Research Article CODEX: IJRPJK ISSN: 2319 – 9563

International Journal of Research in Pharmaceutical and Nano Sciences

Journal homepage: www.ijrpns.com

A STUDY ON BIOSORPTION AND PHYTOREMEDIATION OF HEAVY METALS BY LEAVES AND BARK OF *PHYLLANTHUS EMBLICA*

L. Sripriya*[1] and M. Vijayalakshmi[1]

[1*]Department of Biotechnology, Dr. M.G.R. Educational and Research Institute, Dr. M.G.R. University, Maduravoyal, Chennai - 600 095, Tamilnadu, India.

ABSTRACT

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. Hence, this investigation was designed to study the levels of heavy metals contamination in effluents from automobile industry situated at Guduvancheri. An attempt was also made to study the levels of heavy metals absorbed after phyoremediating the industrial effluent with plant materials such as leaf, seed bark of *Phyllanthus emblica*. The leaf sample of investigated plant was found to absorb heavy metals such as lead and zinc very effectively. The bark sample of investigated plant was found to absorb heavy metals such as lead and zinc was as same as in the leaf sample. This study has demonstrated that the plant materials of *Phyllanthus emblica* can be used as effective bioabsorbent for removal of lead and zinc from aqueous solutions.

KEY WORDS

Heavy metals, *Phyllanthus emblica*, Phytoremediation, Biosorbent, Biosorption and Phytoremediation by *Phyllanthus sp.*

Author for Correspondence:

Sripriya L,
Research Scholar,
Dr. M.G.R. Educational and Research Institute,
Dr. M.G.R. University, Maduravoyal, Chennai.

Email: yuvas2010@gmail.com

INTRODUCTION

In recent years, heavy metal pollution has become one of the most serious environmental problems. Presence of heavy metals even in traces is toxic and detrimental to both flora and fauna. With the rapid development of many industries (mining, surface finishing, energy and fuel producing, fertilizer, pesticide, metallurgy, iron and steel, electroplating, electrolysis, electro-osmosis, leather, photography, electric appliance manufacturing, metal surface treating) and aerospace and atomic energy installations, wastes containing metals are directly or indirectly being discharged into the environment causing serious environmental pollution and even threatening human life. Pollution of environment with heavy metals can't be biologically degraded, they can only be transformed from one oxidation state or organic complex to another[1, 2]. Once the environment becomes polluted with zinc, it begins it journey to man's body[3] (Islam *et al.*, 2007) by been readily absorbed by plants[4] which are subsequently consumed by man.

Recent studies have showed that heavy metals can removed by using plant materials such as palm pressed fibres and coconut husk[5] water fern *Azolla filiculoids*[6] peat moss[7]. Heavy metal pollution is amongst the commonest form of environmental pollution. The removal of heavy metal constituents from industrial waste water is of paramount important taken into consideration the environmental problems associated with soil and water polluted with heavy metals. Tyler *et al*, reported that the release of heavy metals in biologically available forms by human activity may damage or alter both natural and man-made ecosystems. More researches have recently been stepped up in the field of remediating water polluted with heavy metals. In recent time, emphases have been drawn to the use of plants that has high metal absorbing capacity to remediate metal contaminated waste water. This study aimed to investigate the adsorption potential of *Phyllanthus emblica* parts (leaf,bark,and seed) for the removal of $Pb2^+$, $Cu2^+$, $Cd^+$and Zn^+ ions from wastewater within various experimental conditions.

MATERIAL AND METHODS

Collection and processing of plant materials (biosorbents)

The leaf and bark material of *Phyllanthus emblica* was collected from local Environment of Thiruvallur, Tamilnadu, India. The collected biomaterial is washed extensively in running tap Water and with deionized water to remove dirt and other particulate matter. The dried plant materials are powdered into required particle size (2mm) and stored in desiccators and used for biosorption studies.

Collection of industrial effluent

The industrial effluent was collected from a pond near Ambattur Industrial estate where the effluents from automobile and other related industries were drained.

Preparation of synthetic water

An Aqueous stock solution (1000mg/l) of Cu, Pb, Cd and Zn ions was prepared using corresponding metals and used as the source of Cu, Pb, Cd and Zn in the synthetic Waste water.

Digestion of biosorbents

5g of the dried powder of *Phyllathus emblica* bark and leaves were treated with 3ml of concentrated HNO_3 and Hcl. Then the treated samples were diluted and made up to 100ml with distilled water and filtered.

Analysis of heavy metals content in plant materials

The filtrate obtained by digestion was analysed for the presence of heavy metals such as Lead (Pb), Cadmium (Cd), Copper (Cu) and Zinc (Zn).

Analysis of heavy metals content of industrial and synthetic water

The influence of biosorbent dose on metal absorption is investigated by taking 10mg/l of Cu, Pb, Cd and Zn solutions and equilibrating with varying amount of biosorbent (leaf and bark) (0.5g to 3g) for 30 minutes at room temperature and at agitation speed of 200rpm. After equilibration time the solutions are separated using filters and the supernatant was analyzed for residual Cu, Pb, Cd and Zn concentration to establish the extent of removal in each case.

Analysis of metals using Atomic Absorption Spectroscopy

The elemental analysis of Pb, Cu, Cd and Zn in the samples was determined by Atomic Absorption Spectroscopy Varian AAS model 240.

Reagents

Lead standard solution

1.598g of lead nitrate was dissolved in dilute nitric acid and cooled in desiccators. The solution was then made up to 1liter with 2% nitric acid. Concentration: 1000 µg/ml.

Cadmium standard solution

0.100 g cadmium metal was dissolved in 4ml of concentrated HNO_3 and 0.8ml of conc.HNO_3 was added and made up to 1l with deionized water. Concentration: 0.1mg/ml.

Copper standard solution

0.100g copper metal was dissolved in 2ml concentrated HNO_3 and 10.0ml of conc.HNO_3 was added and diluted to 1000ml with deionized water. Concentration: 0.1mg/ml.

Zinc standard solution

0.100g zinc metal was dissolved in 20ml of Hcl and diluted to 1000ml with deionized water. Concentration: 0.1mg/ml.

Apparatus

Atomic absorption spectrophotometer equipped with a burner for air/acetylene flame, Hollow cathode lamps for Pb. Atomic absorption spectrophotometer (Pb, Cd, Cu, and Zn) equipped with gas flow meter for nitrogen and hydrogen, arsenic, electrode less discharge lamps with power supply background correction at measurement wavelength and appropriate strip chart recorder. Boiling- type burner head for nitrogen air entrained-hydrogen flame. Cylinder quartz cell, 10 to 20 cm long electrically heated by external nichrome wire to 800-900^{0}C. Cylindrical quartz cell with internal fuel rich hydrogen-oxygen flame. The minimum detection limit for lead with Flame AAS was 0.1 µg/ml. The minimum detection limit determined by the reproducibility of the filter paper weight difference was 5 µg/m^3.

RESULTS AND DISCUSSION

The concentration of Zinc is highest in both leaf and bark sample of *Phyllanthus emblica* whereas the concentration of Pb is lowest in leaf sample and Cd in bark sample. Among the heavy metal content of industrial effluent zinc was observed to be in high concentration whereas Pb and Cd were less in concentration. The absorption of Pb in synthetic water by leaf and bark sample is very effective (it showed BDL level). The absorption of Cu is very effective in both samples when compared to others heavy metals. It decreases nearly 50% of Cu. The absorption of Zn and Cd is very effective in leaf sample whereas the bark sample absorb only trace amounts. The absorption of Cd in industrial water is significantly high by leaves and bark. Cd uptake rose with increase biosorbent concentration 1% at 0.1g biomass to 98% at 2.0g biomass. When compared to synthetic water, the absorption of Zn in industrial water is very effective in both samples. The absorption range of Pb is the same as in the synthetic water. The cadmium is absorbed in very trace amount by both samples. Due to the BDL level of Cu in industrial water, the biosorption was not analysed.

Phytoremediation, an emerging clean up technology for contaminated sols, groundwater and wastewater that is both low - tech and low - cost is defines as the engineered use of green plants (including grasses, forbs and woody species) to remove, contain or render harmless such environmental contaminants as heavy metals, trace elements, organic compounds and radioactive compounds in soil or water. The process include biological, chemical and physical processes that aid in the uptake, sequestration, degradation and metabolism of contaminants, either by plants or by the free - living organisms that constitute the plant's rhizosphere. Phytoremediation takes advantage of the unique and selective uptake capabilities of plant root systems, together with the translocation, bioaccumulation and contaminant storage / degradation abilities of the entire plant body.

Phytoremediation include phytoextraction, phytostabilization, rhizofiltration and phytovolatilization. Induced phytoextraction involves chelate - mediated release of bound metals into soil solution vis - a - vis transport of metals to the harvestable shoot[8]. Hyper accumulators are those plant species which can accumulate one or more inorganic elements to levels 100 fold higher than other species grown under the same condition and will concentrate more than 10 mg kg -1 Hg, 100 mg kg -1 Cd, 1000 mg kg -1 Co, Cr, Cu and Pb and 10000 mg kg -1 Zn and Ni[9]. Thalaspi caerulescens, a member of family brassicaceae, is the best known metal hyperaccumulator that has been reported to accumulate up to 26000 mg kg -1 Zn without showing any symptoms of toxicity[10]. Another plant, Alyssum bertolonii, has been found to phytoremediate Ni[11] and can accumulate Ni at levels as high as 1%, which is over 100-1000 times higher than other plants[12]. Brassica juncea, while having one-third the concentration of Zn in its tissue is more effective at Zn removal from soil than T. Caerulescens - a known hyper accumulator of Zn - as the former produces ten times more biomass than the latter. It is expected that further research with classical or molecular genetics methods will produce a range of crops that can be used for the phytoextraction of several heavy metals[13].

Phytostabilization is a plant-based remediative technology that exploits the ability of heavy metal-tolerant plants to reduce the mobility of the metal contaminants as the latter are absorbed and accumulated by roots, adsorbed onto the roots or precipitated in the rhizosphere. Plants chosen for phytostabilization should be poor translocators of metal contaminants to shoots, such as grasses, thus minimizing exposure of wildlife to toxic elements. To further reduce the risk of ground water contamination by downward leaching, grasses should be grown along with fast transpiring trees, such as poplar, which are deep rooted and transpire at very high rates, creating powerful upward flow[14].

Rhizofiltration is a phytoremediative technology concerned with the removal of metals from theaquatic environments. Plants used for rhizofiltration are first hydroponically grown in clean water until a large root system has developed. This is followed by acclimatization of the plant to the pollutant by substituting the clean water supply for a polluted water supply. Then these acclimatized plants are transplanted into metal-polluted waters where plants absorb and concentrate metals in their roots and shoots[15, 16]. Several aquatic plant species such as water hyacinth, pennywort and duckweed have the ability to remove heavy metals from water[16, 17, 18]. Recent studies have showed that heavy metals can removed by using plant materials such as palm pressed fibres and coconut husk[5] water fern *Azolla filiculoids*[6] peat moss[7]. The most convenient means of determining metal uptake abilities is through a batch reaction process. In recent research work, *Tridax procumbens* (Asteraceae) a novel medicinal plant material was used as low cost sorbent for subsequent removal of Cu.

Table No.1: Heavy metal content in plant materials

S.No	Heavy metals	Leaf sample	Bark sample
1	Lead (Pb)	0.03	0.38
2	Cadmium (Cd)	0.078	0.023
3	Copper (Cu)	0.173	0.144
4	Zinc (Zn)	1.2394	0.6288

ACKNOWLEDGEMENT

Thanks are due to the technical support by Dr. Rajkumar, Chairman, Heubert Enviro Care systems.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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Please cite this article in press as: Sripriya L and Vijayalakshmi M. A study on biosorption and phytoremediation of heavy metals by leaves and bark of *phyllanthus emblica*, *International Journal of Research in Pharmaceutical and Nano Sciences*, 2(2), 2013, 140-144.