

Accumulation and Distribution of Heavy Metals in *Imperata cylindrica* at Lead-zinc Mining Area

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Abstract. Aiming at the present serious situation of heavy metals contaminated soil in lead-zinc mining area of Huize County. This paper analyzed the the Pb, Zn, Cu and Cd enrichment characteristics of *Imperata cylindrica* growing in the different distance from the abandoned smelter. Results showed that the content of heavy metals in soils showed a tendency to decrease with increasing distance from the abandoned smelter, and the content of heavy metals in the soil 50m away from the abandoned smelter was the highest. There was a significant positive correlation between the contents of Pb, Zn, Cu and Cd in *Imperata cylindrica* and soil around the abandoned smelter. Four heavy metals of *Imperata cylindrica* showed that the content of the underground part was higher than that of the aboveground part. These Results showed that *Imperata cylindrica* could absorb and enrich a variety of heavy metals and had the characteristics of heavy metal resistance. Based on the characteristics of large biomass and fast growth rate, *Imperata cylindrica* has a good application prospect as a heavy metal pollution restoration plant.

1. Introduction

Mining is a production base for raw materials and energy. Because the distribution of mineral resources were zonal, and most of them were buried deep underground, these mining location also had fixed location, therefore, mining development had inevitably lead to land occupation and environmental damage, and the emissions of toxic mining waste in the mining process, produced a large number of abandoned land, formed the severe and enduring sources of pollution^[1-3]. Lead-zinc mine areas contain a large amount of heavy metals such as lead, zinc and cadmium, often lead to serious soil pollution, and thus need to seek a good repair lead-zinc mine and disposal methods of heavy metal pollution.

At present, scholars had focused their research on the environmentally friendly and low-cost technology, namely phytoremediation. The basis of phytoremediation is the screening of plants with heavy metal tolerance and super-rich ability^[4-6]. Heavy metal-tolerant plants refer to a special kind of plants that have certain special physiological mechanisms and can normally grow, settle, and even reproduce in heavy metal-contaminated soils and can resist the stress of heavy metals^[7].

Generally speaking, the naturally settled plants in abandoned areas of mines are mostly resistant plants^[8-9]. Therefore, the study of natural growth plants on abandoned mine sites is one of the



effective ways to find plants suitable for the characteristics of abandoned habitats.

The aim of this study therefore is to assess the tolerance and enrichment characteristics of heavy metals in *Imperata cylindrica*, a dominant herb that naturally grows in the lead-zinc mine areas of Huize County in Yunnan province. The research results can provide references for the treatment of heavy metal pollution and vegetation restoration in the mining area.

2. Experimental materials and methods

2.1. Study area

Huize County is located in the northeast of Yunnan Province, and is located at the junction of the Eastern Guizhou Plateau and the Western Yunnan Plateau (25°48'N to 27°04'N, 103°03'E to 103°55'E), with an average elevation of 2120m. Mild climate, abundant rainfall, average annual temperature of 12.6°C, average annual rainfall of 858.4mm, and average annual relative humidity of 79%.

2.2. Sample Collection and Treatment

In this study, a waste site outside the plant site of an abandoned lead-zinc smelter (26°39'7"N, 103°33'9"E, 2468 m) in Zhehai Town, Huize County was selected as sampling point. Sample points were set at 50m, 100m, 150m, and 200m from the smelter, and select a sampling point as a control in the surrounding farmland, a total of 5 sampling points, each sample randomly collected 6 plant samples, and collected the corresponding soil at the plant sample collection point Samples (0~15 cm surface soil).

The collected plant samples were divided into two parts on the ground and underground, rinsed with deionized water, kept green at 105 °C for 30 min, and then baked at 65 °C until constant weight. After drying, grind it with a grinder, pass a 0.2mm sieve, and store it for testing.

After the soil samples were naturally air-dried, foreign bodies such as plant roots were removed, and the samples were crushed and ground with wooden sticks, sieved through 0.2 mm, and stored for testing.

The plant heavy metals were determined by HNO₃-HClO₄ digestion and atomic absorption spectrophotometry. The total amount of heavy metals in soil was determined by HNO₃-HClO₄ digestion-atomic absorption spectrophotometry. The available state was determined by DTPA-TEA extraction-atomic absorption spectrophotometry.

The data was processed and graphed with Excel 2013 and correlated with SPSS 17.0 software.

3. Results

3.1. Heavy metal content in soil

Heavy metal content in soil was shown in Table 1 and Table 2. The contents of Pb, Zn, Cu, and Cd in the soils at different distances from the abandoned smelter were high, and there was a significant difference in the total and dissolved contents of Pb, Zn, and Cd between the different distances from the abandoned smelter ($P < 0.05$). There was no significant difference in total and soluble Cu contents between different distances from abandoned smelters. Except for Cu, the content of the other three kinds of heavy metal soils showed a trend of decreasing with the distance from the abandoned smelter.

Table 1 Total heavy metal contents of elements in different distances from the abandoned smelter

Different distances	Total Pb (mg/kg)	Total Zn (mg/kg)	Total Cu (mg/kg)	Total Cd (mg/kg)
50m	14988.33±2072.12a	53177.01±1579.63a	28.66±1.97a	319.14±16.50a
100m	3619.31±192.28b	10990.07±796.73b	18.75±1.60c	86.58±1.36b
150m	2364.30±123.66c	6843.61±161.86c	24.50±1.68b	28.29±1.80bc
200m	1145.01±89.96d	3118.24±209.41d	27.00±3.49a	16.02±1.35c
CK	498.46±23.44d	555.21±3.15e	12.67±1.77d	6.55±1.05c

Table 2 Soluble heavy metal contents of elements in different distances from the abandoned smelter

Different distances	Soluble Pb (mg/kg)	Soluble Zn (mg/kg)	Soluble Cu (mg/kg)	Soluble Cd (mg/kg)
50m	280.16±19.76a	1279.51±144.79a	2.99±0.12a	27.72±1.30a
100m	58.02±2.68b	775.51±22.72b	1.71±0.19b	7.73±0.39b
150m	11.03±1.56c	470.75±20.96c	1.67±0.17b	4.39±0.23c
200m	5.47±1.11cd	375.41±29.80d	1.70±0.20b	1.48±0.35d
CK	1.19±0.14d	59.17±5.09e	1.07±0.10c	0.83±0.050e

3.2. biomass of *Imperata cylindrical*

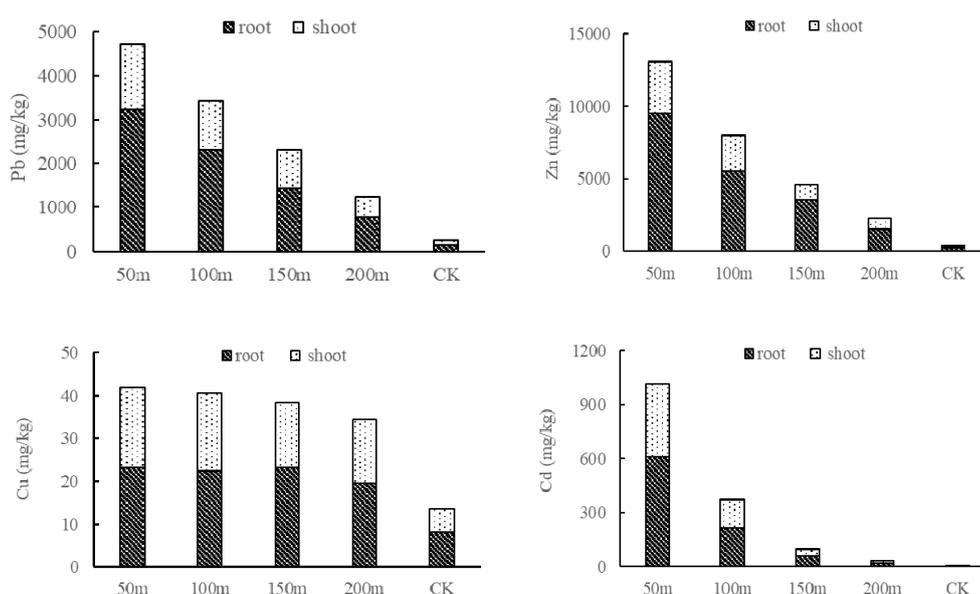
Biomass of *Imperata cylindrical* was shown in table 3. The maximum quality of the dry masses was 200m from the abandoned smelter and the minimum was 50m. The highest plant height was the control, followed by 200m, and the lowest was 50m. Dry quality and plant height both showed a tendency to decrease with increasing distance from the abandoned smelter.

Table 3 Biomass of *Imperata cylindrical* in different distances from the abandoned smelter

Different distances	dry masses (g/plant)	plant height (cm/plant)
50m	22.73±2.51	39.47±2.35
100m	38.90±4.13	58.57±3.43
150m	53.36±4.98	89.22±7.21
200m	81.24±5.80	123.30±9.00
CK	70.98±6.21	127.81±9.83

3.3. Heavy metals are distributed in different parts of *Imperata cylindrical*

The accumulation and distribution of heavy metals in *Imperata cylindrical* was shown in Figure 1. All four heavy metals showed that the content of the underground part was higher than that of the aboveground part. Except for Cu, the contents of the other three kinds of heavy metal soils showed a trend of decreasing with the distance from the abandoned smelter, which is consistent with the change trend of heavy metal content in the soil.

Figure 1 Content of heavy metals in different parts of *Imperata cylindrical*

3.4. Enrichment coefficient and Translocation factors

From Table 4, regarding the enrichment coefficient of various heavy metals by *Imperata cylindrica*, the enrichment capacity of the plant to each metal at 50m, 100m and 150m away from the abandoned smelter was Cd>Cu>Pb>Zn; the enrichment capacity of the plant to each metal at 200m away from the abandoned smelter was Cd >Cu>Zn>Pb; the enrichment capacity of the plant to each metal for the control soils was Cu>Cd>Zn>Pb. The Cd enrichment coefficient was the highest at a distance of 100m from the abandoned smelter, which was 2.447.

The Translocation factors of *Imperata cylindrica* to each heavy metal in the 50m and 100m from the abandoned smelter was Cu>Cd>Pb>Zn; The Translocation factors of *Imperata cylindrica* to each heavy metal in the 150m, 200m from the abandoned smelter, and the control soils was Cd>Cu>Pb>Zn.

Table 4 Enrichment coefficient (EC) and translocation factors (TF) of plant to heavy metals

Different distances	Pd		Zn		Cu		Cd	
	EC	TF	EC	TF	EC	TF	EC	TF
50m	0.216	0.466	0.179	0.368	0.811	0.807	1.917	0.663
100m	0.636	0.492	0.500	0.454	1.202	0.807	2.447	0.752
150m	0.614	0.595	0.512	0.310	0.949	0.652	2.115	0.664
200m	0.603	0.696	0.486	0.484	0.724	0.764	1.240	0.775
CK	0.287	0.782	0.463	0.536	0.735	0.691	0.373	0.716

3.5. Relationships between concentrations of heavy metals in plants and soils

According to Table 5, there was a very significant positive correlation between the contents of Pb, Zn, Cu and Cd in the soil and the contents of *Imperata cylindrica* at different distances from the smelter. It indicated that the absorption of heavy metals by *Imperata cylindrica* was affected by the content of heavy metals in the soil.

Table 5 Relationships between concentrations of heavy metals in plants and soils

soil	<i>Imperata cylindrica</i>			
	Pb	Zn	Cu	Cd
Pb	0.862**			
Zn		0.922**		
Cu			0.853**	
Cd				0.716**

4. Discussion

Due to the characteristics of dusting, low viscosity, high content of heavy metals and lack of plant nutrition, tailings often cause major environmental problems, such as geological disasters, soil heavy metal pollution, etc. [10-11]. Due to the long-standing backward mining history and other reasons, the Huize lead-zinc mining area has formed a large number of abandoned lead-zinc smelters. The surrounding soil contains high Pb, Zn and other heavy metals, which not only limits the settlement of the plant in the mining area. At the same time, it will pollute the surrounding arable land through migration, causing damage to agricultural production and local residents. At present, there is still no effective method for the treatment of abandoned land and Pb and Zn contaminated farmland. Although Pb and Zn polluted phytoremediation technologies have great potential, there are still many problems in the practice of vegetation restoration. The most critical problem is the lack of ideal plant materials.

Although Pb and Zn hyperaccumulator screened from nature can accumulate high levels of Pb and Zn in the body, they cannot extract large amounts of Pb and Zn from the soil in a short time because of their low biomass and slow growth [12]. Some investigations and analysis in the mining area show that there are often plants in the abandoned area, tailings yard, and surrounding areas of the mining area that have strong adaptability, large biomass, short growth cycle, and are resistant to various heavy

metal pollution. Some of them can accumulate higher concentrations of heavy metals in the body [13]. Compared with existing hyperaccumulators, these plants have a higher efficiency of remediation of heavy metal pollution in the soil and should be used as an important research and application direction for soil heavy metal contaminated phytoremediation materials.

In this study, *Imperata cylindrica* was not fully satisfied with the characteristics of hyperaccumulators. However, the amount of Pb and Zn absorbed in the body were high in all parts, and had the characteristics of large biomass, rapid growth rate, developed root systems, and widespread distribution of lead-zinc mine areas of Huize County, which could be performed within a short period of time. Absorb a large amount of heavy metals such as Pb and Zn from the soil, and quickly reduce the heavy metal content of Pb and Zn in the soil. Therefore, it can be applied to vegetation restoration and heavy metal contaminated soil restoration in the mining area.

5. Conclusion

(1) The content of heavy metals in soil decreased with the distance from the abandoned smelter, and the content of heavy metals in the soil 50m away from the abandoned smelter was the highest.

(2) *Imperata cylindrica* had higher enrichment of Zn and Pb, there was a very significant positive correlation between the contents of Pb, Zn, Cu and Cd in the soil and the contents of *Imperata cylindrica* at different distances from the smelter.

(3) All four heavy metals showed that the content of the underground part was higher than that of the aboveground part.

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