ELEMENTS IN ECTOMYCORRHIZAL FUNGUS *PAXILLUS INVOLUTUS* (BATSCH EX FR.) FROM VARIOUS SITES IN POLAND

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Abstract
Data on metallic elements accumulation of wild growing ectomycorrhizal fungus Poison Pax *Paxillus involutus* (Batsch ex Fr.) collected from different (contaminated and uncontaminated) ecosystems in Poland are presented. Concentrations of essential metals (e.g. K, Na, Mg, Ca, Mn, Fe, Cu, Zn, Co, Ni) and other which have no apparent essential function (e.g. Hg, Pb, Cd, Rb, Al, Ag) were determined in caps, stalks or whole fruiting bodies. The mushrooms were collected between 1999 and 2001 from sites located in northern, central and southern Poland. Dried and pulverized samples were wet digested with concentrated nitric acid in Teflon® vessels XP-1500 under pressure in a microwave oven (Mars 5, CEM Corporation, USA). The elements were detected and quantified using atomic emission spectroscopy with induced coupled plasma (Optima 2000 DV, Perkin-Elmer, USA) and cold-vapor atomic absorption spectroscopy (Mercury Monitor 3200, Thermo Separation Products, USA). Accuracy of the method was assessed with certified reference materials CTA-OTL-1 and IAEA-359. Poison Pax is very common fungus all over Europe and is well known to grow in symbiosis with various trees (*Pinus sylvestris, Picea abies* etc.) this kind of complex research could be very useful in understanding interactions in fungus-metal-environment-tree system and on the other hand it may be one step further in investigation this species and its metal accumulation abilities. All these elements could be absorbed and accumulated by different physic-chemical mechanisms and transport systems.

Introduction
Poison Pax *Paxillus involutus* (Batsch ex Fr.) is an ectomycorrhizal fungus very common in Europe. It grows in symbiosis with birch, oak, pine, fir etc. Because of this many research on possible application on land reclamation are led presently. It is known, that mycorrhizal fungi increase metal tolerance in forest trees. in case of this species the effect of increased metal tolerance of host tree seedlings was observed with Al, Cd, Pb and *Picea abies*, Zn and *Pinus sylvestris* as well as *Betula sp*. (1, 2). Moreover, *Paxillus involutus* is able to produce specific enzymes. It was observed that this species is able to biotransform and metabolize polycyclic aromatic hydrocarbons (PAHs): phenanthrene, chrysene, pyrene and benzo[a]pyrene (3). On the other hand, elevated concentrations of some heavy metals are often observed in the fruiting bodies of higher fungi collected from polluted sites (4, 5). Even fungi from unpolluted sites accumulate some heavy metal at high levels (6, 7).

The applicability of fungi to the monitoring of environmental pollution by heavy metals is still under consideration (8, 9, 10, 11).

The aim of this study was to determine 19 metals concentration in fruiting bodies of *Paxillus involutus*. It would be helpful to examine abilities of this species to act as bioindicator of metal contamination.

Materials and methods

The fruiting bodies of Poison Pax – *Paxillus involutus* were collected from different forest ecosystems in Poland between 1999 and 2001. The sampling sites were as follows: Klodzka Hollow (southern Poland), Notecka Forest (central Poland) and Community of Gdansk, Lezno (northern Poland) (Fig. 1.). Sites Klodzka Hollow and Community of Gdansk, Lezno are situated in areas under anthropogenic influence. The samples were dried at 40ºC for 48 h and pulverized in agate mortar. Clean, dried and pulverized samples were wet digested with concentrated nitric acid (65%, Suprapur®, Merck) in Teflon® TFM vessels XP-1500 under pressure in a microwave oven (Mars 5, CEM Corporation, USA). The analysis was performed with atomic emission spectroscopy with induced coupled plasma (Optima 2000 DV, Perkin-Elmer, USA) and cold-vapor atomic absorption spectroscopy (Mercury Monitor 3200, Thermo Separation Products, USA). Quality assurance and quality control protocol was applied including analyses of certified reference materials CTA-OTL-1 (Institute of Nuclear Chemistry and Technology) and IAEA-359 (International Atomic Energy Agency). Statistical analyses were executed by the STATISTICA (Version 6.0, StatSoft, Inc., Tulsa, OK, US).

Fig. 1. Localization of sampling sites in Poland (1 – Klodzka Hollow; 2 – Notecka Forests; 3 – Community of Gdansk, Lezno).

Results and discussion

Mean concentrations of macroelements (Ca, K, Mg, Na) are presented in table 1 (mean value±SD; range and median value in mg/kg dry wt., concentrations of K in mg/g dry wt.). Macroelements are present in fruiting bodies in high concentrations. These metals are essential for normal, proper function, metabolism and differentiation of fungi.

Table 1. Macroelement concentrations in fruiting bodies of *Paxillus involutus* in mg/kg dry wt. (mean±SD, range; median value; n – number of samples)

Element	Sampling site and year			
	Klodzka Hollow, 2000	Notecka Forests, 2000	Community of Gdansk, Lezno, 1999	
	C (n=15)	W (n=10)	C (n=20)	S (n=20)
Ca	140±57 75-240 120	280±210 74-730 220	660±210 280-1100 710	1300±380 380-1800 1400
K*	31±6 24-46 30	53±3 49-57 53	30±4 24-38 30	30±5 19-39 31
Mg	940±140 740-1200 910	1500±75 1400-1600 1500	1200±210 830-1800 1200	690±130 500-990 700
Na	170±63 33-270 180	580±190 330-1000 520	180±120 55-440 120	310±190 93-730 310

C – cap; S – stalk; W – whole fruiting body; *mg/g

Mean concentrations of microelements (Ag, Al, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Rb, Sr, Zn) are presented in table 2 (mean value±SD; range and median value in mg/kg dry wt.).

In case of Ag, Al, Ba, Fe and Sr, higher concentrations were observed in samples from Klodzka Hollow and Community of Gdansk, then in samples from Notecka Forests. The highest concentrations of cadmium were measured in samples from Klodzka Hollow (caps 2.0±1.9 mg/kg dry wt.). In samples from Notecka Forests and community of Gdansk (caps) Cd concentrations were at similar level. Concentration of that element in stalks from community of Gdansk, were below detection limit. Cobalt and chromium concentrations in samples collected from three sampling sites were below 0.5 mg/kg dry wt (in two cases below detection limit). The highest copper concentrations were observed in samples from Klodzka Hollow (caps - 77±15 mg/kg dry wt.) and from Notecka Forests (whole fruiting bodies - 82±11 mg/kg dry wt.). In samples from community of Gdansk, Cu concentrations were approximately 1.5 times lower. Mercury was present in samples at very low level. The highest concentrations of that metal were observed in samples from community of Gdansk (0.11±0.06 mg/kg dry wt. in caps and 0.07±0.05 mg/kg dry wt. in stalks). In case of manganese, the highest concentrations were observed in samples from community of Gdansk (caps - 100±42 mg/kg dry wt. and stalks 200±85 mg/kg dry wt.). This is 5 to 10 times more then in samples from other sites. The highest nickel concentrations were measured in samples from Klodzka Hollow (caps – 2.8±0.8 mg/kg dry wt.). Lead was detected in samples from Klodzka Hollow and Notecka Forests at the same level approximately 2 mg/kg dry wt. Rubidium is present in fruiting bodies of *Paxillus involutus* in quite high amounts. The highest concentrations were present in samples from Notecka Forests (670±110 mg/kg dry wt. in fruiting bodies). The highest zinc content was in samples collected from community of Gdansk (270±58 mg/kg dry wt. in caps and 170±35 mg/kg dry wt. in stalks) as well as in samples from Notecka Forests (240±41 mg/kg dry wt. in whole fruiting bodies).

Table 2. Microelement concentrations in fruiting bodies of *Paxillus involutus* in mg/kg dry wt. (mean±SD, range; median value; n – number of samples)

Element	**Sampling site and year**			
	Klodzka Hollow, 2000	**Notecka Forests, 2000**	**Community of Gdansk, Lezno, 1999**	
	C (n=15)	**W (n=10)**	**C (n=20)**	**S (n=20)**
Ag	1.8±0.8 0.5-3.6 1.6	0.49±0.17 0.26-0.81 0.50	2.5±1.0 0.8-4.4 2.4	1.9±0.8 0.8-3.8 1.9
Al	140±120 44-370 77	42±12 28-69 41	110±50 44-210 110	240±130 49-470 250
Ba	1.6±0.9 0.7-3.3 1.3	0.4±0.1 0.2-0.7 0.3	1.7±0.8 0.9-4.3 1.4	3.9±1.8 1.1-8.2 3.6
Cd	2.0±1.9 0.2-4.9 1.1	0.20±0.10 0.11-0.37 0.19	0.24±0.09 0.12-0.47 0.23	<0.1
Co	0.19±0.07 0.11-0.31 0.17	<0.1	0.44±0.34 0.12-1.6 0.34	0.35±0.26 0.12-1.2 0.27
Cr	0.42±0.27 0.14-0.89 0.30	0.33±0.10 0.23-0.53 0.32	0.37±0.13 0.22-0.74 0.34	<0.1
Cu	77±15 60-97 77	82±11 70-100 79	54±10 38-73 53	30±12 13-62 27
Fe	190±97 64-320 210	54±7 47-66 52	170±77 74-400 150	290±170 74-540 230
Hg	0.03±0.01 0.02-0.05 0.03	0.02±0.02 0.02-0.10 0.01	0.11±0.06 0.02-0.25 0.09	0.07±0.05 0.01-0.22 0.05
Mn	22±8 11-38 20	24±12 9-53 22	100±42 47-200 97	200±85 66-370 190
Ni	2.8±0.8 1.4-3.6 3.3	0.7±0.2 0.5-1.1 0.7	0.8±0.2 0.4-1.2 0.8	1.2±0.3 0.8-1.8 1.2
Pb	2.5±0.5 1.8-3.2 2.4	2.2±0.4 1.8-2.9 2,2	0.84±0.29 0.37-1.5 0.82	0.90±0.61 0.20-2.3 0.72
Rb	430±170 130-680 410	670±110 470-860 670	270±110 100-450 290	150±61 49-260 160
Sr	1.0±0.5 0.5-2.1 1.0	0.2±0.1 0.1-0.6 0.2	1.2±0.6 0.6-3.0 1.1	2.6±1.4 0.5-5.7 2.3
Zn	130±24 100-170 130	240±41 170-310 240	270±58 150-400 260	170±35 110-220 170

C – cap; S – stalk; W – whole fruiting body

In ongoing studies samples of *Paxillus involutus* from other sampling sites in Poland are being analyzed. The idea is to collect samples from different forest ecosystems and different regions of country. Sites, which are under anthropogenic pressure as well as unpolluted are chosen for the studies. Furthermore soil surface (0-10 cm layer) will be analyzed and relationship between metal content in fungi and in soil will be taken into consideration. Correlations between concentrations of different metals in fruiting bodies would be calculated.

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