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Full Length Research Paper

Phytoremediation of heavy metals from municipal wastewater by *Typhadomingensis*

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The use of plants for the removal of heavy metals from spillage sites, sewage waters, sludges and polluted areas has become an important experimental and practical approach. A study was carried out to investigate the phytoremediation of heavy metals from municipal wastewater by *Typhadomingensis* according to randomized complete block design (with three replications). Every *Typhadomingensis* was planted in pots containing 7 liter of municipal wastewater, and aeration was done. After 24 and 48 h, the samples were taken for testing. The concentrations in the root and shoot tissues were found in the order of Fe>Mn>Zn>Ni>Cd. The evidences provided by this experiment indicated that the *Typhadomingensis* was capable to remove heavy metals from urban wastewater. These results also showed that most metal removal from wastewater by *Typhadomingensis* was after 48 h.

Key words: Heavy metals, phytoremediation, *Typhadomingensis*, municipal wastewater.

INTRODUCTION

Heavy metal pollution is a global problem, although severity and levels of contamination differ from place to place. Common heavy metals such as cadmium (Cd), lead (Pb), cobalt (Co), zinc (Zn) and chromium (Cr) etc. are phytotoxic at both low concentrations as well as very high concentration and are detected in wastewater from mining operations, tanneries, electronics, electroplating, batteries and petrochemical industries as well as textile mill products (Singh et al., 2011) .

Contaminated soils and waters pose a major environmental and human health problem, which may be partially solved by the emerging phytoremediation technology. The use of plants for the removal of xenobiotics and heavy metals from spillage sites, sewage waters, sludges and polluted areas has become an important experimental and practical approach over the last 15 years. Knowledge of the physiological and molecular mechanisms of phytoremediation has begun to emerge together with biological and engineering strategies designed to optimise and improve the phytoremediation process (Schwitzguebel, 2000).

Several plants that have been identified in the last two decades as highly effective in absorbing and accumulating various toxic trace elements are being evaluated for their role in the phytoremediation of soils and waters polluted with trace elements (Liao and Chang, 2004), some metal hyper accumulator species with respective metal accumulated is shown in Table 1.

Phytoremediation is one new approach that offers more ecological benefits and a cost-efficient alternative. Although it is a cheaper method but requires technical strategy, expert project designers with field experience that choose the proper species and cultivars for particular metals and regions (Mudgal et al., 2010).

Phytoremediation presents many advantages, as compared to other remediation techniques: it can be performed with minimal environmental disturbance; it is applicable to a broad range of contaminants, including many metals with limited alternative options; possibly less secondary air and/or water wastes are generated than with traditional methods; organic pollutants may be degraded to CO_2 and H_2O, removing environmental toxicity; it is cost-effective for large volumes of water having low concentrations of contaminants; plant uptake of contaminated groundwater can prevent off-site migration (Schwitzguebel, 2000).

Table 1. Several metal hyper-accumulator species with respective metal accumulated (Hooda, 2007).

No.	Plant species	Metal
1	*Thlaspicaerulescens*	Zn, Cd
2	*Ipomeaalpina*	Cu
3	*Sebertiaacuminata*	Ni
4	*Haumaniastrumrobertii*	Co
5	*Astragalusracemosus*	Se
6	*Arabidopsis thaliana*	Zn, Cu, Pb, Mn, P
7	*Thlaspigoesingens*	Ni
8	*Brassica oleracea*	Cd
9	*Arabidopsis halleri*	Zn, Cd
10	*Sonchusasper*	Pb, Zn
11	*Corydalis pterygopetala*	Zn, Cd
12	*Alyssum bertolonii*	Ni
13	*Astragalusbisulcatus*	Se
14	*Stackhousiatryonii*	Ni
15	*Hemidesmusindicus*	Pb
16	*Salsola kali*	Cd
17	*Sedum alfredii*	Pb, Zn
18	*Pterisvittata*	As
19	*Helianthus anus*	Cd, Cr, Ni

Plant based technologies for metal decontamination are extraction, volatilization, stabilization and rhizofiltration. Use of transgenic to enhance phytoremediation potential seems to promise. Despite several advantages, phytoremediation has not yet become a commercially available technology. Progress in the field is hindered by lack of understanding of complex interactions in the rhizosphere and plant based mechanisms, which allow metal translocation and accumulation in plants (Hooda, 2007).

The most vital factor in implementing phytoremediation is the selection of an appropriate plant. This is often done by considering previous applications and research. The final plant choice will be influenced by the situation of the site which will affect the plant growth. Inorder to select the most appropriate plant, a list of potentially beneficial plants for remediation should be prepared first (Kutty et al., 2009).

Plants may play a vital role in metal removal through absorption, cation exchange, filtration, and chemical changes through root. There is evidence that wetland plants such as *Typhalatifolia*, *Cyperus malaccensis* and, etc. can accumulate heavy metals in their tissues (Yadav and Chandra, 2011).

Eichhornia crassipes (water hyacinth) has been tested for removal of two important heavy metals chromium (Cr) and zinc (Zn) from metal solution by Mishra and Tripathi (2009). According to these results, biochemical parameters viz.protein, sugar and chlorophyll in experimental plants have shown a decreasing trend due to accumulation of Zn and Cr. This result also showed that this methodology was safe for the removal of Zn and Cr and could be utilized at large scale.

Liao and Chang (2004) reported water hyacinth to be a promising candidate for phytoremediation of wastewater polluted with copper (Cu), lead (Pb), zinc (Zn) and cadmium (Cd). Generally, the concentration of these five elements (Cu, Pb, Zn, and Cd) in the roots was 3 to 15 times higher than those in the shoots.

The phytoremediation of heavy metals from wastewater offers a low cost method so the aim of the study was to investigate the phytoremediation of heavy metals from urban wastewater by *Typha domingensis*.

MATERIALS AND METHODS

Sample preparation

This study was carried out at greenhouse according to randomized complete block design (with three replications). Every *Typha domingensis* plant was put in pots containing 7 liter of municipal wastewater, and aeration was done. Some *Typha domingensis* plants were put in pots containing 7 liter of water as control. After 24 and 48 h, the samples were taken for testing. The plant tissues were prepared for laboratory analysis by Wet Digestion method (Campbell and Plank, 1998).

Laboratory analysis

Extractable DTPA iron (Fe), manganese (Mn), zinc (Zn), nickel (Ni) and cadmium (Cd) in wastewater and plant tissues were carried out by DTPA in accordance the Standard Methods (APHA, 1998). Wastewater and water properties are shown in Table 2.

Table 2. Water and wastewater properties.

pH	EC ($dS.m^{-1}$)	N (ppm)	K (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Ni (ppm)	Cd (ppm)	BOD_5 (ppm)
Wastewater									
6.85	1.48	28.9	29.1	0.491	0.104	0.079	0.032	0.071	26.4
Water									
7.00	0.29	0.0	0.01	0.00	0.00	0.00	0.00	0.00	-

Table 3. Comparing the heavy metals in wastewater after 24 and 48 h.

Fe (ppm)	Mn (ppm)	Zn (ppm)	Ni (ppm)	Cd (ppm)
Primary wastewater				
0.491[a]	0.104[a]	0.079[a]	0.032[a]	0.071[a]
Wastewater after 24 h				
0.298[b]	0.080[b]	0.061[b]	0.028[b]	0.063[b]
Wastewater after 48 h				
0.091[c]	0.026[c]	0.020c	0.014c	0.033[c]

+ Numbers followed by same letters in each column are not significantly (P<0.05) different according to the DMR test.

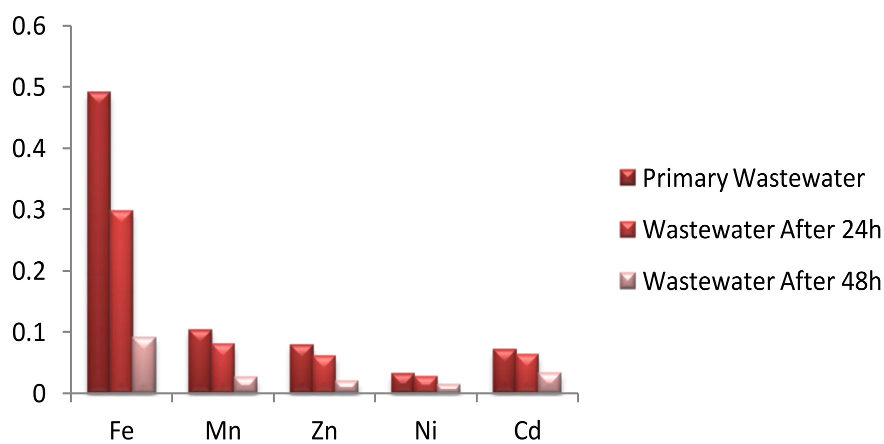

Figure 1. Heavy metals in wastewater.

Statistical analysis

Descriptive statistical analysis, including mean comparison using Duncan's Multiple Range Test (DMRT), was conducted using SPSS software.

RESULTS AND DISCUSSION

The comparing the heavy metals in urban wastewater after 24 and 48 h can be seen in Table 3 and Figure 1. Data on the extractable concentration of heavy metals in *Typha domingensis* in the applied treatments can be seen in Table 4.

According to Table 3, extractable Fe, Mn, Zn, Ni and Cd (ppm) were recorded in order of 0.491, 0.104, 0.079, 0.032, and 0.071 in urban wastewater before phytoremediation, but they were found in order of 0.298, 0.080, 0.061, 0.028, and 0.063 after 24 h from phytoremediation, and they were found in order of 0.091, 0.026, 0.020, 0.014, and 0.033 after 48 h from phytoremediation. These results showed that the phytoremediation could be effective to decrease of heavy

Table 4. Comparing the heavy metals in *Typhadomingensis* after 24 and 48 h.

Fe (ppm)	Mn (ppm)	Zn (ppm)	Ni (ppm)	Cd (ppm)
		***Typhadomingensis* in pots containing 7 liter water (after 24 h)**		
		Root		
1.002[a]	0.430[a]	0.091[a]	0.005[a]	0.001[a]
		Shoot		
0.712[b]	0.102[b]	0.011[b]	0.000[b]	0.000[b]
		***Typhadomingensis* in pots containing 7 liter water (after 48 h)**		
		Root		
1.000[a]	0.428[a]	0.089[a]	0.005[a]	0.001[a]
		Shoot		
0.701[b]	0.099[b]	0.010[b]	0.000[b]	0.000[b]
		***Typhadomingensis* in pots containing 7 liter wastewater (after 24 h)**		
		Root		
1.912[c]	0.902[c]	0.761[c]	0.081[c]	0.069[c]
		Shoot		
0.937[d]	0.143[d]	0.102[d]	0.009[d]	0.006[d]
		***Typhadomingensis* in pots containing 7 liter wastewater (after 48 h)**		
		2Root		
4.001[e]	1.989[e]	1.320[e]	0.091[e]	0.090[e]
		Shoot		
2.633[f]	1.001[f]	0.962[f]	0.023[f]	0.019[f]

+ Numbers followed by same letters in each column are not significantly ($P<0.05$) different according to the DMR test.

metals from municipal wastewater. This is in line with findings of Singh et al. (2011) and Yadav and Chandra (2011).

According to Table 3, *Typha domingensis* decreased the heavy metals in municipal wastewater. Decreasing of Fe, Mn, Zn, Ni and Cd after 48 h were 1.63, 1.77, 1.76, 0.86 and 0.79 times higher than 24 h, respectively. These results showed that the decreasing of heavy metals from urban wastewater by *Typha domingensis* after 48 h was more than after 24 h.

According to Table 4, the accumulation of heavy metals in *Typha domingensis* after 48 h was more than after 24 h.

This result also showed that the accumulation of heavy metals in roots was more important than in shoots, this is in line with findings of Mojiri and Aziz (2011). The concentrations in the root and shoot tissues were found in the order of Fe>Mn>Zn>Ni>Cd.

Ye et al. (1997) reported; *Typha* and *Phragmites* sp. have been successfully used for phytoremediation of Pb/Zn mine tailings under waterlogged situations.

Hegazy et al. (2011) investigated the phytoremediation of industrial wastewater potentiality by *Typha* domingensis. Results indicated that *Typha domingensis* was capable of accumulating the heavy metal ions preferentially from wastewater than from sediments. The accumulation of metals in plant organs attained the highest values in roots, rhizomes and old leaves. Rhizofiltration was found to be the best mechanism to explain *Typha domingensis* phytoremediation capability.

Conclusion

Polluted soils and waters pose a major environmental and human health problem, which may be partially solved by the emerging phytoremediation technology. These results showed that the *Typha domingensis* could be effective to decrease of heavy metals from municipal wastewater. These results also showed that the decreasing of heavy metals from wastewater by *Typha domingensis* after 48 h was more than after 24 h.

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