The International Journal of Engineering and Science (IJES)
|| Volume || 13 || Issue || 11 || Pages || PP 13-25 || 2024 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Investigation, Determination, and Analysis of Dominant Vegetation in Mining Areas

Zhang Qian[1] Xiong Jian[2]

(1 School of Civil and Architectural Engineering, Panzhihua University, Panzhihua City, Sichuan Province, 617000)

(2 School of Biology and Chemical Engineering, Panzhihua University, Panzhihua City, Sichuan Province, 617000)

ABSTRACT

During the mining process, a large amount of untreated and unusable land, namely mining wastelands, is generated. Ecological remediation in mining areas aims to rehabilitate polluted mining wasteland, thus enabling the reuse of land resources. Phytoremediation technology can effectively restore pollution in mining areas, with the prerequisite of identifying suitable tolerant or dominant plant species, which are typically found in the vicinity of mining sites with a long history of exploitation. This study conducted field surveys and collected samples, followed by laboratory analyses to explore the dominant plant species in the vanadium-titanium mining area of Zhujiabaobao, Panzhihua. Field surveys revealed a low coverage of wild vegetation due to the fragile ecological environment, primarily consisting of low, medium, and high-coverage vegetation types. Based on a comprehensive analysis of 13 dominant plant species in terms of their quantity, quality, morphological characteristics, and potential value, Eriophorum vaginatum, Rumex hastatus, and Dodonaea viscosa were identified as the three most suitable species for ecological remediation in this mining area.

Keywords: *Panzhihua; Vegetation restoration; Vanadium-Titanium mining area; Ecological survey; Ecological remediation*

Date of Submission: 20-10-2024 Date of acceptance: 04-11-2024

I. Introduction

As various mining activities proceed, serious pollution and ecological destruction have been caused to the environment. Heavy metal pollutants can enter the soil through various pathways, especially the "three wastes" discharged into the environment by mining and smelting industries, which are important sources of heavy metal contamination in soil. The destruction of vegetation around mining areas is becoming increasingly severe, leading to growing environmental concerns[1]. The harmful effects of heavy metals on plants have been extensively studied both domestically and internationally. However, due to the biodiversity of plants and their geographical distribution, the effects of different heavy metals on the growth and development of different plants varies. Many studies have demonstrated that many dominant species that are good candidates for ecological restoration can be found close to mining regions because they can better resist adverse conditions. For this reason, it is essential to explore and research the dominant plants in mining regions, especially those with extended durations of exploitation[2]. In the process of investigating dominant plants, the ecological conditions of mining areas play a vital guiding role. Nevertheless, there is currently a lack of thorough research on ecological surveys and dominant plants in mining areas. Therefore, conducting a more comprehensive ecological survey in mining areas is imperative.

Phytoremediation technology is a soil remediation method that does not damage the site structure, is cost-effective, and has both economic and ecological values. It has long become one of the important methods for environmental pollution remediation worldwide[3].

1.1 Study of Phytoremediation Technology

1.1.1 Phytoremediation Technology

Phytoremediation refers to a technical approach that utilizes plants to remove pollutants from water bodies and soil, thereby restoring contaminated environments[3-4]. It harnesses the natural processes of plants and rhizosphere microorganisms to degrade and sequester organic and inorganic pollutants, effectively decomposing a wide range of contaminants[5]. Phytoremediation has been successfully applied in the treatment of organic pollutants such as explosives (TNT), herbicides (atrazine), and polychlorinated biphenyls (PCBs)[6].

Some inorganic pollutants in the environment may originate from elements naturally present in the earth's crust or atmosphere. They may be released into the environment due to human activities such as mining, industrial production, and daily life[5-6]. Phytoremediation technology can not only treat inorganic pollutants but also absorb radioactive isotopes like 137CS, 238U, 90Sr, and non-essential elements such as Co, F, Cd, Hg, Se, etc. Pollution in farmland (from herbicides, pesticides), wood treatment sites (from PAHs), and other areas can be addressed through phytoremediation[5-6]. Additionally, phytoremediation can filter out volatile halogenated hydrocarbons, ozone, dust, soot particles, or nerve gases from both outdoor and indoor air[7].

1.1.2 Application of Phytoremediation Technology in Soil Pollution Control

Compared with general physical and chemical remediation methods, such as adsorption and immobilization, soil replacement, etc., phytoremediation technology has the incomparable advantages of not causing secondary pollution, double economic benefits, lower cost, and easy operation[8], thus being applied in soil pollution treatment. This is mainly achieved through the extraction action of hyperaccumulating plants to remove heavy metals from polluted soil. It involves repeated planting and cultivating corresponding dominant plants to reduce the concentration of heavy metals in contaminated soil and achieve the goal of cleaning up contaminated soil. The technology mainly includes the following aspects:

(1) Phytoextraction: This technique involves the absorption and accumulation of heavy metals by the aboveground parts of plants, which are then harvested to achieve the goal of reducing heavy metal concentrations. This technique includes induced plant extraction and sustained plant extraction[9]. The former uses chelating agents to enhance the absorption and accumulation of heavy metals by ordinary plants, while the latter involves utilizing plants that accumulate heavy metals in the soil to reduce their content and absorption[10].

(2) Rhizofiltration: Plant root channels allow the transfer of heavy metals from soil through water[10].

(3) Phytostabilization: This process involves plants converting soil heavy metals into non-toxic or less toxic forms, rather than actually removing them from the soil[10].

(4) Phytovolatilization: In this process, plants convert heavy metals in the soil into gaseous forms and allow them to volatilize. For example, some plant roots can absorb harmful elements such as selenium and mercury from the environment and convert them into volatile forms like dimethylated selenium and mercury vapor[11].

The application of phytoremediation for soil heavy metal contamination primarily involves the utilization of phytoextraction. This requires first identifying plant species that possess strong absorptive and accumulative capabilities for specific heavy metals, known as "hyperaccumulators" of heavy metals[12]. These plants are then artificially cultivated, and the principle of phytoextraction is employed to remove contaminated metals from the soil, ultimately achieving the goal of purifying the soil from pollution[7].

1.1.3 Advantages of Phytoremediation Technology

The application of phytoremediation technology in managing heavy metal-contaminated soils boasts remarkable efficacy and promising prospects. Compared to other chemical and physical remediation measures, this technology offers the following advantages: (1) Eco-friendly and Green: It is a more environmentally benign technology that harnesses and utilizes solar energy. (2) Cost-effective: As the biological processes are driven by solar energy, phytoremediation is significantly less expensive than engineering-based remediation methods like soil replacement and soil washing, saving approximately 10 times the cost and accounting for only 10% to 50% of the mechanical treatment expenses. (3) In-situ Remediation: By treating contaminants on-site, it eliminates the risk of transporting pollution, thereby reducing the exposure time of humans, wildlife, and the environment to these contaminants. (4) Economic Benefits: Following the harvest of plants, the heavy metals accumulated within can be recycled and reused, generating additional economic value. (5) Environmental Aesthetics: It contributes to greening efforts, enhancing the beauty of the environment and fostering greater public appreciation and support for sustainable practices[13].

1.2 Research on Hyperaccumulator Plants

1.2.1 Distribution Characteristics of Hyperaccumulator Plants

According to relevant literature, approximately 500 species of hyperaccumulator plants have been identified worldwide, with the majority belonging to the Brassicaceae family[15]. These plants have limited natural distribution and exhibit a particular affinity for polluted environments[16]. Many hyperaccumulator plants discovered through field surveys are found in areas with high concentrations of heavy metals, such as tailings heaps, various mining areas under exploitation, abandoned mine sites, or locations with exceptionally high background levels of heavy metals in the soil. The utilization of these plants offers promising prospects for the application of phytoremediation technology to remediate soils contaminated with heavy metals[17].

1.2.2 Principles of Phytoremediation for Heavy Metal Contamination

(1) Chelation Mechanism

Chelation refers to the process where heavy metal ions bind with large molecules (such as citric acid, malic acid, etc.) in plants that have a high affinity for heavy metals, forming chelates. This mechanism reduces the concentration of free heavy metal ions in the soil, thereby mitigating their toxicity[18].

(2) Compartmentalization Mechanism

Hyperaccumulator plants sequester absorbed heavy metal ions within specific compartments such as vacuoles and cell walls of epidermal cells in leaves[19]. Under certain conditions, metal ions in hyperaccumulator plants accumulate primarily in the form of phosphates within the cell walls of epidermal cells in the roots, while in leaves, they are primarily stored in the vacuoles of mesophyll cells[19].

(3) Mechanism of Absorption and Accumulation Capacity

Compared to ordinary plants, hyperaccumulator plants exhibit superior abilities to absorb and accumulate heavy metals[19]. Generally, the hyperaccumulation ability and tolerance of hyperaccumulator plants are governed by distinct physiological mechanisms. The hyperaccumulation ability is related to the increased number of binding sites for heavy metals in their root cells, whereas tolerance is associated with the compartmentalization within plant cells[20].

1.3 Significance and Research Contents of This Study

1.3.1 Ecological Remediation of Mining Areas and the Significance

Ecological remediation, as it is generally referred to, involves minimizing human intervention in ecosystems to alleviate stress and pressure, allowing the ecosystem to evolve towards a more ordered state through its self-regulatory capabilities. Alternatively, it involves harnessing the inherent self-recovery potential of ecosystems, coupled with artificial measures, to gradually restore damaged ecosystems to their original conditions[21]. The process of revitalizing natural ecosystems that have been degraded by natural disasters or human activities and restoring them to their pristine states is termed "ecological remediation"[21]. When it comes to ecologically degraded mining areas, where the degradation is severe, several strategies can be employed for ecological restoration. These include supplementing nutrients, applying soil cover, and planting resilient, dominant grass species or tree species that are well-adapted to the environment[22].

In recent years, with the development of various mining industries such as coal and vanadium-titanium mining, the destruction of vegetation surrounding mining areas has become increasingly severe. Consequently, the resulting environmental issues have gradually garnered public attention, leading to the emergence of numerous methods for soil pollution remediation. Among these, phytoremediation technology stands out as one of the most promising approaches due to its advantages of not disrupting the ecological environment, low cost, and minimal potential for secondary pollution[23]. However, the current diversity of plant species capable of accumulating heavy metals, as well as the number of hyperaccumulator plants, remains relatively limited, underscoring the urgent need to identify more superior plants to adequately support phytoremediation technology.

Numerous studies indicate that these superior plants often grow in proximity to mining areas. As the soil in mining areas inherently contains high levels of heavy metals, plants growing there have developed a higher tolerance to high concentrations of heavy metals compared to those in non-mining regions. Thus, mining areas with a long history of mining activities represent crucial areas for identifying these dominant species[24]. In the search for these plants, the ecological status of mining areas plays a decisive role. Nonetheless, current research on dominant vegetation in vanadium-titanium mining areas is still inadequate, necessitating a more in-depth investigation in these areas.

Panzhihua City, located in western China, is rich in mineral resources, with titanium accounting for approximately 53% of the national total[23]. Titanium is a rare metal, yet there are still limited investigations into the dominant vegetation in vanadium-titanium mining areas. This survey aims to sample dominant plants in the mining area to gain familiarity with the ecological vegetation status, laying a foundation for the recovery and utilization of metallic elements within these plants. Furthermore, it seeks to contribute to ecological remediation and environmental pollution improvement in the region[24].

1.3.2 Contents of This Study

(1) A field survey was conducted to investigate the growth conditions and distribution patterns of major plant species within the vanadium-titanium mining area of Zhujiabaobao in Panzhihua City. Photos were taken, and plant samples featuring robust growth, wide distribution, and strong resilience, as well as soil samples from the mining area, were collected.

(2) In the laboratory, all collected plant samples were identified, classified, and subjected to experimental methods such as weighing and observation to explore the impact of heavy metal elements on the growth of dominant vegetation in the mining area.

(3) Among the collected plants, suitable species for ecological remediation in the vanadium-titanium mining area were identified, laying a foundation for improving the environmental conditions and facilitating ecological remediation efforts in the region.

II. Materials and Methods

2.1 Study Area Overview

Panzhihua City is located in the southwestern part of Sichuan Province, at the juncture of Sichuan and Yunnan provinces, spanning 26°05′N to 27°21′N and 101°08′E to 102°15′E. It is where the Jinsha River and Yalong River converge. Panzhihua borders Huili of Liangshan Prefecture to the east, Yongren County of Yunnan Province to the south, Huaping County and Ninglang County of Yunnan Province to the west, and Dechang County and Yanyuan County of Liangshan Prefecture to the north. The terrain here is deeply dissected, with pronounced vertical differentiation[24]. The terrain tends to be high in the north and south, and low in the east and west, with an area of approximately 7440km^2, making it a vast mountainous city endowed with abundant resources. Panzhihua is a pivotal mining city renowned as the "Capital of Vanadium and Titanium" in China, characterized by vast resource reserves, diverse mineral types, shallow burial depths, excellent mineral processing properties, and high comprehensive utilization value. It is also an ideal destination for health preservation and recreation[24].

The surveyed mining area is a vanadium-titanium magnetite mine with a long history of mining and extremely rich mineral resources, located in the eastern part of Panzhihua. Sampling was conducted in the Zhujiaobao Vanadium-Titanium Ore Mining Area. The overview of the mining area along with the growth conditions of plants in the sampling region are shown in the following figures. The altitude ranges from 1,283 to 1,466 meters, with geographical coordinates between 26°38′N to 26°61′N and 101°45′E to 101°72′E.

Fig.1 Ecological Environment of the Mine

Fig.2 Appearance of Some Plant Communities in the Mining Area

Fig.3 Overview of Selected Sampling Areas

Fig.4 Pattern of Sampling Area from the Field of *Eriophorum comosum*

Fig.5 Growth Conditions of Some Plants in the Sampling Areas

2.2 Field Survey and Sampling

In December 2017, the first visit was made to the Zhujiabababao Vanadium-Titanium Mining Area in Yinjiang Town, Panzhihua City, to conduct a survey of dominant vegetation. The primary focus was on identifying the major natural vegetation species and their distribution patterns within the mining area. The survey locations were primarily selected along the transportation roads, near the mining excavation sites, and at the ore washing and dressing plants. Through this initial ecological survey, a general understanding of the mining area's condition was obtained.

In early March 2018, the second survey was conducted in the same mining area. Based on different types of plant communities, 13 plant samples were collected for laboratory experimental analysis. The sampling method adopted was random sampling: representative sampling points were selected within the study area, with the number of sampling points determined by the size of the sampling area. After selecting the points, a certain number of sample plants were randomly collected, or samples were taken from a prescribed area at each sampling point. The dominant plant samples collected covered nearly all dominant plant species growing in the mining area.

2.3 Sample Preparation

Firstly, the collected mine area plant samples were thoroughly rinsed with tap water to remove dirt and soil adhering to them. Subsequently, they were washed with distilled water and drained of excess moisture. Finally, the plants were air-dried in a well-ventilated laboratory, and then crushed using a mill and mortar. The dried and powdered plant samples were then bagged, sealed, and stored for experimental use.

2.4 Sample Analysis and Measurement

(1) Measurement of Plant Weight

Prepared plant samples were first placed into weighing containers. Then, an electronic balance was used to weigh each plant sample, and the data was recorded for analysis.

(2) Measurement of Plant Height

Firstly, the prepared plant samples were securely fixed. Next, a ruler was used to measure the distance from the root-neck to the top of the main stem. The reading obtained was the plant height.

2.5 Research Process

The research process flowchart is shown as follows Fig.6:

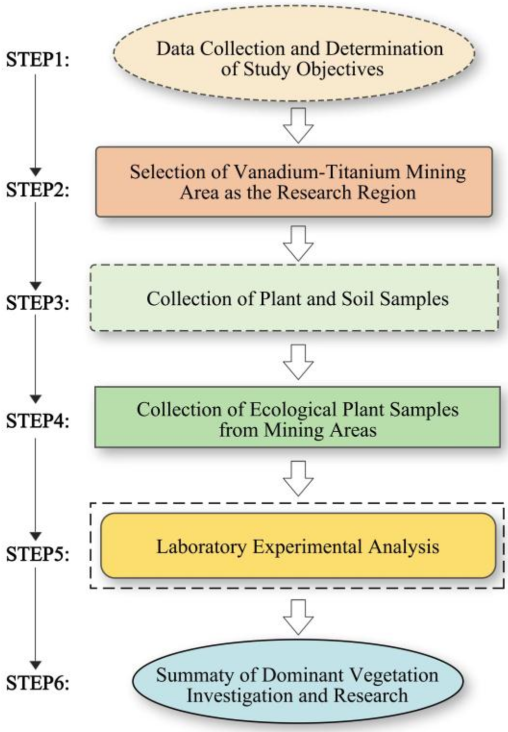

Fig.6 Research Process Flowchart

III. Results and Discussion

3.1 Composition of Plant Species

After prolonged mining activities and natural succession, the original evergreen broad-leaved forest vegetation in the mining area has been severely damaged, giving way to the emergence of some secondary shrublands. The majority of the vegetation here comprises herbaceous plants, with a minority of dwarf subshrubs and shrubs, as well as a small number of taller shrubs. Tall trees are largely confined to the sides of major traffic arteries and have been planted artificially. This survey recorded a total of 13 plant species, with the *Asteraceae*, *Fabaceae*, and *Verbenaceae* families being the most represented. The dominant herbaceous plants in the area include *Eriophorum comosum*, *Eupatorium adenophorum*, and *Rottboellia exaltata*, etc. The dominant shrub species are *Dodonaea viscosa* and *Lantana camara*. As for trees, *Vernicia fordii* dominates. In some areas, there is a high dominance of single plant species, such as *Indigofera bungeana Walp.*, *Rumex hastatus*, and *Setaria viridis*. The specific survey results are shown in Fig.7.

Plant Species Composition in the Zhujiabao Vanadium-titanium Mining Area,Panzhihua City

	Family	Plant Speciese	Genus	Life Form
1	Asteraceae	Artemisia apiacea	Artemesia	Annual herb
2	Asteraceae	Eupatorium adenopho1um	Eupatoriume	Perennial herb
3	Asteraceae	Zinnia elegans	Zinnia	Annual herb
4	Sapindaceae	Dodonaea viscosa	Dodonaea	Shrub or small tree
5	Cyperaceae	Eriophorum comosum	Eriophorum	Perennial herb
6	Verbenaceae	Verbena officinalis L.	Verbena Linn	Perennial herb
7	Verbenaceae	Lantana camara	Lantana	Evergreen shrub
8	Polygonaceae	Rumex hastatus	Rumex	Shurb
9	Poaceae	Rottboellia exaltata	Rottboellia	Annual herb
10	Fabaceae	Indigofera bungeana Walp.	Indigofera L.	Subshrub or shrublet
11	Poaceae	Setaria viridis	Setaria P. Beauv.	Annual herb
12	Fabaceae	Crotalaria pallida	Crotalaria Linn.	Annual herb
13	Spurge	Vernicia fordii	Vernicia Lour.	Tree

Fig.7 Plant Species Composition in the Zhujiabao Vanadium-titanium Mining Area, Panzhihua City

3.2 Characteristics of Plant Communities

According to literature records, the forest coverage rate in Panzhihua is approximately 39%, boasting a diverse array of biological resources. However, in the mining area surveyed in this study, there is severe soil exposure, indicating a significant impact on the ecological environment due to mining activities[24]. During the investigation, several plant communities were found with good growth and substantial numbers, suggesting their adaptability to the local ecological conditions. They were subsequently collected for study and screening, which will lay a solid foundation for ecological remediation and vegetation rebuilding in the area.

The plant community status of the 6 sample plots investigated in this study is shown in Table 2. It can be observed that the species composition of the plant communities is not very diverse. The dominant families of plants in the mining area are *Asteraceae*, *Polygonaceae*, *Poaceae*, and *Fabaceae*. They exhibit vigorous growth and wide distribution. Among all the external characteristics of the plant communities, herbaceous plants dominate, especially those from the *Fabaceae* and *Poaceae* families. In terms of community structure, representative species include *Vernicia fordii* in the tree layer, and *Lantana camara*, *Dodonaea viscosa*, and *Rumex hastatus* in the shrub layer. The herbaceous layer is represented by *Eupatorium adenophorum* and *Rottboellia exaltata*. The survey results are shown in Table 1 and Fig.8 .

Table 1 Characteristics of Plant Communities in the Zhujiabao Mining Area

Sample Plot	Community	Plant Height (cm)	Species Composition	Number of Plants	Habitat
1	Eupatorium adenophorum + Rumex hastatus	55~145	Eupatorium adenophorum Rumex hastatus	5 3	Mining area
2	Eriophorum comosum + Lantana camara	12~165	Eriophorum comosum Lantana camara Verbena officinalis L.	20 3 2	Roadside
3	Dodonaea viscosa	45~85	Dodonaea viscosa Rottboellia exaltata	10 3	Mining area
4	Rottboellia exaltata + Crotalaria pallida	30~85	Rottboellia exaltata Crotalaria pallida	5 10	Roadside
5	Setaria viridis + Artemisia apiacea	50~90	Setaria viridis Artemisia apiacea	15 2	Mining area
6	Indigofera bungeana Walp. + Zinnia elegans	45~138	Indigofera bungeana Walp. Zinnia elegans	5 15	Mining area

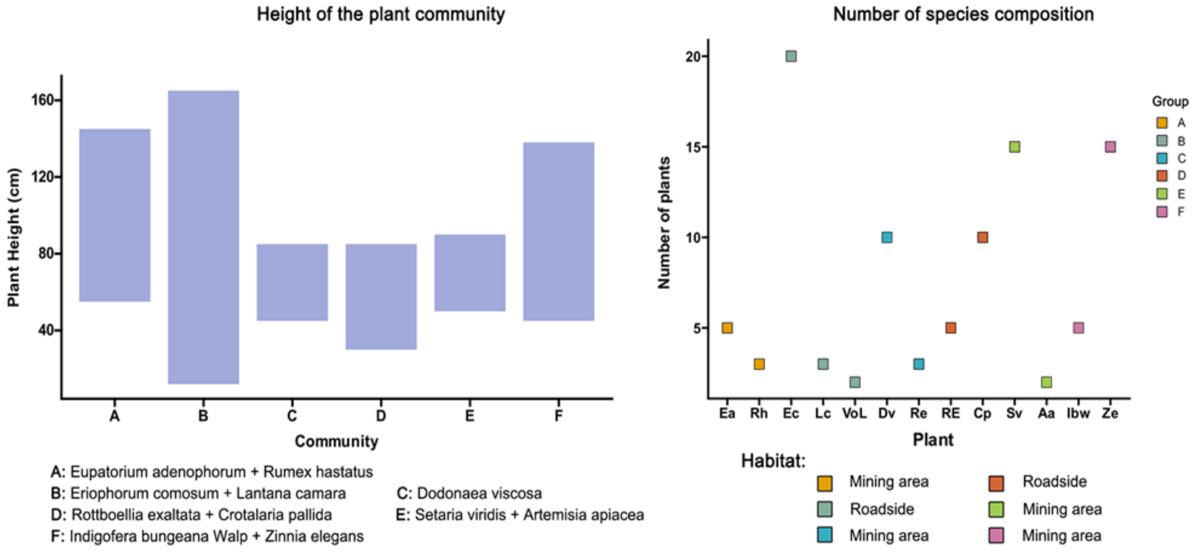

Fig.8 Survey Results Statistical Chart

3.3 Characteristics of Several Dominant Plants in the Mining Area

The relevant characteristics of the three plant species—*Rumex hastatus*, *Indigofera bungeana Walp.*, and *Crotalaria pallida*—initially screened in this investigation are shown in Table 2 and Fig.9 . As can be seen, these three plant species all possess certain medicinal values, and their morphological characteristics and growth environments are suitable for the later stages of ecological remediation work in mining areas. Among them, *Rumex hastatus* produces brightly colored flowers, which possess a certain ornamental value. This characteristic is of great significance for ecological remediation, as the use of this type of vegetation in ecological remediation can make mining areas more appealing for tourism.

At the same time, through the observation of sampled plants, it was found that the morphological characteristics of plants in the mining area are somewhat different from those of the same type of plants in non-mining areas. Specifically, the plants in the mining area are generally shorter, and the leaves are relatively small and slightly yellowish in color, which may be related to the lack of sufficient nutrients in the mining area. Therefore, to carry out ecological remediation work, it is necessary to find plants that have low nutrient requirements and are adaptable to the climate of the mining area. Through literature review, it was found that *Dodonaea viscosa* meets these criteria[25].

Table 2 Characteristics of Several Dominant Plant Species in the Mining Area

Plant Name	Morphological Characteristics (Non-mining Area)	Morphological Characteristics (Mining Area)	Growing Environment	Distribution Range	Main Value
Rumex hastatus	Height 50-90cm, with many branched stems. The leaves are alternate or clustered. It has a terminal inflorescence with sparsely branched,	Height 40-65cm, with slightly yellow and dull leaves, and fine rhizomes.	Generally grows on sandy barren slopes and sunny hillsides, at an altitude of approximately 600-3200m.	Mainly distributed in Yunnan, Sichuan, and southeastern Tibet.	Medicinal: Used for lung moisturizing, cough relief, and edema, phlegm, asthma treatment.

	brown, and glossy stems.				
Crotalaria pallida	Height 10-25cm, with cylindrical stems and branches featuring small grooves, and distinct veins on both surfaces of the leaves.	Height 8-15cm, with thin stems and branches, and small and slightly yellow leaves.	Generally grows on slopes and roadside, at an altitude of approximately 500-3000m.	Mainly distributed in Shandong, Fujian, Guangxi, Sichuan, and Yunnan.	Medicinal: clear away heat and promote diuresis, dispel toxicity and disperse nodulation.
Indigofera bungeana Walp.	Height 60-90cm, with an erect stem and many branches. Inside, there are several kidney-shaped seeds.	Height 40-68cm, with short and slender stems and sparse leaves.	Generally grows on sunny hillsides and sandy areas, at an altitude of approximately 300-3000m.	Mainly distributed in Yunnan, Sichuan, and Guizhou.	Medicine: clear heat and detoxify, as well as reduce swelling and dissipate nodules. It is used for treating cold coughs, tonsillitis, hemorrhoids, and other conditions.
Eupatorium adenophorum	Height 35-200cm, with thick and well-developed rhizomes. The rhizomes are purple in color and covered with short, white or rusty hairs. The edges of the leaves are irregularly serrated.	Height 30-162cm, with relatively thin rhizomes that are light purple in color. The leaves are smaller and have irregular serrations along their edges.	Generally grows in dry and barren areas with poor soil, even in crevices of rocks and on rooftops.	Mainly distributed in southwestern China, including Yunnan, Guizhou, and Sichuan.	Economic Value: a natural dye and can also be used as an insecticide, fungicide, and for other purposes. Medicinal Value: dispelling wind pathogens, detoxifying, and reducing swelling, etc.
Artemisia apiacea	Height 30-150cm, with many branches at the upper part of the stem. The lower part of the stem is slightly woody, slender, and glabrous. The main root is single and vertical, with few lateral roots. The leaves are green or light green on both sides.	Height 15-90cm, with slender and short stems	Generally grows in low-altitude areas, sandy riverbanks, valleys, and other similar environments.	Mainly distributed in provinces and regions such as Chongqing, Liaoning, Sichuan, and Guizhou.	Medicinal Value: dispelling deficient heat, cooling the blood and eliminating night sweats, relieving summer heat, and suppressing malaria.
Dodonaea viscosa	Height 1-3m, with slightly flattened twigs. The tips are short and sharp, blunt, or round, with inconspicuous shallow undulations. Both sides of the leaves are sticky and glabrous.	Height 90-135cm, with slender stems. The leaves are dark yellow in color.	Mainly distributed in lower-elevation areas and is not particularly selective about soil nutrients. Generally grows in arid hillsides and open fields.	Distributed in southwestern, southern, and southeastern regions.	Environmental Value: drought-tolerant and serves as an excellent species for sand fixation and soil conservation. Economic Value: The oil from its seeds can be used for lighting and making soap.

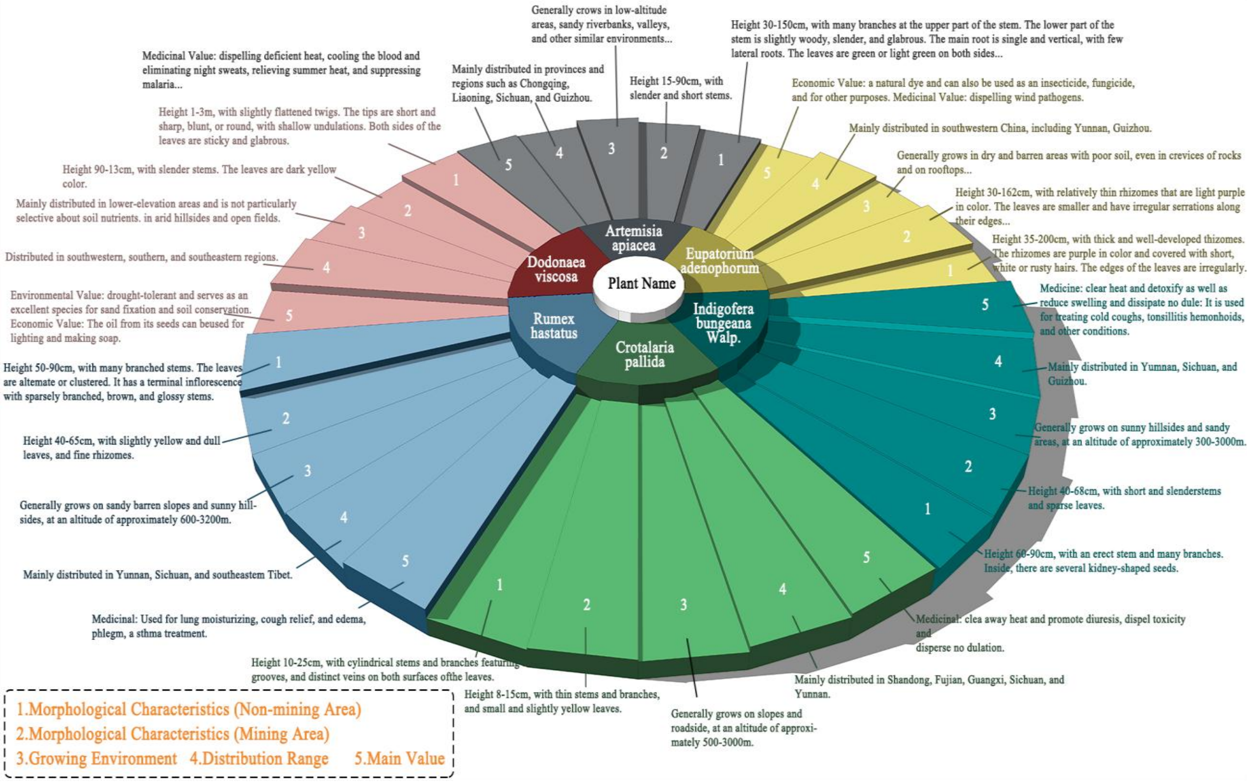

Fig.9 Initially Screened Pie Chart

3.4 Quality of Dominant Plants in the Mining Area

The weight of the dominant plant samples collected was measured indoors, and the results are shown in Table 3 and Fig.10 . It is evident that the weights of plants in this mining area are lighter compared to those of the same species grown under normal conditions outside the mining area, ranging from 13.1-308.0g, whereas under normal conditions, the weights range from 25-400g. This suggests that the mining area may suffer from soil infertility and lack of sufficient nutrients for plant growth, compounded by a dry climate. Therefore, if ecological remediation and environmental improvement in the mining area are to be achieved through plant restoration, it is necessary to identify plants that are more drought-resistant and require less soil nutrient content[25]. Regarding the plant samples collected in this study, *Eriophorum comosum* seems more suitable due to its characteristic drought resistance.

Table 3 Weight of Major Dominant Plants in the Mining Area

No.	Plant Name	Plant body measurement weight (g)	Normal weight range of plant body (g)
1	Artemisia apiacea	23.7	30~60
2	Eupatorium adenophorum	102.5	110~140
3	Zinnia elegans	113.3	115~135
4	Dodonaea viscosa	130.0	140~160
5	Eriophorum comosum	172.4	170~200
6	Verbena officinalis L.	24.0	30~50
7	Lantana camara	52.0	65~90
8	Rumex hastatus	308.0	350~400
9	Rottboellia exaltata	73.1	90~100

10	Indigofera bungeana Walp.	86.2	95~110
11	Setaria viridis	13.1	25~50
12	Crotalaria pallida	172.5	180~220

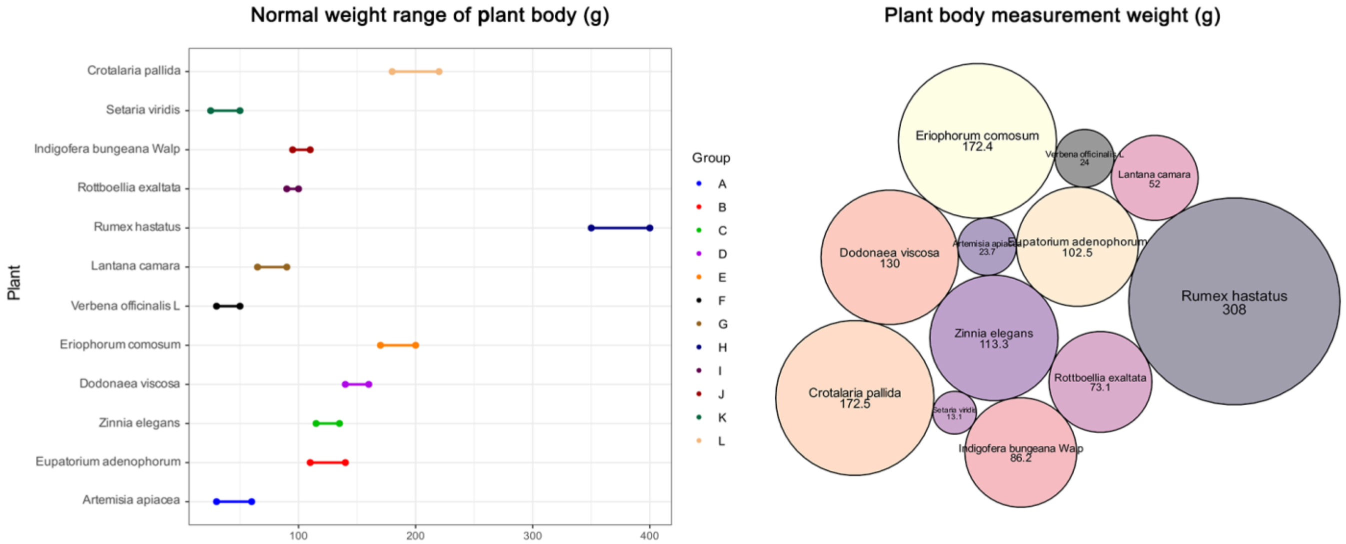

Fig.10 Results Statistical Chart

IV. Conclusion

Based on this study, the following main conclusions were drawn:

(1) Through field surveys of the mining area, it was observed that due to its fragile ecological environment, the coverage of wild vegetation was relatively low, mainly consisting of low, and medium-high coverage vegetation. A total of 13 plant species were recorded in this study. Analysis of plant quantity and growth conditions revealed that herbaceous plants dominate, with widespread distribution of *Asteraceae*, *Fabaceae*, and *Poaceae*. In terms of community structure, dominant plants include *Vernicia fordii* in the tree layer, and *Lantana camara*, *Dodonaea viscosa*, and *Rumex hastatus* in the shrub layer. The dominant herbaceous plants in the mining area include *Eupatorium adenophorum*, *Zinnia elegans*, *Eriophorum comosum*, and *Rottboellia exaltata*. *Dodonaea viscosa*, *Lantana camara*, and *Vernicia fordii* are the dominant shrub plants. In some areas, individual plant species exhibit a high degree of dominance, such as *Eriophorum comosum*, *Zinnia elegans*, and *Setaria viridis*.

(2) Through a comprehensive analysis of these 13 dominant plant species in terms of their population, quality, tolerance to the environment in mining areas, morphological characteristics, and their respective values, this study concludes that three plants – *Eriophorum comosum*, *Rumex hastatus*, and *Dodonaea viscosa* are the most suitable for ecological remediation in this mining area. Most of the dominant vegetation in this mining area possesses certain economic and medicinal values. For instance, *Rumex hastatus*, *Crotalaria pallida*, and *Indigofera bungeana Walp*. exhibit excellent medicinal properties; *Eupatorium adenophorum* can be used as feed and fragrance; and *Lantana camara* is applicable in rubber production and bio-pesticide manufacturing. Additionally, *Rumex hastatus* boasts ornamental value, which can enhance the tourism appeal of the rehabilitated mining area. Through proper cultivation and utilization, these plants can contribute not only to environmental protection but also to economic benefits.

References

[1]. Xu Rong. Low-carbon management of laboratory environmental pollutants[J]. Journal of Green Science and Technology. 2014, 31(5): 353-356.
[2]. Tan Xiaojuan. Investigation of vegetation communities and analysis of plant metal content in Panzhihua vanadium-titanium region [D]. Sichuan Agricultural University. 2009.
[3]. Ye Yinlong. Research on the heavy metal pollution of agricultural products in Lanping lead-zinc mining area [J]. Foreign Medical Science Section of Medgeography. 2012 (6): 13-155.
[4]. Chen Jing. Research progress on plant remediation and hyperaccumulation of soil heavy metal pollution [J]. Journal of Chinese Academy of Environmental Administration. 2014 (8): 25-45.
[5]. Shi Zhenyu. Plant remediation of soil heavy metal pollution [J]. Guide of Sci-tech Magazine. 2011, 21(7): 1196-1203.
[6]. Tang Lian, Liu Zhenzhong, Jiang Renfei. Plant remediation method for heavy metal polluted soil [J]. Environmental Protection Science. 2003, 29(120): 33-36.
[7]. Chen Chengli, Liao Min. Research progress on soil heavy metal pollution remediation technologies [J]. Guangdong Trace Elements Science. 2004, 11(10): 1-8.

[8]. Zhou Guohua. Research on plant remediation of contaminated soil [J]. Geophysical and Geochemical Exploration. 2003, 27(6): 473-475, 489.
[9]. Zhou Qiong. Research progress on screening hyperaccumulating plants in China [J]. Journal of Anhui Agricultural Science. 2005, 33(5): 910-912, 916.
[10]. Liu Fang. Research progress on hyperaccumulating plants of heavy metals [J]. Heilongjiang Environmental Journal. 2015, 7(1): 7-12.
[11]. Mao Haili. Filtramtions for Hyperaccunmlators and Abundant plants of Cd in Contaminated Soft [J]. Journal of Qiannan Normal University for Nationalities. 2017, (2): 29-30.
[12]. Mcgrat h S P , Chaudhri A M1 Long term effect s of metals in sewage on soils micro2organisms and plant [J].1 Journal of indust rial microbiology.1995 , 14 : 94-101.
[13]. 2005(06).Cao Deju, Wang Guangyu, Wang Yan, Xiang Jian, Si Youbin. Accumulation of heavy metals in dominant plants growing on mineral areas in Anhui Tongling [J]. Journal of Agro-Environment Science. 2005 (06).
[14]. Li Honglu. Environmental geological problems and governance suggestions in Panzhihua area [J]. Geology in China. 1999, (2): 29-30.
[15]. Zhao Yi, Zhao Baowei. Advances in the Research of the impact of soil pollution on the growth of plant roots [J]. Environmental Science and Management. 2008, 33 (6): 13-16.
[16]. Pankhurst CE, Doube BM, Gupta VVSR. Biological Indicators of Soil health [M]. Wallindord: CAB International, 2007.Pp, l2l- 156.
[17]. Jiang Xingyu, Zhao Kefu. Mechanism of heavy metal injury and resistance of plants [J]. Chinese Journal of Applied and Environmental Biology. 2001, 7(1): 92-99.
[18]. Luo Chunling, Shen Zhenguo. The Mechanisms of Heavy Metal Uptake and Accumulation in Plants [J]. Chinese Bulletin of Botany. 2003, 20(1): 59-66.
[19]. Yang Shengxiang, Tian Qijian, Liang Shichu, et al. Bioaccumulation of Heavy Metals by the Dominant Plants Growing in Huayuan Manganese and Lead/Zinc Mineland,Xiangxi [J]. Environmental Science. 2012.
[20]. Wei Zhaoyang, Chen Tongbin. Hyperaccumulators and phytoremediation of heavy metal contaminated soil:a review of studies in China and abroad [J]. Acta Ecologica Sinica. 2001, 21(7): 1196-1203.
[21]. Bowen HJM.Environmental Chemistry of the Elements.Academic Press,London,1979.243-272.
[22]. Wang Jianhong, Ma Mi. Biological mechanisms of phytoremediation [J]. Chinese Bulletin of Botany. 2000, 17(6): 504-510.
[23]. Ye Yao. A Review of Impact of Coal Mining on Vegetation [J]. Anhui Agricultural Science. 2013, 11(7): 46-47.
[24]. Guo Youhong. Impact of coal mining subsidence on plant diversity in mining areas [J]. Mining Surveying. 2009 (6): 13-155.
[25]. Zhou Ying, He Xiao, Xu Jun, et al. Effects of coal mining subsidence on vegetation composition and plant diversity in Semi-arid Region [J]. Acta Ecologica Sinica. 2009 (8): 4517-4525.