Research on the Role and Technology of Microorganisms in the Remediation of Heavy Metal-contaminated Soil in China

Zixuan Zhang

Lund University, Lund, Sweden

757122973@qq.com

Abstract. In the development process of environmental engineering, remediation of heavy metal-contaminated soil is one of the important research directions. Currently, considering the environmental pollution situation in our country, heavy metal contamination constitutes a significant proportion and poses serious threats to the soil environment. Therefore, the remediation of heavy metal-contaminated soil is urgent. Among various soil remediation techniques, microbial remediation technology has shown promising results. This paper begins with an overview of microbial heavy metal remediation techniques. Subsequently, it analyzes the three roles of microbial remediation in heavy metal-contaminated soil. Finally, the research explores the practical application of microorganisms in the remediation of heavy metal-contaminated soil.

Keywords: heavy metal-contaminated soil, microorganisms, remediation, immobilized microbial technology.

1 Introduction

China's economic and social development is still continuing at a high speed, industrial enterprises in such a context are also continuing to expand and grow, and heavy metal materials are very important materials in industrial production and development, so, with the rapid progress and development of industrial society, the emission of heavy metals and the number of uses will only increase, if not take scientific and effective means of heavy metal emissions for good management will lead to China If we do not take scientific and effective measures to manage heavy metal emissions, it will lead to irreversible damage to land resources and will have a huge impact on the human living environment and food safety. At present, there are many kinds of treatment technologies for heavy metal pollution in China, among which the microbial remediation technology has accumulated very mature experience and achieved good results in a large number of practical remediation work, which has many obvious advantages over other remediation technologies [4]. These are very important advantages of microbial remediation technology. Therefore, the research of heavy metal soil remediation technology is of great importance. The research on soil remediation technology for heavy metals is

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of great importance, and the research on soil remediation technology for heavy metals will also become one of the future development trends of sustainable development research projects in China.

2 Hazards and Sources of heavy metal pollution in Soil

Heavy metal pollution of soil has the characteristics of long accumulation time, strong destructive force, and high concealment. Although soil, as an important part of the ecosystem, has the function of self-purification, with the face of powerful heavy metal pollution, the purification function possessed by the soil itself can no longer be regulated. Soil heavy metal pollution will not only lead to serious damage to the natural ecosystem and bring impact the normal growth of crops but also cause serious threats to people's life and property safety [1].

Soil heavy metal pollution refers to the content of heavy metal elements with biological toxicity, such as lead, zinc, cadmium, and mercury, which exceed certain standards and lead to the destruction of the soil's ecosystem. Usually, there are three main ways to cause soil heavy metal pollution.

2.1 Agricultural activities

As a largely agricultural country, China's agriculture is one of the largest in the world, but in the process of agricultural production, some calcium superphosphate and phosphorus-containing fertilizers of substandard quality contain elements such as arsenic, mercury, and lead, which can cause the heavy metal content in the soil to exceed the standard. In addition, some farms in the production process, to improve the growth efficiency of animal husbandry, will use some feed containing heavy metal elements such as copper, manganese, and cadmium zinc compounds, these heavy metal elements cannot be digested by the animals, and eventually excreted with animal manure and enter the soil [9].

2.2 Industrial pollution

With the rapid development of China's chemical industry, a large amount of industrial wastewater and industrial waste gas will be discharged every year, and these discharged wastes also contain many heavy metal elements, which will directly lead to heavy metal pollution of the soil near chemical plants. In addition, some raw materials, and solid wastes in the process of chemical products will also cause heavy metal pollution to the soil along the way during transportation.

2.3 Human life

With the continuous improvement of people's material living standards, more and more cars and electronic products are entering people's life, in which the exhaust of cars con-

tains many heavy metal elements and the wear and tear of car parts in the daily operation process will also produce dust containing heavy metal elements [5]. At the same time, the electronic components and batteries of some electronic products will also lead to heavy metal pollution in the soil when they are discarded at will.

3 Microbial remediation technology for soil heavy metal pollution

Microbial remediation technology for soil heavy metal pollution is to use indigenous soil microorganisms or functional microorganisms domesticated by culture to play the role of adsorption, oxidation-reduction, precipitation, and other effects on one or more heavy metals in order to change the presence of heavy metal elements and reduce the toxicity of heavy metals in soil [2].

3.1 Adsorption

Adsorption is mainly divided into two stages, the first stage is surface adsorption, the surface of microorganisms with a negative charge, the existence of a variety of polar functional groups, mainly through electrostatic adsorption and complexation of functional groups adsorption of heavy metal ions, thereby reducing the uptake of heavy metals by cells. The cell wall components such as phosphoglycans, skin glycans, and glyoxalate phosphoglycans, swollen glycans contain functional groups such as radicals, pressors, and amino groups, and phosphoglycans contain phosphocool functional groups, which can effectively bind metal cations after deprotonation. Some bacteria produce extracellular polymeric substances (EPS) such as lipopolysaccharides [8], glycoproteins, and polysaccharides that contain sites on their surfaces that can provide cation binding and form integration with heavy metal ions. Czaban et al showed that microorganisms in loam produce large amounts of soluble organic matter that can form and integrates with the microorganisms that have a very large surface area and can provide effective binding sites for Cd [7].

The second stage is intracellular accumulation, in which the microorganisms accumulate heavy metals into the microorganisms through active transport. Li et al [6] found that a novel strain of Streptomyces was able to adsorb Zn and Cd to the cell wall and transport them into the cell for accumulation.

3.2 Redox

The redox effect refers to the change in the valence state of heavy metals in soil by the redox reaction of microorganisms, which effectively reduces the toxicity of heavy metals. Siripormadulsil et al showed that iron-reducing and acid-reducing bacteria can reduce the uptake of Cd by rice by complexing with Cd in the soil through redox reaction and reducing the biological effectiveness of Cd. The main application methods are microbial drenching. Microbial drenching has a good application prospect, but due to the

long drenching cycle, soil composition and complex heavy metal form makes this technology is still in the laboratory exploration stage [3]. If we want to accelerate the engineering application of microbial drenching technology in the remediation of heavy metal contaminated soil, I believe that we need to conduct in-depth research in the following aspects:

(1) Since heavy metals are toxic to the growth and metabolism of microorganisms, only by finding highly tolerant microorganisms and understanding their cell structure and genetic metabolism can we significantly promote the application of microbial drenching in the remediation of heavy metal-contaminated soils.

(2) Microbial drenching cycle is long, and the drenching process will be affected by environmental conditions and drenching methods. For different microorganisms and different soil heavy metals, different drenching methods should be selected to optimize the drenching conditions, shorten the drenching cycle and improve the drenching efficiency.

(3) Different forms of heavy metals in the soil have different biological effectiveness, toxicity, and mobility. The mechanism of interaction between microorganisms and different heavy metal forms should be studied to target the removal or transformation of heavy metal forms in soil with high toxicity, high bio effectiveness and high migration capacity.

4 Research on the role of microorganisms in the remediation of heavy metal-contaminated soil

4.1 Remediation of contaminated soil using bacteria

There are many types of microorganisms, and many of them are useful for soil remediation and degradation. Bacteria are one of the effective microorganisms for heavy metal adsorption. The cell surface of bacteria has a distinctly different structure from other microorganisms, and they can use their own cell walls to adsorb heavy metal ions well, and this adsorption ability is more stable and can achieve long-term adsorption effect. At the same time, in the heavy metal contaminated soil, this heavy metal resistant bacteria will have stronger adsorption ability and survival ability, through the metabolism of their own structure, the adsorption of heavy metal substances on the cell surface to fully precipitate and metabolize, and through their own bacterial cell structure to reintegrate and dissolve heavy metal ions, so as to well reduce the toxicity of heavy metals. If the bacteria reach a certain size and number of bacteria in the contaminated soil, they can effectively influence the soil structure in a detailed manner and exert a good degradation effect. From the existing research theories and experimental results, a variety of bacteria have been proven to have good soil remediation effects, for example, Pseudomonas, Micrococcus, Rhizobium, Streptomyces spp., and Bacillus, etc. The most successfully studied bacteria is Bacillus, and according to the relevant experimental data, the maximum adsorption of heavy metals by Bacillus can reach 363 mg/g, while the adsorption amount for single ion Cd is about 196 mg/m [10].

4.2 Remediation of contaminated soil using fungi

Fungi consist of mycelium and spores, mycelium branching into clusters to form mycelium can be several times or even dozens of times larger than bacteria, and the extensive branching mycelium can passively absorb metal ions through functional groups on the cell wall or combine with specific enzymes to actively transfer to the intracellular formation of intracellular precipitation. However, compared with bacteria, fungi have more stringent requirements for soil environment and often grow slowly in heavy metal-contaminated soil, the number and species do not meet the requirements of degradation, so it is necessary to select suitable immobilization materials to provide relatively high-quality and stable growth environment for fungi, for example, the use of magnetic nanomaterials and calcium alginate co-immobilized yellow spore protochlorophyllum found that immobilization technology increases the mechanical strength and stability of mycelium The immobilization technique increased the mechanical strength and stability of the mycelium and improved the processing efficiency.

4.3 Use of plants for remediation of contaminated soil

In nature, some plants have good heavy metal adsorption capacity and can adsorb heavy metal pollutants from contaminated soil into their own rhizomes, thus reducing the heavy metal content in the soil in their area. Phytoremediation technology is the use of such plants, with the assistance of biotechnology or chemical technology, to adsorb, transform and degrade the heavy metal pollutants in the soil. From the point of view of the implementation effect, phytoremediation technology with its low cost, high safety, less destructive to the soil, green and environmental protection and other significant advantages in the heavy metal contaminated soil remediation work has been widely used. In China, after years of unremitting research, we have found a plant that is generally suitable for the remediation of heavy metal-contaminated soil in most areas and different types of heavy metal-contaminated soil in China, namely Centipede grass. Centipede grass can play a good adsorption role for many kinds of heavy metal pollutants such as zinc, lead, and arsenic in the soil, and can be applied to most of the areas polluted by heavy metals in China.

5 Conclusion

Soil heavy metal pollution remediation has always been a challenge that needs to be taken seriously in China, and microbial techniques for remediation of contaminated soil are safer and more friendly than physical and chemical remediation, and more active and efficient than free microorganisms. In summary, microorganisms have a very important role in the remediation of heavy metal-contaminated soils. Therefore, in the future development process, the application of microorganisms in the remediation of heavy metal-contaminated soil should be innovated for different microbiota and their application effect should be continuously improved to achieve the goal of improving the soil environment and ensuring the sustainable development of the soil environments.

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