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BIOACCUMULATION OF ALUMINIUM IN THE AQUATIC ENVIRONMENT OF THE DOBRA RIVER IN WROCLAW

BIOAKUMULACJA GLINU W ŚRODOWISKU WODNYM RZEKI DOBREJ WE WROCŁAWIU

Abstract: Laboratory tests were carried out regarding the aquatic environment of the Dobra River within the borders of the city of Wroclaw. The study material was constituted by the river water and aquatic plants. The concentration of aluminium in the water oscillated between 0.0517 mgAl · dm^{-3} and 0.2130 mgAl · dm^{-3}. The maximum concentration of aluminium in the aquatic plants amounted to 7.178.65 mgAl · kg^{-1} and the minimum to 118.75 mgAl · kg^{-1}. The tests indicated that the Dobra River waters should be classified as water of medium pollution. Aluminium concentrations in the plants were also found to be moderate.

Keywords: bioaccumulation, aluminium, aquatic plants, water, rivers

Aluminium is the third most common building material of the earth's crust, after oxygen and silicon. It is found in water in the form of hydrogen and oxygen compounds, sulfate, fluoride or aluminium fluoride complexes. Aluminium concentration in soil ranges from 150 mgAl · kg^{-1} to 600 mgAl · kg^{-1}, in the air – amounts up to 1.00 μgAl · m^{-3}, and in water depends on its pH value. Aluminium is characterized by high solubility in acidic environments. Its solubility in soil is proportional to soil acidity. The process occurs most effectively in an environment of pH = 4.00–4.50. When pH is 5.50 aluminium concentration can reach 100.00 mgAl · dm^{-3} [1–6]. The element is easily absorbed by bottom deposits in water reservoirs and is quickly activated when water acidity increases. Aluminium is also carried into rivers by water flowing from cultivated land. The process is seasonal in nature, occurs principally from the direct catchment area during heavy rainfalls or the melting of snow, and depends on

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the type of cultivation and fertilizers used, the sowing cycle and the cultivation schedule [5, 7–13].

Because of high aluminium concentrations in surface waters, a decision was made to determine aluminium concentrations in the water and aquatic plants as well as its accumulation in the aquatic plants in the Dobra River in Wroclaw.

Material and methods

The study material was made up by water and aquatic plants collected in the year 2007 (spring, summer, autumn). The following aquatic plant species were sampled:

– Common reed (Spermatophyta, Monocotyledoneae, Lilidae, Graminales, Gramineae: *Phragmites australis* (Cav.) Trin. ex Steud;

– Acorus calamus (Spermatophyta, Monocotyledoneae, Arecidae, Arales, Araceae: *Acorus calamus* L.)

– Reed canarygrass (Spermatophyta, Monocotyledoneae, Lilidae, Graminales, Gramineae: Phalaris arundinacea L.);

– Canadian pondweed (Spermatophyta, Monocotyledoneae, Alismatidae, Hydrocharitales, Hydrocharitaceae: *Elodea canadensis* L.);

– Great pond-sedge (Spermatophyta, Monocotyledoneae, Lilidae, Cyperales, Cyperaceae: *Carex riparia* Curtis).

Sampling sites:

– above Pawlowski Bridge;

– below Pawlowski Bridge;

– above Klokoczycki Bridge;

– below Klokoczycki Bridge.

The plants were dried in room temperature until air-dry. Whole plants were pre-ground by crushing and then homogenized. Mineralization was performed with concentrated nitric and perchloric acids at a ratio of 1 to 3 in a Mars 5 microwave oven. Aluminium concentrations were determined using atomic absorption spectrophotometry by means of a Varian Spectr AA-110/220 unit.

The aluminium accumulation rate (k) in the plants was computed by dividing the metal concentration in the plants by its concentration in the water.

Results and discussion

The aluminium concentration in the water of the Dobra River ranged between 0.0517 mgAl · dm^{-3} and 0.2130 mgAl · dm^{-3} (Tables 1–3). The maximum concentration was recorded in the autumn, at the site above Pawlowicki Bridge and the minimum – in the summer, at the site below the same bridge (0.0517 mgAl · dm^{-3}). At all of the sites the highest concentrations were found in the autumn and the lowest in the summer. Over the entire section of the river covered by the sampling sites, aluminium concentrations in the water were falling slightly downstream, irrespective of the season.

Aluminium concentrations in water as determined in the research in question were very similar to those found in the waters of the Dobra and the Strzegomka Rivers as

Table 1

Aluminium in water and aquatic plants – spring 2007 (mean values)

Site	Plant species	Al plants [mg · kg^{-1}]	Al water [mg · dm^{-3}]	Accumulation rates (k)
Above Pawlowski Bridge	*Phragmites australis*	449.18	0.0940	4778.51
	Acorus calamus	4285.88		45594.50
Below Pawlowski Bridge	*Phalaris arundinacea*	7178.65	0.0788	91099.60
Above Klokoczycki Bridge	*Phragmites australis*	902.76	0.0836	10798.60
	Elodea canadensis	1209.51		14467.80
	Acorus calamus	367.17		4391.98
Below Klokoczycki Bridge	*Phragmites australis*	1563.83	0.0615	25428.10
	Acorus calamus	1040.99		16926.70

Table 2

Aluminium in water and aquatic plants – summer 2007 (mean values)

Site	Plant species	Al plants [mg · kg^{-1}]	Al water [mg · dm^{-3}]	Accumulation rates (k)
Above Pawlowski Bridge	*Phragmites australis*	118.75	0.0570	2083.33
	Acorus calamus	696.34		12216.50
Below Pawlowski Bridge	*Phragmites australis*	791.33	0.0517	15306.20
	Acorus calamus	955.41		17479.90
Above Klokoczycki Bridge	*Phragmites australis*	1150.20	0.0702	16384.60
	Elodea canadensis	293.21		4176.78
	Acorus calamus	1173.25		16713.00
Below Klokoczycki Bridge	*Phragmites australis*	1735.91	0.0546	31793.20
	Acorus calamus	1843.65		33766.50

Table 3

Aluminium in water and aquatic plants – autumn 2007 (mean values)

Site	Plant species	Al plants [mg · kg^{-1}]	Al water [mg · dm^{-3}]	Accumulation rates (k)
Above Pawlowski Bridge	*Acorus calamus*	882.03	0.2130	4140.98
Below Pawlowski Bridge	*Phragmites australis*	3943.81	0.0946	41689.30
	Carex riparia	846.08		8943.76
	Acorus calamus	386.27		4083.19
Above Klokoczycki Bridge	*Phragmites australis*	2384.87	0.1046	22799.90
	Acorus calamus	4098.07		39178.50
Below Klokoczycki Bridge	*Phragmites australis*	1563.83	0.0699	22372.40
	Carex riparia	1040.99		14892.60

well as in the flowing waters near the city of Zielona Gora [14, 15]. The values recorded for the Dobra River in 2007 were higher than those quoted for the rivers in western

Poland (0.009–0.035 mgAl · dm^{-3}) [16]. However, they were not higher than the concentrations established for the water flowing from the landfill site into the Topór River (a tributary of the Dobra River), which ranged from 0.5900 to 0.8100 mgAl · dm^{-3} [17] or the Biala Przemsza River, which flows through Upper Silesia [18].

Aluminium concentrations in the aquatic plants from the Dobra River oscillated between 118.75 mgAl · kg^{-1} in common reed at the site above Pawlowicki Bridge in the summer and 7,178.65 mgAl · kg^{-1} in reed canary grass below Pawlowicki Bridge in the spring (Tables 1–3). The minimum and maximum accumulation rates for the above sites amounted to 2.083 and 91.099 respectively. The highest average aluminium concentration in aquatic plants was found in the spring (2.124.75 mgAl · kg^{-1}) and the lowest, at 973.12 mgAl · kg^{-1}, in the summer.

Similar aluminium concentrations in aquatic plants were observed in the rivers of western Poland – from 935 mgAl · kg^{-1} to 3.124 mgAl · kg^{-1} [16]. Aluminium concentrations in macrophytes in the reservoirs located in urbanized areas were similar to those found for the Dobra River [14, 18]. Analysis of plant samples from water reservoirs in Germany and France indicates that aluminium concentrations there are similar to those determined for the Dobra River, with the maximum at 6.800 mgAl · kg^{-1} [19, 20].

Recapitulation

The tests indicated that the Dobra River water should be classified as water of medium pollution with aluminium. The highest aluminium concentrations in the water for all of the four sampling sites were found in the autumn, and the lowest in the summer. Most probably this is a result of surface flows from the soils after the autumn rainfalls, which happens every year.

Aluminium bioaccumulation in the biotic components of the aquatic environment – aquatic plants – occurs similarly to that in areas with a moderate pollution of the aquatic environment.

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Abstrakt: Przeprowadzono badania środowiska wodnego rzeki Dobrej na terenie Wrocławia. Materiałem badawczym były woda rzeczna i rośliny wodne. Poziom glinu w wodzie zawierał się między 0,0517 $mgAl \cdot dm^{-3}$ a 0,2130 $mgAl \cdot dm^{-3}$. W roślinach wodnych maksimum zawartości glinu wyniosło 7178,65 $mgAl \cdot kg^{-1}$, a minimum 118,75 $mgAl \cdot kg^{-1}$. Wody rzeki Dobrej można zaliczyć do wód o średnim stopniu zanieczyszczenia. Obecność glinu w badanych roślinach utrzymuje się również na umiarkowanym poziomie.

Słowa kluczowe: bioakumulacja, aluminium, rośliny wodne, woda, rzeki