Removal of lead (Pb) by Hybrid Constructed Wetland with enhanced treatment by Bio coagulant (Moringa oleifera) and Low Cost Adsorbent (Charcoal)

Arnab Saha, Mrs. Hema Patel, S.J. Mane

Abstract— In this study, Hybrid constructed wetlands were used to remove lead (Pb) with pre-treatment by Bio coagulation with *Moringa oleifera* (MO) seed extract. Performance of vegetated Horizontal Surface-Flow (*Eichhornia crassipes)* and Vertical Flow Wetlands (*Canna indica*) were evaluated. Finally the effluent from the wetland system was subjected to Adsorption by Charcoal Gravity Filter. Hourly analysis of lead concentration in cultivation sample for both Horizontal flow system and vertical flow system were done by Atomic Adsorption Spectrophotometer. The Optimum dosage of Bio coagulant extract of Moringa oleifera was found to be 20 mg/litre, with removal efficiency of 79.3 %. The Optimum Removal efficiency was found to be 16.5% by *Eichhornia crassipes* and 96.5% by Canna indica, with a detention period of 1 hour. The removal efficiency of lead with Activated charcoal column filter was 99.99%. The overall performance of the Advanced Hybrid Wetland system was found to be 99.99% in removal of lead (Pb). The concentration of Lead was determined by Atomic Adsorption Spectrophotometer (AAS-201).

Index Terms— Hybrid Constructed Wetland, Moringa oleifera, Adsorption, Bio-coagulation, Heavy Metal Removal.

1 INTRODUCTION

POLLUTION with toxic metals has become a worldwide crisis, affecting agriculture and contributing to bioaccumulation and biomagnifications in the food chain [1]. Recently, researches have recognized that certain toxic metals may remain in the environment for a long period and can eventually bio accumulate to higher levels that could affect human being. As an alternative, to the traditional treatment of pollutants, an ecological approach has been developed using of plants to remediate soils or water contaminated with toxic metals. Traditional technologies such as using of plants to remediate soils or water contaminated with toxic metals. Traditional technologies such as chemical precipitation, Electro-coagulation, Membrane filtration etc for removal of heavy metals can be successful in specific situations, but they are not cost effective and produce toxic sludge and waste product that requires further treatment[2]. There is very dynamic effort to develop new, more cost-effective and eco-friendly techniques to remediate polluted soils, and now Phytoremediation which is based on the use of plants to extract, sequester or detoxify pollutants is in the front line.

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Constructed wetlands have been used widely for the treatment of municipal, industrial and agricultural wastewater, as well as for urban storm water. the electronic
This is owing to their high nutrient absorption capacity, simplicity, low construction, operation and maintenance costs, low energy demand, process stability, low excess sludge production and potential for creating biodiversity. It acts as a bio filter, removing sediments and pollutants such as heavy metals from the water, and constructed wetlands can be designed to emulate these features[3]. Phytoremediation can be defined as the process of using plants to absorb, accumulate, detoxify and to render harmless, contaminants in the environment through physical, chemical or biological processes.

Lead is an extremely toxic heavy metal, which is a serious threat to the health of children and wildlife. Several plant species can hyperaccumulate soluble lead in the soil [4]. It has been reported that water Hyacinth and *Canna indica* can accumulate significant amounts of lead in their roots, stems and shoots. The biggest challenge to effective phytoremediation of lead is its extremely low solubility, as only minute amount of soil lead is available for extraction. Phytoremediation has been projected as a cost-effective unconventional technology for the remediation of Lead in the soil [5].

2 MAERIALS AND METHODS

2.1 Materials

Collection and acclimatization of experimental plants

Canna indica collected from local nursery (Tathawade, Pune, Maharashtra) and Water hyacinth *(Eichhornia crassipes* was collected from Pawana river (Length: 58 km, Source: Western Ghats, Mouth: Mula River Cities: Pune, Pimpri-Chinchwad, Maharashtra, India) and brought to the laboratory. The plants were acclimatized in laboratory for three days and then used for the present study. Plants with uniform size were selected to reduce errors in the experiment

Aqueous Extract of *Moringa oleifera* (MO)

Dry MO pods were collected from Tathawade, Pune, Maharashtra. deshelled manually and sun dried for 5 days .The kernels were grounded in a domestic blender and an aqueous extract was prepared by using 200ml of distilled water and 2 g of MO seed powder, mixed by a magnetic stirrer for 30 minutes and settled for 15 minutes. Moringa oleifera aqueous extract is finally filtered through 20µm paper filter

Preparation of Activated charcoal (AC) column Filter

Pieces of timber is collected, washed and dried in an oven. Oven dried timber is burnt in a muffle furnace for one hour at 350^{o} C. Charcoal thus produced is withdrawn from the furnace , cooled, washed with water and again oven dried at 110^{o} C and ground into fine particle by means of pestle. Charcoal powder thus produced is sieved and activated at 350^{o} C for 1 hour and cooled in a decicator. A column filter with 40 cm height and 10 cm internal diameter ,is made by using coarse sand (2-3 mm) ,activated charcoal (.5 -1mm,)gravel (10 -15 mm), zhama brick pieces (20-25mm). The bed depth of coarse sand, activated charcoal, gravel and zhama brick pieces are 4cm, 6 cm, 8 cm and 10 cm respectively.

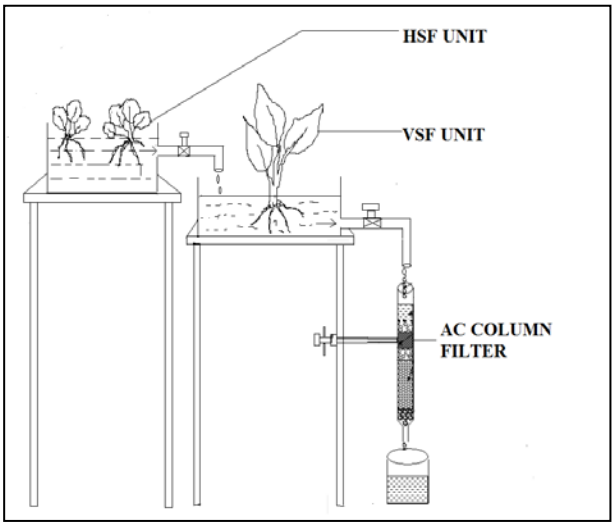

Fig. 1. Shows the test set up of hybrid constructed wetland system.

Test set up of Hybrid Constructed Wetland System

Horizontal Surface Flow (HSF) wetland tanks planted with water hyacinth (*Eichhornia crassipes*) and Vertical flow (VF) wetland tanks planted with *Canna indica* are constructed with valves , outlets and fixtures as shown in Fig. 1

Preparation of Synthetic waste water

0.1599 g Lead (II) nitrate dissolved in 10 ml of diluted nitric acid (1 → 10) and made up to a litre. 1 ml of this solution contains 0.1 mg of lead (Pb). Synthetic waste water with desired concentration of lead was prepared using lead standard stock solution.

2.2 Procedure

Synthetic waste water was taken in four beakers A, B, C, and D. (250 ml each). Aqueous extract of MO solution with dosage of 2ml, 5ml, 7ml and 10 ml was added in each beaker respectively. Jar test was conducted to determine the effective dosage of coagulant. Lead concentration of filtered sample was determined for each beaker.

Hybrid constructed wetland was watered with Synthetic waste water and samples were collected at specific time intervals for both HSF and VF tank.

Finally synthetic waste water is passed through Activated Charcoal column filter and the Filtrate is collected.

Samples collected at every stage were analyzed by Atomic Adsorption Spectrometer to determine lead ion concentration.

4 RESULTS AND DISCUSSIONS

Phytoremediation, a method to remove pollutants from the environment by using plants and algae, has been known as a promising cost-effective and environmentally sustainable technology for the remediation of water polluted by toxic trace elements. Table I shows the percentage of Pb removal by bio coagulation with MO seed extract.The initial Pb concentrations in the synthetic waste water sample was 68.4 ppm. The results revealed optimum removal efficiency of lead(79.3%) when the sample was given a dosage of 20 ml/L of aqueous MO seed extract.

TABLE 1

Dosage (ml/l)	Removal Efficiency %
8	49.41
20	79.3
28	83.3
40	87.13

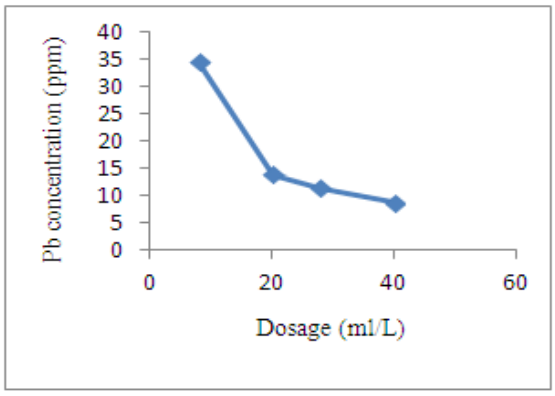

Fig. 2. Shows reduction of Pb ion concentration by Bio coagulation with different dosage of Aqueous extract MO with 68.3 ppm initial concentration of Pb ions.

Eichhornia crassipes and *Canna indica* were used for the simultaneous removal of heavy metals in laboratory experiences respectively along regular intervals. The initial Lead concentration was 40 ppm and the metal removal percentages by HSF and VF tank unit were shown in Table 2 and Table 3 respectively.

TABLE 2

Detention time in Hous	Removal Efficiency %
0.5	13.5
1	15.5
2	16.5
4	16.5
8	25.5

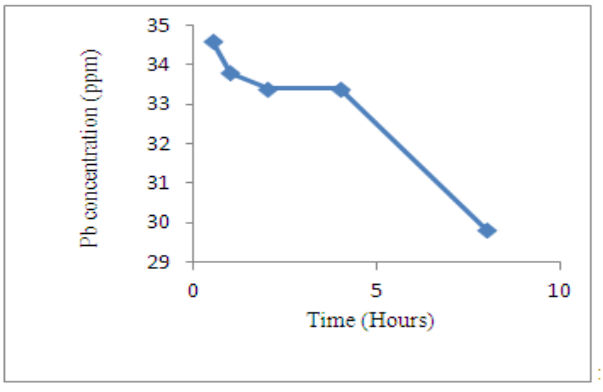

Fig. 3. Shows reduction of Pb ion concentration by HSF constructed wetland (Eichhornia crassipes) at specific time intervals with 40 ppm initial concentration of Pb ions.

The results showed that aquatic plant *Eichhornia crassipes* is effective in Pb ion extraction for the first 2 hours. Removal efficiency of the HSF unit got decreased after 2 hours.

TABLE 3

Detention time in Hous	Removal Efficiency %
0.5	96
1	96.5
2	96.5
4	98.5
8	98.5

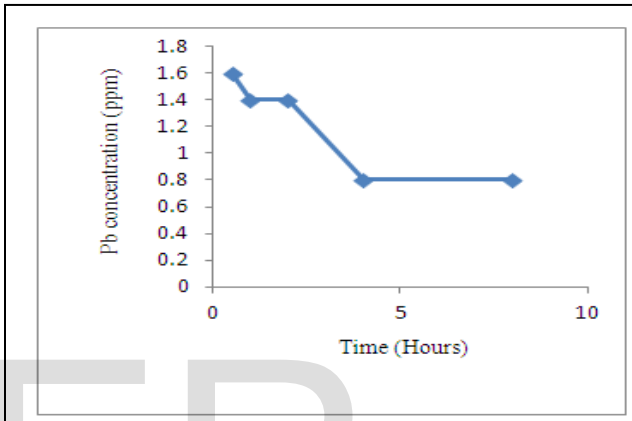

Fig. 4. *Shows reduction of Pb ion concentration by VF constructed wetland (Canna indica) at specific time intervals with 40 ppm initial concentration of Pb ions.*

Phytoremediation with Canna indica showed significant reduction in Pb concentration for the first 1 hour after that removal efficiency of VF unit got decreased.

Effluent sample of various concentrations from Hybrid constructed wetland is further treated by passing through Activated Charcoal column filter. The results in Table 4, shows that concentration of lead is brought to less than 0.1 ppm after passing though AC column filter unit.

TABLE 4

Influent Concentration ppm	Effluent Concentration ppm	Removal Efficiency %
1.6	<0.1	99.99
1.4	<0.1	99.99
0.8	<0.1	99.99

The overall efficiency of the Hybrid Constructed wetland System with enhanced performance by Bio coagulation and Adsorption is found to 99.99 %. Synthetic Waste water sample of 68.4 ppm Pb concentration was brought under 0.1 ppm with

an effective operation time of 3.5 hours.

Present study shows that Hybrid Constructed wetland system is an effective means of extracting heavy metals (Pb) from industrial waste water. This system is cost effective as compared to the traditional techniques such as Membrane Filtration, Chemical Precipitation etc. It does not require costly chemicals and electricity for its operation. Small scale industries such as Battery manufacturers, Electroplaters etc faces financial crisis in establishing an Effluent treatment plant (ETP), moreover operating cost and maintenance cost of an ETP is also very high as compared wetland system. High performance Hybrid wetland system with its inherent advantages can serve as an effective alternative for heavy metal removal from industrial effluents.

4 Conclusion

The removal of Pb in synthetic wastewater by using Hybrid constructed wetland with enhanced performance by Bio coagulation and Adsorption is studied. Based on the results, the following conclusions can be drawn. Moringa oleifera is an effective bio coagulant in removal of lead. The uptake capacity of Pb ions by macrophytes *Eichhornia crassipes* and *Canna indica* is effective for the first one hour. The performance of HSF and VF treatment units in removal of lead got decreased with increased detention time. Activated charcoal is an efficient biomaterial for removal of lead from industrial waste water. The findings from this study can be useful in designing a Continuous flow Hybrid Constructed Wetland system.

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