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Original Research Article

Comparatives effectiveness of two vetiveria grasses species *Chrysopogon zizanoides* and *Chrysopogon nigritana* for the remediation of soil contaminated with heavy metals

ABSTRACT

The study was carried out at the screen house of the institute of agricultural Research and Training (I.A.R&T) to determine the responses of two vetiver grasses cultivars (*Vetiver zizanioides* and *Vetiver nigritana*) on four different contaminated soils and their potential to remediate metal contaminated soil. The experiment was a 3x4 factorial experiment arrange in a randomized complete block design and replicate thrice. There were 3 levels of vetiver grass (*V. zizanioides, V. nigritana,* and no vetiver) and four (4) contaminated soils. The absorption of metal contaminated like lead, cadmium, and zinc by the two vetiver cultivars were determined in all treatments. In mechanic village soil, *V. zizanioides* absorbed more of zinc followed by *V. nigritana* with percentage reduction of 7.0, 5.9 respectively. In industrial soil, the percentage reduction of heavy metal in the soil was 27.6, 18.8 by *V. zizanioides and V. nigritana*, respectively. Also in refuse dumped soil, there was a percentage reduction of 13.7, 6.1 by *V. nigritana* and *V. zizanioides*, respectively. In mechanical village soil *V. nigritana* absorbed more of cadmium in the soil than *V. zizanioides* with percentage reduction of cadmium being 30.5, 26.2., respectively. In refuse dumped soil there were percentage reductions, of 7.1, 6.8 in V. *nigritana* and *V. zizanioides.* In mechanic village soil, *V. nigritana* absorbed more of lead than *V. zizanioides* with percentage reduction of 36.3, 43.4 by *V. zizanioides* and *V. nigritana* respectively, in refuse dumped soil there were percentage reduction of 10.2 and 6.3 by *V. zizanioides* and *V. nigritana* respectively. In industrial soil, there were percentage reduction of 39.2, 29.9 by *V. zizanioides* and *V. nigritana* respectively. *V. nigritana*, the local variety, proved to have the greater potential of phytoextracting the heavy metals in the soils more than the exotic cultivar (*V. zizanioides*).

Keywords: *V. zizanioides,*phytoextracting, *V. nigritana,* contaminated soils, refuse dumped soil, industrial soil, mechanical village soil

INTRODUCTION

The need to meet market demand and generate additional sources of short term income by subsistence farmers and some artisans has led to expansion of cultivation to marginal lands including soil contaminated with heavy metals. ~~Beside, with~~ increasing use of agrochemicals to maintain and improve soil fertility, unwanted elements such as Cadmium (Cd) Zinc and (Zn, from contaminated agrochemicals, ~~are being introduced~~ into agricultural soil, which of course

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poses a potential threat to the food chain (Chameye*et al*, 1998). Majority of farm land in Nigeria today where dry season vegetables are grown are dumping sites for urban wastes (Oluwatosin*et al*, 2009). Due to ever increasing industrial, agricultural, and mining activities worldwide, heavy metal pollution of land and water is becoming globally important environmental, health, economic, and planning issues. There is an increase in world population, and unpleasant disposal of industrial effluents, especially in the third world countries, is causing soil pollution. Utilization of these lands for agricultural purposes and urban development's requires a safe and efficient decontamination process. The need to clean up these lands from toxic pollutants becomes more important for our society to be free from ill health. Phytoremediation becomes more important technology ~~plant~~ to clean up pollutant in the environment. Besides being an economical, energy efficient and environmental friendly method, phytoremediation can be applied to large areas and is useful for removing a wide variety of contaminants (metal, radionuclide and organic substance) from growth media (soil, sludge, sediment and water). Phytoremediation can be either phytoextraction, in which plants decontaminate soil through uptake of heavy metals in to aerial part and can be thereafter harvested and removed from the site; phytostabilization, in which plants are used to minimize heavy metal mobility in contaminated soil or phytovolatilzation in, which plants extract volatile metals from contaminated soil and volatilize them from foliage (Cunnungham *et al.*, 1995).

Vegetation is important for all phytoremediation application, it is necessary to use plants that tolerate high levels of toxic pollutants. Different plants have been used globally for phytoremediarion but the level of tolerance of most them to toxic metals raise questions in their suitability for phytoremediation. The use of vetiver grass (*Vetiver zizanioides* (L) nash) has been well documented to have a good resistance to the execrable environment and to be able to survive in high concentration of heavy metal (Tang ~~NS~~ Ba, 1998). Application of vetiver for phytoremediation, however, depends upon various factors such as physical and chemical properties of growth media as well as agronomic practice. All these should be carefully investigated and properly considered in applying for site specific conditions to achieve the desired goal. The Vetiver System (VS), which is based on the application of vetiver grass, was first developed by the World Bank for soil and water conservation in India in the 1980s. in addition to its very important application in agricultural lands, scientific research conducted in the last 20 years has clearly demonstrated that VS is also one of the most effective and low natural methods of environmental protection.

Land degradation is becoming one of the major environmental issues in the world, especially in developing nations. Land contamination, usually accompanied by release of heavy metals, always results in a decrease or complete loss of land productivity, and produces on-site and off-site pollution to soil and water. The methods for land reclamation vary from physical chemical to biological control. The cost of reclamation f degraded land using old methods such as farming, is huge, but far cheaper, using new biological methods. Vegetation or re-vegetation is a chief biological measure, but the key is choosing the right species of vegetation. Trees, shrubs, creepers and herbs can be used to reclaim degraded land, but the best species are grasses due to their strong residence to adverse conditions, and fast-growing features. Among the grasses ~~bt~~ that are prominently being used worldwide is vetiver grass (V. zizanioides) toxic and metal contaminated soil. Vetiver has various kinds of miraculous characteristics and functions, such as rapid growth, huge biomass, massive and long roots (can grow up to 3m soil depth). Applications around the globe indicate that vetiver has a great potential for land reclamation, including

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reclamation of barren mountains or hills, contaminated water and soil, mined lands, quarries etc. stiff foliage of the grass and the dense but porous nature of the hedge formed by the strip makes vetiver grass s-strip suitable to perform the function (Grimshaw and Helfer, 1995). In previous reports, vetiver grass strips were compared with either no vetiver grass reprints, vetiver grass strips were compared with either no vetiver grass treatments or other grasses on a particular soil but there was little or no information on the potential of different species of vetiver grass in reclamation of metal contaminated soils.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the screen house of the Institute of Agricultural and Training (7 23^0 N, 3 51^0 E). Soil samples were collected from four different sites within Ibadan metropolis. Refuse-dump site at NYSORT and Ajibode, industrial waste soil from Iron and Steel Industry at Oluyole Industrial Estate, mechanic village at Eleyele and Sango, and Agricultural farm plot at I.A.R &T farm. The soil samples (0.20cm depth) were collected randomly from each site and allowed to pass through a 4mm mesh sieve to remove debris from the soil sample. The sieved soil samples were transferred into concrete slabs of 108cm long, 54cm high. The bottom of each slab has been perforated to allow free drainage while a geo-textile (tissue paper) was laid on the bottom of each slab to limit particle flushing by percolation flow. Thirty-six (36) concrete slabs were used with a slab filled with 4mm screen sieved soil samples and compacted to a density of 1.10Mg m^3

Experimental layout treatments and analyses

Two vetiver grass species *Vetiver zizanioides* (exotic cultivar) and *Vetiver nigritana* (local species) were used for the purpose of phytoremediation. The slips of vetiver grass were prepared by cutting the shoots of the uprooted grass to a length of 20cm (plate 1). The root of each slip were treated with cow tea (cow dung mixed with water) to prevent root desiccation. Each species of vetiver grass was planted into 2 of 3 slabs containing soil samples collected from a sample site. There were 12 treatments of 4x3 factorial experiment arranged in a randomized complete block design. The experimental layout is shown below in fig. 1. The soil samples was sieved to take off thrashes and non soil remnants, air dried and parked into an identified slab at bulk density of 1.2g/cm^3

The soil was wet to field capacity before planting the two vetiver grasses. The vetiver slips that was planted were cut to a length of 30cm, while their roots were treated with cow tea (cow dung slurry) to prevent dehydration before planting. These grasses were constantly wetted with water to allow normal growth and early tillering

s/no Treatment	Description
: MV +C-Ziz	Mechanic village soil + *Chrysopogon zizanioides*
: MV +C-Nig	Mechanic village soil + *Chrysopogon nigritana*
: MV +No Vetiver	Mechanic village soil + vegetable

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: ID +C-Ziz	Industrial waste + *C. zizanioides*
: ID +C-Nig	Industrial waste + *C. nigritana*
: ID +No Vetiver	Industrial waste + vegetables
: UW +C-Ziz	Urban waste + *C. zizanioides*
: UW +C-Nig	Urban waste + *C. nigritana*
: UW +No Vetiver	Urban waste + vegetables
: AS +C-Ziz	Agricultural soil + *C. zizanioides*
: AS +C-Nig	Agricultural soil + *C. nigritana*
AS+ No Vetiver	Agricultural soil + vegetable

At 2 months after vetiver grass has been fully established the shoots were pruned to a length of 20cm high. The biomass from the pruning was weighed (fresh and ~~weight~~) to compare the biomass yield as affected by the level of contaminants. The width of the over strips was also measured before pruning subsequently, the height and width of the grass were measured on weekly basis to determine the growth rate of vetiver in each plant slab as it was affected by contaminant in the soil.

Plant parameter and measurement

At 1 week after pruning (WAP) of the vetiver grass shoots to a length of 20cm, the vetiver grass shoot was measured using measuring tape graduated in centimeter from soil surface level to the tip of the plant. The height of the grass was measured at 1WAP, 2WAP, 3WAP, and 4WAP after which the shoots were pruned again. The routing height measurement were repeated for another 4 week to confirm whether there was an influence of contaminant on the physiological growth of the two cultivar of vetiver grass.

Dry matter yield

The dry matter yields of the two cultivars of vetiver were determined at every time the vetiver shoots were pruned. The vetiver shoot and roots were cut fresh, ~~weighted~~ and thereafter dried at 65°c. Sub-sample of the dried shoots were taken for further drying at 105°C to constant weight for the determination of dry matter yield. The sub sample of vetiver shoots dried at 65°c was milled with milling machine for chemical analysis. The analysis of the vetiver grass shoots and roots were done to determine the part in which heavy metal accumulates.

Soil and plant analysis

1g of air dried soil samples were ~~weighed~~, with 1M MgSl2 + 4ml aqua-regia, was added and filtered. To the residues, 8ml of sodium acetate solution adjusted to pH5 with acetic acid and 4ml ~~h~~aqua regia solution. The heavy metal fractions were determine in the filtrate using atomic

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absorption spectrophotometer (AAS) for plant analysis, 1g of ground plant samples were digested in concentrated HNO_3 and $HClO_4$ (5:v/v) using digested block (Allen, 1980). The digested samples were analyzed for Pd, Cd, and Zn using AAS.

Statistical analysis

Analysis of variance (ANOVA) was used to analyze the experimental data, while the mean were separated using Duncan multiple range test at the $p < 0.05$ significance level.

RESULTS AND DISCUSSION

Soil characteristics and metal concentration

The general properties of the soil used for this study are presented in table 3 below. The textural class showed that refuse dumped soil was loamy (udic soil), mechanic village and industrial soils were loamy sand (vertisol), and agricultural soil was sandy loam (mollisol or histisol) with pH 6, 8, 7, 1, 7, 3 and 5.2 respectively. The background metal concentrations indicated that heavy metals were generally high especially Cadmium (Cd) and Lead (Pb) in all soils above the permeable levels except agricultural soil. In general, soil that contain >300mg/kg extractable Zinc (Zn), >20mg/kg lead (Pb) and Cadmium (Cd) are considered to be phytotoxic to plants (Chamey and Oliver, 1998). Although lead (Pb) in agricultural soil was high, this may be unconnected to the source of the organic material used by the farmers for manuring.

Table 3: Concentration of heavy metals in soils

Parameter	industrial waste soil	mechanic village soil	urban waste soil	Agricultural soil
Soil pH	7.3	7.1	6.8	5.3
Soil texture	loamy	loamy sand	loamy sand	sand loamy
Organic matter (mg/kg)	12.1	1.4	30.3	10.1
Pb (mg/kg)	265.2	328.8	241.2	87.6
Cd (mg/kg)	171.6	217.2	172.8	14.4
Zn (mg/kg)	61.2	122.8	87.8	18.0

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Growth performance of vetiver grass cultivars

Plants absorb contaminants through root system and store them in the root biomass and or transport them to the stem and or leaves. They may continue to absorb contaminants unit they are harvested and ~~purpose of safety~~. The growth performance data (survival rate, height and biomass) of both *V. zizanioides* and *V. nigritana* are shown in table 4. The two vetiver grass species showed the best survival (100%) in all the soil types except in mechanic village soil where both grasses showed (75%) survival rate. This might not be unconnected with the high level of Pb in mechanic village soil. Similar result was obtained by (Truong, 1999; [illegible], 2003)

Table 4: Survival rate, height and biomass yield of *V. zizanioides* and *V. nigritana* as affected by soil contaminants

Treatment	survival (%)	height (week after planting(cm)			biomass (WAP) (mg/kg)		
		1	2	3	4	4	8
ID + Vziz	100	42.3a	69.1bc	81.7bc	87.7a	1.31a	1.86c
ID + Vnig	100	43.2a	69.0bc	81.7bc	87.0a	1.32a	1.88c
MV + Vziz	75	49.7b	85.7e	93.7d	100.0b	2.30c	2.33d
MV + Vnig	75	42.5a	74.7d	88.3cd	106.6b	1.76b	2.51d
UW + Vziz	100	40.7a	59.7a	81.0bc	82.7a	0.94a	0.70a
UW + Vnig	100	42.7a	66.0bc	74.0ab	83.7a	0.95a	1.20b

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AS + Vziz	100	52.7b	70.3cd	78.0ab	82.0a	1.10a	1.85c
AS + Vnig	100	42.2a	65.3b	71.3a	82.2a	1.19a	1.67c

Mean values with the same letter(S) in a column are not significantly different by Duncan Multiple Range Test (ADMRT) (P≤ 0.0)

~~(b) table~~ 5 below show that the concentration of lead is higher than the amount of cadmium and zinc present indifferent soil samples collected. The concentration of mechanic soil ranges between 5.12-50.25mg/kg followed by industrial soil which is 7.97-26.42mg/kg and refuse soil 3.72-6.42mg/kg. Agric soil have the lowest concentration of heavy metal ranges between 1.37-4.17mg/kg.

Table 5: Concentration of heavy metals in the root of vertiver

	Cd (mg/kg)	Pb(mg/kg)	Zn (mg/kg)
IndSoil S1	17.45	58.52	5.250
Mechanic Soil S2	40.30	69.77	2.467
Refuse Soil S3	6.83	11.63	1.717
Agric S4	2.47	9.29	0.756
LSD	2.42	2.743	0.332

Table 6 below also showed that lead has the highest concentration in the soil samples used, followed by the cadmium and zinc. Mechanic village soil has the large amount of heavy metal concentration which is between 5.12-50.3mg/kg. Second by industrial soil 7.97-26.42mg/kg heavy metal concentration refuse soil ranged between 3.72-6.47mg/kg while agricultural soil has the least 1.37-4.17.

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Table 6: Concentration of heavy metals in the shoot of vetiver

	Pb (mg/kg)	Zn (mg/kg)	Cd mg/kg
IndSoil S1	26.42	7.967	8.72
Mechanic Soil S2	50.25	5.117	19.82
Refuse Soil S3	6.47	6.333	3.72
Agric S4	4.17	1.517	1.37
LSD	1.899	0.3328	0.940

Level of metal concentration in the roots and the shoots of the vetiver cultivars

Table 7 below showthat the amount of heavy metal concentration in the root of *V. zizanioides* was higher that of *V. nigritana*. .

Table 7: Concentration of heavy metal in the roots of both *V. zizanioides* and *V. nigritana*

Vetiver 2-VI	14.60	40.48	3.025
Vetiver n-v2	18.94	34.13	2.07
LSD	1.71	1.94	0.24

CONCLUSION

In conclusion, the study demonstrated that vetiver grass (*V. zizanioides and V, nigritana*) grown in heavy metal contaminated soil has the potential to reduce the contaminants through phytoextraction. Even though the survival rate of vetiver grass in mechanic village was not more than 75%, both species still perform very well in extracting heavy metals contained in the soil.

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However, the level of organic matter in the soil can enhanced the level of absorption of heavy metal by vetiver grass especially *V. nigritana*. This was reflected in the growth performance of the grass in all the soil. Refuse dumped soil with highest organic matter content enhanced the growth and absorption rate of vetiver grass compared with other soil types with low organic matter contents.

RECOMMENDATION

The use of vetiver grass should be encouraged in Nigeria to remediate contaminated soils in order to ensure food security. However, *V. nigritana* is recommended for all mechanic village soil. For industrial soil,*V. zizanioides* is recommended for use while in refuse dump soil, the two cultivars can be recommended of use since the two cultivars performed better in the phytoextraction of metals. However there is still need for further trial on the field to find out the potential of the two species of vetiver grass for phytoremediation.

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