



Mini-Review

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Prospects of Plant-Based Systems as an Eco-Technological Approach for Heavy Metals Removal from Polluted-Waters



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Contamination of natural waters by the release of aqueous effluents containing organic and inorganic poisoning substances, mostly from agro-industrial origin, has been hard increased since the beginning of the 21st century. In the last decades, environmental contamination with heavy metals has turned to a worldwide problem due to the fast growing of industrialization and urbanization. Metals are major pollutants of fresh-water reservoirs because of their non-biodegradability and high-persistence in nature. In addition, some metals are highly toxic even at very low concentrations [1]. Heavy metals are not only a serious threat to the environment but also to all living beings, including humans, since all metallic ions are inert to chemical and biological degradation and can be transferred through the trophic chain [2].

Metal's poisoning has been recognized as a major public health concern, particularly in developing and poor countries where sanitary issues are wicked, and solutions are scarce. For example, arsenic (As), cadmium (Cd), mercury (Hg), and lead (Pb) are toxic metals of high environmental importance currently included by the World Health Organization in the list of the ten chemicals of major public risk [3]. Although heavy metals toxicity is a highly explored matter, complete control and prevention over metals exposure is still far from being attained. Therefore, the search for new technologies, preferably clean and inexpensive ones, that can be used to remove heavy metals from the environment is still desired.

Conventional wastewater treatment technologies for heavy metals elimination are usually expensive and somewhat

inefficient. Chemical flocculation/precipitation, ion exchange, electrochemical deposition and membrane filtration are some of the methods typically applied for heavy metals removal from industrial effluents. However, much of such processes are restricted due to technical or economical limitations, specially to remediate large volumes of polluted waters [1]. In such sense, the use of vascular plants for the removal of heavy metals from wastewater and industrial effluents (*i.e.*, phytoremediation) have been proved to be an eco-friendly and sustainable biotechnology [4-6]. Moreover, in high-flow treatment systems, the use of free-floating macrophytes have been shown to be satisfactory.

One of its major advantages is that plants can be used as low-cost extract pumps to purify contaminated water, thus being an appropriate solution to remediate large areas or to complete decontamination in longer periods of time. In general, phytoremediation technology can be explained on plants ability to adsorb, accumulate, sequester and/or tolerate high concentrations of metals in plants roots or leaves. Its success depends on the physicochemical properties of the plants utilized, and some other genetic and biological features such as high biomass productivity, geographical distribution, climate adaptation, and tolerance to toxic metals [7,8].

For a plant-based wastewater treatment system to be feasible and sustainable, it is essential that plants used are not only efficient in heavy metals removal, but also highly abundant at the region, easily accessible, and do not require special culture conditions in order to minimize costs. Plant-based technologies have been shown to be highly competitive for heavy metals elimination compared to the classical Physico-chemical methods. In general,

metal sorption by the plants roots is the fastest component of the metal uptake mechanism and may occur by a combination of physical and chemical processes such as ionic bonds, chemical chelation, and ionic exchange.

The content of macromolecules such as polysaccharides, lipids, and proteins with negatively charged groups (*e.g.*, carboxyl, sulphate, phosphate) at the plant's surfaces are key factors that determine the binding mechanism between the positively charged metal ions and the biomass [9]. In addition, different biological-regulated processes such as metal uptake by transmembrane proteins and/or ionic channels, expression of metalloproteins and phytochelatin, and translocation to leaves are also part of the heavy metals' removal mechanisms used by plants [10].

Moreover, some studies with native or autochthonous free-floating macrophytes exposed to high levels of heavy metals have revealed that toxic effects to plants related to metals exposition were minimal or absent [9,10]. In addition, these plants were also resistant to daily-metal exposition at long term [11]. Therefore, it seems that metal-selective metabolic and/or physiological responses in some plant species could also exist, and such responses may not only be dependent on the physicochemical behavior of the metal but also on its concentration, and to a lesser extent, on the exposure time to the toxicant [10].

Phytoremediation of industrial effluents has been satisfactorily implemented both in constructed wetlands and treatment lagoons [1,4-6]. In addition, the use of plants for heavy metal remediation from aquatic environments have the additional advantage that plant biomass can be easily harvested and treated for metal recovery before its final disposal. Additionally, free-floating, and emerging plants (*i.e.*, helophytes) are naturally distributed in several tropical and subtropical regions around the globe, thus, the implementation and management of plant-based ecotechnologies for treating metal-containing effluents seems to be a worldwide viable solution in all such environments with high yield of autochthonous plants species [9-11].

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