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Research Article

USE OF DIATOMS TO ASSES WATER QUALITY OF ANTHROPOGENICALLY MODIFIED MATYSÓWKA STREAM

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ABSTRACT

Matysówka stream is small, under 6 km long watercourse, which is a right-bank tributary of Strug River. In 2009–2011studies on the subject of diversity of diatom communities using diatom indices IPS, GDI and TDI for water quality assessment were conducted. On the stream 271 diatom taxa were identified, among which: *Achnanthidium minutissimum* var. *minutissimum, Navicula cryptotenella, N. gregaria, N. lanceolata, N. tripunctata, Nitzschia linearis, N. pusilla, N. recta, Planothidium frequentissimum, Rhoicosphenia abbreviata* were the most frequent. Middle and lower section of Matysówka stream was characterized by increased concentrations of phosphates, nitrites, ammonium, total phosphorus and nitrogen, BOD_5. On the basis of diatom indices IPS and GDI waters were characterized as III–IV quality classes, while the TDI index revealed the worst water quality classes (IV–V).

Keywords: diatoms, diversity, diatom indices IPS, GDI, TDI, water quality, Matysówka.

INTRODUCTION

Diatoms (Bacillariophyceae) are microscopic algae, common in all waters of the Earth. They are sensitive to many variable environmental factors: light, humidity, temperature, current speed, content of oxygen, salinity, pH, biogens, etc. Therefore, they are excellent indicators of changes taking place in the environment, including acidity, eutrophication (trophy), pollution (saprobia) and climate changes [25].

Benthic diatoms are used to assess water quality in many European countries, including Poland [3, 6, 8, 9, 11, 14, 15, 23, 24, 25, 26, 31].

Studies have been conducted for a few years, on the territory of the Podkarpacie Province, concerning the diversity of diatoms in running waters and on soils [17, 18, 19, 21, 28, 29]. Early single research studies were carried out in the upper course of the River San in connection with massive development of *Didymosphenia geminata* below the dammed reservoirs of "Solina" and "Myczkowce" [7]. Studies conducted on the Matysówka stream in 2009–2011 indicated that the stream is a habitat for many rare and endangered species of diatoms [20].

The aim of this work is to recognize the diversity of diatom communities developing along the course of the Matysówka stream and to assess ecological water status based on the bio-indicative role of diatoms as indicative organisms.

STUDY AREA

The Matysówka stream runs through the village of Matysówka located in the district of Tyczyn. It then enters the territory of Rzeszów and falls into the Strug in Biała. The length of the stream is over 6 km, width fluctuates from a few centimeters at the source part up to 2–3 meters in its lower course, and its average fall is from 2 to 3‰ (Fig. 1). The stream runs in a deep, forested ravine, meandering between homesteads. There are numerous houses and outbuildings located on both sides of the valley created by the stream. The current flows, in a few streams, at a height of about 300 m above sea level. Its upper section has a natural character, in a small area, which is devoid of human interference. The major part of the valley of the Matysówka stream is used as a wild landfill site by surrounding residents, including worn out tires. The section of the stream located on the territory of Rzeszów (from Zalesie to Robotnicza Street) is completely regulated – there are concrete boards on both sides at the bottom of the stream. Its lower section, located on the territory of the Biała, runs through agriculturally used territories [12].

MATERIALS AND METHODS

Materials for the studies were taken in three seasons: in spring and summer of 2009 and in the autumn of 2011, from all available communities on a given study site (rocks, mud and water plants). pH, electrical conductivity and water temperature were measured on each site. Water was also taken, in autumn 2011, for chemical analyses, conducted with the measuring device PeakNet Dionex 2001-2006 (version 6.80) in the Departmental Laboratory of Analysis of Wholesomeness of Environment and Materials of Agricultural Origin, Rzeszów University.

Laboratory processing of the diatoms was carried out by applying methods used by Kawecka [5]. In order to obtain pure valves of diatoms, part of the obtained material was subjected to maceration in a mixture of sulphuric acid and potassium dichromate in proportion 3:1, rinsed in a centrifuge (at 2 500 revol./min). Solid diatomic preparations were fixed in synthetic resin Pleurax.

Diatoms were identified using the optical microscope "Nikon ECLIPSE 80i", and keys: Krammer, Lange-Bertalot [13], Hofmann et al. [4]. Pictures were taken using the same microscope. Selected taxa of diatoms are presented in Figure 2.

The number of given species was obtained through calculating specimens in a random sample in the ocular fields of an optical microscope until a total number of 400 valves was obtained. Species, whose participation in a given community was 5% or more, were found to be the most numerous.

In order to calculate diatomic indexes, the computer program OMNIDIA [16] (version 4.2),

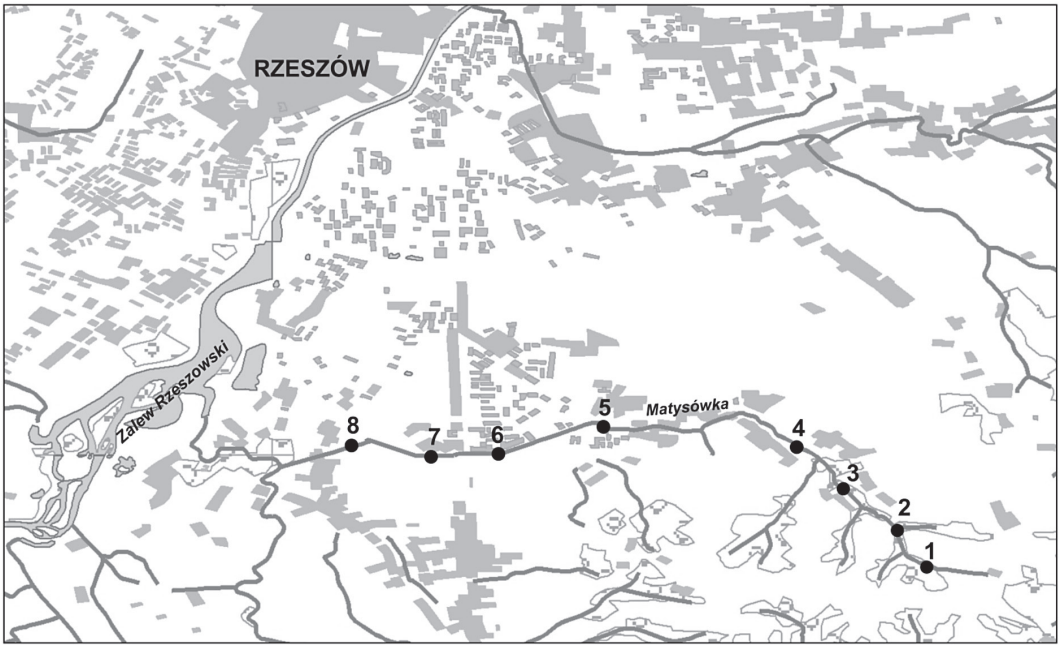

Fig. 1. Location of sampling sites at Matysówka stream (1–8 number of sites)

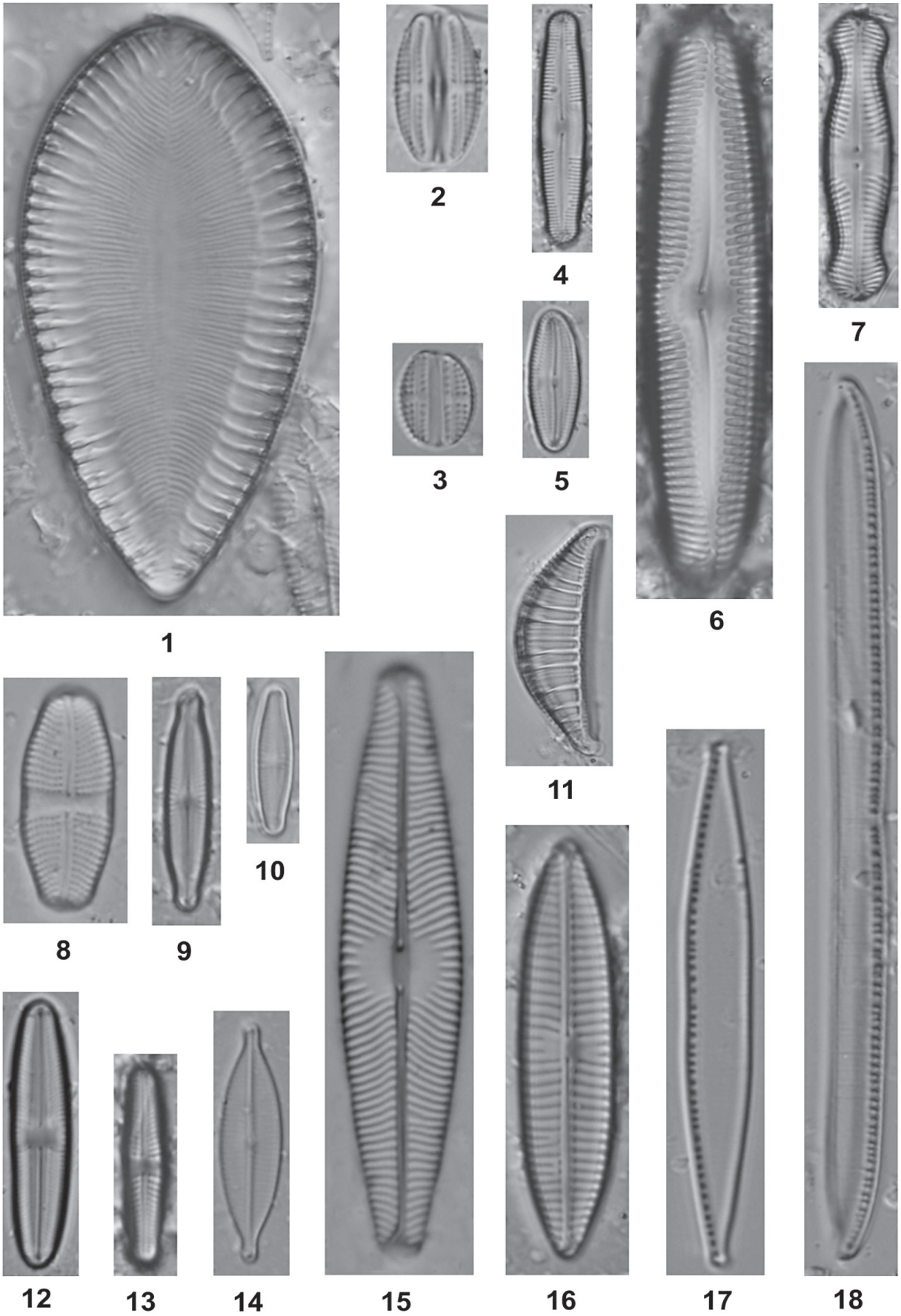

Fig. 2. Selected diatoms taxa in Matysówka stream

was used. It also contains ecological and taxonomic data [23]. An analysis of the community structure was carried out in order to determine the ecological status of the Matysówka stream. Results of the analyses were presented applying the chosen diatomic indexes, for which a range of ecological classes of water qualities and the ecological status conforming to them was outlined by a mutual agreement [3]:

Water Quality Class*	Ecological status	IPS	GDI	TDI	Trophic status
I	high	> 17	> 17	<35	oligotrophic
II	good	15–17	14–17	35–50	oligo/mesotrophic
III	moderate	12–15	11–14	50–60	mesotrophic
IV	poor	8–12	8–11	60–75	eutrophic
V	bad	<8	<8	>75	hypertrophic

* according to the Decree of the Minister of the Environment from 9 Nov. 2011 (Dz. U. No 257, pos. 1545).

Indexes of organic pollution: the SPI – Specific Pollution Sensitivity Index [1] and the GDI – Generic Diatom Index [2] are scaled from 1 to 20 (when water quality increases there is an increase in indicator value). The TDI – Trophic Diatom Index [9] is scaled from 1 to 100 (the higher the value, the bigger trophy of water). Percentage participation of species characteristic for organic pollution (PT) must be taken into account in interpretation of the TDI index. There is a possibility of organic pollution if PT values are above 20%.

RESULTS

The measurements of pH made during the conducted studies always had an alkaline character. Electronic conductivity was high, both the lowest and the highest values were registered on study site number 6. The lower course of the Matysówka stream was characterized by increased values in most studied parameters in relation to standards corresponding to quality class I, especially phosphoresces, nitrites, ammonia, phosphorus, general nitrogen and BOD_5 (Table 1).

271 taxa of diatoms were identified in the Matysówka stream, altogether, during three research seasons. The most numerous were species of genus *Nitzschia*, *Navicula*, *Gomphonema* and *Pinnularia* (see list of taxa of diatoms, Fig. 2). 17 taxa were defined as dominant, i.e. those, whose percentage participation in a given site was 5% or more. The biggest populations were made up of *Navicula lanceolata,* which dominated in all seasons, mainly in the middle and the lower courses of the stream. *Achnanthidium minutissimum* var. *minutissimum* was numerous in the upper course above all, creating the highest populations in spring 2009. Site number 2 differed from the others in terms of domination. *Adlafia bryophila* appeared the most numerously on this site, and was not stated on other study sites at all (Table 2).

In order to determine the water quality of the Matysówka stream the diatom indices (GDI, IPS, TDI, %PT), counted with OMNIDIA computer software, were taken into consideration. Values of the GDI index (Generic Diatom Index) indicated class III water

Table 1. Chemical water parameters of the Matysówka stream in years 2009–2011

Parameter	1	2	3	4	5	6	7	8
Temperature [°C]	14.5	12.1	10.2–15.5	10.2–17.0	10.0–16.0	11.8–18.3	12.9–18.3	12.8–19.9
pH	7.4	7.1	7.3–8.2	7.4–8.3	7.4–7.8	7.1–8.0	7.6–8.0	7.6-8.3
Conductivity [$\mu S \times cm^{-1}$]	546	493	588–620	600–635	550–690	635–764	504–751	416–765
COD [mg $O_2 \times l^{-1}$]	–	–	14.7	3.72	10.9	6.23	20.3	26.6
BOD_5 [mg $O_2 \times l^{-1}$]	–	–	1.43	1.11	1.94	1.74	8.3	8.2
N_{NH4} – N [mg×l^{-1}]	–	–	0.02	< 0.01	< 0.01	< 0.01	6.1	7.6
Total N [mg×l^{-1}]	–	–	2.1	2.2	2.2	2.3	10.1	11.2
N_{NO3} – N [mg×l^{-1}]	–	–	1.9	2.1	2	2.2	1.8	1.9
N_{NO2} – N [mg×l^{-1}]	–	–	0.026	0.015	0.016	0.013	0.175	0.176
Total P [mg×l^{-1}]	–	–	0.15	0.12	0.16	0.12	0.72	0.85
PO_4 – P [mg×l^{-1}]	–	–	0.65	0.2	< 0.1	0.1	1.26	1.48
Cl [mg×l^{-1}]	–	–	15.66	18.23	23.7	25.92	34.14	38.45
SO_4–S [mg×l^{-1}]	–	–	54.3	54.6	59.49	61.29	64.29	64.99

Table 2. Dominance in diatom communities in the Matysówka stream at sites 1–8 in years 2009–2011

Date	05 2009						08 2009								09 2011					
Taxa	3	4	5	6	7	8	1	2	3	4	5	6	7	8	3	4	5	6	7	8
Achnanthidium minutissimum var. *minutissimum*																				
Adlaphia bryophyla																				
Amphora inariensis																				
A. pediculus																				
Cocconeis placentula var. *lineata*																				
Navicula cryptotenella																				
N. gregaria																				
N. lanceolata																				
N. tripunctata																				
Nitzschia capitellata																				
N. lineralis																				
N. pusilla																				
N. recta																				
N. subtilis																				
N. tenuis																				
Planothidium frequentissimum																				
Rhoicosphenia abbreviata																				

[%] occurrence:

0	<5	5–20	21–40	>40

quality on most study sites. Only in spring on study site number 3 did the water indicate class I values, whereas water was class V quality in the lower current of the stream (study site number 8). Based on the IPS index (Specific Pollution Sensitivity Index) the Matysówka stream was characterized by moderate and poor water quality (III and IV class), whereas TDI index values (Trophic Diatom Index) classified the stream waters as IV and V class quality. Only study site number 3 was characterized by very good water quality (class I) in the spring season (Fig. 3). A high participation of species indicating organic pollution in the middle and lower course of the stream was noted in spring 2009.

25 taxa from the Polish Red List of Algae were noted during the studies conducted on the Matysówka stream. They made up over 9% of flora diatoms were found in the studied material (see the list of diatom species).

DISCUSSION

The conducted studies indicated an alkaline water (pH>7) on all study sites and in all seasons. The highest values of electrolytic conductivity were measured on study site number 8 (765 μS/cm). That parameter also reached high values in other stations. This would provide evidence that biogens have travelled from housing estates, or maybe from nearby farmlands, into the stream waters. This phenomenon is also encouraged by the fact that the stream is small and shallow. There are numerous rubbish dumps in the stream valley, especially a "dump" of worn-out tires. Undoubtedly all this results in an increase in the fertility of Matysówka's waters, especially in the lower part.

Diatoms are distinguished by numerous varieties of adaptations to ecological conditions. The conditions in the Matysówka stream are appropriate for their development, as is shown by the great richness of species (271 taxa). Also, numerous

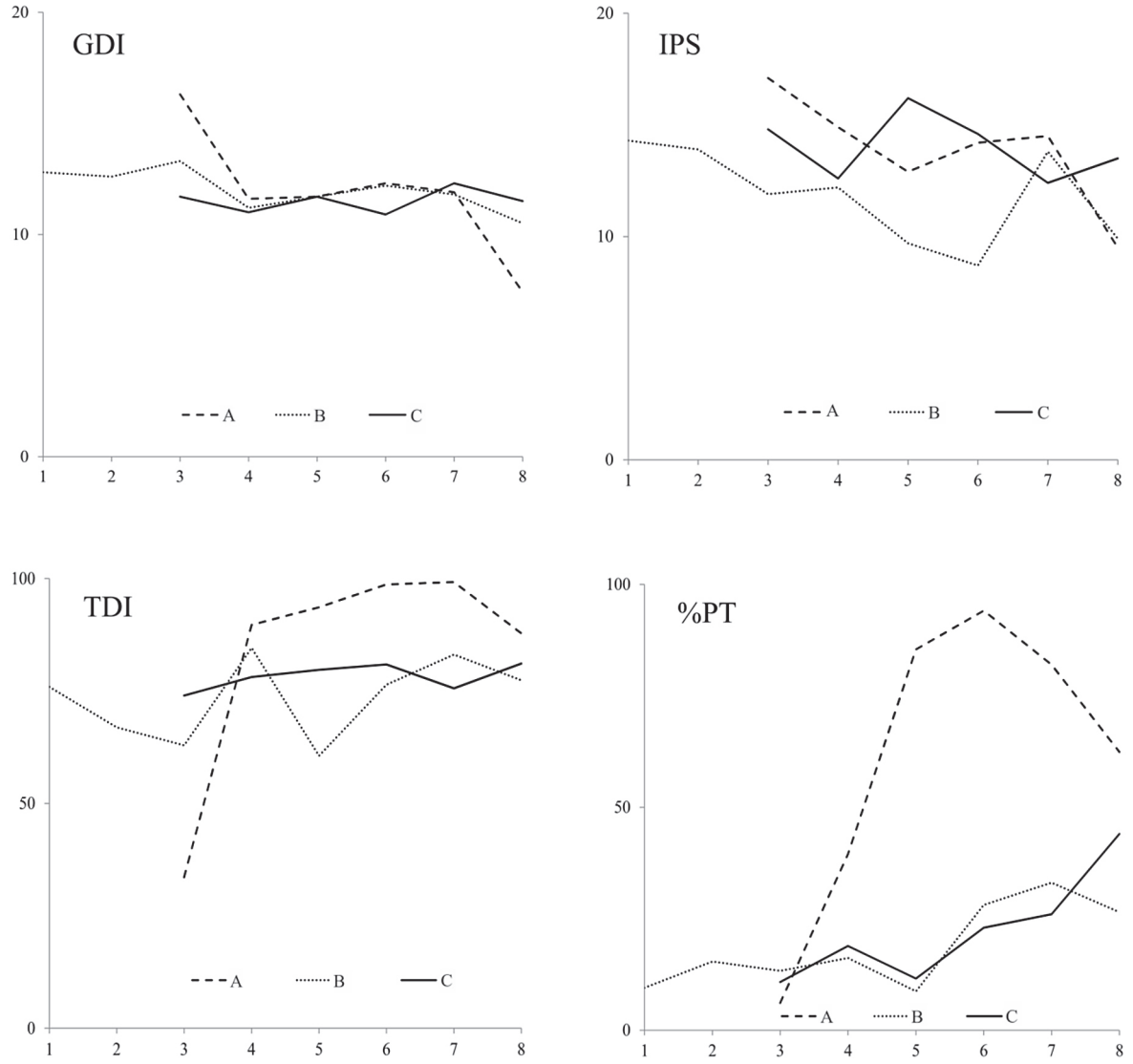

Fig. 3. The values of diatoms indices GDI, IPS, TDI and %PT for stations in Matysówka steram in the years 2009–2011 (1–8 numbers of stations; A– spring 2009, B– summer 2009, C– autumn 2011)

studied rivers and streams on the territory of the Podkarpacie Province are characterized by a large species diversity of diatoms [17, 20, 21].

Species of genus *Nitzschia* and *Navicula* predominated along the dominants. They are cosmopolitan diatoms, very often occurring in Central Europe. They prefer alkaliphil (pH >7) and eutrophic waters [4, 13, 30]. *Navicula lanceolata* developed massively in all seasons and made up the most numerous populations. Also, in the regulated section (studying positions number 5 and 6) it created massive populations in spring, reaching above 80% of the total number in community (Table 2). *Navicula lanceolata* prefers waters rich in electrolytes and it has a wide range of occurrence. It is one of the most commonly noted dominants on the territory of Podkarpacie Province [13, 17, 20, 21].

The upper section of the Matysówka stream was characterized by numerous developments of *Achnanthidium minutissimum* var. *minutissimum* and *Adlafia bryophila*.

Achnanthidium minutissimum var. *minutissimum* is one of the most common diatoms in waters with different hydrological conditions. It prefers waters from oligo- to eutrophic,

ß-mesosaprobic, and it has a wide range of pH tolerance: from 4.3 to 9.2 [13, 30].

Adlafia bryophila developed numerously along mosses on study site number 2 in the summer season, where it was a dominant species, making up almost 50% of the total number in the

community. It is a very rare species, appearing only a few times on the territory of Poland, inter alia in a peat bog in Modlniczka near Cracow and in the Krakowsko-Częstochowska Upland [22, 32]. It appears sporadically on the territory of the Podkarpacie Province [20].

The conducted studies with the application of diatomic indices showed that the organic pollution indices IPS [1] and GDI [2] indicate better water quality in comparison to the trophic index TDI [9]. The Matysówka stream runs through anthropogenically transformed areas, that is why it was characterized by similar organic pollution index values to the big rivers Wisłok and Wisłoka in their middle and lower sections [3].

The TDI values index indicated a bad state of waters (V class) along the whole length of the Matysówka stream. High values of the PT indicator (up to over 90% in spring season in the middle and lower courses – Fig. 3), which takes into consideration the percentage participation of species characteristic for organic pollution. When there is participation of over 20% PT, the possibility of organic pollution should be considered, and when it is over 40% there is a risk of the phenomenon of eutrophication [9, 10]. The growth of the PT values indicates the eutrophic character of water, additional evidence of which is supplied by the domination of species of genus *Navicula* (*N. gregaria* and *N. lanceolata*) and *Nitzschia* (*N. dissipata* ssp. *dissipata* and *N. pusilla*).

The Matysówka stream is subject to strong anthropopression along almost the whole length. Additionally it is regulated in the middle section, resulting in a significant decrease of species diversity of diatoms. Sloped valley sides, regulation and intensive single family building (many homesteads in the small town of Matysówka do not have a sewage system) additionally promote the supply of biogens to the waters of the stream. Despite that, the stream valley is a very valuable ecosystem in terms of landscape and nature. Many interesting, rare, and endangered species of diatoms develop in its waters [20].

The list of diatoms taxa found in waters of Matysówka stream in years 2009–2011 with category of endangered according to Siemińska et al. [27]: E – Endangered, V – Vulnerable, R – Rare, I – Indeterminate

Achnantes coarctata (Bréb.) Grun. [R]
Achnanthidium minutissimum (Kütz.) Czarn. var. ***minutissimum***
A. pyrenaicum (Grun.) Round & Bukht.
Adlafia brockmannii (Hust.) Bruder & Hinz
A. bryophila (Petersen) Moser, Lange-Bert. & Metzeltin
Amphora copulata (Kütz.) Schoeman & Archibald
A. inariensis Krammer
A. indistincta Levkov
A. ovalis (Kütz.) Kütz.
A. pediculus (Kütz.) Grun.
A. veneta Kütz.
Asterionella formosa Hassall
Aulacoseira sp.
Brachysira brebissonii Ross
Caloneis amphisbaena (Bory) Cleve
C. fontinalis (Grun.) Lange-Bert. & Reichardt [R]
C. lancettula (Schulz) Lange-Bert. & Witkowski [R]
C. molaris (Grun.) Krammer [R]
C. silicula (Ehrenb.) Cleve
C. tenuis (W.Gregory) Krammer
C. vasileyevae Lange-Bertalot, Genkal & Vekhov
Caloneis cf. ***aerophila*** Bock
Caloneis sp.
Chamaepinnularia submuscicola (Krasske) Lange-Bert.
Cocconeis pediculus Ehrenb.
C. placentula var. ***euglypta*** (Ehrenb.) Grun.
C. placentula var. ***lineata*** (Ehrenb.) Van Heurck
Craticula ambigua (Ehrenb.) Mann
C. molestiformis (Hust.) Lange-Bert.
Cyclotella meneghiniana Kütz.
Cylindrotheca gracilis (Bréb.) Grun.
Cymatopleura solea var. ***apiculata*** (W. Smith) Ralfs
C. solea (Bréb.) W. Smith var. ***solea***
Cymbella aspera (Ehrenb.) Cleve [V]
C. compacta Østrup
C. excisa Kütz.
C. helvetica Kütz. [R]
C. parva (W. Smith) Cleve
C. subcistula Krammer
Cymbopleura amphicephala Naegeli
Denticula subtilis Grun.
D. tenuis Kütz.
Diadesmis contenta (Grun.) D.G. Mann
D. perpusilla (Grun.) D.G. Mann
Diadesmis sp.
Diatoma ehrenbergii Kütz.
D. vulgaris Bory

Diploneis fontium Reichardt
D. krammeri Lange-Bert. & Reichardt
D. minuta Petersen
D. ovalis (Hilse) Cleve [R]
D. petersenii Hust.
D. puella (Schumann) Cleve
D. separanda Lange-Bert.
Discostella pseudostelligera (Hust.) Houk & Klee
Encyonema caespitosum Kütz.
E. minutum (Hilse) D.G. Mann
E. prostratum (Berkeley) Kütz.
E. silesiacum (Bleisch) D.G. Mann
E. ventricosum (Agardh) Grun.
Encyonopsis cesatii (Rabenh.) Grun.
E. microcephala (Grun.) Krammer
Eolimna minima (Grun.) Lange-Bert.
E. subminuscula
(Manguin) Gerd Moser, Lange-Bert. & Metzeltin
Eucocconeis austriaca (Hust.) Lange-Bert.
Eunotia bilunaris (Ehrenb.) Mills
E. mucophila Lange-Bert. & Nörpel
E. exigua (Bréb.) Rabenh**.**
E. meisteri Hust. [I]
Fallacia insociabilis (Krasske) D.G. Mann
Fallacia lenzii (Hust.) Lange-Bert. [E]
F. monoculata (Hust.) Lange-Bert.
F. subhamulata (Grun.) D.G. Mann [R]
Fistulifera pelliculosa (Bréb.) Lange-Bert.
Fragilaria acus (Kütz.) Lange-Bert.
F. austriaca (Grun.) Lange-Bert.
F. gracilis (Østrup) Hust.
F. capucina Desmaziéres var. ***capucina***
F. vaucheriae (Kütz.) Lange-Bert.
F. parasitica (W. Smith) Grun. var. ***parasitica***
F. pinnata var. ***pinnata*** Ehrenb.
F. ulna (Nitzsch) Lange-Bert. var. ***ulna***
Frustulia crassinervia (Bréb.) Lange-Bert. & Krammer
F. vulgaris (Thwait) De Toni
Gomphonema acuminatum Ehrenb.
G. angustatum (Kütz.) Rabenh.
G. clavatum Ehrenb.
G. elegantissimum Reichardt & Lange-Bert.
G. exilissimum (Grun.) Lange-Bert. & Reichardt
G. gracile Ehrenb.
G. hebridense Gregory
G. micropus Kütz.
G. minutom Ag.
G. olivaceum (Hornemann) Bréb. var. ***olivaceum***
G. parvulum (Kütz.) Kütz. var. ***parvulum***
G. parvulius
(Lange-Bert. & Reichardt) Lange-Bert. & Reichardt
G. productum (Grun.) Lange-Bert. & Reichardt
G. pumilum (Grun.) Reichardt & Lange-Bert.
G. sarcophagus Gregory
G. subclavatum (Grun.) Grun.
G. tergestinum (Grun.) Fricke
G. truncatum Ehrenb.
G. utae Lange-Bertalot & Reichardt
Gomphonema cf. ***angustum*** Ag.
Gomphonema sp. 1
Gomphonema sp. 2
Gomphonema sp. 3
Gyrosigma acuminatum (Kütz.) Rabenh.
G. attenuatum (Kütz.) Rabenh.
G. sciotonense (Sulivant) Cleve
G. obtusatum (Rabenh.) Cleve
Halamphora montana Krasske
H. normannii Rabenh.
Hantzschia abundans Lange-Bert.
H. amphioxys (Ehrenb.) Grun.
Hippodonta capitata
(Ehrenb.) Lange-Bert., Metzeltin & Witkowski
Luticola acidoclinata Lange-Bert. [R]
L. dismutica (Hust.) D.G. Mann
L. goeppertiana (Bleisch) D.G. Mann
L. mutica (Kütz.) D.G. Mann
L. nivalis (Ehrenb.) D.G. Mann
L. paramutica (Bock) D.G. Mann
L. ventricosa (Kütz.) D.G. Mann
Mayamaea atomus var. ***alcimonica*** (Reichardt) Reichardt
M. atomus var. ***atomus*** (Kütz.) Lange-Bert.
M. atomus var. ***permitis*** (Hust.) Lange-Bert.
M. fossalis var. ***obsidialis*** (Hust.) Lange-Bert.
Mayamaea sp.
Melosira varians Ag.
Meridion circulare Ag. var. ***circulare***
M. circulare var. ***constrictum*** (Ralfs) Van Heurck
Muelleria gibbula Spaulding & Stoermer
Navicula amphiceropsis Lange-Bert. & Rumrich
N. antonii Lange-Bert.
N. arvensis var. ***maior*** Lange-Bert.
N. bacilloides Hust.
N. cari Ehrenb.
N. cincta (Ehrenb.) Ralfs
N. cryptocephala Kütz.
N. cryptotenella Lange-Bert.
N. cryptotenelloides Lange-Bert.
N. erifuga Lange-Bert.
N. exigua Gregory
N. gregaria Donkin
N. harderi Hust.
N. kotshyi Grun.

N. lanceolata (Ag.) Kütz.
N. libonensis Schoeman
N. radiosa Kütz.
N. recens (Lange-Bert.) Lange-Bert.
N. reichardtiana Lange-Bert.
N. rostellata Kütz.
N. simulata Manguin
N. sinuata Schumann
N. slesvicensis Grun.
N. tenelloides Hust.
N. tripunctata (O.F. Müller) Bory
N. trivialis Lange-Bert.
N. upsaliensis (Grun.) Peragallo [R]
N. veneta Kütz.
N. vilaplanii
(Lange-Bert. & Sabater) Lange-Bert. & Sabater
N. viridula (Kütz.) Kütz.
N. wiesneri Lange-Bert.
Navicula sp. cf. ***catalanogermanica***
Lange-Bert. & Hofmann
Navicula sp. 1
Navicula sp. 2
Neidium ampliatum (Ehrenb.) Krammer [V]
N. binodeforme Krammer
N. bisulcatum var. ***subampliatum*** Krammer
N. productum (W. Smith) Cleve
Nitzschia acicularis (Kütz.) W. Smith
N. acidoclinata Lange-Bert**.**
N. amphibia Grun.
N. acula (Kütz.) Hantzsch
N. calida Grun.
N. capitellata Hust.
N. communis Rabenh.
N. constricta (Kütz.) Ralfs
N. debillis (Arnott) Grun.
N. dissipata (Kütz.) Grun. ssp. ***dissipata***
N. dissipata var. ***media*** (Hantzsch) Grun.
N. dubia W. Smith
N. frustulum var. ***frustulum*** (Kütz.) Grun.
N. gracilis Hantzsch
N. hantzschiana Rabenh.
N. heufleriana Grun.
N. hungarica Grun.
N. incospicua Grun.
N. lacuum Lange-Bert.
N. linearis (Ag.) W. Smith
N. palea (Kütz.) W. Smith
N. palea var. ***debilis*** (Kütz.) Grun.
N. perminuta (Grun.) Peragallo
N. pusilla Grun.
N. recta Hantzsch
N. salinarum Grun.
N. sigma (Kütz.) W. Smith
N. sigmoidea (Nitzsch) W. Smith
N. sociabilis Hust.
N. solgensis Cleve-Euler
N. subtilis (Grun.) Hust.
N. supralitorea Lange-Bert.
N. tenuis (W. Smith) Grun.
N. tubicola Grun.
N. umbonata (Ehrenb.) Lange-Bert.
N. vermicularis (Kütz.) Hantzsch
N. vermicularoides Lange-Bert.
Pinnularia borealis Ehrenb. var. ***borealis***
P. brebissonii (Kütz.) Grun.
P. divergentissima var. ***triundulata*** Krammer
P. globiceps Gregory
P. isselana Krammer
P. marchica Schönfelder
P. obscura Krasske
P. oriunda Krammer
P. perirrorata Krammer
P. schoenfelderi Krammer [E]
P. silvatica Petersen
P. subcommutata Krammer
P. subcommutata var. ***nonfasciata*** Krammer
P. subgibba Krammer [R]
P. subrupestris Krammer [R]
P. viridiformis Krammer [R]
P. viridis (Nitzsch) Ehrenb.
Pinnularia sp. cf. ***kuetzingii*** Krammer
Pinnularia sp. cf. ***stomatophora*** (Grun.) Cleve
Pinnularia sp. cf. ***subrombica*** Krammer
Placoneis paraelginensis Lange-Bert.
P. elginensis (Gregory) Cox
Placoneis sp.
Planothidium ellipticum (Cleve) Round & Bukht.
P. frequentissimum (Lange-Bert.) Bukht. & Round
P. lanceolatum (Bréb.) Round & Bukht.
Rhopalodia gibba (Ehrenb.) Müller
R. gibberula (Ehrenb.) Müller
Rhoicosphenia abbreviata (Ag.) Lange-Bert.
Reimeria sinuata (Gregory) Kociolek & Stoermer
R. uniseriata Sala, Guerrero & Ferrario
Sellaphora hustedtii (Krasske) Lange-Bert. & Werum [V]
S. joubaudii (Germain) Aboal
S. pseudopupula (Krasske) Lange-Bert. [E]
S. pupula (Kütz.) Mereschkovsky
S. seminulum (Grun.) D.G. Mann
S. stroemii (Hust.) Kobayasi
Simonsenia delognei (Grun.) Lange-Bert.
Stauroneis acidoclinata Lange-Bert. & Werum

S. amphicephala Kütz.
S. anceps Ehrenb.
S. borrichii (Petersen) Lund
S. legumen (Ehrenb.) Kütz.
S. leguminopsis Lange-Bert. & Krammer
S. parathermicola Lange-Bert.
S. phoenicenteron (Nitzsch) Ehrenb. [V]
S. producta Grun. [V]
S. reichardtii Lange-Bert.
S. separanda Lange-Bert. & Werum
S. smithii Grun.
S. tackei (Hust.) Krammer & Lange-Bert.
S. thermicola (Petersen) Lund [R]
Stephanodiscus hantzschii Grun.
Surirella angusta Kütz.
S. brebissonii Krammer & Lange-Bert. var. ***brebissonii***
S. brebissonii var. ***kuetzingii*** Krammer & Lange-Bert.
S. brebissonii var. ***punctata*** Krammer
S. linearis W. Smith
S. minuta (Bréb.) Kütz.
S. ovalis Bréb.
S. spirallis Kütz.
S. terricola Lange-Bert.
Surirella sp.
Tabellaria flocculosa (Roth.) Kütz.

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