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RESEARCH ARTICLE

Bio-assessment of surface waters in the south-east of Gaziantep (Turkey) using diatom metrics

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Abstract – Diatom metrics can be used to identify the ecological status of water bodies due to their good responses to anthropogenic disturbances. Our study is aimed to use diatom metrics developed from different ecoregions for assessing the ecological status of 11 surface waters in the south-east of the Gaziantep catchment (Turkey). Ecological characterizations of the sampling stations were introduced by Trophic Index Turkey (TIT), Trophic Index (TI), and Eutrophication and/or Pollution Index-Diatom (EPI-D). According to TIT and TI, Karkamış Reservoir had a good ecological condition while it had high ecological status based on EPI-D. This good ecological condition was approved by the presence of pollution sensitive species (*e.g.*, *Cymbella affinis*, *Encyonema minutum*, *E. silesiacum*, *Cymbopleura amphicephala*, and *Navicula radiosa*) and relatively low nutrients. Kayacık (TIT ranging 3.15–3.23) and Hancağız (TIT = 3.35) reservoirs had poor and bad ecological conditions, respectively. High nutrient, conductivity, and pollution-tolerant species (*e.g.*, *Nitzschia amphibia*, *N. palea*, *N. umbonata*, *N. linearis*, *N. phyllepta*, *Tryblionella calida*, and *Pinnularia brebissonii*) supported the ecological statuses of the Hancağız and Kayacık reservoirs. The first two axes of canonical correspondence analysis explained 0.943 of relationships between diatom species and explanatory variables. Explanatory variables, *e.g.*, calcium, conductivity, orthophosphate, nitrate, nitrite, sodium, pH, and sulfur, had strong impacts on the distribution of diatom assemblages among the sampling stations. TIT and TI separated ecological statuses of sampling stations in the south-east of the Gaziantep catchment, which correlated well with the evidence of water chemistry and response of diatom assemblages.

Keywords: Biological assessment / diatoms / Turkey / Trophic Index Turkey

1 Introduction

The biological assessments of surface waters are becoming more important to evaluate the deterioration of aquatic ecosystems and to accomplish environmental sustainability since the implementation of the European Water Framework Directive (WFD). This directive requires that European members have to enhance ecological qualities of deteriorated surface waters in order to achieve a good ecological status (European Commission, 2000; European Communities, 2009). Responses of phytobenthos, benthic invertebrates, phytoplankton, macrophytes, and fish have been addressed to assess the ecological status of aquatic ecosystems (European Communities, 2009).

Diatoms as ecological quality indicators have been widely used to evaluate changes in stream and river water quality due to their specific tolerances to nutrient gradients and a broad spectrum of ecological conditions (Rimet, 2012; Hamilton *et al.*, 2015; Lobo *et al.*, 2015, 2016; Çelekli *et al.*, 2018a). Biological metrics provide information to identify biological changes under various pollutants gradients. These metrics are mainly developed according to the ecological responses and preferences of each species at different stressor gradients. A variety of diatom indices [*e.g.*, Specific Pollution-Sensitive Index (SPI) in France (Cemagref, 1982), Trophic Index (TI) in Austria (Rott *et al.*, 1999), Eutrophication and/or Pollution Index-Diatom (EPI-D) in Italy (Dell'uomo, 2004), and Trophic Diatom Index (TDI) in United Kingdom (Kelly and Whitton, 1995)] are used to assess water quality. The ecoregion is a geographical region that is characterized by specific ecological patterns, including geology, climate, vegetation, wildlife, hydrology, and human factors (Omernik, 1995). Trophic weights and indicator values of diatom species vary among the diatom metrics because the ecological preferences of diatom species can fluctuate in different ecoregions. Therefore, Trophic Index Turkey (TIT) was developed by Çelekli *et al.* (2019) to evaluate the ecological status of the Anatolia and

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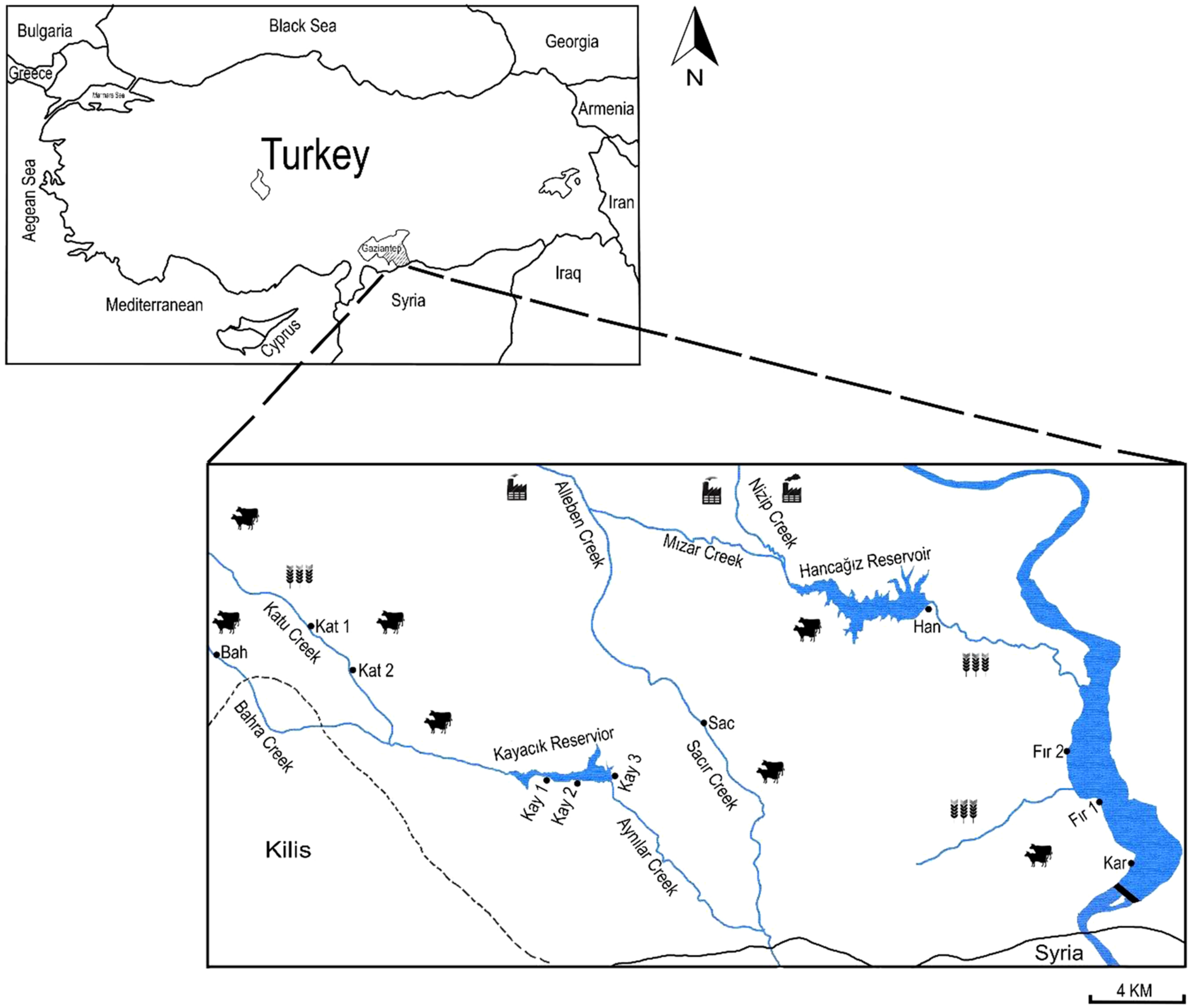

Fig. 1. Sampling stations in the south-east of the Gaziantep catchment. Full names and codes of stations are given in Table 1.

Mediterranean region. This index was tested and compared with other known diatom indices in the different water bodies in Turkey (Toudjani *et al.*, 2017; Çelekli *et al.*, 2018) and the results pinpointed the better suitability of TIT than other indices (*e.g.*, EPI-D and TI).

Studies dealing with the bioassessment of ecological conditions of surface waters based on the biotic indices have not been found in the south-east of the Gaziantep catchment except Çelekli *et al.* (2016). This showed that studies to identify and monitor affected freshwaters and quantify their ecological status for achieving a good condition toward a target state are required. This showed the need of studies to identify and monitor affected freshwaters and quantify their ecological status for achieving a good condition toward a target state. Thereby, the main aim of the present study is to use various diatom metrics developed from different ecoregions for assessing the ecological status of 11 aquatic ecosystems in the south-east of the Gaziantep catchment (Turkey). Based on this main aim, we also estimated the most important explanatory variable(s) drive the distribution of diatom composition and the ecological preferences of diatom species in this catchment.

2 Material and methods

A total of 11 surface waters in the south-east of the Gaziantep catchment in Turkey (Fig. 1) were sampled three times in October of 2013 and May and October of 2014. A few properties of the sampling stations are given in Table 1. This catchment includes three districts; Karkamış with three sampling stations, Oğuzeli with seven stations, and the Nizip region with one station. Unfortunately, the south-east of the Gaziantep catchment is poor in terms of the percentage of forest and so mostly includes agricultural lands. Agricultural lands are used especially for the production of pistachios, olives, and cereals and farming livestock in the ecoregion (Fig. 1). The ecosystems in the south-east of the Gaziantep

Table 1. Sampling stations in the south-east of the Gaziantep catchment. Fir1 and Fir2 are in pool-locations of Fırat River.

Code	Stations	Latitude (N)	Longitude (E)	Altitude (m a.s.l.)	Rainfall (mm)
Bah	Bahra Creek	36° 51′ 19″	37° 20′ 32″	728	463
Kat1	Katu Creek1	36° 50′ 39″	37° 27′ 18″	630	460
Kat2	Katu Creek2	36° 48′ 46″	37° 28′ 25″	608	454
Kay1	Kayacık Reservoir1	36° 48′ 36″	37° 31′ 07″	615	454
Kay2	Kayacık Reservoir2	36° 49′ 09″	37° 32′ 55″	614	454
Kay3	Kayacık Reservoir3	36° 49′ 34″	37° 34′ 01″	613	454
Sac	Sacır Creek	36° 50′ 47″	37° 37′ 12″	566	454
Kar	Karkamış Reservoir	36° 52′ 39″	38° 01′ 56″	340	333
Fir1	Fırat River1	36° 53′ 37″	38° 01′ 10″	343	333
Fir2	Fırat River2	36° 54′ 27″	38° 00′ 08″	344	333
Han	Hancağız Reservoir	36° 57′ 49″	37° 53′ 28″	390	464

catchment are subjected to various sources of pollution including industrial and domestic wastes, livestock farming, and agricultural activities. Bahra Creek is located at 728 m a.s.l, whereas Karkamış Reservoir built on Fırat River for power and flood prevention is located at 340 m a.s.l. The industrial and municipal wastewaters of Gaziantep are transferred to the Hancağız Reservoir *via* Nizip and Mızar creeks and then connect to the Fırat River (Fig. 1). The district of Oğuzeli is close to the city center of Gaziantep. Annual precipitation is about 454 mm in this catchment where are used for the production of pistachios, olives, and cereals. The Gaziantep Airport and Gaziantep central domestic wastewater treatment plant are in this district. Discharging of the effluent of this plant into Alleben Creek joined to the Sacır Creek. Thus, Sacır Creek had relatively high turbid waters due to the impact of industrial and domestic waste, livestock farming, and agricultural activities. Additionally, this studied catchment has a semi-arid climate and annual precipitation varied from approximately 333 mm in the Karkamış district to 464 mm in the Nizip region (obtained from the Directorate of Gaziantep Meteorology).

Geographical data of the sampling stations were obtained with a geographical positioning system. Before the diatoms sampling, water temperature (°C), electrical conductivity (EC, $\mu S\,cm^{-1}$), total dissolved solid (TDS, $mg\,L^{-1}$), pH, oxygen saturation (%), dissolved oxygen concentration ($mg\,L^{-1}$), and salinity (ppt) were measured using an oxygen–temperature meter (YSI professional plus) *in situ* and water samples were taken and protected in an icebox for the chemical analyses. Diatom samples were collected by brushing and scraping the upper surfaces of at least five stones taken from the riffle parts of running water ecosystems and the littoral zones of the reservoirs. Resulting suspensions were fixed with Lugol-glycerol solution in polyethylene bottles and stored in dark conditions until the laboratory analysis (European Committee for Standardization, 2004). In the laboratory, the suspension was oxidized with hydrogen peroxide and heated on a hotplate at 90 °C to remove organic acid material in samples (European Committee for Standardization, 2004). Clean diatom frustules were mounted on the Entellan (refraction index 1.49–1.52). Subsequently, at least 500 diatom valves were counted from each sample and then identified under a light microscope with a magnification of 1000× (Olympus BX53 attached a DP73 model) using the taxonomic books of Krammer and Lange-Bertalot (1991a, b, 1999a, b), Lange-Bertalot (2001), Krammer (2000, 2002), and Bey and Ector (2013).

Chemical analyses of the water samples were done by the standard methods of APHA (1989). Sartorius filtration process was applied to remove the particles from the water samples. Then, chemical analyses [*e.g.*, nitrate-nitrogen ($N\text{-}NO_3$), orthophosphate ($P\text{-}PO_4$), ammonium-nitrogen ($N\text{-}NH_4$), and nitrite-nitrogen ($N\text{-}NO_2$)] were performed using Ion Chromatography (Thermo Scientific Dionex ICS-5000, HPIC system). Heavy metals (*e.g.*, copper, chromium, nickel, lead, *etc.*) in the water samples were measured using ICP-OES – inductively coupled plasma-optical emission spectrometry (Perkin Elmer, Optima 2100 DV).

Diatom indices, *e.g.*, TI in Austria (Rott *et al.*, 1999), EPI-D in Italy (Dell'uomo, 2004), and TIT in Turkey (Çelekli *et al.*, 2019) were used to assess the ecological quality of sampling stations in the south-east of Gaziantep.

Duncan's multiple range test (SPSS version 15.0, SPSS Inc., Chicago, IL, USA) was used to compare physico-chemical variables among the sampling stations. The percentile analysis was carried out to determine the 25th, 50th, and 75th percentiles of $P\text{-}PO_4$ gradients. The Spearman correlation analysis was performed to assess the relationships between diatom indices and environmental factors. Detrended correspondence analysis was applied to the dataset of diatom assemblages to determine the gradient length for deciding to use which one of the linear or unimodal analysis. The lengths of gradient are larger than 3.0, which justified the performing of unimodal ordination techniques (ter Braak and Šmilauer, 2002). A canonical correspondence analysis (CCA) was conducted using CANOCO 4.5 software to evaluate the relationship between 10 environmental (explanatory) variables and 58 diatom species from the 11 sampling stations (ter Braak and Šmilauer, 2002). Physico-chemical variable data with exception of pH were $\log(x+1)$ transformed to reduce skewness and to obtain a normal distribution (ter Braak and Šmilauer, 2002). The Monte Carlo permutation test was performed to identify which environmental factor(s) was/were significantly affected the diatom composition. The optima and tolerance values of diatom species for environmental variables were calculated according to the weighted averaging regression model (Juggins and ter Braak, 1992).

3 Results

3.1 Physical and chemical variables

Environmental variables among the sampling stations changed during the study and the main results of descriptive analyses are given in Table 2. The lowest mean temperature value (12.2 °C) was found in Bahra Creek, whereas the highest mean temperature (21.2 °C) was recorded in the Hancağız Reservoir. Most of the sampling stations had relatively high water EC. The Hancağız Reservoir had the highest mean value of EC (1606 $\mu S\ cm^{-1}$) that is followed by Sacır Creek with 980 $\mu S\ cm^{-1}$ while the lowest mean value of EC was measured in the Karkamış Reservoir (347 $\mu S\ cm^{-1}$). The mean pH values ranged from 7.8 in Bahra Creek to 8.7 in Fırat River1 (Tab. 2).

Temporal and spatial changes in nutrient values were recorded from the sampling stations during the study time. High nutrient values were found in Sacır Creek (49.2 $\mu g\ L^{-1}$ P-PO_4, 64.00 $mg\ L^{-1}$ N-NO_3, 3.75 $mg\ L^{-1}$ N-NO_2, and 60.0 $mg\ L^{-1}$ SO_4), Hancağız Reservoir (86.6 $\mu g\ L^{-1}$ P-PO_4, 3.12 $mg\ L^{-1}$ N-NH_4, and 64.0 $mg\ L^{-1}$ SO_4), and Kayacık Reservoir's stations, whereas relatively low mean values were measured in the Karkamış Reservoir (30.0 $\mu g\ L^{-1}$ P-PO_4 and 2.57 $mg\ L^{-1}$ N-NO_3) and Fırat River1 (28.8 $\mu g\ L^{-1}$ P-PO_4 and 1.43 $mg\ L^{-1}$ N-NO_3). Sacır Creek showed relatively high mean calcium values ($p < 0.05$), followed by Hancağız Reservoir. The mean values of heavy metals in Sacır Creek (*e.g.*, 0.65 $mg\ L^{-1}$ Pb and 0.40 $mg\ L^{-1}$ Cu), Hancağız Reservoir (*e.g.*, 0.40 $mg\ L^{-1}$ Pb and 0.27 $mg\ L^{-1}$ Cu), and Kayacık Reservoir's stations (*e.g.*, 0.40 $mg\ L^{-1}$ Pb and 0.27 $mg\ L^{-1}$ Cu at Kay3) are relatively higher than other stations (Tab. 2).

3.2 Diatom composition–environment relationships

In total, 58 diatom species were identified (Tab. 3) from 11 sampling stations in the south-east of the Gaziantep catchment. *Cocconeis placentula*, *Cyclotella meneghiniana*, *Gomphonema parvulum*, *Navicula phyllepta*,*Nitzschia palea*, *N. umbonata*, and *Ulnaria ulna* species were frequently encountered during the study.

The first two axes ($\lambda1 = 0.744$ and $\lambda2 = 0.465$) of CCA explained 94.3% of the relationship between diatom assemblages and environmental factors with a relatively high percentage (27.4%) of the total variance of diatom species. Among environmental variables, calcium ($\lambda = 0.688$, $F = 4.426$, $p = 0.002$), EC ($\lambda = 0.647$, $F = 4.120$, $p = 0.002$), P-PO_4 ($\lambda = 0.616$, $F = 3.887$, $p = 0.002$), sodium ($\lambda = 0.562$, $F = 3.500$, $p = 0.002$), N-NO_2 ($\lambda = 0.512$, $F = 3.144$, $p = 0.010$), N-NO_3 ($\lambda = 0.425$, $F = 2.554$, $p = 0.010$), ORP ($\lambda = 0.392$, $F = 2.335$, $p = 0.002$), SO_4 ($\lambda = 0.383$, $F = 2.280$, $p = 0.004$), pH ($\lambda = 0.349$, $F = 2.057$, $p = 0.004$), and temperature ($\lambda = 0.326$, $F = 1.913$, $p = 0.020$) played significant roles in the distribution of the diatom assemblages among the sampling stations in the south-east of the Gaziantep catchment (Fig. 2). All environmental factors positively correlated with the first canonical axis except pH, while negatively correlated with the second canonical axis except calcium and oxidation–reduction potential (ORP) (Fig. 2).

Sampling stations were separated into four groups by CCA: Group A is pollution-tolerant diatom species closely related to Hancağız and Kayacık Reservoirs and high nutrients and EC, Group B is ORP-tolerant diatom species associated with Sacır Creek, Group C is pollution-sensitive diatom species associated with Karkamış Reservoir and Fırat River1 located at negative site of the first axis, and Group D is diatom species that prefer warm waters integrated Bahra Creek and Katu Creek 1 and 2 situated on the positive site of the second canonical axis of the ordination and are located at high altitude (Fig. 2). Stations of the first two groups were mainly characterized by the occurrence of pollution-tolerant diatom species, *e.g.*, *N. phyllepta*, *N. amphibia*, *N. palea*, *N. umbonata*,*N. linearis*, *Pinnularia brebissonii*, and *Tryblionella calida* were associated with the Hancağız and Kayacık Reservoir stations. However, pollution-sensitive diatom species, *e.g.*, *Cymbella affinis*, *Encyonema minutum*, *E. silesiacum*, *Cymbopleura amphicephala*, and *N. radiosa* corresponded to stations of the Group C.

Weighted average (WA) regression results indicated that each diatom assemblage had different optima for the used environmental factors (Tab. 4). Some of the species showed high EC and nutrient optima such as *N. palea* (1025 $\mu S\ cm^{-1}$ EC, 58.3 $\mu g\ L^{-1}$ P-PO_4, 19.4 $mg\ L^{-1}$ N-NO_3, and 60.5 $mg\ L^{-1}$ SO_4), *N. umbonata* (1101 $\mu S\ cm^{-1}$ EC, 55.6 $\mu g\ L^{-1}$ P-PO_4, 17.9 $mg\ L^{-1}$ N-NO_3, and 54.0 $mg\ L^{-1}$ SO_4), *N. linearis* (1338 $\mu S\ cm^{-1}$ EC, 59.2 $\mu g\ L^{-1}$ P-PO_4, 18.9 $mg\ L^{-1}$ N-NO_3, and 57.4 $mg\ L^{-1}$ SO_4), *P. brebissonii* (1399 $\mu S\ cm^{-1}$ EC, 62.4 $\mu g\ L^{-1}$ P-PO_4, 8.7 $mg\ L^{-1}$ N-NO_3, and 57.9 $mg\ L^{-1}$ SO_4), and *Craticula cuspidata* (1203 $\mu S\ cm^{-1}$ EC, 61.8 $\mu g\ L^{-1}$ P-PO_4, 48.3 $mg\ L^{-1}$ N-NO_3, and 64.5 $mg\ L^{-1}$ SO_4). On the other hand, a few diatom species such as *C. affinis* (26.7 $\mu g\ L^{-1}$), *C. amphicephala* (26.8 $\mu g\ L^{-1}$), *E. silesiacum* (26.7 $\mu g\ L^{-1}$ P-PO_4), *E. minutum* (26.5 $\mu g\ L^{-1}$), and *N. radiosa* (26.7 $\mu g\ L^{-1}$) associated with relatively low P-PO_4 optima. The percentile analysis indicated that 25th, 50th, and 75th of P-PO_4 were found as 28.7, 45.0, and 55.3 $\mu g\ L^{-1}$, respectively. The diatom species related to sampling stations of the Group A (Fig. 2) had higher P-PO_4 optima than the 75th percentile, whereas species associated with the Group C's optima were lower than the 25th percentile.

3.3 Ecological status

The results of TIT, TI, and EPI-D with the ecological status of sampling stations are given in Table 5. TIT values ranged from 1.71 at the Karkamış Reservoir with a good ecological condition to 3.35 at the Hancağız Reservoir with a bad condition. Similar to TIT, TI indicated a good ecological condition with a score of 1.46 for the Karkamış Reservoir and a poor condition for the Hancağız Reservoir with a score of 3.27. Kayacık Reservoir1 had the highest EPI-D value (2.75) that means it had a poor ecological condition, while the lowest score (0.99) was found at the Karkamış Reservoir with high ecological status. All diatom indices indicated that Kayacık Reservoir stations had poor ecological conditions. TI mainly showed similar results with the findings of TIT but different from EPI-D (for more see Tab. 5).

Spearman correlation analysis revealed that TIT, TI, and EPI-D showed significantly positive correlations with P-PO_4

Table 2. Mean ± standard deviation of physical and chemical variables at sampling stations. Full names and codes of stations are given in Table 1. Temp. – temperature, EC – electrical conductivity, TDS – total dissolved solid, DO – dissolved oxygen, NH_4 – ammonium, PO_4 – orthophosphate, SO_4 – sulfate, NO_2 – nitrite, NO_3 – nitrate, Cl – chloride, Na – sodium, Mg – magnesium, Ca – calcium, Ni – nickel, Cr – chromium, Pb – lead, Cu – copper, and n.d. – not detected.

		Bah	Kat1	Kat2	Kay1	Kay2	Kay3	Kar	Fir1	Fir2	Han	Sac
Temp.	°C	12.2 ± 2.3	13.1 ± 2.1	13.7 ± 1.9	19.1 ± 3.1	19.9 ± 2.6	20.0 ± 1.7	19.2 ± 5.3	19.6 ± 3.1	20.8 ± 3.6	21.2 ± 3.6	19.6 ± 1.6
EC	$\mu S\ cm^{-1}$	452 ± 43	412 ± 61	647 ± 198	790 ± 106	857 ± 41	857 ± 49	347 ± 18	356 ± 41	716 ± 377	1606 ± 336	980 ± 17
TDS	$mg\ L^{-1}$	387 ± 39	343 ± 66	560 ± 185	600 ± 36	618 ± 30	618 ± 34	252 ± 15	260 ± 17	498 ± 229	1120 ± 171	747 ± 63
Salinity	ppt	0.30 ± 0.03	0.25 ± 0.07	0.38 ± 0.06	0.47 ± 0.06	0.50 ± 0.02	0.50 ± 0.02	0.20 ± 0.002	0.20 ± 0.002	0.40 ± 0.20	0.87 ± 0.15	0.55 ± 0.07
DO	$mg\ L^{-1}$	6.9 ± 1.2	7.5 ± 1.8	6.3 ± 1.5	7.2 ± 1.8	9.2 ± 3.2	9.6 ± 4.3	8.7 ± 4.9	9.0 ± 3.6	6.2 ± 1.2	5.5 ± 2.6	5.1 ± 1.6
pH		7.8 ± 0.3	8.0 ± 0.4	8.1 ± 0.3	8.0 ± 0.5	8.2 ± 0.7	8.1 ± 1.0	8.4 ± 0.5	8.7 ± 0.6	8.3 ± 0.8	8.2 ± 0.7	7.9 ± 0.1
ORP	SHE	166 ± 18	158 ± 16	157 ± 13	145 ± 20	130 ± 22	139 ± 42	121 ± 20	108 ± 18	118 ± 6	133 ± 33	147 ± 13
NH_4	$mg\ L^{-1}$	0.04 ± 0.03	0.02 ± 0.02	1.09 ± 1.52	2.96 ± 4.58	3.86 ± 6.69	4.11 ± 7.04	0.19 ± 0.15	0.21 ± 0.27	0.09 ± 0.03	3.12 ± 2.51	2.91 ± 0.83
N-NO_2	$mg\ L^{-1}$	0.10 ± 0.08	0.05 ± 0.07	0.60 ± 0.85	5.98 ± 6.79	7.73 ± 8.72	8.60 ± 11.00	0.13 ± 0.06	0.01 ± 0.00	0.07 ± 0.06	0.13 ± 0.12	3.75 ± 1.48
N-NO_3	$mg\ L^{-1}$	6.60 ± 2.31	5.30 ± 1.98	3.80 ± 0.28	25.13 ± 23.97	31.97 ± 23.62	30.63 ± 23.59	2.57 ± 1.65	1.43 ± 0.70	9.97 ± 14.15	2.90 ± 1.85	64.00 ± 0.99
P-PO_4	µg L-1	30.2 ± 2.8	29.9 ± 1.98	43.8 ± 20.9	51.8 ± 7.8	48.4 ± 7.6	51.2 ± 4.8	30.0 ± 8.3	28.0 ± 3.3	27.8 ± 2.1	86.6 ± 29.2	49.2 ± 18.6
SO_4	$mg\ L^{-1}$	46.8 ± 17.6	29.0 ± 26.9	34.3 ± 34.0	58.4 ± 7.8	59.7 ± 9.8	60.0 ± 9.2	37.9 ± 1.6	38.6 ± 0.7	46.0 ± 6.4	64.0 ± 11.4	60.0 ± 5.4
Cl-	$mg\ L^{-1}$	19.0 ± 7.6	14.0 ± 8.6	22.6 ± 20.6	68.1 ± 20.9	81.4 ± 4.1	80.6 ± 2.4	22.7 ± 2.0	25.1 ± 7.9	108.4 ± 103.6	254.8 ± 108.1	99.1 ± 1.1
Na	$mg\ L^{-1}$	21.0 ± 8.4	14.2 ± 11.0	17.9 ± 16.1	61.6 ± 23.4	73.5 ± 5.8	73.0 ± 4.7	20.5 ± 2.1	18.7 ± 0.5	47.5 ± 31.8	220.1 ± 131.6	67.8 ± 3.5
F-	$mg\ L^{-1}$	0.20 ± 0.01	0.20 ± 0.01	0.25 ± 0.07	0.20 ± 0.08	0.17 ± 0.06	0.17 ± 0.06	0.10 ± 0.01	0.10 ± 0.01	0.33 ± 0.23	0.03 ± 0.06	0.30 ± 0.14
Mg	$mg\ L^{-1}$	18.7 ± 7.3	13.5 ± 7.8	18.5 ± 14.8	19.0 ± 6.8	15.0 ± 1.7	15.1 ± 1.8	14.8 ± 1.4	15.3 ± 1.4	29.8 ± 12.6	16.6 ± 1.2	15.0 ± 0.6
Ca	$mg\ L^{-1}$	79.0 ± 4.6	80.7 ± 1.8	90.5 ± 12.0	98.2 ± 7.0	96.3 ± 5.7	96.4 ± 5.5	43.8 ± 2.1	41.1 ± 3.5	67.3 ± 39.2	114.4 ± 12.4	134.5 ± 2.5
Hardness	$meq\ L^{-1}$	5.5 ± 0.6	5.2 ± 0.7	6.1 ± 1.8	6.5 ± 0.7	6.0 ± 0.3	6.0 ± 0.3	3.4 ± 0.1	3.3 ± 0.2	5.8 ± 2.8	7.1 ± 0.7	8.0 ± 0.2
Al	$mg\ L^{-1}$	nd	nd	0.02 ± 0.03	0.01 ± 0.02	0.04 ± 0.06	nd	nd	0.01 ± 0.01	0.01 ± 0.02	nd	0.23 ± 0.32
Ni	$mg\ L^{-1}$	0.40 ± 0.28	0.30 ± 0.14	0.15 ± 0.07	0.28 ± 0.29	0.27 ± 0.12	0.23 ± 0.12	0.13 ± 0.06	0.23 ± 0.23	0.07 ± 0.06	0.23 ± 0.15	0.20 ± 0.14
Cr	$mg\ L^{-1}$	0.20 ± 0.09	0.15 ± 0.07	0.10 ± 0.01	0.20 ± 0.14	0.17 ± 0.12	0.17 ± 0.06	0.07 ± 0.06	0.13 ± 0.15	0.07 ± 0.012	0.13 ± 0.12	0.15 ± 0.07
Pb	$mg\ L^{-1}$	0.01 ± 0.01	0.01 ± 0.01	0.010 ± 0.01	0.35 ± 0.52	0.37 ± 0.55	0.40 ± 0.53	0.37 ± 0.55	0.37 ± 0.55	0.37 ± 0.55	0.40 ± 0.61	0.65 ± 0.64
Cu	$mg\ L^{-1}$	0.04 ± 0.01	0.03 ± 0.01	0.02 ± 0.01	0.19 ± 0.19	0.23 ± 0.21	0.27 ± 0.25	0.20 ± 0.17	0.23 ± 0.21	0.20 ± 0.17	0.27 ± 0.15	0.40 ± 0.14

Bad ecological status – Hancağız Reservoir; poor ecological status – Kayacık Reservoir, Fırat River2, Sacır creek, and Katu Creek2; moderate ecological status – Bahra creek and Katu Creek1; and good ecological status – Karkamış Reservoir and Fırat River1.

Table 3. List of diatom species found in the present study.

Code	Species
aug	*Aulacoseira granulata* (Ehrenberg) Simonsen 1979
aum	*Aulacoseira muzzanensis* (F. Meister) Krammer 1991
cas	*Caloneis schumanniana* (Grunow) Cleve 1894
cop	*Cocconeis placentula* Ehrenberg 1838
cra	*Craticula ambigua* (Ehrenberg) D.G. Mann in Round, R.M. Crawford and D.G. Mann 1990
crc	*Craticula cuspidata* (Kutzing) D.G. Mann in Round, R.M. Crawford and D.G. Mann 1990
cyc	*Cymbella cymbiformis* C. Agardh 1830
cya	*Cymbella affinis* Kützing 1844
cyam	*Cymbopleura amphicephala* (Nägeli) Krammer 2003
cyi	*Cyclotella iris* Brun and Héribaud-Joseph in Héribaud-Joseph 1893
cym	*Cyclotella meneghiniana* Kützing 1844
enm	*Encyonema minutum* (Hilse) D.G. Mann in Round, R.M. Crawford and D.G. Mann 1990
ens	*Encyonema silesiacum* (Bleisch) D.G. Mann in Round, R.M. Crawford and D.G. Mann 1990
dek	*Denticula kuetzingii* Grunow 1862
dim	*Diploneis modica* Hustedt 1945
dio	*Diploneis oblongella* (Nägeli ex Kützing) Cleve-Euler 1922
dis	*Diploneis subovalis* Cleve 1894
div	*Diatoma vulgaris* Bory 1824
epa	*Epithemia argus* (Ehrenberg) Kützing 1844
epgo	*Epithemia gibba* (Ehrenberg) Kützing 1844
ulu	*Ulnaria ulna* (Nitzsch) Compère 2001
goa	*Gomphonema acuminatum* Ehrenberg 1832
goan	*Gomphonema angustum* C.Agardh 1831
goang	*Gomphonema angustatum* (Kützing) Rabenhorst 1864
gob	*Gomphonema vibrio* var. *bohemicum* (Reichelt and Fricke) R. Ross in Hartley 1986
goo	*Gomphonema olivaceum* (Hornemann) Brébisson 1838
gog	*Gomphonema gracile* Ehrenberg 1838
gom	*Gomphonema minutum* (C. Agardh) C. Agardh 1831
gop	*Gomphonema parvulum* (Kützing) Kützing 1849
got	*Gomphonema truncatum* Ehrenberg 1832
ict	*Iconella tenera* (W. Gregory) Ruck and Nakov in Ruck *et al.*, 2016

Table 3. (continued).

Code	Species
nac	*Navicula capitatoradiata* H. Germain 1981
nacr	*Navicula cryptocephala* Kützing 1844
nacry	*Navicula cryptotenella* Lange-Bertalot 1985
nam	*Navicula margalithii* Lange-Bertalot in Krammer and Lange-Bertalot 1985
nap	*Navicula phyllepta* Kützing 1844
napr	*Navicula protracta* Grunow 1880
nar	*Navicula radiosa* Kützing 1884
nare	*Navicula recens* (Lange-Bertalot) Lange-Bertalot in Krammer and Lange-Bertalot 1985
nat	*Navicula tripunctata* (O.F. Müller) Bory 1822
natr	*Navicula trivialis* Lange-Bertalot 1980
nav	*Navicula veneta* Kützing 1844
nia	*Nitzschia amphibia* Grunow 1862
trc	*Tryblionella calida* (Grunow) D.G. Mann in Round, R.M. Crawford and D.G. Mann 1990
nico	*Nitzschia commutata* Grunow 1880
nili	*Nitzschia linearis* W. Smith 1853
nip	*Nitzschia palea* (Kützing) W. Smith 1856
niu	*Nitzschia umbonata* (Ehrenberg) Lange-Bertalot 1978
pib	*Pinnularia brebissonii* (Kützing) Rabenhorst 1864
pim	*Pinnularia microstauron* (Ehrenberg) Cleve 1891
rha	*Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot 1980
epg	*Epithemia gibba* (Ehrenberg) Kützing 1844
sua	*Surirella angusta* Kützing 1844
sub	*Surirella brebissonii* Krammer and Lange-Bertalot 1987
sul	*Surirella librile* (Ehrenberg) Ehrenberg 1845
sum	*Surirella minuta* Brébisson ex Kützing 1849
suo	*Surirella ovalis* Brébisson 1838
sus	*Surirella subsalsa* W. Smith 1853

($r = 0.732$, 0.720, and 0.632) and EC ($r = 0.764$, 0.734, and 0.715) at cut-off level 0.01, respectively.

4 Discussion

Ecological characterizations of sampling stations were endorsed by performing TIT, TI, and EPI-D. TIT separated the sampling stations in the south-east of the Gaziantep catchment from bad to good ecological statuses. TIT and TI indicated that the Hancağız Reservoir had a bad ecological status and a poor

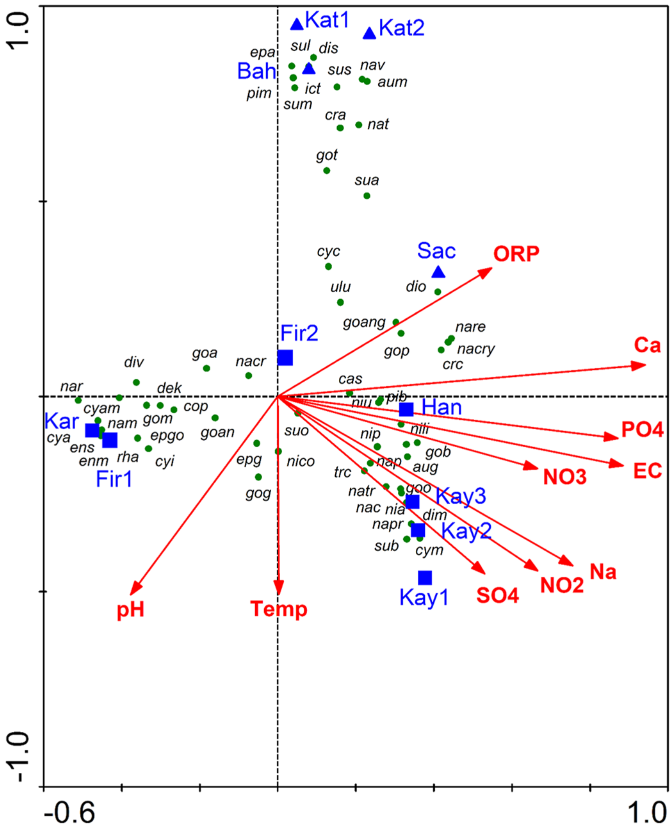

Fig. 2. CCA plot of diatom assemblages (circle) related to environmental (arrow) variables in the sampling stations (triangle-creeks and square-reservoirs). PO_4 – orthophosphate, SO_4 – sulfate, NO_3 – nitrate, NO_2 – nitrite, Na – sodium, EC – electrical conductivity, Ca – calcium, and ORP – oxidation-reduction potential. Full names and codes of stations and species are given in Tables 1 and 3, respectively.

ecological condition, respectively. Besides, all diatom indices indicated that Kayacık Reservoir stations had poor ecological statuses. The ecological status of Sacır Creek was characterized as a poor environmental condition by TIT and TI when it had a moderate ecological status according to EPI-D. Hancağız Reservoir and Sacır Creek were under the pressures of loading organic and inorganic nutrients from municipal and industrial waste, livestock farming, and agricultural land-use, whereas the Kayacık Reservoir was under the impacts of the discharge of domestic waste, livestock farming, and agricultural activities. Çelekli *et al.* (2016) also reported that Sacır Creek has high EC and nutrients. With regard to the Hancağız and Kayacık Reservoirs, deposition of nutrients and pollutants along the watersheds could be a consequence of the transferring of nutrients and metals from loading catchments *via* the drainage systems. Similar findings were also reported in some previous limno-ecological studies (Kibena *et al.*, 2014; Çelekli *et al.*, 2016). Additionally, the semi-arid climate in the south-east of the Gaziantep catchment causes excessive evaporation, resulting in the worsening of water quality of aquatic ecosystems. The Eastern Mediterranean is affected by climate change, associated with human affairs, which causes fluctuations in the water levels of freshwater bodies during the drought and flood seasons (Lelieveld *et al.*, 2012). Results showed that TI mainly showed similar results with the findings of TIT but it shows differentiation from EPI-D (Tab. 5).

Used diatom indices indicated good ecological conditions for Karkamış Reservoir and Fırat River1 and also Karkamış Reservoir had high ecological status due to the result of EPI-D. These stations were characterized by the pollution-sensitive diatom species (*e.g.*, *C. affinis*, *E. minutum*, *E. silesiacum*, and *C. amphicephala*) in agreement with previous limno-ecological studies (Van Dam *et al.*, 1994; Potapova *et al.*, 2004; Rimet *et al.*, 2004; Delgado *et al.*, 2012; Wang *et al.*, 2014; Çelekli *et al.*, 2019). Also, relatively low EC and nutrient contents were measured in the Karkamış Reservoir and it fed by a large water potential of the Fırat River.

Discharging organic and inorganic nutrients from waste is a major driver of deterioration in surface waters, leading not only to water quality impairments but also to biological community impairments (Stevenson *et al.*, 1996). The CCA could separate sampling stations into four main groups. Group A, the Hancağız Reservoir related to high nutrients especially P-PO_4 and high conductivity. Therefore, pollution-tolerant species such as *N. palea*, *N. umbonata*, *N. linearis*, and *P. brebissonii* (Fig. 2) are also associated with this group. A similar situation is also present for the Kayacık Reservoirs that was closely related to calcium, EC, sodium, and nutrients. Group B, Sacır Creek was associated with ORP and corresponded with pollution-tolerant species, *e.g.*, *G. parvulum*,*Gomphonema angustatum*, *Diploneis oblongella*, *N. cryptotenella*, and *N. recens*. In addition, high nutrient and conductivity and aforementioned pollution-tolerant taxa were also endorsed previously explained ecological statuses of Sacır Creek, Hancağız, and Kayacık Reservoirs. Furthermore, the WA indicated that aforementioned diatom species preferred high nutrients and EC values in the present study (Tab. 4). These diatom species had higher P-PO_4 optima than the 75th percentile of phosphate gradient that sound *tolerant taxa*. The occurrences of these diatom species in polluted ecosystems were previously reported from different region of the World, *e.g.*, the Eastern Highlands of Zimbabwe (Bere, 2016), the Ul River, a tributary of the Vouga River, in north-central Portugal (Resende *et al.*, 2010), the subtropical temperate Brazilian rivers (Lobo *et al.*, 2010), Mountain Rivers of the Segre basin of Catalonia (Goma *et al.*, 2005), the western Mediterranean river basin of Turkey (Toudjani *et al.*, 2017), and the Richmond River Catchment of Australia (Oeding and Taffs, 2017).

Group C, the Karkamış Reservoir and Fırat River1 closely corresponded to the pollution-sensitive diatom species, *e.g.*, *C. affinis*, *E. minutum*, *E. silesiacum*, *C. amphicephala*, and *N. radiosa*, which were located at the opposite sites of high nutrient, EC, and ORP (Fig. 2). Also, these species called as sensitive taxa preferred low P-PO4 optima than the 25th percentile. This finding corresponds to the previous limno-ecological studies (Gómez and Licursi 2001; Delgado *et al.*, 2012; Wang *et al.*, 2014; Rimet *et al.*, 2016; Marcel *et al.*, 2017; Çelekli *et al.*, 2018). Fırat River2 had a poor ecological condition and located at the center of CCA diagram (Fig. 2). This station was under pressures of loading organic and inorganic nutrients from livestock farming, agricultural land-use with manure, and fertilizers and characterized by the occurrence of a pollution-tolerant *N. cryptocephala* (Lobo *et al.*, 2010; Wang *et al.*, 2014; Çelekli *et al.*, 2019). Group D,

Table 4. The optimum and tolerance values of diatom species were determined by using weighted average regression. opt and tol indicate optima and tolerance, respectively. Codes of species are given in Table 3. RMSE is the root mean square error.

	Temp.		EC		P-PO_4		N-NO_3		N-NO_2		SO_4		Ca	
code	opt	tol	opt	tol	opt	tol	opt	opt	4.15	2.33	tol	tol	opt	tol
aug	15.8	2.8	772	231	47.9	11.1	5.6	88.2	0.33	0.34	16.2	11.9	88.2	16.2
aum	13.0	1.8	578	198	51.1	21.0	3.7	94.5	1.87	2.33	12.4	34.1	94.5	12.4
cas	18.5	2.8	810	231	53.5	11.1	5.7	90.1	0.76	2.67	16.2	11.9	90.1	16.2
cop	18.8	2.7	486	283	32.2	12.7	4.2	52.2	0.49	0.66	21.2	10.0	52.2	21.2
cra	14.4	5.9	626	303	41.0	16.3	8.8	91.0	2.71	2.25	16.7	6.6	91.0	16.7
crc	20.3	1.8	1203	470	61.8	20.3	48.3	131.3	0.07	0.07	7.5	9.4	131.3	7.5
cya	21.3	3.9	367	24	26.7	1.4	2.4	42.9	0.07	0.07	4.5	1.1	42.9	4.5
cyam	19.6	4.5	365	40	26.8	1.9	2.4	46.1	1.42	4.39	13.7	5.0	46.1	13.7
cyc	17.1	4.6	708	364	38.8	13.1	14.6	84.1	0.04	0.06	30.9	14.0	84.1	30.9
cyi	17.9	0.2	413	156	28.5	4.9	1.4	42.9	10.95	8.14	2.7	2.8	42.9	2.7
cym	19.5	2.0	942	269	54.9	11.2	30.5	100.6	0.38	0.92	9.6	9.0	100.6	9.6
dek	19.4	4.2	424	199	28.5	7.0	8.3	53.0	7.61	7.08	24.3	11.7	53.0	24.3
dim	20.2	2.8	853	45	47.5	6.4	39.5	98.2	3.00	1.48	5.5	9.0	98.2	5.5
dio	20.4	1.6	989	17	48.2	11.5	64.5	135.8	0.29	0.83	2.5	5.4	135.8	2.5
dis	14.4	1.8	427	198	35.0	21.0	3.9	85.0	0.06	0.03	12.4	34.1	85.0	12.4
div	24.5	1.0	379	19	26.6	0.4	2.5	41.6	0.06	0.08	2.7	0.5	41.6	2.7
enm	19.9	3.7	355	25	26.5	1.6	2.0	42.3	0.07	0.08	3.2	1.1	42.3	3.2
ens	20.5	3.7	362	23	26.7	1.5	2.2	42.6	0.07	0.06	3.1	0.9	42.6	3.1
epa	14.0	1.8	399	59	29.4	1.0	4.9	80.5	1.10	0.38	1.7	26.0	80.5	1.7
epg	18.3	1.1	649	27	35.5	2.0	1.7	44.3	0.24	0.85	0.7	1.7	44.3	0.7
epgo	17.7	1.6	391	137	27.8	6.5	2.2	45.7	0.19	0.59	11.1	3.7	45.7	11.1
goa	22.8	3.6	657	534	35.6	18.6	8.2	68.3	0.31	0.11	37.8	14.9	68.3	37.8
goan	18.8	0.8	576	159	33.2	5.9	2.5	45.0	0.54	1.51	1.0	2.2	45.0	1.0
goang	17.7	2.3	1225	397	71.6	15.7	2.2	100.6	1.40	0.43	12.1	9.0	100.6	12.1
gob	22.0	3.0	1704	286	81.9	6.7	1.8	117.8	0.41	0.33	10.3	13.1	117.8	10.3
gog	18.0	2.8	642	231	35.0	11.1	1.6	44.1	0.29	1.34	16.2	11.9	44.1	16.2
gom	14.8	4.6	389	486	27.6	23.6	4.8	50.2	2.58	2.33	39.8	14.6	50.2	39.8
goo	21.9	2.8	853	231	46.0	11.1	52.6	100.6	2.62	3.21	16.2	11.9	100.6	16.2
gop	18.9	3.4	953	351	54.6	14.9	30.7	110.3	0.54	0.48	23.7	10.7	110.3	23.7
got	15.0	4.6	638	90	47.6	15.1	3.4	76.7	0.11	0.06	32.6	10.6	76.7	32.6
ict	12.9	1.8	434	59	29.9	1.0	6.0	79.5	4.97	4.75	1.7	26.0	79.5	1.7
nac	19.3	2.5	836	41	48.3	5.5	23.5	94.1	1.05	0.46	5.9	7.3	94.1	5.9
nacr	21.7	3.1	726	328	35.2	5.4	8.8	62.7	3.25	2.16	37.0	6.7	62.7	37.0
nacry	19.9	1.8	1116	405	59.9	17.7	54.2	132.3	0.12	0.09	6.4	8.9	132.3	6.4
nam	19.8	4.7	358	35	25.8	1.3	2.6	43.3	3.96	5.53	3.1	1.5	43.3	3.1
nap	18.8	2.8	822	228	45.9	11.0	25.8	90.2	3.16	1.15	29.0	9.3	90.2	29.0
napr	20.1	5.0	835	73	43.7	4.9	33.1	95.7	0.11	0.08	8.7	2.3	95.7	8.7
nar	18.1	4.4	372	47	26.7	2.2	3.1	49.2	3.02	2.29	14.6	3.6	49.2	14.6
nare	20.0	1.9	1169	450	61.9	18.9	50.4	131.5	1.21	1.36	7.0	9.5	131.5	7.0
nat	15.8	4.1	642	316	43.2	15.4	22.0	103.2	4.18	4.33	28.0	30.7	103.2	28.0
natr	20.1	2.3	855	219	46.7	10.2	24.4	87.4	0.44	0.35	23.5	9.9	87.4	23.5
nav	12.7	1.2	528	144	42.7	18.2	4.8	88.3	5.21	5.14	12.2	20.7	88.3	12.2
nia	20.1	2.7	916	274	50.8	10.9	30.6	98.4	0.42	0.27	9.2	7.6	98.4	9.2
nico	19.3	4.8	733	341	35.8	2.8	6.3	57.0	1.22	3.94	48.4	6.9	57.0	48.4
nili	23.3	1.9	1338	465	59.2	23.4	18.9	111.3	6.17	6.02	18.5	10.7	111.3	18.5
nip	18.9	3.2	1025	420	58.3	15.9	19.4	100.5	2.32	5.66	16.8	10.1	100.5	16.8
niu	21.3	3.2	1101	432	55.7	19.4	17.9	98.9	2.17	0.98	24.0	14.2	98.9	24.0
pib	22.9	2.2	1399	530	62.4	26.4	8.7	104.4	0.09	0.06	33.8	14.9	104.4	33.8
pim	13.4	1.8	419	59	29.7	1.0	5.5	79.9	0.04	0.07	1.7	26.0	79.9	1.7
rha	16.3	2.5	320	14	24.4	0.5	0.7	41.4	1.07	0.71	2.2	1.9	41.4	2.2
sua	16.4	5.4	720	359	39.2	13.1	35.5	107.4	8.07	8.07	38.1	11.0	107.4	38.1
sub	21.2	1.7	870	22	47.3	6.1	46.6	99.9	0.17	0.09	1.1	8.6	99.9	1.1
sul	13.9	1.7	437	140	34.5	15.1	4.4	84.0	0.11	0.06	9.4	27.9	84.0	9.4
sum	13.0	1.8	434	59	29.9	1.0	6.0	79.5	1.68	0.76	1.7	26.0	79.5	1.7

Table 4. (continued).

	Temp.		EC		$P\text{-}PO_4$		$N\text{-}NO_3$		$N\text{-}NO_2$		SO_4		Ca	
code	opt	tol	opt	tol	opt	tol	opt	opt	4.15	2.33	tol	tol	opt	tol
suo	23.4	1.7	1092	652	50.1	26.5	8.8	88.7	0.39	0.34	43.1	12.3	88.7	43.1
sus	12.8	1.8	595	198	52.8	21.0	3.7	95.5	4.06	5.86	12.4	34.1	95.5	12.4
trc	20.4	2.4	835	299	46.6	11.8	32.5	93.8	2.11	4.98	25.2	9.4	93.8	25.2
ulu	17.4	3.5	745	245	46.6	14.2	15.9	84.6	4.15	2.33	29.1	15.4	84.6	29.1
RMSE	1.4		190		6.7		7.3		2.63		7.3		5.7	
R^2	0.85		0.76		0.85		0.89		0.79		0.73		0.97	

Table 5. Characterization of the sampling stations in the south-east of Gaziantep by Trophic Index Turkey (TIT), Trophic Index (TI), and Eutrophication and/or Pollution Index-Diatom (EPI-D). Fir1 and Fir2 are in pool-locations of Fırat River.

Stations	TIT	Status	TI	Status	EPI-D	Status
Bahra Creek	2.67 ± 0.19	Moderate	2.34 ± 0.17	Moderate	1.13 ± 0.09	Good
Katu Creek1	2.63 ± 0.20	Moderate	2.81 ± 0.21	Poor	1.60 ± 0.12	Good
Katu Creek2	3.16 ± 0.21	Poor	3.24 ± 0.23	Poor	1.98 ± 0.15	Moderate
Kayacık Reservoir1	3.18 ± 0.20	Poor	3.06 ± 0.24	Poor	2.75 ± 0.13	Poor
Kayacık Reservoir2	3.23 ± 0.17	Poor	3.17 ± 0.15	Poor	2.72 ± 0.24	Poor
Kayacık Reservoir3	3.15 ± 0.16	Poor	3.17 ± 0.24	Poor	2.67 ± 0.14	Poor
Karkamış Reservoir	1.71 ± 0.12	Good	1.46 ± 0.27	Good	0.99 ± 0.06	High
Fırat River1	1.91 ± 0.10	Good	1.56 ± 0.21	Good	1.14 ± 0.16	Good
Fırat River2	3.12 ± 0.17	Poor	2.82 ± 0.26	Poor	1.76 ± 0.34	Moderate
Hancağız Reservoir	3.35 ± 0.21	Bad	3.27 ± 0.23	Poor	2.23 ± 0.10	Moderate
Sacır Creek	3.12 ± 0.14	Poor	3.17 ± 0.22	Poor	2.14 ± 0.31	Moderate

Bahra Creek and Katu Creek1 and 2 located at the positive site of the second canonical axis and at the opposite of temperature (Fig. 2). The species preferring relatively low water temperature (*e.g.*, *Surirella subsalsa*, *Surirella minuta*, *Epithemia argus*, and *P. microstauron*) were encountered in these stations during the present study. Aforementioned species were also recorded in various aquatic ecosystems (Çelekli and Külköylüoğlu, 2007; Dell'uomo, 2004; Cochero *et al.*, 2015; Çelekli *et al.*, 2019). The occurrence of the pollution tolerant and/or sensitive species can reflect the integrated effect of different pressures that may affect the quality of the water bodies, *e.g.*, organic and inorganic pollutants. Discharging organic and inorganic nutrients and pollutants from domestic and industrial wastes, livestock farming, and agricultural land-use could lead to the deterioration of water quality, which causes biological impairment in aquatic ecosystems. Unlike Bahra Creek and Katu Creek1, Katu Creek2 had a poor ecological condition. Deterioration of the water quality of this station could be the consequences of a number of more anthropogenic pressures (*e.g.*, sewage discharges from settlements, livestock, runoff from fertilized agricultural land-uses, habitat destruction, and flow modification, *etc.*) than those of Bahra Creek and Katu Creek1.

Results of Spearman correlation analysis revealed that all diatom indices (TIT, TI, and EPI-D) showed significant positive correlations with $P\text{-}PO_4$ ($p < 0.01$). TIT and TI had higher correlation coefficient values than that of EPI-D. Previous studies in the Western Anatolia basin (Toudjani *et al.*, 2017) and the North Aegean catchment (Çelekli *et al.*, 2018) showed that TIT was suitable to assess ecological conditions of surface waters in Anatolia. With regard to the separation of the ecological status of sampling stations, TIT and TI had mainly similar results (see more detail in Tab. 5). This could be a consequence of the unsuitability of EPI-D's class boundary values for the Anatolia catchment.

5 Conclusion

In the present study, stressors, *e.g.*, calcium, conductivity, orthophosphate, nitrate, nitrite, sodium, and sulfur had significant effects on the distribution of diatom assemblages. Ecological characterization of the sampling stations was introduced by TIT, TI, and EPI-D. The occurrences of pollution tolerant and sensitive diatom species were also strengthening the results of these indices. Used diatom indices have high potential to clearly separate the ecological conditions of the studied stations. Diatom indices separated the ecological status of the sampling stations in the south-east of the Gaziantep catchment that is also supported by the water chemistry and response of diatom assemblages to stressor factors.

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