AQUATIC FLOATING PLANTS WITH POTENTIAL USE IN PHYTOREMEDIATION

PLANTE ACVATICE PLUTITOARE CU POTENȚIAL DE UTILIZARE ÎN FITOREMEDIERE

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***Abstract**. Fast industrialization, increasing urbanization, growing living standards, development of sustained way chemicals administration in the current century require a greater consumption of water and implicitly increased charging with different residues and contaminants. Therefore, studies concerning the treatment of contaminated water are presents interest and impetuous necessary. The contamination of waste waters with toxic heavy metals is a major environmental issue, much debated on nationally and internationally level. Many aquatic plants (hydrophytes) have the capacity to decontaminate water (called hyperaccumulators) through phytoremediation. For this purpose, the floating aquatic species are used with great success: Azolla pinnata R. Br., Eichhornia crassipes L., Hydrocharis morsus ranae L., Lemna minor L., Lemna gibba L., Pista stratiotes L., Salvinia natans Kunth. They are used in different aquatic landscapes for decorate ponds and lakes. It creates real floating islands to remediation of contaminated wastewater and biomonitoring. This paper presents some measures to filter wastewater with aquatic plants and the assortment of widely used aquatics for this purpose.*
Key words: contaminated water, plants, floating islands.

***Rezumat.** Industrializarea rapidă, creşterea gradului de urbanizare, ridicarea standardului de viață, dezvoltarea în mod susținut a chimizării impun în secolul actual un consum mai ridicat de apă şi implicit o încărcare mărită cu diferite reziduuri şi contaminați. De aceea, studiile privind epurarea apelor contaminate sunt de actualitate şi impetuos necesare. Contaminarea apelor reziduale cu metale grele toxice, este o problematică majoră de mediu, mult dezbătută pe plan național şi internațional. Numeroase plante de apă (hidrofite) au capacitatea de a decontamina apele (numite hiperacumulatori), prin fitoremediere. În acest scop, dintre speciile acvatice plutitoare se utilizează cu mare succes: Azolla pinnata R. Br., Eichhornia crassipes L., Hydrocharis morsus ranae L., Lemna minor L., Lemna gibba L., Pistia stratiotes L., Salvinia natans Kunth. Acestea se folosesc şi în diferite amenajări acvatice, pentru decorul ochiurilor de apă şi a lacurilor. Se creează adevărate insule plutitoare (floating islands) pentru depoluarea şi biomonitorizarea apelor reziduale şi contaminate. Lucrarea de față prezintă câteva măsuri de filtrare a apelor uzate cu ajutorul plante şi sortimentul de acvatice folosite pe scară largă în acest scop.*
Cuvinte cheie: ape contaminate, plante, insule plutitoare.

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INTRODUCTION

Phytoremediation is a process that uses different types of plants in association with microbes to remove, destruct, relocate, extract and absorb contaminants from wastewaters or soils. Plants can clean or remove many kinds of pollution including heavy metals, pesticides, explosives, and oil. This technology is an innovative, cost-effective alternative method the more utilized treatment ways used at cleanup the waste sites.

Plants can remediate organic compound and metal contaminations, but they are usually used for removing toxic metals from soil or aquatic sediments. When plants remove pollutants completely out of a contaminated site, the process is called phytoextraction (Maczulak, 2009).

Aquatic plants absorb heavy metals from the water; and those rooted ones also from the bed material. Generally, aquatic plants accumulate high amounts of heavy metals via roots, stems or leaves, and accumulate them in organs. They can absorb elements selectively. In this way, they reflect the toxicity of the water environment and may serve as a tool for the biomonitoring of contaminated waters (Wang, 1991; Sawidis et al., 1995; Ravera, 2001, Zurayk et al., 2001; Cardwell et al., 2002). Accumulation and distribution of heavy metals in the plant depends on the plant species, bioavailability, pH, cation exchange capacity, dissolved oxygen, temperature, and secretion of roots. Plants are employed in the decontamination of heavy metals from polluted water and have demonstrated high performances in treating mineral water and industrial effluents (Cheng, 2003).

Water contamination with heavy metals is a very important problem in the current world (Kaur et al., 2010). Since the dawn of civilization, metal pollutants have been a part of human history. However, toxic metal pollution of the biosphere has intensified rapidly since the onset of the industrial revolution, posing major environmental and health problems (Chandra, Srivastava, 2003).

One of specific methods for removal of metals from these environmental segments is use plant species which have the ability to accumulate and distribute heavy metals. The term, "hyperaccumulation" was first described by Jaffre et al. (1976), when they observed the New Caledonian plant *(Sebertia acuminata)* accumulated Ni in their above ground biomass (Chandra, Srivastava, 2003).

A plant can be named hyperaccumulator if it has capacity to concentrate the pollutants in a minimum percentage which varies according to the pollutant involved (for example: more than 1000 mg/kg of dry weight for nickel, copper, cobalt, chromium or lead; or more than 10,000 mg/kg for zinc or manganese) (Baker, 1989). This capacity for accumulation is due to hypertolerance, or phytotolerance: the result of adaptative evolution from the plants to hostile environments through many generations.

Biofiltration of the heavy metals (Pb, Zn, Cu, Cd, Co) has been successfully demonstrated using many aquatic plants such as: *Salvinia sp.* (Espinoza-Quinones et al., 2005), *Potamogeton crispus* (Aysel et al., 2010), *Potamogeton pectinatus* and *Potamogeton malaianus* (Peng et al., 2008), *Eichhornia crassipes* (Buta et al., 2011), *Typha angustifolia* (Dilek and Ahmet, 2004), *Myriophyllum heterophyllum* (Aysel et al., 2010)*, Lemna minor* (Yeşim et al., 2003) and *Azolla caroliniana* (Bennicelli et al., 2004). In addition, Lavid et al., (2000) discovered that water lilies (*Nymphaea* variety) are endowed with anatomical and physiological traits that allow them to thrive on water with high concentrations of heavy metals such as Cd, Hg, Ni and Co.

The National Aeronautics and Space Administration/National Space Technology Laboratories (NASA/NSTL) have successfully used water hyacinths to remove organics and heavy metals from chemical wastes before their discharge (Wolverton et al., 1977).

Heavy metals can be clean, destruct or remove from waste or contaminated waters with grasses and other aquatic species. In Auckland region the reduction of Cu, Zn from urban storm water is made by floating wetlands.

Floating treatment wetlands (FTWs), consisting of rooted emergent wetland plants growing on a mat floating on the water surface of a pond, have the potential to combine the strengths of both conventional ponds and wetlands into one system, whilst overcoming some of the limitations of each. For this kind of waste water treatment can be used grasses as: *Carex dipsacea, Carex virgata, Cyperus ustulatus, Eleocharis acuta, Juncus edgariae*, and *Schoenoplectus tabernaemontani* (Headley, 2007).

Regarding the metal removal through floating wetlands (FTW), the first report found by Headley (2006) was the pilot FTW system constructed at Heathrow Airport in London for the treatment of glycol-laden de-icing water. Copper removal was approximately 20-30%, while removal of zinc was ineffective. However, the floating structure in this system was apparently constructed using galvanized steel materials which may have acted as a source of metals such as zinc, whilst the limited time frame of the study renders the information of limited value.

The ecosystems of floating wetland occur naturally in various locations around the world, such as the Danube Delta, Germany, New Zealand, The Netherlands, England, the lower reaches of the South in Africa, the Central Amazon, the Gulf Coast of the USA, and Tasmania in Australia.

The aim of this study was to assess the mode of action and role of aquatic plants in removing heavy metals from wastewater.

MATERIAL AND METHODS

As was shown above many aquatic plants can be used in phyotremediation. In some of cases for wastewater treatment are utilized the free-floating aquatic plants which float either as thin layer on the water surface (e.g., *Lemna* and *Azolla*) or have specially adapted as floating leaf-bases (e.g., *Eichhornia*, *Pistia* and *Salvinia*).

Floating treatment wetlands are distinguished from free-floating aquatic plant systems by the fact that they utilize larger emergent wetland plants growing on a somewhat consolidated floating mat, as opposed to an unconsolidated mass of small, individual buoyant plants lacking any significant mat. Free-floating aquatic plant systems have been used to reduce particulate and organic loads in sewage and industrial wastewaters. Artificial wetlands has many other functions: increasing biodiversity, recreational, esthetical and educational (Tomescu, 2009).The high growth and uptake rates of many free-floating plants can also result in significant removal of nutrients and metals if there is enough land area available and the plants are regularly harvested.

Floating treatment wetlands may be likened to a hydroponics system, as the plants acquire their nutrition directly from the water column in which their roots are suspended, rather than from the soil (Headley, 2006).

Natural floating wetlands typically consist of a 40 – 60 cm deep floating organic mat supporting plant growth, the upper portion of which is comprised of densely intertwined live, dead and decaying roots with some litter collection on the surface. Below the active root zone a layer of low-density decomposed peat and decaying plant detritus develops, the depth of which is usually dictated by the rooting depth of the plants. Beneath the peat layer a zone of relatively clear free-water exists, that varies in depth (0 – 2 m) with the lake or wetland water level. On the base of the wetland basin, beneath the free-water zone, a layer of organic sludge develops over the native subsurface material (Headley, 2006).

The most common approach to constructing floating wetlands is through the creation of a floating raft or frame supporting a mesh on which plants are grown. Coconut fiber or peat is often used as a growth medium. Constructed treatment wetlands typically involve flow of contaminated water through the root-zone of emergent species of sedges, rushes and reeds.

As biological material can be use: *Phragmites australis* (Common reed) has been very widely used throughout Europe, Asia, and Australia and is known to perform well in treatment wetlands, *Schoenplectus tabernaemontani*, *Typha orientalis*, *Baumea articulate, Eleocharis sphacelata* and *Carex secta*. *Typha* species have effectively been used in floating treatment wetlands in Canada and the USA (Headley, 2006). Other species recommended for floating islands: *Alisma plantago-aquatica, Glyceria maxima, Mentha aquatica*, Myosotis palustris, *Sagittaria sagittifolia, Sium erectum, Sium latifolium, Sparganium erectum, Symphytum officinale, Thelypteris palustris, Typha laxmannii, Typhoides arundinacea*.

The selected growing media must provide suitable growth conditions, including porosity, water retention, capillarity, and fertility with pH between 5.0 and 6.5.

RESULTS AND DISCUSSIONS

Phytoremediation process of contaminated waters usually uses green plants to remove pollutants from the environment, by up taking, concentrating, incorporating and distributing them in harvestable parts. Is a newly introduced field of science and technology to clean and remediate contaminated sites. This method is cost-effective, long lasting aesthetic solution and environmental friendly. Disadvantages of this process can be related to the climate and the phytotoxicity of some plants when the metal concentration is high (Liang, 2009). The role of aquatic plants in phytoextraction was established through numerous researches. Using hyperaccumulators (more than 1 g/mg heavy metals) as biofilter is frequently, because these plants not only tolerates high quantity of toxic elements, but also distribute them in their roots or leaves. More than 400 plants were reported as hyperaccumulators from 45 botanical families (Liang, 2009). Generally, for phytoextraction are selected plants with very high productivity, higher rate of metal removal, easy to harvest, easy to grow, safety to process by drying, ashing or composting for recycling (Lu, 2004). It is important to use native plants for phytoremediation because these plants are grown and reproduce without stress conditions. The identification of hyperaccumulators is an important task as the key of phytoextraction.

Concerning the constructed wetlands, the advantages being easy and cheap to construct, and suitable for wastewater purification. They help to prevent the spread of heavy metals contamination from land to aquatic environment (Lu, 2004) and it is used to improve the water quality.

Heavy metal contamination of waters becomes serious and continuous problem on the whole world, which can attract the attention on implementation and development of different remediation methods.

CONCLUSIONS

Phytoremediation can detoxify, remove, degrade, absorb, relocate, immobilize, or extract contaminants, depending on the nature of the pollution and the type of plant or microbe. It is an eco friendly method, is gentle to ecosystems and long lasting aesthetic solution.

These methods work slowly, however, and may not always be suitable for large cleanup tasks or cleanups that require fast action.

Hyperaccumulators has superior capacity to absorb contaminants from wastewaters and can remove and distribute high quantity of heavy metals in roots or leaves.

Floating islands are gentle to ecosystems and can be used not only to clean waste waters, but also to decorate lacks and ponds.

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