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Characterization of Spatiotemporal Variations in Mert Stream Water Quality by Phytoplankton Community and Biological Indices

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ABSTRACT

In order to determine the water quality of the Mert Stream, algal indicators and some biological indices (TDI, IDG, PTI, Palmer, DAIpo) based on phytoplankton species were used. Phytoplankton samples were performed monthly from six different sites at a depth of 0.5 meter using a one-litre water sampler between July 2011 and June 2012. After phytoplankton samples were placed in 250-mL dark bottles and fixed with Lugol's solution until processed in the laboratory, they were identified and counted in the tubular plankton counting chambers using an inverted microscope according to Utermöhl method. Bacillariophyta members became the dominant division in the phytoplankton with an abundance rate of 83.3% and 71 taxa. *Lindavia glomerata*, *Navicula cryptocephala*, *Cyclotella planctonica*, and *Navicula veneta* were determined as the most dominant species among phytoplanktonic taxa of Mert Stream. Trophic diatom index (TDI) and Generic diatom index (IDG) based on planktonic diatoms were used to determine the trophic status of the Mert Stream. Pollution tolerance index (PTI), Diatom assemblage index (DAIPo) and Palmer index were also included to assess the organic load-based sabrobity level of the Mert Stream. According to the results of mean TDI and IDG (55 and 13, respectively), the trophic status of the Mert Stream is a mesotrophic structure with moderate nutrients and good water transparency. According to the average PTI result (2.7), Mert Stream is in the ß-mesosaprobic class, which corresponds to moderate pollution. Considering DAIpo indice, the saprobity of Mert stream is α-oligosaprobic level and the stream is not exposed to a serious organic-based pollution. However, according to the Palmer index, all stations of the Mert Stream except the 6th station are under the threat of high organic pollution. In present study, it was seen that the best biological index that reflects the station-based trophic structure of the stream is IDG, and the best biological index that reflects the station-based organic pollution of the stream is PTI.

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Mert Irmağı Su Kalitesi'ndeki Mekansal ve Zamansal Değişimlerin Fitoplankton Topluluğu ve Biyolojik İndeksler Yardımıyla Belirlenmesi

ÖZET

Mert Irmağı'nın su kalitesini belirlemek için, algal indikatörler ve fitoplankton temelli bazı biyolojik indeksler (TDI, IDG, PTI, Palmer, DAIpo) kullanılmıştır. Fitoplankton örneklemeleri, Temmuz 2011 ile Haziran 2012 arasında bir litrelik su örnekleyici kullanarak altı farklı noktada 0.5 metre derinlikten aylık olarak gerçekleştirildi. Fitoplankton örnekleri 250 mL'lik koyu renkli kaplara konup laboratuvara taşınıncaya kadar Lugol çözeltisi ile fikse edildikten sonra Utermöhl metoduna göre inverted mikroskoba yerletirilen tüpsü plankton sayım çemberlerinde teşhisleri ve sayımları yapıldı. Bacillariophyta üyeleri % 83.3'lük bolluk oranı ve 71 takson ile fitoplanktonun baskın divizyosu olmuştur. *Lindavia glomerata*,

Çevre Bilimi

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Navicula cryptocephala, *Cyclotella planctonica* ve *Navicula veneta* Mert Irmağı'ndaki fitoplanktonik taksonlar arasında en baskın türler olarak belirlenmiştir. Mert Irmağı'nın trofik durumunu belirlemek için planktonik diyatome temelli Trofik diatom indeksi (TDI) ve Genel diatom indeksi (IDG) kullanıldı. Mert Irmağı'nın organik yük temelli sabrobite seviyesini değerlendirmek için ise Kirlilik tolerans indeksi (PTI), Diatom topluluk indeksi (DAIPo) ve Palmer indeksi dahil edildi. Ortalama TDI ve IDG sonuçlarına göre (sırasıyla 55 ve 13), Mert Irmağı trofik durumu, orta düzey besin ve iyi su şeffaflığına sahip mezotrofik bir yapıdır. Ortalama PTI sonucuna göre (2.7), Mert Irmağı orta düzey kirliliğe karşılık gelen ß-mezosaprobik sınıftadır. DAIpo indeksi dikkate alındığında, Mert Irmağı'nın saprofikliği α-oligosaprobik düzeyde olup ırmakta organik kaynaklı ciddi bir kirlilik söz konusu değildir. Fakat, Palmer indeksine göre Mert Irmağı'nın 6. istasyon haricinde tüm istasyonları yüksek organik kirlilik tehdidi altındadır. Bu çalışmada, ırmağın istasyon bazlı trofik yapısını en iyi yansıtan biyolojik indeksin IDG, istasyon bazlı organik kirliliği en iyi yansıtan biyolojik indeksin ise PTI olduğu görülmüştür.

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INTRODUCTION

The algae co-occur even though each species has a specific niche based on its physiological requirements and the constraints of the environment. These are many detailed descriptions of phytoplankton succession being correlated with changes in environmental parameters particularly temperature, light, nutrients availability and mortality factors such as grazing and parasitism. Because the variation of phytoplankton succession is strongly linked to meteorological and water stratification mixing processes, patterns in temperate ecosystems differ considerably from those of tropical waters (Wetzel, 2001). The dynamics of phytoplankton are a function of some environmental processes that affect species diversity. The abundance of algae of different kinds is rather closely associated with restricted seasonal periodicity, differing of course in widely separated geographical locations (Smith, 1951).

All of the physical, chemical and biological properties of the water constitute a water quality (Anonymous, 1999). The phytoplankton in a freshwater source is an important biological indicator of the water quality. Phytoplankton and algae monitoring is crucial because monitoring based only on physical and chemical analysis can be insufficient at times. Over the last few decades, there has been much interest in the processes influencing the development of phytoplankton communities, primarily in relation to water quality (Martín et al., 2010; Solak 2011; Tokatlı and Dayıoğlu, 2011; Delgado et al., 2012; Atıcı and Udoh, 2016; Temizel et al., 2017; Maraşlıoğlu et al., 2017; Maraşlıoğlu and Soylu, 2018; Tokatlı et al., 2020; Maraşlıoğlu et al., 2020).

Bioindicators have a number of advantages over chemical assessments when it comes to environmental monitoring has some general advantages. The main advantages can be summarised as the following; firstly, lowering the cost of sampling and analysis on a regular basis (Wu et al., 2010), secondly, the equipment is reasonably priced (Kienzl et al., 2003), thirdly, a fairly simple analysis (Zbikowski et al., 2007), fourthly, the likelihood to discover both short-term changes in water quality and long-term changes in the environment, and lastly, sensitivity to a variety of environmental influences (Stein et al., 2007). As a result, biological criteria are increasingly being used in environmental assessment and pollution monitoring around the world (Wu et al., 2010).

The use of algae for biological monitoring of stream water quality has a long history in Europe (e.g. Butcher, 1947; Fjerdingstad, 1964). Trophic Diatom Index (TDI), Generic Diatom Index (IDG), Pollution Tolerance Index (PTI), Palmer Index, and Diatom Assemblage Index are some of the regionally scaled biocenotic indices to organic water pollution (DAIpo). The trophic Diatom Index (TDI) was developed for English streams and rivers (Kelly et al., 1995; revised by Kelly et al., 2001) and has since been used in Australia, Europe, North, and South America, and

Asia (Prygiel and Coste, 1993; Lobo et al., 1995; Kelly and Whitton, 1995; Jüttner et al., 1996; Gómez and Licursi, 2001; Newall and Walsh, 2005), and Turkey (Gürbüz and Kıvrak, 2002; Solak, 2011; Tokatlı, 2013; Ongun-Sevindik and Küçük, 2016; Temizel et al., 2017; Tokatlı et al., 2020; Maraşlıoğlu et al., 2020). Rumeau and Coste (1988) proposed the generic diatom index (IDG), which is likewise based on the generic composition of assemblages. The pollution tolerance index for diatom assemblages (PTI) shows how nutrient concentration affects diatom assemblages and water trophic status (Anonymous, 2002). The PTI is similar to the trophic diatom index (Kelly, 1998) and other diatom indices which use relative abundance and eutrophication-tolerance values assigned to taxa (Lange-Bertalot, 1979; Watanabe et al., 1986). With the equation promoted by Watanabe et al. (1981), the diatom assemblage index to organic water pollution (DAIpo) is determined considering the relative abundances of taxa belonging to saprophilous and saproxenous species. The Palmer index is based upon the existence of algal genera that have allowance to organic pollution in aquatic structures (Palmer, 1969). Algal genera that are sensitive to organic pollution are given a fewer number, while algal genera that are tolerant to organic pollution are given a greater number.

Mert Stream is the most significant lotic ecosystem for the Central Black Sea Region of Turkey and it is well documented that this system is being exposed to partial anthropogenic pressure by means of agricultural and industrial applications conducted around the watersheds (Bektaş, 2016; Maraşlıoğlu et al., 2018; Maraşlıoğlu et al., 2020). The goal of this qualitative study is to use phytoplankton assemblages and biological indices (TDI, IDG, PTI, DAIpo, Palmer) for estimating trophic structure, water quality, and amount of organic pollution in Mert Stream. It is expected that the research will contribute to current knowledge of Turkey's ecology and freshwater algal flora.

MATERIAL and METHODS

Study Site

The Mert Stream flows through the province of Samsun in Turkey's Central Black Sea Region (between 41°09'02"-41°17'04" N and 35°48'04"-36°21'50" E). The stream is bordered on the west by the Kızılırmak River Basin, on the south by the Yeşilırmak River Basin, and on the east by the Abdal Creek Basin. Mert stream is vital to the region since it serves as an irrigation source for several of the settlements along the path. During the summer, the stream's depth drops to less than 50 cm, but it rises to 4-5 meters in the winter (Bakan and Şenel, 2000).

Sampling Strategy

From July 2011 to June 2012, water samples were performed monthly from 0.5-m depth at six sites using a one-litre water sampler. Figure 1 depicts the six sampling stations chosen from the Mert Stream to represent the whole stream as well as the stream's location. The sampling locations were chosen based on the basin's potential for point and non-point pollution loads, primarily from agricultural and light industrial activities. Phytoplankton samples were placed in 250-mL dark bottles and fixed with Lugol's solution (IKI) until processed in the laboratory. After water samples taken from the field for counting delivered to the laboratory, they were placed in 100 mL measuring cylinders for settling and 1-2 more drops of Lugol's solution were dropped on them.

Phytoplankton Analyses

Water samples put into tubular plankton chambers depending on phytoplankton density, after standing overnight by dropping lugol's solution, counting phytoplankton were made by using inverted microscope (Utermöhl, 1958). The average of three countings from each station was utilized in the evaluations. Every colony and threadlike creature was treated as a distinct unit during the counting process. Except for Bacillariophyta, the remaining portion of the water sample was filtered using Whatman GF/A glass fibre filter paper with a pore size of 55 m, and the residue on the filter paper was utilized to identify the algae. Among the planktonic algae that were counted in the counting chambers, some diatom species that could not be underdiagnosed due to the organic matter on frustules were identified on permanent slides which had been prepared according to the method of Della Bella and Mancini (2009).

For the idetification of algal species Hustedt (1985), Round et al. (1990), Hartley et al. (1996), Krammer and Lange-Bertalot (1991a; 1991b; 1999a; 1999b), and John et al. (2002) were used. AlgaeBase web (Anonymous, 2021) and Turkishalgae web (Anonymous, 2022) were used for classification and verification of currently-accepted taxonomic names of algae. The water quality indicators of taxa in phytoplankton were classified in three categories as sensitive (S), tolerant (T) and facultative (H/T) based on the phytoplankton composition metrics in the lakes reported by Phillips et al. (2010) at the wiser project.

Biological Indices

Trophic Diatom Index (Kelly and Whitton, 1995; Kelly et al., 2001) and Generic Diatom Index (based on genera) (Coste and Ayphassorho, 1991) were used to characterize the planktonic diatoms at each site. The organic pollution level in Mert Stream was determined by Diatom Pollution Tolerance Index (Muscio, 2002), Diatom Assemblage Index to organic water pollution (Watanabe, 1981), and Palmer index (Palmer, 1969). The organic pollution indices (PTI, DAIpo, Palmer) are based on the presence of algal species or genus, which have the organic pollution tolerance in water bodies. Ecological and pollution classification belonging to the TDI, IDG, PTI, Palmer and DAIpo values were given in Table 1.

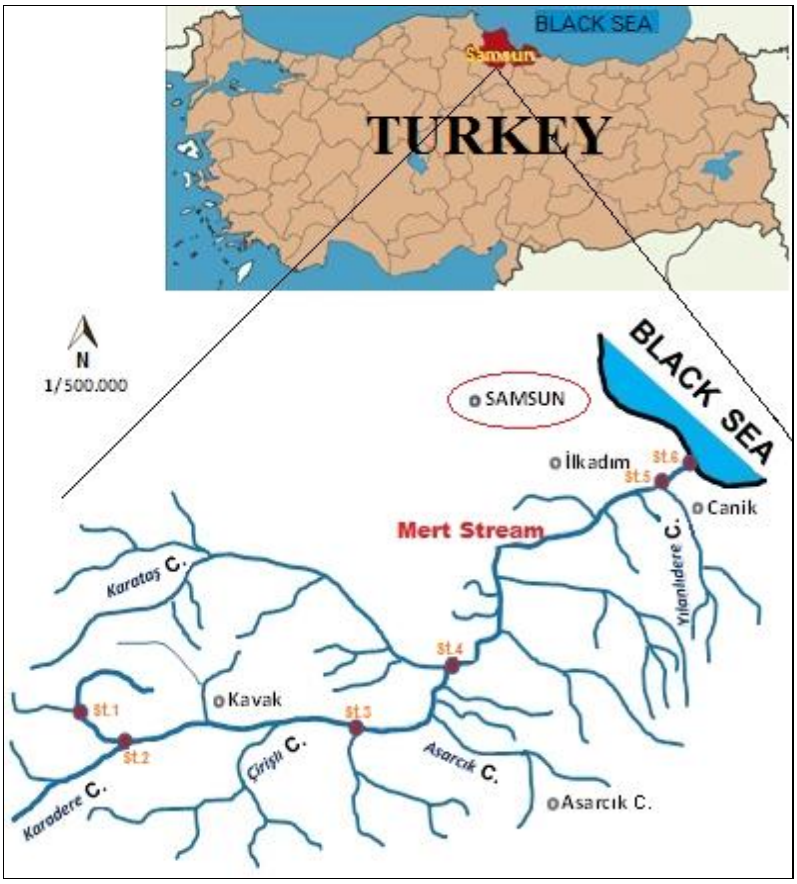

Figure 1. Location and sampling stations of the Mert Stream
Şekil 1. Mert Irmağı'nın konumu ve örnek alma istasyonları

Table 1. Ecological and pollution classification of some biological indices (TDI, IDG, PTI, Palmer and DAIpo)
Çizelge 1. Bazı biyolojik indekslerin (TDI, IDG, PTI, Palmer ve DAIpo) ekolojik ve kirlilik sınıflandırması

Ecological classification				Pollution classification			
TDI	**IDG**	**Ecological class**	**Trophic status**	**PTI**	**Palmer**	**DAIpo**	**Saprobic level**
< 35	> 17	High	Oligotrophic	> 4	< 5	100-70	ß-oligosaprobic
35 –50	15–17	Good	Oligo-Mesotrophic	4	5-10	70-50	α-oligosaprobic
50 – 60	12 –15	Moderate	Mesotrophic	3	10-15	50-30	ß-mesosaprobic
60 – 75	9–12	Low/ Poor	Eutrophic	2	15-19	30-15	α-mesosaprobic
> 75	< 9	Bad	Hypertrophic	1	≥ 20	15-0	polysaprobic

RESULTS

Algal community structure

A total of 122 taxa belonging to 8 divisions was found in the phytoplankton of Mert Stream throughout the study period. In the phytoplankton, divisio Bacillariophyta dominated in the community being presented by a total of 71 taxa, followed by the divisions Chlorophyta (16 taxa), Euglenozoa (11 taxa), Charophyta (10 taxa), Cyanobacteria (9 taxa), Miozoa (3 taxa), Ochrophyta (1 taxon), and Rhodophyta (1 taxon).

Algal abundance

In the phytoplankton, Bacillariophyta was the most dominant phylum in the stream with a total organism rate of 83%. Cyanobacteria with 7% and Ochrophyta with 5.3% were secondary important phyla, even though they did not reach a very important percentage in terms of the total organism. *Dinobryon divergens*, non-diatom taxa, from Ochrophyta became one of the dominant organisms in phytoplankton by peaking at the second station in September 2011. Dominant organisms in phytoplankton are all diatoms except one species from Ochrophyta. Dominant and subdominant organisms of phytoplankton are *Lindavia glomerata*, *Navicula cryptocephala*, *Cyclotella planctonica*, *Navicula veneta*, *Dinobryon divergens*, *Ulnaria ulna*, and *Brachysira exilis*. The abundance rates of dominant and subdominant taxa in phytoplankton were shown in Figure 2.

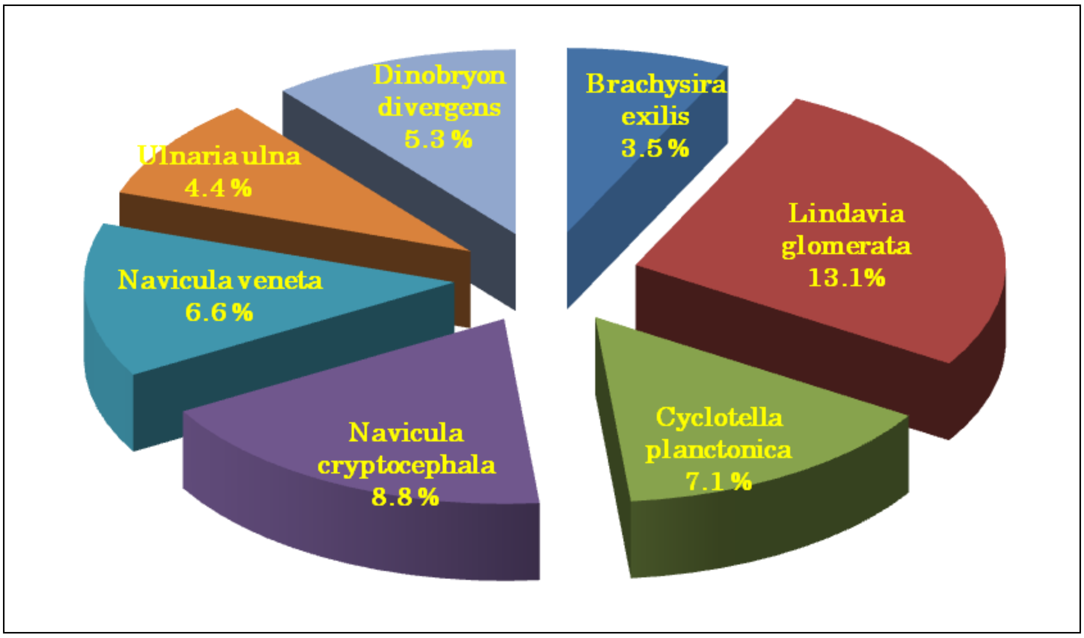

Figure 2. The abundance rates of dominant and subdominant taxa in phytoplankton
Şekil 2. Fitoplanktondaki dominant ve subdominant taksonların bolluk oranları

Spatiotemporal variations in phytoplankton commnity

The highest species diversity in phytoplankton was seen at the 2nd station with 82 taxa. On the other hand, the least species diversity in phytoplankton was seen at the 6th station with 60 taxa. The phytoplankton at 1st and 2nd stations was characterized by similar dynamics with diversity maximum in February with 30 identified species affiliated primarily to Bacillariophyceae and Cyanobacteria. For the entire period, the lowest species diversity was detected in August at both stations. At the 3rd and 5th stations, around 65 taxa were recorded at both stations, distributed as follows: 27 taxa in the June samples (3rd and 5th stations) with the pronounced dominance of Bacillariophyceae. In the samples from 4th station, 71 different taxa were identified for the studied period with twenty-nine species registered in February and thirty-four in September, October, and April. At the 6th station, the phytoplankton community was presented by 31 taxa in April.

The montly variatons in phytoplankton abundance at the sampling stations of Mert Stream were reported in Figure 3. In terms of total organisms, the highest phytoplankton density was found in September and November 2011 in the Mert stream, while the lowest number of organisms was detected in May 2012. While all stations contributed equally to the phytoplankton peak registred in November, the peak in September was caused by the 2nd and 3rd stations. While station-based highest phytoplankton abundance was counted at the 2nd and 3rd stations, the least number of organisms was found at the 1st station. When the seasonal variation of the phytoplankton in the Mert stream was analyzed, it was seen that the season with the highest cell density in the stream was autumn (234.330 cells ml^{-1}). The number of organisms detected in the autumn season constituted 60% of the number of organisms throughout the year.

Water quality and biological metrics

When the water quality status of the taxa is analyzed on the basis of the Wiser report (Phillips et al., 2010), it was seen that the tolerant taxa in phytoplankton had the highest rate with a rate of 40%, even if they were not at a overdominance level. It was observed that facultative taxa were important at the second level with a rate of 34%, while sensitve species corresponded to a rate of 26%.

TDI results ranged from 50-62, with an average of 55. The TDI value of the 1st station separated from the TDI values of the other stations with exceeding 60. The average IDG values were around 13 and only stations 2 and 3 had low scores (around 11). The PTI results of the stations are close to each other, only the PTI value of the 3rd station (2.5) was below that of the other stations. DAIpo index results ranged from 53.0 to 61.8, with an average DAIpo value of 57. Palmer index scores were recorded the lowest value at 6th station (12) and the highest value at the 4th station (32). Index results of sampling stations based on trophy and sabrophy were shown in Table 2.

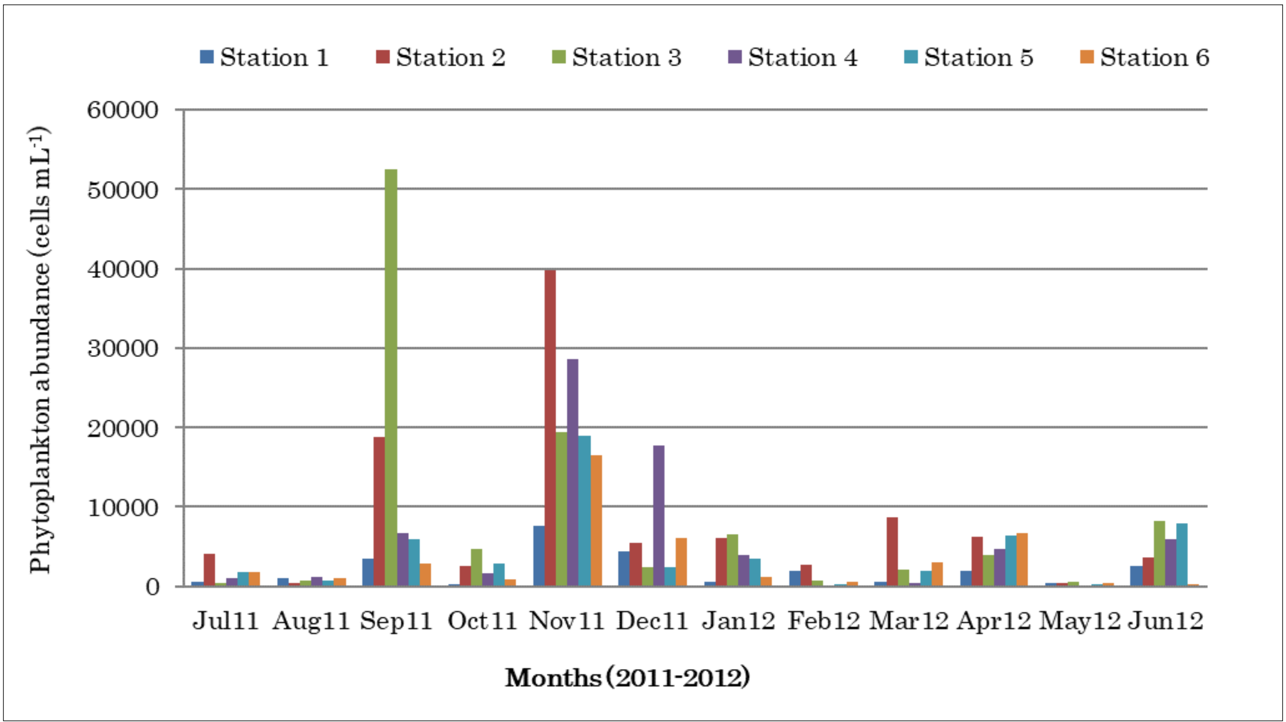

Figure 3. Monthly variations in phytoplankton abundance at the sampling stations of the Mert Stream
Şekil 3. Mert Irmağı örnekleme istasyonlarındaki fitoplankton bolluğunun aylık değişimleri

Table 2. Index results of sampling stations based on trophy and sabrophy (blue: high, green: good, yellow: moderate, orange: poor, red: bad)
Çizelge 2. Örnekleme istasyonlarının trofi ve saprofi temelli indeks sonuçları (mavi: yüksek, yeşil: iyi, sarı: orta, turuncu: zayıf, kırmızı: kötü)

	Trophic status		Saprobic level		
	TDI	IDG	PTI	Palmer	DAIpo
St.1	eutrophy	mesotrophy	β-mesosaprobic	polysaprobic	α-oligosaprobic
St.2	mesotrophy	meso-eutrophy	β-mesosaprobic	α-mesosaprobic	α-oligosaprobic
St.3	mesotrophy	meso-eutrophy	α-mesosaprobic	polysaprobic	α-oligosaprobic
St.4	mesotrophy	mesotrophy	β-mesosaprobic	polysaprobic	α-oligosaprobic
St.5	mesotrophy	mesotrophy	β-mesosaprobic	polysaprobic	α-oligosaprobic
St.6	mesotrophy	mesotrophy	β-mesosaprobic	β-mesosaprobic	α-oligosaprobic

DISCUSSION

In the study, we have identified a hundred and twenty-two taxa in which Bacillariophyta was dominant with a rate of 83%. Most of the taxa collected from Mert Stream have a cosmopolitan distribution. Bacillariophyta were also dominant in other Turkish rivers (Altuner, 1988; Altuner and Gürbüz, 1989; Soylu and Gönülol, 2003). Generally, in lotic systems, there is a dominance of diatoms originating from benthic systems. The author has proven that the diatoms dominate in the community and the phytoplankton fluctuations are highly seasonal dependent. The water and temperature regimes have a significant impact on the development of phytoplankton. The high summer temperatures reduce the intensity of diatoms and the temperature decrease leads to increase of their number respectively.

When we examined the seasonal variation of phytoplankton, it was seen that 60% of the total organism in all stations of the stream was detected in the autumn months. Considering that 83% of the total organisms detected in phytoplankton are members of Bacillariophyta, it can be said that the increase in organisms in the autumn months is normal. This prevalence of diatoms during the autumn months are generated a higher flow of nutrients and suspended particles into this area than elsewhere, creating changes in both diatom abundance and the community structure between regions (Ben Brahim et al., 2015). In the autumn season, the increase in the number of organisms in September and November was remarkable. It was also detected in Yeşilırmak river that Bacillariophyta members increased in September in autumn, then decreased in October and then increased in numbers again in November (Soylu and Gönülol, 2003). While all stations contributed equally to the increase of the total organism in November, approximately 60% of the increase of organism in September accounted for the 3rd station. This has made the 3rd station where the most species and organisms in phytoplankton are detected. The main reason for this is the poultry facilities operating near the 3rd station. In the study area, after the 3rd station the most remarkable station was 2nd station in terms of total organism. The number of organisms at the 2nd station in November constituted 40% of the total number of organisms in this station and 30% of the total organism in November. It is thought that the agriculture activities with chemical fertilizers in the environment are effective in the increase of the total organism in the 2nd station. According to Lavoie et al. (2008), the integration duration varies depending on the stream's trophic state and nutrient concentration variations. The diatom communities of oligotrophic streams are more sensitive to nutrient changes and are directly affected by nutrient increases, whereas the diatom communities of eutrophic rivers are less susceptible to nutrient fluctuations and substantial changes take longer to be integrated into index values. Although the increase in nutrient originating from agricultural and poultry activities near the 2nd and 3rd stations of the Mert Stream with a meso-eutrophic structure caused an increase in the numbers of organisms of the phytoplankton (diatoms) in these stations, it did not cause a serious variation in the species diversity of the diatoms.

Agreeing with what has already been pointed out by Claps (1996), a reduction in the algal population can be seen after the spring rains. The planktonic algae of the Mert Stream were also affected in the same way by rains in spring. Similiar conditions were also observed in Meram (Yıldız, 1985) Karasu (Altuner and Gürbüz, 1989), and Yeşilırmak (Soylu and Gönülol, 2003) streams. However, spring rains can sometimes affect algal communities of rivers in different ways. In the study area, while the spring rains depleted the number of organisms in the phytoplankton, it caused an increase in the algal abundance of the benthic environment. On the other hand, in the Pampean River of Argentina, the spring rains caused the opposite situation (Solari and Claps, 1996). The phytoplankton was enriched whereas on the sediments an impoverishment took place.

Lindavia glomerata, *Cyclotella planctonica*, *Navicula cryptocephala*, and *N. veneta* were the most common species in Mert Stream. *Lindavia glomerata* (*Cyclotella glomerata*), one of the dominant species of phytoplankton, constituted 13.1% of the total organism and became the species with the highest number of organisms in the stream. Species of genus *Cyclotella* are primarily planktonic and frequent in the freshwaters. *Cyclotella* species generally bloomed from spring to autumn or early winter (Cho, 1996). As a matter of fact, *Cyclotella* species in the phytoplankton of the Mert stream reached the highest number of organisms in September and November. *Cyclotella* species more rich and diverse than before the construction of estuarine dam. Cho (1996) stated that the richness and diversity of *Cyclotella* species decreased due to the water became eutrophic after the construction of estuarine dam at Naktong River. A few *Cyclotella* species were recorded in 5th and 6th stations of the Mert Stream (the part of the stream within the city), where the water flow rate is very low. *N. cyrptocephala*, one of the symmetric biraphid diatoms, has been the secondary important organism in the stream with a rate of approximately 9%. It was reported that *Navicula* species are included in facultative or unregistered species and can be found widely and abundantly in both organic matter rich and organic matter poor environments (Van Dam et. al., 1994). It was observed that 20.2% of the dominant taxa in the study consisted of pelagic origin and 28.8% of them consisted of diatoms of benthic origin. This shows that benthic origin organisms are more common in the phytoplankton. This result is a normal for streams that do not have much pelagic zone, such as the Mert Stream.

Even if the abundance of Ochrophyta members didn’t reach a very serious level, the fact that the one species from Ochrophyta reached an abundance of 5.3% made this division a section of secondary importance in the phytopankton. The presence of golden algae such as *Dinobryon*, which favor water with a lower inorganic phosphorus level, suggests oligotrophic conditions throughout a majority of the lake (Barinova et al., 2006). In the stream, *D. divergens* species, which is the only representative of the *Dinobryon* genus, peaked at the 2nd station. This station has a mesotrophic character with low level of pollution in terms of index results.

The fact that only 7% of Cyanobacteria members represented in the Mert Stream shows that there is no serious pollution in the stream, except for part-time pressures. Among the members of the Cyanobacteria division, the only taxon found in all stations was the toxic *Microcystis aeruginosa* species with an abundance of 2.5%. One of the most important biological stressors in the aquatic environment is cyanobacterial blooms. *M. aeruginosa* blooms can be seen in natural and artificial water bodies of eutrophic character all over the world.

In the study area, 11 species from Euglenozoa division were identified. The fact that the members of the Euglenozoa division, which are found in high numbers in areas with organic pollution, are represented by only 1.2% in the study area, also shows that there is no serious pollution due to sewage waste in the area. There was no organism that became prominent in terms of the total number of organisms in the Euglenozoa group. *Lepocinclis acus* from the Euglenozoa group was the only taxon present in all stations.

Other divisions (Chlorophyta, Charophyta, Rhodophyta) detected in phytoplankton of Mert Stream could not reach a very serious abundance rate. Although the Chlorophyta division was the one with the most species after the diatoms (16 taxa), its abundance rate remained at only 2%. Charophyta division was represented by 10 taxa and Rhodophyta division by a taxon.

Indicator organisms are species that are sensitive to changes in water quality and react in predictable ways to changes in their surroundings. Algae are an example of this type of organism. The degree of stress a stream is under can be evaluated by the organisms that reside in that stream, because different algae species have different levels of pollution tolerance. By eliminating sensitive creatures and increasing the number of tolerant ones, environmental degradation reduces the number of diverse sorts of organisms in a group. This reduces the stream's biodiversity (the amount of various types of species). The indicator organisms are classified into three groups as tolerant, facultative and sensitive based on their pollution tolerance (Muscio, 2002). When the water quality indicator ratios of the phytoplanktonic taxa in Mert Stream are examined, it is seen that the pollution-tolerant algae dominate the area with a ratio of 40%, even if not at a dominant level. The heartiest organisms, they are tolerant of pollution. In large numbers, they point to poor water quality conditions, but can also be present in good and fair water quality. The rate of taxa that can prefer both tolerant and sensitive environments, which we call facultative, is close to the rate of tolerant species in the area and is at the level of 34%. These organisms can survive in a greater variety of water quality settings than sensitive organisms. As a result, they can be found in waters other than poor- and high-quality waters. The rate of pollution-sensitive taxa in Mert Stream remained at the level of 26%. Because sensitive water creatures cannot thrive in contaminated environments, their existence usually signifies good water quality. According to all these ratios, it can be said that there is pollution pressure especially in certain stations, even if it is not serious in the area. Because tolerant species are more dominant than sensitive species in the area, the result is that the trophic structure of the Mert Stream is a meso-eutrophic structure.

In present study, two different index types were used to determine both trophic status and saprobic level in the stream. Station-based trophic status of the stream was determined using TDI and IDG indices, and station-based saprobic level of the stream was determined using PTI, Palmer and DAIpo indices. The least tolerant group has the highest index value, while the most tolerant group has the lowest. The number of indicator species present in each group determines a stream's index score.

Based on all this information, according to the mean result of TDI and IDG (55 and 13, respectively), the trophic status of the Mert Stream is a mesotrophic structure with moderate nutrients, dominated by plants or algae and good water transparency. According to the TDI index result, 1st station is an eutrophic class. This means that frequent algal blooms due to high nutrients and moderate to poor water transparency should be seen at 1st station. However, such typical characters of eutrophic class were not observed in the 1st station of the Mert Stream. According to the IDG index result, 2nd and 3rd stations are a meso-eutrophic class. Both transparency and quality of the water are poor due to the poultry farms near the 3rd station and the intensive farming activities around the 2nd station. Indeed, the phytoplankton community structure in 2nd and 3rd stations of the stream also reflected this situation. In the TDI studies based on planktonic diatoms conducted by Shaimaa et al. (2017) and Amal (2012) to determine the trophic structure of the Tigris and Shatt AL-Arab rivers, trophic structure results determined as mesotrophic were similar to the TDI results in the Mert Stream.

The results acquired in the saprobic system can be used to classify trophic states (Dokulil, 2003). As a result, phytoplankton species identification is important for determining the trophic condition of aquatic environments. Saprobic indicators in phytoplankton are commonly employed in European and Asian countries to assess water quality (Walley et al., 2001; Barinova et al., 2004). The quantity of saprobic activity determines the classification of a water body in the saprobic system. The index aims to organize water bodies on a numerical scale based on their saprobity (Heckman et al., 1990). The saprobic technique is only useful for assessing organic pollution that is being decomposed by bacteria, and it is not ideal for assessing toxin or other pollution. This index is relevant to both natural and man-made minor water bodies. It also applies to all organic matter contaminants found in freshwater and marine environments. In summary, this technique can be employed in a variety of aquatic environments, including water quality assessments for drinking water, industrial, and surface water contamination (Dokulil, 2003). According to the average PTI results (2.7), Mert Stream is at ß-mesosaprobic level with moderately polluted. Considering PTI index results, only the 3rd station differed from the others sampling points with α-mesosaprobic level, which corresponds to poor water quality. This was an expected result in the 3rd station, where organic pollution originating from chicken farms is high. Station 3 is also an area where water turbidity and BOD value are high due to bacterial activity density. The DAIpo saprobity index ranged from 53.0 to 61.8. Accordingly, Mert Stream is at α-oligosaprobic level, which corresponds to good water quality. Considering DAIpo index result, which is calculated by proportioning the cleanliness indicator saproxenous species to the pollution indicator saprophilous species, there is no organic pollution load at any station of the stream. Considering all of saprobity index values between 1.5-2.5, the Kenozero waters is classified as oligo-ß-mesosaprobic state or class II of water quality, which matches moderate content of organic substances (Abakumov, 1992). According to the Palmer index, which is based on the presence of algal genera with organic pollution tolerance in water bodies, all sites of the Mert Stream except the 6th station are under the threat of high organic pollution. Considering the Palmer index scores, the highest organic load was found at the 3rd and 4th stations. The organic pollution load at the 6th station is at the ß-mesosaprobic level, which corresponds to moderate pollution. The quality of the water in Nhu Yriver was characterised by highly organically polluted conditions because the Palmer index values were over 20 at all sites (Te et al., 2018). The ten most tolerant species stated by Palmer (1969) were not dominant or subdominant in Mert Stream indicates that the nutrient richness of the stream is not very high. It has been observed that genus such as *Anomoeoneis*, *Brachysira*, *Brebissonia*, *Craticula*, *Gomphonella*, *Sellaphora*, *Ulnaria*, *Chroococcus*, *Leptolyngbya*, *Lyngbya*, *Limnothrix*, *Microcystis*, *Pseudanabaena*, *Spirogyra*, *Cladophora*, *Desmodesmus*, *Pediastrum*, *Ulothrix*, *Volvox*, *Messastrum*, *Ceratium*, and *Trachelomonas*, which are not among pollution-tolerant genera of the Palmer index (1969), are mostly found in polluted waters (Maraşlıoğlu et al., 2005; Phillips et al., 2010; Te et al., 2018). Similar genera were recorded in the present investigation. *Cyclotella* species, which were found to be the most active participants at all stations in Mert Stream, may be good indicators of less contaminated water bodies as similar observations were recorded by Willen (1991), Hornstrom et al. (1993), Saros and Anderson (2014).

CONCLUSION

The results of this study revealed the benefits of using biotic factors (phytoplankton community and index) together in water quality assessment studies and showed that minor changes in environmental conditions may cause major effects in the phytoplankton communities. In present study, it was seen that the best biological index that reflects the station-based trophic structure of the stream is IDG, and the best biological index that reflects the station-based organic pollution load of the stream is PTI. Another result of this study is that the use of indicator organisms in phytoplankton gave good results in determining the trophic structure and water quality level of the stream. While more research is needed for the assessment of quality status of the investigated water ecosystem, the results of the present research do have the characteristics of a preliminary research with the aim of providing resources for any future bioindication investigation in the region.

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Researchers' Contribution Rate Statement Summary

The authors declare that they have contributed equally to the article.

Conflict of Interest Statement

The article authors declare that they do not have any conflict of interest.

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