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Industrial Wastewater Treatment using Reed bed Constructed Wetland

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***Abstract* - Sequel to industrialization, many industries produce toxic wastes which are discharged into streams and rivers with little or without treatment; an action which constitute risk to public and aquatic lives. In this paper, reed bed treatment system for removal of toxic metals from industrial waste water was investigated. A vertical subsurface flow wetland for the removal of toxic metals from industrial wastewater in Elewi-Odo stream in Ibadan North Local Government area of Oyo State, Nigeria was designed. Reed plant, phragmites Karka, was used for the Wetland system while granite and washed sand were used as substrates. The treatment performance was recorded for hydraulic retention periods of 3, 7, 11, 15 and 19 days. The results showed a gradual reduction of the toxic metals as the retention periods increases. The removal rate of the reed bed lies in the range of 36.8% to 61.5%. These results further confirm the efficiency of the reed plant, phragmites karka, in the treatment of industrial wastewater.**

Keywords: Industrial wastewater, Reed bed, Toxic, Treatment, Wetland.

1. INTRODUCTION

One of the major global threats that our environment is facing today is environmental pollution, increasing with every passing day and causing grave and irreparable damage to the atmosphere. Pollution of soil and water with waste waters of different characteristics is a common practice. Waste water treatment before disposal is the only remedy for this problem. The constructed wetland systems have proved to be an adequate technology for the treatment of a wide variety of waste water in urban, suburban and rural areas of many developed countries (ITRC, 2003).Wastewater treatment is a means of producing a disposable effluent without causing harm to the environment. Battery effluents contain metals such as Cadmium, Lead, Zinc, Manganese and Nickel which are highly toxic chemicals (Dhanya and Jaya, 2013). The Environmental Protection Agency (EPA) stated that lead acid batteries of which 65% is Lead and 35% combination of Nickel and Cadmium are found in municipal solid waste and battery wastes in streams, rivers etc. (EPA, 2011). The possible health effects associated with consumption of water, food or air that has been contaminated with high level of toxic metals range from headaches and abdominal discomfort to seizures, cancer, coma and even death (FEPA, 2010). The severity of the health effects is usually dependent on the total concentration of the metals to which one is exposed overtime (Omari *et al.,* 2003) Over the decades, there is an increasing focus on the use of constructed wetlands for industrial wastewater treatment. Historically, the birthplace of wetlands was in Europe where village-scale applications have been used to treat domestic wastewaters (Wallace, 2010; Langergraber, 2013). Unlike domestic applications, industrial wastewater is typically composed of highly toxic chemicals that have adverse effects on the environment. A diversity of wetland types (including surface flow, horizontal subsurface flow, tidal flow, vertical flow and surface horizontal flow) exist in the constructed wetland literature (Kadlec *and Wallace,* 2009; Nivala and Hous, 2007; Alagbe and Alalade 2013; Diana *et al.,* 2013). These constructed wetlands have been widely applied for both domestic and industrial wastewater treatment (Jardinier and Blake, 2000; Begg *et.al.*, 2001; Grismer and Carr, 2003; Munoz and Drizo, 2006; Tela *et al.*, 2008; Kadlec and Wallace, 2009; Davis and Wilion, 2009; Isiorhio and Oginni, 2013).

In this paper, a reed bed with vertical subsurface flow was designed for the treatment of the industrial wastewater discharged from Markeen Battery Industry into Elewi-Odo stream both located in Ibadan North local government area of Oyo State, Nigeria. Our objective is to study the performance efficiency of the reed bed system in the removal of toxic chemicals contained in the contaminated water.

2. METHODOLOGY

2.1 Wastewater Sample

Firstly, untreated wastewater sample from the battery industry was taken to the laboratory for analysis of the concentration of the toxic metals present in the battery waste discharge.

2.2 Pilot Wetland Design

The next phase involved the construction of a small scale pilot unit made up of two plastic tanks to be used in the treatment of the wastewater. The first bed was used to evaluate the reed plants with retention periods of 3, 7, 11, 15 and 19 days to obtain the retention period while the second pilot bed is a control bed set up to assess the removal efficiency rate of the reed plant. The beds were filled with granite and sand as substrates to aid filtration and uptake of nutrients by the plants. These beds were of dimension $1200mm \times 600mm$. The first bed was planted with Phragmites karka while the control bed was without a reed plant. The control bed was supplied with wastewater and substrates only. Vertical subsurface flow with reed bed was adopted for intermittent supply of wastewater to the constructed wetland. The treatment performances of the two beds were recorded for the retention periods of 3, 7, 11, 15 and 19 days. The effluents from the beds are analyzed and the concentration of these metals are compared with that of the untreated wastewater.

2.3 Wetland Design

The constructed wetland system comprises two experimental reed beds dimension $1200mm \times 1000mm \times 600mm$ made in 1000 litres plastic tank of rectangular shape. The support media for the bed consists of granite at the bottom layer for $450mm$ and washed sand for $150mm$ at the top layer. The first bed was called the Reed bed and was planted with Phragmites karka equipped with drain outlets at the base of the tank, the second bed called the control bed consists of granite and washed sand but without the reed plant were labeled RB1 and CONTROL BED respectively.

RB1 CONTROL BED

Figure 1: Set up of Reed bed and Control bed

2.4 Plant Cultivation

The reed plant, Phragmites karka seed were obtained and planted at $150mm$ apart. They were irrigated with 40 litres of potable water on a daily basis for 10 days to ensure quick and proper growth before the introduction of wastewater. The stems of the reed plants were cut in a way that each cutting had two nodes, one node entering the soil while the other node is exposed to the surface. Each length of the cutting was about $250mm$. The plants were monitored as the buds grew from the nodes of the stems. After 15 days of planting of the stalks, some reed buts emanated from the nodes of the stems paving way for commencement of the experiment.

2.5 *IRRIGATION*

In this analysis, industrial wastewater from Elewi-Odo stream was used. RB1 and CONTROL BED were irrigated with 40 litres of wastewater. The influent was drained off after 3, 7, 11, 15 and 19 days and the same process of irrigation was repeated throughout the period of the experiment. The two beds were irrigated in the morning.

3. RESULTS AND DISCUSSION

Table 1: Concentration of metals in untreated industrial wastewater, and reed Wastewater treated in reed beds with and without plants.

Chemicals	Initial Concentration of Metals (mg/l)	Red bed with plant (mg/l)	Control bed without plant (mg/l)	Percentage Reduction for reed bed	Percentage Reduction for control bed
Lithium	11.13	7.03	7.87	36.8	29.3
Cadmium	31.59	19.84	21.01	37.2	33.5
Mercury	138.76	56.48	57.86	59.3	53.4
Zinc	116.27	52.21	52.21	55.1	55.1
Nickel	12.95	7.98	9.23	38.4	28.7
Manganese	12.47	7.54	8.08	38.1	35.2
Lead	149.87	57.69	59.50	61.5	58.3
Silver	84.18	49.75	50.34	41.3	40.2

$$\left(\%\ \text{Reduction}= \frac{\text{initial conc.without treatment-Reed bed conc.}}{\text{initial conc. without treatment}} \times 100\right)$$

3.1 Hydraulic Retention Time (Hrt)

Table 2 shows the results for the Reed beds for different hydraulic retention times. This was done to determine the hydraulic retention time. There was steady decrease in the concentration of toxic metals as the retention time increases. The hydraulic retention time of 19 days was found in the study.

Table 2: Concentration of toxic metals in wastewater treated in Reed bed with Plants (RB1)

Metals	Hydraulic Retention Time (days)				
	3	7	11	15	19
Lithium	11.08	10.12	9.53	8.72	7.03
Cadmium	23.53	22.44	21.06	20.79	19.84
Mercury	60.51	59.84	58.60	57.15	56.48
Zinc	56.37	55.69	54.30	53.46	52.21
Nickel	11.32	10.34	9.73	8.28	7.98
Manganese	11.23	10.74	9.39	8.24	7.54
Lead	61.42	60.11	59.63	58.14	57.69
Silver	53.54	52.35	51.16	50.77	49.75

Table 3: Concentration of toxic metals in wastewater treated in Reed bed without plants (CONTROL BED)

Metals	Hydraulic Retention Time (days)				
	3	7	11	15	19
Lithium	11.42	10.29	9.78	8.64	7.87
Cadmium	25.36	24.91	32.45	22.73	21.01
Mercury	61.41	60.17	59.82	58.63	57.86
Zinc	56.70	55.15	54.61	53.42	52.21
Nickel	62.41	61.33	60.92	59.85	58.03
Manganese	12.31	11.12	10.34	9.69	8.08
Lead	63.48	62.10	61.36	60.78	59.50
Silver	54.14	53.28	52.36	51.76	50.34

Also, Table 3 shows the results of the toxic metals concentration in Reed bed without plants. The Table shows that there was reduction in the toxic metals as the hydraulic retention time increases. Also, the hydraulic retention time of 19 days was found in the study.

From the study, it was noted that the waste-water discharged by Markeen Battery Recycling industry contains toxic, metals such as lead, cadmium, Lithium, Mercury, Zinc, Silver, Manganese and Nickel. The wastewater was treated using a reed bed constructed wetland containing reed plant Phragmites karka. Performance efficiency of reed bed with respect to removal of toxic metals gradually increased as the hydraulic retention times (HRT) increases. The results showing a removal rate of 36.8% to 61.5% while control bed record a removal efficiency of 28.7% to 58.3%, It was revealed that there was waste water toxic reduction in RB1 than the CONTROL BED.

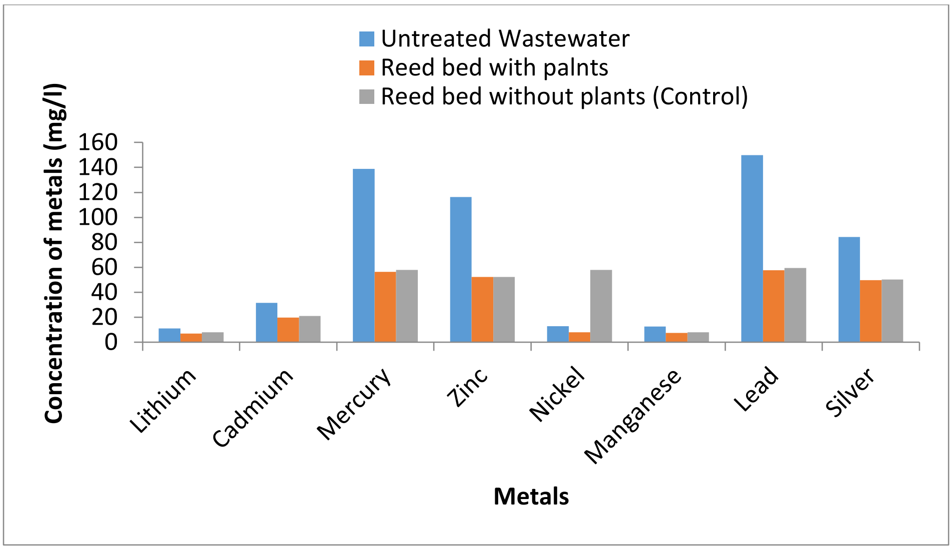

Figure 2: concentration of metals in untreated wastewater, Reed beds with and without plants

4. CONCLUSION AND RECOMMENDATIONS

At the present stage of wetland technology development, it is apparent that a wide variety of constructed wetlands exist for industrial wastewater treatment, reed bed wetlands have been shown to have good removal efficiency for toxic metals found in a battery industry and waste water generally. The effectiveness of reed bed wetland system in reducing the concentration of the metals support the fact that reed beds are able to offer comparable treatment efficiencies with substantially less operator input for treatment of industrial wastewaters. The experiment carried out indicated that Reed bed can be used for the treatment of industrial wastewater. Consequent upon this, it is recommended that Reed bed vegetation with Phragmites karka should be employed for treatment of industrial wastewater. This will help to control pollution of stream caused by discharge of untreated wastewater and it creates a more sustainable environment for the protection of the natural ecosystem as well as aquatic life at large.

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