Phytoremediation: An Economical Solution for Removal of Heavy Metals

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***Abstract*: The removal & mobilization of heavy metals from various industries and industrial processes has led to the release of these elements into the environment. Since heavy metals are non biodegradable, they accumulate in the environment and subsequently contaminate it. This contamination poses a risk to environment and human health as some heavy metals is carcinogenic, mutagenic, & teratogenic, which causes harmful effects to human health. Thus remediation of heavy metal pollution deserves the great attention and becomes very necessary. Different Conventional methods used for this purpose leads to serious limitations like high cost, intensive labor, skilled personnel, etc. To overcome limitation of convention method different methods like phytoremediation, biofiltration, etc. Hence, Phytoremediation is a better solution to the problem. Phytoremediation is the use of plants which reduces the concentrations or toxic effects of contaminants in the environment. It is a efficient recent technology and is perceived as cost-effective, eco-friendly, and solar-driven technique with good public acceptance. Phytoremediation is an area of relatively active current research. Various aquatic plants are economically beneficial and are used for the remediation of heavy metal pollution. This review article comprehensively discusses the background, concepts and various techniques for phytoremediation of heavy metals.**

***Key Words:* Heavy metals, Copper, Zinc, Removal, Industrial effluent, Phytoremediation, Water plants.**

I. INTRODUCTION

Water pollution due to heavy metal is more risky as heavy metals are non biodegradable and thus they accumulate in area where ever water logging or holding of water takes place. Increase in heavy metal in water is due to increasing industrialization & disturbance of natural biogeochemical cycles. Different sources of heavy metal are natural and anthropogenic sources, e.g. Weathering of minerals, erosion, electroplating, mining, industrial discharges & smelting.(Modaihsh et al., 2004; Chehregani and Malayeri, 2007;Fulekar et al., 2009; Sabiha-Javied et al., 2009; Wuana and Okieimen, 2011). Effluent from various industries like electroplating, mining, pesticide manufacturing etc contains huge amount of heavy metals.

These effluent needs to be treated for removal of heavy metal before disposing to any source of water or for reuse of water. Generally, heavy metals are removed by ion exchange, chemical precipitation, electro dialysis, coagulation, clarification, reverse osmosis, ultra and nano filtration etc, these technique are very costly and efficiency of few is not up to the mark (Akpor and Muchie, 2010). Chemical technique generates large volumetric sludge and increases the cost for disposal. Pytoremediation have lesser side effects than other physical, thermal & chemical approaches.

II. PYTOREMEDIATION

The term ‘‘phytoremediation’’ is a combination of two words, Greek word “phyto” means plant & Latin word “remedium” means to correct or remove an evil. Green plants have an enormous ability to uptake all contaminants from the wastewater. The concept of phytoremediation (as phytoextraction) was suggested by Chaney (1983). It is suitable for application at very large amount of wastewater present where other remediation methods are not cost effective or practicable (Garbisu and Alkorta, 2003). Utilization of specific plant for removal of heavy metal from waste water and effluent is one of the most economical techniques. It is a cost-effective, efficient, environment- and eco-friendly, and solar-driven remediation strategy (Clemens, 2001; Suresh and Ravishankar, 2004; LeDuc and Terry, 2005; Chehregani and Malayeri, 2007; Odjegba and Fasidi, 2007; Turan and Esringu, 2007; Lone et al., 2008; Kawahigashi, 2009; Saier and Trevors, 2010; Kalve et al., 2011; Sarma, 2011; Singh and Prasad, 2011; Vithanage et al., 2012).

In the process of phyoremediation plant remove pollutants from effluent by breaking it, or degrading , it can also stabilize metal contaminants by acting as filters or traps. Contaminant uptake is mainly caused by roots of plants. Leaves & roots work as a good accumulators. Roots provide wide surface area to absorb the contaminants. Plants utilized for the process accumulates the wastewater, beneficial nutrients & also the non beneficial or harmful contaminants from effluent in leaves and roots. Plants generally handle the contaminants without affecting the surrounding environment. Molecular tools are being used to better understand the mechanisms of metal uptake, translocation, sequestration and tolerance in the plants. Hyper accumulators of metals are used for applications

in phytoremediation. The establishment of vegetation on polluted wastewater also helps to prevent metal leaching (Chaudhry et al., 1998). It has low installation and maintenance costs compared to other remediation options (Van Aken, 2009). Regarding cost, it can cost as less as 5% of alternative clean-up techniques (Prasad, 2003). Thus, Phytoremediation is a green solution & promising approach to the problem of heavy metal pollution.

There are various techniques of Phytoremediation:

1. Phyto extraction (accumulation)
2. Phyto degradation (transformation)
3. Rhizo filtration (phytofiltration)
4. Rhizo degradation (stimulation)
5. Phyto stabilization (restoration).

Plants Utilized For Heavy Metals Removal

Depending upon the location of contaminated wastewater and the plants growing in respective habitats are chosen, which are suitable for removal and remediating the heavy metals contaminated wastewater.

Table 2.1. Water plant & its removal efficiency:

Sr.no	NAME OF PLANT	HEAVY METAL REMOVED.
1	Pista Stratoites (water lettuce)	Lead = 99.28% Cadmium = 65.89% Mercury, TDS , TSS, Total hardness
2	Lemna minor (duck weed)	Lead = 98% Copper, Zinc = 90% Total nitrogen = 8% Total phosphorus = 46%
3	Eichhronia Crassipes (water hyacinth, jal kumbhi).	Chromium = 99.8% Copper = 98 to 99% Zinc = 96.88% COD = 64% Total hosphorus = 3% Total nitrogen = 21% Total hardness Other heavy metals: Lead, Cadmium, Mercury.
4	Hydrilla verticillata (esthwaite waterweed)	Lead = 98% Copper
5	Nelumbo lutea.	Copper = 98% Cadmium
6	Typha latifolia.	Cadmium, Mercury, Manganese = 29% Chromium = 50% Lead = 75% Copper, Zinc, Iron = 81%

(Source: Divya Singh, Archana Tiwari and Richa Gupta, 2012, Chhotu D.Jadia and M. H. Fulekar, 2008)

Advantages of Phytoremediation

Phytoremediation is one of the most economical methods of removal of heavy metal from effluent of various industries. Addition of the additional chemicals and coagulants are not added in the effluent which reduces the cost of treatment as well as reduces sludge formation and further treatment of effluent as compared to the conventional techniques. The cost of whole phytoremediation technique depends on the production cost of the plants to be used for the treatment of heavy metals. It does not require expensive equipment or highly specialized personnel. Hence, it is amendable technique to a variety of organic and inorganic compounds present in effluent.

Phytoremediation of effluent takes place by two major techniques:

Phytostabilization: Phytostabilization or phytoimmobilization is the use of certain plants for stabilization of contaminants in contaminated water (Singh, 2012). This technique of phytoremediation is used to reduce the mobility and bioavailability of pollutants present in the environment. Plants can immobilize heavy metals in effluent through sorption by roots, precipitation, & metal reduction (Barcelo and Poschenrieder, 2003; Ghosh and Singh, 2005; Yoon et al., 2006; Wuana and Okieimen, 2011). Plants used in this method should have highly developed root systems which absorbs, adsorbs & accumulate the contaminants.

Phytoextraction: Phytoextraction (also known as phytoaccumulation, phytoabsorption or phytosequestration) is the uptake of contaminants from water by plant roots and accumulation of biomass. i.e., shoots (Sekara et al., 2005; Yoon et al., 2006; Rafati et al., 2011, Susarla et al. 2002). The plants used in this method are tolerated of high concentrations of heavy metals or organic compounds.

2.1.2 Disadvantages of Phytoremediation:

The harvested plant biomass from phytoremediation process may be classified as a hazardous waste; hence disposal of it should be proper. Climatic conditions are a limiting factor with respect to plants used in this technique. Long time is required for clean-up of pollutants.

Phytoremediation efficiency of most metal, hyper accumulators is usually limited by their slow growth rate and low biomass. This method is applicable for the low to moderate levels of metal concentration present in the wastewater. There is a risk of food chain contamination in case of mismanagement and lack of proper care. (Clemens, 2001; Tong et al., 2004; Le Duc and Terry, 2005; Karami and Shamsuddin, 2010; Mukhopadhyay and Maiti, 2010; Naees et al., 2011; Ramamurthy and Memarian, 2012).

III. CONCLUSION

Since, contamination of waters & soils by toxic heavy metals is a serious environmental problem; therefore effective remediation methods are necessary. Other conventional methods for cleanup and restoration of heavy metal-effluent have serious limitations like high cost, installation & cleanup problems etc; in contrast, phytoremediation is a better solution to the problem. Phytoremediation is environment- friendly and ecologically responsible solar-driven technology with good public acceptance. It is a relatively recent technology and is mostly in research stage. Its research is highly interdisciplinary in nature. Research is in progress to screen an efficient & native plants for phytoremediation which targets the heavy metals and to evaluate the effect of different parameters on phytoremediation efficiency. Most of the studies have been done in developed countries and knowledge

of suitable plants is particularly limited in India. In India, commercial application of Phytoremediation of effluent for Heavy metal or Organic compounds is in its earliest phase.

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