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Letter to Editor

The Content of Heavy Metals (Cu, Ni, Cd, Pb, Zn) in Common Reed (*Phragmites australis*) and Floating Pondweed (*Potamogeton natans*)

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Abstract

We collected and examined water plant samples of floating pondweed (*Potamogeton natans*) and Common reed (*Phragmites australis*). The samples were taken from places situated along the Drawa River (before, next to and below the military training ground). Cu, Ni, Cd, Pb and Zn content was indicated in plants.

The received results showed the essential difference of the heavy metals content between plants from various places. The military training ground is a source of Drawa River contamination by heavy metals.

Keywords: heavy metals, water plants, contamination, Drawa River

Introduction

Drawa National Park (DNP), founded in 1990, is one of 23 national parks in Poland. It is situated in the southwestern Poland in the Pomorze Lake District. The area of the DNP is 11,019 ha, with forests covering 83% of it. The DNP task protects endangered plants and animals, for example the Turk's Cap Lily (*Lilium martagon*), Sandews (*Drosera*), Wild Service Tree (*Sorbus torminalis*), White-Tailed Eagle (*Haliaeetus albicilla*), European Beaver (*Castor fiber*), and Lesser Spotted Eagle (*Aquila pomarina*).

The DNP is situated in a catchment of the Drawa River. With its side stream, Płociczna, the watercourse takes the main part of the park. The spring of the Drawa River is in Połczyn Zdrój Munticipality, which is situated within the DNP. The whole length of the Drawa River is 186 km, and in the end the river flows into the Noteć River. At 99 km of the river length the closed section begins. Here is located Drawa Military Training Ground (DMTG) for ground and air forces. At 36,111 ha it is one of the largest and most modern military traning facilities in Europe. Part of the facility is situated inside DNP. DMTG runs alongside about 8 km of the river.

The authors decided to measure the influence of DMTG on the local environment through estimation of the content of chosen heavy metals. The military zone is entirely closed for civilians and unavaliable for environmental research, which is why the authors used water plants, which have the ability to accumulate these metals. Based on special plant species that grow in the region, the climate (for example air and soil temperature, light balance) or chemical (acidity or calcium content) conditions can be estimated. The function of the ability to accumulate heavy metals is more and more commonly used to check the changes that result from environmental pollution [1-3]. Albers et al. [4] found that the concentrations of metals in aquatic plants can be more than

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100,000 times greater than in the associated water. Plants that have a specific tolerant range to determinated ecological factors best show effects that can be hard to detect by people or equipment.

Materials and Methods

To achieve the purpose of the research, 2 water plant species were used: Floating pondweed (*Potamogeton natans*) and Common reed (*Phragmites australis*). Common around the world, they were chosen because they were easy to find and collect. Common reed is a widespread, dominant plant species in many aquatic ecosystems. It forms dense stands that are among the most productive ecosystems in temperate areas [5]. It also has a wide ecological tolerance range (it occures in reservoirs and on shores, peatbogs and water-meadows). The root and rootstock are resistent to water waving and regular inundation (even to 2 meters). The main part of the plan is above the water surface. Floating pondweed lives in stagnant and floating water as well. Usually it occures at about 1-2 meters depth.

Samples were collected in 2007 in 19 different places situated along the Drawa River (11 places were located before DMTG: 2 next to it and 6 below).

After picking up by scoop, plants were washed, crumbled and packed in foil bags. As fast as possible plants were spread on cuvets and dried at a normal temperature. After this, dried plants were additionally crumbled and homogenized. Finally, prepared materials were ready for mineralization in a MARS-5 microwave.

1,500 mg of material (with exactitude to 0.1 mg) was put in special teflon containers. All samples flooded by 5 cm^3 of concentrated nitrogenous acid 1:1 (Suprapur by SIGMA). After mineralization, liquids were transferred to clean the PP test-tubes (Falcon type).

Metals concentrations in investigative solutions were measured in the SpectrAA 220 FS apparatus by the Varian Company.

The results were determined (calculation of average values, standard deviations, significance of differences) using Statgraphic 5.0 and GraphPad Prism 5.1.

Outcomes

Heavy metals are a group of 38 different metals. Their specific weight ranges from 4.5 g/cm^3 for Ti to 22.59 g/cm^3 for Os. The proper growth and development of organisms depends on consistent metals in the natural environment. However, some of them are very toxic and can be accumulated in plant tissues.

Contents of Cu, Ni, Cd, Pb and Zn were estimated. Results are in Table 1.

Heavy metals content in plants is even 2-3 times higher in samples collected next to and below the military area than in ones collected before this zone. We saw essential differences in Cu, Zn, Cd, and Pb content in samples collected before and after DMTG. Only Ni content did not affirm essential differences between these two areas.

Differences in heavy metals content between two types of plants are visible on each part of the river. Floating pondweed (submereged plant) acumlulated essentialy fewer heavy metals than common reed (the main part of this plant is above the water surface). For a region located before DMTG the diffrences in amounth of Cu, Ni, Cd, Pb and Zn between common reed and floating pondweed look as follows 57.5; 45.7; 57.4; 61.3 and 28.0%. For the region located close to the DMTG the differences in amount of Cu, Ni, Cd, Pb and Zn come to 11.9, 31.7, 59.3, 35.2 and 35.6%, and for the region located below the DMTG 60.3, 57.3, 87.8, 62.1 and 50.08% (as in the previous order).

Discussion

Mazej et al. [6] maintain that the bioavailability of trace elements for plants is dependent on many environmnetal factors such as concentration of the elements in the environment, exposure time or sampling period. As Duman et al. [7] affirm, the mean amount of the elements on plants, including heavy metals and their concentrations in water, is sesonal. During our work in summer, the concentration of these factors was precisely determined (Table 1).

The content of metals in samples collected next to and below DMTG is significantly ($p \leq 0.05$) higher than those in plants growing before it. Concentrations of heavy metals in aquatic plants depend both on metal speciation and on the species of plants absorbing the metals [8]. Aguatic macrophytes may accumulate considerable amounts of heavy metals in their tissues [7]. The results of Fritioff et al. [9, 10] showed that the highest accumulation of heavy metals is found in the roots. That is why authors decided to examine these factors in leaves to balance the results.

The results of other researchers [7] proved that in summer season the concentration of heavy metals in plant water amounts to (in ppb) 26.72 ± 9.31 (Pb), 45.58 ± 6.8 (Cu), 59.41 ± 3.94 (Ni), 24.21 ± 21.32 (Zn) and 2.44 ± 0.44 for Cd.

Fritioff et al. [10] also remarked in their research that time is a significant agent when plants were taken in August from the eutrophic lake. This type of water is able to accumulate the high quantity of Zn, Cu, Cd and Pb factors, which authors admitted in water plants.

Polish scientists [11, 12] have announced lower values for water plants – 3.0-5.0 (Cu), 0.1-1.2 (Ni), 0.05-0.2 (Cd) 2.0-4.5 (Pb), 15.0-50.0 (Zn) and 0.9-5.1 (Cu), 1.2-6.2 (Ni), 1.0-2.1 (Pb), and 19.8-24.7 (Zn). Similarly, the lower values of heavy metals were noticed by Czarnowska et al., Kozanecka et al., Wislocka et al. [13-15], except the content of Zn, for which the results obtained by authors were slightly higher.

However, our results were much lower then values for water plants given by Russian and Italian authors – Gladyshev at al. [16, 17]: 4.5-7.9 ppm (Cu), 4.7-13.0 (Ni), 2.5-3.7 (Pb), 20.0-24.6 (Zn); Mikryakova et al. [18] – 3.4-3.8 (Cu), 7.4-9.7 (Ni), 0.5-0.7 (Cd), 4.6-5.7 (Pb), 21.7-22.0 (Zn); Brekhovikikh et al. [19] – 2.2-3.4 (Cu), 2.6-4.3 (Ni), 0.1-0.2 (Cd), 2.2-4.5 (Pb), 11.5-30.4 (Zn), and Valitutto et al. [20] 0.4-1.5 (Cu), 1.8-5.8 (Ni), 0.1-0.4 (Cd), 1.3-2.5 (Pb), 35.3-57.5 (Zn).

Table 1. Content of heavy metals in water plants collected from places located before, next to and below the military training ground (ppm).

			Common reed (*Phragmites australis*)					Floating pondweed (*Potamogeton natans*)				
			Cu	Ni	Cd	Pb	Zn	Cu	Ni	Cd	Pb	Zn
military training ground	Before	Min	1.01	0.42	0.16	0.95	10.85	2.20	1.38	0.45	2.15	7.70
		Max	3.30	1.04	0.31	1.49	38.77	5.63	1.90	0.62	3.32	63.19
		Average	1.85	0.88	0.23	1.03	21.70	4.35	1.62	0.54	2.66	30.15
	Next to	Min	5.08	1.33	0.50	2.48	76.65	5.75	1.90	0.85	3.50	63.96
		Max	6.47	1.42	0.50	2.57	127.66	7.22	2.10	1.42	4.14	88.58
		Average	5.77[a]	1.38	0.50[a]	2.52[a]	102.15[a]	6.55[a]	2.02	1.23[a]	3.89[a]	75.33[a]
	Below	Min	3.60	1.19	0.44	2.12	45.24	7.43	2.39	1.85	4.43	93.65
		Max	4.53	1.28	0.46	2.43	71.67	14.75	3.66	4.58	7.59	134.26
		Average	4.05[a]	1.22	0.45[a]	2.30[a]	54.25[a]	10.20[a]	2.86	2.97[a]	6.07[a]	108.69[a]

a – $p \leq 0.05$

The analysis of water plants collected from places located before, next to and below the DMTG show essential differences of the heavy metals content between them. Therefore, this area has a big influence on Drawa River contamination by heavy metals. It affirmed overcrossing of their content value only by Polish standards [11, 12].

Summary

Results confirm that aquatic plants can play an important role as a transportation link for metals from the sediments up into shoots [21]. Contamination of soils and plants with heavy metals is a serious worldwide problem both for human health and agriculture [22]. Aquatic plant species are known to have great importance, forming a substantial component of the primary production in many aquatic ecosystems, especially in lakes [23]. Contamination of the environment cannot always estimated by direct methods, so more and more often indirect methods are used. A useful method of environmental pollution estimation is using plants as bioindicators. It is especially helpful for areas where there is no direct access. That is why authors decided to use this method to estimate environmental pollution by heavy metals in the neighbourhood of the DTMG that is closed to civilians. The outcomes showed that this military area has a siginicant influence on heavy metal concentration in plants that grow in that region.

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