# Nanofibers for Transdermal Drug Delivery Phytoremediation: A Green Technology to Clean Up Metal Polluted Soil in East Calcutta Wetland Ecosystem (A Ramsar Site; No 1208) Sustainable Algal Technologies for Detoxifying and Valorizing Tannery

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Phytoremediation: A Green Technology to Clean Up Metal Polluted Soil in

East Calcutta Wetland Ecosystem (A Ramsar Site; No 1208)

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Abstract

Phytoremediation is a cost-effective, eco-friendly technology that harnesses natural processes for remediation of contaminated soil and water by use of plants. The systematic use of plants for environmental contaminant treatment encompasses technologies that use plant influenced biological, chemical, and physical processes that aid in the remediation of contaminated substrates. Researches till date on East Calcutta Wetland health have revealed high level of metal content due to industrial and municipal disposal especially tannery discharges (both in solid and liquid form). Plants are capable of accumulating uncommonly high concentrations of metals like Chromium (Cr), Copper (Cu), Zinc (Zn), Lead (Pb), Cadmium (Cd) etc. and respond to the metal toxicity in a variety of different ways. The current work has been aimed to investigate the uptake and bioaccumulation of metals by hyperaccumulators, with a special emphasis on Cr accumulation. The study reveals that the tested plants can be used as phytoremediators in East Calcutta Wetland areas to remove metal load from soil.

Key Words: Metal, Phytoremediation, East Calcutta Wetland, Ramsar Site, Cr toxicity

Introduction

Phytoremediation is a cost-effective, eco-friendly technology that harnesses natural processes for remediation of contaminated soil and water by use of plants. Researches till date on East Calcutta Wetland

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(ECW >:> Ramsar site (No 208) health have revealed high level of metal content in its biota due to industrial and municipal disposal especially tannery discharges both in solid and liquid form( Aich et. al. 2012, ) . Plants are capable of accumulating uncommonly high concentrations of metals like Chromium (Cr), Copper (Cu), Zinc (Zn), Lead (Pb), Cadmium (Cd) etc. and respond to the metal toxicity in a variety of different ways. Farmers from ECW areas learnt the mechanism of modifying waste into wealth, as this raw municipal and industrial effluent of Kolkata city has been productively utilized for pisciculture in fishponds and agriculture in wastewater-irrigated farmlands, which was unique to this wetland area.

Therefore, the site was very important in the context of ecotoxicology. Concentrations and distributions of these biologically active as well as inactive metals which are prevalent in the composite effluents, mainly originate from the tannery, paint, battery and electroplating industries located along the eastern boundary of the ECW. The current research work has aimed for the implementation of phytoremedial measures to clean up the metal load from ECW soil. Sequestration and partitioning of metals in different parts of phytoremediator plants survived under metal stress are evaluated through the present study through pot culture experiment.

2. Materials and methods:

2.1 Study Area:

Uptake of heavy metals by plants was studied by setting on the selected plants in contaminated soil, collected from Dhapa, Kolkata. This soil was contaminated with industrial

effluents especially with tannery effluents containing heavy metals mainly Chromium (Cr).

2.2 Pot Culture Experiment:

Uptake of heavy metals by plants in a metal contaminated soil was studied in pot culture experiment. Plants were allowed to grow for 60 days in pot containing contaminated soil. Pots were filled with 2kg of soil both from East Calcutta Wetland as well non contaminated soil from a village area 80 Km away from Kolkata city.

In each pot 6-8 seedlings were planted. Plant samples were free of disease symptoms. The plants were watered once every day and care was taken to avoid leaching of water from the pots. Soil and air temperature was measured after every 20 days. In all these days growth, development and physical characters were recorded.

2.3 Abiotic and biotic samples for the study

Agro soil from agricultural fields those were irrigated regularly by wastewater and occasionally filled up with canal bottom soil sludge and solid municipal garbage, were collected. The metal concentrations of the pot soil samples were estimated before and after cultivation of the plant varieties.

Pot culture experimentation was carried out with the same three economically important plant species namely sunflower (Helianthus annuus), marigold (Tagetes patula) and cock's comb (Celocia cristata). The plant parts were separated into root, stem and leaves for the study.

2.4 Metal Analysis

Heavy metal analysis of the collected samples was done by Energy dispersive X-ray Fluorescence (EDXRF;

Table 1: Metal concentrations (ug/g) (Mean ± SD) in different plant parts

Root

Name of

Growth Condition

Cr Mn Fe Cu Zn Pb

Plant

Marigold Control 99.78 117.89 1950.65 15.28 87.34 22.28 Contaminated 247.66 113.05 2095.69 37.75 330.12 43.16 Cock's Comb Control 123.54 78.97 1876.23 12.56 15.90 Contaminated 389.94 447.24 5593.05 60.09 372.44 66.10 Sunflower Control 124.875 62.34 1896.98 16.07 74.61 20.27 Contaminated 391.39 164.98 3063.99 42.03 347.29 52.10

Xenematrix EX-3600) following the method described by Aich et al. 2011. Standard Reference Materials (SRM) from NIST - Apple leaf, SRM 1515, Coal fly ash SRM 1633b and Estuarine Sediment SRM 1646a were used for quantification of the elements and checking reliability of the data obtained by the system (Aich et. al. 2012).

3. Results

Results on pot culture experiment for metal accumulations in sunflower, marigold and cock's comb were depicted in the Table (1). It was found that general accumulation pattern of metals concerned in different plant parts were root>leaf>stem. Plants grown in non-contaminated soil thoroughly showed lower accumulation of all the metals in every plant's species. High Cr accumulation was distinct in root, whereas stem and leaf showed comparable values. The Cr concentration in the root of cock's comb was recorded highest followed by root of sunflower. Among aerial parts, maximum accumulation of Cr was in leaf with highest in cock's comb and lowest in flower of marigold. Interestingly, concentration of Cu and Pb in the flower of sunflower was found very high in comparison to that of other plants indicating the same as an efficient hyper-accumulator plant.

Pot soils were analyzed before plantation and after uprooting of the respective plants. Variation in the trace metal remediation was in record. Percentage reduction in pot soil for Cr was cock's comb (35.1%)> sunflower (32.5%)> marigold (20.9%). It had been found that percent decline of Fe in all three plants was almost similar (around 17%). Among all other metals, Pb was found to be best removed from the soil with an effective percentage reduction of 71% in sunflower, 48.9% in marigold and 72.2% in cock's comb cultivation.

Marigold Control 10.68 11.12 123.89 4.12 11.23 2.12 Contaminated 11.25 12.02 189.97 6.86 21.82 7.65 Cock's Comb

Control 9.43 9.49 231.56 6.28 28.79 3.12 Contaminated 12.87 19.87 354.49 8.38 40.31 6.18 Sunflower Control 10.92 10.92 192.67 9.99 51.89 2.67 Contaminated 13.99 18.96 261.93 7.77 47.05 4.81

Leaf

Stem

Name of

Growth Condition

Cr Mn Fe Cu Zn Pb

Plant

Name of

Growth Condition

Cr Mn Fe Cu Zn Pb

Plant

Marigold Control 7.67 25.89 260.23 7.50 34.54 8.31 Contaminated 10.72 39.05 440.33 8.91 44.98 9.63 Cock’s Comb

Control 7.45 31.29 320.21 8.28 43.92 8.10 Contaminated 11.80 45.39 563.48 10.01 52.96 11.49 Sunflower Control 6.78 27.11 270.85 8.01 69.49 8.32 Contaminated 8.69 34.04 403.14 8.07 36.35 5.35

4. Discussion

Most of the elements under investigation, like Fe, Mn, Cu and Zn are now known to be essential for higher plants. However, heavy metals such as Cr and Pb do not play any significant role in the plant physiology (Marschner, 1995). In the present study, three non-edible plants important from floricultural standpoint, namely, sunflower, marigold and cock’s comb are found to be good accumulator of heavy metals. Roots and leaves are the dominant sites for metal accumulation of plants grown in polluted environment is also supported by earlier workers (Anikwe and Nwobodo, 2002). Low uptake and translocation of Cr in plant body than Pb was noted in the present study owing to the fact that the soil Cr is largely unavailable to plants as it (Cr3+) bound tenaciously to negatively charged sites of clay and organic matters (Banks, Schwab and Henderson, 2006). In the present study, the chosen plants important from floricultural standpoint, are characteristically tolerant and showed ability to produce huge biomass in metal-rich soils, absorbing heavy metals into the roots and transferring metals to the aboveground parts, thus exhibiting all enviable features for effective phytoremediation.

5. Conclusion

Productive use of municipal sewage and industrial effluent by the rural artisans from this area is an age old practice for supporting their livelihood. On the hand, it is also a fact that the use of this contaminated and metal loaded wastewater for the agriculture and pisciculture practice is a threat to the biota of this unique ecosystem in the context of toxicity. At this point, it becomes necessary to adopt an alternative source of earning for the community. Floriculture in the contaminated soil is thought to be the best option for such alternative agricultural practice. It would reduce the metal concentration levels of contaminated lands before cultivation of any edible products in one hand while providing a steady source of income on the other, as flowers have a very big market in the areas concerned.

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