; Witkowski et al., 2007; Zarei-Darki, 2011a;

Kheiri et al., 2018a; Kheiri et al., 2018b; Hirano, 1973; Zarei-Darki, 2011b).

Encyonema lange-bertalotii Krammer morphotype 2, Fig. 36

Ref: Krammer 1997 (p. 96, pl. 6: 1-4)

Dimension: 16 µm long, 6.38 µm wide, 14-16 striae in 10 µm.

Distribution in Iran: This taxon is only recorded from northern Iran (Kheiri et al., 2018a).

Encyonema ventricosum (C.Agardh) Grunow, Fig. 35

Ref: Krammer 1997a (p. 98, pl. 6: 8-13)

Dimension: 16.45 µm long, 5.98 µm wide, 14 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Moghadam, 1975; Witkowski et al., 2007; Compere, 1981; Kheiri et al., 2018a; Zarei-Darki, 2011b).

Encyonopsis minuta Krammer and Reichardt, Figs 18-19.

Ref: Krammer (1997b) (p. 95-pl. 143a: 1-29).

Dimension: 13.31-13.76 µm long, 3.25-3.28 µm wide, 28 Striae in 10 µm.

Distribution in Iran: This taxon is only recorded from northern Iran (Kheiri et al., 2018a).

Encyonopsis microcephala (Grunow) Krammer, Fig. 20.

Ref: Krammer 1997b (p. 91, pl. 143: 1, 4, 5, 8-26).

Dimension: 13.51 µm long, 3.57 µm wide, 26 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Moghadam, 1975; Witkowski et al., 2007; Compere, 1981; Kheiri et al., 2018a; Zarei-Darki, 2011b).

Encyonopsis subminuta Krammer and Reichardt, Figs 21-22.

Ref: Krammer 1997b (p. 96-pl. 144:1-11, 16, 17)

Dimension: 15.66-17.32 µm long, 3.44-4.06 µm wide, 25-28 striae in 10 µm.

Distribution in Iran: This taxon is distributed at western Iran (Witkowski et al., 2007), northern Iran (Kheiri et al., 2018a).

Fallacia subhamulata (Grunow) D.G. Mann, Fig. 40

Ref: Krammer and Lange-Bertalot 1986 (p. 199-pl. 66: 32-34)

Dimension: 13.52 µm long, 4.43 µm wide, striae are not visible in LM.

Distribution in Iran: This taxon is only recorded from northern Iran (Kheiri et al., 2018a).

Gomphonema micropus Kützing

Ref: Hofmann et al., 2011 (p. 305, pl. 98: 21-25)

Dimension: 32.41 µm long, 7.78 µm wide, 11striae in 10 µm.

Distribution in Iran: This taxon is distributed at central Iran (Zarei-Darki, 2011a), northern Iran (Kheiri et al., 2018a) and western Iran ((Kheiri et al., 2018b).

Gomphonema lateripunctatum Reichardt & Lange-Bertalot, Fig. 3

Ref: Hofmann et al., 2011 (p. 305, pl. 95: 25-30)

Dimension: 24.82 µm long, 5.37µm wide, 15 striae in 10 µm.

Distribution in Iran: This taxon is only distributed at western Iran (Witkowski et al., 2007).

Gomphonema pumilum var. *rigidum Reichardt* and Lange-Bertalot, Fig. 4

Ref: Hofmann et al., 2011 (p. 315, pl. 97:15-20)

Dimension: 16.20 µm long, 3.80 µm wide,

11striae in 10 µm.

Distribution in Iran: This taxon is only recorded from northern Iran (Kheiri et al. 2018a).

Navicula capitatoradiata Germain, Figs 30-31

Ref: Krammer and Lange-Bertalot, 1986 (p.105, pl. 32: 12-15), Lange-Bertalot, 2001 (p. 22, pl. 29: 15-20)

Dimension: 35.82-37.59 µm long, 7.03-7.14 µm wide, 14 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Soltanpour-Gargari et al., 2011; Witkowski et al., 2007; Compere, 1981; Kheiri et al., 2018a; Kheiri et al., 2018b).

Navicula cryptotenella Lange-Bertalot, Fig. 34

Ref: Krammer and Lange-Bertalot 1986 (p.106, pl. 33: 9-11); Lange-Bertalot 2001 (p. 28, pl. 26: 17-32, 27: 19-22)

Dimension: 20.88 µm long; 4.88 µm wide; 14 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Soltanpour-Gargari et al., 2011; Witkowski et al., 2007; Shams et al., 2012; Zarei-Darki, 2011a; Kheiri et al., 2018a; Zarei-Darki, 2011b).

Navicula veneta Kutzing, Figs. 32-33

Ref: Krammer and Lange-Bertalot 1986 (p.104, pl, 32: 1-4); Lange-Bertalot 2001 (p. 78-pl. 14: 23-30).

Dimension: 18.99-22.03 µm long; 4.91-5.16 µm wide; 14-15 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Witkowskiet al., 2007; Shams et al., 2012; Cheraghpour et al., 2013; Zarei-Darki, 2011a; Compere, 1981; Kheiri et al., 2018a; Shariatmadari et al., 2007; Zarei-Darki, 2011b).

Nitzschia communis Rabenhorst, Fig. 15

Ref. Krammer and Lange-Bertalot 1991 (p. 110, pl. 79:1-6), Hofmann et al., 2011 (p. 439, pl. 112: 1-5).

Dimension: 18.02 µm long, 3.95 µm wide, 14 fibulae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Compere, 1981; Shariatmadari et al., 2007; Zarei-Darki, 2011b).

Nitzschia dissipata var. *media* (Hantzsch) Grunow, Fig.17

Ref: Krammer and Lange-Bertalot, 1991 (p. 19, pl. 11: 8-14); Hofmann et al., 2011 (p. 441: 14-18).

Dimension: 36.30 µm, long: 3.61 µm, wide: 9 fibulae in 10 µm.

Distribution in Iran: This taxon is distributed at northern Iran (Soltanpour-Gargari et al., 2011; Kheiri et al., 2018a).

Nitzschia frustulum (Kutzing) Grunow, Figs. 12-13.

Ref: Krammer and Lange-Bertalot, 1988 (p. 94, pl. 68: 1-8).

Dimension: 13.95-14.20 µm long, 2.47-2.72 µm wide, 26 striae and 11-13 fibulae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Moghadam, 1975; Soltanpour Gargari et al., 2011; Shams et al., 2012; Zarei-Darki, 2009; Compere, 1981; Panahy-Mirzahasanlou et al., 2018; Kheiri et al., 2018a; Shariatmadari et al., 2007; Zarei-Darki, 2011b).

Nitzschia linearis (Agardh) W. Smith, Fig. 29

Ref: Krammer and Lange-Bertalot, 1988 (p.69, pl. 55: 1-4).

Dimension: 121.1 µm long; 5.56 µm wide, 11 fibulae in 10 µm.

Distribution in Iran: This taxon is widespread

in Iran (Jamaloo et al., 2006; Moghadam, 1975; Witkowski et al., 2007; Zarei-Darki, 2011a; Panahy-Mirzahasanlou et al., 2018; Kheiri et al., 2018a; Kheiri et al., 2018b; Hirano 1973; Wasylik, 1975; Zarei-Darki, 2011b)

Nitzschia palea (Kützing) W.Smith, Fig. 16

Ref. Krammer and Lange-Bertalot, 1991 (p. 85, pl. 59: 1-10); Hofmann et al., 2011 (p. 454, pl. 111: 1-9).

Dimension: 27.16 µm, long: 2.96 µm, wide: 14 fibulae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Moghadam, 1975; Soltanpour-Gargari et al., 2011; Shams et al., 2012; Nejadsattari, 2005; Cheraghpour et al., 2013; Masoudi et al., 2011; Compere, 1981; Panahy-Mirzahasanlou et al., 2018; Hirano, 1973; Shariatmadari et al., 2007; Zarei-Darki, 2011b).

Nitzschia pusilla Grunow, Fig. 14

Ref: Hofmann et al., 2011 (p. 457, pl. 112: 10-15).

Dimension: 22.96 µm long, 3.71 µm wide, 12 fibulae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Shams et al., 2012; Compere, 1981; Zarei-Darki, 2011b).

Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot Figs. 38-39

Ref: Hofmann et al., 2011 (p. 508, pl. 24: 29-35).

Dimension: 4.33-12.06 µm long, 4.33-4.74µm wide, 14-16 striae in 10 µm.

Distribution in Iran: This taxon is distributed at northern Iran (Soltanpour-Gargari et al. 2011) and north-western Iran (Panahy-Mirzahasanlou et al., 2018).

Sellaphora stroemii (Hustedt) Kobayasi Figs41

Ref: Hofmann et al., 2011 (p.538, pl. 42: 17-21); Krammer and Lange-Bertalot, 1986 (p.194, pl. 69: 1-10).

Dimension: 14.32 µm long, 3.90 µm wide, 22 striae in 10 µm.

Distribution in Iran: This taxon is only recorded from the northern Iran (Kheiri et al., 2018a).

Staurophora tackei (Hustedt) Bahls, Fig. 9

Ref: Krammer and Lange-Bertalot 1986 (p.249, pl. 91: 12-13).

Dimension: 20 µm long, 5.56 µm wide, 22 striae in 10 µm.

Distribution in Iran: This taxon is distributed at north-western Iran (Panahy-Mirzahasanlou et al., 2018) and northern Iran (Kheiri et al., 2018a).

Surirella angusta Kützing, Fig. 43

Ref: Krammer and Lange-Bertalot 1988 (p. 187, pl. 133:6-13).

Dimension: 29.01 µm long, 7.90 µm wide, 8 fibulae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Jamaloo et al., 2006; Moghadam, 1975; Zarei-Darki, 2011a; Compere, 1981; Panahy-Mirzahasanlou et al., 2018; Kheiri et al., 2018a, Kheiri et al., 2018b; Hirano, 1973; Zarei-Darki, 2011b).

Ulnaria ulna (Nitzsch) Compère, Fig. 44

Ref: Krammer and Lange-Bertalot 1991a (p. 143-pl.122: 1-8).

Dimension: 134.16 µm long, 5.74 µm wide, 11 striae in 10 µm.

Distribution in Iran: This taxon is widespread in Iran (Jamaloo et al., 2006; Soltanpour-Gargari et al., 2011; Synder et al., 2001; Witkowski et al., 2007; Shams et al., 2012; Nejadsattari,

2005; Zarei-Darki, 2011a; Compere, 1981; Panahy-Mirzahasanlou et al., 2018; Kheiri et al., 2018a; Kheiri et al., 2018b).

Discussion

The comparison of the diatom flora of Tizab and the aquatic ecosystems revealed that the flora is the most similar to the Karaj River as the majority of the species (22 out of 33) in the studied sites are also found in the Karaj River (Kheiri et al., 2018a). *Planothidium frequentissimum, Nitzschia pusilla, Nitzschia palea, Nitzschia communis, Cyclotella meneghiniana, Achnanthidium pyreniacum, Achnanthidium* cf. *minutissimum* var. *jackii, Caloneis aerophila* were not observed in Karaj river.

Certain level of similarity among the Tizab River and the Karaj River can be attributed to the fact that geographical and climatic conditions of both rivers are identical and flowing in the southern slope of the Central Alborz mountains which are affected by semi arid dry climate (Noroozi et al., 2008). Comparing the distribution of the taxa in Iran based on the available references showed two species (*Achnanthidium pyrenicum* and *Caloneis aerophila*) as new records for diatom flora of Iran and most species as widespread. The species with limited distribution were *Achnanthidium* cf. *minutissimum* var. *jackii, Encyonema lange-bertalotii* morphotype 2, *Fallacia subhamulata, Gomphonema pumilum* var. *rigidum* and *Nitzschia dissipata* var. *media* which were distributed at northern provinces in Iran (Soltanpour-Gargari et al., 2011; Kheiri et al., 2018a). Species such as *Planothidium frequentissimum, Sellaphora stroemii* and *Staurophora tackei* were found in northern and north-western Iran (Panahy-Mirzahasanlou et al., 2018, Kheiri et al., 2018a). *Gomphonema lateripunctatum* was only distributed at western Iran (Witkowski et al., 2007). The remaining twenty species and near 2/3 of flora were found widespread throughout Iran (Hirano, 1973; Moghadam, 1975; Synder et al., 2001; Nejadsattari, 2005; Jamaloo et al., 2006; Atazadeh et al., 2007; Witkowski et al., 2007; Shariatmadari et al., 2007; Zarei-Darki, 2009a; Zarei-Darki, 2009b; Khosravi-Rineh et al., 2011; Masoudi et al., 2011; Soltanpour Gargari et al., 2011; Shams et al., 2012; Cheraghpour et al., 2013; Kheiri et al., 2013; Zarei-Darki, 2011a; Zarei-Darki, 2011b; Kheiri et al., 2018a; Kheiri et al., 2018b; Panahy-Mirzahasanlou et al., 2018; Kheiri, 2019).

Comaparison of the Tizab spring and associated river's diatoms distribution in the European and American databases revealed the species are cosmopolitan and widespread elements of northern hemisphere according to known references (Krammer and Lange-Bertalot, 1986–1991b; Lange-Bertalot and Krammer, 1989; Krammer, 1997a, b; Krammer 2003; Lange-Bertalot, 2001; Lange-Bertalot et al., 2003; Levkov, 2009; Hofmann et al., 2011).

The study of diatom flora in Central Alborz rivers and springs is in the infancy stage. Majority of taxonomic work should be performed to reveal the flora's attributes. Investigation of biodiversity in the Damavand River, as the main and permanent river of

the region is the aim of future work. Further investigation may lead to the identification of new records and endemic species.

Acknowledgement

This study was supported by the Research Institute of Forests and Rangelands (RIFR) (Grant No. 20909101960806). The author would like to thank Ms. Bita Siavash, the botanist at the RIFR for the assistance in sampling and the lab work, Ms. Leila Zenouzi, the senior expert at the Soil Science laboratory of the RIFR in the division of desert and her team for physicochemical analysis and Ms. Asieyeh Shamekhi, the graphic designer at the RIFR for preparing the map.

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