Arch. Pol. Fish.	Archives of Polish Fisheries	Vol. 15	Fasc. 4	273-286	2007

HEAVY METALS IN THE KONIN LAKES SYSTEM

Elżbieta Królak, Jakub P. Pyka**, Bogusław Zdanowski***

*Department of Ecology and Environmental Protection, Institute of Biology, University of Podlasie, Siedlce, Poland

**Department of Hydrobiology, The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn, Poland

ABSTRACT. The aim of the current research project was to analyze the contents of heavy metals in tissues of *Vallisneria spiralis* (L.), *Sinanodonta woodiana* (Lea), and *Dreissena polymorpha* (Pall.) and in the bottom sediments of the Konin lakes system located in the vicinity of the Konin and Pątnów power plants (central Poland). It was determined that the mussels occurring in the studied lakes accumulate higher quantities of heavy metals in comparison with species from the same family that occur in unpolluted lakes. *V. spiralis* cumulated higher quantities of zinc, copper, cadmium, and lead than did submerged vegetation in basins that were not exposed to power plant pollution. The contents of lead and copper in the bottom sediments of the Konin lakes system exceed levels that are accepted as the norm for Polish lakes.

Key words: HEAVY METALS, *VALLISNERIA SPIRALIS*, *SINANODONTA WOODIANA*, *DREISSENA POLYMORPHA*, BOTTOM SEDIMENTS, KONIN LAKES

INTRODUCTION

As filter feeders, mollusks, including mussels, are currently widely used as bioindicators of heavy metal levels in aquatic environments (Bush 1991, Kraak 1992, Jurkiewicz-Karnkowska 1998, 2004, Jamil et al. 1999). Macrophytes also play an important role in the accumulation of metals in aquatic environments (see Ozimek 1988).

The Konin lakes are subjected to the effects of pollution emitted by two nearby power plants: Konin, operational since 1958, and Pątnów, operational since 1970. In addition to nonmetal oxides that are generated in the coal burning process, heavy metals are also released into the atmosphere. These fall to the ground in the vicinity of the power plants and accumulate in the environment. Due to the heating of the Konin lakes, they offer advantageous conditions for the expansion of animal and vegetation species that are alien to Poland. The Chinese mussel, *Sinanodonta woodiana* (Lea), has

CORRESPONDING AUTHOR: Elżbieta Królak, Akademia Podlaska, Instytut Biologii, Katedra Ekologii i Ochrony Środowiska, ul. Prusa 12, 08-110 Siedlce, Tel.+48 25 6431217; e-mail: kruell@02.pl

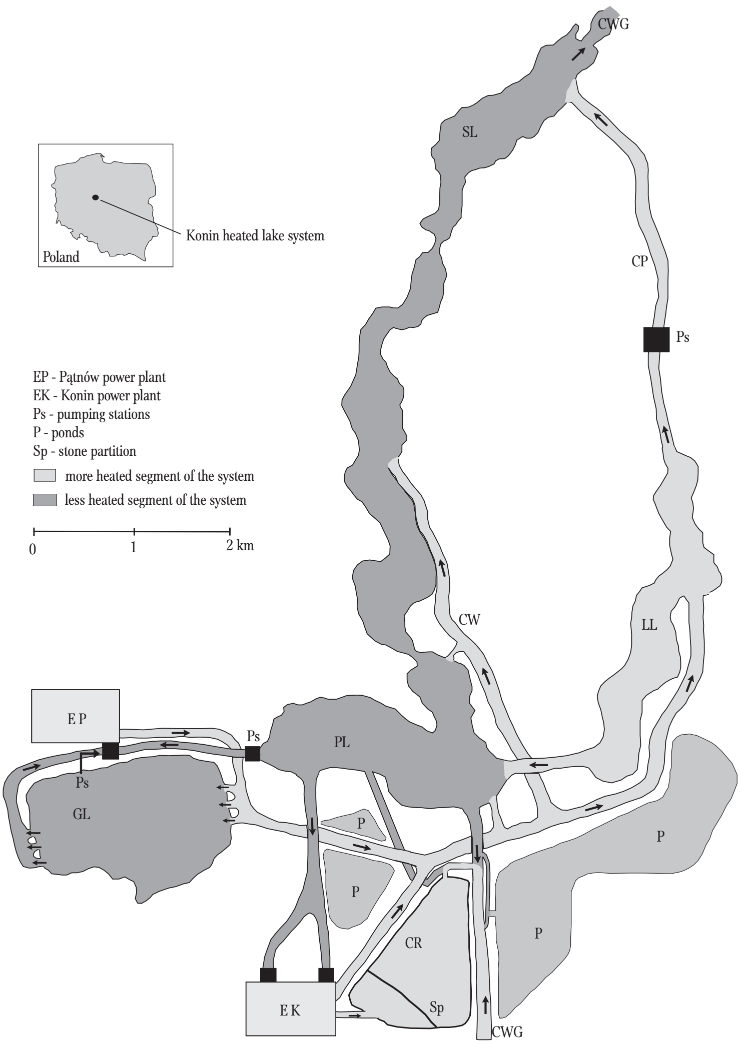

Fig. 1. Konin lakes system. GL – Gosławskie Lake, PL – Pątnowskie Lake, LL – Licheńskie Lake, SL – Ślesińskie Lake, CW – Wąsowski Canal, CWG – Warta-Gopło Canal, CR – Initial cooling reservoir.

found good habitat conditions in these lakes and has been noted in them since 1993 (Zdanowski 1996). Currently, it is the dominant species among the Unionidae (Kraszewski 2004). *Vallisneria spiralis* (L.), one of the new plant species that occurs mainly in lakes Licheńskie and Pątnowskie and the canals that link the individual lakes, was noted for the first time in the early 1990s (Protasov et al. 1994).

The aim of the research was to determine the contents of selected heavy metals in the mussels *S. woodiana* and *Dreissena polymorpha* (Pall.), in the macrophyte *V. spiralis* that dominates the lake littoral zones and canals, and in the bottom sediments. Based on the results of the analyses, an attempt was made to estimate the impact that the nearby Konin and Pątnów power plants have on the Konin lakes system.

MATERIALS AND METHODS

The research included four lakes, Pątnowskie, Gosławskie, Licheńskie, and Ślesińskie, located in the Wielkopolsko-Kujawskie Lakeland (central Poland), an initial cooling reservoir, and the canals that connect the individual lakes (Fig. 1). The lakes are used as post-cooling water reservoirs for the two nearby power plants (Stawecki et al. 2007). In June 2001, divers collected *S. woodiana* and *D. polymorpha* mussel samples and *V. spiralis* samples with a Bernatowicz grab. The analysis of the heavy metal contents in the surface layer of bottom sediments was based on samples collected with a tube grab from the same mussel and macrophyte sampling sites.

The mussels were preserved in ethyl alcohol, and then dried to a constant weight at a temperature of 60°C separating the soft tissues from the shell in the laboratory. Next, the samples were homogenized. Sub-samples of the processed soft-tissue (0.5 g) and shell (1.0 g) samples were mineralized in 4 cm^3 of concentrated nitric acid and 2 cm^3 hydrogen peroxide, and then moved quantitatively to a measuring flask and distilled water was added to a volume of 50 cm^3. *V. spiralis* samples were dried at a temperature of 60°C, following which 2 g of plant tissue was subjected to dry mineralization at 420°C. The ash obtained was dissolved in the same way as with the mussel samples. The bottom sediment samples were subjected to identical dry and wet mineralization. The contents of metals in the solutions obtained from mineralization were determined with the AAS method (Szczepaniak 2004), with a Carl-Zeiss Jena 30 analyser.

RESULTS

The highest mean average copper content was noted in the soft tissues of *S. woodiana* (196.8 mg kg^{-1}) and the lowest in the shells of *D. polymorpha* (6.95 mg kg^{-1}). The mean copper content in *V. spiralis* was 142.7 mg kg^{-1}. Variations in the copper content of the tissues of the analyzed organisms and the bottom sediments in the lakes

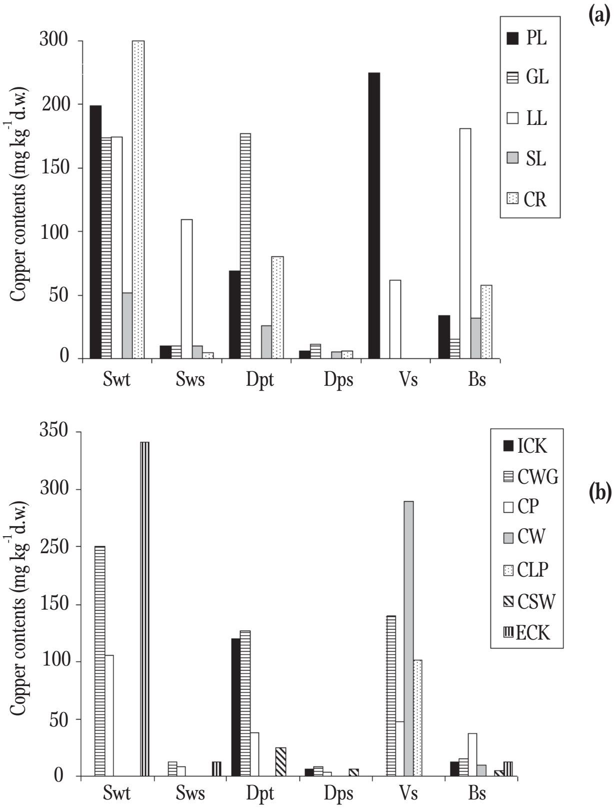

Fig. 2. Copper contents in *S. woodiana*, *D. polymorpha*, *V. spiralis* and bottom sediments of lakes (a) and canals connecting lakes (b); Swt – *S. woodiana* tissues; Sws – *S. woodiana* shells; Dpt – *D. polymorpha* tissues; Dps – *D. polymorpha* shells; Vs – *V. spiralis*; Bs – bottom sediments; PL – Lake Pątnowskie, GL – Lake Goławskie, LL – Lake Licheńskie, SL – Lake Ślesińskie, CR – Initial Cooling Reservoir, ICK – inlet canal into Konin Power Plant, CWG – Warta-Gopło Canal, CP – Piotrkowicki Canal, CW – Wąsoski Canal, CLP – Licheńskie-Pątnowskie Canal, CSW – Ślesińskie-Wąsoskie Canal, ECK – effluent canal from Konin Power Plant.

(Fig. 2a) and canals (Fig. 2b) compared were great, although it was impossible to distinguish a general pattern of dependence between copper content and the type of aquatic environment.

The highest mean content of zinc was noted in the soft tissues of *S. woodiana* (957.4 mg kg^{-1}) and the lowest in the bottom sediments of the canals that connect the lakes (15.2 mg kg^{-1}; Fig. 3). The shells of *S. woodiana* contained a twofold higher mean zinc content in comparison with *D. polymorpha* (239.1 and 120.7 mg kg^{-1}, respectively), while that noted in *V. spiralis* was 234.1 mg kg^{-1}.

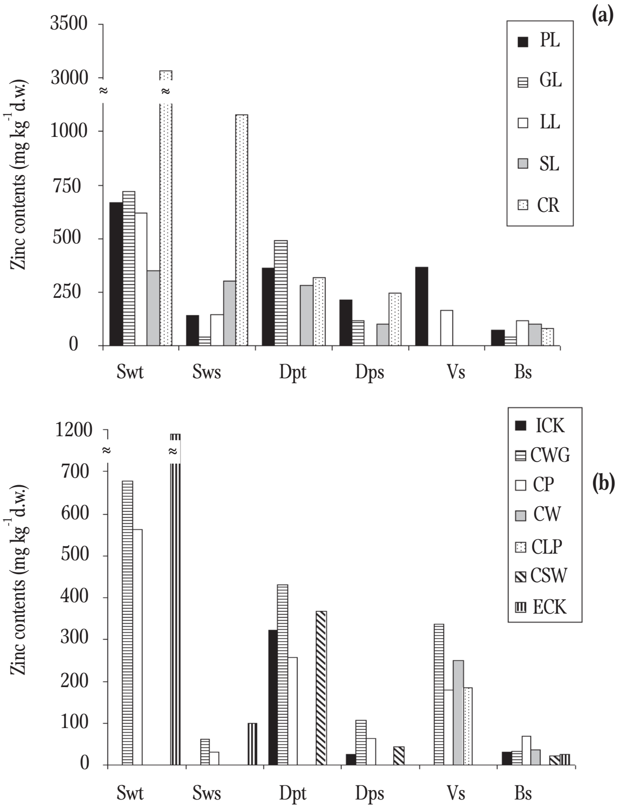

Fig. 3. Zinc contents in *S. woodiana*, *D. polymorpha*, *V. spiralis* and bottom sediments of lakes (a) and canals connecting the lakes (b); for explanation see Fig. 2.

The soft tissues of *S. woodiana* were confirmed to have the highest mean content of manganese (4814.9 mg kg^{-1}), and the lowest mean content of this element was detected in the shells of *D. polymorpha* (51.5 mg kg^{-1}; Fig. 4). The mean content of manganese in *V. spiralis* was 1015.3 mg kg^{-1}, and in the bottom sediments it was 148.5 mg kg^{-1}. Only in the case of *V. spiralis* the mean content of manganese was lower in the lentic zone than in the lotic zone (Fig. 4b).

The highest mean content of iron was confirmed in the soft tissues of *S. woodiana* (2683.1 mg kg^{-1}; Fig. 5). There was high variation in the content of this element in the tissues of this mussel species. The iron content of the samples from Lake Ślesińskie was 28-times lower than that in those from the Konin Power Plant effluent canal (494.2 and 13870 mg kg^{-1}, respectively). The mean iron content in the bottom sediments and

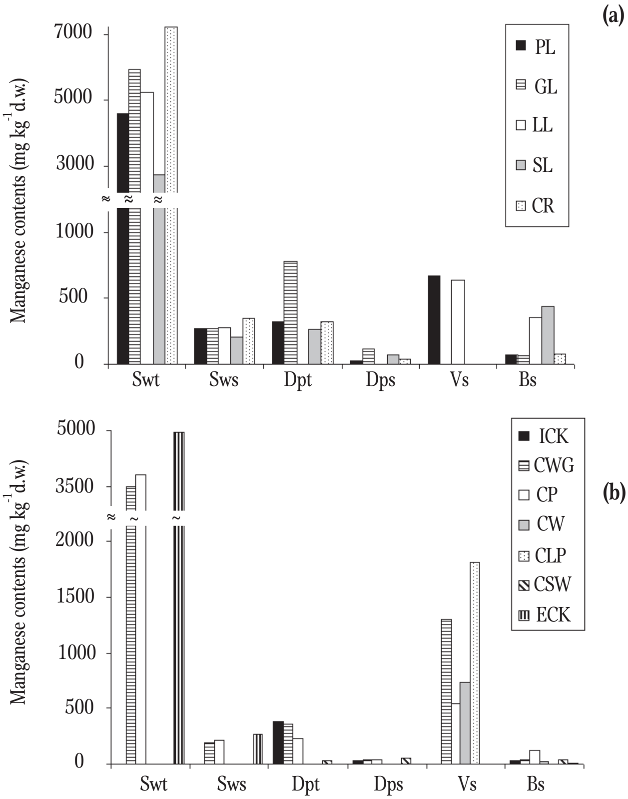

Fig. 4. Manganese contents in *S. woodiana*, *D. polymorpha*, *V. spiralis* and bottom sediments of lakes (a) and canals connecting the lakes (b); for explanation see Fig. 2.

the *V. spiralis* samples from the lakes studied was also very high (2683.1 and 2531.8 mg kg^{-1}, respectively). The lowest mean iron content was confirmed in the shells of both of the mussel species; in *S. woodiana* it was 192.0 and in *D. polymorpha* it was 122.1 mg kg^{-1}.

The tissues of *V. spiralis* were confirmed to contain the highest mean levels of lead (69.6 mg kg^{-1}; Fig. 6). The mean lead content in the soft tissues of *S. woodiana* and *D. polymorpha* were 16.1 and 7.42 (mg kg^{-1}), while the mean lead contents in the bottom sediments from the lakes and canals were 31.4 and 10.7 mg kg^{-1}, respectively. The lowest mean lead content was noted in the mussel shells; 1.3 and 1.8 mg kg^{-1}, respectively, for *S. woodiana* and *D. polymorpha*.

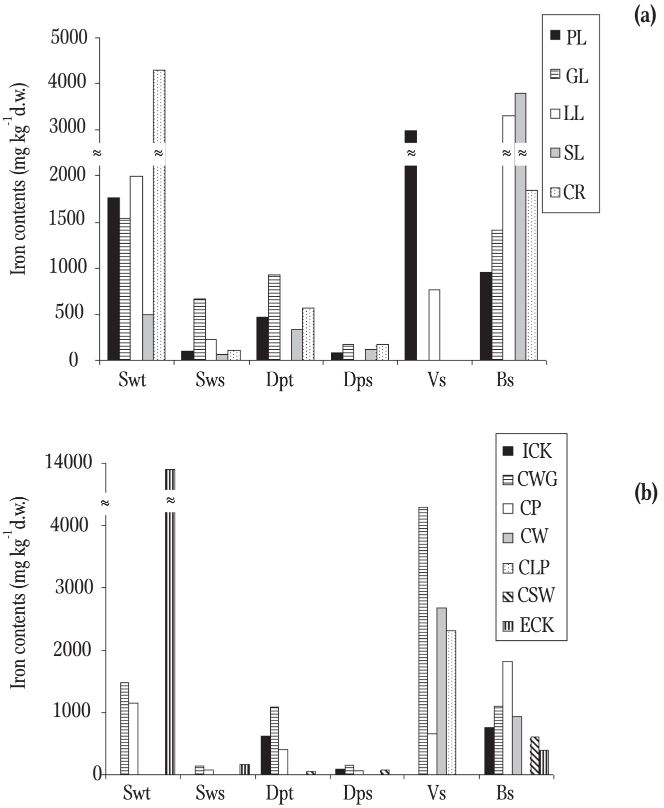

Fig. 5. Iron contents in *S. woodiana*, *D. polymorpha*, *V. spiralis* and bottom sediments of lakes (a) and canals connecting the lakes (b); for explanation see Fig. 2.

The highest mean content of cadmium was confirmed in the tissues of *V. spiralis* (5.8 mg kg^{-1}), while the lowest was in the shells of *S. woodiana* (0.0026 mg kg^{-1}; Fig. 7). The soft tissues of *D. polymorpha* contained mean cadmium levels of 0.3 mg kg^{-1}, while the bottom sediments of the lakes and canals contained 0.7 (Fig. 7a) and 0.6 mg kg^{-1}(Fig. 7b), respectively.

DISCUSSION

The metal contents in the bottom sediments of the Konin lakes are similar to those measured in the sediments of lakes in other regions of Poland. For example, in Lake Góreckie (Wielkopolska National Park, Poland) the content of heavy metals in the

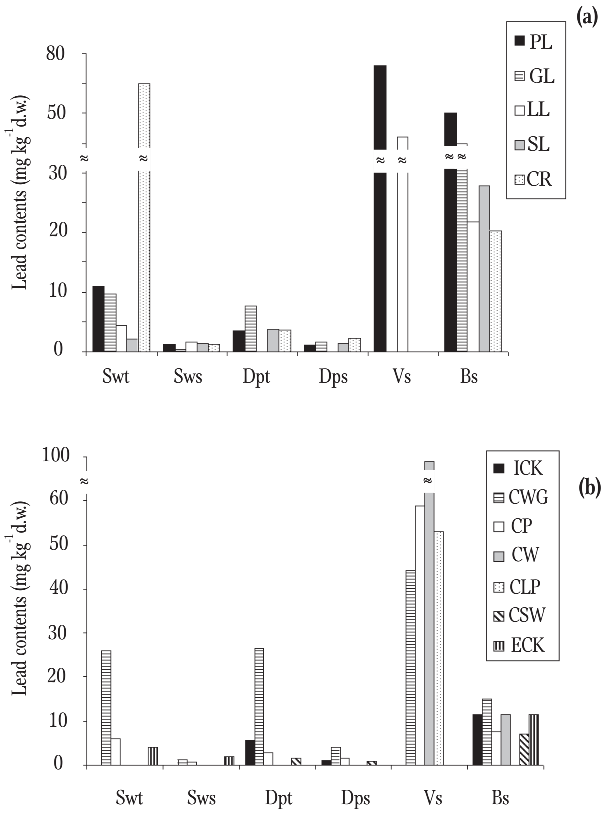

Fig. 6. Lead contents in *S. woodiana*, *D. polymorpha*, *V. spiralis* and bottom sediments of lakes (a) and canals connecting the lakes (b); for explanation see Fig. 2.

bottom sediments was within the following range (in mg kg^{-1}): Cu – 2.85-19.20; Zn – 12.7-110.0; Cd – 1.19-4.76; Pb – 11.2-74.4 (Sobczyński et al. 1996). The sediments of lakes in the Kaszubskie Lakeland (Bojakowska and Sokołowska1996a) were found to contain the following quantities of metals (in mg kg^{-1}): Zn – 126, Cd – 0.7; Cu – 11.0; Pb – 36.0. In the littoral zone of Lake Piaseczno (Łęczyńsko-Włodawskie Lakeland), Górniak et al. (1993) confirmed that the mean copper content was 11 mg kg^{-1}, lead – 47 mg kg^{-1}, and manganese – 161 mg kg^{-1}. Bojakowska and Sokołowska (1996b) proposed the following values of metals as the geochemical norms for lake sediments in Poland (in mg kg^{-1}): Zn < 100; Cd < 1; Cu < 20; Pb < 20. The comparison of these values to those determined for the bottom sediments from the lakes of the Konin system indicate that the values for zinc and cadmium do not exceed the values

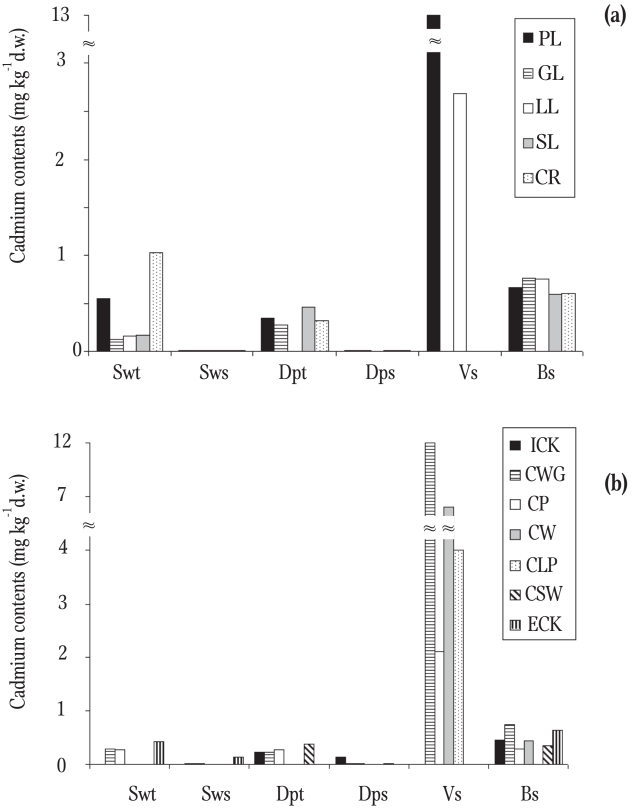

Fig. 7. Cadmium contents in *S. woodiana*, *D. polymorpha*, *V. spiralis* and bottom sediments of lakes (a) and canals connecting the lakes (b); for explanation see Fig. 2.

considered as normal. However, in some lakes, for example Lake Licheńskie, the values of zinc are higher than that which is considered normal. Substantially higher metal contents in bottom sediments than those in the Konin lakes were determined in Rybnik Reservoir located near the Rybnik Power Plant by Loska et al. (1994). The values determined in the Rybnik Reservoir were as follows: Zn > 100 mg kg^{-1}; Cd – approximately 30 mg kg^{-1}; Cu – approximately several hundred mg kg^{-1}, Pb – approximately in excess of 100 mg kg^{-1}. According to Hławiczka (1994, 1995), the metal emission indicators are much higher for bituminous coal burning than they are for lignite burning. For the sake of comparison, they are as follows: Zn – 1.795 and 1.084 g Mg^{-1}; Pb – 0.93 and 0.19. Due to this, the areas located within the vicinity of a bituminous-burning power plant appear to be more susceptible to environmental pollution with heavy metals than areas surrounding power plants that burn lignite.

The metals that are released into the environment by energy generation are carried on the smallest dust fractions. Linak and Miller (2000) estimated that the most of metals produced during the coal burning process are released into the atmosphere with dust fractions that are < 2.5 μm particle size. Cadmium can be carried for a long distance from the point source of pollution (Steinnes et al. 1989, 1997); however, the content of lead in the environment decreases with distance from the point source of pollution (Steinnes et al. 1989, 1997, Hewitt and Candy 1990, Donisa et al. 2000). Copper concentrations also decrease with distance from the emission source (Grzebisz et al. 2001, Lyanguzova 2003). The content of cadmium in the bottom sediments of the studied lakes did not differ much and ranged from 0.6 mg kg^{-1} (initial cooling reservoir) to 0.78 mg kg^{-1} (Lake Licheńskie). Among the studied lakes, much higher differences were noted in the bottom sediment contents of copper, lead, and zinc. The Lake Licheńskie bottom sediments had the highest concentrations of copper and zinc, while the highest lead content in bottom sediments was noted in Lake Pątnowskie, which is nearest the power plants.

Metals that reach the Konin lakes with the small dust fractions accumulate in both aquatic plants and animals. Submerged macrophytes are especially capable of accumulating metals (Ozimek 1988). In the Konin lakes, *V. spiralis* accumulates copper, zinc, lead, and cadmium in quantities that exceed nearly twenty-fold the values determined in emerged vegetation (e.g., *Potamogeton* sp.) occurring in other lowland Polish waters such as Lake Łękuk (Smoleński 1999) or the Zegrzyński and Siedlecki reservoirs (Jurkiewicz-Karnkowska and Królak 1999). According to data from the literature, the metal content of *Potamogeton* sp. (Smoleński 1999, Jurkiewicz-Karnkowska and Królak 1999) or *Myriophyllum spicatum* (Smoleński 1999) in basins that are not under high anthropogenic stress is as follows (in mg kg^{-1}): Zn – 11.25 and 34.80 ; Cu – 2.54 and 12.2; Pb – 1.17 and 16.80; Cd – 0.05 and 1.43.

Mollusks play an important role in the accumulation of heavy metals in the aquatic environment. The source of heavy metals for mollusks is food (among others, see Pentreath 1973, Luoma et al. 1992, Jurkiewicz-Karnkowska 2000, 2004). Mussels that are good filter feeders strain the metals contained in the water along with suspensions. Kraszewski (2004) calculated that the water filtration rate of *S. woodiana* in the Konin lakes can be as high as 510 cm^3 water per $indiv.^{-1}$ $hour^{-1}$. According to calculations by Stańczykowska (1968), *D. polymorpha* filters about 35 (10-100) cm^3 water $indiv.^{-1}$ $hour^{-1}$. Jurkiewicz-Karnkowska (2000) draws attention to the strict correlation between the metal content of water and accumulation in mollusks, including *D. polymorpha*.

Of the results presented, the relatively high contents of Cu, Zn, and Pb in the tissues of the mussels occurring in the Konin lakes are significant. Jurkiewicz-Karnkowska (2004) noted the following metal contents in mussels of the genus Anodonta in lowland dam reservoirs (Zegrzyński, Siemianówka, Sulejowski, Włocławski) (in mg kg^{-1}): Cu – 7.2-10.7; Zn – 131.8-318.7; Pb – 0.7-13.2. While in the soft tissues of *D. polymorpha* the same researcher noted the following metal contents (in mg kg^{-1}): Cu – 7.3-20.5; Zn – 95.1-177.1; Pb – 1.0-14.4. The contents of these elements were higher in the shells of the mussels from the Konin lakes than in those of the mussels inhabiting the dam reservoirs mentioned above.

The highest density of *S. woodiana* in the Konin lakes was noted in the initial cooling basin into which the Konin Power Plant discharges heated water (Kraszewski 2004). Their abundance ranged from 26 to 60 indiv. m^{-2}, and biomass from 11.3 to 26.3 kg m^{-2}. The determining factor for *S. woodiana* growth in the Konin lakes was temperature. According to Kraszewski (2004), this mussel grew more intensely in the initial cooling reservoir and the warm canals than it did in the lakes. It is worth noting that the soft tissues of the *S. woodiana* occurring in the initial rearing basin accumulated the greatest amounts of Cu, Zn, Mn, Pb, and Cd. This dependency was not noted in the case of *D. polymorpha*, as this mussel is not very tolerant of high temperatures (Stańczykowska 1976, Sinicyna et al. 2001), which limited its occurrence in this basin. The levels of heavy metals in the soft tissues of mollusks can be determined by the metal content in the environment, the filtration rates of different species, the conditions set by species characters, and environmental factors. The mean contents of heavy metals in the soft tissues of *S. woodiana* inhabiting the Konin lakes were from several to several tens of times higher than in the soft tissues of *D. polymorpha*. The metals determined accumulated in the mussel shells in much lower quantities than they did in the soft tissues. *S. woodiana* was particularly adept at accumulating biophilic metals, especially copper, zinc, and manganese in its soft tissues. The relatively high concentration of zinc (3022.4 mg kg^{-1}; Fig. 3a) and lead (66 mg kg^{-1}; Fig. 6a) in the soft tissues of *S. woodiana* inhabiting the initial cooling basin are worthy of mention.

Considering that metals emitted from the chimneys of power plants are carried on the smallest dust fractions (Linak and Miller 2000), when estimating the impact of pollution emitted from the Konin and Pątnów power plants on the accumulation of heavy metals in the Konin lake environments, it would also be useful to analyze the content of these elements in the water, including in the seston. This is indicated, among other factors, by the accumulation of metals in the soft tissues of the mussels studied. The results of the current research suggest that the contents of heavy metals in the fish caught in the Konin lakes should also be analyzed.

CONCLUSIONS

1. The accumulation of zinc and cadmium in the bottom sediments of the Konin lakes system does not exceed the values proposed as the geochemical background values for Polish lakes; however, lead and copper contents are in excess of the background values.
2. The submerged macrpohytes occurring in the Konin lakes (*V. spiralis*) accumulate zinc, copper, cadmium, and lead in higher amounts in relation to emerged aquatic vegetation (*Potamogeton* sp or *Myriophyllum spicatum*) occurring in other Polish basins. The accumulation of manganese and iron is similar in the two plant types.
3. The mussels (*S. woodiana* and *D. polymorpha*) inhabiting the lakes were noted to have higher heavy metal contents than mussels belonging to the same families occurring in other regions of Poland.
4. The fish caught in the Konin lakes should be analyzed for heavy metal contents.

REFERENCES

Bojakowska I., Sokołowska G. 1996a – Heavy metals in the bottom sediments of lakes in the Kashubian Lakeland – Prz. Geol. 44: 920-923 (in Polish).

Bojakowska I., Sokołowska G. 1996b – Results of geochemical monitoring of aquatic sediments in Poland in 1994-1995 – Biblioteka Monitoringu Środowiska, PIOŚ, Warszawa (in Polish).

Busch D. 1991 – Entwicklung und Erprobung von Methoden für einen Einsatz der Süßwassermuschel *Dreissena polymorpha* (Pallas) für ein Biomonitoring von Schwermetallen im Ökosystem Weser – Ph.D. Dissertation, Universität Bremen.

Donisa C., Mocanu R., Stennes E., Vasu A. 2000 – Heavy metal pollution by atmospheric transport in natural soil from the northern part of Eastern Carpathians – Water Air Soil Pollut. 120: 347-358.

Górniak A., Misztal M., Magierski J. 1993 – Differentiation of the chemical composition of near-bottom waters and bottom sediments of the mesotrophic Lake Piaseczno (Łęczyńsko-Włodawskie Lake District, Poland) – Acta Hydrobiol. 35: 193-202.

Grzebisz W., Cieśla L., Diatta J.B. 2001 – Spatial distribution of copper in arable soils and non-consumable crops (Flax, Oil-Seed Rape) cultivated near a copper smelter – Pol. J. Environ. Stud. 10: 269-273.

Hewitt C.N., Candy G.B.B. 1990 – Soil and street dust heavy metal concentrations in and around Cuenca, Ecuador – Environ. Pollut. 63: 129-136.

Hławiczka S. 1994 – Atmospheric emissions of heavy metals from fueled energy processes in Poland. Part.I. – Ochr. Powiet. Probl. Odpadów 164: 143-145 (in Polish).

Hławiczka S. 1995 – Atmospheric emissions of heavy metals from fueled energy processes in Poland. Part II. – Ochr. Powiet. Probl. Odpadów 165: 5-8 (in Polish).

Jamil A., Lajtha K., Radan S., Ruzsa G., Cristofor S., Postolache C. 1999 – Mussels as bioindicators of trace metal pollution in the Danube Delta of Romania – Hydrobiologia 392: 143-158.

Jurkiewicz-Karnkowska E. 1998 – The reaction of molluscs to environmental pollution and the possibility of employing them as bioindicators – Wiad. Ekol. 44: 217-234 (in Polish).

Jurkiewicz-Karnkowska E. 2000 – Can molluscs be bioindicators of heavy metal contamination of the Zegrzyński Reservoir (Central Poland)? – Chemia Inż. Ekol. 7: 1067-1076.

Jurkiewicz-Karnkowska E. 2004 – Malacocoenoses of large lowland dam reservoirs of the Vistula River basin and selected aspects of their function – Folia Malacol. 12: 1-56.

Jurkiewicz-Karnkowska E., Królak E. 1999 – The level of Cu, Zn, Mn, Fe, Pb and Cd in some elements of two dam reservoirs (bottom deposits, macrophytes and snails) – Ochrona Środowiska i Zasobów Naturalnych 18: 325-337 (in Polish).

Kraak M.H.S. 1992 – Ecotoxicity of metals to the freshwater mussel *Dreissena polymorpha* – Ph.D. Thesis, University of Amsterdam.

Kraszewski A. 2004 – Structure and functioning of the Chinese mussel *Anodonta woodiana* (Lea, 1834) in the Konin heated lakes system – Ph. D. Thesis, Inland Fisheries Institute, Olsztyn, 116 p. (in Polish).

Linak W.P., Miller C.A. 2000 – Comparison of particle size distributions and elemental partitioning from the combustion of pulverized coal and residual fuel Oil – J. Air Waste Manage. Assoc. 50: 1532-1544.

Loska K., Wiechuła D., Pelczer J., Kwapuliński J. 1994 – Occurrence of heavy metals in bottom sediments of a heated reservoir (the Rybnik Reservoir, southern Poland) – Acta Hydrobiol. 36: 281-295.

Luoma S.N., Johns C., Fisher N.S., Steinberg N.A., Oremland R. S., Reinfelder J.R. 1992 – Determination of selenium bioavailability to a benthic bivalve from particulate and solute pathways – Environ. Sci. Technol. 26: 485-491.

Lyanguzova I. 2003 – Effect of environmental pollution by heavy metals on their accumulation in flower plants – Ekologija (Vilnius) 2: 49-52.

Ozimek T. 1988 – The role of macrophytes in cycling of heavy metals in water ecosystem – Wiad. Ekol. 34: 31-44 (in Polish).

Pentreath R.J. 1973 – The accumulation from water of ^{65}Zn, ^{54}Mn, ^{58}Co, and ^{59}Fe by the mussel, *Mytilus edulis* – J. Mar. Biol. Ass. U.K. 53:127-143.

Protasov A.A., Afanasjev S.A., Sinicyna O.O., Zdanowski B. 1994 – Composition and functioning of benthic communities – Arch. Pol. Fish. 2: 257-284.

Sinicyna O.O., Protasov A.A., Zdanowski B., Kraszewski A. 2001 – Ecological niche of *Dreissena polymorpha* (Pall.) aggregations in the heated Konin lakes system – Arch. Pol. Fish. 9: 133-142.

Smoleński A. 1999 – Heavy metals in components of the aquatic environment within the drainage basin of Lake Łękuk – Ochrona Środowiska i Zasobów Naturalnych 17: 19-44 (in Polish).

Sobczyński T., Zerbe J., Elbanowska H., Siepak J. 1996 – Chemical examination of bottom sediments of the Góreckie Lake in the context of an anthropogenic stress impact evaluation – Ekol. i Tech. 2: 14-18 (in Polish).

Stańczykowska A.1968 – The filtration capacity of populations of *Dreissena polymorpha* (Pall.) in different lakes as a factor affecting circulation of matter in the lake – Ekol. Pol. 14: 372-379 (in Polish).

Stańczykowska A. 1976 – Occurrence and growth of *Dreissena polymorpha* (Pall.) in lakes included in a cooling system – Rocz. Nauk Rol. H-97: 109-123 (in Polish).

Stawecki K., Pyka J.P., Bogusław Zdanowski B. 2007 – The thermal and oxygen relationship and water dynamics of the surface water layer in the Konin heated lakes ecosystem – Arch. Pol. Fish. 15: 247-258.

Steinnes E., Solberg W., Petersen H.M., Wren C.D. 1989 – Heavy metal pollution by long range atmospheric transport in natural soils of Southern Norway – Water Air Soil Pollut. 45: 207-218.

Steinnes E., Allen R.O., Petersen H.M., Rambæk J.P., Varkskog P. 1997 – Evidence of large scale heavy-metal contamination of natural surface soils in Norway from long-range atmospheric transport – Sci. Total Environ. 205: 255-266.

Szczepaniak W. 2004 – Instrument-based methods in chemical analysis – Wyd. Naukowe PWN, Warszawa (in Polish).

Zdanowski B. 1996 –An unidentified mussel (*Anadonta* sp.) in the heated Konin lakes – Proc. XII Krajowe Seminarium Malakologiczne, 25-27.04.1996 Łódź (in Polish).

Received – 14 December 2006

Accepted – 10 April 2007

STRESZCZENIE

METALE CIĘŻKIE W SYSTEMIE JEZIOR KONIŃSKICH

Jeziora konińskie położone w pobliżu elektrowni Konin i Pątnów (rys. 1) narażone są na działanie zanieczyszczeń, w tym metali ciężkich, emitowanych z elektrowni. W pracy przedstawiono wyniki oznaczeń zawartości metali: Cu, Zn, Mn, Fe, Pb i Cd w osadach dennych jezior konińskich i kanałach oraz w *Vallisneria spiralis* (L.), małżach *Sinanodonta woodiana* (Lea) i *Dreissena polymorpha* (Pall.) (rys. 2-7). Ustalono, że zawartość ołowiu i miedzi w osadach dennych systemu jezior konińskich przekracza wartości uważane za normalne dla jezior Polski. Koncentracja miedzi, cynku, ołowiu i kadmu w tkankach *V. spiralis* jest znacznie większa niż zawartość tych metali w roślinach zanurzonych występujących w zbiornikach niezanieczyszczonych. Także małże zasiedlające jeziora konińskie kumulują metale ciężkie w podwyższonych ilościach w stosunku do rodzin, reprezentowanych przez badane gatunki, zasiedlających inne zbiorniki Polski.