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Short research contribution

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CONTENT OF SELECTED CHEMICALS IN TWO PROTECTED MACROPHYTES: *NYMPHAEA ALBA* L. AND *NUPHAR LUTEA* (L.) SIBITH. & SM. IN RELATION TO SITE CHEMISTRY

ABSTRACT: Concentration of heavy metals and macronutrients were measured in water, bottom sediments and in the leaves of *Nymphaea alba* and *Nuphar lutea* sampled from fourteen eutrophic lakes in West Poland. The concentrations of macro- and microelements in examined plants differ significantly and depend on chemical properties of the water and bottom sediments. These dependences are confirmed by calculated significant correlations. Strong positive correlations were found between concentrations of Ba, Co, Mn, and Cu in *Nymphaea alba* as well as Sr in *Nuphar lutea* and concentration of this element in environment, indicating the potential of examined plants for monitoring for these metals.

KEY WORDS: heavy metals, nutrients, elements content in water plants, site chemistry, *Nymphaea alba*, *Nuphar lutea*

The distribution of many aquatic plants is often correlated with water quality (Agami *et al.* 1976, Carbiener *et al.* 1990, Romero and Onaindia 1995). Among the principal characteristics of aquatic macrophytes is their ability to accumulate nutrients and accelerate nutrient cycling in the environment (Nogueira *et al.* 1996). These plants concentrate elements and integrate temporal fluctuations in water, therefore making them more useful for monitoring purposes compared to chemical analyses of water and sediments (Jones 1985). Therefore, these taxa can be used as indicators of the trophic level of the ambient water (Carbiener *et al.* 1990). The evaluation of the role of the aquatic macrophytes in nutrient cycling requires studies of the chemical composition of plant tissues as well as of the water and sediments in which plant community develops (Nogueira *et al.* 1996).

The aim of this paper was to determine chemical characteristics of *Nymphaea alba*, *Nuphar lutea*, water, and sediments from fourteen lakes of Pojezierze Leszczyńskie (West Poland) with different levels of some nutrients and heavy metals and to study the bioindicative value of both examined species. According to Franzin and McFarlane (1980) the relationships between metal concentration in plant tissues and its concentration in environment suggest that plants can be very useful in bioindication of this metal contamination (Franzin and McFarlane 1980). Both

Nymphaea alba and *Nuphar lutea* are protected species; it increases their role as bioindicators because of necessity of conservation of their habitats and limits possibility of their use in common monitoring.

Investigations were made in fourteen eutrophic lakes of Pojezierze Leszczyńskie (in West Poland – Poznan Province) (15°47'–17°8' East, 51°51'–52°6' North). Presence of at least one of the examined species was the basic criterion to choose study lakes. The area and average depth of these water bodies range from 16.4 to 343.9 ha and from 0.5 to 7 m, respectively (Joachimiak 1995).

In July samples of water, bottom sediments and plants were taken in triplicate from 25 sites from littoral of examined lakes. The large part of the biomass of examined plants consists of floating leaves (Kok *et al.* 1990), so these organs were selected for present investigation. Because of species protection, only three leaves of *Nymphaea alba* and *Nuphar lutea* were collected in each study site.

Prior to analysis the water samples were filtered using a Whatman glass microfiber filter (GF/C), bottom sediments – dried, and leaves of the plants – washed thoroughly, dried at 60°C and pulverised. The concentrations of Al, Ba, Ca, Cr, Co, Fe, Mg, Mn, Ni, K, Na, Sr, V, and Zn in water were determined with Inductively Coupled Plasma Emission Spectrophotometry – ICP (Spectroflame SIMSEQ) and Cd, Cu, and Pb with atomic absorption spectrophotometry (graphite furnance Philips PU 9200X). Bottom sediments and plant material (200 mg) was digested with nitric acid during 24 hours at room temperature. Following this the temperature was raised to about 95°C and hydrogen peroxide was added until digest became clear. Then the digest was diluted with distilled water to 5 cm^3 and used for chemical determinations of contents of Al, Ba, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Na, Sr, V, and Zn with the Inductively Coupled Plasma Emission Spectrophotometry – ICP (Spectroflame SIMSEQ). In case of bottom sediments the plant-available fractions of Ca, Mg and K were determined as indicated above, but after extraction with a 1 N ammonium acetate solution (Knudsen and Peterson 1982). Concentrations of Cr, Co, Mn, Ni, and V in water from some sites were lower than detection level like 2.57, 3.14, 0.47, 4.25 and 6.83 $\mu g \times dm^{-3}$, respectively.

All elements were measured against standards (BDH Chemicals Ltd, reagent grade) and blanks were prepared in 0.5 nitric acid. The reproducibility of these procedures, as compared to the results of an interlaboratory study on digesting and analysing reference material (Wageningen Evalu-

Table 1. Average (n=25 sites) concentrations and coefficient of variation [%] (in parenthesis) of elements in water, bottom sediments and leaves of *Nymphaea alba* and *Nuphar lutea*. Bold – the CV values close to 100%.

	Water	Bottom sediments mg kg^{-1} DW	*Nymphaea alba* mg kg^{-1} DW	*Nuphar lutea* mg kg^{-1} DW
N	NH_4 0.54 [mg dm^{-3}] (30) NO_2 0.005 [mg dm^{-3}] (36) NO_3 0.92 [mg dm^{-3}] (21)	4594 (62)	21866 (14)	24130 (10)
P	PO_4 0.36 [mg dm^{-3}] (86)	122 (24)	1861 (18)	2928 (13)
K	6.01 [mg dm^{-3}] (79)	310 **(115)**	8122 (28)	10858 (32)
Ca	54.2 [mg dm^{-3}] (28)	65113 (37)	14705 (21)	17407 (13)
Mg	13.6 [mg dm^{-3}] (18)	2550 (24)	1616 (30)	1935 (27)
Fe	0.004 [mg dm^{-3}] **(115)**	2.01 **(97)**	94.4 (50)	182 (40)
Sr	211 [μg dm^{-3}] (21)	219 (68)	8.42 (45)	20.5 (28)
V	<6.83 [μg dm^{-3}]	22.3 **(120)**	1.54 (60)	1.82 (26)
Cu	22.2 [μg dm^{-3}] **(123)**	5.62 **(98)**	1.49 (70)	1.80 (25)
Cr	3.71 [μg dm^{-3}] (55)	21.5 (87)	5.64 (31)	4.77 (27)
Mn	53.8 [μg dm^{-3}] **(94)**	359 (59)	195 (69)	157 (37)
Ni	<4.25 [μg dm^{-3}]	23.7 (79)	3.20 (38)	2.80 (32)
Cd	0.07 [μg dm^{-3}] (52)	0.08 (74)	1.13 (34)	1.26 (19)
Al	8.75 [μg dm^{-3}] (29)	586 **(102)**	49.5 (33)	43.5 (33)
Co	13.7 [μg dm^{-3}] **(94)**	10.6 (65)	4.15 (29)	4.81 (16)
Pb	4.11 [μg dm^{-3}] (64)	16.0 (77)	7.44 (47)	8.14 (21)
Zn	98 [μg dm^{-3}] (19)	49.1 **(108)**	32.3 (36)	37.1 (22)
Ba	64.8 [μg dm^{-3}] (27)	125 (66)	9.65 **(99)**	88 (45)

ating Programmes for Analytical Laboratorie (WEPAL)), was found to be 97±4%. The reference material consisted of pine needles and leaves of *Nymphaea alba*.

All analyses were done in triplicate. All results for plants and bottom sediments were calculated on a dry weight basis.

Variation of the elements concentrations in water, bottom sediments, and leaves of plants were evaluated with coefficient of variation (Żuk 1989). Pearson regressions and correlation coefficients were calculated to examine the relationships between the concentrations of elements in water, bottom sediments, and plants (Parker 1983). All calculations were done with the program CSS Statistica (StatSoft 2000).

Mean concentrations of elements in water, bottom sediments, and plants of the examined lakes are presented in Table 1. High coefficient of variation (close to 100%) of Fe, Cu, Co and Mn concentration in water and K, Fe, V, Cu, Al, and Zn in bottom sediments gave evidence to higher variability of these parameters than the rest of examined elements. Elements content in *Nymphaea alba* and *Nuphar lutea* demonstrated low variability (in more cases lower than 50%).

Positive correlation between Mg concentration in bottom sediments and leaves of *Nuphar lutea* (Table 2) suggested that sediment is the primary source for its uptake. According to Barko and James (1998) also Fe is principally taken from sediment by rooted macrophytes. However present study revealed that nymphaeids could accumulate Fe also from water (significant, positive correlations between Fe in water and tissue of *Nymphaea alba* and *Nuphar lutea* – Table 2). In case of *Nymphaea alba*, significant positive correlation between K in water and plants (Table 2) confirmed data of Barko and James (1998), that potassium is taken up mainly from the water. Also Jackson (1998) and Fernandez-Alaez *et al.* (1999) announced that nutrient concentration in aquatic plants is depended on their concentration in environment.

The concentrations of Ba and Co in leaves of *Nymphaea alba* were positively correlated with concentrations of these elements in water. However Cu and Mn content in these plants were correlated with Cu and Mn in sediment (Table 2). The concentration of Sr in leaves of *Nuphar lutea* depends on Sr content in water (Table 2). According to Franzin and McFarlane (1980) as well Jones (1985) strong positive associations between metal concentrations in plants and their environment suggest that this plant has a potential for pollution monitoring in general and for the examined elements. So significant, positive correlations between concentrations of Ba, Co, Mn, and Cu in *Nymphaea alba* as well as Sr in *Nuphar lutea* and these elements in their environment suggest that the examined nymphaeids may be useful as the indicator of those metals.

Table 2. Statistically significant relations (Pearson correlations) between chemical characteristics of environment and of plants *Nymphaea alba* and *Nuphar lutea*.

Species	Relations	Regression equation[1]	Significance Level (p)	$R_{est.}^2$
Nymphaea alba	K in water and K in plants	y=3265.6+906.5x	0.024	0.58
	Fe in water and Fe in plants	y=53.8+10031.5x	0.000	0.79
	Ba in water and Ba in plants	y=–13.0+359.6x	0.034	0.55
	Co in water and Co in plants	y=3.32+87.73x	0.034	0.55
	Cu in bottom sediments and Cu in plants	y=0.91+0.17x	0.004	0.67
	Mn in bottom sediments and Mn in plants	y=35.3+0.35x	0.019	0.60
Nuphar lutea	Fe in water and Fe in plants	y=53.3+3347.8x	0.036	0.54
	Sr in water and Sr in plants	y=0.29+95.83x	0.009	0.65
	Mg in bottom sediments and Mg in plants	y=553.4+0.53x	0.016	0.61

[1]Regression equation, where
y=concentration of element in plants [mg kg^{-1}]
x= concentration of element in water [mg dm^{-3}] or in bottom sediments [mg kg^{-1}]
[2]$R_{est.}$ – R estimated

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