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The Application of Diatom Indices in the Upper Porsuk Creek Kütahya - Turkey

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Abstract

In this study, the epilithic diatoms were investigated monthly to reveal the water quality of Upper Porsuk Creek. The Samples were collected from three stations between December 2004 and August 2005. In this study, a total of 57 diatom taxa were found along the creek. The water quality of Upper Porsuk Creek was determined according to these taxa. Different diatom indices (SLA- Sládeček Index-, EPI-D-Eutrophication/Pollution Index, TDI-Trophic Diatom Index- and DESCY-Descy Index) were used in this study. There were significant differences among three stations with regard to diatom index values. Also, the diatom indices were compared with each other and it was found that the correlation coefficients between the indices were quite high.

Keywords: Benthic diatom, diatom indices, Porsuk Creek, water quality.

Diyatome İndekslerinin Yukarı Porsuk Çayı'nda, Kütahya-Türkiye Uygulanması

Özet

Bu çalışmada, Yukarı Porsuk Çayı'nın su kalitesinin belirlenmesi amacıyla epilitik diyatome örnekler Aralık 2004 ile Ağustos 2005 tarihleri arasında aylık olarak incelenmiştir. Çalışma sonucunda, toplam 57 diyatome türü tespit edilmiş ve Porsuk Çay'nın su kalitesi bu türlere göre SLA- Sládeček İndeksi, EPI-D-Ötrofikasyon-Kirlilik İndeksi, TDI-Trofik Diyatome İndeksi and DESCY-Descy İndeksi kullanılarak tespit edilmiştir. İndeks değerlerine göre, üç istasyon arasında belirgin farklılıklar ve yine, indeksler arasında da önemli korelasyon olduğu gözlenmiştir.

Anahtar Kelimeler: Bentik diatom, diatom indekleri, Porsuk Çayı, su kalitesi.

Introduction

Algae are the essential components of primer productivity in aquatic ecosystems. These organisms are the sources of essential oxygen for aquatic life. Diatoms are so ecologically important that they are used for monitoring environmental conditions of waters. They indicate water quality level of many aquatic environments. Diatoms have been used in a number of countries as indicators of river pollution (Whitton *et al*., 1991; Whitton and Kelly, 1995; Whitton and Rott, 1996; Stevenson and Pan, 1999; Ács *et al*., 2003, 2004, 2006; Blanco *et al*., 2004; Gomá *et al*., 2004; Szabó *et al*., 2004; Gosselain *et al*., 2005), but this topic is still new in Turkey; Sarıçay (Barlas *et al*., 2001), Akçapınar and Kadın Azmağı (Barlas *et al*., 2002) in Muğla; Aksu (Kalyoncu, 2002) stream in Isparta was investigated by using Saprobity Index (Zelinka and Marvan, 1961). Also, Gürbüz and Kıvrak (2002) practised firstly three different indices (TDI, SI and IDG) on Karasu River (Erzurum) while, OMNIDIA software program was firstly used by Solak *et al*. (2007) for Akçay stream (Muğla) in Turkey (Solak, 2009). Also, Kalyoncu *et al*. (2009) compared the performance of three types of benthic diatom index (Swiss Diatom Index (DI-CH), Trophic Index (TI) and Saprobic Index (SI)) in Isparta streams and they concluded that in these rivers, DI-CH and TI could be more useful than SI. The aims of this study are testing the use of epilithic diatoms as indicators and the use of diatom indices as a tool for estimating the creek water quality.

Materials and Methods

Porsuk River orginates in the Western Anatolian Plateau near Tokul village at the altitude of 1,170 m

and flows eastwards for 435.5 km until it empties into the Sakarya River at the altitude 600 m. The river flows through two big cities, Kütahya and Eskişehir. The river receives the manicipal wastes, wastes from sugar beet factory, fertilizer plants, the magnezite factory, the slaughter house and other industrial establishments from the city of Kütahya and joins the Porsuk Dam. The dam is 140 km from the source of the river (Yıldız, 1987; Çınar *et al*., 1999). In this study, diatom samples were collected monthly from three stations, selected from its source to Porsuk Dam, between December 2003 and August 2004. The 1st station (P1) was entrance of Kütahya Province. DSI regulatory was selected as the 2nd station (P2). The 3rd station (P3) was out side of Kütahya Province towards Porsuk Dam (Figure 1). Diatoms were collected by scraping 20 cm^2 area stones. They were cleaned with acid (HNO_3) and mounted on microscopie for observation with a magnification of 1000X. Three slides were prepared for each site and approximately 200 valves enumerated in each slide to determine the relative abundance of each taxa and identified according to Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Round (1990), Sims (1996) and then DESCY, SLA, TDI and EPI-D were calculated for each station.

Diatom Indices

Zelinka and Marvan (1961) developed an index to assess water quality with algae (among which diatoms);

$$ID = \sum_{i=1}^{n} Aj \,.\, Ij \,.\, Vj \;/\; \sum_{i=1}^{n} Aj \,.\, Vj$$

with Aj; species abundance, Ij; pollution index of species, Vj; indicative value or stenoecy degree of the species.

The index of Zelinka and Marvan served as a basis for several indices:

1. DESCY index: 5 classes of sensitivity, 106 species are used.

2. TDI index: 5 classes of sensitivity of trophic state and 3 classes of reliability are used. This index is widely used in the United Kingdom, and is part of a suite of techniques used to detect eutrophication in rivers caused by large, predominantly lowland sewage Works.

3. EPI index: the sensitivity of species is an integrated index from 0 to 4, and reliability from 1 to 5.

4. SLA index: 5 classes of sensitivity (from 0 to 4), 323 species are used.

Results

In this study, a total of 57 diatom taxa were identificated belonging to Bacillariophyta (Table 1). The most abundant taxa were *Nitzschia palea* (Kützing) W. Smith, *Achnanthidium minutissimum* Kützing, *Diatoma vulgaris* Bory, *Cymbella affinis* Kützing and *Planothidium lanceolatum* (Brébisson ex Kützing) Lange-Bertalot. The pollution stituation of Upper Porsuk Creek was determined considering diatom indices. According to TDI value, P1 and P2 stations were II quality while P3 was V quality. EPI values were III quality for P1; were IV quality for P2 and were V quality for P3 station. DESCY values were II quality for P1 and P2 stations, whereas were V quality for P3 station. SLA values were III quality for P1 and P2 stations, but were IV quality for P3 station (Table 2; Figure 2).

There were significant negative correlation between DESCY and other indices (with SLA index (** $P<0.01$ (n=8)); with TDI and EPI-D indices (* $P<0.05$ (n=8)) while, there was no significant correlation between other indices (Table 3).

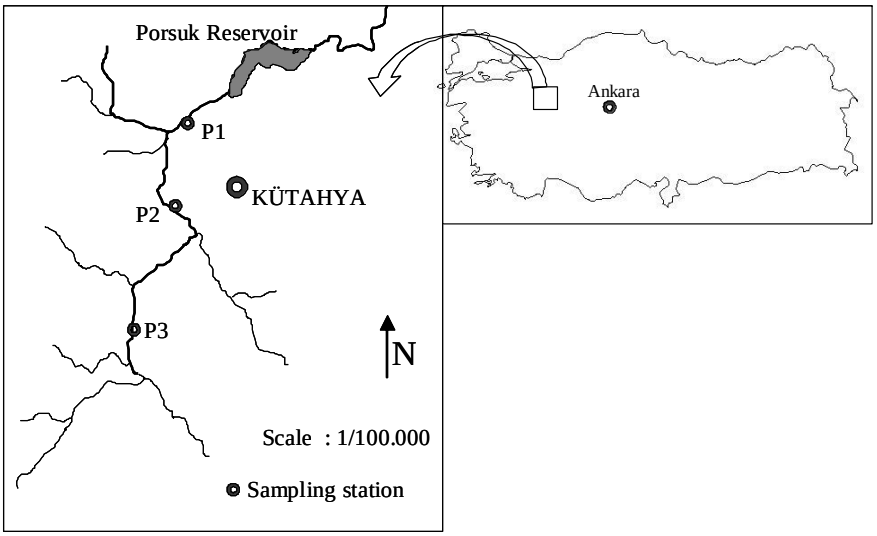

Figure 1. Map of Upper Porsuk Creek and the sampling stations along the creek.

Table 1. The List of Upper Porsuk Creek Diatoms

Phyllum: Bacillariophyta	
Classis: Coscinodiscophyceae	Family: Gomphonemataceae
Order: Thalassiosirales	*Gomphonema augur* Ehrenberg
Family: Stephanodiscaceae	*Gomphonema minutum* (C.Agardh) C.Agardh
Cyclotella meneghiana Kützing	*Gomphonema olivaceum* (Hornemann) Brébisson
Family: Melosiraceae	*Gomphonema parvulum* (Kützing) Kützing
Melosira lineata (Dillwyn) C.Agardh	*Reimeria sinuata* (Gregory) Kociolek et Stoermer
Melosira varians C.Agardh	Family: Rhoicospheniaceae
Classis: Bacillariophyceae	*Rhoicosphenia abbreviata* (Agardh) Lange-Bertalot
Family : Fragilariaceae	Family: Naviculaceae
Diatoma tenuis C. Agardh	*Navicula capitatoradiata* Germain
Ulnaria acus (Kützing) Aboal in Aboal	*Navicula cari* Ehrenberg
Ulnaria biceps (Kützing) P. Compére	*Navicula exigua* Gregory
Ulnaria ulna (Nitzschia) P. Compére	*Navicula radiosa* Kützing
(Kützing) Czarnecki	*Navicula tripunctata* (O.F.Müller) Bory
Order: *Achnanthales*	*Navicula veneta* Kützing
Family: Achnanthidiaceae	Family: Pinnulariaceae
Achnanthidium minutissimum (Kützing) Czarnecki	*Pinnularia viridis* (Nitzsch) Ehrenberg
Planothidium lanceolatum (Brébbisson ex Kützing) Lange-Bertalot	Family: *Pleurosigmataceae*
Family: Cocconeidaceae	*Gyrosigma sciotense* (W.Sç Sullivant) Cleve
Cocconeis pediculus Ehrenberg	Family: Sellaphoraceae
Cocconeis placentula Ehrenberg	*Fallacia pygmaea* (Kützing) A.J.Stickle et D.G.Mann
Order: Bacillariales	*Sellaphora pupula* (Kützing) Mereschkowsky
Denticula elegans Kützing	Family: Stauroneidaceae
Nitzschia amphibia Grunow	*Craticula cuspidata* (Kützing) D.G. Mann
Nitzschia dissipata (Kützing) Grunow	Family : Rhopalodiaceae
Nitzschia flexa Schumann	*Rhopalodia gibberula* (Ehrenberg)O.Müller
Nitzschia incrustans Grunow	Family: Surirellaceae
Nitzschia linearis (Agardh) W. Smith	*Campylodiscus hibernicus* Ehrenberg
Nitzschia palea (Kützing) W. Smith	*Cymatopleura elliptica* (Brébisson) W. Smith
Nitzschia recta Hantzsch ex Rabenhorst	*Cymatopleura solea* (Brébisson) W. Smith
Nitzschia sigmoidea (Nitzsch) W. Smith	*Surirella angusta* Kützing
Nitzschia subacicularis Hustedt	*Surirella ovata* Kützing
Nitzschia sublinearis Hustedt in Schmidt	*Surirella ovalis* Brébisson
Nitzschia vermicularis (Kützing) Hantzsch in Rabenhorst	*Surirella robusta* Ehrenberg
Tryblionella apiculata Gregory	Order: Thallassiophysales
Family: Cymbellaceae	Family : Catenulaceae
Cymbella affinis Kützing	*Amphora ovalis* (Kützing) Kützing
Cymbella aspera (Ehrenberg) H.Peragello	*Amphora pediculus* (Kützing) Grunow ex Schmidt
Cymbella helvetica Kützing	
Cymbella tumidula Grunow	
Cymbopleura naviculiformis (Auerswald) Krammer	
Encyonema silesiacum (Bleisch) D.G. Mann	

Table 2. Water Quality Values of Upper Porsuk Creek According to Different Diatom Indices

Diatomindices	Stations		
	P1	P2	P3
TDI	II (39)	II (44.5)	V (121.3)
EPI	III (1.55)	IV (1.81)	V (2.01)
	Fairly good quality	Weakly good quality	Moderately polluted
DESCY	II (4.06)	II (4.01)	V (1.81)
	Slight pollution	Slight pollution	Very heavy pollution
SLA	III (1.92)	III (2.02)	IV (2.48)
	Low polluted	Low pollluted	Critical polluted

Discussions

Whereas members of *Nitzschia* genus were the highest density among the genera, other high membered genera were *Navicula* and *Cymbella*. According to Kalyoncu (1996), *Cymbella* was the most intense genera in respect of species number after this genus, *Nitzschia, Navicula* and *Gomphonema*

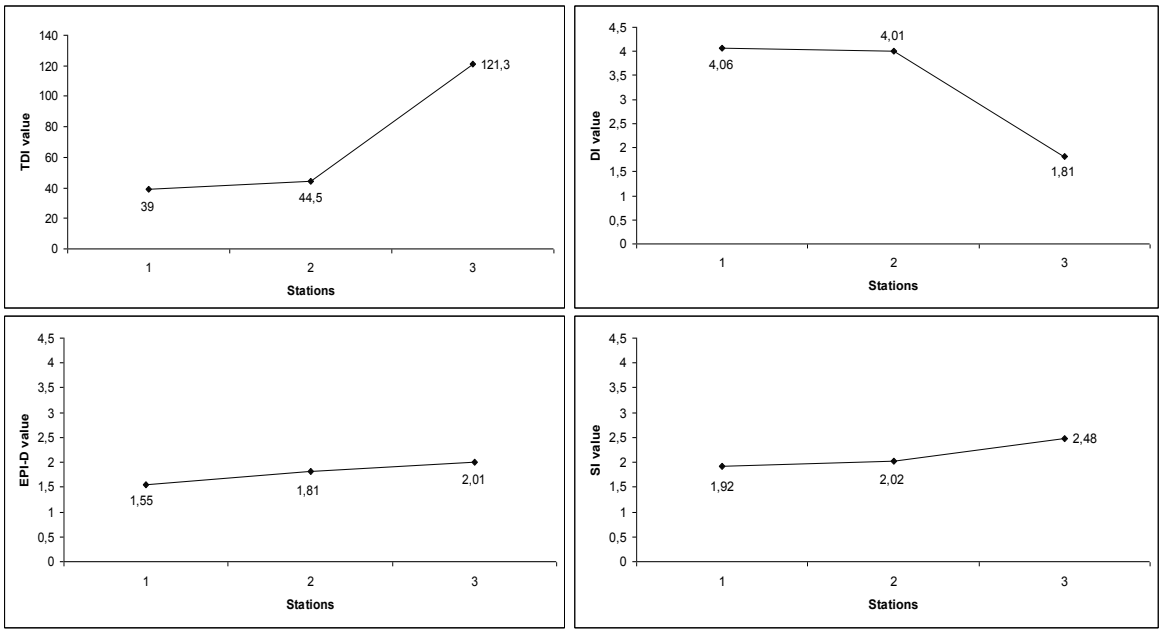

Figure 2. Changes in the diatom indices at three sampling sites along the creek.

Table 3. Canonical correlation coefficients between physical-chemical variables of water at sampling sites of Upper Porsuk Creek

	TDI	EPI-D	DESCY	SI
TDI	1			
EPI-D	0.593	1		
DESCY	-0.636	-0.661	1	
SLA	0.542	0.556	-0.825	1

were other high members in Isparta Creek. Yıldız and Özkıran (1991) reported that the species of *Navicula, Nitzschia, Cymbella, Surirella, Gomphonema* and *Pinnularia* were the most abundant in Kızılırmak River. Also, Barlas *et al*. (2001) had reported a similar result in Sarıçay Creek.

Diatoma tenuis C. Agardh, *Achnanthidium minutissimum* and *Gomphonema olivaceum* (Hornemann) Brebbisson were the most dominant taxa in the 1st station. Gürbüz and Kıvrak (2002) had found *Cymbella affinis* and *Achnanthidium minutissimum* especially in unpolluted areas, upper basin of streams, so these taxa were sensitive-organic pollution taxa (Nather Khan, 1990; Kelly, 1998; Kwandrans *et al*., 1998; Gómez and Licursi, 2001; Steinberg and Schiefele, 1988; Solak *et al*., 2005; Solak *et al*., 2007). Krstić *et al*. (1999) reported that, *Gomphonema olivaceum* was a typical taxon of α-β-mesosaprobic condition. *Achnanthidium minutissimum* and *Nitzschia linearis* W. Smith were the most abundant taxa in the 2nd station. According to Cox (1996), *Nitzschia linearis* was found commonly in β-α-mesosaprobic condition. *Nitzschia palea, Melosira varians* C. Agardh, *Navicula capitatoradiata* Germain, *Craticula cuspidata* (Kützing) D.G. Mann and *Nitzschia dissipata* (Kützing) Grunow were the most abundant taxa in the 3rd station. Among these taxa, the dominance value of *Nitzschia palea*, resistant to organic pollution (Lange-Bertalot, 1978, 1979a, 1979b; Descy, 1979; Barlas, 1988; Steinberg and Schiefele, 1988; Klee, 1991; Kelly, 1998), was less than 1% in the 1st and 2nd stations while higher than 52% in the 3rd. According to Cox (1996), this taxon was found in α-mesosaprob to polysaprobic condition. Another dominant taxon was *Melosira varians*. According to the same author, this taxon was dominant especially in eutrophic waters. According to Krstić *et al*. (1999), *Nitzschia dissipata* was found in α-β-mesosaprobic and *Navicula capitatoradiata* in β-α-mesosaprobic condition. Also, another important result from this station was that *Planothidium lanceolatum* was only found in this station.

According to diatom indices, water quality levels were found different between stations. When considering the TDI index, P1 and P2 were under eutrophication threat while P3 was eutrophic, very polluted and approximately three time higher eutrophied than other stations. According to the EPI-D index, P1 revealed fairly good quality while P2 was weakly good quality while P3 was in a moderately polluted quality. According to the DESCY index, P1

and P2 were slightly polluted but P3 was very heavily polluted and there were some dominant taxa in the community at this station. The SLA index showed low pollution in P1 and P2 but a critical pollution stituation in P3.

In conclusion, the dominance of identified taxa revealed different positions among the stations in which some taxa were dominant in the upper sections of the creek while others were dominant in the lower parts. Also, according to diatom indices, water quality levels were found in different levels between stations. According to author's opinion, these differencies resulted from the alteration of diatom communities in the indices. Water quality monitoring based on diatom indices is still a new topic in Turkey; and will be getting more improved with new the research in the near future. For this reason, by doing more and more studies using the indices, I think that we can restructure the current monitoring procedures with respect to aquatic organisms like diatoms. Pollution in the creek increased throughtout the course according to the indices values.

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