Main Tile: Removal of Heavy metals and Agrochemicals residues through Plants

Short Tile: Heavy metals and agrochemicals residue phytoremediation

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Abstract

The present paper presents about removal of heavy metals, agrochemicals residues through natural plants. The removal of heavy metals residues and agrochemical residues with the interception of natural plants is called phytoremediation. The advancement of applied research produced various phytoremediation plants like weed plant, aquatic plant, tree and crops. The natural plant eradicates heavy metals and agrochemicals residues through phytostabilization, rhizodegradation, rhizofilteration, phytodegradation and phytovoltalization process. The terrestrial and aquatic plant eradicates heavy metals and agrochemicals residues from soil and water. Indian mustard removes 3 fold Cd, Pb, Se and Cs radioactive metals and diesel fuel spillage. *Oryza sativa* L. is cereal crop, removes Cu, Cd, from contaminated soil. *Spinacia oleracea* (Spinach) is vegetable crop, removes Cd, Cu, Fe, Ni, Pb, Zn and Cr from contaminated soil. *Cicer arientinum* is pulse crop, eradicates Pb and Cr from the contaminated soil. Pea is vegetable crop plant, removes Cd from the contaminated soil. *Brassica napus* L. oilseed crop, removes Cd, Cu, Zn, Pb from the contaminated soil. *Cajanus cajan* L. is pulse crop, removes As, Cd from the contaminated soil. *Cucumis sativus* L. is vegetable crop, removes Pb from the contaminated water. Annual grass and broad leaf weed removes atrazine, simazine, propazine, prometryn from the soil. *Chenopodium album* L., *Hordeum juhatum* L., *Panicum capillare* L., *Nepeta cataria* L., *Caedus nutans* L., *Poa annua* an *Fostuca* sp. removes atrazine, phosphorus, nitrate, ammonium. The phytoremediation plant recovers natural resources and restricts outbreak of diseases in the nature. Further, the scientific studies and research may build products of phytoremediation controlled plants for removing heavy metal and agrochemicals residue from the soil.

Keywords: Phytoremediation, plants, heavy metals, agrochemicals, residue

Novelty

Incorporation of Plant in heavy metal eradication in natural ecosystem,

Incorporation of Plant in agrochemical residue eradication in natural ecosystem,

Contribution of plant in recovering of soil properties and crop growth,

Contribution of plant in balancing of ecology and ecosystem.

Introduction

The abolishment of heavy metals and agrochemicals residues from with the intervention of plant is called phytoremediation. The heavy metal and agrochemicals residues pollution is found China, European Union, United Kingdom, Canada and India. The educated people are aware about phytoremediation plant in conventional period. The awareness and adoption of phytoremediation plants are less in the conventional period. The advancement of technology are insisted into recognition of phytoremediation plants. The hydrophytic plants, terrestrial plants and weed plants utilizes for removal of heavy metals and agrochemicals residues from the ecosystem. The phytoremediation plant actively absorbs heavy metals with phytostabilization, rhizodegradation, rhizofilteration, phytodegradation and phytovoltalization process. The scientists, professor and researchers investigated the various plants through experiment that eradicates heavy metals and agrochemicals residues i.e.,

i) Removal of Heavy metals through Plants

Jay (2015) explained the best plants for removal heavy metals i.e., Indian mustard, willow. Poplar tree, Indian grass (*Sorghastrum nutans*) and Sunflower. Indian mustard removes 3 fold Cd, Pb, Se and Cs radioactive metals and diesel fuel spillage. Poplar tree (*Populus deltoides*) grows in soil as well as water. It removes chlorinated solvents, organic pollutants, carcinogenic pollutants and petroleum hydrocarbons. Indian grass (*Sorghastrum nutans*) and wheat grass removes organic pollutants and petroleum hydrocarbons. Sunflower adapts on the soil and removes PAHs molecules, Pb, Zn. Cs and Sr heavy metals. Maize and Palm tree removes N, P, K, Cd, Cu and Mn from the soil.

Gyatri *et al*. (2019) studied removal of heavy metals from Indian mustard resulted that it removes Zn, Cu, Cr, Ni, Pb from the soil. Parvez (2018) mentioned that water hyacinth is hydrophytic plant, removes Cd, Zn, As, Pb, Cr, Al, Cu, Mn and Ni heavy metals from the water in 3 weeks. Prieto *et al*. (2018) stated that *Lemna minor*, *Lemna crassipies* and *Lemna gibba* are aquatic plant that removes Ni, Cu, Cd, Zn, Mn, B, Ur and As from the contaminated water. *Spirodela polyrhiza* grows in lake, river, pond and sloughs and eradicates As and Pb from contaminated water. *Lemna minor* and *Spirodela polyrhiza* are aquatic plant and removes Pb and Cd from contaminated water. *Azolla pinnata* is aquatic plant, removes Cd and Hg heavy metals from contaminated water. *Potamogeton pectinatus* is submerged plant, grows in in fresh water, brackish water and saline water, removes Cd, Pb, Cu, Zn and Mn heavy metals from contaminated water. *Pistia startiotes* is free floating aquatic plant, removes heavy metals from contaminated water (Vineet and Preetpal, 2017). *N. caerulescens* is terrestrial plant, removes Cd and Zn metals from the soil. *Sesbania drummondii* is aquatic plant, removes Pb from the water. *Alyssum bertolonii* is terrestrial

plant, removes Ni from the soil. *Nicotiana tabacum* is terrestrial plant, emoves Hg from the soil. *Aradiopsis thaliana* is terrestrial plant, removes Hg, Cd, Pb from the soil. *Beta vulgaris* is terrestrial plant, removes Cd, Zn, Cu from the soil. Tomato is terrestrial plant, removes Cd, Co, Cu, Ni, Pb, Zn from the soil (Suman *et al*., 2018). *Ipomea carnea* weed plant, grows in rivers, canals, and removes As and Pb heavy metal from the contaminated water. *Euphorbia genicuata* is small plant, grows in roadsides, fields, yards, removes Cd, Cr metals from the soil. *Eucalyptus globulus* aromatic tree, grows in rocks, soils, removes Fe and Zn metal from the land. *Polygonum glabrum* is grass plant, removes Ni metal from the land (Subha and Srinivas, 2017). *Serbertia acuminate* (Caledonian tree) is terrestrial tree, removes Ni metal from the land. *Thalaspi Calaminare* is terrestrial small plant, removes Zn metal from the soil. *Alyssum berotionii* is terrestrial plant, removes Ni metal from the soil. *Pimela suteri* is terrestrial shrub plant, eradicates Cr metal from the soil. *Leptospermum scoparium* is terrestrial tree, abolishes Cr metal from the soil. *Uncinia leptostachya* is terrestrial grass plant, eradicates Ur metal from the soil. *Betula papyrifera* is terrestrial tree, removes Hg metal from the soil (Cristina and Ray, 1995) and *Allium schoenoprasum* are vegetable crop, eradicates Ni, Co and Cd from the soil. *Cicer arientinum* is pulse crop, eradicates Pb and Cr from the contaminated soil. *Pisum sativum* L. is vegetable crop plant, removes Cd from the contaminated soil. *Brassica napus* L. oilseed crop, removes Cd, Cu, Zn, Pb from the contaminated soil. *Cajanus cajan* L. is pulse crop, removes As, Cd from the contaminated soil. *Cucumis sativus* L. is vegetable crop, emoves Pb from the contaminated water. *Jatropha curcas* L. is terrestrial tree, removes Fe, Al, Cu, Mn, Cr, As, Zn, Hg from contaminated soil. Lantana camara is terrestrial weed plant, removes Pb from the contaminated soil. *Lens culinaris* is pulse crop, removes Pb from the contaminated soil. *Lepidium sativum* is terrestrial plant, removes As, Cd, Fe, Pb, Hg from contaminated soil. *Lattuca sativa* L. is green terrestrial tree, removes Cu, Fe, Mn, Zn, Ni, Cd, Pb, Co, As from contaminated soil. *Oryza sativa* L. is cereal crop, removes Cu, Cd, from contaminated soil. *Spinacia oleracea* (Spinach) is vegetable crop, removes Cd, Cu, Fe, Ni, Pb, Zn and Cr from contaminated soil. *Solanum nigrum* L. (Black night shade) is terrestrial plant, removes Cd from contaminated soil. *Sorghum bicolor* L. (Sorghum) is cereal crop, removes Cd, Cu, Zn, Fe from contaminated soil (Sumaniahadi and Acar, 2018). *Echinochloa pyramidalis* and *Ludwigia stolonifera* L. are aquatic plant, removes Ni, Cd, Pb from contaminated soil (Alaa Eldin *et al*., 2020) **(Table 1, Fig. 1).** Faridah *et al*. (2017) evaluated that *D. asper*, *B. vulgaris*, *D. membranaceus* and *B. blumeana* are suitable for restoration of Cr-contaminated tannery sites.

ii) Removal of agrochemicals residues through Plants

Veronica *et al*. (2013) explained that *Asparagus africana* L., *Cleome hirta* L., *Nymphea nouchali* L. removes dieldrin, aldrin, 1, 1 dicholoro – 2,2 bis (p-chlorophenyl) ethylene, 1,1,1 tri-chloro 2,2 bis (p- chlorophenylethane), DDT, endosulfan, trichlorobenezene from the soil. Belden *et al*. (2013) stated that praire grass abolishes metachlor, trifluorin, pendimethalin from the soil. *Elodea canadenesis* L. removes cooper sulfate, flazasulfuron and dimethomorph from the soil (Premla *et al*., 2018). *Lemna minor* L., *Elodea Canadensis* L., *Cabomba aquatica* L. removes copper sulphate, flazausulfuron and dimethomoroph from the soil (Rachel *et al*., 2007). Jean *et al*., (2006) discussed that annual grass and broad leaf weed removes atrazine, simazine, propazine, prometryn from the soil. *Typha latifolia* L. remove

simazine from the contaminated water. *Kochia acoparia* L., *Chenopodium album* L., *Hordeum juhatum* L., *Panicum capillare* L., *Nepeta cataria* L., *Caedus nutans* L., *Poa annua* an *Fostuca* sp. removes atrazine, phosphorus, nitrate, ammonium. *Schoeplectus lacusturis* L., *Typha latifolia* L., *Iris pseudacorus* L., *Phragmites australis* L. removes atrazine from contaminated water. Vetiver is tropical grass, removes atrazine from the soil **(Table 2, Fig. 2).** Pesticides (herbicide, insecticide), benzene, toluene, ethylbenzene, xylene (BTEX), total petroleum hydrocarbon (TPH), polycyclic aromatic hydrocarbons (PAH), surface active substances, chlorinated solvents (TCE, TCA), pentachlorophenol (PCP) polychlorinated biphenyls (PCB) are through Mint (*Mentha spicata* L.), red berry (*Morus rubra* L.), lucerne (*Medicago sativa* L.), and reedmace (*Typha latifolia* L.) (EPA, 2000).

Conclusions

The advanced technology determines various plants that involves in heavy metal absorptions and fertilizer residues absorptions. The afforestation of phytoremediation plants overcomes soil problems, soil plasticity and incurs recovery of soil fertility. It recovers biogeochemical cycle, irrigation, ecosystems and human health. It stabilizes forest recovery rate, ecology and ecosystem of the surroundings. It encourages crop production and income of the farmers.

Acknowledgement

The author acknowledges that the informations received from reference papers and were not copied with respective journal authors.

References

Belden, J.B., Clark, B.W. Phillips, T.A., Henderson, K.L. and Arthur, E.L. 2004. Detoxification of Pesticide Residues in Soil Using Phytoremediation. Entomology Publications, Iowa State University, Digital repository, 155-167.

Cristina M.N. and Ray, R.H. 1996. Plants That Remove Contaminants From the Environment. *Laboratory Medicine*, **27**(1)**:** 36-40.

Faridah, H. W., Godfrey, A.W. and Simon, W. 2017. Phytoremediation Using Bamboo to Reduce the Risk of Chromium Exposure from a Contaminated Tannery Site in Kenya. *J. Health Pollution*, **16:** 12-25.

Gayatri, N., Sailesh, A. R. and Srinivas, N. 2019. Phytoremediation Potential of *Brassica juncea* for removal of selected heavy metals in urban soil amended with cow dung. *Journal of Materials and Environmental Sciences*, **10**(5)**:** 463-469.

Jay, B. 2015. Five best plants for phytoremediation. Landscape Architects Network, Washington D.C., USA.

Jean, P.S., Joana, M. and Petra, K. 2006. Pesticides removal using plants: phytodegradation versus phytostimulation. Phytoremediation Rhizoremediation, pp. 179 198.

Premla, D.C., Chow, M.F. and Chai, M.K. 2018. Removal of Pesticides Using Aquatic Plants in Water Resources: A Review. International Conference on Energy and Environmental Science, IOP Publishing, pp. 1-5.

Rachel, O., Michel, C., Sylvie, B. and Philippe, E. 2008. Toxicity and removal of pesticides by selected aquatic plants. *Chemosphere*, **70:** 1414-1421.

Subha, M. and Srinivas, N. 2017. Phytoremediation Potential of Weedy plants in Heavy Metal Contaminated Benthic Lake sludge. *International Journal of Applied Engineering Research*, **12**(14)**:** 4534-4538.

Suman, J., Ondrej, U., Jitka, V. and Tomas, M. 2018. Phytoextraction of Heavy Metals: A Promising Tool for Clean-Up of Polluted Environment. *Frontiers in Plant Science*, **9:** 3-15.

Veronica, C.O., Beauty, M.M., Harriet, O., Ketlhatlogile M. and Nelson,T. 2013. Extraction of Pesticides from Plants using Solid Phase Microextraction and QuEChERS. *S. Afr. J. Chem*., 66: 183-188.

Vineet, S. and Preetpal, K. 2018. Efficacy of Aquatic Plants for Removal of Heavy Metals from Wastewater. *Int. J. Life Sci. Scienti. Res*., **4**(1)**:** 1527-1530.

EPA. 2000. Introduction to Phytoremediation, EPA/600/R-99/107. Ohio 45268, USA: National Risk Management Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Cincinnati.

Table 1: Removal of Heavy metals through Plants				
S.No.	**Plant**	**Habitat**	**Heavy metals**	**References**
1	*Brassica juncea* L. (Indian mustard)	land	Cd, Pb, Se and Cs	Jay, 2015
2	*Helianthus annus* L. (Sunflower)	soil	PAHs molecules, Pb, Zn. Cs and Sr	Jay, 2015
3	*Brassica juncea* L. (Indian mustard)	land	Zn, Cu, Cr, Ni, Pb	Gyatri *et al*., 2019
4	*Ecchornia crassipies* L. (Water hyacinth)	water	Cd, Zn, As, Pb, Cr, Al, Cu, Mn and Ni	Parvez, 2018
5	*Lemna minor*, *Lemna crassipies* and *Lemna gibba*	water	Ni, Cu, Cd, Zn, Mn, B, Ur	Prieto *et al*., 2018
6	*Beta vulgaris* L.	land	Cd, Zn and Cu	Suman *et al*., 2018
7	*Cicer arientinum* L.	land	Pb and Cr	Sumaniahadi and Acar, 2018
8	*Pisum sativum* L.	land	Cd, Cu, Zn, Pb	
9	*Cajanus cajan* L.	land	As, Cd	
10	*Jatropha curcas* L.	land	Fe, Al, Cu, Mn, Cr, As, Zn, Hg	
11	*Lattuca sativa* L.	land	Fe, Al, Cu, Mn, Cr, As, Zn, Hg	
12	*Echinochloa pyramidalis and Ludwigia stolonifera L.*	water	Ni, Cd, Pb	Alaa Eldin *et al*., 2020
13	*D. asper, B. vulgaris, D. membranaceus and B. blumeana as suitable for restoration of Cr-contaminated tannery sites.*	tannery sites	Cr	Faridah *et al*., 2017

Table 2: Removal of agrochemical residues through Plants				
S.No.	**Plant**	**Habitat**	**agrochemical residues**	**References**
1	*Asparagus africana* L., *Cleome hirta* L., *Nymphea nouchali* L.	soil	dieldrin, aldrin, 1, 1 dicholoro – 2,2 bis (p-chlorophenyl) ethylene, 1,1,1 tri-chloro 2,2 bis (p-chlorophenylethane), DDT, endosulfan, trichlorobenezene	Veronica *et al.*, 2013
2	Praire grass	soil	metachlor, trifluorin, pendimethalin	Belden, 2013
3	*Elodea canadenesis* L.	soil	cooper sulfate, flazasulfuron and dimethomorph	Premla *et al.*, 2018
4	*Lemna minor* L., *Elodea Canadensis* L., *Cabomba aquatica* L.	soil	copper sulphate, flazausulfuron and dimethomoroph	Rachel *et al.*, 2007
5	Annual grass and Broad leaf weeds	soil	atrazine, simazine, propazine, prometryn	Jean *et al.*, 2006
6	*Typha latifolia* L.	water	simazine	
7	Vetiver	soil	atrazine	
8	*Kochia acoparia* L., *Chenopodium album* L., *Hordeum juhatum* L., *Panicum capillare* L., *Nepeta cataria* L., *Caedus nutans* L., *Poa annua* an *Fostuca* sp.	soil	atrazine, phosphorus, nitrate, ammonium.	
9	*Mint (Mentha spicata L.), red berry (Morus rubra L.), lucerne (Medicago sativa L.), and reedmace (Typha latifolia L.)*	soil	Pesticides (herbicide, insecticide)	

Fig. 1: Phytoremediation plants applies for heavy metal residues absorption

Fig. 2: Phytoremediation plants uses for agrochemical residues eradication