International Journal of Bioassays
ISSN: 2278-778X
www.ijbio.com

Review Article

IMPACT OF HEAVY METAL AND OTHERS POLLUTANTS ON HEALTH AND ROLE OF THE PLANT IN TOXIC REMEDIATION

Preeti Sonkar* and Vinit Kumar
S. S. Memorial College, Sultiyani Mod, Etawa, Uttar Pradesh, India

Received for publication: June 12, 2013; **Revised**: July 25, 2013; **Accepted**: July 28, 2013

Abstract: An increased uptake of toxic metals by food crops grown on such soils together with human health risks are often recorded. Environmental pollution affects the quality of pedosphere, hydrosphere, atmosphere, lithosphere and biosphere. Great efforts have been made in the last two decades to reduce pollution sources and remedy the polluted soil and water resources. Phytoremediation, being more cost-effective and fewer side effects than physical and chemical approaches, has gained increasing popularity in both academic and practical circles. More than 400 plant species have been identified to have potential for soil and water remediation (Lone *et al.,* 2008). This paper will provide a brief idea on recent progresses in research and practical applications of phytoremediation for soil and water resources.

Keywords: Food Safety, Heavy Metal Risk, Health Effect, Phytoremediation

INTRODUCTION

Healthy environment are most essential for human life. It refers to natural things around us, which sustain life. Pollution of land, water, air through generated as result of increasing population, urbanization and industrialization is a challenge of serious climates. Food safety issues and potential health risks make this is one of the most serious environmental concern (Cui *et al.,* 2004). Crop and vegetables grown in soils contaminated with heavy metals have greater accumulation of heavy metals than those grown in uncontaminated soil (Marshall *et al.,* 2007, Sharma *et al., 2006*, 2007). All these released pollutants have great ecological impact the water quality and its surrounding food web (Abhishek *et al.,* 2008). Heavy metals are widespread pollutants of great environmental concern as they are non-biodegradable, toxic and persistent with serious ecological ramifications on aquatic ecology (Chopra *et al.,* 2009, Jumbe *et al.,* 2009). The contamination of heavy metals to the environment, i.e., soil, water, plant and air is of great concern due to its potential impact on human and animal health. Phytoremediation, also referred as botanical bioremediation (Chaney *et al.,* 1997), involves the use of green plants to decontaminate soils, water and air. It is an emerging technology that can be applied to both organic and inorganic pollutants present in the soil, water or air (Salt *et al.,* 1998).

Organics: People worry the most about potentially toxic chemicals and metals in water. Only a few of the toxic organic chemicals that occur drinking water are regulated by drinking water standards. This group of contaminants includes:

Trihalomthanes (THMs): Which are formed when chlorine in treated drinking water combines with naturally occurring organic matter.

Pesticides: Including herbicides, insecticides, and fungicides.

Volatile Organic Chemicals (VOCs): Which include solvents, degreasers, adhesives, gasoline additives, and fuels additives. Some of the common VOCs are: benzene, trichloroethylene (TCE), styrene, toluene, and vinyl chloride. Possible chronic health effects include cancer, central nervous system disorders, liver and kidney damage, reproductive disorders, and birth defects.

Inorganics: These contaminants include toxic metals like arsenic, barium, chromium, lead, mercury, and silver. These metals can get into your drinking water from natural sources, industrial processes, and the materials used in your plumbing system. Toxic metals are regulated in public water supplies because they can cause acute poisoning, cancer, and other health effects.

- Lead is hazardous to health as it accumulates in the body and affects the central nervous system. Children and pregnant women are most at risk.
- Fluoride Excess fluorides can cause yellowing of the teeth and damage to the spinal cord and other crippling diseases.
- Nitrates Drinking water that gets contaminated with nitrates can prove fatal especially to infants that drink formula milk as it restricts the amount of oxygen that reaches the brain causing the 'blue

***Corresponding Author:**
Preeti Sonkar,
S. S. Memorial College,
Sultiyani Mod, Etawa,
Uttar Pradesh, India

baby' syndrome. It is also linked to digestive tract cancers. It causes algae to bloom resulting in eutrophication in surface water.

- Chlorinated solvents these are linked to reproduction disorders and to some cancers.
- Arsenic Arsenic poisoning through water can cause liver and nervous system damage, vascular diseases and also skin cancer.
- Other heavy metals: Heavy metals cause damage to the nervous system and the kidney, and other metabolic disruptions.
- Nitrate is another inorganic contaminant. The nitrate in mineral deposits, fertilizers, sewage, and animal wastes can contaminate water. Nitrate has been associated with "blue baby syndrome" in infants.

Radioactive Elements:

Radon is a radioactive contaminant that results from the decay of uranium in soils and rocks. It is usually more of a health concern when it enters a home as a soil gas than when it occurs in water supplies. Radon in air is associated with lung cancer.

Pesticides: The organophosphates and the carbonates present in pesticides affect and damage the nervous system and can cause cancer. Some of the pesticides contain carcinogens that exceed recommended levels. They contain chlorides that cause reproductive and endocrinal damage.

Numerous regions in the world are known where cultivation of food and feed crops is irresponsible due to the presence of excessive amounts of plant-available toxic metals, leading to economic losses and negative effect for food chain (Meers *et al.,* 2010). Severe toxic metal contamination of soil may cause a variety of problems, including the reduction of crop yield, serious damage of plants and intoxication of animals and humans.

The methods used to phytoremediation metal contaminants are slightly different to those used to remediate sites polluted with organic contaminants. (Table.1).

Metal	**Organic**
Phytoextraction	Phytodegradation
Rhizofiltration	Rhizodegradation
Phytostabilisation	Phytovolatilisation

Phytoremediation is an emerging technology that employs the use of higher plants for cleanup of contaminated environments. Fundamental and applied research have equivocally demonstrated that selected plant species possess the genetic potential to remove, degrade, metabolilize a wide range of contaminants. Despite this tremendous potential, phytoremediation is yet to become a commercial technology.

- Alfalfa (symbiotic with hydrocarbon-degrading bacteria)
- Arabidopsis (carries a bacterial gene that transforms mercury into a gaseous state)
- Bamboo family (accumulates silica in it's stalk and nitrogen as crude protein in it's leaves) Bladder campion (accumulates zinc and copper)
- *Brassica juncea* (Indian mustard greens) (accumulates selenium, sulfur, lead, chromium, cadmium, nickel, zinc, and copper)
- Buxaceae (boxwood) and Euphorbiaceae (a succulent) (accumulates nickel)
- Compositae family (symbiotic with Arthrobacter bacteria, accumulates cesium and strontium)
- Ordinary tomato and alpine pennycress (accumulates lead, zinc and cadmium) Poplar (used in the absorption of the pesticide, atrazine).

Richard Meagher and colleagues introduced a new pathway into *Arabidopsis* to detoxify methyl mercury, a common form of environmental pollutant to elemental mercury which can be volatilized by the plant.

Pb accumulator species:

1. *Apocynum cannabinum* (Hemp dogbane)
2. *Ambrosia artemisiifolia* (Common ragweed)
3. *Carduus nutans* (Nodding thistle)
4. *Commelina communis* (Asiatic day flower)

Table.2: Phytoremedition by plant species

Plant species	Metal	Leaf content (ppm)	References
Thlaspi caerulescens	Zn: Cd	39,600 : 1,800	Reeves & Brooks (1983), Baker &walker (1990)
Ipomea alpina	Cu	12,300	Baker &walker (1990)
Haumaniastrum rabertii	Co	10,200	Brooks (1997)
Astragalus racemosus	Se	14,900	Beath *et al.,* (1937)
Sebertia acuminata	Ni	25% by weight dried sap.	Jaffre *et al.,* (1976)
T. goesingense	Ni		Kramer *et al.,* (1997); Kramer *et al.,* (1996)
Alyssum bertolonii	Zn		Glick R.B. (2011) and Lone I. M. (2008)
Berkheya coddi	Zn		Lone I. M. (2008)

Table.3: In phytoremediation also include medicinal plant

Species name	Metal name	Name of accumulate plant part
H. perforatum	Cu and Cd	Mental accumulation in individual plant organs (Kralova & Masarovicova, 2004)
M. recutita	Cd	High Cd concentration in shoot.
Chamomile plant	Cd	Accumulated in root and shoot.
S. officinalis	Cd	Accumulated in plant organs (Marquard & Schneider, 1998).

However it has been tested successfully in many places around the world for many different contaminants.

Table.4: This table shows the extent of testing across some sites in the USA

Location	Application	Pollutant	Medium	plant(s)
Ogden, UT	Phytoextraction & Rhizodegradation	Petroleum & Hydrocarbons	Soil & Groundwater	Alfalfa, poplar, juniper, fescue
Anderson, ST	Phytostabilisation	Heavy Metals	Soil	Hybrid poplar, grasses
Ashtabula, OH	Rhizofiltration	Radionuclides	Groundwater	Sunflowers
Upton, NY	Phytoextraction	Radionuclides	Soil	Indian mustard, cabbage
Milan, TN	Phytodegradation	Expolsives waste	Groundwater	Duckweed, parrotfeather
Amana, IA	Riparian corridor, phytodegradation	Nitrates	Groundwater	Hybrid poplar

(Table No.4 . Source from articles of Phytoremediation)

Phytoremediation for water pollution:

Cd uptake by three hydrophytes: *Gladiolous*, *Isoetes taiwaneneses* Dwvol and *Echinodorus amazonicus* Li H. *et al.*, (2005).

Cu removal from the contaminated water by *Elsholtzia argyi* and *Elsholtzi splendens* in hydroponics. Zhang *et al.*, (2005)

Pteris vitta commonly known as Brake fern has been identified as hyper accumulator for contaminated soils and waters. It can accumulate up to 7500 mg As/kg on a contaminated site (Ma *et al.*, 2001)

Several aquatic species have been identified and tested for the phytoremediation of heavy metals from the polluted water. These include sharp dock (*Polygonum amphibium* L.), duck weed (*Lemna minor* L.), water hyacinth (*Eichhornia crassipes*), water lettuce (*P. stratiotes*), water dropwort [*Oenathe javanica* (BL) DC], calamus (*Lepironia articulate*), pennywort (*Hydrocotyle umbellate* L.) (Prasad and Freitas, 2003). The roots of Indian mustard are found to be effective in the removal of Cd, Cr, Cu, Ni, Pb and Zn, and sunflower can remove Pb, U, Cs-137 and Sr-90 from hydroponic solutions (Zaranyika and Ndapwadza, 1995; Wang *et al.*, 2002; Prasad and Freitas, 2003).

According to a study by Wilson and Moore, elodea was effective at absorbing zinc and chromium from water and was not adversely affected by the heavy metals. A study by Rice *et al.*, showed that elodea can remove metholachor and atrazine, toxic herbicides, from polluted water. This aquatic plant can also remove trinitrotoluene (TNT), a contaminant usually found near military installations.

Application of remediation in Industrial pollution: Some recent research knowledge has been given as:

- Phyto extraction of trace elements and physiological changes in Indian mustard plants (*Brassica nigra L.*) grown in post methanated distillery effluent (PMDE) irrigated soil. (Bharagava *et al.*, 2008).
- Metal accumulation in aquatic macrophytes from Southeast Queensland (Cardwell *et al.*, 2002).
- Bioremediation of melanoidin containing digested spent wash from cane-molasses distillery with white rot fungus *Coriolus versicolor*. (Chopra *et al.*, 2004).
- Accumulation of heavy metals in *Typha anguistifolia* (L.) and *Potamogeton pectinatus* (L.) living in Sultan Marsh (Kayseri, Turkey) (Demirezen *et al.*, 2004).
- Phytoextraction of Zn by oat (*Avena sativa*) Barley (*Hordeum vulgare*) and Indian mustard (*Brassica juncea*) (Ebbs *et al.*, 1998).
- Treatment of anaerobically digested distillery spent wash in a two–stage bioreactor using *Pseudomonas putida* and *Aeromonas sp*. (Ghosh *et al.*, 2002).
- Phytoremediation of phenol from wastewater, by peroxidase of tomato hairy root cultures. (Gonzalez *et al.*, 2006).
- Decolourization of molasses wastewater by *Bacillus sp*. under thermophilic and anaerobic conditions (Kambe *et al.*, 1999).
- Batch decolourization of molasses by suspended and immobilizes fungus of *Geotrichum candidum* (Kim and Shoda 1999).
- Detoxification of distillery effluent through *Bacillus thuringiensis* (MTCC 4714) enhanced phytoremediation potential of *Spirodela polyrrhiza (L.)* Schliden (Kumar *et al.*, 2004).
- Colour elimination from molasses wastewater by *Aspergillus niger* (Miranda *et al.*, 1996).
- Decolourization of molasses wastewater by a strain no. BP103 of Acetogenic bacteria. (Sirianuntapiboon *et al.*, 2004).

CONCLUSION

Fundamental and applied researches have equivocally demonstrated that selected plant species possess genetic ability. Planning, engineering and design with the ecological paradigm as our template is the work of Sustainable Strategies. For example, the ecological paradigm reveals how to safely utilize all of the polluting components and water of human and animal wastewater to ultimately grow plants that have economic value**.** Only in advanced and highly developed countries these plants are also used as technical plants (eg. for alternative source of energy or Environment protection). Moreover, topic of the effect of toxic substances including heavy metals on physiological and production characteristics of the both, crops and medicinal plants is in general extraordinarily important. Progress in the field is precluded by limited knowledge of basic plant remedial mechanisms

REFERENCES

1. Elena Masarovicová and Katarína Králová (2012), Plant-Heavy Metal Interaction: Phytoremediation, Biofortification and Nanoparticles, Advances in Selected Plant Physiology Aspects, Dr Giuseppe Montanaro (Ed), ISBN: 978-953-51-0557-2, InTech, Available from: http://www.intechopen.com/books/advances-inselected-plant-physiology-aspects/crops-and-medicinal-plants-under-metal-stress

2. Bharagava RN, Chandra R, Rai V (2008b), Phytoextraction of trace elements and physiological changes in Indian mustard plants (*Brassica nigra L*) grown in post methanated distillery effluent (PMDE) irrigated soil, Biores Technol, 99: 8316–8324.

3. Cardwell AJ, Hawker DW, Greenway M (2002), Metal accumulation in aquatic macrophytes from Southeast Queensland, Australia Chemosphere, 48: 653–663.

4. Chopra P, Singh D, Verma V, Puniya AK (2004), Bioremediation of melanoidin containing digested spent wash from cane-molasses distillery with white rot fungus *Coriolus versicolor, Indian J Microbiol,* 44: 197–200.

5. Demirezen D, Aksoy A (2004), Accumulation of heavy metals in *Typha anguistifolia (L)* and *Potamogeton pectinatus (L)* living in Sultan Marsh (Kayseri, Turkey) Chemosphere, 56: 685–696.

6. Ebbs SD, Kochian LV (1998), Phytoextraction of Zn by oat (*Avena sativa*) Barley *(Hordeum vulgare)* and Indian mustard (*Brassica juncea), Environ Sci Technol,* 32: 802–806.

7. Ghosh M, Ganguli A, Tripathi AK (2002), Treatment of anaerobically digested distillery spent wash in a two–stage bioreactor using *Pseudomonas putida* and *Aeromonas sp., Process Biochem,* 37: 857–862.

8. Gonzalez PS, Capozucca CE, Tigier HA, Milard SR, Agostini E (2006), Phytoremediation of phenol from wastewater, by peroxidase of tomato hairy root cultures, *Enzyme Microb Technol* 39: 647–653.

9. Kambe TN, Shimomura M, Nomura N, Chanpornpong T, Nakahara T (1999) Decolourization of molasses wastewater by Bacillus sp under thermophilic and anaerobic conditions, *J Biosci Bioeng* 87, 119–121.

10. Kim SJ, Shoda M (1999), Batch decolourization of molasses by suspended and immobilizes fungus of *Geotrichum candidum Dec 1, J Biosci Bioeng,* 88: 586–589.

11. Kumar P, Chandra R (2004), Detoxification of distillery effluent through Bacillus thuringiensis (MTCC 4714) enhanced phytoremediation potential of *Spirodela polyrrhiza (L) Schliden Bull Environ Contam Toxicol* 73: 903–910.

12. Miranda PM, Benito GG, Cristobal NS, Nieto CH (1996) Colour elimination from molasses wastewater by *Aspergillus niger Biores Technol* 57: 229–235.

13. Sirianuntapiboon S, Phothilangka P, Ohmomo S (2004), Decolourization of molasses wastewater by a strain no BP103 of *Acetogenic bacteria Biores Technol* 92: 31–39.

14. Marquard R & Schneider M (1998), Zur Cadmiumproblematik im Arzneipflanzenbau In: *Fachtagung Arznei- und Gewurzpflanzen* R Marquard & E Schubert, (Ed), 9-15, 1-2 101998, Giessen, Germany.

15. Králová K & Masarovicová E (2004) Could complexes of heavy metals with secondary metabolites induce enhanced metal tolerance of *Hypericum perforatum*? In: *Macro and Trace Elements Mengen- und Spurenelemente* ed M Anke *et al,* 411-416.

16. Ma LQ, Komar KM, Tu C, Zhang WH, Cai Y & Kennelley, ED (2001) A fern that hyperaccumulates arsenic - A hardy, versatile, fast-growing plant helps to remove arsenic from contaminated soils *Nature,* Vol 409, No 6820, (February 2001), p 579, ISSN 0028-0836.

17. Lone M I, He Z, Stoffella P J,and Yang X ,(2008) Phytoremediation of heavy metal polluted soils and water: Progresses and perspectives Zhejiang Univ Sci B 9(3): 210–220.

18. Li H, Cheng F, Wang A, et al Cadmium Removal from Water by Hydrophytes and Its Toxic Effects; Proc of the International Symposium of Phytoremediation and Ecosystem Health; Sept 10-13, 2005; Hangzhou, China 2005.

19. Prasad MNV, Freitas HMD Metal hyperaccumulation in plants, Biodiversity prospecting for phytoremediation technology *Electron J Biotechnol* 2003;93 (1):285–321.

20. Salt DE, Smith RD, Raskin L Phytoremediation Ann Rev Plant Phys Plant Mol Biol 1998; 49 (1): 643–668.

21. Wang Q, Cui Y, Dong Y Phytoremediation of polluted waters potential and prospects of wetland plants Acta Biotechnol 2002;22(1-2):199–208.

22. Brooks RR 1977 Copper and cobalt uptake be *Haumaniastrum* species, Plant Soil, 48:541-544.

23. Beath OA, Eppsom HF, Gilbert CS 1937 Selenium distribution in and seasonal variation of vegetation type occurring on seleniferous soils, J American Pharm Assoc, 26:394-405.

24. Baker AJM, Walker PL 1990 Ecophysiology of metal uptake by tolerant plants *In* Heavy Metal Tolerance in Plants: Evolutionary Aspects, *ed* AJ Shaw, pp 155-177, CRC Press, Boca Raton, FL.

25. Reeves RD, Brooks RR 1983 European species of *Thlaspi* L (Cruciferae) as indicators of nickel and zinc J Geochem Explor 18: 275-283.

26. Jaffre T, Brooks RR, Lee J, Reeves RD 1976 *Sebertia acuminata*: a nickel-accumulating plant from new Caledonia Science 193: 579-580.

27. Krämer U, Smith RD, Wenzel W, Raskin I, Salt DE 1997 The role of metal transport and tolerance in nickel hyperaccumulation by *Thlaspi goesingense* Halacsy *Plant Physiol* 115: 1641-1650.

28. Krämer U, Cotter-Howells JD, Charnock JM, Baker AJM, Smith AC 1996 Free histidine as a metal chelator in plants that accumulate nickel 379 *Nature*: 635-638.

29. Cui,YJYH Zhu, R HZhai, DYChem YZFhing, YQui &JZ Liang(2004) Transfer of metals from near a smelter in Naning, China *Environmental* 30:785-791.

30. Chopra, Ak C Pathak and G Prasad(2009), Scenario of heavy metals contamination in agricultural soil and its Management *J Applied nat Sci*, 1: 99-108.

31. Sharma, RK, M Agrawal & FM Marshall,(2006), Heavy metals contamination in vegetables grown in waste water irrigated areas of Varanasi, *india Bulletin of Environmental contamination and toxicology* 77 : 311-318.

32. Sharma, RK, M Agrawal & FM Marshall, (2007), Heavy metals contamination of soil and vegetables in suburban areas of varanasi, *india Ecotoxicology and Environmental safety* 66: 256-266.

33. Marshall, FM, J Holden, C Ghose, B Chisala, E Kapungwe, J Volk, M Agrawal, R Agrawal, RK Sharma & RP Shingh (2007) Contaminated Irrigation Water and Food Safety for the Urban and periurban poor: Appropriate measures for monitoring and control from field research in india and Zambia, Inception Report DFID Enkar RS 160,SPRU, University of Sussex

34. Jumbe, A S and N Nandini(2009) Impact assessment of Heavy metals, pollution of vartur lake, Bangalore, J Applied nat sci, 1:53-61.

35. Abhishek, M and VKMishra (2008) Bioaccumulation of heavy metals in crop irrigated with secondary treat sewage waste water in surrounding villages of Varanasi city Res Envi life Sci1:103-108.

36. Meers, E; Van Slycken, S; Adriaensen, K; Ruttens, A; Vangronsveld, J; Du Laing, G;Witters, N; Thewys, T Tack, FMG (2010) The use of bio-energy crops (*Zea mays*) for phytoattenuation of heavy metals on moderately contaminated soils: A field experiment *Chemosphare*, Vol 78, No 1, (January 2010), pp 35-41.

Source of support: Nil
Conflict of interest: None Declared