The ability of some woody trees to remove some of soil pollutants

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Abstract: A Pot experiments was carried out in National Research Centre Cairo Egypt during two successive seasons 2015/2016 to investigate the effect of pollutants soil by (Zn, Cd and Pb) on *Harpullia pendula, Sterculia acerifolia* and *Ficus racemosa growth.* Cadmium as cadmium carbonate was added at the rate of 0.089 kg^{-1} soil+Liad as liad carbonate was added to the rate of 0.08 kg soil+Zn as Zink citrate was added at the rate of 1-2 g kg^{-1} soil, all this were added and thoroughly mixed with before cultivation. Results showed that, Pb+Cd+Zn applied in combination have been proved effective in increasing plant height, number of leaves, root length, as well as stem diameter and fresh weight and dry weight of leaves and roots of *Sterculia acerifolia* tree compared with untreated tree. On the contrary, *root length, stem diameter and dry weight* not affected and approximately equal to the untreated plants in both of Harpullia and Ficus plant. The highest values concentration of (Zn+Cd+Pb) was found in roots of all trees. While the previous heavy metals recorded lowest concentration in leaves of the three mentioned plants compared to control. All *Harpullia pendula, Sterculia acerifolia and Ficus racemosa* trees showed higher tolerance to heavy metals Zn, Cd and Pb especially *Ficus racemosa* tree accumulated the higher Cd in roots.

Keywords: heavy metals, ornamental plants, soil pollutant

Citation: Metwally, S. A., K. A. Hashish, B. H. A. Leila. 2017. The ability of some woody trees to remove some of soil pollutants. Agricultural Engineering International: CIGR Journal, Special issue: 263–267.

1 Introduction

Many cities around the world are faced with the pollution of soil with heavy metal such as sewage effluents and industrial water disposal. Therefore some investigators have used ornamental plants and woody trees as phytomediator of pollutants in the soil (Hasnain et al., 2010; Wang et al., 2011; Banon et al., 2011).

Environmental pollution has contaminated soil, water and biotic community with heavy metals. Evaluating the comprehensive human risk and deriding cost-effective remedial action require specific knowledge of the fact and behavior of individual contaminate and/or all contaminates (Loehr, 1976; and Overcach and Pal, 1979). Among these pollutants element Pb, Cd and Zn which considered of major concern. With respect to Pb the presence of lead in soil simultaneously very often presents problems in food chain, agriculture and ecosystem. Therefore, these are campelling reasons for a thorough investigation on the effect previous mentioned pollutants on the growth, potency of other nutrients.

The objectives of this study is to quantity and compare the soil- to plant transfer of Pb, Cd and Zn and other nutrients and to determine the potentiality of the chosen wood trees as a phytoremidators of pollutants. Moreover, the experiment was conducted to study, the growth and performance of the trees under pollution condition.

2 Materials and Methods

Tow pots experiments were carried out in two successive growing seasons at green house of the National Research Centre. Doki, Cairo. The soil texture were sandy loamy. The mechanical and chemical analyses of the soil are presented in Table 1. Pots with 6 kg capacity were filled with the soil. At the soil perpration normal agriculture practices were following.

Three types economic trees namely *Harpullia pendula,*

Received date: 2017-08-08 **Accepted date:** 2017-12-29

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Sterculia acerifolia and *Ficus racemosa* were chosen. The experiment included six treatments with 10 replicates for each group and arranged in complete randomized design. For pollutants Cadmium as cadmium carbonate was added at the rate of 0.089/kg soil+Liad as liad carbonate was added to the rate of 0.08 kg soil+Zn as Zink citrate was added at the rate of 1-2 g/kg soil, all this were added as chelating and thoroughly mixed with soil before cultivation.

Nitrogen, Phosphorus and Patassuim were added at the beginning of the experiment in the form of ammonium Sulphate, Calcium monohyden phosphate and potassium sulphate respectively using the recommended dose of Ministry of Agriculture. During the tree growth a constant level of moisture 70 WHC was used and the trees were allowed to grow for 300 days.

The same treatments were repeated in pots without pollutants as control for each type of trees, to evaluate the status of pollutants and some ether elements which have are expected to have a relationship with the pollutants.

At the end of the experiment, the trees were harvested and the growth parameters were estimated, then the sample washed, dried 70^o and ground to determine N, P and K according to Romero et al. (2000).

At the end of experiment soil sample were analyzed according to Wani et al. (1988) Table 1.

Table 1 Physical and chemical constituents of the investigated soil

Particle size distribution							
Sand, %	Silt, %	Clay, %	Soil texture	Field capacity, %			
70.8	25.6	3.6	sandy loam	20.1			
Chemical properties							
Ecdsm-1	pH (1:25)	$CaCO_3$, %	O.M, %	Soluble cobalt, ppm			
1.2	7.9	3.57	0.23	0.49			
Soluble cations, meq L^{-1}				Soluble Anions, meq L^{-1}			
Ca^{++}	Mg^{++}	K^+	Na^+	CO_3^-	HCO_3^-	Cl^-	SO_4^-
2.4	2	0.162	1.87	-	1.5	0.65	4.28
Total N, mg 100 g^{-1}	Available, mg 100 g^{-1}		Available micronutrients, ppm				
	P	K	cd	Pb	Zn	Cu	
15.1	13	21	0.2	0.4	1	0.4	

3 Results and Discussion

3.1 Growth

Data presented in Table 2 show that, Pb+Cd+Zn applied in combination have been proved effective in increasing plant height, number of leaves, root length, as well as stem diameter of *Sterculia acerifolia* tree compared with untreated tree, the increment respectively reached,163.15%,115.78%,19.23% and 31.5%.

Table 2 Effect of soil pollutant by heavy metals on growth parameters of *Harpullia pendula, Sterculia acerifolia and Ficus racemosa* trees (average of two seasons 2015/2016)

Plants	Treatments	Plant height cm	Number of leaves	Length of root cm	Stem diameter cm
Sterculia acerifolia	Control	19	41	26	1.9
	Pb+Cd+Zn	50	40	31	2.5
Ficus racemosa	Control	25.25	10.5	30	1.8
	Pb+Cd+Zn	26.75	17.5	17	2.3
Harpullia pendula	Control	34	28	24	1.2
	Pb+Cd+Zn	28	34	26	1.1
L.S.D at 5%		3	2.8	2.56	0.17

Ficus racemosa polluted with the same polluted element Pb+Cd+Zn combination showed significant increment in leaves number 66.66% and stem diameter 55.55% while root length decreased and plant height was approximately equal to control plants. Significant increase in *Harpullia pendula* trees was achieved in number of leaves by Pb+Cd+Zn polluted, while root length and stem diameter not affected and approximately equal to the untreated plants.

Data presented in Table 3 show that the greatest values of fresh and dry weight of leaves and root were observed when Straculia trees polluted with Pb+Cd+Zn in combination.

Table 3 Effect of soil pollutant by heavy metals on fresh and dry weight of leaves and roots of *Harpullia pendula, Sterculia acerifolia and Ficus racemosa* trees (average of two seasons 2015/2016)

Plants	Treatments	Fresh weight of leave, gm	Fresh weight of roots, gm	Dry weight of leaves, gm	Dry weight of roots, gm
Sterculia acerifolia	Control	22.17	68	17	30.5
	Pb+Cd+Zn	62	79	25	43
Ficus racemosa	Control	40	63	20	34.5
	Pb+Cd+Zn	35	72	21	36
Harpullia pendula	Control	50	24	20	19
	Pb+Cd+Zn	56	32	24	24
L.S.D at 5%		4.41	5.63	2.11	3.1

On the contrary leaves and root dry weight of Ficus were approximately equal to the control trees. Harpullia tree dry weight of both leaves and roots increased by about 20% and 26.31% over the control plants, while the fresh weight of both leaves and roots increased by about 12 and 33.33% compared with untreated plants.

The N, P and K concentration in leaves and roots of *Harpullia pendula, Sterculia acerifolia* and *Ficus racemosa* trees were shown in Table 4. It is evident that phosphorus uptake in leaves of Sterculia higher than the roots, the values reached 0.265 mg g^{-1} in leaves and roots 0.245 mg g^{-1}.

Table 4 Effect of soil pollutant by heavy metals on leaves and roots contents from N, P and K of *Harpullia pendula, Sterculia acerifolia and Ficus racemosa* trees (average of two seasons 2015/2016)

Plants	Treatments	Leaves, ppm			Roots, ppm		
		N	P	K	N	P	K
Strucolia acerifolia	Control	1.53	0.175	2.23	1.62	0.120	2.08
	Pb+Cd+Zn	1.98	0.265	2.26	1.75	0.245	2.07
Hurpolia pendula	Control	1.45	0.155	2.30	1.23	0.125	2
	Pb+Cd+Zn	1.56	0.255	1.81	1.47	0.240	2.24
Ficus racemosa	Control	1.74	0.150	1.81	1.47	0.130	2.24
	Pb+Cd+Zn	1.23	0.285	2.05	1.75	0.235	1.75

As for nitrogen uptake it is evident that values increase by about 29.41% over the control plant in leave and in roots was higher 8.02% compared to untreated plants. In Sterculia plants potassium concentration was approximately equal in both leaves and roots compared with the control plants.

For Harpullia trees in polluted plants the uptake of potassium did not show apparent effect between treated and untreated plants. However, considerable differences in the mineral uptake was recorded translocation of phosphorus reached in leaves 0.255 mg g^{-1} while it increased in roots to 0.240 mg g^{-1}.

As for nitrogen concentration in Harpullia trees the increments in leaves reached 7.58% while in roots it increased up to 9.51%.

Roots polluted ficus trees accumulated 19.04 N, 80.67 P while 21.87% K concentration decreased compared with control plants. As for leaves the uptake of N in leaves decreased while the values of phosphorus and K increased and reached 0.285 and 2.05 mg g^{-1} respectively.

3.2 Heavy metals

For Sterculia trees. The data in Table 5 show that Zn uptake for roots was higher than the leaves, the increment over the control reached 11.20%. On the other hand the translocation of Pb and Cd decreased in both leaves and roots. These lower values were reaches 63.75% for Pb and 38.58 mg g^{-1} in leaves and roots respectively. For Cd the reduction reached 21.32 and 16.89 for leaves and roots respectively.

Table 5 Effect of soil pollutant by heavy metals on chemical constituents of leaves and roots of *Harpullia pendula, Sterculia acerifolia and Ficus racemosa* trees (average of two seasons 2015/2016)

Plants	treatments	Leaves, mg g^{-1}			Roots, mg g^{-1}		
		Zn	Pb	Cd	Zn	Pb	Cd
Strucolia acerifolia	Cont.	18.6	200	68	17.4	112	74
	Pb+Cd+Zn	12.15	72.5	53.5	19.35	75.5	61.5
Hurpolia pendula	Cont.	16.2	180	59	16.80	88	49.30
	Pb+Cd+Zn	13.68	148.8	57.20	19.33	168	79.5
Ficus racemosa	Cont.	15.75	102	61	12.6	78	84
	Pb+Cd+Zn	13.50	90	44	16.2	150	68.5

3.3 Harpullia trees

It is worth to note that the highest concentration of heavy metal Zn, Pb and Cd were recorded in the root polluted with Zn, Pb and Cd in combination. On the contrary the lower values of Zn, Pb and Cd were in leaves. These lower values of the Zn, Pb and Cd in leaves reached 13.68, 148.8 and 57.20 mg g^{-1} respectively.

3.4 Ficus tree

For ficus trees it is in general noticed that the lowest amount of these heavy metals were found in leaves compared with the control plants. On the other hand root accumulated 28.75 Zn and 92.30% Pb over the control plants.

3.5 Discussion

The aformented results indicated that, the three used trees *Harpullia pendula,Sterculia acerifolia and Ficus racemosa* had higher tolerance specially Sterculia tree, where the pollutant facilitate and increased plant growth. Our results showed that under pollution with Zn Pb and Cd combination all treated trees shows increments over the control plants in leaves number, fresh and dry weight.

These results may be due to that, some of the used heavy metals are micro nutrients necessary for plant growth such as Zn. This increase in plant growth may be due to the beneficial vital role in plant growth of Zn. In these respect, Zn is essential in tryptophan metabolism and consequently effective the auxin content of plant. Also, several enzyme activated by Zn which has effect on protein synthesis (Marschener, 1995). Also, Anberger (1982) and Vallee and Aud (1990) recorded that Zn has three functional, catalytic, Co-Catalytic and structural. Also various investigators demonstrated the beneficial effect of Zn on several plants (Pada et al., 2007; Said-Alahl and Omer, 2009; Aziz et al., 2010; Losak et al., 2011; Hafeez et al., 2013; Sirohi et al., 2015; Barlog et al., 2016).

In these respect Chakravarty and Strivastava (1997) recorded that the uptake and translocation rate in plant of Zn is higher than Cd.

Our results also revealed that, under pollution with Zn, Pb and Cd in combination, the root of the used trees showed inhibition in growth in most cases compared with the control trees, in this respect Mohan and Hostti (1997) suggested that both cadmium and lead drastically depressed catalase activity but stimulated peroxidase activity and interaction between lead and cadmium inhibited the root of *Juncus acustus*. Also Wierazbika (1998) reported that this two metals combined to the cell wall. Thus weakening their toxic effect on plant. Also, it is worth to note that the leaves of the polluted trees were rich in phosphorus and nitrogen control than that in the roots; these increments over the control may be the reason for increasing plant growth in terms of number of leaves, fresh and dry weight of the polluted trees which grow normally and overcome the control trees.

For heavy metals accumulation it is evident that plants have highly specific metabolism to translocate and store elements where the uptake of elements differ according to trees species. However the main problem with heavy metals is the ion imbalance that results when they accumulate.

In this respect Berry et al. (1977) and Kirkham (1986) mentioned that, heavy metals taken up by vegetable grown with waste water tend to remain in the root. Only a fraction of the heavy elements are translocated to the shoots and even smaller fraction reaches fruits. In these respect our results hold true with these results and the highest level of the heavy metals are recorded in polluted trees compared with the untreated trees.

4 Conclusion

All *Harpullia pendula, Sterculia acerifolia* and *Ficus racemosa* trees showed higher tolerance to heavy metals Zn, Cd and Pb especially *Harpullia pendula* tree accumulated the higher Cd in roots where it showed a great tolerance because Cd in the leaves where lower than in the root.

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