

Distribution of benthic diatoms in the Świnka River (Polesie Region) in relation to salinity

Agnieszka Pasztaleniec¹, Anna Połec

*Department of Botany and Hydrobiology
The John Paul II Catholic University of Lublin
Poland*

Key words: benthic diatoms, salinity, rivers

Abstract

The River Świnka (Polesie Region, southeastern Poland) receives salty mine waters from the “Bogdanka” SA coal mine. In April, July and October of 2005, investigations of benthic diatoms were conducted at four stations, two of which were located downstream of the entry point for canal mine waters, with the remaining two stations free from the influence of mine waters. Studies showed differentiation of diatom community species structure and relative abundance, as well as conductivity and Cl⁻ concentrations at particular stations. Higher salinity (Cl⁻ concentration reached 338.8 mg cm⁻³) and the appearance of saltwater diatom species (e.g. *Navicula halophila*, *N. salinarum*, *Nitzschia commutata*, *N. constricta* or *Thalassiosira weissflogii*) were observed in the part of the river influenced by mine waters.

¹ Corresponding author: paszta@kul.lublin.pl

INTRODUCTION

Mining operations can introduce salt-loaded effluents into rivers, which severely increases the total mineral content or concentration of certain ions and changes considerably the environmental conditions and aquatic biological community (Pudwill and Timm 1997, Ziemann et al. 2001). Diatoms are often used to monitor these ecological changes, because the salinity and concentrations of major ions have an influence on the distribution of many diatom taxa (Van Dam et al. 1994, Leland et al. 2001, Ziemann et al. 2001, Potapova and Charles 2003). Benthic diatoms are especially useful for ecological monitoring in smaller rivers due to the absence of real phytoplankton and to the common scarcity of macrophyte vegetation (Eloranta and Soinenen 2002). The small Świnka River (Polesie Region, South-Eastern Poland) plays a significant role in the functioning of ecosystems lying in its catchment area and has been designated an ecological corridor between the Chełm Protected Landscape Area and Nadwieprzański Landscape Park (Chmielewski and Łyszczarz 2005). The Świnka River is, however, exposed to the serious environmental hazard of introduced mine waters from the "Bogdanka" SA coal mine. These waters are characterized by increased conductivity as well as concentrations of specific ions, particularly chlorides (Czernaś et al. 2003).

The aim of this study was to characterize the distribution of benthic diatoms in the Świnka River along a gradient of conductivity (as a measure of salinity) and chloride concentration, the most important ion in polluted mine water.

STUDY AREA AND METHODS

Investigations were carried out on the Świnka River, Wieprz River's right-bank tributary flowing through the southern part of the Polesie Lubelskie region (South-Eastern Poland) (Fig. 1). The river (width from 3 to 6 m) runs predominantly in a natural, meandering bed whose bottom in the upper course is sand-gravel and in the lower course, peat. The surroundings of the river are mostly meadows overgrowing peat soils, which is characteristic of the region. The input of salty waters from "Bogdanka" is on average about 13 500 m³ daily (Chmielewski and Łyszczarz 2005). Inflow of salty-polluted waters into the Świnka River occurs via a canal situated near the town Puchaczów.

Biological and chemical studies (diatom species structure, conductivity and Cl⁻ concentration) were carried out at 4 stations (Fig. 1). Two stations, I and II, were located 6 and 2 km upstream of the canal-mouth, respectively. The remaining two sites were placed downstream, station III – approximately 200 m and station IV 2 km below the canal discharging mine water into the river.

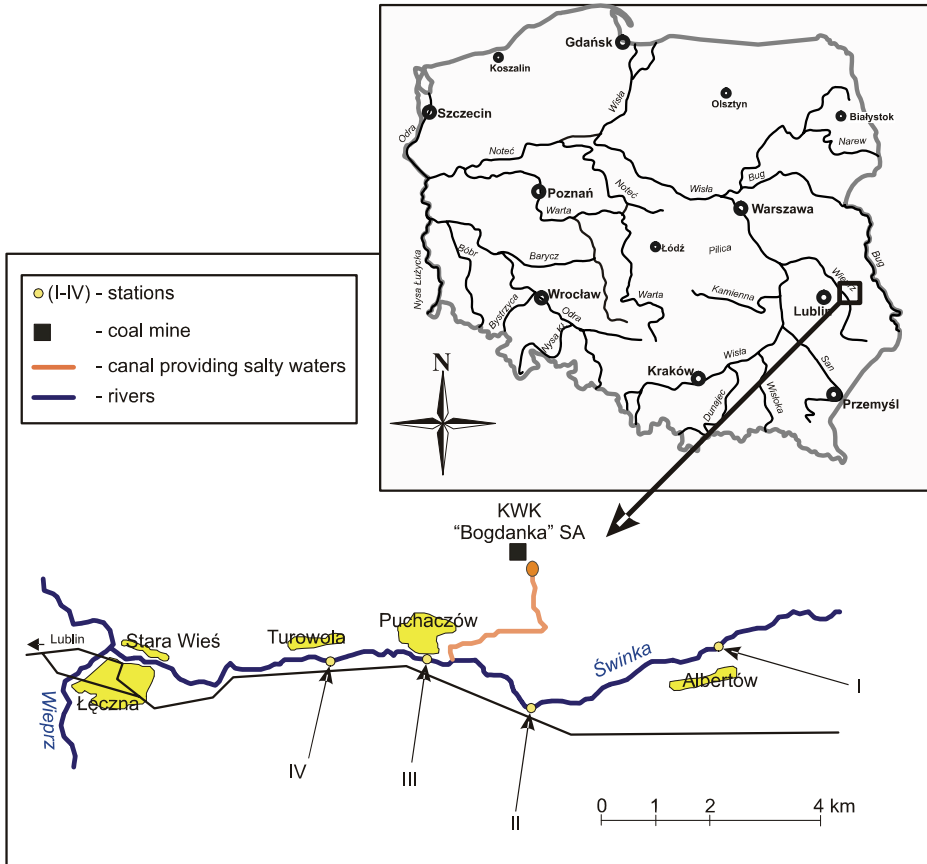


Fig. 1. Location of sampling area.

Samples of benthic diatoms were collected non-quantitatively in April, July and October 2005. Diatoms were picked with a plastic pipette from various substrata covering the river bed, such as sand, mud and stones. The sediment samples were put into plastic containers, and immediately fixed with glycerin-formaldehyde solution (2-3%).

Slides were prepared by boiling diatom sediments in H_2O_2 in order to remove organic matter from the samples (Krammer and Lange-Bertalot 1986). The cleaned frustules were mounted on permanent slides using Naphrax (Northern Biological Supplies, Ipswich, UK). Identification of species was completed according to Krammer and Lange-Bertalot (1986-2003) using a NIKON Eclipse E600 microscope with an oil immersion objective and phase contrast. In order to obtain species abundances, at least 300 frustules on each

slide were identified and counted; relative abundance was estimated as percentage share of each counted species.

Water samples for chemical analyses were taken simultaneously with diatom sampling. Conductivity of the water was measured under field conditions and concentration of Cl^- ions was determined in the laboratory using the standard argentometric (Mohr) method (Hermanowicz et al. 1999).

RESULTS AND DISCUSSION

The analyzed chemical parameters, conductivity and chloride concentration, differed between the studied stations independent of season (Table 1). Differences in these parameter values were especially great between the upper course of the Świnka River (stations I and II) and downstream stations III and IV. Likewise, clear changes in water conductivity were noted along the river.

Table 1

Seasonal variations of conductivity [$\mu\text{S cm}^{-1}$] and chloride concentration [mg dm^{-3}] at stations in the Świnka River

		Station I	Station II	Station III	Station IV
Spring	conductivity	863.0	854.0	1234.0	1178.0
	Cl^-	22.8	16.0	109.9	105.8
Summer	conductivity	854.0	754.0	2560.0	2560.0
	Cl^-	14.7	14.7	338.8	262.2
Autumn	conductivity	778.0	750.0	2170.0	2140.0
	Cl^-	12.3	12.1	277.8	231.9

Upstream sites (stations I and II) were characterized by a conductivity range from 750 to 865 $\mu\text{S cm}^{-1}$. Whereas at stations III and IV, located below the inflow of mining waters, conductivity varied from 1178 to 2560 $\mu\text{S cm}^{-1}$. A similar pattern was observed for chloride concentrations; the higher concentrations of Cl^- (maximum 338.8 mg dm^{-3}) were observed at stations lying within the mining influenced water (Tab. 1). At sites I and II, chloride concentrations were lower and varied between 12.1 and 22.8 mg dm^{-3} .

Moreover, both conductivity and Cl^- concentration decreased with growing distance from the site of mine water input, and at station IV these parameter values were lower than at station III (Table 1).

Seasonal changes in conductivity and chloride concentration at stations I and II were not noticeable and fluctuated within a narrow range, for example, at site I from 12.1 $\mu\text{S cm}^{-1}$ in autumn to 16 $\mu\text{S cm}^{-1}$ in spring and from 750 to 854 mg dm^{-3} of Cl^- , respectively. The higher values of both parameters were

observed in spring. In contrast, at stations receiving salty mining waters, conductivity and chloride concentrations increased in summer and remained high in autumn (Table 1). One cause of the salinity increase during summer could be a decrease in the water level.

The diatom assemblage was characterized based on species number (list of species occurring at particular stations; Table 2) and relative abundance of species (Table 3, Fig. 2).

A total of 52 diatom taxa were identified at the studied stations of the Świnka River, of which the vast majority belonged to the Pennales group, primarily from the genera: *Achnanthes*, *Fragilaria*, *Gomphonema*, *Navicula* and *Nitzschia* (Table 2). The differences in species richness between stations and seasons were slightly notable, with higher richness (47 taxa) observed in the salinized river section (stations III and IV) than at unsalinized stations I and II (39 taxa, combined). This could be the result of the appearance of some additional brackish and saltwater species (Table 3).

The diatoms that occurred most frequently, such as *Achnanthes lanceolata*, *Cocconeis placentula*, *Cyclotella meneghiniana*, *Fragilaria ulna*, *Gomphonema olivaceum*, *Nitzschia amphibia* and *N. palea*, are cosmopolitan and common species (Krammer and Lange-Bertalot 1986-2003). They were noted in each sample and in every season (Table 2). All above-mentioned species are classified as oligohalobic, occurring in freshwater but small increases in salinity can also stimulate their development (Rakowska 2001).

Differences in the water salinity of the Świnka River were reflected in different diatom communities, and in the relative abundance of species characteristic of saline environments. The appearance of 11 species preferring brackish waters was observed, and their number and relative abundance was significantly higher at stations III and IV (Tables 2 and 3). The highest relative abundance was reached in spring by *Navicula halophila* and *Navicula salinarum* (23% and 37%, respectively). The dominance of these two species in salty waters was also noted by other authors, for example in salty springs at Pełczyska (Poland) (Rakowska 2001) or in the salinized section of the river Wipper (Germany) (Ziemann et al. 2001). According to Rakowska (2001), *N. halophila* and *N. salinarum* can be characterized as indicators of salty waters. Ziemann et al. (2001) include these species as typical mesohalobic taxa. Abundant species (several percents of relative abundance at station III), known to tolerate brackish waters or frequent salinity fluctuations, were also noted, including *Nitzschia dubia* and *Surirella ovalis*. The autecology of *N. dubia* is characterized by an extremely high optimum of Cl⁻ concentration (1.27 meq dm⁻³) (Potapova and Charles 2003). *S. ovalis* is a mesohalobic species with a

Table 2

The diatom species list of the Świnka River (stations I-IV)

Taxa	Station I			Station II			Station III			Station IV		
	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn
<i>Achnanthes exigua</i> Grunow										+		
<i>A. hungarica</i> (Grunow) Grunow	+	+	+	+	+	+	+	+	+	+	+	+
<i>A. lanceolata</i> (Brébisson) Grunow	+	+	+	+	+	+	+	+	+	+	+	+
<i>A. lanceolata</i> var. <i>rostrata</i> (Oestrup) Lange-Bertalot			+									
<i>Amphora ovalis</i> (Kützing) Kützing					+						+	
<i>A. veneta</i> Kützing	+			+	+		+	+		+	+	
<i>Amphora</i> sp.			+	+		+			+			+
<i>Caloneis amphisbaena</i> (Bory) Cleve							+	+				
<i>Cocconeis placentula</i> Ehrenberg	+	+	+	+	+	+	+	+	+	+	+	+
<i>Cyclotella meneghiniana</i> Kützing	+	+	+	+	+	+	+	+	+	+	+	+
<i>Cymatopleura solea</i> (Brébisson) W. Smith	+	+		+			+			+	+	
<i>Entomoneis alata</i> (Ehrenberg) Ehrenberg						+	+	+		+	+	
<i>Eunotia pectinalis</i> (Dillwyn) Rabenhorst	+		+	+				+		+	+	
<i>Fragilaria bicapitata</i> Mayer			+									
<i>F. capucina</i> var. <i>vaucheriae</i> (Kützing) Lange-Bertalot	+	+	+	+	+	+	+	+	+	+		+
<i>F. construens</i> (Ehrenberg) Grunow					+				+			
<i>F. pinnata</i> Ehrenberg		+		+	+	+	+		+		+	+
<i>F. parasitica</i> var. <i>subconstricta</i> Grunow	+											
<i>F. pulchella</i> (Ralfs ex Kützing) Lange-Bertalot								+	+			+
<i>F. ulna</i> (Nitzsch) Lange-Bertalot	+	+	+	+	+	+	+	+	+	+	+	+
<i>Frustrulia vulgaris</i> (Thwaites) De Toni						+				+		+
<i>Gomphonema acuminatum</i> Ehrenberg	+		+				+			+		
<i>G. angustatum</i> Kützing (Rabenhorst)				+	+	+	+		+	+	+	+
<i>G. angustatum</i> var. <i>productum</i> Grunow	+		+									
<i>G. olivaceum</i> (Hornemann) Brébisson	+	+	+	+	+	+	+	+	+	+	+	+
<i>G. truncatum</i> Ehrenberg												+
<i>Gyrosigma acuminatum</i> (Kützing) Rabenhorst							+			+		
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow										+		
<i>Meridion circulare</i> (Greville) Agardh	+	+	+	+	+	+	+	+	+	+		+
<i>Navicula capitata</i> Ehrenberg	+			+	+	+		+		+	+	

<i>N. cryptocephala</i> Kützing	+	+		+	+	+	+	+	+	+	+	+
<i>N. halophila</i> Grunow (Cleve)	+	+			+		+	+	+	+	+	+
<i>N. reinhardtii</i> Grunow		+		+	+		+	+	+		+	
<i>N. salinarum</i> Grunow	+						+	+	+	+	+	+
<i>N. trivialis</i> Lange-Bertalot							+	+		+	+	+
<i>Nitzschia acicularis</i> (Kützing) W. Smith		+					+					
<i>N. amphibia</i> Grunow	+	+	+	+	+	+	+	+	+	+	+	+
<i>N. angustata</i> Grunow							+					
<i>N. calida</i> Grunow											+	+
<i>N. capitellata</i> Hustedt							+					
<i>N. commutata</i> Grunow							+	+				
<i>N. constricta</i> (Gregory) Grunow								+			+	+
<i>N. dissipata</i> (Kützing) Grunow	+			+	+	+	+	+			+	+
<i>N. dubia</i> W. Smith	+	+	+	+	+		+	+	+	+	+	+
<i>N. linearis</i> (Agardh) W. Smith	+	+	+	+	+	+	+			+	+	+
<i>N. palea</i> (Kützing) W. Smith	+	+	+		+	+	+	+	+	+	+	+
<i>N. subacicularis</i> Hustedt			+									
<i>Stauroneis smithii</i> Grunow	+											
<i>Stephanodiscus hantzschii</i> Grunow	+		+		+	+	+		+		+	+
<i>Surirella angusta</i> Kützing		+		+			+				+	+
<i>S. ovalis</i> Brébisson				+			+	+	+	+	+	+
<i>Thalassiosira weissflogii</i> (Grunow) Fryxell & Hasle											+	
Total number of species	25	17	22	23	21	21	33	26	22	29	29	28

Table 3

Relative abundance of salty and brackish species of diatoms (according to the key of Krammer and Lange-Bertalot (1986-2003))

Taxa	Station I			Station II			Station III			Station IV		
	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn
	Relative abundance (%)											
<i>Amphora veneta</i> Kützing				1	<1		<1	<1		<1	<1	<1
<i>Caloneis amphisbaena</i> (Bory) Cleve							<1	<1				
<i>Entomoneis alata</i> (Ehrenberg) Ehrenberg							<1	<1		1		
<i>Fragilaria pulchella</i> (Ralfs ex Kützing) Lange-Bertalot								<1	5			
<i>Navicula halophila</i> (Grunow) Cleve	<1		<1		<1		10	<1	5	37	2	3
<i>N. salinarum</i> Grunow in Cleve & Grunow	<1						23	7	5	6	3	3
<i>Nitzschia dubia</i> W. Smith		<1	<1				4	<1	10	2	3	5
<i>N. commutata</i> Grunow							<1	<1				
<i>N. constricta</i> (Gregory) Grunow									<1	1	<1	<1
<i>Surirella ovalis</i> Brébisson				1			13	<1	4	<1	<1	5
<i>Thalassiosira weissflogii</i> (Grunow) Fryxell & Hasle										<1		

