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HEAVY METALS PHYTOREMEDIATION USING *Typha domingensis* FLOURISHING IN AN INDUSTRIAL EFFLUENT DRAINAGE IN KANO, NIGERIA

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ABSTRACT
Phytoremediation as a tool employs aquatic macrophytes as a principal and inexpensive strategy for controlling environmental pollution. It is achieved through various mechanisms such as phytoextraction, phytostabilization, and phytovolatilization. In this study, heavy metal content of a contaminated drainage that empties into the Kano River was investigated by assessing the uptake of heavy metal contaminants by a notorious aquatic weed, "Typha domingensis". Atomic Absorption Spectrophotometer (AAS) was used to determine the concentration of Pb, Cu, Zn, Cr and Fe in the effluent, sediment and T. domingensis in the months of January, April and July 2013, covering the seasonal weather pattern in the area. In addition, the Bioconcentration factor (BCF) of these metal pollutants in T. domingensis, were calculated as the ratio of their concentration in Typha domingensis to the effluent while the Transfer factor (TF), as the ratio of these substances in T. domingensis to the sediment. From the results, Cu, Fe and Zn concentrations were statistically different (p<0.05) in the effluent as well as in the sediment across the sampling months, while Pb and Cr were significant only in the sediment. The BCF values obtained for these metals in the test plant were >1 except for Fe in April, which indicates the plant capacity for phytoextraction. Similarly, TF values obtained were >1 except for Pb, Fe and Cu in the months of January, April and July respectively. This also indicates the potentiality of T. domingensis as a nutrient and metal-accumulating plant through the process of sequestration. The findings of this work have demonstrated the capacity of T. domingensis in the effluent drainage, not only playing an ecological role in the environment, but also to remove heavy metal pollutants. Therefore, the plant species could be used for phytoremediation of industrial effluent contaminating ecosystems.
Keywords; T. domingensis, phytoremediation, Heavy metals, industrial effluent

INTRODUCTION

Environmental pollution is one of the major problems in both developed as well as developing countries. Existing technologies used for removing contaminants particularly metal pollutants are usually expensive (Singh *et al.*, 2010). In recent years, however, researchers are exploiting other valuable options including living organisms to control industrial pollution of water systems as well as soil. Aquatic macrophytes among other living organisms have been employed as the principal mechanism for metal uptake and subsequent sequestration in their roots and shoots systems. Phytoremediation, the technique that involves the use of plant species to decontaminate soils, water and also atmospheric conditions has its advantages and perhaps limitations. It can be achieved via different mechanisms which include phytoextraction, phytostabilization, and phytovolatilization Chibuike and Obiora, (2014). It is regarded as an emerging technology for control of chemical pollutants in the environment (Hazra *et al.*, 2015).

Aquatic macrophytes including *Typha* species are widespread in various habitats in Kano which results in serious ecological problem to efficient water management in the area such as siltation and blockage of river channels (which causes general reduction of free flow of water into irrigation fields); contributes significantly to the loss of water for crop production and fisheries; also shelters dangerous reptiles and grain eating birds such as Quelea. However, these aquatic weed employ their remarkable growth capacity to exploit different freshwater habitats as well as contaminated or effluent sites. The ability of this plant species to withstand high concentrations of substances such as heavy metals, and successfully proliferate in the contaminated water, attracts attention from researchers. The works of Chandra and Yadav (2011); Dordio *et al;* (2009) Dordio *et al.*, (2011) Eid *et al.*, (2012) and Grisey *et al.*, (2012) that focused on the use of *Typha* spp for phytoremediation of contaminated sites prompted the present study in Kano, Nigeria. This study was aimed at assessing the phytoremediation potentials of some heavy metals contained in industrial effluent mainly from carbonated drink factory by *Typha domingensis*, a widely growing aquatic plant species in Kano area both in the dry and rainy seasons.

MATERIALS AND METHODS

Study Area

Nigeria is the largest country in Tropical West with an area of 923,770sq. Km. It extends between latitude 40 16'N and 13052'N and between longitude 20 49' and 140 37'E. Kano, the most populous state in Nigeria is located at 11.99°North latitude, 8.51 East longitude and about 479 meters elevation above sea level. The study area is a drainage system that receives and discharges effluent from a factory located at latitude N11°53'30.1" and longitude E008°32'29.8" which subsequently drains into a river tributary at latitude N11°53'39.2" and longitude E008°31'37.5" covering a distance of about 2 Km.

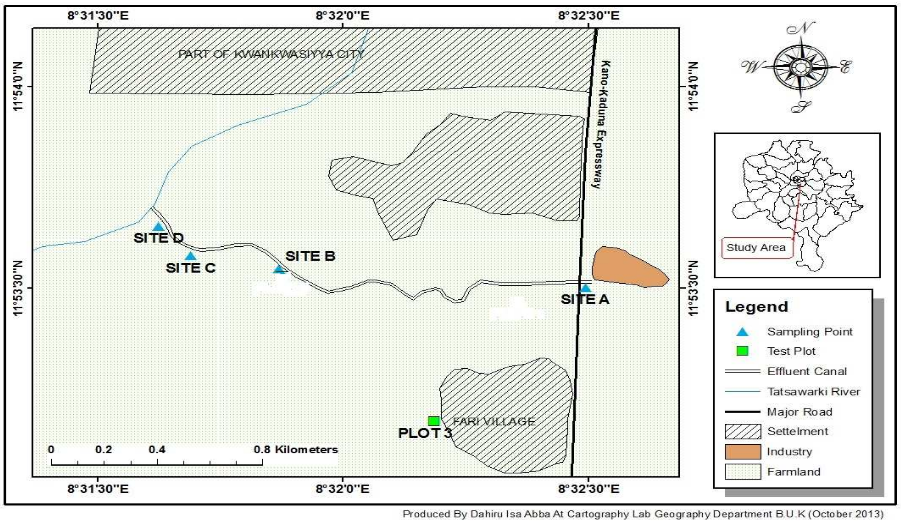

Figure 1: Map showing the sampling sites

Sampling and Sample Collection

Sample collection was carried out across the two major Seasons of Nigeria (Rainy and Dry Seasons) in the months of January, April and July 2013.Two sampling months i.e January and April were selected in the dry season due to its longer period in comparison to the rainy season.

i) Sampling Sites

Four sampling sites were selected for effluent and soil/sediment sampling along the major drainage discharging the factory's waste water. They include; **Site A**- The factory's discharge point which is located at latitude N11°53'30.1" and longitude E008°32'29.8". **Site B**- The site dominated by *Typha* sp., located at latitude N11°53'31.7" and longitude E008°31'52.6". **Site C**- This is the site beyond site B and where there is little or no growth of *Typha* sp. It is located at latitude N11°53'34.5" and longitude E008°31'41.2". **Site D**- This is the site further away from site C and very close to a river tributary (*Tatsawark*i). It is located at latitude N11°53'39.2" and longitude E008°31'37.5" (Figure 1).

ii) Sampling of Effluent/Wastewater and Sediment

Stratified sampling of effluent and sediment from the industrial effluent's drainage was conducted across dry and wet seasons in 2013. Soil and effluent samples were collected twice in the months of January, April and July and from the four sampled sites (A-D) along the effluent's channel. Sampling was carried out in the morning hours between 8:00am to 12:00pm.

Laboratory analysis

Wastewater/effluent samples collected were subjected to HNO3 acid digestion method as described by Eaton, (2005) prior to heavy metal determination. The soil/sediment samples collected were air dried and then disaggregated with mortar and pestle. Dried samples were then passed through 2mm size sieve and then subjected to double acid digestion as described by Udo *et al.* (2009). *T. domengensis* samples were also air dried and grinded to obtain powdered form, digestion of plant samples was carried out according to Benton and Vernon (1990). Heavy metals were determined using the Atomic Absorption Spectrophotometer (AAS) for all the digested samples. The heavy metals determined include Lead (Pb), Copper (Cu), Zinc (Zn), Chromium (Cr) and Iron (Fe).

Determination of Bioconcentration Factor (BCF) and Transfer Factor (TF)

Bioconcentration factors (BCFs) were calculated as the ratio of the concentrations of heavy metals in *Typha* whole plant to that of effluent water, while Transfer Factor (TF) was also calculated as the ratio concentration of an element in the plant body (mg/kg) to concentration of the same element in the sediment at the same site (mg /kg), (Chamberlin, 1983):

$BCF = {}^{CP}/_{CE}$ Where CP= Chemical concentration in Plant (*Typha domingensis*)

CE= Chemical concentration in environment (effluent water).

$TF = {}^{CP}/_{CS}$ Where CP= Chemical concentration in Plant (*Typha domingensis*)

CS= Chemical concentration in environment (sediment).

Data Analysis

One-way ANOVA was used to compare heavy metal concentrations of effluent and sediments across the sampling months using Microsoft Excel. Differences between means were considered significant if $p < 0.05$. Values that differ significantly were separated using Fisher LSD Method.

RESULTS AND DISCUSSION

Heavy metal concentration in wastewater (mg/l) and the standard errors across the sampling months in 2013 were presented in Table 1. From the results, the concentration of Zn (in all sampling months) and Cu (in January and July) in the wastewater/effluent were within permissible limits for effluent discharge in mg/L by NESREA (2009) while Pb, Cr and Fe exceeded the permissible limits. Most of the heavy metal concentrations such as that of Pb concentrations in the 3 sampling month, Cu in January & July, Cr in January & April, and Fe in January were in line with the findings of Tariq *et al*. (2006) who reported a similar findings of heavy metal concentration (Cu=0.35, Fe=0.16, Pb=0.27, Zn= 0.01, and Cr=0.16) in wastewater from a carbonated drink effluent (Pepsi industry) in Pakistan. On the other hand, the concentrations of Pb, Cu and Zn varies significantly across the sampling months of January, April and July which is in line with earlier findings of Grisey *et al*. (2012), whom reported significant seasonal variation of some heavy metals among which include Cr, Cu, Pb and zinc, in water samples collected from Etueffont lagooning system in France with two macrophyte spp (*P. australis and T. latifolia*) growing in the site. Table 2 also shows the concentrations of the selected heavy metals in sediments collected from the effluent channel in sampling months in 2013. Statistical analysis using one-way Anova revealed significant difference in all the heavy metal concentrations across the sampling months. This variation may likely be as a result of other environmental factors as well as different climatic conditions across the sampling months which may affect the heavy metal accumulation by aquatic plants as reported by Bonanno and Lo Giudice, (2010). Almost all heavy metal concentrations in *T. domingensis* with the exception of Fe concentration in July were found to be higher in the month of April as seen in Table 3. This could be as a result of optimum production of carbonated drinks during the hot weather of April and as such more wastewater would be generated which was expected to be the cause of high concentrations of the heavy metal contaminants. The BCF and TF values were also presented in the same table. Lin and Zhang, (1990) reported that Nutrient and metal accumulation by macrophytes is in particular affected by their concentrations in the water and sediment. Zabin and Howladar, (2015) also reported that BCF and TF can be used to evaluate the potentiality of plant sp for phytoextraction and phytostabilization. Nearly all BCF values were greater than 1, which according to Li *et al*., (2007); and Juarez-Santillan *et al*., (2010) shows a clear indication of plant potential to phytoextraction.

The Transfer factors (TF) on the other hand generally indicated movements of heavy metals from soil to the plant tissue as described by (Eid *et al*., 2012). From the result, all TF values were relatively higher in the month of April than that of January and July with the exception of Fe, and this corresponds to the concentration of Heavy metals in *T. domingensis* as described earlier. Again, the TF value of Pb in January, Fe in April and Cu in July were <1 while all other heavy metal TF were >1. Zu *et al*., (2005) reported that TF > 1 were found in nutrient- and metal-accumulating plants, whereas TF <1 occur in nutrient- and metal-excluding plants. Therefore *T. domingensis* having about 80% transfer factor >1 could be regarded as a metal accumulating plant.

Table 1: Heavy Metal concentration Levels and Standard Errors of Wastewater (mg/l) in Sampling Months in 2013

	Month				
Heavy Metals (mg/l)	January	April	July	p-value	LSD
Pb	0.203±0.0131	0.162±0.0371	0.315±0.130	0.4	-
Cu	0.205±0.116	1.045±0.107	0.385±0.048	0.001	0.305
Zn	0.785±0.436	1.543±0.156	0.104±0.007	0.013	0.856
Cr	0.227±0.117	0.188±0.144	0.375±0.136	0.437	-
Fe	0.130±0.008	12.038±1.929	0.308±0.0243	0.001	3.564

Table 2: Heavy Metal concentrations Levels and Standard Errors of sediment (mg/kg) across the sampling months in 2013

	Month				
Heavy Metals (mg/l)	January	April	July	p- value	LSD
Pb	4.500±0.558	1.902 ± 0.278	1.228±0.554	0.002	1.541
Cu	1.400±0.196	13.640±2.451	9.925±2.882	0.009	6.998
Zn	6.023±1.088	14.240±3.731	2.348±0.0896	0.013	7.181
Cr	1.920±0.196	2.545±0.443	4.405±0.142	0.001	0.932
Fe	2.625±0.554	12.965±1.464	8.053±1.489	0.001	3.99

Table 3: Bioconcentration Factor (BCF), Transfer Factor (TF) and Heavy Metal Concentration of *Typha domingensis*, across Sampling Months in 2013

	JAN			APR			JUL		
Heavy Metals	*T. domingensis*	BCF	TF	*T. domingensis*	BCF	TF	*T. domingensis*	BCF	TF
Pb	4.35	21.7	0.96	4.35	27.19	2.28	1.67	5.22	1.35
Cu	2.80	13.3	2.00	27.3	26.00	2.00	9.55	24.49	0.96
Zn	6.94	8.78	1.15	47.00	30.51	3.30	6.35	63.5	2.74
Cr	3.85	16.73	2.01	12.9	67.89	5.06	5.40	14.21	1.22
Fe	4.40	33.85	1.67	7.40	0.61	0.57	19.44	62.71	2.41

Keys: BCF- Bioconcentration Factor, TF – Transfer Factor

CONCLUSION

The study demonstrates the phytoremediation capacity of heavy metals by *T. domingensis* flourishing in an industrial effluent drainage. The result therefore provides an insight perspective of *T. domingensis* being a metal accumulating plant with great potentials of phytoextraction. Hence the plant species can be used effectively for the treatment heavy metal contaminants in present in soil and wastewater.

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