Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology
Vol. XXXVII, No. 4

Institute of Oceanography (85-91) University of Gdańsk
ISSN 1730-413X 2008 eISSN 1897-3191

DOI 10.2478/v10009-008-0019-8
Original research paper

Received: *July 05, 2008*
Accepted: *November 07, 2008*

The distribution of lead, zinc, and chromium in fractions of bottom sediments in the Narew River and its tributaries

Mirosław Skorbiłowicz[1], Elżbieta Skorbiłowicz

Institute of Civil Engineering, Technical University of Białystok
ul. Wiejska 45 A, 15-351 Bialystok, Poland

Key words: bottom sediments, heavy metals, grain distribution.

Abstract

The purpose of the paper was to evaluate the distribution of lead, zinc and chromium contents in different grain fractions of bottom sediments in the Narew River and some of its tributaries. This study also aimed to determine which fractions are mostly responsible for bottom sediment pollution. The studies of the Narew and its tributaries (the Supraśl, Narewka, and Orlanka) were conducted in September 2005 in the upper Narew catchment area. The analyzed bottom sediments differed regarding grain size distribution. The studies revealed the influence of the percentage of particular grain fractions present on the accumulation of heavy metals in all bottom sediments.

[1] Corresponding author: *mskorbilowicz@pb.bialystok.pl*

INTRODUCTION

The presence of heavy metals in bottom sediments are a good indicator of aqueous environmental pollution (Helios-Rybicka 1991). The amount of heavy metals in river bottom sediments is not uniform. This is not only because of river-bed processes (Ladd et al. 1998). Sediments are not uniform material, and it is difficult to estimate their age or the time when pollution occurred without specific techniques (Wardas 2001). One of the reasons for this is the grain size distribution of bottom sediments (Zhao et al. 1999, Wardas 2000).

Examinations of bottom sediments were conducted for various grain fractions [mm]: <02; <0.18; <0.125; <0.1; <0.063; <0.04; <0.02; <0.02 and even <0.006 and <0.002 (Förstner and Wittmann 1979, Müller and Furrer 1994, Kralik 1999). In Poland, the fraction <0.2 mm was examined during monitoring (Bojakowska et al. 2000) and geochemical mapping (Lis and Pasieczna 1995). Studies of other grain sizes were also conducted: <1mm (Ciszewski 1998), <0.1 mm (Mikucki 1994), <0.063 (Ciszewski 1998, Helios-Rybicka et al. 1999, Bolałek et al. 1999), or <0.02 mm (Helios-Rybicka et al. 1999). Different fractions relate to a different extent to the total metal content in sediments; thus their responsibility for contamination also differs (Sikora et al. 2001, Aleksander et al. 2002).

The purpose of the present paper was to evaluate the distribution of lead, zinc, and chromium contents within the various grain size fractions of bottom sediments in the Narew River and some of its tributaries. The studies also aimed at determining which fractions are mostly responsible for the pollution of sediments.

MATERIALS AND METHODS

Studies were conducted in September 2005 in the upper Narew catchment area. The Narew (basin area of 6270 km^2) and its tributaries, the Supraśl (1856 km^2 basin area), Narewka (711 km^2 basin area), and Orlanka (521 km^2 basin area), were examined. The number of selected measurement points was 10 on the Narew, 7 on the Supraśl, and 4 on the Narewka and Orlanka each. Samples of bottom sediments were collected from shore zones. That zone is characterized by the sedimentation of suspended material (Bojakowska 2003). A higher accumulation of metals in shore zone sediments than in the active zone of a river-bed is considered specific for lowland rivers in regions of moderate climate (Bubb et al. 1991). Several individual samples of bottom sediments from their surface layers (up to 10 cm deep) were taken at every selected point. A representative sample was made by combining the material studied. Bottom sediment, divided into the following grain size fractions, was analyzed (mm):

1.0-0.2; 0.2-0.1; 0.1-0.63; <0.063. The lead, zinc and chromium content of these sediment fractions was determined with the AAS technique, after previous wet digestion in nitric acid in a MARS 5 microwave system. The appropriateness of the method was confirmed by the analysis of reference material NCS DC 73312. Medians were calculated for the particular grain size fractions of bottom sediments from the Narew and its tributaries.

RESULTS AND DISCUSSION

The studied bottom sediments differed in terms of grain size distribution, and mostly exhibited properties of weak loamy and loose sand. The grain characteristics of particular sediments in rivers is presented in Figure 1. In general, the higher percentage of the thickest fraction was recorded (<1.0 mm) within a range from 82% (the Supraśl) to 84% (the Narewka). The <0.2 mm fraction was characterized by a much lower percentage, which was from 12% (the Narewka) to 15% (the Supraśl). The share of the <0.1 mm fraction in the sediments studied was from 2% (Narewka) to 3% (Supraśl). The <0.063 mm fraction was present within a range of 1% (Narew) and 2% (Narewka).

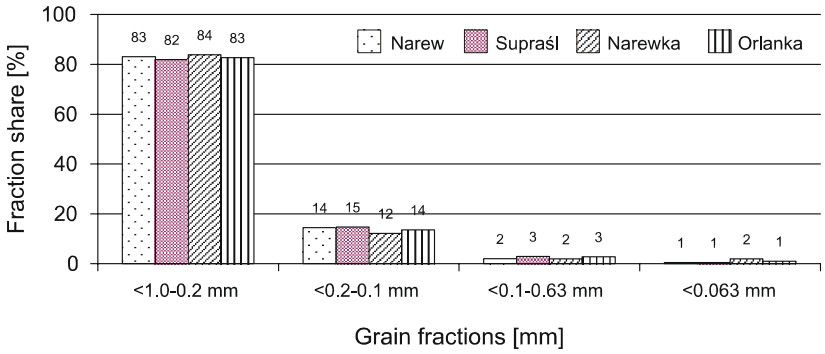

Fig. 1. Share of grain size fractions in the bottom sediments of the studied rivers.

The analyzed sediments were characterized by a lead content range of 1.0 mg kg^{-1} to 34.5 mg kg^{-1} (Fig. 2). The study revealed that the bottom sediments of the <0.2 mm fraction had the highest lead levels, except for those in the Narew. The lowest lead concentration in sediments from all rivers was found in the <0.1 mm fraction. The highest lead content (14.00 mg kg^{-1}) was recorded in the <0.063 mm fraction of sediments from the Narew. In the other rivers, the <0.063 mm fraction contained more lead as compared to the

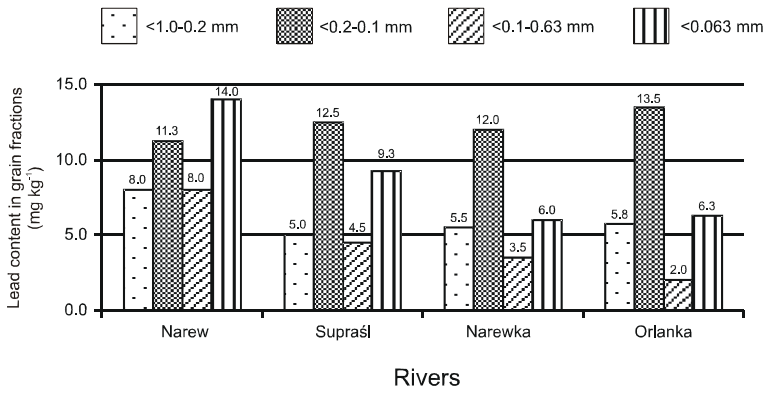

Fig. 2. Lead content in the grain size fractions of the studied rivers.

<0.1 mm fraction. These results are, in part, confirmed by the research of Förstner (1989) and Wardas (1998). In their opinion, high levels of heavy metals are often observed in the thickest fractions as compared to the finest ones.

The concentration of zinc in the bottom sediments from the upper Narew and its tributaries ranged from 2.3 mg kg^{-1} to 95.8 mg kg^{-1}. In general, the zinc content in particular grain fractions increased along with a reduction of grain diameter in almost all the rivers studied (Fig. 3). Only the <0.1 mm fraction from the Narewka and the <0.2 mm fraction from the Narew contained the lowest zinc levels, as compared to other grain fractions. In the case of zinc

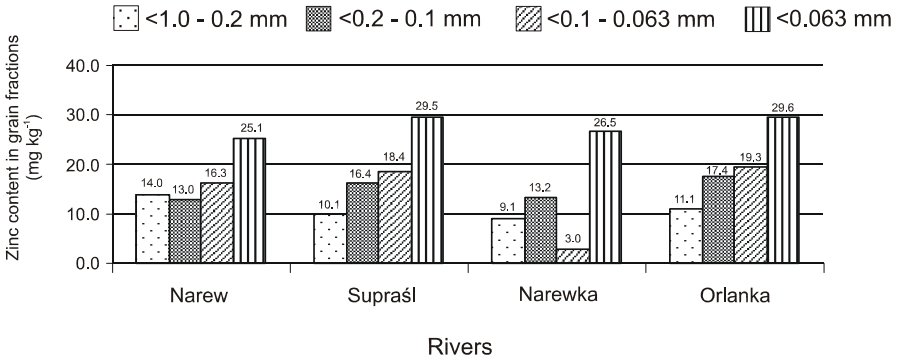

Fig. 3. Zinc content in the grain size fractions of the studied rivers.

concentration in sediments from the Narewka, these levels do not increase along with a reduction of grain size. Similar results were noted by Aleksander et al. (2002), who claimed that zinc content was higher in the thinner fraction of bottom sediments from the Oder River than in thicker ones. In their opinion, the thicker fraction, which has less zinc, causes the "dilution" of the element content in the sediments; thus the greater the fraction, the less zinc there is in sediments. Bojakowska and Sokołowska (1998) found that thinner grain fractions were characterized by higher contents of heavy metals, as compared to thick-particle fractions of the same sample. This was probably associated with the presence of silty minerals and other components with sorption properties. The results of the present study confirm such observations.

Chromium concentration in the tested sediments ranged from 2.9 mg kg^{-1} to 401 mg kg^{-1}. Studies revealed the highest chromium levels in <1 mm and <0.063 mm sediment fractions from all rivers (Fig. 4). Chromium content in <0.2 mm and <0.1 mm fractions appeared to be very similar for all the analyzed rivers. These results were confirmed by the authors cited above.

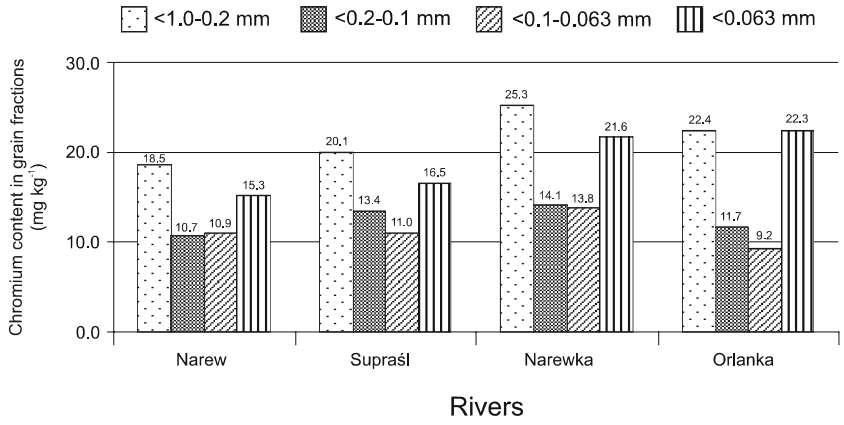

Fig. 4. Chromium content in the grain size fractions of the studied rivers.

CONCLUSIONS

1. The study revealed the highest percentage of the <1 mm fraction and the lowest content of the <0.63 mm fraction in all rivers.
2. The influence of grain composition in bottom sediments on heavy metals accumulation was apparent.
3. Zinc contents increased along with a decrease of sediment grain size.

4. Thicker fractions of bottom sediments accumulated high amounts of lead and chromium.

ACKNOWLEDGEMENTS

This study was financed by the Ministry of Education and Science within the framework of Scientific Project No 3 TO9D 112 28, (2005-2007).

REFERENCES

Aleksander U., Sikora S., Wanda, Wójcik R., 2002, *Distribution of zinc contents among grain fractions of bottom sediments from river Odra*, Cynk w środowisku-problemy ekologiczne i metodyczne. Zesz. Nauk. "Człowiek i środowisko", PAN, 33, 281-288.

Bojakowska I., 2003, *Geochemical characteristics of bottom sediments from the Narew River and its tributaries.* [W]: Zagospodarowanie zlewni Bugu i Narwi w ramach zrównoważonego rozwoju. Mater. Konf. Warszawa-Popowo, 23-24 May 2003, IMGW, Warszawa: 137-146.

Bojakowska I., Sokołowska G., 1998, *Geochemical purity classes of bottom sediments*, Przeg.Geolog. 46, 1, 49-54.

Bojakowska I., Gliwicz T., Sokołowska G., 2000, *Geochemical monitoring results of bottom sediments in Poland in 1998-1999.* Warszawa 92 ss.

Bolałek J., Dembska G., Aftanas B., Hofman J., Szefer P., 1999, *Vertical distribution of labile of heavy metals in different granulometric fraction of sediments cores collected at Gdańsk Harbor.* 7 EUCC International Conference Coastlines 99, 7-12 June, Międzyzdroje, Poland, 20.

Bubb J., Rudd T., Lester J.N., 1991, *Distribution of heavy metals in the River Yare and its associated broads. I. Mercury and Methylmercury.* Sci. Total Environ., 102, 147-168

Ciszewski D., 1998, *Channel processes as a factor controlling accumulation of heavy metals in river bottom sediments; consequences for pollution monitoring (Upper Silesia, Poland).* Environmental Geology, 36,45-54.

Förstner U., 1989, *Contaminated Sediments.* Springer-Verlag, Berlin.

Förstner U., Wittmann G. T. W., 1979, *Metal Pollution in the Aquatic Environment* Springer-Verlag, Berlin.

Helios Rybicka E., Strzebińska M., Wardas M., 1999, *Sedimentqualität in Oder und Weichsel – Sediment Quality of the Rivers Oder and Vistula,* in: Bundesanstalt für Gewässerkunde. Mitteilung, 22, Sedimentbewertung in europäischen Flussgebieten – Sediment Assessment in European River Basins. Beiträge zum internationalen Symposium, Berlin, 45-52.

Helios-Rybicka E., 1991, *Accumulation and mobilization of heavy metals in bottom sediments of aqueous environment: dated sediments as chronological indicator*, Mat. Konf.: Geologiczne aspekty ochrony środowiska, Kraków s.18-23.

Kralik M., 1999, *A rapid procedure for environmental sampling and evaluation of polluted sediments*. Appl. Geochem. 14, 807-816.

Ladd S. C., Marcus W. A., Cherry S., 1998, *Differences in trace metal concentrations among fluvial morphologic units and implications for sampling,* Environmental Geology 36, 3-4, Springer-Vveriag, 259-270.

Lis J., Pasieczna A., 1995, *Geochemical atlas of Poland in scale 1 : 2 500 000,* Państw. Inst. Geol., Warszawa, 72.

Mikucki S. Z., 1994, *Influence of a former mining on Ziemia Kłodzka alluvia pollution with metallic elements.* Przegląd Geologiczny 42, 470-476.

Müller G., Furrer R., 1994, *Die Belastung der Elbe mit Schwermetallen.* Erste Ergebnisse von Sedimentuntersuchungen. Naturwissenschaften 81, 401-405.

Sikora W.S., Aleksander U., Wójcik R., Wardas M., Łagan Ł., 2001, *Contents of heavy metals in grain fractions of bottom sediments from river Odra near Głogów***.** „Nauki o Ziemi w badaniach podstawowych, złożonych i ochronie środowiska na progu XXI wieku", Kraków 28-29 czerwiec 2001, Mat. Konf., 409-412.

Wardas M., 1998, *Different lead contents in river bottom sediments depending on sampling site and technique.* Ołów w środowisku-problemy ekologiczne i metodyczne. Zesz. Nauk., Człowiek i środowisko", PAN, 21, 149-160.

Wardas M., 2000, *Contamination of bottom sediments from upper Vistula catchment with cadmium. Cadmium in an environment*–ecological and methodological problems. Zesz. Nauk.,,Człowiek i środowisko", PAN, 26, 157-168.

Wardas M., 2001, *Studies upon heavy metals in bottom sediments in southern Poland. Analytical problems at bottom sediments studying,* Sympozjum Naukowe Komitetu Chemii Analitycznej PAN, Komisja Analizy Wody, Radom-Jedlnia 2001, Materiały pokonferencyjne pod redakcją Jerzego Siepaka, Poznań, 63-74.

Y. Zhao, S. Marriott, J. Rogers, K. Iwugo, 1999, *Preliminary study of heavy metal distribution on the floodplain of the River Severn, UK, by a single flood event.* The Science of the Total Environment, 243/244, 219-231.