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Macrophytes in phytoremediation of heavy metal contaminated water and sediments in urban inland ponds

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Inroduction

General contamination of heavy metals (HM) in the environment is a major global concern which has provoked the emergence of phytoremediation technologies for cleaning soils (Salt et al., 1998; McGrath, 1998; Baker et al.,2000; Galiulin, Galiulina, 2003)), aqueous streams (Dushenkov et al., 1995), mine wastes and sewage (Galiulin, Galiulina, 1999) by use of plants. In urban areas both natural and artificial poor-drained inland ponds became the objects of heavy metals pollution one way with the soils. The biogeochemical cycling of elements in aquatic ecosystems being determined by balancing of processes in the "water-biota-bottom sediments" system becomes broken within the city limits under the input of industrial and municipal sewage. In urban aquatic complexes the high productive fresh-water macrophytes are of great importance as annual depot of pollutants together with the bottom sediments. Their biogeochemical significance is mainly in extracting and accumulating along with essential nutrients also of trace elements including HM (Osmolovskaya, Kurilenko, 2001) that is often combined with fair resistance to increased levels of pollutants and gives specific interest for using certain macrophytes in phytoremediation of sewage and of polluted water bodies (Galiulin, Galiulina, 1999).

In the city of Saint-Petersburg there are 86 rivers and canals and over 100 ponds covering 10,2% of its total area. The inland ponds ecosystems include certain set of macrophytes. The objective of the present work was to evaluate the accumulating potential and the perspectives of several macrophytes for using them in phytoremediation of HM contaminated inland aquatic complexes within the city of Saint-Petersburg.

Material and Methods

5 species of typical fresh-water macrophytes belonging to 3 ecologically different groups: coastal hygrophytes, rooted in sediments (*Phragmites communis Trin*. and *Typha latifplia L.*); partly immersed rooted hydrophytes (*Potamogeton natans L.*) and fully immersed unrooted hydatophytes (*Elodea canadensis Rich. et Michx*. and *Ceratophyllum demersum L.*). were collected in the late August from 5 inland ponds (leaves or fool immersed plants) together with water and sediments samples for the analysis on HM content. Fe, Mn, Zn, Cu, Cr, Ni, Pb, Cd were determined after wet ashing of the dried plant material in $HNO_3/HClO_4$ mixture (4/1, v/v) by atomic absorption spectroscopy (AAS-3).

Results and Discussion

All macrophytes grown in urban inland ponds were characterized by intense accumulation of heavy metals in their leaves, particularly of Fe and Mn as compare to the background plants. The maximal extent of accumulation (up to 63-155 times) was found in less productive fully immersed *Elodea canadensis* and *Ceratophyllum demersum* the highest contents of Fe and Mn in their tissues were 8800 mg kg^{-1} DW against 600-915 mg kg^{-1} DW in the leaves of most productive *Phragmites communis* and *Typha latifolia*. At the same time Mn accumulation in dry biomass of the former plants was up to 20 times more effective comparing to its presence in sediments while for Fe the opposite regularity was estimated. Among others HM their maximal concentration relative to unpolluted plants took place in *C. demersum* for Cr (up to 16,5 times), Cu (10,8 times) and Zn (5,3 times), some less it was in *Ph. communis* and *T. latifolia* (up to 9,7-10,8; 9,1-10,4 and 3,1-4,5 times correspondingly). The highest absolute concentrations of the above HM were estimated for Cr as 14,9 mg kg^{-1} DW in C. *demersum*, for Cu as 63,0 in *P. natans*, for Zn as 61,0 in *E. canadensis* and 74,0 mg kg^{-1} DW in C. *demersum*. Ni accumilation was most pronounced in *P. natans* and both hydatophyts, while the highest level of Pb was found in *E. canadensis* (27,4) followed by C. *demersum* (10,7) and *P. natans* (9,3 mg kg^{-1} DW). The total sum of HM content in C. *demersum* and *E. canadensis* plants varied from 182 è 216 mg kg^{-1} DW in background specimens to 11946 è 13853 mg kg^{-1} DW in plants from the most polluted pond. The same maximum for *P. natans* was 2423, and for *Ph. communis* and *T. latifolia* 728 and 964 mg kg^{-1} DW. Thus fully immerse macrophytes known as barrier-free species showed the highest ability for total HM accumulation in their bodies. However it seems that coastal hygrophytes rooted to sediments *Ph. communis* among them have certain advantage as well because of great biomass production that make it possible to regard them as suitable for HM phytoremediation in urban inland water reserves.

The estimation of some biogenous elements (K, Ca, Na, S and P) contents in plant material showed their levels to be much higher in macrophytes selected from urban ponds than from background one. The differences in Ca levels achieved 5 times for *E. canadensis* and *C. demersum* and 2,5 times for *Ph.communis* while the rise in Na accumulation achieved 7-11 and 2,3 times correspondingly. The reason may be specifically in the input of ice-protected salts as well as of detergents. The maximal 5-11 times rise in P accumulation was found in *C. demersum* plants while the rise in the total S content was maximal (up to16 times) in *E. canadensis* with 10-11 times in *P. natans* and *Ph. communis*, 5 times in *C. demersum* and only 1,3-2,7 times in *T. latifolia.* The latter observations deserve more special study. Though the increase in P and S levels can really result from proper pollution it seems more likely that both elements are in great demand when forming ligands essential for HM complexation and detoxification in plants through synthesis of phytochelatins. Thus the macrophytes association undoubtedly has its advantages in HM phytoremediation of waters and sediments. At the same time the annual harvesting and excavation of macrohytes could be the right way to prevent a secondary water contamination.

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