Removal of Lead from Contaminated Soil using Phytoremediation Technique in Constructed Wetland

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Abstract - *Heavy metals are among the most important sorts of contaminant in the environment. Several methods already used to clean up the environment from these kinds of contaminants, but most of them are costly and difficult to get optimum results. Currently, phytoremediation is an effective and affordable technological solution used to extract or remove inactive metals and metal pollutants from contaminated soil and water. This technology is environmentally friendly and potentially cost effective. This paper aims to compile some information about heavy metal lead (Pb) sources, effects and their treatment. It also reviews deeply about phytoremediation technology, including the heavy metal uptake mechanisms and several research studies associated about the topics. Additionally, it describes other measures or alternatives to be used to increase the efficiency of lead removal process, and also heavy metal uptake mechanisms in phytoremediation technology as well as the factors affecting the uptake mechanisms. Some recommended plants which are commonly used in phytoremediation and their capability to reduce the contaminant are also reported*

Key Words: **Lead, Contaminated Soil, Removal, Phytoremediation Technique, Constructed Wetland.**

1. INTRODUCTION

A constructed wetland (CW) is an artificial wetland created as a new or restored habitat for native and migratory wildlife, for anthropogenic discharge such as wastewater, storm water runoff, or sewage treatment, for land reclamation after mining, refineries, or other ecological disturbances such as required mitigation for natural areas lost to a development.

Constructed wetlands serve mainly a purpose of treating contaminated water. They are engineered systems that use natural functions of vegetation, soil, and organisms to treat different water streams. Depending on the type of water stream that has to be treated the system need to be adjusted. Accordingly, pre or post-treatments might be necessary for wetlands.

Use of water comprising of heavy metals for the irrigation purpose would contaminate the soil with heavy impurities which would in turn reduce the cultivability of that soil for a very long period of time. To remediate this soil, phyto-remediation along with the concept of constructed wetland can be used.

2. MATERIAL

The efficiency of CWs to remove the contaminants from the wastewater and soil mainly depends on the root zone interactions between soil, contaminants, helophyte roots and a variety of microorganisms. The soil is the main supporting material for plant and microbial growth. It was observed that fine gravel promotes greater growth of plants and therefore increases the amount of contaminants removal. Helophytes are directly involved in the uptake of nutrients and in direct degradation of pollutants by releasing oxygen in the root zone. That imparts microbial activity and gives aerobic degradation of pollutants. The main mechanism for the removal of metals from contaminated soil in constructed wetlands includes Uptake by the helophytes and microorganisms.
To serve this purpose, following are the model and material setup is provided for project test results.

2.1.1 General Design Consideration for Wetland:

For the design of wetland system, we need to understand the general requisites of the design.

Following are the general considerations of wetland design.

2.1.1.1 Depth

In general, the depth of substrate in subsurface flow CW is restricted to approximately the rooting depth of plant so that the plants are in contact with the flowing water and has an effect on soil treatment. The recommended depth of the filter media is:
i) For horizontal filters: 50 - 100 cm
ii) For vertical filters: 50 - 120 cm

2.1.2 Laboratory Scale Model:

Vertical continuous flow rate constructed wetland laboratory size model. Rectangular tank made up of glass 12mm thick with dimension 450mm wide x 450mm deep and 1200mm long is used. Two baffles at 1/3rd length are provided to increase the travelling period of water. Baffles provided in the setup will be quite efficient to serve the purpose of increasing the length of time, thus will provide wider contact of inlet waste water with plant species. Well

graded sub grade will also impart efficiency by removing lead by the process of adsorption.
Slope of 1% is provided to accelerate the movement of wastewater to some extent. Baffles divide the tank in three compartments of equal length. First baffle is provided at the top side which will force inlet water to flow down vertically instead of directly movement by surface flow. It will allow water to get more contact with plant roots and sub grade too. After first baffle water will move vertically upwards by 2nd baffle to get contacted with plants and sub grade of 2nd compartment and lastly it will have outlet access at lower middle part of third compartment.

2.1.3 Subgrade:

Material- Boulders of size 35 to 45mm, coarse aggregates- 25 to 28mm, aggregates 18 to 20mm, coarse river sand 8 to 10mm and soil.

Sub grade to be provided for CW should be able to serve different purposes like better adsorption, filtration and should not get disturbed after continuous loading of wastewater. Sub grade should not get clogged because of impurities present in waste water otherwise it will not achieve effective filtration. Severe short-circuiting can result from improper grading. In the other hand it should not be much porous that it may get disturbed after loading and also will not serve the purpose of adsorption.

Keeping all these things in mind the substrate is selected such that it will not fail for the abovementioned causes. Sub grade is provided in five layers. Four layers are provided with 35 to 45 mm size boulders, 25 to28mm size coarse aggregates, 18 to 20 mm aggregates, 8 to 10mm coarse sand of each 80mmthick.Soil is provided over for 100mm thickness to plant seeds. Above gradation provided served above said purposes. This can be noted from the transparent glass model. The layers not only maintained their position but also served better adsorption and filtration.

Waste water from Battery Industry is used in this experiment as irrigation water. Waste water was collected from Autobat Battery Industry, Khadakwasla. Two samples of waste water were collected, one sample was taken from still water and other was taken after mixing the waste water. Both the samples were tested and the sample that was mixed thoroughly was selected for the experiment.

3. METHDOLOGY

Phytoremediation is defined as an emerging technology using selected plants to clean up the contaminated environment from hazardous contaminant to improve the environment quality.

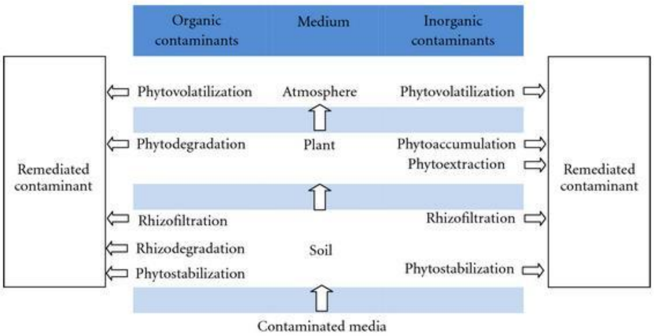


Fig -3.1

Based on figure, some certain essential processes involved in phytoremediation technology are phytostabilization and phytoextraction for inorganic contaminants, and phytotransformation/phytodegradation, rhizofiltration, and rhizodegradation for organic contaminants.

Specific plant species can absorb and hyperaccumulate metal contaminants and/or excess nutrients in harvestable root and shoot tissue, from the growth substrate through phytoextraction process. This is for metals, metalloids, radionuclides, nonmetals, and organics contaminants in soils, sediments, and sludges medium.

4. EXPERIMENTAL ANALYSIS

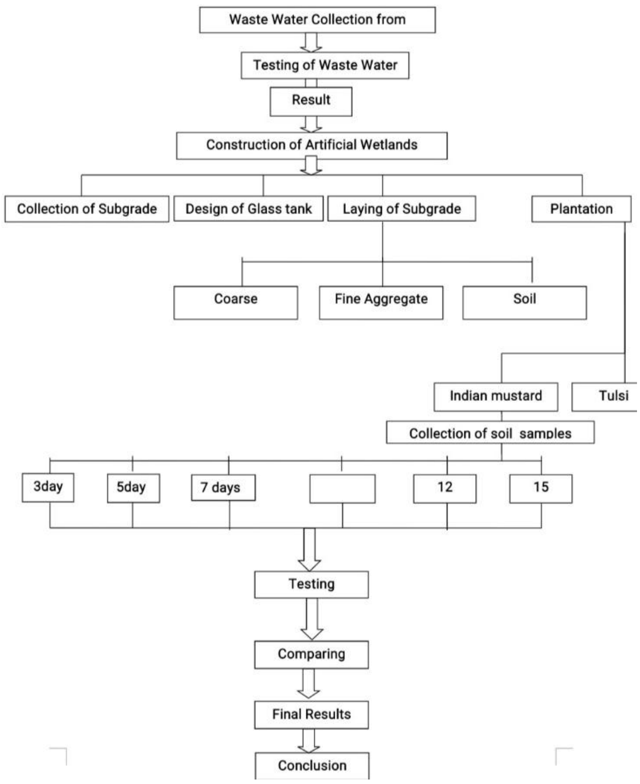
4.1 Experimental study

In this experiment the efficiency of Indian Mustard to remove Lead from contaminated soil through wetland construction is studied.

Soil can be contaminated with Lead from several sources such as industrial sites, from leaded fuels, old lead plumbing pipes, or even old orchard sites in production where lead arsenate is used.

A sample of waste water from Battery industry (Autobat Accumulator Pvt. Ltd.) was collected and tested, Lead content in waste water was found to be 37.44 mg/L {IS 3025 Part -2 (2004)}

Fig -4.1: Collection of Waste Water from Battery Industry



A known volume of wastewater was mixed with soil and kept overnight. This soil was then tested and the results obtained were- 426.2 mg/kg {USEPA 3050B}.

Plantation in the CW was done in such a way that half of the surface of soil on top was planted with Indian Mustard and the other half was planted with Tulsi. The Indian Mustard plants were allowed to grow till they reach a height of 10cm and above.

Fig -4.2: Preparation for Plantation

Wastewater containing Lead was applied from the day plants were grown to above mentioned height at a rate of 2 litre twice a day.

Soil samples were collected from various points of Indian Mustard section and Tulsi section at regular intervals of 3, 5, 7, 10, 12, 15 days and were regularly tested.

The soil testing results obtained were plotted on a graph of Lead content VS Retention time.

Fig -4.3: Growth of Plant after 3 Days

Fig -4.4: Growth of Plant after 10 Days

Fig -4.5: Growth of Plant after 15 Days

5. RESULT

Lead content in Waste Water = 37.44 mg/L
Lead content in Contaminated Soil without Plantation = 426.2 mg/Kg

Sr.no	Retention Time (days)	Pb (Lead) Concentration (mg/ Kg)	Efficiency (%)
1	3	394.021	7.5
2	5	386.733	9.26

3	7	382.173	10.33
4	10	371.007	12.95
5	12	366.020	14.12
6	15	365.722	14.19

Maximum efficiency achieved = 14.19 % due to Indian Mustard
Permissible safe level for lead in soil is 400 mg/kg as per TSCA

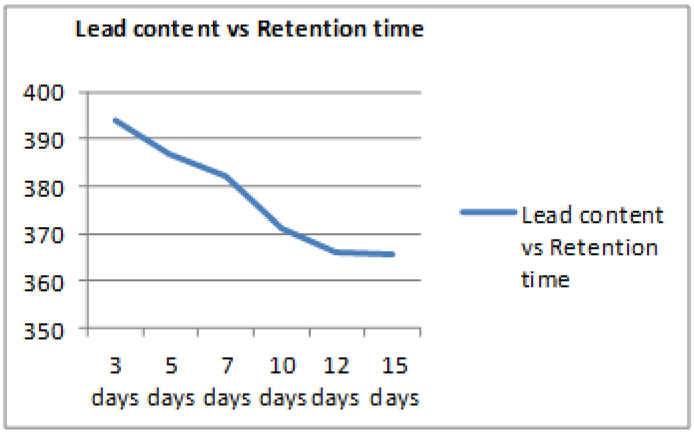


Chart -1: Lead Content vs Retention Time

Lead removal by plants was recorded and above graph was plotted that consists of:

Lead content in mg/kg Vs Retention time in days.
A significant drop in Lead concentration can be seen according to days in the graph.

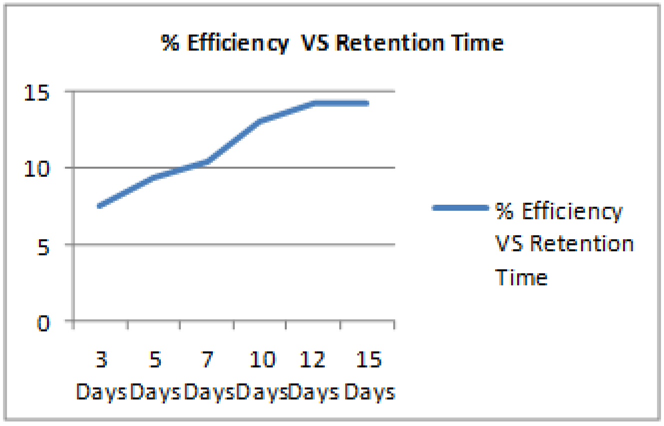


Chart -2: % Efficiency vs Retention Time

Efficiency of Indian Mustard to uptake Lead from soil at regular intervals is plotted on the above graph.

Following observations are made from this graph:

- % Efficiency of plants to uptake Lead significantly increases from 3rd day to 12th day.
- After 12th day % efficiency was observed to be almost constant till 15th day.
- Maximum Efficiency of plants to uptake Lead from soil is 12% - 15%.

6. CONCLUSIONS

Lead in soil has been recognized as a public health problem, particularly among children. In recent years, attention has been directed to cumulative adverse effects of lead at low levels of intake. Lead-contaminated soil and dust have been identified as important contributors to blood lead levels. Based on available data on blood lead and lead in soil, an approach has been developed to suggest a permissible level of lead in soil, below which there will be reasonable certainty that adverse health effects will not occur. An acceptable level of 400 ppm of lead in soil suggested as a "safe" level would contribute no more than 5 micrograms/dl to total blood lead of children under 12 years of age.

Heavy metals uptake, by plants using phytoremediation technology, seems to be a prosperous way to remediate heavy-metals-contaminated environment. It has some advantages compared with other commonly used conventional technologies. Several factors must be considered in order to accomplish a high performance of remediation result. The most important factor is a suitable plant species which can be used to uptake the contaminant. Even the phytoremediation technique seems to be one of the best alternative, it also has some limitations. Prolong research needs to be conducted to minimize this limitation in order to apply this technique effectively.

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