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ORGANIC CARBON CONTENTS IN BOTTOM SEDIMENTS FROM THE UPPER RIVER NAREW AND ITS TRIBUTARIES*

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Abstract

The study dealt with the bottom sediments from the Narew River in the section Bondary-Tykocin 1 8 tributaries in he catchment of the upper Narew. Samples were collected in summer (August) and autumn (October) 2005 from the surface layer of bottom sediments in the shore zone. Determinations of organic carbon were performed on a TOC 1200 analyzer (Thermo Euroglas). The bottom sediments collected from the upper Narew contained less organic carbon, which resulted from intensive mineralization. Sediments from the small rivers were most abundant in organic carbon. These rivers are characterized by a low flow rate and, in most cases, they are overgrown by water plants. The organic carbon contents were highly varied between the sampling points. Positive linear correlation was found between combustion loss and organic carbon content.

Keywords: organic carbon, bottom sediments, rivers.

KSZTAŁTOWANIE SIĘ ZAWARTOŚCI WĘGLA ORGANICZNEGO W OSADACH DENNYCH GÓRNEJ NARWI I JEJ DOPŁYWACH

Abstrakt

Badaniami objęto osady denne z rzeki Narew na odcinku Bondary-Tykocin oraz 18 jej dopływów w obrębie zlewni górnej Narwi. Próbki pobrano latem (sierpień) i jesienią (październik) 2005 r. z powierzchniowej warstwy osadu dennego w strefie brzegowej. Węgiel organiczny oznaczano na analizatorze TOC 1200 firmy Thermo Euroglas. Osady denne pobrane z rzeki Narew zawierały mniej węgla organicznego – jest to wynik intensywnej mineralizacji. Naj-

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zasobniejsze w węgiel organiczny były osady denne małych rzek. Rzeki te mają małe prędkości przepływu, w większości przypadków są porośnięte roślinnością wodną. Zawartość węgla organicznego wykazała dużą zmienność w zależności od lokalizacji punktów poboru próbek. Stwierdzono dodatnią korelację liniową między zawartością straty prażenia a węglem organicznym.

Słowa kluczowe: węgiel organiczny, osady denne, rzeki.

INTRODUCTION

Water has considerable chemical influence on bottom sediments in rivers and lakes. Sediments accumulated at the bottom of rivers and water reservoirs are a very useful geochemical medium to control the surface water quality in terms of contamination by heavy metals and hazardous organic compounds (CHEN et al. 2000, WARDAS 2001, BOJAKOWSKA, GLIWICZ, 2003, KANIA et al. 2005, SKORBIŁOWICZ 2005). Organic carbon content in water and bottom sediments is of interest, too (HELLAND et al. 2003, WARNKEN SANTSCHI 2004, OUYANG et al. 2006, WIŚNIOWSKA-KIELIAN 2007). Carbon, one of the most widespread elements, is also a general constituent of organic matter. Organic compounds in surface waters are produced from minerals by autotrophic organisms during photosynthesis (algae, blue-green algae, macrophytes) and chemosynthesis (bacteria) (AZAN et al. 1983). A significant portion of organic compounds in water consists of decaying aqueous plant and animal-origin organisms (decomposed by parasites) or active metabolite excretion (urea, feces, enzymes, pheromones, etc.) (GÓRNIAK, ZIELIŃSKI 1999). All those substances directly produced in water are called *autochthonic organic matter* (WETZEL 1990). Humus substances are the main group of natural organic compounds in waters and bottom sediments (DE HAAN 1992, GÓRNIAK 1996). JAMBERS (1999) suggests that organic matter may play an important role in forming and aggregating minerals. Large amounts of organic matter are present in particles abundant in heavy metals, which suggests the occurrence of organic complexes and a high probability of metal sorption on fine organic fraction (EISMA 1992).

The present study was aimed at evaluating the organic carbon contents in bottom sediments of the upper Narew River and its tributaries.

MATERIAL AND METHODS

The study dealt with the bottom sediments from the Narew in the section Bondary-Tykocin and 18 tributary rivers in its upper catchment basin (Figure 1). Depending on the catchment area, river length and flow

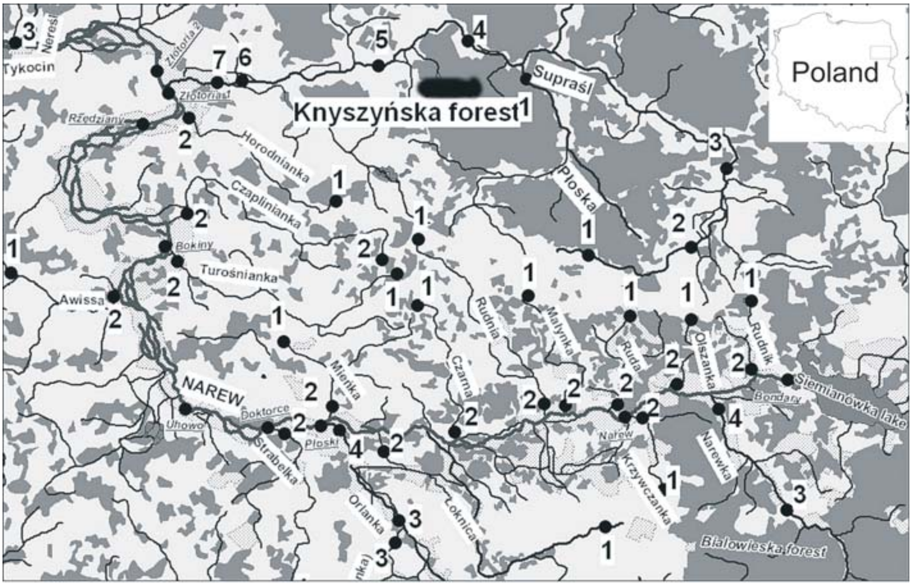

Fig.1. Sediment sampling points

speed, the rivers were divided into larger (the Orlanka, Narewka, Nereśl) and smaller ones (the Awissa, Ruda, Małynka, Rudnia, Czarna, Mieńka, Czaplinianka, Horodnianka, Jaskranka, Krzywczanka, Łoknica, Strabelka, the Biała, a tributary of the Orlanka, and the Płoska, a tributary of the Supraśl). The Narew and Supraśl were analyzed separately. In the case of the smaller rivers, sampling points were set at their mouths to the main rivers. The number of sampling points along with their location on the Narew, Supraśl, and other larger rivers was established according to the contamination sources. Samples were collected in summer (August) and autumn (October) of 2005 at 44 sampling points from the surface layer of bottom sediments in the shore zones. Acidity of the sediments was measured by potentiometry; combustion loss was determined by combusting sediments for 2 hrs in a muffle oven at 550°C. Samples were weighed on analytical scales at ± 0.0001 g precision. Sample weight loss defined as the combustion loss was expressed in per cents to the initial weight. Organic carbon contents were determined using a TOC 1200 analyzer (Thermo Euroglas).

RESULTS AND DISCUSSION

The results of the analyses of the contents of organic carbon in the bottom sediments from the Narew and tributary rivers are presented in Tables 1 and 2. Acidity of the sediments was neutral and weakly acidic, which proves good buffering properties of aqueous environment. The lowest pH values were measured in the Narew River (at the village Narew) – 5.80, while the highest pH occurred in the Orlanka (the village Chraboły)

Table 1

Results of analyses of bottom sediments from the Narew and Supraśl

River	Sampling point	Combustion loss (%)		Organic carbon (%)		Acidity in H_2O	
		August	October	August	October	August	October
Narew	Bondary	3.99	5.5	2.27	2.84	7.77	6.66
	Narew	3.66	6.9	1.98	3.61	7.45	5.8
	Ploski	3.21	0.55	1.99	0.33	7.33	6.64
	Doktorce	3.54	1.98	1.98	1.23	7.22	7.25
	Uhowo	4.99	4.86	2.71	2.5	7.23	6.99
	Bokiny	4.3	6.39	2.79	4.8	7.03	6.36
	Rzędziany	4.12	2.33	2.29	1.98	6.76	6.83
	Złotoria	6.7	1.32	3.74	0.49	7.11	7.14
	Weir Złotoria	4.94	4.97	2.97	2.6	7.42	7.23
	Tykocin	3.56	2.8	2.19	1.73	7.43	7.01
Minimum		3.21	0.55	1.98	0.33	6.76	5.8
Maximum		6.7	6.39	3.74	4.8	7.77	7.25
Arithmetic mean		4.3	3.76	2.49	2.21	-	-
Supraśl	Topolany	5.78	6.84	4.89	3.77	7.32	6.45
	Mościska	5.12	5.32	4.66	4.26	7.36	6.99
	Michałowo	15.21	12.54	10.07	9.12	7.1	7.12
	Gródek	3.98	3.68	2.36	2.22	7.15	7.06
	Supraśl	4.92	0.98	3.58	0.4	7.31	7.2
	Nowodworce	5.32	2.9	3.32	1.49	7.45	7.2
	Fasty	3.82	3.9	2.34	2.95	7.35	7.21
Minimum		3.82	0.98	2.34	0.4	7.1	6.45
Maximum		15.21	12.54	10.07	9.12	7.45	7.21
Arithmetic mean		6.31	5.17	4.46	3.46	-	-

Table 2

Results of analyses of bottom sediments from some tributaries of the Narew

River	Sampling point	Combustion loss (%)		Organic carbon (%)		Acidity in H_2O	
		August	October	August	October	August	October
Narewka	Eliaszuki	3.61	1.87	2.49	1.54	6.73	6.56
	Lewkowo	2.52	2.65	1.53	1.95	6.94	6.83
	Białowieża	6.43	4.18	5.74	2.28	6.88	6.77
Nareśl	Piaski	4.98	4.8	3.18	2.83	6.69	7.16
	Czechowizna	7.4	11.5	5.71	6.49	7.39	7.34
	Kalinówka (Dutki)	16.34	8.43	12.83	5.04	6.84	7.02
Orlanka	Chraboły	3.97	3.4	2.1	2.15	7.12	7.39
	Kotły	3.94	11.6	2.27	6.15	6.92	6.66
	Krzywa	4.9	1.51	3.03	0.91	7.08	7.13
	Orla	2.87	1.4	2.07	0.8	7.12	6.99
Minimum		2,52	1.4	1.53	0.8	6.69	6.56
Maximum		16,34	11.6	12.83	6.49	7.39	7.39
Arithmetic mean		5,7	5.13	4.1	3.01	-	-
Awista	Płonka Kościelna	4.92	4.09	3.38	2.7	7.5	6.69
Czaplinianka	Zawady	4.67	3.32	3.54	2.9	7.01	7.23
Czarna	Pawły	4.21	1.98	2.26	1.2	7.36	7.16
Horodnianka	Choroszcz	4.93	6.18	2.67	4.35	7.38	7.06
Jaskranka	Knyszyn	3.65	10.74	1.95	5.6	7.31	6.76
	Zofiówka	10.23	10.33	5.61	5.3	6.54	7.17
Krzywczanka	Hajdukowszczyzna	4.91	2.33	2.51	1.8	7.12	6.69
Łoknica	Kożyno	2.95	5.84	1.77	2.95	7.45	6.65
Małynka	Trześcianka	13.2	10.6	9.56	5.69	7.3	6.06
Mieńka	Czerewki	3.78	0.93	2	0.5	6.84	7.02
Ruda	Narew	4.67	2.31	3.81	1.65	7.53	6.72
Rudnia	Trześcianka	8.34	2.5	5.01	1.19	7.3	6.65
Strabelka	Strabla	3.19	1.81	2.56	1.17	6.82	6.71
Płoska	Rudnica	15.32	12.34	8.78	7.56	7.21	7.15
Biała	Kuriany	4.89	4.99	2.73	2.58	7.26	7.2
	Bielsk Podlaski	3.96	15.6	2.25	6.13	7.25	7.05
	Lewki	26.32	25.21	20.11	18.6	7.27	7.23
Minimum		2.95	0.93	1.77	0.5	6.54	6.06
Maximum		26.32	25.21	20.11	18.6	7.53	7.23
Arithmetic mean		7.3	7.12	4.74	4.23	-	-

– 7.39. Organic carbon was present at varied concentrations: from 0.40 to 18.6%. The highest value of an arithmetic mean for organic carbon (4.74% in summer and 4.23% in autumn) occurred in group of small rivers, whereas the lowest levels were recorded in the Narew River (2.49% in summer and 2.21% in autumn). Such a low content of organic carbon in the bottom sediments of the upper Narew River, as compared to the Supraśl River and the other rivers, probably resulted from slight sedimentation of particles suspended in the water as well as intensified mineralization of organic matter, which was affected by several factors including aerobic conditions in the river. The rate at which oxygen penetrates from the atmosphere into water depends on the water surface area in contact with air, the flow rate (SQ 5.44 $m^3 \cdot s^{-1}$) and waves. Similar levels of organic carbon were found in the bottom sediments in the Danube (from 0.14% to 4.26% with an arithmetic mean about 2%) (WIŚNIOWSKA-KIELIAN 2007). Some screening studies performed in Norway revealed carbon content in bottom sediments from large rivers ranging from 0.35% to 4.38% (HELLAND et al. 2003).

The bottom sediments from the small rivers were most abundant in organic carbon. These rivers are characterized by a low flow rate and they are mostly overgrown by aqueous plants. Plant communities create conditions favorable for matter accumulation and, at the same time, they are a considerable source of organic matter. The study revealed similar concentrations of organic carbon in the Supraśl and other larger rivers, with an arithmetic mean above 4% in summer and above 3% in autumn. In autumn, a decrease in the organic carbon content became apparent. It is possible that organic matter formed from decaying macrophytes mainly precipitated from the solution and the dissolution process was weaker as the temperatures dropped in autumn (ŁAWACZ 1971). Higher organic carbon concentrations recorded in summer (August) probably resulted from life separation of organic matter by aqueous organisms, as well as decomposition of phytoplankton, which developed abundantly in that season. However, no significant differences in the organic carbon levels between the seasons were observed. WIŚNIOWSKA-KIELIAN (2007) claims that organic carbon concentration in sediments from flows is a resultant of properties of the soil in the catchment, land use, surface runoffs and contamination sources, a conclusion which was confirmed by the present study. The content of organic carbon varied greatly and depended on the location of the sampling points. The highest levels of organic matter and carbon were recorded in the Biała River in the village Lewki. Higher values of these parameters were due to the surface runoffs from fields and the influx of municipal and industrial sewage from Bielsk Podlaski. ALLAN (1998) found that rivers flowing through an urban area carry large amounts of suspensions. DOJLIDO (1995) reported that organic carbon penetrates into water along with municipal and industrial sewage. The excess of unused organic fertilizer components contributes to increase of organic matter in aqueous environment. In the Supraśl (Michałowo) and Płoska Rivers the elevated level of organic matter and carbon may have been generated by the post-bog soils, which are found in that area (MIROWSKI et al. 1990).

The statistical analysis of the data did not reveal statistically significant correlation between the acidity of the bottom sediments and their organic carbon content. As expected, there was significant dependence between combustion loss and organic carbon content in the Narew and Supraśl Rivers as well as in the groups of smaller and larger rivers, where correlation coefficients were R = 0.9403, R = 0.9769, R = 0.9606, and R = 0.9667, respectively.

CONCLUSIONS

1. Bottom sediments collected from the Narew River contained the lowest amounts of organic carbon, which was a consequence of intensive mineralization.

2. Bottom sediments from the smaller rivers were most abundant in organic matter, which was due to the low flow rates and aqueous plant communities growing on the banks of these rivers.

3. The content of organic matter was highly varied between the sampling points.

4. Positive correlation between the combustion loss and organic carbon content was recorded.

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