

Copper contamination of lake sediments in the vicinity of Konin (Poland) due to the inclusion of lakes to a power plant cooling system

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Introduction: Copper is an element essential to the life of many organisms, is involved in the carbohydrate metabolism and the action of several enzymes. However, excessive concentrations of copper can be toxic and copper is considered to be one of the most toxic metals in the aquatic environment [1]. Due to the harmful effects of copper to aquatic organisms, its *PEC* level in sediments has been fixed at 149 mg/kg [2].

Methods: Sediment samples were collected from the 5-cm thick surface layer of the profundal zone of 14 lakes located in the south of the Gniezno Lake District near Konin (central Poland). Determinations of the concentrations of Ag, As, Ba, Cd, Co, Cr, Cu, Ni, Pb, Sr, Ti, V, Zn and elements included in the phases, whose compounds can retain pollutants in aquatic sediments (Ca, Mg, Fe, Mn, P and S), were determined by ICP-AES methods from solutions obtained after digestion in aqua regia. The Hg concentration determinations were made using the TMA method and the organic carbon content (TOC) was determined by coulometric titration.

Results: The concentrations of the trace elements varied over a wide ranges of content within the following intervals: for copper - 9-674 mg/kg, barium 57-409 mg/kg, mercury - 0.058-0.366 mg/kg, nickel - 5-25 mg/kg, lead - 16-53 mg/kg, strontium - 53-758 mg/kg and zinc - 30-184 mg/kg. It has been found that the sediments of five lakes (Gosławskie, Licheńskie, Pątnowskie, Ślesieńskie, and Wąsosko-Mikorzyńskie) whose waters are included in the power plant cooling system, are characterized by much higher contents of Cu, Ba, Hg, Mn, Sr and Zn as compared to the other lakes. The average concentrations of Cu, Ni, Pb, Hg and Zn in the sediments of the latter lakes are comparable with the concentrations of these elements in sediments of lakes from other regions and are similar to the geochemical background values. The sediments of lakes included in the Konin-Pątnów power plant cooling system are conspicuous by a very high concentration of copper: the geometric mean is 385 mg/kg and is 35-times higher than its average concentration in lake sediments (7 mg/kg). The average content of Ba in the sediments of these lakes is three times higher; of Ni, Hg and Zn – twice

higher. The results showed that the concentrations of As, Cd, Co, Cr and V in the sediments were low and characterized by a relatively low variability. The concentrations varied within the following intervals: for As <3-11 mg/kg, Cd - <0.5-1.3 mg/kg, Co - 1-4 mg/kg, Cr - 4-16 mg/kg and V - 6-15 mg/kg. These values are similar to those measured in the lake sediments of other regions of Poland. The copper concentration in sediments of lakes included in the Konin-Pątnów power plant cooling system shows a significant correlation ($r > 0.9$, $p=0.05$, $n=5$) with the Cr, Hg and Zn concentrations. And its content in the sediments of the lakes not included in power plant cooling system shows a correlation ($r \approx 0.6-0.7$, $p=0.05$, $n=9$) with the concentrations of As, Co, Ni and Cr. The water of Lakes Licheńskie, Gosławskie, Pątnowskie, Wąsosko-Mikorzyńskie and Ślesieńskie are used in the Konin-Pątnów power plant cooling system from over 50 years. The long-term utilization of the water from these lakes resulted in supplying copper loads originating from corrosion of heat exchangers made of copper or its alloys. The past and present use of copper sulfate as a compound limiting the occurrence of algal blooms, e.g. in fish ponds and power plant cooling ponds, can also be an additional source of copper in lakes.

Conclusions: The studies of the Konin region lakes sediments have shown that they contain high copper concentrations that may cause harmful effects on aquatic organisms. However, it is necessary to perform further tests to determine the copper content in fish tissues due to the fact that these lakes are used for recreational and angling purposes on a large scale.

References: [1] Dethloff G.M., Bailey H.C., Maier K.J. 2001. Effects of dissolved copper on select hematological, biochemical, and immunological parameters of wild rainbow trout (*Oncorhynchus mykiss*). Arch. Environ. Contam. Toxicol., 40: 371–380. [2] MacDonald D., Ingersoll C., Berger T. 2000. Development and evaluation of consensus-based sediment development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol., 39: 20–31.