Indian J.L.Sci.2(1) : 149-152, 2012

Review

PHYTOREMEDIATION- AN EMERGING GREEN TECHNOLOGY FOR REMOVAL OF POLLUTANTS FROM SOIL AND WATER RESOURCES

KESHAV SINGH JATAV[a], R P SINGH[b1], J K MISHRA[c] AND A K S CHAUHAN[d]

Department of Botany, Govt. Chhatrasal College, Pichhore, Shivpuri, MP, India

[a]E-mail: ksingh_botany@rediffmail.com

Department of Botany, Govt. Excellence P. G. College, Morena, MP, India

[b]E-mail: rpsingh.aga@gmail.com

[c]E-mail: j_mishra70@yahoo.com

[d]E-mail: amitsinghgwl23@gmail.com

Quality of natural resources like soil, water and biosphere is greatly affected by environmental pollution. Any unfavourable changes in natural resources lead negative effects on organisms which ultimately affects humans. Natural events such as volcanic eruptions, continental drift as well as anthropogenic activities such as mining, metal working industries, combustion of petroleum fuels lead emission of heavy metals and accumulation of these chemicals in ecosystem. Phytoremediation is a low cost effective ecofriendly technology in which higher plants and their associated microorganism are used according to their potential to minimized contaminants from soil and water resources. The present paper focuses a brief review of Phytoremediation as an emerging green technology for removal of pollutant from natural resources.

KEYWORDS : Phytoremediation, Soil, Water, Metal, Pollution, Pollutant

Soil and water are very essential resources for the sustainability of agriculture and mankind. Anthropogenic activities create many pollution sources such as emission, effluents and solid discharge from industries, vehicle exhaustion and metals from smelting and mining industries. In agriculture use of insecticides and pesticides, disposal of industrial and municipal wastes is responsible for soil and water toxicity (McGrath et al., 2001). Each pollutant has its own damaging effect on life of plants, animals and humans. Sources of contamination that add heavy metals to soils and water is a matter of serious concern because they remain in environment for a long period of time and are cause of carcinogenicity to humans (Garbisu and Alkorta, 2001; Gisbert et al., 2003).

Recently the term phytoremediatiion has been substituted by the term phytotechnology to indicate all applications in which plants are used to manage and control pollutants, even without removing or destroying it (ITRC, 2001). This technology has greater potential to remediate contaminants from soil and water over conventional and costly methods. In this various plant species according to their capability are used to degrade, extract and immobilize contaminants from soil and water resources. Phytoremediation potential of *Eichhornia crassipes* was studied in vitro by Padhi et al., (2012); Cornell et al., (1977) and Reddy et al., (1990).

Take up of organic contaminants from waste water by plant roots to leaves and ultimately in plant body has been reported by Goel ,(2006). Using water hyacinth waste water purification and removal of nitrogen and phosphorus has been reported by Mandi (1994). More than 400 plant species have been identified to have potential for polluted soil and water remediation among them *Thlaspi sp., Brassica* sp.*, Sedum alfredii* and *Arabidopsis* sp. have been studied (Mohammad et al., 2008).

PHYTOREMEDIATION TECHNOLOGY

Phytoremediaton technologies are based upon biological mechanisms occur in plants and their associated rhizospheric microorganisms, such as transpiration, photosynthesis, metabolism and mineral nutrition. At present following processes of this technology as applicable for remediation of toxic metals from soil and water are.

Phytoextraction

It is based on ability of certain metal-accumulating plants to transport and concentrate polluting metals from soil into the harvestable above ground plant parts . Some well known plant species for phytoextraction are Indian mustard and sunflower due to their fast growth, high biomass, high tolerance and accumulation of metals and other organics (Blaylock and Huang, 2000; Salt et al., 1995b).

At present at least 45 plant families are known to contain metal accumulating species (Reeves and Baker, 2000). A number species among them are member of Brassicaceae including a species of *Arabidopsis, A. halleri* capable of hyperaccumulation of Zn in its shoot (Reeves and

[1]**Corresponding author**

Baker, 2000).

Recently Yanqun et al., (2005) identified *Sonchus asper* and *Corydalis pterygopetata* as heavy metal hyperaccumulators of Lead-Zinc.

Phytovoltilization

This process involves the release of contaminants from the plants to the atmosphere as a gas. Terry et al., (1992) reported same members of *Brassica* sp. and some microorganisms as good volatilizes of Selenium. Some aquatic plants like *Azolla* sp., Rabbit foot grass and Pickle weed are the best Selenium volatilizers (Hansen et al.,1998; Zayed et al., 2000). It is very effective technology as volatilization completely removes the contaminants from the polluted area in the form of gas. It does not need harvesting and disposal of plants.

According to Lin et al., (2000) and Meagher et al., (2000) volatile Selenium (Se) and Hg disperse and diluted to such an extent that it does not pose a threat. Bizily et al. (2000) reported that in Hg-contaminated soil and sediments microbial activity converts the highly toxic mercury into organomercurials.

Phytostabilization

Phytostabilizatin involves the use of plants to immobilize contaminants in the soil, sediments and ground water through the absorption and accumulation into the roots or the precipitation or immobilization within the root zone. These inorganic and organic then are rendering in a stable form (ITRC, 2001). Following three processes are involved that determine the fate of contaminants (1) Phytostabilization in root zone (2) Phytostabilization in root membrane (3) Phytostabilization in the root cells. In these three processes plant products like protein and enzymes can bind and stabilize contaminants in root, root membrane and root cell respectively (EPA, 1999).

Table: Some metal hyperaccumulator plant species with respective metal accumulated

S. N.	Plant species	Metal
1	*Arabidopsis thaliana*	Zn,Cu,Pb
2	*Thlaspi caerulescens*	Zn, Cd
3	*Helianthus anus*	Cd, Cr,Ni
4	*Sonchus asper*	Zn, Pb
5	*Arabobidipsis halleri*	Zn, Cd
6	*Thlaspi rotundifolium*	Ni, Pb, Zn
7	*Brassica Juncea*	Zn, Cd
8	*Brassica napus*	Zn, Cd
9	*Pteris vittata*	As
10	*Sedum alfredi*	Pb, Zn

Rhizofiltration

Rhizofiltration is concerned with the remediation of contaminated ground water rather than remediation of polluted soils. The contaminants are either adsorbed on the root surface or are absorb by plant root. Plant species used for rhizofiltration are hydroponically grown in clean water rather than soil, until a large root system has developed. The plants are than planted in the contaminated area where the roots take up the water and contaminants along it (EPA, 1999).

Rhizofiltration is also a useful method to clean up the environment using plants. Among hundreds of species certain varieties of sunflowers are identifies as having the highest metal removal potential. Hydroponically grown sunflower plant root were found to remove various heavy metals like Cu, Pb, U, Sr, Cs, Co, and Zn from water to such an extent as it reaches its accepted standards (Ruskin et al., 1997).

Recently Vallini et al. (2005) reported two bacterial strains, *Bacillus mycoides* and *Stenotrophomonas maltophilia* to have potential to detoxify Selenium.

Phytodegradation (Phytotransformation)

Phytodegradation, also called phytotransformation, is the breakdown of contaminants taken up by plants through metabolic processes within the plant, or the breakdown of contaminants external to the plant through the effect (Such as enzymes) produced by the plants. Pollutants are degraded, incorporated into the plant tissues and used as nutrients (EPA, 1999).

Phytoremediation Using Transgenic Plants

In phytoremediation potential of plant species to remediate contaminants may improved through genetic engineering technology. Certain naturally occurring plant species like *Brassica juncea* can be genetically engineered for enhanced phytoremediaton of heavy metals from soil (Dushenkov et al. 1995); *Helianthus anus* (Dushenkov et al. 1995) and *Chenopodium amaranticolor* (Eapen et al., 2003) for rhizofiltration of Uranium.

Diderjean et al., (2002) also reported of a successful transgenic approach with a gene for cytochrome P450 involved in phase I of metabolism. In future this gene may be an important tool for phytotransformation of contaminants through herbicides in soil and water. Ruiz et al .,(2003) suggested genetically engineered chloroplast genome as a valuable way to obtain high expression without any risk.

CONCLUSION

It is evident from the above mentioned account that the phytoremediation process as a green, ecofriendly, low cost technology which is quite important and helpful for removing the pollutants including heavy metals, toxic chemicals, etc. from soil and water resources. This technology can also be useful for maintaining environmental equilibrium.

ACKNOWLEDGEMENT

The authors are grateful to Principal of concerning college for providing required facilities and encouragement during the investigation.

REFERANCES

Bizily S.P., Rugh C.L. and Meagher R.B., 2000. Phytodetoxification of hazardous organomercurials by genetically engineered plants. Nat. Biotechnol., **18**:213-217.

Blaylock M. and Huang J.W., 2000. Phytoextraction of metals. In: Phytoremediation of toxic metals using plants to clean up the environment.Edited by I. Raskin and B. D. Ensley(Wiley), New York :55-70.

Cornell D. A., Zoltek Partinely C. D., Furmen T. and Kim J. I., 1977. Nutrient removal by water hyacinth. J. WPCF, **8**:57- 65.

Diderjean L., Gondet L., Perkins R., Lau S-M. C., Schaller, H., O'Keefe D. P., Werck-Reickhart, D., 2002. Engineering herbicide metabolism in tobacco and Arabidopsis with CYP76B1, a cytochrome P450 enzyme from Jerusalem artichoke, Plant Physiol., **130**:179189.

Dushenkov V., Kumar P. B. A. N., Motto, H. and Raskin, I., 1995. Rhizofiltration: The use of plants to remove heavy metals from aqueous stream. Eniron v. Sci. Technol., **29**:1239-1245 .

Eapen S., Suseelan K. N., Tivarekar S., Kotwal S. A. and Mitra R., 2003. Potential for rhizofiltration of Uranium using hairy root culture of Brassica juncea and Chenopodium amaranticolor. Environ. Res., **91**(2):127-133.

Environmental Protection Agency (EPA), 1999. Phytoremediation Resource Guide U.S. Office of Solid Waste and Emergency Response Technology Innovation Office Washington, DC 20460.

Garbisu C., Alkorta I., 2001. Phytoextraction: A cost effective plant-based technology for the removal of metals from the environment. Biores. Technol., **77**(3):229-236.

Gisbert C., Ros R., de Haro A., Walker D.J., Pilar Bernal M., Serrano R., Avino J.N., 2003. A plant genetically modified that accumulates Pb is especially promising for phytoremediation. Biochem. Biophys. Res. Commun., **303**(2):440-445.

Goel P. K., 2006. Water pollution causes effect and control. New age international publisher, New Delhi.

Hansan D., P. Duda J., Zayad A. and Terry N.,1998. Selenium removal by constructed wetlands: Role of biological volatilization. Environ. Sci. Technol., **32**:591-597 .

Li M. and Tadano T. (1996) Soil Sci. Plant Nutr. 42:753763.

Mandi L. ,1994. Waste water purification experiment using vascular aquatic plants *Eichhornia crassipes* and *Lemna gibba*. Water Sci.Technol., **29**:283- 287.

McGrath S.P., Zhao F.J., Lombi E., 2001. Plant andrhizosphere process involved in phytoremediation of metal-contaminated soils. Plant Soil, **232**(1/2):207-214.

Meagher R. B., Rugh C. L., Kandasamy M. K. ,Gragson G. and N. J. Wang, 2000. Engineered phytoremediaion of mercury pollution in soil and water using bacterial genes. In: Phytoremediation of contaminated soil and water. Edited by N. Terry and G. Banuelos,(Boca Raton), Lewis:201-221.

Mohammad Iqbal Lone, Zhen-Li H.E., Peter J. ,Stoffella and Xiao-e Yang, 2008. Phytoremediation of heavy metal polluted soil and water: Progress and perspectives. J Zhejiang Univ Sci., **9**(3): 210-220.

Kumar P. S., Kumar,S. S. Kumari A., Bharti S. and Ansari S., 2012. Phytoremediation as an alternative for treatment of paper industry effluents by using water hyacinth (*Eichhornia crassipes*) - A polishing treatment. Int.J. Res. Chem. Environ., **2**:95-99.

Raskin I., Smith R. D. and Salt D. E., 1997. Phytoremediation of metals: Using plant to remove pollutants from the environment. Curr. Opin. Biotechnol., **8**: 221-226.

Reddy K. R., Agami M. and Tuckker J. C., 1997. Influence of phosphorous on growth and nutrient storage by water hyacinth (*Eichhornia crassipe*s). Aquatic Botany, **37**:355-365.

Ruiz O. N., Hussein H. S. ,Terry N. and Deniell H., 2003. Phytoremediation of organomercurials compounds via chloroplast genetic engineering. Plant Physiol., **132**:1344-1352.

Salt D. E., Prince R. C, Pickering I. J. and Raskin I., 1995 b. Mechanism of cadmium mobility and accumulation of Indian mustered. Plant Physiol., **109**:1427-1433.

Terry N., Carlson C., Raab T. K. and Zayed A. M. ,1992. Rates of Selenium volatilization among crop species. J. Environ. Qual., **21**:341-344.

Vallini G., Gregorio S. Di and Lampis S. ,2005. Rhizosphere induced Selenium precipitation for possible applicatons in phytoremediation of Se polluted effluents. Z. Naturforsch (C), **60**(3-4):349-356.

Zayed A., Pilon Smits E. , deSouza M., Lin Z. Q. and Terry N.,2000. Remediation of Selenium polluted soils and waters by phytovolatilization. In: Phytoremediation of contaminated soil and water .Edited by N. Terry and G.Banuelos,(Boca Raton), Lewis:61-83.