RESEARCHERID
THOMSON REUTERS

[Imam * *et al.*, 6(7): July, 2017]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

PHYTOREMEDIATION: A METHOD TO REDUCE METAL IONS PRESENT IN WASTE WATER

Shirin Imam*

*Department Of Chemical Sciences Christian Eminent College, Indore India

DOI: 10.5281/zenodo.829805

ABSTRACT

Heavy metal pollution is a worldwide concern; its severity and degree of pollution vary from place to place Metal contamination can be carried with soil particles get carried away from the original areas of pollution by wind and rain. The heavy metals which are mostly found in mining waste include arsenic, cadmium, chromium, copper, lead, nickel, and zinc, all of which cause risks for human health and the environment. Industrial waste water also adds to this problem. When waste water comes in contact with soil it pollutes it as well. Prolonged exposure and higher buildup of such heavy metals have harmful health effects on soil, human life, water bodies and aquatic biota. The discharge of these metals without suitable treatment creates a major risk to human health. There are several methods to remediate or reduce the concentration of heavy metal pollution. The physicochemical processes include chemical precipitation, reverse osmosis, and ion exchange method. Each and every method has its merits and demerits and apart from this they are capital intensive as well. During past few years Phytoremediation is gaining importance as one of the green technology to remediate metal ion pollution. Phytoremediation is the use of green plants to clean-up contaminated hazardous waste sites and water. It is an in situ method in which various types plants are used to transfer, remove and destroy the contaminants from soil and water. The present research work is focused on minimizing lead ions present in soiled contaminated by waste water of chemistry laboratory using Phytoremediation done by Indian Mustard plant.

KEYWORDS: Phytoremediation, Heavy Metals, Green Technology, Pollution, Soil, Waste Water.

I. INTRODUCTION

The term “heavy metals” refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). Heavy metals are elements with an atomic density greater than 6 g/cm^3 or 5 times or more, greater than water. Their occurrence and buildup in the environment is a consequence of direct or indirect human activities. Heavy metals are chiefly a concern because they do not get eliminated by degradation; hence they accumulate throughout the food chain. Surface water, and ground water worldwide, is gradually more affected by contaminations from industrial, mining, research experiments, and agricultural activities. Heavy metal pollution increases potential human health risks and ecological instability. The remediation of contaminated soil, groundwater, and surface water requires the removal of toxic metals from contaminated areas. The common heavy metals that are present in polluted water include arsenic, copper, cadmium, lead, chromium, nickel, mercury selenium, silver and zinc. Prolonged contact and higher buildup of such heavy metals can have harmful health effects on human life and aquatic biota. Many of them are toxic even at very low concentrations.

Table1.Toxic effects of heavy metals on human health.

Heavy Metal	Toxic effect
Arsenic	Affect cellular processes like oxidative phosphorylation and ATP synthesis
Copper	Brain and kidney damage, liver cirrhosis and chronic anemia, stomach and intestine irritation
Cadmium	Carcinogenic, mutagenic, endocrine disruptor, lung damage and fragile bones, affects calcium regulation in biological systems
Lead	Reduced intelligence, short-term memory loss, disabilities in learning and coordination problems, risk of cardiovascular disease

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Chromium	Hair loss
Nickel	Allergic skin diseases
Mercury	Autoimmune diseases, depression, drowsiness, fatigue, hair loss, insomnia, loss of memory, restlessness, disturbance of vision, tremors, temper outbursts, brain damage, lung and kidney failure

Table 2.Sources of heavy metals

Metal	Anthropogenic sources
Arsenic	Pesticides, ore mining and smelting
Copper	Pesticides, fertilizers, bio solids, ore mining and smelting process
Cadmium	Electroplating Paints and pigments, plastic stabilizers, , phosphate fertilizers
Lead	Aerial emission from combustion of leaded fuel, batteries waste, insecticide and herbicides
Chromium	Electroplating Tanneries, steel industries, fly ash
Nickel	Electroplating, industrial Effluent, kitchen appliances, surgical instruments, automobile batteries
Mercury	Au-Ag mining, coal combustion, medical waste

In order to prevent and preserve the environment and make it healthier for human beings, contaminated water bodies, soil and land need to be cured to make them free from heavy metals. There are several techniques to remove these heavy metals, including chemical precipitation, oxidation or reduction, filtration, ion-exchange, reverse osmosis, membrane technology, evaporation and electrochemical treatment. Each of these methods has its own advantages and disadvantages.

A. Chemical precipitation:-

Chemical precipitation of heavy metals in water has been practiced as a leading method of treatment for industrial waters. The advantage of Chemical precipitation method is their low costs and it can be performed by a simple pH adjustment.

Other advantages are:

1. It is an entrenched method.
2. It is convenient, requires low maintenance since only replenishment of chemicals is required, and no need for skilled operators.

Chemical precipitation of metals in water has the following disadvantages:

1. Large volumes of sludge are generated, incurring added waste-disposal costs. The addition of treatment chemicals may increase the quantity of waste sludge many folds.
2. Metal hydroxides are increasingly soluble above or below their individual maximum precipitation point, even a slight pH change to precipitate one metal may put other metal back into solution by dissolving it.

B. Ion exchange

Ion Exchange is a reversible chemical process where an ion from wastewater solution is exchanged for a similarly charged ion attached to an immobile solid particle. These solid ion exchange particles are either naturally occurring inorganic zeolites or synthetically prepared organic resins. This technique has been effectively used in the removal of several heavy metals from water. The disadvantage is that it is quite costly. Reclamation of exhausted zeolites and resin is another constraint.

C. Reverse Osmosis

Reverse osmosis (RO) technology has long been used to remove metal ions from water as well as to purify mixed wastewater for reuse. Reverse osmosis method uses semi-permeable membranes to separate water from a solution of metal and solids. By applying pressure to a solution, water and other smaller, lighter molecules are

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

forced through pores of the membrane, while larger molecules such as dyes and metal compounds get caught. Water is thus purified as it passes through the membrane.
Advantage of Reverse osmosis is that it is capable of removing up to 97% of dissolved solids, 98 %of organics, and 99 %of bacteria. Reverse osmosis is a fine component of a low- or zero-discharge configuration. But the limitation is that it is expensive and requires specialized set up.

The basic aim of present research is to study eco friendly methods to deal with metal pollution. During the present work Phytoremediation was studied as one of the green method to remove metal ions from the waste water of Chemistry laboratory of college.

Phytoremediation deals with the use of green plants to clear out polluted hazardous waste sites. The idea of using plants to remove heavy metals and other compounds was first introduced in 1983. It has the advantage of relatively low cost and wide public acceptance (Schnoor, 1997). A significant advantage of phytoremediation is that a variety of organic and inorganic compounds can be removed to the phytoremediation process. Phytoremediation is described as a green and natural process carried out by plants and trees to clear out the contaminated soils and ground water. Garbisu defined phytoremediation as an emerging cost effective, non-intrusive, aesthetically pleasing, and low cost technology using the remarkable ability of plants to metabolize various elements and compounds from the environment in their tissues. Plants help to minimize pollutants in three different ways (1) By accumulating toxic trace elements in the roots (2) By precipitating them in root zone. (3) By adsorption on root surfaces. Plants also help in changing the chemical form of the contaminants by changing the soil pH and redox potential about plant roots. The microbes, soil bacteria and mycorrhiza living in the rhizosphere of plants have significant role in these processes as well. They actively contribute to change the trace element speciation, and also assist the plant in overcoming phyto toxicity, thus supporting in the re vegetation process [1] (van der Lelie et al. 1999; Mastretta et al. 2006). The plants either take up or help in the degradation of the organic contaminants. Crops of hyper accumulating plants reduce soil concentrations of toxic inorganic or organic up to the extent that remaining concentrations left behind after phytoremediation is in environmentally acceptable limit and no longer considered hazardous.

Table 3 Plants useful for phytoremediation

Botanical name of the Plant	Common name
Brassica Juncea L.	Indian Mustard
Populus Deltoides	Poplar Tree (Cotton Wood)
Sorghastrum Nutans	Indian Grass
Helianthus Annuus L	Sunflower
Triticum Aestivum	Wheat
Brassica Napus	Turnip
Salix Species	White Willow

II. MATERIAL AND METHOD

The waste water coming of lab was analyzed for ions present in it and their concentration. The water was used to irrigate the soil to grow Brassica Juncea commonly known as Indian mustard. The metal ions selected for study was lead. Lead is naturally present in all types of soil. Its concentration ranges from 15 to 40 parts lead per million parts of soil. Due to pollution soil lead levels increases to several thousand ppm. The main reason of lead pollution of soil in inhabited areas is lead-based paints, automotive lead emissions. Though nowadays use of unleaded petrol has reduced the automotive lead emission considerably but the key point is that the residence time of lead in soil is very large therefore the lead pollution problem needs to be addressed. Laboratory experiments were carried out using a sandy-silt soil collected from a garden area of college.

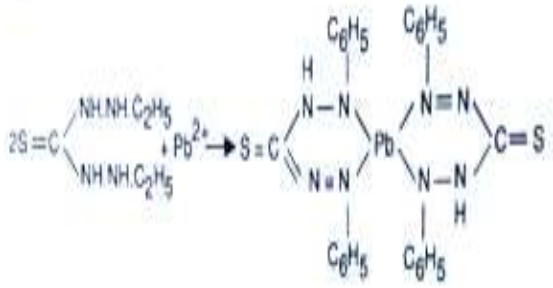
The soil was collected from the 35cm top soil layer. After removal of debris like grass, stone the soil was sieved to obtain soil particles of size less than 2 mm. The bulk amount of soil hence obtained was divided in to two

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

parts by weight thus two samples A and B of 2kg DW of soil were taken. First sample **A** of soil artificially contaminated with a waste water of chemistry lab containing lead ions. The sample **B** was contaminated by $Pb(NO_3)_2$ solution. Both the samples of soil were contaminated so as to obtain a homogeneous Pb concentration of 600 mg kg^{-1} soil. After contamination procedure, the soil was Kept for air drying for a period of 2 week and then manure was added and soil was moisturized as well. After this soil was covered and allowed to equilibrate at room temp for a total period of 3 months. Before planting 3 soil samples were collected from each bulk and analyzed for Pb content.

For experiment four plastic pots of size 35 x 25 x 15 cm were used. Pots were numbered. Pot number one to four were filled with 1 kg DW of soil sample A and pot number five to eight were filled with 1 kg DW of soil sample B. Plastic saucers were placed below each pot for the leachate collection. Indian mustard was planted at a density of 15 seeds per pot. After 28 days of growth, the density of seedlings per pot were reduced to 10 plants this is done to enhance the proper growth of seedlings. During the experiments the plants were irrigated every 2 or 3 days with distill water. The leachate collected in each plastic saucer was again poured into the respective pot to prevent the loss of Pd ions due to leaching of soil by water used to irrigate plants.

The plants were harvested after six weeks and then washed thoroughly with running tap water. Root is separated from aerial part and dried for further analysis. The results are not given here. In present study the main focus was to determine the amount of lead extracted from soil by Indian mustard plant. The analysis of soil was done for lead before growing plants and after harvesting the same
The soil sample from each pot is collected by means of a soil rod at depths 5 and 10 cm. Samples collected were air dried for 6 days. One gram of each sample is digested separately using nitric acid and per chloric acid. Lead was determined using spectrophotometric Dithizone Method. The method is based on principle that when lead ions reacts with dithizone in chloroform to form complex which is soluble in chloroform and imparts cherry red colour .The red extract is measured at an absorbance of 515 nm against a reagent blank. The 7 - 1 0 pH range is optimal for the extraction of this complex.



III. RESULTS

The formerly plotted calibration curve was used to determine the amount of lead present in the digested soil sample solutions and to calculate the content of lead per kg of dry mass of soil. The determination for every sample collection site was done twice or three times. The differences between the obtained results did not exceed ±5 %

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

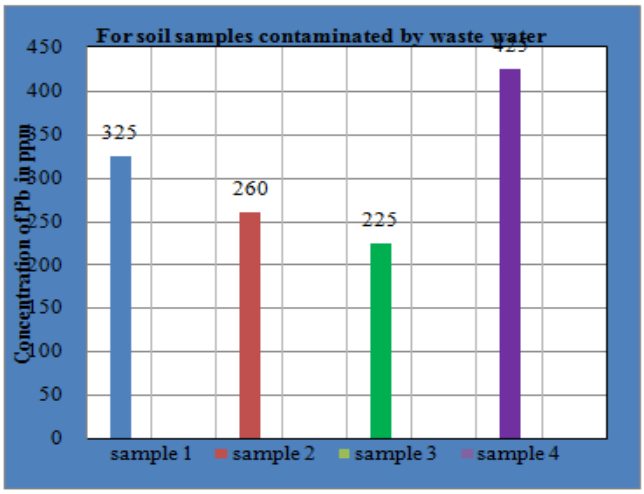


Fig. 1 For soil samples contaminated by waste water

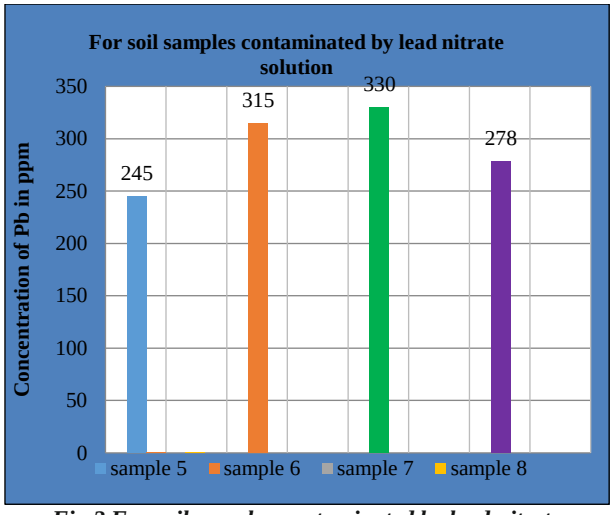


Fig 2.For soil samples contaminated by lead nitrate

IV. CONCLUSION

The above results (as depicted in graph) shows that Indian mustard plant bears very good ability to remove lead from the soil. In case of soil contaminated with laboratory waste water the amount of uptake of lead by Indian mustard plant is low as compared to soil contaminated with lead nitrate solution the reason being presence of other heavy metal ions like Cd, Cr, Ni in waste water of chemical laboratory. Growth of plants were observed to be slow due contamination but the presence of heavy metal ions in soil was well tolerated by the plants. However an optimized methods need to be developed for the complete utilization of phyto remedative property of Indian mustard plant.

Phytoremediation is a potential green technology that can be used to remediate heavy metal contaminated soils. The phytoremediation of heavy metal contaminated soil basically involves the extraction of metal ions from contaminated soil. Phytoremediation certainly has a great potential to improve the dilapidation of soil, it can be employed for removal of organic pollutants from soil, wetland and shallow waters as well. However, based on data obtained from pot experiments, interpretations and promises have been made concerning the possibilities of metal by phytoextraction. In many situations, soil contamination may have exclusive factors such as pH, presence of other pollutants that needs special evaluation. The other factors that control the effectiveness of this technique are the properties of soil, plant variety and climatic conditions. To perfect the technique, more researches need to be conducted at different levels. We need to identify more and more local plant species that have remediative properties.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Hence the technology needs proper and detailed evaluation before its complete utilization for removal of pollutants from soil and water. With all the challenges phytoremediation, remains a very promising approach and feasible alternative to prevent and cure pollution

V. REFERENCES

[1] Negri, M.C. and R.R. Hinchman. "Plants That Remove Contaminants From the Environment". Laboratory Medicine 27(1): 36-40(1996).
[2] Wierzbicka, M. and Obidzinska, J. "The Effect of Lead on Seed Imbibition and Germination in Different Plant Species". Plant Science, 137, 155-171. http://dx.doi.org/10.1016/S01689452(98)001381(1998).
[3] Saxena P, Krishnaraj S, Dan T, Perras M, Vettakkorumakankav "Phytoremediation of heavy metals contaminated and polluted soils". In: Prasad MNV, Hagemaer J (eds) Heavy metal stress in plants: from molecules to ecosystems. Springer, Berlin,pp 305–329 (1999).
[4] Lombi, E., Zhao, F.J., Dunham, S.J. and MacGrath, S.P. "Phytoremediation of Heavy Metal Contaminated Soils: Natural Hyperaccumulation versus Chemically Enhanced Phytoextraction". Journal of Environmental Quality, 30, 1919-1926. http://dx.doi.org/10.2134/jeq2001(2001).
[5] Cluis, C. Junk-Greedy "Greens:Phytoremediation as a New Option for Soil Decontamination. BioTeach Journal,2, 61-67(2004).
[6] Mastretta C, Barac T, Vangronsveld J, Newman L, Taghavi S, van der Lelie D "Endophytic bacteria and their potential application to improve the phytoremediation of contaminated environments". In: Harding SE, Tombs MP (eds) Biotechnology and genetic engineering reviews, vol. 23. Lavoisier, Paris, pp 175–207. ISBN 1-84585003-3(2006).
[7] Butcher, D. "Phytoremediation of Lead in Soil;Recent Applications and Future Prospects". .Applied Spectroscopic Review, 123-139 (2009).
[8] Jadia, C.D. and Fulekar, M. H"Phytoremediation of Heavy Metals: Recent Techniques". African Journal of Biotechnology,8, 921-928 .(2009)
[9] Danh, L.T., Truong, P., Mammucari, R., Tran, T. and Foster, N. Vetiver Grass, Vetiveria zizanioides "A Choice Plant for Phytoremediation of Heavy Metals and Organic Wastes". International Journal of Phytoremediation,11,664-691. http://dx.doi.org/10.1080/15226510902787302 (2009).
[10] Sherene, T. "Mobility and Transport of Heavy Metals in Polluted Soil Environment". Biological Forum—An International Journal, 2, 112-121 (2010).
[11] Singh, J. and Kalamdhad, A.S. "Chemical Speciation of Heavy Metals in Compost and Compost Amended Soil".A Review. International Journal of Environmental Engineering Research, 2, 27-37 (2013).
[12] Farid, M., Ali, S., Shakoor, M.B., Bharwana, S.A., Rizvi, H., Ehsan, S., Tauqeer, H.M., Iftikhar, U. and Hannan, F "EDTA Assisted Phytoremediation of Cadmium, Lead and Zinc". International Journal of Agronomy and Plant Production, 4, 2833-2846 (2013).
[13] K., Cao, T., Li, T. and Cheng, H. "Study on Application of Phytoremediation Technology in Management and Remediation of Contaminated Soils". Journal of Clean Energy Technologies, 2, 216-220. (2014)
[14] Ochonogor, R.O. and Atagana, H.I. "Phytoremediation of Heavy Metal Contaminated Soil by Psoralea pinnata"..International Journal of Environmental Science and Development, 5, 440-443.http://dx.doi.org/10.7763/IJESD.2014.V5.524 (2014)

CITE AN ARTICLE

Imam, Shirin . "PHYTOREMEDIATION: A METHOD TO REDUCE METAL IONS PRESENT IN WASTE WATER ." ***INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*** **6.7 (2017): 629-34. Web. 15 July 2017.**