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Screening a Number of Local Plants Capable Of Cadmium Remediation in Northern Tan Uyen, Binh Duong, Vietnam

Nguyen ThanhHung [1,2], Doan VanPhuoc [1], Nguyen ThanhKieu [1], Mai HuongTra [3](*)

(1) Thu Dau Mot University, (2) Dong Nai University, (3) Lac Hong University

Abstract

The study was conducted in two years in the north of Tan Uyen, Binh Duong Province, Vietnam to screen indigenous plant species capable of absorbing heavy metal Cd. The results showed that only 9 per 52 plant species studied were able to live in soil polluted with Cd concentration from 25 to 50mg/kg, among of which *Solanum nigrum* L. and *Physalis angulata* , BF more than 10, are proven to be a Cd super- accumulator.

Key words: Physalis angulata, Solanum nigrum L, remediation of contaminated soils, Cadmium.

1. INTRODUCTION

Nowaday, heavy metal pollution in soil is a real concern for most countries in the world. Organisms living in polluted soil with heavy metals will accumulate them in their body, which causes many serious diseases. Among those, Itai Itai causing bone deformation and death occurred in the early 1970s in Japan when people consumed rice containing Cd with the concentration of 0.5 to 1 mg/kg (Alloway B & et al. 1993).

Cadmium (Cd) is a metal that has great influence on human health. Cadmium is less absorbed in the soil and in the sediment, more mobile than other metals; therefore, it is easy to penetrate the human body through food. Once Cd infiltrates the body, it is accumulated in kidneys and bones, destroying the kidney function and causing bone deformation.

More than 400 hyperaccumulators have been detected so far but few specices has ability to accumulate Cd (Brooks, R. R., et al. 1977). Therefore, the identification of more efficient heavy metal hyper-accumulators is still an important step in the

phytoremediation application in practice to gradually replace traditional methods with high investment cost, less friendly environment.

Northern Tan Uyen District, Vietnam, has a strong development in mining industry with huge natural resources reserves. More than 50 soil samples in this area were collected, analysing heavy metal content such as Cd, Cu, Pb, Cr. Results showed that the Cd concentration exceeded the threshold in comparison with Vietnam standards. This leads to the fact that the specialized farming and the massive development of the mining industry contaminated soil with Cd, endangering organisms and people in this area.

Based on these facts, the subject "screening some native plants capable of absorbing Cd in soil in northern Tan Uyen, Binh Duong Province, Vietnam" was carried out. Initially, the scientific basis for further research to improve the application of plant technology to the treatment of heavy metal pollution

2. MATERIALS AND METHODS

2.1. Materials

Cd was added to the soil as $CdCl_2 * 2.5H_2O$

Soil was filtered through a sieve with a diameter of 4mm, supplemented with organic fertilizer, then the soil was poured into the pots (¢ = 45cm, H = 35cm) containing 0, 10, 25, 50mg / kg Cd / 10kg of soil and stabilized two weeks before planting.

Chemical and physical composition of soil before experiment as follows:

pH: 7.98 ± 0.2, OM: 10.2 ± 0.4, N (ts): 0.038 ± 0.2, P_2O_5: 0.0203 ± 0.6, K_2O: 0.034 ± 0.3.

HNO_3, $HClO_4$ 70%, HF, standard Cd solution 1000 mg/l.

Map of Bac Tan Uyen, Binh Duong province, Vietnam, digital camera, dark plastic bag, nylon cord, tape measure, scissors, pen, notebook, ...

2.2. Methods

2.2.1. Field study

a. Line survey

Line survey located in 10 communes of Northern Tan Uyen district is predicted of heavy metal hyper-accumulator (fast growth, large biomass, short life cycle, long root). Habitat types concluded broad-leaved forest, mixed forest and plantation and shrubs forests.

Each habitat in each area is arranged in 3 routes (3 lines x 10 communes x 3 habitats = 90 lines), each route is 3-5 km long, each side is 5m wide.

b. Point survey

By standard plotting method of 100 m^2 (10m x 10m). Each habitat type in each area was set up 2 plots (2 plots x 10 communes x 3 habitats = 60 plots).

* Information noted included:

Using GPS to confirm locations collecting samples. Survey results were recorded in the available form: line number, location, main forest type, elevation, slope, slope direction, date and name of investigator, number and life form of trees, etc.

To interview local people to identify what species are named locally through photos, specimens, information on where to find species, etc.

2.2.2. Planting experiments in membrane house

The experiment was conducted in two years from August 2016 to August 2018 at 88/5 Dang Duc Thuat street, Bien Hoa city, Dong Nai province. This area were in the tropical climate, rainy season lasted from August to December and dry seasons from January to July, temperature 25.6^oC and average humidity 82%.

After having collected, samples were inoculated then three seedlings of the same age, roots and leaves were grown in each pot. Two days once, the plants were watered (tap water not detected heavy metal Cd) to maintain 80% water- holding capacity of soil. All treatments were replicated three times as shown in Tables 1 and 2.

Table 1. Cd concentration in the study

No.	Species	Treatment	Cd concentration mg/kg/10kg soils/ 3 plants
1	A	CK1	0
		T1	10
		T2	25
		T3	50
2	B	CK2	0
		T4	10
		T5	25
		T6	50
n+1	n	CKn	0
		T....	10
		T....	25
		T....	50

Table 2. Layout of experiments

No.	Plant species	Layout of experiments				Number of repetitions
1	A	CK1	T2	T1	T3	1
		T2	T1	CK1	T3	2
		T1	T2	T3	CK1	3
2	B	T4	CK2	T5	T6	1
		T6	T4	CK2	T5	2
		CK2	T6	T5	T4	3
n+1	....	T...	T...	T...	CK...	1
		T...	CK...	T...	T...	2
		CK...	T...	T...	T...	3

2.2.3. Screening plants capable of absorbing Cd

Determination of the ability to accumulate Cd was conducted by using concentration gradient experiment and TF and BF were recorded via indicators such as height (cm), biomass (g), the ability to accumulate Cd in roots, shoots, leaves (mg/kg) under the influence of different Cd concentrations.

2.2.4. Result evaluation

Analysis of Cd content to calculate TF and BF: Soils and plants were treated with 87% HNO3 and 13% HClO4. Cd is determined using atomic absorption spectrophotometry (AA-400, PerkinElmer, USA). For quality control, standard materials (GBW-08.505 for plants and GBW-08303 for soil) are purchased from the Standard Materials Research Center, Beijing, China.

Statistical analysis: Data were expressed ± SD, statistical significance for differences between groups was assessed by ANOVA, LSD using the most significant difference $p < 0.05$. Pearson correlations were calculated to examine relationships with 95% confidence intervals, using Microsoft Excel, SPSS 16.0 and Sigma Plot 12.5 software.

3. RESULTS AND DISCUSSION

3.1. The composition of plants with external morphology of heavy metal hyper-accumulator collected in the north of Tan Uyen

After 2 years with 6 surveys, 52 species with the external morphology of heavy metal hyper-accumulator were collected, which belonged to 19 orders, 24 families, 40 genus. Results were shown in Table 3.

Table 3. A list of plants with external morphology of heavy metal hyper-accumulator collected in the north of Tan Uyen

Study site	Order name	Sample symbol	Family name	Genus name	Species name
Tan Binh	*Violales*	T1	*Passifloraceae*	*Passiflora*	*P. foetida* L.
	Cucurbitales	T2	*Cucurbitaceae*	*Momordica*	*M. charantia* L.
Tan Lap	*Malvales*	T3	Tiliaceae	*Corchorus*	*C. aestuans* L.
		T4	*Sterculiaceae*	*Melochia*	*M. corchorifolia* L.
		T5	*Malvaceae*	*Abelmoschus*	*A. moschatus* Medikus
		T6		*Sida*	*S. acuta* Burm.f.
		T7			*S. rhombifolia* L.
		T8		*Urena*	*U. lobata* L.
Tan Dinh	*Euphorbiales*	T9	*Euphorbiaceae*	*Acalypha*	*A. indica* L.
		T10		*Euphorbia*	*E. hirta* L.
		T11			*E. hypericifolia* L.
		T12		*Phyllanthus*	*P. amarus* Schum. & Thonn.
		T13			*P. debilis* Klein ex Willd.
Hieu Liem	*Myrtales*	T14	*Onagraceae*	*Ludwigia*	*L. adscendens* (L.) Hara
		T15			*L. hyssopifolia* (G. Don) Exell
		T16			*L. octavalvis* (Jacq.) Raven
Thuong Tan	*Scrophulariales*	T17	*Solanaceae*	*Lycopersicum*	*L. esculantum* (L.) Mill.
		T18		*Capsicum*	*C. frutescens* L.
	Pteridales	T19	Pteridaceae	Pteris	*Pteris vittata L.*
		T20	*Acanthaceae*	*Ruellia*	*R. tuberosa* L.
	Solanales	T21	Solanaceae	*Solanum*	*Solanum nigrum L.*
		T22		*Physalis*	*Physalis angulata*
Tan Thanh	*Magnoliales*	T23	*Annonaceae*	*Annona*	*A.glabra* L**.**
	Piperales	T24	*Piperaceae*	*Piper*	*P. lolot* C. DC.
	Caryophyllales	T25	Portulacaceae	*Portulaca*	*P. oleracea* L.
		T26	*Amaranthaceae*	*Alternanthera*	*A. sessilis* (L.) A. DC.
		T27		*Amaranthus*	*A. spinosus* L.
		T28			*A. viridis* L.

Study site	Order name	Sample symbol	Family name	Genus name	Species name
		T29		*Gomphrena*	*G. celosioides* Mart.
Binh My	*Capparales*	T30	*Capparaceae*	*Cleome*	*C. chelidonii* L.f.
		T31			*C. viscosa* L.
	Ebenales	T32	*Sapotaceae*	*Mimusops*	*M. elengi* L.
Lac An	*Fabales*	T33	*Fabaceae*	*Canavalia*	*C. lineata* (Thunb.) DC.
		T34			
		T35		*Mimosa*	*M. pigra* L.
		T36			*M. pudica* L.
		T37		*Vigna*	*V. luteola* (Jacq.) Benth.
Dat Cuoc	*Rhamnales*	T38	Vitaceae	*Cayratia*	*C. trifolia* (L.) Domin
	Gentinales	T39	Rubiaceae	*Paederia*	*P. lanuginosa* Wall.
	Polemoniales	T40	Convolvulaceae	*Ipomoea*	*I. alba* L.
		T41			*I. aquatica* Forssk.
		T42			*H. triloba* L.
		T43	Boraginaceae	*Heliotropium*	*H. indicum* L.
	Brassicales	T44	Brassicaceae	*Brassica*	*Brassica juncea (L.) Czern*
		T45			*Brassica sinensis L.*
Tan My	*Asterales*	T46	Asteraceae	*Conoclinium*	*Conoclinium* sp.
		T47		*Eclipta*	*E. prostata* (L.) L.
		T48		*Eleutheranthera*	*E. ruderalis* (Swartz) Schultz Bipontinus
		T49		*Struchium*	*S. sparganophorum* (L.) Kuntze
		T50		*Synedrella*	*S. nodiflora* (L.) Gaertn.
		T51		*Vernonia*	*V.cinerea*(L.) Less.
		T52		*Wedelia*	*W. trilobata* (L.) Hitch.

The composition of the flora was unevenly distributed such as in mining areas, there are only savans; samples were mostly distributed around residential areas. Consequently, species composition as well as number of individuals were poor.

3.2. Screening and identification of plants capable of absorbing Cd in northern Tan Uyen

In order to screen plants capable of absorbing Cd in the north of Tan Uyen , growth characteristics of each species after 3 months of planting were identified such as dead, live, heigh, biomass, root length, etc. Results showed that only 9 per 52 species planted in soil contaminated with Cd concentration 10, 25, 50 mg/kg were alive (Table 4).

Table 4. Plants capable of accumulating Cd in the north of Tan Uyen

No	Scientific name	Sample symbol	Ability to live in soil polluted with Cd (mg/kg)	Fresh biomass (g/pot)	Cd concentrations in plants (mg/kg dry biomass)	BF
1	*Brassica juncea (L.) Czern*	T44	25	5.2	213.4±1.32	8.52
2	*Brassica sinensis L.*	T45	25	6.2	221.4±2.13	8.84
3	*A. sessilis* (L.) A. DC.	T26	25	6.5	214.1±2.92	8.56
4	*A. spinosus* L.	T27	25	6.3	201.1±1.53	8.04
5	*A. viridis* L.	T28	25	6.2	211.6±2.11	8.44
6	*G. celosioides* Mart.	T29	25	5.1	208.1±1.87	8.32
7	*Solanum nigrum L.*	T21	50	4.6	524.3±3.61	10.4
8	*Physalis angulata*	T22	50	4.1	512.2±3.19	10.2
9	*Pteris vittata L.*	T19	25	6.5	215.1±2.15	8.60

In the list of plant species capable of accumulating heavy metals in the study area, we found that there was a great deal of overlap with published species in the world such as species of the family Amaranthaceae, Asteraceae, Brassicaceae.

Many families in the study area have many species, but few of them were able to accumulate heavy metals such as the family: Euphorbiaceae, Mimosaceae, Sterculiaceae, Urticaceae, Vitaceae, Smilacaceae. This is due to the fact that samples of all their species have not been collected full for screening. Therefore, it is not possible to accurately assess the species of these families that have the capacity to accumulate heavy metals.

3.3. Compared with species capable of Cd hyper-accumulators in the world

According to published data, there are 420 plants capable of heavy metal hyper accumulator in the world. In the process of screening, studying and comparing with the list of Vietnamese plants as well as combined with those of Institute of Ecology and Biological Resources, Institute of Environmental Technology, 9 species were able to accumulate Cd accumulation in the study area.

Of 9 species that survived in Cd-contaminated soil from 25-50 mg/kg (Table 4), we found that T21 and T22 samples were alive and grew in soil contaminated with Cd up to 50 mg/kg and BF was more ten. According to Baker, A. J. M, (1994); Ma, L. Q, (2011). if BF was more 10, that species was classified as "hyper-accumulator". Thus, two species *Solanum nigrum* L. and *Physalis angulata* screened were Cd hyper-accumulators.

4. CONCLUSION

In 10 communes of Northern Tan Uyen, there are 9 species of plants capable of absorbing Cd, and 2 species *Solanum nigrum* L. and *Physalis angulata* were Cd hyper-accumulators.

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