

# Analysis of Heavy Metals in Waste Slag from Taihe Iron Mine

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**Abstract:** The Taihe Iron Mine mining area is one of the four major vanadium titanium magnetite deposits in the Panxi region, with a project capacity of 300t/a. The generated waste slag is spread out in the slag yard. To fix the waste slag and prevent it from being blown up by the wind and causing pollution, local plants such as mulberry trees are planted on the waste slag. This engineering practice aims to study whether *Dodonaea viscosa* has adsorption effect on heavy metals. Soil samples close to the roots of *Dodonaea viscosa* and *Dodonaea viscosa* were collected for heavy metal determination. At present, microwave digestion and electric thermal digestion methods have been used to pretreat the soil to be tested, and flame atomic absorption spectrophotometry has been used to determine the three heavy metals chromium, lead, and cadmium in the digestion solution of polluted soil and plant samples. Analyze the impact of plants in the project area on soil heavy metal adsorption capacity based on the different concentrations of heavy metals in soil and plants.

**Keywords:** Heavy metal, Waste slag, microwave digestion method, Electric digestion method, Flame atomic absorption spectrophotometry.

## 1. Introduction

Soil is an important carrier of material circulation and energy exchange, and also an important natural resource for human survival<sup>[1]</sup>. In the global economic development, the degree of mineral resource development is higher, and more heavy metal elements enter the soil, leading to very serious soil pollution problems, directly affecting production and life. The Panxi region is a concentrated area for steel smelting in China, and it is easy for a large amount of metal elements to remain in the waste residue<sup>[2]</sup>. Based on existing research, it is known that the content of heavy metal elements in waste residue is very high, but they are often in a stable state. However, under the influence of weathering and leaching, they will gradually migrate to the surrounding ecological environment. If heavy metal elements are integrated with the soil environment, they cannot be degraded by microorganisms and will exist in the soil for a long time, then accumulate through the food chain, posing a serious threat to the safety of people's lives<sup>[3]</sup>. On a specific level, heavy metal elements have strong toxicity, which is related to their content and their occurrence forms. In general, changes in the forms of heavy metals in soil can lead to varying degrees of pollution, and these forms have a significant impact on toxicity and migration processes<sup>[4-6]</sup>. Therefore, by understanding the characteristics and distribution patterns of heavy metals in different soil depths, more reasonable ways can be found to solve the problem of heavy metal pollution and ensure the stability of the ecological environment.

## 2. General Situation

Taihe Iron Mine is located in Taihe Town, Kaiyuan Township, and Zhangmuqing Township, Xichang City, Sichuan Province. Its geographical coordinates are between 102°10'20"E and 102°3'57"E longitude, and 27°52'5"N and 27°57'37"N. Taihe Iron Mine is 7 kilometers away from the Chengdu Kunming Railway and the Yapan Expressway,

adjacent to the Anning River, and faces the Anning River Valley plain, the second largest plain in Sichuan Province, across the river. The mining area is 3700 meters long from east to west and 3500 meters wide from north to south. The Anning River flows through the east side of the mining area from north to south. In terms of geographical location, Taihe Iron Mine is one of the most advantageous mining areas in China's iron ore mountains. Taihe Iron Mine, along with Panzhihua, Hongge, and Baima, is known as the "Four Great Vanadium Titanium Magnetite Mines in Panxi" and is a well-known "treasure trove" both domestically and internationally. The iron ore reserves have reached 900 million tons, making it one of the largest mines in China. Rich in various resources such as iron, vanadium, titanium, cobalt, nickel, sulfur, and phosphorus, the associated metals include 77.91 million tons of titanium dioxide, 1.659 million tons of vanadium pentoxide, 157700 tons of copper, 94300 tons of cobalt, and 82800 tons of nickel, making it a promising mine.

## 3. Sample Collection and Processing

### 3.1. Sample collection method

The soil samples were collected in May 2025 in the Taihe Iron Mine area of Taihe Town, Xichang City. Due to one of the tasks being to investigate the heavy metal adsorption capacity of plants (*Dodonaea viscosa*), soil samples were collected at depths of 0-5cm, 5-10cm, 25-30cm, 50-55cm, 75-80cm, and 100-105cm from the ground surface, respectively. The sampling diagrams are shown in Figure 1, with a total of six sets of samples.

Mix and shrink the collected soil samples, air dry them naturally, remove impurities from the soil samples, grind them finely with a grinding rod, pass them through a 100 mesh sieve, mix well, and set them aside.

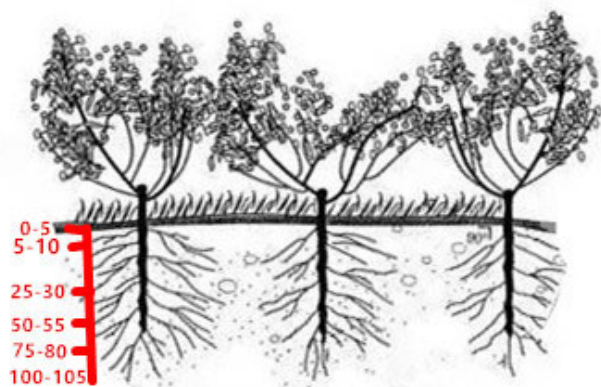


Figure 1. Schematic diagram of soil sample collection

### 3.2. Electric digestion

Accurately weigh six sets of soil samples into a 250 ml conical flask, add 8 ml of aqua regia to each sample, shake well, and place the conical flask containing the samples on an electric digestion instrument for 4 hours, or on a microwave digestion instrument. Start the digestion program and set the program as shown in Table 1.

Table 1. Microwave digestion instrument setting program

Step	Heating up time (min)	Target temperature (°C)	Hold (min)
1	5	100	2
2	5	150	3
3	5	180	25

### 3.3. Flame atomic absorption spectrophotometry

Measure the content of Cr, Pb, and Cd in the standard curve and sample separately using a flame atomic absorption spectrophotometer. Measure each sample three times. The instrument parameters are shown in Table 2.

Table 2. Parameters related to flame atomic absorption spectrophotometer

Condition	Cr	Pb	Cd
Wavelength/nm	357.9	283.3	228.88
Spectral bandwidth /nm	0.2	0.2	0.2
Flame type	Acetylene -air, Oxidizing flame		
Lamp current/mA	10	10	10
Negative high voltage /v	291	343	434

## 4. Result and Analysis

### 4.1. Standard Curve

Use Origin software to linearly fit the standard curves of various heavy metal elements obtained from the experiment, and obtain the regression equation and its  $R^2$  as shown in Table 3.

Table 3. Standard curve regression equation and  $R^2$

Metal	Regression equation	$R^2$
Cr	$y = 0.00662x + 5.03684E^{-4}$	0.99885
Pb	$y = 0.01918 - 0.00276$	0.99902
Cd	$y = 0.3115 - 0.0042$	0.99927

### 4.2. Heavy metal content

From Fig. 2-Fig. 4, it can be seen that the content of heavy metals Cr and Cd in soil increases with the increase of sampling depth, reaching the maximum value at a depth of 75-80 cm; Afterwards, the content slightly decreased at 100-105 cm, but still ranked second in heavy metal content at various depths. However, the content of Pb did not show significant changes at different soil depths, roughly maintaining around  $0.6 \mu\text{g/ml}$ , and its content was not affected by soil depth.

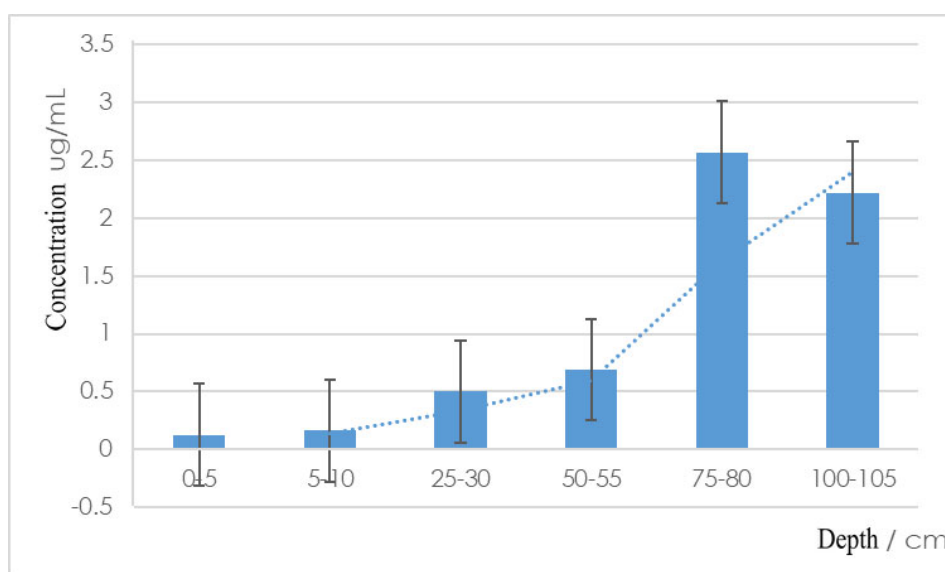
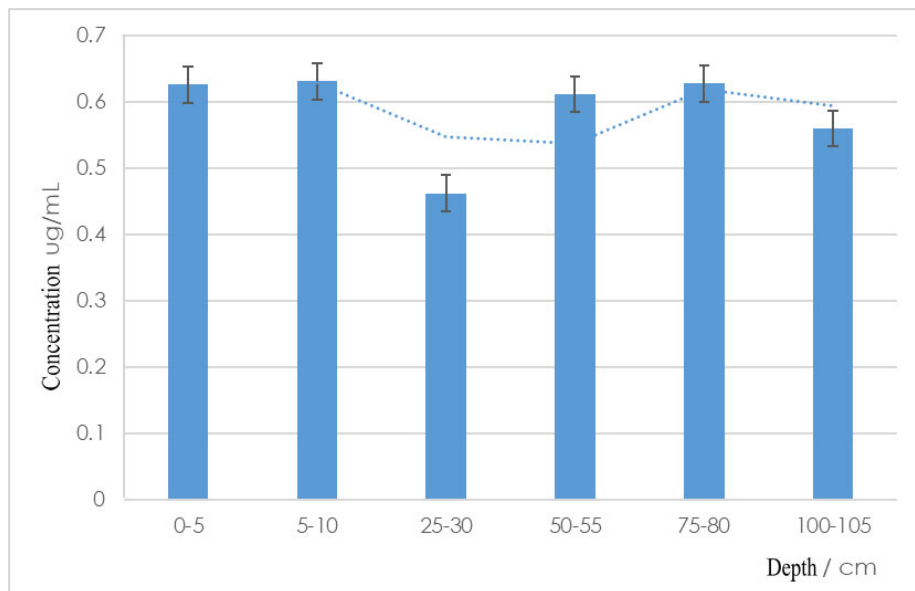
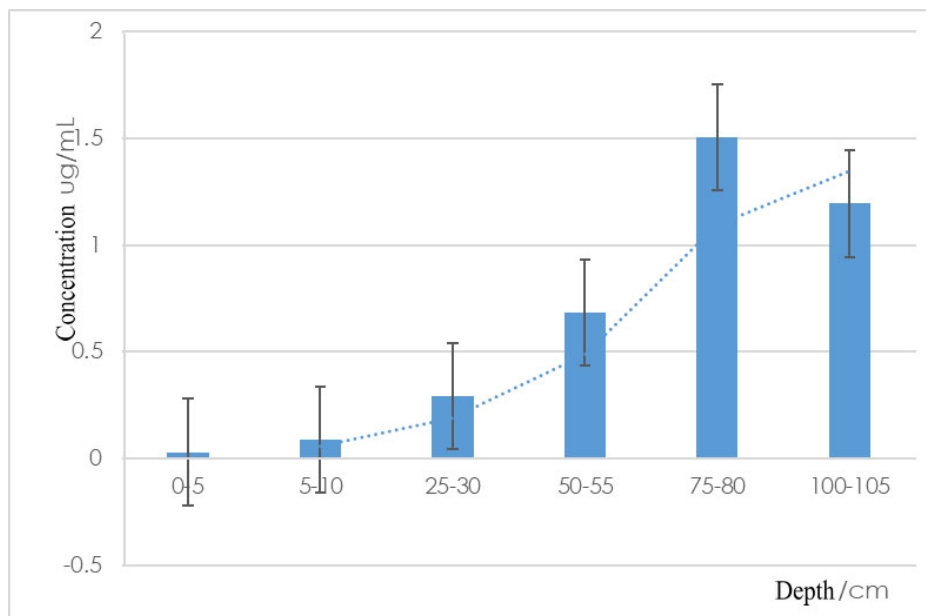


Figure 2. Changes in Cr concentration in the sample



**Figure 3.** Changes in Pb concentration in the sample



**Figure 4.** Changes in Cd concentration in the sample

## 5. Conclusion and Discussion

The content of heavy metals Cr and Cd increases with soil depth, mainly due to leaching. Leaching refers to the process in which finer soil particles and chemical elements in the soil move from the surface layer to the lower layer with soil moisture. During this process, heavy metal elements will move downwards with water, leading to an increase in heavy metal content in the lower soil layer. However, as the depth increases, the effect of leaching gradually weakens, and the content of heavy metals also decreases<sup>[7]</sup>. This explains why the content of Cr and Cd reaches its maximum at a depth of 75-80 cm in the soil, and then slightly decreases at a depth of 100-105 cm.

The migration of Pb pollutants is more complex: (1) Pb pollution is mainly concentrated in the surface soil (0-30 cm), originating from human activities such as industrial emissions, automobile exhaust, Pb containing pesticides, and sewage irrigation. For example, the Pb content in the surface soil of the Hun River alluvial plain is significantly higher than that in the deep layers, and shows a decreasing trend with

increasing depth<sup>[8]</sup>. Pb enrichment is particularly evident in the surface soil near industrial areas and transportation arteries. (2) The barrier effect of soil itself, mentioned the fixation effect of organic matter and clay minerals on Pb, supplemented by the influence of redox conditions - Pb is more likely to form insoluble compounds in hypoxic environments. Additionally, it is emphasized that the lower the pH value, the easier it is for Pb to dissolve, but deep soil often has a higher pH (especially calcareous soil), which can actually lock in Pb<sup>[9,10]</sup>. (3) Pb is easily fixed by soil colloids (such as clay minerals, iron manganese oxides) and organic matter through adsorption, precipitation, or complexation<sup>[11]</sup>. Especially in alkaline or neutral soils with pH>6, Pb can form insoluble phosphate, carbonate, or hydroxide precipitates, making it difficult to migrate downwards. (4) Plant roots are mainly distributed in shallow soil (0-20 cm) and can absorb a small amount of Pb (about 0.1-0.3%), of which more than 90% accumulates in the roots and hardly migrates to deeper layers; Root exudates may also promote the precipitation of Pb in the rhizosphere<sup>[12,13]</sup>.

Overall, the core logical chain of surface enrichment

should be: anthropogenic pollution sources (concentrated on the surface) → chemical inertness of lead (difficult to migrate) → soil fixation mechanisms (organic matter/clay adsorption, alkaline precipitation) → ultimately leading to lead "lying" in shallow layers without movement<sup>[14]</sup>. Occasional high values in deep layers may be due to residual geological processes (known as inherited parent rocks) or special cases of human activities.

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