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Study on Heavy Metal Pollution in Soil Around Coal Mining Areas and Its Comprehensive Prevention and Control

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Abstract

In the process of coal resource production, mining, coal washing and coal selection, a large amount of fly ash or gangue and other wastes will be generated. These wastes will cause serious heavy metal pollution to the surrounding surface during the large-scale accumulation. After the soil is polluted by heavy metals, it will inevitably affect the growth quality of crops and even threaten people's life and health. Therefore, it is of great practical significance to discuss the heavy metal pollution problem and pollution sources around coal mining areas and take targeted countermeasures.

Keywords

Coal mine; Soil; Heavy metal pollution; Prevention and control measures

Introduction

As the world's most important energy source, coal provides about 27% of the world's energy every year. The current world coal consumption is also growing. In the process of coal mining, coal washing and coal selection, a large amount of waste such as gangue and fly ash will be generated. These wastes will cause serious pollution to the surface soil during the large-scale accumulation process. Coal mining waste contains a large amount of minerals such as iron sulfide, which are easily weathered or oxidized in the natural environment. The heavy metal elements such as NI, Zn, and Pb contained in them will be released. In view of this, the heavy metal pollution problem in coal mining areas is also a major pollution source problem that needs to be solved urgently. After heavy metal elements enter the soil, not only will the properties of the soil itself change greatly, affecting the productivity of the soil, but also will pollute water sources, crops, etc., causing people's living environment to be destroyed, and even posing a serious threat to people's life and health. Therefore, the problem of heavy metal pollution in coal mining areas has become a current focus of environmental governance.

1. Analysis of the hazards of heavy metal pollution

A large amount of heavy metal elements in the soil will gradually accumulate with the growth of plants and animals, and gradually accumulate in the human body under the influence of the food chain. When the heavy metals in the human body accumulate to a certain extent, they will cause irreversible harm to the human body [1]. For example, when a person ingests a large amount of lead through the food chain, most of the lead will be absorbed by the intestines and gradually diffuse into the human organs and blood tissues, and will also enter the human bones. However, the excretion rate of lead compounds stored in the human body is very slow, which will cause chronic poisoning in

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the human body. When the human body ingests excessive cadmium, it will cause the human body to be unable to fully absorb calcium, which will cause symptoms such as osteoporosis. In this case, the human bones will become soft. Excessive intake of cadmium will cause edema or osteomalacia. In addition, arsenic compounds will flow through the human blood and gather in different tissues, causing poisoning. This heavy metal element is also considered to be one of the most toxic substances. Excessive intake of mercury will cause central nervous system disorders and even cause serious harm to the human digestive system and kidneys. The human respiratory system, blood, eyes, skin and other tissues will be affected. Although cadmium is an indispensable trace element for the human body, excessive intake can cause symptoms such as arteriosclerosis, serious damage to the liver and kidneys, and even cause cancer.

2. Sources of heavy metal pollution in coal mining areas

2.1 Coal mining wastewater discharge causes heavy metal pollution

At present, most coal mining in my country is underground mining. In order to ensure the safety of underground mining, a large amount of mine water will inevitably be discharged during the coal mining process. In addition, different coal mining areas have great differences in geographical location, climate, geological structure, mining depth, etc., which leads to great differences in the quality of mine water in different mining areas. In this case, a large amount of mine water will be discharged into the soil, and the large amount of heavy metal elements contained in the mine water will cause heavy metal pollution in the soil, which reflects uncertainty and complexity.

The heavy metal content in the soil may continue to increase due to the quality of mine water. For example, if the mine water is acidic, the amount of heavy metal elements dissolved will be greater, making it more toxic. In some cases, the expanded heavy metal elements will even have a synergistic effect, which will not only increase the absorption of heavy metal elements by crops, but also increase the harm of heavy metals to the soil. In this case, the production quality of crops will be greatly affected. For most mine water, even after purification, there are still many pollutants in it. Long-term agricultural irrigation operations with these mine waters will inevitably bring serious threats to the soil environment [2]. In addition, the actual discharge of mine water in the process of coal production and mining is very large, and the impact range is also very wide. Affected by people's understanding of mine water and coal mining technology, the heavy metal pollution of soil will become more and more serious. Therefore, it is of great practical significance to study the mechanism and law of soil heavy metal pollution caused by mine water in various parts of China.

2.2 Air pollution in coal mining areas

The production and mining of coal mines will cause serious pollution to the atmosphere in the coal mining area. These large amounts of pollutants will gradually settle on the surface with dust, thus becoming an important source of soil pollution. In a related study on the Hanliang mining area in Pingdingshan, Henan, it was found that coal dust and ash deposition were the main pollution factors among the soil pollutants in the entire Shilong area.

Melting generated during the production, mining, processing and stacking of coal mines will have a certain impact on the soil, and areas far away from the coal mining area will also be polluted by the deposition of large amounts of coal seams and smoke particles floating in the air. After the pollutants settle on the surface, they eventually enter the organisms through the geochemical chain and food chain, thus posing a serious threat to the food safety, ecological safety and social harmony of residents around the mining area [3].

2.3 Solid waste causes heavy metal pollution in soil

A large amount of coal gangue is produced during the production and mining process of coal mines. When the coal gangue is transported to the surface, it is very easy to weather in the natural environment. In addition, the large amount of toxic heavy metal elements contained in it will eventually enter the soil environment under the dissolution and separation of rainwater and surface water, which will cause huge changes in the heavy metal content in the soil of the mining area.

2.4 Heavy metal pollution in coal mine soil

A coal mine was built in the 1970s, with an annual productivity of about 2 million tons. The coal mine has played an important role in the local economic construction, but it has also seriously damaged the local ecological environment during the years of production and mining. In addition, the amount of coal gangue accumulated in the nearby area during the mining process is very large, and surface collapse has occurred in many places, and the heavy metal pollution problem in the surrounding soil is very serious. In order to effectively improve the ecological environment of the coal mining area, it is necessary to repair the surrounding ecological problems. Before repair, it is necessary to conduct in-depth research on the problem of heavy metal pollution in the soil.

Effective remediation of heavy metal pollution in coal mining areas must first evaluate the types, contents and pollution levels of heavy metal elements in the soil in detail. In the process of evaluation, the geoaccumulation index method needs to be used. According to the size of the accumulation index (I), the heavy metal pollution in the soil can be divided into the following levels: I index value below zero indicates no pollution; I index value in the range of 0-1 indicates light-moderate pollution; I index value in the range of 1-2 indicates moderate pollution; I index value in the range of 2-3 indicates medium -intensity pollution; I index value in the range of 3-4 indicates strong pollution; I index value in the range of 4-5 indicates strong- extreme pollution; I index value above five indicates extremely strong pollution. After using professional heavy metal element detection technology to conduct detailed detection of the content of heavy metal elements in the soil of the coal mining area, the detection results are compared with the background values of various heavy metal elements in the region in detail, and the comparison results are evaluated. The specific evaluation results are shown in Table 1 below.

Table 1. Geoaccumulation Index method and evaluation results of heavy metal elements in soil

	Zinc	Lead	Copper	Cadmium	Manganese	Arsenic
Geoaccumulation Index	-0.2364	-0.1267	-0.4985	2.4369	-0.6872	-0.1235
Pollution level	No pollution	No pollution	No pollution	Moderate to severe pollution	No pollution	No pollution

From the above table, we can find that the soil in the coal mining area mainly contains zinc, lead, copper, cadmium, manganese, arsenic and other heavy metal elements. Among them, cadmium is the most seriously polluted, and its pollution level reaches medium-intensity pollution. The content of other heavy metal elements is relatively low, so their pollution can be ignored. Therefore, it can be seen that in the process of treating heavy metals in the coal mining area, the focus should be on the treatment of cadmium elements, and targeted treatment measures should be taken to achieve effective control of the content of heavy metal elements in the soil.

3. Practical application of bioremediation technology in coal mine and soil heavy metal treatment

3.1 Overview of bioremediation technology

The so-called bioremediation technology mainly refers to the addition of corresponding organisms according to the specific type and degree of heavy metal pollution in the soil, using the metabolism of organisms to effectively reduce the concentration of heavy metals in the soil, and effectively inhibiting the activity of heavy metals. In this way, the adverse effects of heavy metals on the soil can be effectively controlled. In the practical application process, there are three main types of bioremediation technology: ecological restoration, phytoremediation, and microbial restoration [4].

3.1.1 Phytoremediation

Phytoremediation of soil heavy metal pollution mainly utilizes the ecosystem composed of plants and symbiotic microorganisms to absorb heavy metal elements in the soil. In the current coal mining area multi- heavy metal pollution control process, the absorption of soil heavy metal pollutants mainly utilizes the absorption, volatilization and stabilization characteristics of hyperaccumulators. The so-called absorption mainly refers to the use of plant roots to absorb heavy metal elements. Volatilization mainly refers to the absorption and accumulation of heavy metal elements by the soil and then converting them into a volatile state. Stabilization mainly refers to the effective inhibition of the activity of heavy metals in the soil by using the function, in this case, the concentration and toxicity of heavy metals are gradually reduced, so as to achieve the effect of removing heavy metal pollutants. At present, there are many species of wild plants in China. Among them, canna, sunflower, Schefflera chinensis and other plants that grow in nature are heavy metal-resistant and hyperaccumulators. They can effectively absorb many heavy metal elements such as zinc, lead, copper, cadmium, etc., and have a good effect on soil heavy metal pollution remediation [6].

3.1.2 Microbial remediation

Microbial remediation of heavy metal pollutants in soil is mainly achieved by using artificially cultivated or wild microbial communities that can demonstrate specific functions. These microbial communities can effectively inhibit the activity of heavy metal pollutants in soil under specific conditions and transform them into non-toxic substances. Microbial remediation of heavy metal pollutants in soil mainly includes three remediation principles: enrichment, adsorption and transformation. Enrichment mainly refers to the storage of heavy metal elements in the soil by microorganisms in different parts or extracellular matrices, while using the metabolism of microorganisms themselves to precipitate heavy metal ions, or to slightly chelate them on soluble or insoluble biopolymers, in this way, heavy metal pollutants are effectively removed or the concentration of agents is controlled. Adsorption mainly uses the negative charge carried on the surface of microbial cells and the various functional groups such as aldehyde groups and amino groups inside them to adsorb and fix heavy metal ions to achieve effective removal, or effectively reduce the toxicity of heavy metal ions. Microbial transformation mainly includes several types such as demethylation, biological redox, and heavy metal dissolution. Using microorganisms to remediate heavy metal pollutants in the soil has some advantages, such as simple operation and low invasiveness to the soil.

3.1.3 Animal restoration

Animal remediation of heavy metal pollution in soil mainly uses animal communities to complete absorption, transformation and decomposition, and through the above actions to achieve effective improvement of the physical and chemical properties of the soil. In this way, the fertility of the soil can be further improved, and it can also have a positive promoting effect on the growth of plants and microorganisms, ultimately achieving effective remediation of heavy metal pollutants in the soil.

3.2 Control of heavy metal pollution in soil in a coal mining area

According to the above analysis, it can be known that the most serious heavy metal pollution in the soil of the coal mining area is cadmium, and its pollution level has reached severe pollution. In the process of selecting plants for remediation, the actual characteristics of soil heavy metal pollution must be fully considered first. After selection, it must be able to effectively absorb the cadmium element in the soil, and at the same time, it must also show a strong enrichment ability. During the growth of the plant, the cadmium element in the soil can be effectively absorbed, and the plant can be harvested and processed after growth, so that the concentration of cadmium in the soil can be effectively controlled. According to existing research, it can be known that Solanum nigrum can show good absorption and enrichment ability for cadmium, so Solanum nigrum was selected in the process of plant remediation of the soil in the mining area. In addition, in order to further improve the effect of Solanum nigrum on the treatment of cadmium in the soil of the mining area, the high cadmium concentration culture medium was fully utilized in the laboratory to cultivate a strain of resistant strains. This strain has a very obvious resistance to cadmium, and can also promote the absorption of planting technology elements by plants.

In order to make a detailed comparison of the application effect of bioremediation technology in the treatment of heavy metal pollution in the mining area, three areas of heavy metal pollution in the coal mining area were randomly divided. In the first polluted area, insect-resistant strains were added before planting Solanum nigrum seeds; the second area was directly planted with Solanum nigrum without any treatment; and the third area was not treated as a control.

3.2.1 Evaluation of the application effect of bioremediation technology

(1) The effect of antibacterial strains on the growth of Solanum nigrum. According to the statistics of the germination rate and average plant height of Solanum nigrum in the first and second areas, it can be found that when the antibacterial strains are not added to the soil, the germination rate of Solanum nigrum can reach 60%, and as an annual plant, the average plant height can reach about 75cm. This fully shows that the growth and survival rate of Solanum nigrum plants in cadmium-contaminated soil is relatively high, and they can show good growth conditions. After adding anti-seed strains to the soil, the germination rate of Solanum nigrum can reach 73%, and after one year of growth, the average plant height can reach 97cm. It can be seen that adding anti-seed strains to heavy metal-contaminated soil can have a good promoting effect on the growth of Solanum nigrum plants. This is mainly because microorganisms can better promote biological metabolism and thus actively promote the growth of reincarnation.

(2) Analysis of the degree of cadmium pollution in the soil of different regions. The nightshade plants in the three

plots were sampled and analyzed after one year of growth, and on this basis, the geoaccumulation index and pollution level of cadmium were evaluated (see Table 2 below for details). By analyzing the table, it can be found that although the geoaccumulation index of the untreated areas has decreased, the decline is not obvious, and it still belongs to medium-intensity pollution. Compared with the control plots, the actual decline rate of the geoaccumulation index in the areas where nightshade was planted and the areas where antibacterial strains were added and nightshade was planted reached 19.87% and 28.66%. It can be seen that nightshade can play a good control role in the concentration of cadmium in the soil.

Table 2. Comparison of cadmium levels in soils from different regions

	Anti-seed strains + Solanum nigrum	Solanum nigrum	5
Geoaccumulation Index	1.6832	1.8973	2.3649
Pollution level	Moderate pollution	Moderate pollution	Moderate to light pollution

4. Conclusion

In the current production and mining process in coal mining areas, heavy metal pollution in the soil is inevitable. Therefore, it is necessary to use advanced technology to effectively control the heavy metal pollution in the soil, so as to avoid the damage of heavy metal pollution in the soil to the human body.

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