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Potential of using vetiver grass to remediate soil contaminated with heavy metals

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Abstract. Vetiver grass is a plant with strong vitality in harsh conditions. This grass is now being applied widely in the field of soil erosion in the world. In this study, we evaluated the ability of vetiver grass to absorb some of heavy metals in the soil as Cd, Zn, Cu and Pb to determine the viability of using this species in remediation of soil contaminated. Research results showed that the absorption of heavy metals of this species was low (coefficient of BF and TF <1). However, as a result of high biomass, Vetiver grass can absorb and remove heavy metals greatly from the soil. After 3 months planting, vetiver grass has accumulated from 0.05 to 0.23mg Cd /10kg soil; from 19.78 to 39.51mg Zn /10kg soil; from 0.68 to 3.35mg Cu /10kg soil; from 0.28 to 5.87mg Pb /10kg soil. It is 10 to 100 times higher than the hyper-accumulation species such as *Brassica juncea, Thlaspi caerulescens, and Arabidopsis hallerii.* These results demonstrate that the use of Vetiver grass for remediation of soil contaminated with heavy metal is feasible.

Keywords: vetiver, heavy metals, soil contaminated, remediation, phytoremediation.

1. Introduction

The method using plants to treat soil contaminated (phytoremediation) is of consisderable interest, because it is efficient, cheap and environmentally friendly. However, this method requires long processing time, large area, the plants should have good resistance to environmental pollution, accumulation and transformation of pollutants in high concentrations, high biomass, perennials... In fact, there are very few plant meeting the set point.

Vetiver is commonly used successfully in preventing erosion. It has advanced features that are resistant to high pollution, large biomass, fast growth, strong root system [1, 2]. Using of Vetiver for remedying soil contaminated with heavy metals is still at the pilot level and not systematic [3]. This paper will present some results about the possibility of using Vetiver grass for treating soil contaminated with heavy metals.

2. Materials and methods

2.1. Materials

Research plantis vetiver *(Vetiveria zizanioides (Linn) Nash)* is of 3 months old. We

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have chose the healthy plants, cleaned, cut and left the shoot of 35cm, roots of 5cm.

Soils use for studies include: (1) sandy soil supplemented with manure (symbol MD1) with soil properties: N_{ts} - 0.03%; P_{ts} - 0.03%; K_{ts} - 0.38%; CHC - 6.90%; pH - 5.36; Cd- 0.07; Zn- 37.90; Cu- 15.94 và Pb- 3.40; (2) sandy soil without added manure (symbol MD2): N_{ts} - 0.003%; P_{ts} - 0.02%; Kts - 0.21%; CHC - 0.60%; pH - 4.76; Cd- 0.07; Zn- 31.55; Cu- 15.75 và Zn- 2.63ppm; (3) clay soil (symbol MD3): N_{ts}- 0.08%; P_{ts} - 0.07%; K_{ts} - 0.96%; CHC - 3.59%; pH - 6.28; Zn- 0.19; 103.10; Cu- 35.38 và Pb- 6.78; (4) clay soil (symbol MD4): N_{ts} - 0.004%; P_{ts} - 0.04%; K_{ts} - 0.99%; CHC - 0.39%; pH - 4.42; Cd- 0.08; Zn- 136.28; Cu- 34.28ppm; Pb- 5.68ppm.

The heavy metals used for experiments are: Cd, Zn, Cu and Pb and added in the form of salt $CdCl_2$, $ZnCl_2$, $CuCl_2$ and Pb $(NO_3)_2$ in concentrations exceeding QCVN for agricultural soils. Specifically: Cd concentrations: 10, 30, 60ppm, Zn: 300, 400, 500ppm; Cu: 50, 70, 100ppm, Pb: 100, 300, 700ppm.

Experiment pots with 35 cm height, 25 cm mouth diameter, 20 cm bottom diameter. Each experiment pot adds 10 kg of soil. The experiments are arranged randomly, repeated 3 times with three experimental factors: soils, heavy metals and heavy metal concentrations.

2.2. Methods

Determination of heavy metals has been performaed by means of atomic absorption spectrometry (AAS). Samples were analyzed at the Hydro meteorological Center. Assessing of ability to absorb heavy metals by Vetiver grass was through Bioconcentration factor (BF), also known as Bioaccumulation factor and Translocation factor (TF).

BF was calculated as the ratio between concentrations of heavy metal accumulation in the shoot compared with the concentration of heavy metals in soils [4]. BF allows comparison of metal absorption capacity of plants in different soil types.

TF is calculated as the ratio of heavy metal concentrations accumulated in the shoot compared with the concentration of heavy metal accumulation in roots [4]. TF is used to determine the effects of metal transport from roots to shoots of plants [5].

BF and TF is an index to measure the ability to accumulate heavy metals by plants [6]. In particular, if BF > 1, the plant is "accumulor", if BF <1, the plant is "excluder" [7] and if BF >10, the plant are classified as "hyper accumulator" [8]. If TF >1, plant is species with capable of transporting high-speed metal [8].

3. Results and discussion

3.1. Ability of vetiver grass growth on soil types with concentrations of heavy metals

After 3 months of experiment, results showed that concentrations of heavy metals increased (Cd: 10 - 60ppm, Zn: 300 - 500ppm, Cu: 70 - 100ppm, and Pb: 100 - 700ppm) in the four experimental soils, height growth of vetiver grass is declining, but the difference between the average value is negligible, except for soils with heavy mechanical composition and organic poor (MD4). However, the height, branching, root length and biomass are still growing with time.

Thus, with Cd concentrations between 10 - 60ppm (over QCVN 5 - 30 times), Zn 300 - 500ppm (over QCVN 1.5 - 4 times); Cu 70 - 100ppm (over QCVN 1.4 - 2 times), Pb 300 - 700ppm (over QCVN 4.5 - 10 times), Vetiver grass still growing and developing normally. This is necessary conditions for using of Vetiver grass to remedy soil contaminateds with heavy metals.

3.2. Potential of Uptake heavy metals in soils by Vetiver grass

After 3 months of experiments conducted on four soils with the concentrations of various heavy metals, Vetiver grass normal growth, shown by the increased height, increased root length, generate new shoots and increased biomass. To determine the ability of heavy metal uptake of vetiver, we harvested and then divide the roots and shoot, biomass measurement and analysis of metal content in the plant. Results calculated for BF and TF are presented in Table 1.

Table 1. Potential of uptake heavy metals in soils by vetiver grass throug BF and TF

Soil types	Cd			Zn			Cu			Pb		
	Cd content in soil initially (ppm)	TF	BF	Zn content in soil initially (ppm)	TF	BF	Cu content in soil initially (ppm)	TF	BF	Pb content in soil initially (ppm)	TF	BF
MD1	10	0.10	0.09	300	0.83	1.14	50	0.35	0.30	100	0.26	0.07
	30	0.06	0.05	400	0.56	0.96	70	0.71	0.46	300	0.76	0.13
	60	0.07	0.05	500	0.65	1.08	100	0.84	0.47	700	0.88	0.11
MD2	10	0.11	0.08	300	0.74	1.04	50	0.28	0.24	100	0.23	0.06
	30	0.06	0.06	400	0.56	0.88	70	0.66	0.43	300	0.76	0.13
	60	0.07	0.05	500	0.65	0.98	100	0.78	0.46	700	0.88	0.10
MD3	10	0.11	0.08	300	0.84	1.11	50	0.38	0.28	100	0.17	0.04
	30	0.07	0.05	400	0.75	0.85	70	0.77	0.43	300	0.73	0.12
	60	0.08	0.05	500	0.89	0.97	100	0.86	0.41	700	0.85	0.09
MD4	10	0.13	0.07	300	0.69	1.07	50	0.24	0.20	100	0.16	0.04
	30	0.05	0.04	400	0.62	0.74	70	0.50	0.36	300	0.65	0.11
	60	0.06	0.04	500	0.69	0.86	100	0.69	0.37	700	0.82	0.10

Results in table 1 shows that ability of Vetiver grass to absorb and transport Zn from root to shoot is relatively high (BF: 0.74 to 1.14; TF: 0.56 to 0.89); absorption and Cu transport from roots to shoot at the average (BF: 0.2 to 0.47; TF: 0.24 to 0.86). Meanwhile, ability of Vetiver grass to absorb Pb is very low (BF: 0.04 to 0.13), but the ability to transport Pb from roots to shoot is quite high (TF up to 0.88). The ability of Vetiver grass to absorb and transport of Cd from root to shoot is very low (BF: 0.04 to 0.09; TF: 0.05 to 0.13). Thus, it is proved that vetiver is not considered a "acmulator" or "hyperacumulator".

3.3. Efficient uptake of heavy metals in soils by Vetiver

The results of analysis of heavy metal contents in shoot of vetiver grass are presented in Table 2.

Table 2. Heavy metal contents in shoot of vetiver grass after 3 months growing in pots

Soil types	Cd		Zn		Cu		Pb	
	Cd con. (ppm)	W (mg/ 10kg soil)	Zn con. (ppm)	W (mg/ 10kg soil)	Cu con. (ppm)	W (mg/ 10kg soil)	Pb con. (ppm)	W (mg/ 10kg soil)
MD1	10	0.07	300	25.93	50	1.17	100	0.52
	30	0.12	400	29.65	70	2.40	300	3.03
	60	0.23	500	39.51	100	3.26	700	5.87
MD2	10	0.06	300	21.15	50	0.91	100	0.45
	30	0.13	400	22.95	70	2.22	300	2.89
	60	0.21	500	29.28	100	3.35	700	5.25
MD3	10	0.06	300	24.67	50	1.04	100	0.28
	30	0.11	400	24.99	70	2.08	300	2.67
	60	0.19	500	30.11	100	2.76	700	4.59
MD4	10	0.05	300	22.31	50	0.68	100	0.31
	30	0.08	400	19.78	70	1.69	300	2.23
	60	0.14	500	21.13	100	2.41	700	4.67

W: weight of heavy metals in Vetiver shoot after 3 months experiment (mg/10kg soil)

Results showed that, although the ability to absorb heavy metals in soil by vetiver grass is not high (except Zn), but thanks to the high biomass should be the weight of heavy metal accumulation in vetiver shoot quite large compared to the other plants, including the "hyperacumulators". After 3 months of planting, Vetiver accumulated from 0.05 to 0.23mg Cd /10kg soil; from 19.78 to 39.51mg Zn /10kg soil; from 0.68 to 3.35mg Cu /10kg soil; from 0.28 to 5.87mg Pb /10kg soil, fold from 10 to 100 times that of the "hyperacumulators" such as: *Brassica juncea, Thlaspi caerulescens, Arabidopsis hallerii* [9]. This is the ideal characteristics of vetiver in the treatment of soil contaminated with heavy metals.

4. Conclusion

Through the research process we draw some following conclusions:

Vetiver grass can grow and develop in the sandy soil and clay with Cd concentrations from 10 to 60ppm (over QCVN for agricultural soils 50 to 30 times), Zn concentrations from 300 to 500ppm (over QCVN 1.5 to 4 times), Cu concentrations from 50 to 100ppm (over QCVN 1.4 to 2 times) and Pb concentrations from 100 to 700ppm (over QCVN 4.5 to 10 times).

Ability to absorb heavy metals by vetiver is very low, reflected in both BF and TF <1. In the four heavy metals tested, vetiver grass uptake and transport of Zn from root to shoot is the highest (BF: from 0.74 to 1.14; TF: from 0.56 to 0.89), whereas the ability of absorption and transport of Cu and Pb in medium and low (BF of Cu: from 0.2 to 0.47 and TF: from 0.24 to 0.86; BF and TF of Pb is from 0.04 to 0.13 and from 0.16 to 0.88), especially for Cd is very low (BF: from 0,04 to 12,09; TF: from 0.05 to 0.13).

Conversely, the ability to absorb and remove heavy metals from the soil by Vetiver

grass is very high. After 3 months of planting, Vetiver accumulated from 0.05 to 0.23mg Cd /10kg soil; from 19.78 to 39.51mg Zn /10kg soil and from 0.68 to 3.354mg Cu /10kg soil and from 0.28 to 5.87mg Pb /10kg soil. This result showed that after 3 months of planting grass on soil contaminateds, we carried out cutting grass for biomass handling, would eliminate a huge amount of heavy metals in soil. Different characteristics of Vetiver grass compared to hyper accumulators species such as the genus *Brassica, Thlaspi, Arabidopsis,...* is a good resistance to harsh environments and high biomass, thus effectively handle very large soil contaminateds.

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