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Experimental Model of Heavy Metals Distribution in the System "Collection Ponds of Mining Industry - Aquatic Macrophytes-Environment" on the Instance of Salair Ore Refining Plant

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Collection pond of Salair ore refining plant, Russia, was chosen as research object. It is the nature hollow near the river M.Talmovaja, in which waste of ore cyanidation and flotation were storage in the form of pulp. Three man-made ponds - solid matter of the waste covered by water - had been appeared in the course of time. These ponds are located step-like. The lowest pond - well of the Djukov ravine -, in which drainage water from the first two ponds are flow, was investigated. Main pollutants in it are Cu, Pb, Cd and Zn. The dominant species growing in the well is fluvial horsetail (*Equisetum fluviatile*). A control site was chosen in the upstream of the river M.Talmovaja before any waste of the plant could penetrate in it.

The horsetail and other aquatic plants were taken from unpolluted lake of the Novosibirsk Botanical Garden and introduced into two vessels containing solid matter and water from the well (experimental vessel) and from control site (control vessel) for four months (T = 22ºC, t(light) = 18 h, t (dark) = 6 h).

The main objectives of the study are the follows: 1) to estimate the risk of technogeneous influence on the unpolluted lake coenoses; 2) to receive a complete scheme of heavy metals distribution in the system "sediment - water - plants - organs of plants - atmosphere".

Biogeocoenosis, close to the nature one, have being formed in the control vessel after 115 days. All plant species except fluvial horsetail and common duckweed were absent in the experimental vessel. The horsetail was shorter and had no leaves. The duckweed was smaller than the control one in 1.7 times and necrosis of leaves was observed.

Accordingly to obtained data, the HM concentrations in plant habitat from experimental vessel are lower the control one on 1-3 orders. Concentration of HM decreases in a set: sediment, pore water and bulk water. There is the same picture in the control vessel.

Chemical forms of HM in pore and bulk water were determined with the aid of the thermodynamic program WATEQ4F. 51% of Cd and Zn, 35% Cu and 19% Pb in polluted pore and bulk water are in the ion form, the most available form for plants. So, a big part of the metals must be uptaken by plants in the ion form. In thecontrol vessel the amount of metals in ion form on dozens present more than in experimental one.

Content of HM, except Cu, in horsetail on the hole more than the control one on 1-2 orders (Table 1). Metals concentration in horsetail organs decreases in a set: rootlets, roots and stem. There is a big gradient of concentration between rootlets and roots and between roots and stem. About 57% of Cd are situated in rootlets and only 26% - in roots. Concentration of Pb decreases in 400 times on the verge "roots-stem". Therefore, some protective mechanisms, preventing penetration of pollutants into above ground part of the plant, are working.

Metals penetrate into the above ground part of the plant together with the flow of bleeding sap, in which the highest concentration of HM was observed (Table 1). Then through conductive bundles, containing lower concentration of metals, - into plant organs and tissues. At the end such metals as Cd and Cu are accumulated in vacuole sap. Their concentration in it exceeds concentration in bleeding sap on one order. On the contrary, content of Pb in vacuole sap on one order lower than in the bleeding sap. Hence, Pb is either accumulated in other location of the horsetail or secreted out from it. According to analysis of transpiratoric secretions, there was a high concentration of Pb. So Pb is secreted out from the horsetail in the process of transpiration. Zn as accumulated in vacuole sap as secreted out to a marked amount. The presence of HM in transpiratoric secretion of aquatic macrophytes is one more way of metals migration into environment, which conceals a big threat.

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	Cd	Pb	Cu	Zn	m, g dry wt
	control vessel				
stem	0.29	0.72	33	76	0.26
roots	0.25	26	66	99	0.47
rootlets	1.4	500	480	700	0.18
all plant	0.49	110	140	210	0.91
	experimental vessel				
stem	0.52	3.6	3.1	2400	0.19
roots	1.0	1600	24	3500	0.22
rootlets	92	10000	200	18000	0.15
all plant	25.6	3300	64	7000	0.56
bleeding sap	7.7	220	89	7200	—
conductive bundle sap	0.026	3.2	21	68	—
vacuole sap	33	14	430	7400	—
transpiration, µg/l	0.11	13	6.1	390	—

Table 1. HM concentration in horsetail (mg/g dry wt) and horsetail sap (mg/l).