Pb, Cd, Zn Absorbing Capability Of the Lau Plant (Saccharum arundinaceum) to Treat Heavy Metal Contaminated Soil After Mining at Thai Nguyen Province, Vietnam

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Abstract - This study focuses on the Lau plant's (Saccharum arundinaceum) ability to absorb heavy metals Pb, Cd, Zn to treat contaminated soil after mining. It can be observed that: the quality of soil environment in mineral mining areas has improved significantly compared with the situation before planting Lau plant. In Ha Thuong and Trai Cau mining sites, the pre-treatment soil is acidic (pH = 4.05, pH = 6.12); meanwhile, Hich village soil is alkaline with pH = 8.38 and contaminated with heavy metals. The concentration of heavy metals in the soil exceeds Vietnamese standards 05:2015. After eight months of studying: the plant height, leaf length, and root length showed the ability of Lau plants to grow and normally thrive after planting. The ability to absorb heavy metals in leaves and roots: the heavy metals accumulated in the leaves and roots were many times higher than the initial concentration of heavy metals in the Lau plants when it first planted. After the Lau plantation, the concentration of heavy metals has decreased significantly: Pb content decreased from 1.23 to 1.94 times. Cd content decreased from 1.24 to 1.9 times. The Zn content decreased from 1.23 to 1.73 times than the original content.

Keywords: contaminated soil, heavy metal, mineral mining, Saccharum arundinaceum, Thai Nguyen

I. INTRODUCTION

Nowadays, environmental pollution is one of the global problems [1, 2], as socio-economic development generates waste, affecting the ecological environment and public health. Heavy metal pollution is one of the most severe environmental problems [3]. Soil contamination by heavy metals causes adverse and long-term effects on humans. Aiming at sustainable development, an ecological approach to solving this kind of contamination is inevitable. Fortunately, it is feasible to treat and stabilize toxic metals in soil using flora [4]. Technologies to absorb heavy metals are common in developed countries such as European countries and America [5]. Recently, using plants to absorb and stabilize heavy metals is an environmentally friendly solution and has shown high efficiency [6, 7]. Plants such as *Euphorbia cheiradenia*, *Scariola orientals, Centaurea virgata, Gundelia tournefort*ii, and *Eleagnum angustifolia* have been used to investigate the ability to process metals such as Pb, Zn, Cu, Ni, and Cd [8]. Research and application of heavy metal treatment flora in the soil in Vietnam also emerged recently. Common plants used to survey and treat heavy metal pollution are vetiver, fern, candle grass, etc. [9-12]. Vietnam has a humid tropical climate and high biodiversity, thus having great potential for developing green technology in solving the problem of environmental protection. Meanwhile, Lau is a native plant in Thai Nguyen province, living on different soil types. It is a flexible, adaptable, durable plant with high biomass, making it the ideal candidate for this purpose.

II. RESEARCH GOALS AND METHODS

A. *Research goals*

- Evaluation of the accumulation of heavy metals Pb, Cd, Zn in soils at Trai Cau iron mine, Hich village lead-zinc mine, and Ha Thuong tin mine, Thai Nguyen province.

- Evaluation of the growth of Lau plant on contaminated soil with heavy metals Pb, Cd, Zn.

- Study the ability to absorb and process heavy metals Pb, Cd, Zn of Lau plant.

B. *Research Methods*

1) *The document collection method*

Documents and data related to heavy metal pollution are collected, selected, and processed before being included in this article. The existing domestic and foreign research results and own results from previous topics are included.

2) *Methods of investigation to take soil and plant samples*

The investigation procedure includes performing surveys, taking samples, analyzing and assessing soil quality before and after planting Lau plants in mineral mining areas of Thai Nguyen province. Soil samples were taken at the surface layer from 0 - 20cm on the land area. Soil samples are put in separate bags, marked on the outside of the package.

The sampled Lau plants were taken from each experimental plot with three replication. Plant samples were placed in separate bags and marked with the corresponding soil samples.

3) *Design of experiments method*

The purpose of this experiment is to evaluate the ability of the Lau plant to grow, develop and improve the contaminated soil with heavy metals in the field conditions.

Once the Lau plant is retrieved, it will be analyzed for the original metal composition available in the plant's roots, stems, and leaves. Then select healthy, clean plants for experimental planting.

Lau is planted at a density of 10 branches/pot.

The experimental period lasted eight months (from March 2020 to November 2020). Once a month, measure plant height and leaf length. After 4 and 8 months, plant and soil samples were taken to analyze the heavy metal content and measure the root length.

* The experimental design was completely randomized with four experiments (T); each experiment was one recipe and had three replication (R) planted in pots; each replicate was a pot.

T means the experiment

R means the repetition of an experiment.

For example: the code T1R2 means the second repetition of the first experiment.

The experimental layout is as follows:

Trai Cau	T1R1	Ha Thuong	T2R1
	T1R2		T2R2
	T1R3		T2R3
Hich village	T3R1	Control sample	T4R1
	T3R2		T4R2
	T3R3		T4R3

4) *Laboratory analytical methods*

The specific methods are as follows:

- pH (KCl) was extracted with 1N KCl, measured with a pH meter

- Determination of heavy metal content (Cd, Pb, Zn) in soil and Lau plant by atomic absorption spectroscopy (AAS) method.

These methods provide high accuracy and are commoly used today in soil analysis laboratories in Vietnam.

5) *Data analysis methods*

The analyzed data is summarized into an Excel spreadsheet to draw charts, evaluate and draw conclusions. The concentrations of heavy metals: Pb, Cd, Zn in the soil before and after planting Lau are compared with Vietnamese standard 05:2015/BTMT for agricultural land, thus assessing different pollution levels of the sampled areas.

C. *Monitoring indicators*

- Indicators on the growth and development of experimental plants:

+ Plant height: once per month, measured from the plant base to the tallest leaf (5 plants / 1 replicate experiment). The plant height in each treatment is the average of every replication.

+ Leaf length: once per month, calculated from the leaf sheath edge to the beak. The leaf length in each treatment is the average of the formula repetitions.

- Indicators on soil environment: heavy metals (Pb, Cd, Zn) were monitored before and after the experiment.

- Indicators on the growth and development of Lau: height, root length.

- The ability to accumulate heavy metals of Lau is evaluated by analyzing heavy metals indicators in roots, stems, and leaves.

III. RESULTS

A. *Evaluation of heavy metal pollution level in the studied areas*

Before planting Lau, the pH criteria and the concentration of heavy metals are analyzed to assess the quality of soil samples and calculate the heavy metals available in the soil. By performing this step, we can accurately determine the ability of Lau to grow and absorb heavy metals. The results of the soil analysis are shown in the following table:

TABLE I. SOIL ENVIRONMENTAL FACTORS IN THE STUDIED AREAS BEFORE PLANTING

Location	Sample sign	Interested parameter			
		pH_{KCl}	*Total Pb (mg/kg)*	*Total Cd (mg/kg)*	*Total Zn (mg/kg)*
Control sample	MĐ1	7.04	8	0.21	10
Ha Thuong	MĐ2	4.05	1119	17.7	2419
Trai Cau	MĐ3	6.12	1108	13.4	1712
Hich village	MĐ4	8.38	1591	24.8	2385
QCVN 05:2015/ BTMT		-	70	1.5	200

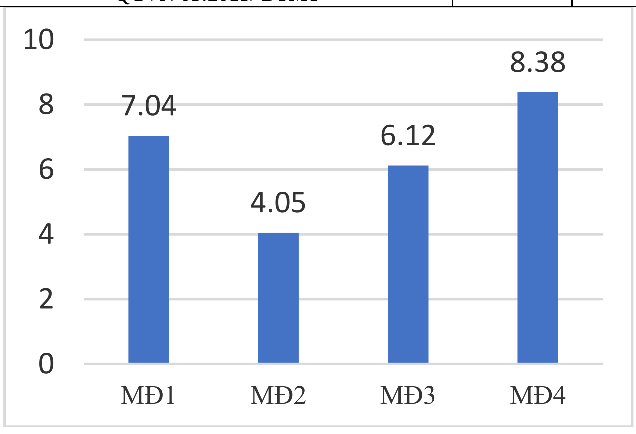

Figure 1.a. pH in the soil

Table 1 and Figure 1.a indicated that the pH in the soil samples varies depending on each type of soil. The lowest pH sample is MĐ2 Ha Thuong (pH= 4.05), the highest one is the soil sample of MĐ4 of Hich village (pH=8.38). Mining activities affect the pH in the mining area significantly and are detrimental to the growth and development of organisms, thus having an effect on soil properties.

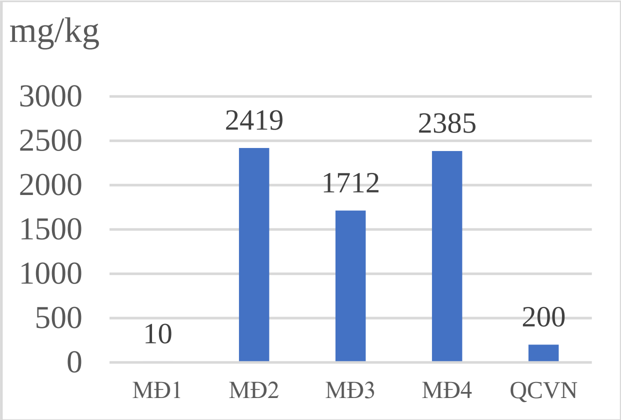

Figure 1.b. The content of Zn

Table 1 and Figure 1.b show that the Zn content in the control soil is 10 mg/kg, within the limit of QCVN 05:2015/BTMT. All soil samples after mining have Zn content exceeding Vietnamese standards. In which, Ha Thuong sample is 2419 mg/kg, 12.01 times higher; Trai Cau sample contains Zn content (1712 mg/kg), 8.56 times higher; The soil sample of Hich village contained 2385 mg/kg, 11.9 times higher than the Vietnamese standard. The soil environment in the post-mining areas is seriously contaminated with Zn.

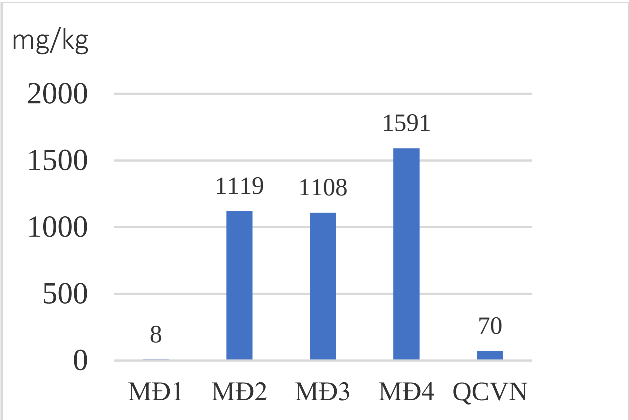

Figure 1.c. The content of Pb

Through Table 1 and Figure 1.c, we see that the Pb content in control sample MĐ1 (8 mg/kg) is below the Vietnamese standard (70 mg/kg); Pb content in soil is very rich in samples from Ha Thuong, Trai Cau, Hich village; Ha Thuong soil sample exceeded 16 times, Trai Cau sample 15.83 times, Hich village sample exceeded Vietnamese standards 22.73 times.

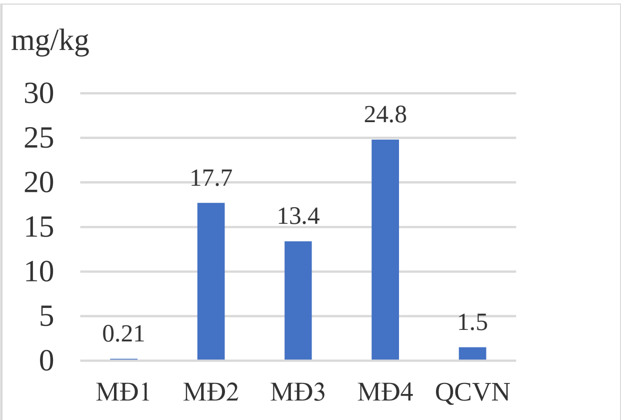

Figure 1.d. The content of Cd

Through Table 1 and Figure 1.d, we see that the Cd content in control sample MĐ1 is within the allowable limit of Vietnamese standard 03:2008/BTMT for agricultural land; soil samples of Ha Thuong (MĐ2), Trai Cau (MĐ2), Lang Hich (MĐ3) exceed Vietnamese standards. The sample with the highest Cd content was from Hich village, with 24.82mg/kg, 12.41 times higher than the standard; Ha Thuong sample has a Cd content of 17.7 mg/kg, 8.85 times higher, Trai Cau has a Cd content of 13.4 mg/kg, 6.7 times higher than Vietnamese standards.

B. Evaluation of the growth and development ability of Lau plant on soil after mineral exploitation at Ha Thuong tin mine, Trai Cau iron mine and Hich village lead-zinc mine

The value of plant height, leaf length after eight months of measuring root length is depicted in Table 2.

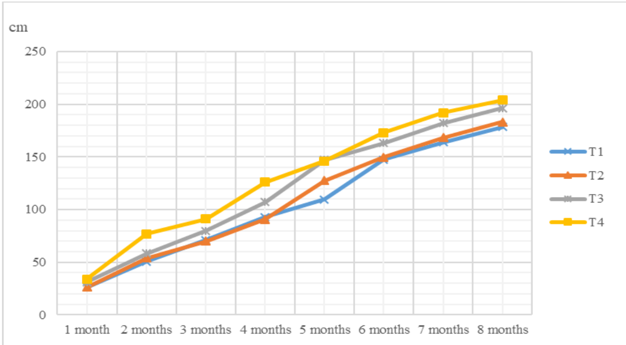

Figure 2.a. Variation in height of the Lau plant after 8 months of planting

Based on figure 2.a, we can see that the Lau plants grow quite fast and well. After 8 months, in experiment T4- control sample, Lau plants grew best (204 cm), then in T3- Hich village (196.33 cm), Lau plants grew better in neutral and alkaline soils than on acidic soil.

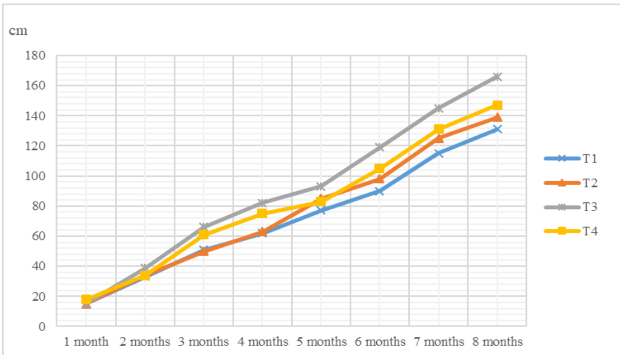

Figure 2.b. Variation in leaf length of the Lau plant after 8 months of planting

Through figure 2.b. Lau leaves grow fast, quite uniformly, and there is no big difference between the treatments. The longest growing leaves are in T3 (166 cm) and T4 (147 cm). From that, it can be seen that Lau is an easy plant to grow, suitable for many different types of soil, but grows best in neutral soil.

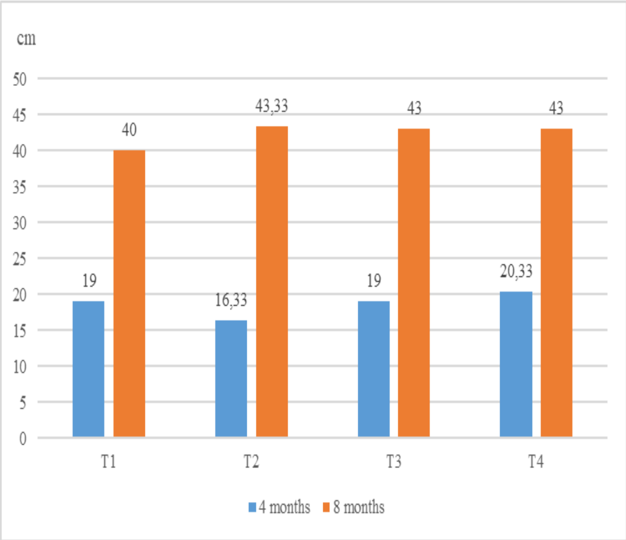

Figure 2. c. The variation in the direction of the roots of the Lau plant after 8 months of planting

Through figure 2.c we can see that, after four months, the root system of Lau plant in the treatments is about 20 cm long, after eight months it is about 40 cm long, the roots develop normally, the difference in size is not large, from which we see that the reed has enduring vitality, can grow on many types of soils, even soils containing high metal content.

The results of the Anova analysis showed that there was no significant difference for the root length in all experimental treatments with the significance level α = 0.05. This shows that there is no sign of affecting the root growth of the Lau plant.

TABLE II. LAU'S ABILITY TO GROW AND DEVELOP DURING THE RESEARCH PERIOD

Unit: cm

Time / Formula	Ban đầu	1 month	2 months	3 months	4 months	5 months	6 months	7 months	8 months
	Variation in Lau leaves height during the study period								
T1	20	26.33±1.25b	50.6±2.05d	71±6.48bc	93±2.94c	109.66±4.99c	147.66±7.04b	164±10.03c	178.33±8.18b
T2	20	26.33±1.7b	54±1.63c	70±4.08c	90.66±4.64c	127.33±6.34b	149.66±6.79b	168.33±7.36bc	183.33±4.98b
T3	20	31±5.89a	58.33±1.25b	80±7.07b	107±10.11b	147±9.09a	163.33±6.94a	182±7.34ab	196.33±5.73a
T4	20	34±1.63a	77±2.16a	91±5.09a	126±7.79a	146±7.11a	173±3.74a	192±2.16a	204±5.88a
LSD_{005}		3.3294	2.8022	9.353	8.8827	11.137	11.195	14.009	10.198
	Variation in Lau leaves length during the study period								
T1	5	15 ± 0.816b	33 ± 1.63b	51±6.48c	62±6.48c	77±6.16c	90±5.72c	115±4.32c	131±3.26d
T2	5	15±1.25b	34 ± 1.63b	50±4.08c	63±2.16c	85±2.16b	98±1.63bc	125±3.74b	139±2.94c
T3	5	15±1.63b	39 ± 2.45b	66±2.94a	82±4.32a	93±3.56a	119±5.35a	145±8.83a	166±3.26a
T4	5	18±1.63a	34±4.32a	61±2.45b	75±2.16b	83±2.16bc	105±6.48b	131±2.45b	147±2.16b
LSD_{005}		0.4173	4.1961	4.9854	3.9941	6.5122	9.0721	8.3144	4.2364
	Length of Lau roots on soil after mineral extraction								
T1					19±1.63b				40±0.82b
T2					16.33±1.25a				43.33±2.05a
T3					19±1.63a				43±1.63a
T4					20.33±2.05a				43±1.41a
LSD_{005}					2.4708				2.9017

C. Absorbing capacity of heavy metals in the stems, leaves, and roots of Lau plants in the studied areas

Accumulation of heavy metals in plants is a special ability of certain plant species. To evaluate the amount of heavy metal absorption in the contaminated soil after mineral extraction of the Lau tree, the plant samples for analysis were grown on the soil collected at the dumping sites of three mines: Trai Cau iron mine, Hich village lead-zinc mine, Ha Thuong tin mine, and a control sample, with each soil type being a formula and repeated three times.

The analysis results of accumulated heavy metals in stems, leaves, and roots of Lau are shown as follows:

TABLE III. CONCENTRATIONS OF HEAVY METALS ACCUMULATED IN STEMS, LEAVES AND ROOTS OF LAU PLANT

Unit: mg/kg

Formula	Content of Cd		Content of Pb		Content of Zn	
	Stems, leaves	*Roots*	*Stems, leaves*	*Roots*	*Stems, leaves*	*Roots*
Control	0.01	0.02	1.2	3.2	8	13
After 4 months						
T1	0.01±0.005c	0.03±0.0009c	3.17±0.081b	4.25±0.012b	12.23±0.111b	15.89±0.213b
T2	0.03±0.005b	0.05±0.004b	1.26±0.03c	2.17±0.11d	11.35±0.16c	15.07±0.043c
T3	0.05±0.005a	0.08±0.005a	10.75±0.137a	15.42±0.238a	30.3±0.19a	50.39±0.27a
T4	0.01±0.0008c	0.02±0.0005d	1.26±0.041c	3.3±0.187c	8.03±0.01d	12.57±0.59d
	0.0093	0.0061	0.1573	0.3034	0.2563	0.6442

After 8 months						
T1	0.03±0.0042c	0.04±0.005bc	6.89±0.093b	8.9±0.238b	35.21±0.196b	41.73±0.224b
T2	0.04±0.002b	0.06±0.002b	2.03±0.017d	3.05±0.04d	21.8±0.196c	29.87±0.127c
T3	0.09±0.005a	0.25±0.024a	29.06±0.054a	41.86±0.112a	79.87±0.25a	111.44±0.42a
T4	0.014±0.002d	0.02±0.0005c	3.29±0.016c	5.4±0.127c	8.18±0.052d	13.39±0.11d
LSD_{005}	0.0067	0.0232	0.1036	0.2775	0.3548	0.4752

D. Accumulation of Cd in Lau plants at Trai Cau iron mine, Ha Thuong tin mine and Hich village lead-zinc mine

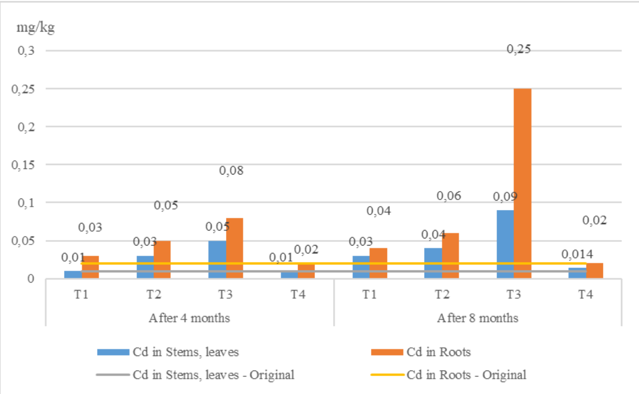

Figure 3. Accumulated Cd content in Lau plants after 8 months of planting

Table 3 and Figure 3 show that: Cd content in the initial plants was lower than the accumulated Cd concentration in the plants after planting on the experimental soil.

After 4 months of planting, the Cd content accumulated in the stems and leaves ranged from 0.01mg/kg to 0.05mg/kg, the accumulated Cd content in the roots ranged from 0.02mg/ kg to 0.08 mg/kg. The concentration of Cd accumulated in leaves and roots was highest in T3 in Hich village. The absorption of Cd in the Lau's roots is 1.6 to 3.0 times higher than in the leaves.

After eight months of planting, the Cd content accumulated in the stems and leaves ranged from 0.014 mg/kg to 0.09 mg/kg, the accumulated Cd content in the roots ranged from 0.02 mg/kg to 0.25 mg/kg. In which, the highest concentration of Cd accumulated in leaves and roots was in T3 in Hich village (0.09 mg/kg in stems, leaves and 0.25 mg/kg in roots); Cd content in T4 control sample in stem + leaf was 0.014 mg/kg, in root was 0.02 mg/kg. The absorption of Cd in the Lau's roots is about 1.3 to 2.77 times higher than in the leaves. Thus, compared with the original, after eight months of planting, the ability to accumulate Cd in Lau plant changed as follows: Accumulated Cd concentration in Lau plant in T3 in Hich village was the highest, Cd in stems, leaves increased 1.8 times; Cd in the roots increased 3.13 times compared to the original; Cd content absorbed in stems, leaves were the lowest in T4 control sample, almost unchanged; in T2 Ha Thuong, Cd in stems and leaves increased by 1.33 times, Cd in root increased by 1.2 times compared to the original; In T1 Trai Cau, Cd in stems and leaves risen by three times, Cd in root increased by 1.3 times compared to the original. The data in the table shows that: the Lau plant is capable of accumulating Pb, Cd, Zn in both stems, leaves, and roots. According to the results of ANOVA analysis, the accumulated concentrations of Pb, Cd, and Zn in the stems, leaves, and roots of Lau in different treatments had differences at the 95% confidence level.

1) Possibility of Pb accumulation in Lau plants at Trai Cau iron mine, Ha Thuong tin mine and Hich village lead-zinc mine

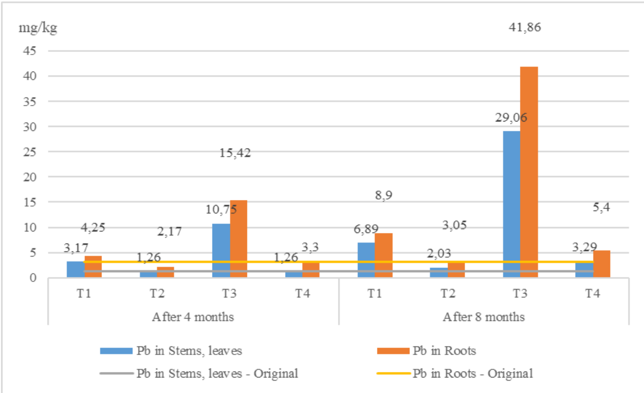

Figure 4. Accumulated Pb content in Lau after 8 months of planting

Through Table 3 and Figure 4, we can observe that: The Pb concentration in the initial plants accumulated in the stems, leaves, and roots was lower than that of Pb accumulated in the plants after planting. The content of Pb elements absorbed in the planting sites is different. After four months of planting, Pb content was accumulated in specific plants: Pb content in stems and leaves ranged from 1.26 mg/kg to 10.75 mg/kg, accumulated in roots from 3.4 mg/kg to 41.86mg/kg, the highest in T3 of Hich village and lowest in T4 control sample. In the experimental areas, the Pb content absorbed in the roots of Lau was 1.3 to 2.63 times higher than in the stems and leaves.

2) The ability to accumulate Zn in Lau trees at Trai Cau iron mine, Ha Thuong tin mine and Hich village lead-zinc mine

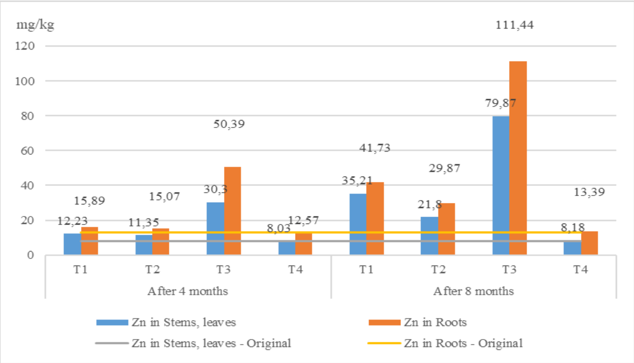

Figure 5. Accumulated Zn content in Lau after 8 months of planting

Table 3 and Figure 5 show that the accumulated Zn content in the plants after planting is higher than the initial plants.After four months of planting, Zn content is accumulated in specific plants:

- Experiment T1 Trai Cau: Zn content in leaves and stems was 12.23 mg/kg. accumulation in roots was 15.89 mg/kg. The Zn content in the roots of Lau s absorbed 1.3 times more than in the leaves.

- Experiment T2 Ha Thuong: Zn content in leaves and stems was 11.35 mg/kg. accumulation in root was 15.07 mg/kg. The Zn content in the roots of Lau was absorbed 1.33 times more than in the leaves.

- Experiment T3 Hich village: Zn content in leaves and stems was 30.3/kg. accumulation in roots was 50.39 mg/kg. The Zn content in the roots of Lau was absorbed 1.66 times more than in the leaves.

- T4 control sample: The Zn content in the leaves and stems was 8.03 mg/kg. and the accumulation in the roots was 12.57 mg/kg. The Zn content in the roots of Lau was absorbed 1.6 times more than in the leaves.

After eight months of planting Lau. the accumulated Zn content in the plant was very high:

- Experiment T1 Trai Cau: Zn content in leaves and stems was 35.21 mg/kg. accumulation in roots was 41.73 mg/kg. The Zn content in the roots of Lau is absorbed 1.2 times more than in the leaves.

- Experiment T2 Ha Thuong: Zn content in leaves and stems was 21.8 mg/kg. accumulation in roots was 29.87 mg/kg. The Zn content in reed roots was 1.37 times more absorbed than in the leaves.

- Experiment T3 Hich village: Zn content in leaves and stems was 79.87 mg/kg. accumulated in root was 111.44 mg/kg. The Zn content in the roots of Lau is absorbed 1.4 times more than in the leaves.

- T4 control sample: Zn content in leaves and stems was 8.18 mg/kg. accumulated in root was 13.39 mg/kg. The Zn content in the roots of Lau is absorbed 1.63 times more than in the leaves.

Through analysis results in samples of Lau grown on soil taken from Trai Cau iron mine, Ha Thuong tin mine, and Hich village lead-zinc mine, the concentration of heavy metals accumulated in the stems, leaves and roots were many times higher compared with the original heavy metal content in the Lau when brought back for planting. The above results also indicated that the concentration of Cd, Pb, Zn accumulated in the roots was higher than that of heavy metals accumulated in the stems and leaves. Therefore, Lau is a plant species with a high ability to accumulate heavy metals in stems, leaves, and roots.

E. Evaluation of the ability to handle heavy metal content in soils after planting Lau

The results of the analysis of heavy metals in the initial soils sample and the concentration of heavy metals accumulated in the soils after four and eight months of the study are shown in the following table:

TABLE IV. THE CONCENTRATION OF HEAVY METALS REMAINING IN THE STUDY SOIL AFTER PLANTING LAU

Time	Location	Sample sign	Heavy metal content (mg/kg)		
			Cd	*Pb*	*Zn*
Initial soils	Trai Cau	T 1	13.4	1108	1712
	Ha Thuong	T 2	17.7	1119	2419
	Hich village	T 3	24.8	1591	2385
	Control sample	T 4	0.21	8	10
After 4 months	Trai Cau	T 1	10.2 ± 0.081c	981 ± 46.43b	1238 ± 2.054c
	Ha Thuong	T 2	14.2 ± 0.081b	994±2.94b	1981 ± 4.54a
	Hich village	T 3	20±0.163a	1205±6.13a	1886±5.56b
	Control sample	T 4	0.17±0.012d	7.2±0.26c	9.03±0.33d
	LSD$_{0,05}$		0.1879	44.177	7.0357
After 8 months	Trai Cau	T 1	7.07±0.25c	715±2.94c	987±4.54c
	Ha Thuong	T 2	11.5±0.29b	777±2.16b	1572±2.94a
	Hich village	T 3	15.5±0.16a	820±3.74a	1410±4.9b
	Control sample	T 4	0.13±0.016d	6.5±2.44d	8.1±0.077d
	LSD$_{0,05}$		0.391	5.4285	6.8712
QCVN 03:2008/BTMT			2	70	200

The processing performance is shown in the following table:

Table 4 shows that the content of Pb, Cd, Zn in the soil tends to decrease sharply after planting Lau. After eight months of planting Lau, the highest treatment efficiency was 48.46% in Pb treatment in Hich village; the lowest was in Pb treatment efficiency in the control experiment of 18.75%. The treatment efficiency depends on the concentration of heavy metals in the soils. Therefore, it can be said that Lau is a suitable plant to improve soil contaminated with heavy metals, capable of handling Pb, Cd, and Zn in the soil.

From the soil environment at the waste dump of Ha Thuong tin mine and Trai Cau iron mine, Hich village's lead-zinc mine, it can be seen that the heavy metal content was significantly reduced after planting reed. Especially in the control sample, the heavy metal content was almost unchanged. This can be explained as follows: The soils in the studied areas are contaminated with heavy metals. The total heavy metal content in the soil is high due to tin, lead-zinc, and iron ore mining operations. After planting Lau in contaminated soil locations, monitoring over time and analyzing soil samples showed that the total heavy metal content in the soil has decreased many times. In the control sample, because the heavy metal content in the soil was not high (under Vietnamese standard QCVN 05:2015), when growing Lau, the heavy metal content in the soil did not change significantly. This result shows that Lau is a very suitable plant for the remediation and improvement of heavy metal contaminated soil.

F. Evaluation of the ability to improve soil pH of the Lau plant

The results of pH analysis in the initial soil samples and after eight months of study are shown in the table 5.

TABLE V. PH IN THE STUDIED SOIL SAMPLES

Time	Location	Sample sign	pH
Initial soils	Trai Cau	T1	6.12
	Ha Thuong	T2	4.05
	Hich village	T3	8.38
	Control sample	T4	7.04
After 8 months	Trai Cau	T1	7.01±0.20
	Ha Thuong	T2	5.02±0.15
	Hich village	T3	7.6±0.22
	Control sample	T4	7.03±0.10

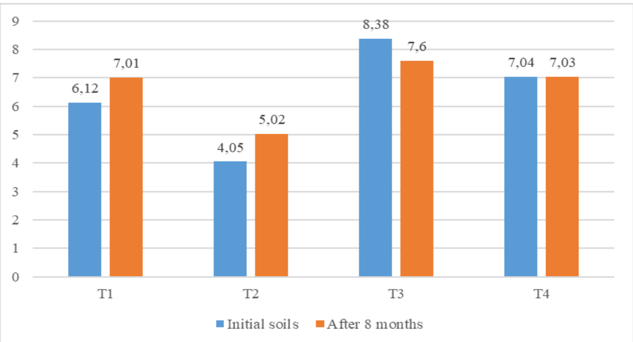

Figure 6. Changes of pH in the studied soil samples

Based on Table 5 and Figure 6, soil pH tends to be neutral after planting Lau. Specifically, soil sample T1-Trai Cau pH increased from 6.12 to 7.01; T2- Ha Thuong from 4.05 to 5.02; T3- Hich village from 8.38 to 7.6; The T4 control sample did not change the pH significantly and remained neutral at 7.03. From there. we observe that the Lau plant can improve soil properties.

IV. CONCLUSIONS

Studying on the ability to absorb heavy metals Pb, Cd, Zn of Lau plants to treat heavy metal contaminated soil after mining, we can observe the quality of soil environment in mineral mining areas before planting Lau plants: In Ha Thuong and Trai Cau, the soil is acidic (pH = 4.05, pH = 6.12), the soil in Hich village is alkaline soil with pH = 8.38 and contaminated with heavy metals, the concentration of heavy metals in the soil exceeds Vietnamese standard QCVN 05:2015 allows many times. The growth and development ability of Lau plants, the results of monitoring after eight months of studying plant height, leaf length, and root length showed the ability of Lau to grow and develop normally after planting. Lau's ability to absorb heavy metals in stems, leaves, and roots: After 8 months of the experiment, the concentration of heavy metals accumulated in the stem, leaves, and roots was many times higher than the initial heavy metal content in LAU plants when brought for planting. After eight months of planting Lau plants to improve soil, heavy metal content decreased significantly: Pb content decreased from 1.23 to 1.94 times compared to the original. Cd content decreased from 1.24 to 1.9 times compared to the original content. The Zn content decreased from 1.23 to 1.73 times compared with the original content.

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