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Short Communication

Removal of Metals from the Refinery Wastewater through Vertical Flow Constructed Wetlands

MUHAMMAD MASUD ASLAM[1], SARFRAZ HASSAN† AND M.A. BAIG‡
Institute of Environmental Science & Engineering, National University of Sciences & Technology, Rawalpindi, Pakistan
†*Faculty of Environmental Resource Economics, University of Agriculture, Faisalabad, Pakistan*
‡*Institute of Environmental Science and Engineering, National University of Sciences and Technology, Pakistan*
[1]Corresponding author's email: masud92pk@yahoo.com

ABSTRACT

A series of experiments was carried out to assess the viability of treating refinery wastewater using coarse sand for the removal of heavy metals. *Typha lattifolia* was planted in two containers to evaluate the treatment efficiencies of vertical flow constructed wetlands. The results demonstrated low treatment efficiency of constructed wetlands during the initial stage but with the growth of plants and bio-film improved gradually. Vertical flow constructed wetland filled with coarse sand was operated for treatment of refinery wastewater at hydraulic loading rate of 1.21, 1.44 and 1.71 m^3/m^2day^{-1}, at regular intervals. The results showed high removal efficiencies for iron (Fe) (49%), copper (Cu) (53%) and zinc (Zn) (59%) in the coarse sand filled wetlands. The coarse sand filled constructed wetland showed good treatment performance at hydraulic loading rate of 1.21 m^3/m^2day^{-1}. It is concluded that that constructed wetland can be used as economical option for wastewater quality enhancement in developing countries. © 2010 Friends Science Publishers

Key Words: *Typha lattifolia*; Wastewater; Constructed wetland; Metals and coarse sand

INTRODUCTION

The key problem in developing countries is wastewater treatment, which contaminates the water bodies thereby increasing health risk and also due to increasing rate of depletion of water resources. Continued existence of these countries depends upon the sustainable use of natural resources. During last decade, the effectiveness of the constructed wetland (CW) is highlighted through industrial wastewater treatment using the constructed wetlands (Kadlec & Knight, 1996). Just like the other developing countries, the requirement for economical and cost effective wastewater treatment alternatives in Pakistan is also higher (Andleeb *et al.,* 2010). The options like Ecotechnological treatment i.e., constructed treatment wetland are now recognized as possible options for industrial wastewater treatment as they are cost effective and simpler technology (Cooper *et al.,* 1996).

The industrial boom in the developing countries resulted in generation of a huge utilization of metals leading to an ecological contamination risk. The constructed wetland creation for secondary and tertiary treatment of wastewater is nowadays a mostly acknowledged and progressively more widespread treatment option (Jenssen *et al*., 1993).

Despite the fact that, full-scale constructed wetland systems were not used in Pakistan, until 2002 but this technology could be promoted for refinery wastewater treatment with parallel sets of vertical flow constructed wetlands with matching plan configurations with coarse sand filter media. Economically viable and effective wastewater treatment can be obtained if proper designing and construction of the constructed wetlands is done (CPP, 1999).

Typha lattifolia is local specie of Northern Pakistan and is an excellent phyto-remediation plant growing naturally in the wetlands. Little work has been done on this species for the industrial wastewater treatment. This study was conducted to evaluate the performance of coarse sand planted with *T. lattifolia* for the treatment efficiency of constructed wetlands in removing iron, copper and zinc from the contaminated soils.

MATERIALS AND METHODS

Two fiber glass constructed wetlands were established in Attock Refinery Limited. The soil media was collected from the surrounding area and the composition of soil was sandy loamy. The dimension of the treatment wetlands were 2.28 m×1 m×0.76 m (W×L×D) having a surface area of 1.74 m^2. The fiber glass constructed wetlands were used to avoid interference of chemicals. The thickness of these wetlands cells was 4 mm with 1% slope to facilitate the water circulation and flow. The fill material in these wetlands was coarse sand with soil media on the surface.

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In order to ensure the smooth flow the perforated PVC pipes were used and for collection of wastewater polyethylene drain flex pipes were used at the exit. *T. lattifolia* was planted in constructed wetlands at a density of 10-12 seedlings m^{-2}. After the completion of the acclimatization phase the treatment wetland, refinery wastewater was applied at regular intervals. The primary treated wastewater was applied to constructed wetlands by gravity flow via spherical valves and PVC pipes at Hydraulic Loading Rate (HLR) of 1.23, 1.44 and 1.71 $m^3/m^2/day$. The water samples were collected thrice in a month to check the performance. Wastewater samples were analyzed in the School of Civil and Environmental Engineering Laboratory of NUST. Chemical analyses was carried out as per the Standard Methods for Fe, Cu and Zn analysis (AWWA, 2005). Statistical significance was carried out between the inlet and an outlet water concentration through regression analysis ($p < 0.05$). Differences in the concentrations of metals between inlet and outlet were determined and calculations were carried out by using ANOVA with the Excel 2007 program.

RESULTS

Constructed wetlands treatment efficiency: At the beginning of the experimental study, the transplanted *T. lattifolia* plants had average height 118 cm ($n = 36$), while the average growth rate was 0.24 mm day^{-1} in the coarse sand wetlands. Following the transplantation, the growth was slow but after acclimatization in the wetlands growth increase up till the end of the life cycle. In order to assess the performance of treatment constructed wetlands, *T. lattifolia* was planted and filled with coarse sand along with native soil from the surrounding refinery premises.

Removal of iron, copper and zinc: The efficiency of inorganic pollutant removal was indicated by the change in Fe concentration of the effluent treated through the constructed wetland systems at three different hydraulic loading rates to achieve high treatment efficiency. At hydraulic loading rate of 1.71, 1.44 and 1.23 $m^3m^{-2}day^{-1}$ the Fe removal was 0.62 - 2.19, 0.6-1.95 and 1.01-2.17 mg L^{-1} (1.64±0.49 mg L^{-1}), the Cu removal was 0.7-3.25, 1-3 and 2-4.38 mg L^{-1} (2.64±0.67 mg L^{-1}) and Zn removal was 0.46-2.77, 1-3 and 1.09-3.47 mg L^{-1} (2.23±0.83 mg L^{-1}) correspondingly (Table I). Removal efficiencies of the coarse sand system at hydraulic loading rate of 1.71, 1.44 and 1.23 $m^3m^{-2}day^{-1}$varied between 41±15% and 49±17% for Fe, 43±13% and 53±13% for Cu and 48±18% and 59±18% for Zn, respectively (Figs. 1-3).

DISCUSSION

Statistical analysis showed 89% variation in the removal efficiency for Fe, which is dependent upon *T. lattifolia* and coarse sand. Coefficient of HLR is 12.95,

Fig. 1: Removal (%) age of iron (Sand and *Typha lattifolia*)

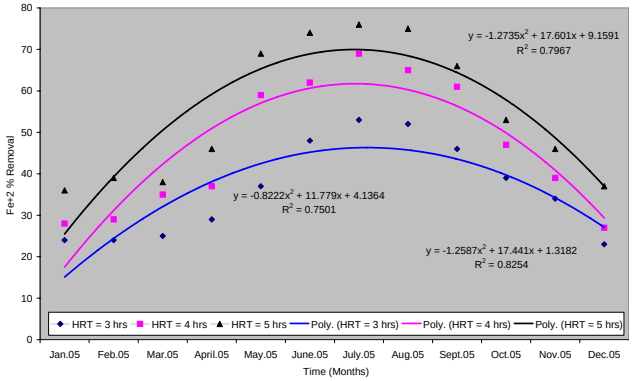


Fig. 2: Removal (%) age of copper (Sand and *Typha lattifolia*)

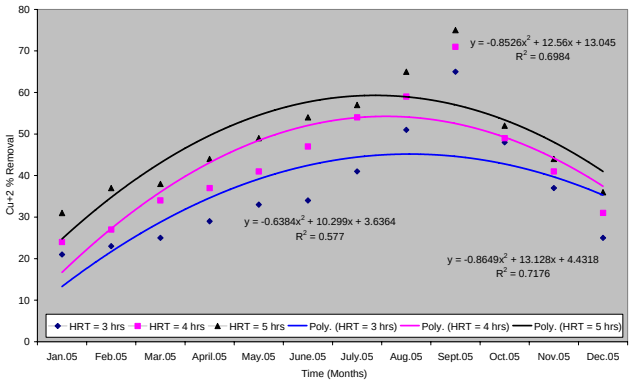
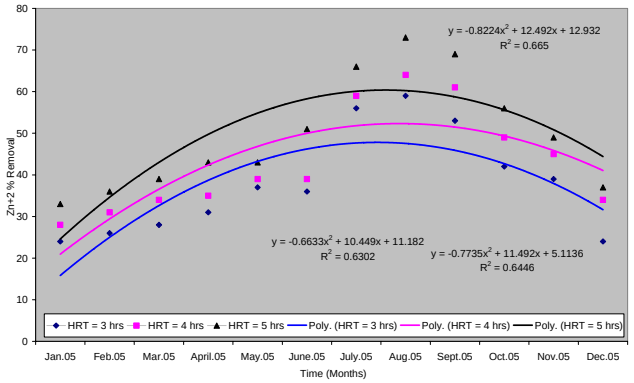


Fig. 3: Removal (%) age of zinc (Sand and *Typha lattifolia*)



indicating that removal increased by 12.95% per unit increase in HLR. A significant ($P = 0.016$) standard error indicated that the hydraulic loading rate variable in increasing removal. In case of Cu 92% variation in removal efficiency is observed and the coefficient of HLR is 11.6 indicated an average removal by 11.6%. The standard error value is 20.2 indicated that coefficient was significant ($P = 0.014$) and the hydraulic loading rate was greatly variable in Cu removal. For Zn 89% variation was observed, which is

Table I: Treatment performance values for iron, copper and zinc influents and effluents (sand & *Typha lattifolia*)

Heavy Metal	Statistical Results	HLR 1 1.71 $m^3m^{-2}day^{-1}$	HLR 2 1.44 $m^3m^{-2}day^{-1}$	HLR 3 1.23 $m^3m^{-2}day^{-1}$
	Max	46	62	73
Iron	Min	24	28	35
	Mean	33	41	49
	Stdev	9	15	17
Copper	Max	65	69	73
	Min	24	28	35
	Mean	43	47	53
	Stdev	13	14	13
Zinc	Max	73	77	85
	Min	24	28	35
	Mean	48	52	59
	Stdev	18	18	18

depended upon *T. lattifolia* and coarse sand. A 12.95 co-efficient of HLR indicated an increase in the removal by 12.95 % per unit increase in HLR. A 3.4 standard error value was significant (P = 0.011) and that the hydraulic loading rate was variable for removal.

During the application of wastewater in constructed wetlands, reddish plaques were observed in the wastewater surface, which indicates the Fe precipitates formation. By and large, Fe, Cu and Zn precipitation occurred following the environmental (abiotic) and bacterial oxidation of Iron (Vymazal, 1995; Groudeva *et al*., 2001). This study indicates that the average pH of Fe-rich industrial wastewaters and the pH of the pipe-borne water added to the constructed wetlands provided conducive environment for Fe removal to occur through chemical precipitation.

The determination of the efficiency of heavy metal removal from the effluent from wetlands having the characteristics of those developed in this study have been studied by a number of researchers (Ali *et al*., 2004; Batty & Younger, 2004; Vymazal *et al.,* 2007; Netpae & Phalaraksh, 2009). Results of this study are on par with previous studies, except for comparative removals, which occurred when the hydraulic loading varied as evident from fluctuation in the removal of the heavy metals.

In conclusion, constructed wetland's treatment efficiency is fairly encouraging. The removal efficiency of the constructed wetlands planted with *T. lattifolia* specifies its usefulness for the secondary and tertiary treatment of refinery wastewater. This study has opened new areas for exploration and achievement of the constructed wetlands, which may prove highly effective for industrial wastewater treatment.

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REFERENCES

Ali, N.A., M. Ater, G.I. Sunahara and P.Y. Robidoux, 2004. Phytotoxicity and bioaccumulation of copper and chromium using barley (*Hordeum vulgare* L.) in spiked artificial and natural forest soils. *Ecotoxicol. Environ. Safety*, 57; 363–374

Andleeb, S., N. Atiq, M.I. Ali, R. Razi-Ul-Hussnain, M. Shafique, B. Ahmad, P.B. Ghumro, M. Hussain, A. Hameed and S. Ahmad, 2010. Biological treatment of textile effluent in stirred tank bioreactor. *Int. J. Agric. Biol.*, 12: 256–260

AWWA, 2005. *Standard Methods for the Examination of Water and Wastewater*. AWWA, Washington

Batty, L.C. and P.L. Younger, 2004. Growth of Phragmites australis (Cav.) Trin. ex Steudel in mine water treatment wetlands: effects of metal and nutrient uptake. *Environ. Pollut.*, 132: 85–93

Cooper, P., M. Smith and H. Maynard, 1996. The design and performance of a nitrifying vertical flow reed bed treatment system. *Water Sci. Technol.*, 35: 215–221

Cleaner Production Program (CPP), 1999. *Revised National Environmental Quality Standards (NEQS).* http://www.cpp.org.pk/legal/RevisedNEQS.pdf

Groudeva, V.I., S.N. Groudev and A.S. Doycheva, 2001. Bioremediation of water contaminated with crude oil and toxic heavy metal. *Int. J. Min. Proc.*, 62: 293–299

Jenssen, P., T. Maehlum and T. Krogstad, 1993. Potential use of constructed wetlands for wastewater treatment in northern environments. *Water Sci. Technol*., 28: 149–157

Kadlec, R. and R.L. Knight, 1996. *Treatment Wetlands*. Lewis Publishers, Boca Raton, Florida

Netpae, T. and C. Phalaraksh, 2009. Bioaccumulation of Copper and Lead in Asian Clam Tissues from Bung Boraphet Reservoir, Thailand. *Int. J. Agric. Biol.*, 11: 783–786

Vymazal Jan, J. Švehla, L. Kröpfelová and V. Chrastný, 2007. Trace metals in Phragmites australis and Phalaris arundinacea growing in constructed and natural wetlands. *Sci Total Environ*., 380: 154–162

Vymazal, J., 1995. *Algae and Element Cycling in Wetlands.* Lewis Publishers, Chelsea, Michigan

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