Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology
Vol. XXXVIII, No. 1

Institute of Oceanography (55-63) University of Gdańsk
ISSN 1730-413X 2009 eISSN 1897-3191

DOI 10.2478/v10009-009-0003-y
Original research paper

Received: *July 03, 2007*
Accepted: *March 07, 2008*

Qualitative and quantitative phytoseston changes in two different stream-order river segments over a period of twelve years (Grabia and Brodnia, central Poland)

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Key words: Phytoseston, Grabia and Brodnia streams, changes after 12 years

Abstract

Phytoseston studies were carried out at two sites near the town of Łask in the third order-stream segment of the Grabia River and the first order-stream segment of the Brodnia River, in two study periods: 1992-1993 and 2005-2006. Water and seston were sampled twice a month. The chemical parameters of $N\text{-}NO_3$, $P\text{-}PO_4$ and chlorophyll *a* were also determined. The aim of the studies was to determine the changes in the nutrient load of these ecosystems in the rivers studied over the course of 12 years and their influence on quantitative and qualitative phytoseston differentiation.

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No important differences in the taxonomic composition of the phytoseston between the two rivers were observed. A high participation of diatoms (over 50%), in relation to other algal groups, was recorded in both rivers. Vegetation in the Brodnia River begins to develop one month earlier than in the Grabia River. The greatest changes in the seasonal rate of algal succession occurred in the spring and summer periods, while no considerable changes in seston composition were recorded in the fall or winter periods. A decrease in phytoseston quantity was observed in the second study period. Chlorophyll *a* content was significantly lower in 2005-2006 than that in 1992-1993.

INTRODUCTION

Periodically repeated studies are required to describe changes occurring in fluvial environments over time. Hydrobiological examinations of the Grabia River were launched in 1928 by Professor Pawłowski. Other researchers and students of Łódź University continued investigations on the flora and fauna of this lowland river, including fish and vertebrates (Siciński and Tończyk 2005), (phyto-) seston (Sulejewicz 1994, Kostrzewa 2006), and diatom communities (Sekulska-Nalewajko 2001). The profile of the river's entire course was analyzed in interdisciplinary studies.

Nutrient levels and the phytoseston composition in the Grabia River and the Brodnia River were examined in 1992 and 1993 (Sulejewicz 1994). The influence of biotic and abiotic factors on nutrient concentrations in the rivers was determined, and the impact of physical and chemical factors on the dynamics of primary seston producers was assessed. These river were re-examined in 2005 and 2006 (Kostrzewa 2006). The changes occurring in both river ecosystems are discussed below.

The aim of the current studies was to determine the changes in the nutrient load of these ecosystems in the rivers studied over the course of 12 years, and their influence on quantitative and qualitative phytoseston differentiation.

STUDY AREA

Grabia is a typical small lowland river with a forested agricultural drainage area covering 820 square kilometers. The river's length is 81 km, and its water sources lie 229 meters above sea level, producing an average of 2.0 l per second (Siciński, Tończyk 2005). The waters of the Grabia River are classified as clean, and their self-purification capacity is high (Babski et al. 1985). The Brodnia River is a right tributary of the Grabia River (Fig. 1).

Grabia site

This is a central quaternary segment of the Grabia River, located in the vicinity of the town of Łask (51º35'N, 19º08'E). The mean stream width in the

Fig. 1. Study area – Grabia and Brodnia sites.

area is approximately 8 m and the maximum depth is approximately 0.95 m. The examined stream segment is located 45 km downstream. The river bottom is sandy and sandy-muddy. The bank line of the river-bed is preserved in this area and meanders strongly, with prevailing insolated segments. However, bank shrubs rich in *Salix purpurea* and *S. cinerea*, with a small participation of alder trees, influence the degree of shading in some stream segments. Land habitats are represented by meadow and marsh communities, while water vegetation is represented by *Elodea canadensis* and *Potamogeton crispus*.

Brodnia site

This is a downstream, first-order segment of the river. The mean stream width is approximately 1.5 m and the mean depth is 0.45 m. The river bottom at this site is sandy and sandy-muddy, covered with detritus in the bends. The bank line of the river-bed is preserved in this area and meanders strongly, with prevailing shaded segments. A pine forest borders the right bank of the examined segment, while meadow communities constitute the left bank. The

banks are overgrown with willow shrubs rich in *Salix purpurea* and *S. cinerea*. Flood waters accumulate during bankful stages. Water vegetation is composed of *Fontinalis antipyretica*, and filamentous algae *Cladophora glomerata* and *Elodea canadensis.*

MATERIALS AND METHODS

Comparative seston studies in both lowland rivers were conducted for one year over two periods: between February 1992 and May 1993, and between March 2005 and May 2006, at permanent sites established on the Grabia River (4^{th} order segment) and the Brodnia River (1^{st} order segment). Water and seston were sampled twice a month. The year of 1992 was particularly dry. The algological material was preserved with J in KJ, CH_3COOH. Algae were identified and counted in a Fusch-Rosenthal chamber. The chemical parameters $N\text{-}NO_3$, $P\text{-}PO_4$, and chlorophyll-*a* were determined in water samples using standard methods.

RESULTS

Seasonal variations within algal groups in both rivers in the two study periods presented in Figures 2 A and B indicates the domination of diatoms. The number of algal cells increased and reached its maximum in spring. Twice as many algal cells were counted in the Grabia River as in the Brodnia River in both study periods. Diatoms with cryptophytes and chrysophytes prevailed in early spring in 1992, and green algae were recorded. Chrysophytes were not observed in the phytoseston in either rivers in the study period in 2005-2006. Vegetation in the lower order stream begins developing earlier (Brodnia - February, Grabia - March).

Representatives of genera belonging to Pennales (*Navicula*, *Nitzschia, Fragilaria*) dominated among diatoms. *Melosira, Aulacoseira, Asterionella, Cyclotella* were some of the colony-forming taxa that occurred singly. Periphyton diatoms of the genera *Cymbella*, *Achnanthes*, *Cocconeis*, and *Amphora* were also recorded. Green algae were represented by species of the genera *Kirchneriella, Monoraphidium*, *Pediastrum*, and *Tetraedron.* However, the greatest number of species recorded belonged to the genus *Scenedesmus*.

Temperature is an abiotic factor that influences the occurrence of algae (Table 1).

The water temperature in the Brodnia River was higher than that in the Grabia River in early spring. As a result, the vegetation period in the Brodnia River begins earlier and diatoms develop. Green algae are produced when the water temperature increases in April. Euglenophytes were observed at the

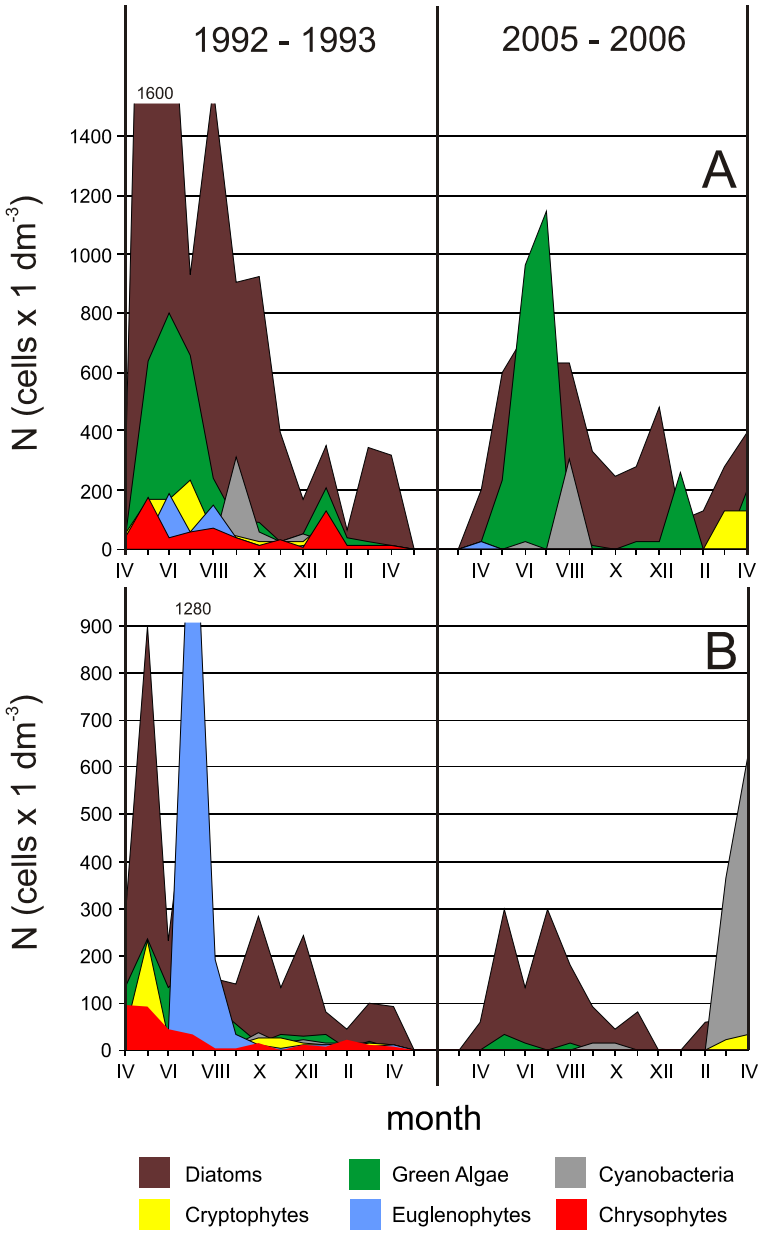

Fig. 2. Seasonal quantitative and qualitative phytoseston variability in the Grabia River (A) and the Brodnia River (B) in both study periods. (Scales on the y-axis are selected proportionally to the varying quantity of algae in both rivers, N – number of cells × 1 dm^{-3}).

Table 1

Physical and chemical parameters in the Grabia and Brodnia rivers in the two study periods.

Month	Parameters	Temperature °C		$N\text{-}NO_3$ μg dm^{-3}		$P\text{-}PO_4$ μg dm^{-3}	
	Season	Grabia	Brodnia	Grabia	Brodnia	Grabia	Brodnia
IV	1 (1992-93)	7	7.2	30	30	11	11
	2 (2005-06)	7	8	25	20	4.8	9
V	1	13	13	96.5	173	33.5	37.5
	2	14	13	50	110	5.3	16.7
VI	1	16.5	16	72	15	32.5	37
	2	17	17	80	14	5.8	17.8
VII	1	20.5	17.7	125	980	83.5	98
	2	20	19	105	155	8.8	35.6
VIII	1	16.5	15.8	185	177.5	56	71.5
	2	17	14.5	85	135	11.1	49.5
IX	1	12	11	49	109.5	48	22.5
	2	16	15	60	125	15.41	77.7
X	1	8.5	8.1	752.5	928	21.5	88.5
	2	8	9.5	90	195	8.3	47.9
XI	1	5.1	5.1	235.5	104	81	74.5
	2	3	5	100	97.5	2.7	23.2
XII	1	2.25	2.9	255	255	108.5	65.5
	2	1.5	2	540	225	13	16.78
I	1	2	1.7	65	90	25.5	39
	2	1	1	58	290	11.24	20.41
II	1	2.5	2.3	40.5	156.5	52.3	59.3
	2	3	3.2	130	148	62.4	20.5
III	1	2.5	5.15	129	160	77.5	14.5
	2	3.5	4.5	200	145	13.5	18.1
IV	1	4	7.2	240	360	70	10.5
	2	7.5	8	475	415	17.1	21.3

beginning of May and the end of June only in the Grabia River. Cyanobacteria occur in the Grabia River in August, while they do so in the Brodnia River in September. Cryptophytes were observed in the Brodnia River in spring months in 2006. The greatest number of diatoms were observed in August and September and that of green algae at the end of June and beginning of July (Figs. 2 A and B).

The greatest chlorophyll-*a* concentration was recorded in April and May when the vegetation period began (Fig. 3).

A second increase in the chlorophyll content was observed in the Grabia River in September. The lowest chlorophyll-*a* concentration was observed in the winter period. Chlorophyll-*a* concentrations in the Grabia River in the spring and fall periods in 2005 were significantly lower than those in 1992. Chlorophyll-*a* levels were similar in summer and winter. The chlorophyll-*a*

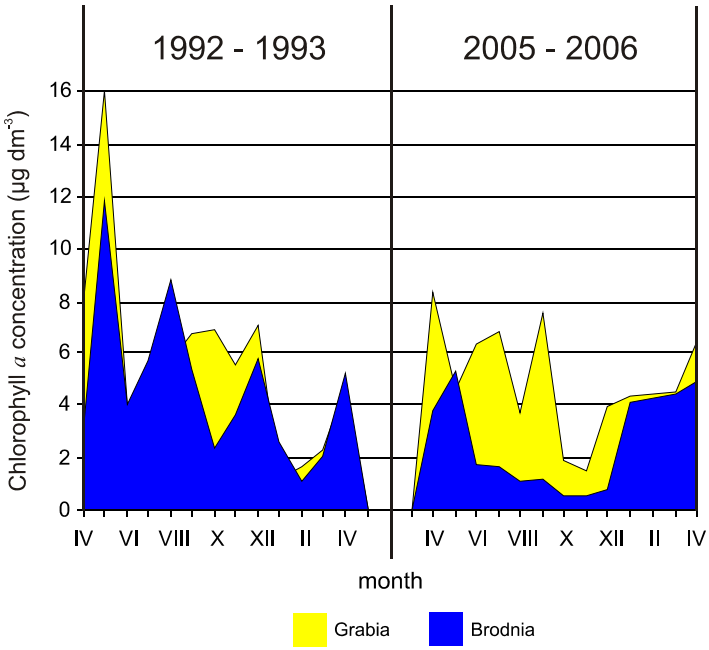

Fig. 3. Chlorophyll-*a* concentration in the Grabia and Brodnia Rivers in the two study periods.

concentration in the Brodnia River was significantly lower in 2005-2006 than in 1992-1993.

Decreases in the concentration of phosphates and nitrates and a temperature increase were observed in the 2005-2006 study period, in comparison with the 1992-1993 study period (Tab. 1).

DISCUSSION

Two major factors influence the occurrence of plankton algae in rivers: very weak water currents (<0.4 m s^{-1}) and the adequate transfer time of water masses required for phytoplankton development and reproduction. This depends on the river length and channel, and changes within valley contractions, cascades, and bars where a partial or entire elimination of plankton environments takes place (Kawecka and Eloranta 1994). An inverse relation between river flow and phytoseston abundance is characteristic of rivers (Allan 1998).

Diatoms were the dominant algal group in the phytoseston in both rivers in the two study periods. Those belonging to Pennales prevailed among them. This

is an algal group, mostly centric diatoms, that dominates quantitatively the phytoseston composition (Allan 1998) in rivers characterized by varying water currents (Messyasz 2006) and at different nitrogen and phosphorus concentrations (Stoyneva 1998, Messyasz 2003).

So-called short-retention time is of crucial importance for phytoseston development (Hilton et al. 2006). It is short in the rivers studied due to their order. The participation of centric plankton diatoms, characteristic of large eutrophic rivers, was very low in the Grabia and Brodnia rivers.

Physical factors (such as temperature) and chemical factors (phosphate and nitrate concentrations) greatly influenced the regulation of seston quantity. A drop in its abundance may be caused by a decrease in the content of nutrients (mostly nitrates and phosphates).

The main growing season, and hence the period of high nutrient requirements, for aquatic plants in northern temperate regions is from March until the end of September. However, the main period for the transport of diffuse, agricultural sources of P is during the winter and particularly the fall rains, which are a key diverse factor in the transport processes involved (Hilton et al. 2006).

Agriculture is the main source of phosphates. A decrease in phosphate concentration was observed in the second study period in relation to the 1992-1993 study period, especially in winter and fall, which resulted in a decrease in phytoseston abundance and differentiation.

CONCLUSIONS

No considerable differences between the taxonomic composition of the phytoseston in the two rivers were observed. The high participation of diatoms (over 50%) in relation to other algal groups was recorded in both rivers.

The spring algal development in the Brodnia River (1st order stream) begins one month earlier than in the Grabia River (4th order stream).

The greatest changes in the seasonal rate of algal succession occurred in the spring and summer periods, while no significant changes in seston composition were recorded in the fall or and winter periods.

A decrease in phytoseston quantity was observed in the 2005-2006 period in comparison with the 1992-1993 period. Representatives of Euglenophyta, Cryptophyta, and Chlorophyta were recorded sporadically in the period 2005-2006. The chlorophyll-*a* content was much lower in 2005-2006 than that in 1992-1993.

A considerable decrease in phosphate concentration in the rivers studied indicated a limited inflow from the forested agricultural catchment, which affects the quantity and composition of the phytoseston.

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