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Research on Microbial-Plant Combined Remediation Technology of Petroleum Contaminated Soil

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Abstract

Soil pollution caused by petroleum has become an urgent environmental problem in the world. Microbial-plant combined remediation technology has been widely valued in the field of petroleum-contaminated soil remediation because of its environment-friendly and low-cost characteristics. This paper focuses on the main pathways, mechanisms and influencing factors of microbial-plant combined remediation of petroleum-contaminated soil, and prospects the problem of microbial-plant combined remediation, in order to provide a theoretical basis for the application prospect of microbial-plant combined remediation in petroleum-contaminated soil remediation.

Keywords

Petroleum contaminated soil, Bioremediation, Combination remediation.

1. INTRODUCTION

As one of the most important energy sources for human beings, petroleum is widely used in people's daily life. However, due to factors such as poor management or accidents, petroleum pollutant leakage will occur in the process of extraction, transportation, storage and use of crude petroleum and petroleum products, especially near major petroleum fields. According to statistics, about 8 million tons of crude petroleum enter the environment every year around the world, causing serious pollution to available agricultural soil, groundwater sources, rivers, and lakes.[1] Petroleum entering the soil causes serious pollution to the environment, and the pollution is mainly concentrated in the depth range of about 20cm on the surface.[2] After soil pollution by petroleum, organic matter and carbon content increase significantly, serious lack of nutrients, such as nitrogen and phosphorus, and changes in soil pH destroy the growth of indigenous microorganisms, which in turn affects the intake of nutrients by surface crops and destroys the local ecological environment.[3] The problem of environmental pollution caused by petroleum spills has become a worldwide problem. Therefore, researchers continue to explore new technologies and methods to remediate petroleum-contaminated soil, especially

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economical, efficient and environmentally friendly microbial-plant combined remediation technology, which has attracted more and more attention from researchers.

Microbial-plant remediation technology is a new method that requires screening organisms that can metabolize petroleum pollutants through physiological and molecular processes from a large number of plants, bacteria, fungi and other organisms, while taking into account the high level of environmental adaptability of microorganisms and plants in petroleum-contaminated soil as well.[4] Therefore, the application of locally grown organisms to remediation practices may be more promising and cost-effective in specific contaminated sites. The microbial-plant combined remediation strategy implemented by introducing exogenous organisms needs to rely on a large number of screening work in the early stage in order to obtain microorganism-plant combinations with clear degradation functions for petroleum pollutants and strong environmental adaptability, and the use of the combination cannot produce fatal toxic effects on each other, which puts forward extremely high requirements for the establishment of such combined systems and increases the difficulty of research. Therefore, when applying microbial-plant combined remediation technology, the selection of indigenous organisms and exogenous organisms should be carried out according to the source of petroleum-contaminated soil to achieve the best remediation effect.

2. SOURCES OF PETROLEUM-CONTAMINATED SOIL

2.1. Leakage during petroleum extraction

When exploiting crude petroleum, petroleum spills sometimes occur, and the leaked crude petroleum is often difficult to collect. A large amount of crude petroleum enters the soil, causing harm to the surrounding animals, plants and microorganisms, resulting in serious damage to the ecosystem of contaminated soil, especially the content of petroleum hydrocarbons in the soil near the petroleum field far exceeds the soil background value[5].

2.2. Improper disposal of petroleum solid waste

Oily solid waste mainly includes petroleum sludge, petroleum sludge, etc. Due to the high concentration of toxic substances in waste drilling mud and petroleum sludge, if it is not properly disposed, it will cause serious pollution and damage to the environment. After it enters the terrestrial environment, it will cause changes in the physical and chemical properties of the soil. Contamination of soil with petroleum solid waste may cause nutrient loss, inhibiting seed germination and plant growth in the soil[6].

2.3. Sewage irrigation

Factory wastewater from petroleum exploitation, smelting and some enterprises related to petroleum production and processing discharge, some other industrial wastewater and domestic sewage in the content of petroleum hydrocarbons are high. These sewage without treatment directly irrigated farmland will lead to petroleum pollution of farmland soil, damage farmland soil properties, and affect the safety of agricultural products.

2.4. Air pollution and automobile exhaust emissions

In the process of petroleum exploitation, processing, refining, transportation and use, some volatile components will enter the atmosphere, and then combine with particulate matter in the atmosphere to form dust precipitation or enter the soil with rainwater. In addition, the exhaust gas of various motor vehicles fueled by gasoline and diesel also contains a large amount of incompletely burned petroleum hydrocarbons, which enter the air and then enter the soil with particulate matter or rainwater.

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2.5. Pharmaceutical pollution

After petroleum is processed into many other chemicals such as emulsifiers, herbicides, pesticides and solvents, with the use of these products, large amounts of petroleum hydrocarbons enter the soil, causing soil pollution.

3. MICROBIAL-PLANT COMBINED REMEDIATION TECHNOLOGY

3.1. The mechanism of microbial-plant combined remediation technology

In the soil microecosystem, plants and microorganisms establish a combined restoration system through symbiosis, giving full play to the complementary advantages between the two and improving the restoration rate. In the combined remediation of microorganisms and plants, the principle mainly uses the interaction between plants and microorganisms to adsorption, decompose and degrade the petroleum hydrocarbon content in the petroleum sludge, and then restore the contaminated petroleum sludge soil to the healthy state of the agricultural soil.[7]

The repair mechanism includes: 1. The growth of plant roots has a reciprocal effect with the soil around the root system, and further changes the soil aeration, water holding capacity, compaction, etc. 2. Plant roots release various enzyme substances during growth, which can catalyze petroleum hydrocarbon organic pollutants and further increase the humification rate of petroleum hydrocarbons. 3. After the combination of the plant root system and high-efficiency petroleum hydrocarbon degrading bacteria, the rhizosphere effect will be produced, and the effect of plant rhizosphere soil and plant adsorption and migration transformation into petroleum organic pollution will be accelerated. 4. As plants grow, the root system produces partial shedding and root secreted substances, which can provide metabolism for hydrocarbon organic matter. 5. In combined restoration, the rhizosphere effect of root production can improve the diversity and richness of microbial communities in rhizosphere soil, and enrich the dominant flora with efficient degradation of petroleum hydrocarbons[8-10].

3.2. Influencing factors of microbial-plant combined remediation technology

3.2.1 Physical and chemical properties of soil

Soil type, soil water content, and porosity affect the restoration effect. Studies have shown that the higher the content of clay and organic matter in the soil, the greater adsorption capacity of petroleum pollutants and the lower bioavailability of petroleum.[11] In addition, the number and activity of microorganisms in the soil need to be guaranteed by appropriate water content. Moreover, most of the microorganisms used for remediation are aerobic microorganisms, and the size of soil porosity affects the oxygen content of the soil. Li reported that the suitable soil moisture content when remediating petroleum pollution with solid fungi is 25%, and the degradation rate of petroleum can reach 40.25%. Reducing the water content lead to a worse restoration effect, while continuing to improve the water content does not improve the restoration effect much.[12] The suitable porosity of the soil is 55% (the degradation rate of petroleum can reach more than 40%), reducing the porosity is not conducive to bioremediation, and continuing to increase the porosity does not improve the restoration effect much, but affects the soil water holding capacity and increases the frequency of water recharge.

3.2.2 Petroleum pollution concentrations

Oil pollution concentration is an important influencing factor in remediation, affecting the survival and adaptive ability of microorganisms. Zhang found that in the early stage of restoration, microorganisms in soil with low crude petroleum concentration can adapt to the environment faster than that in soil with high crude petroleum concentration, so the degradation rate in the initial stage is higher; while in the later stage of restoration, microorganisms in soil with high crude petroleum concentration have a longer proliferation

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and adaptation period than that in soil with low crude petroleum concentration, so the number of microorganisms and degradation capacity are higher, and petroleum degradation is faster.[11]

3.2.3 Nutrients

The growth of microorganisms requires C, N, P and other nutrients, in the process of microbial remediation in petroleum-contaminated soil, the C required by microorganisms is mainly derived from petroleum pollutants, and the content and proportion of N and P elements in the soil generally cannot meet the needs of microorganisms to degrade petroleum. Therefore, in the process of microbial remediation of petroleum-contaminated soil, nutrients containing N and P need to be added.[13] The ratio of N/P in nutrients and the continuous supply of nutrients both affect the repair effect.

3.2.4 Plant roots

The root system is a unique microenvironment and it is able to influence the structure and distribution of microorganisms. The interaction between plants and microorganisms has a strong root effect that promotes decomposition. Studies have shown that plant roots provide indigenous microorganisms with the nutrients they need through secretions, which improves biological activity and metabolic capacity, and then enhances the degradation of petroleum pollutants in contaminated soils.[14] Reilley found that phytoremediation can not only increase the density of indigenous organisms in the plant rhizosphere, but also improve the degradation effect of petroleum hydrocarbons. [15] Child used five kinds of microbial bacteria to impregnate barley seeds, and after germination, the seeds will directly adsorb mycobacteria on the root surface. As the plant grows, the intricate root system makes the degrading bacteria distributed in different soil layers, increasing the degradation rate of pollutants.[16] In addition, root cells and decaying roots also produce secretions that provide nutrients for the growth of microorganisms. Plant root growth and extension can increase soil porosity, which in turn increases the exchange of air between soil and atmosphere, promoting microbial reproduction in the wider soil. The number of microorganisms in rhizosphere soil is generally 5-15 times, even up to 100 times that of the number of microorganisms in plant-free soil. When using plants for restoration, plants with large root systems and more whiskers are generally selected, because the growth of roots can better promote the interaction between plants and microorganisms. Microorganisms can effectively break down pollutants into root exudates based on their composition and plant species. Therefore, better utilization and regulation of the interaction between plants and microorganisms is an important prerequisite for creating healthy soils.

4. CONCLUSIONS AND PERSPECTIVES

At present, the practical application of bioremediation is still lacking. In order to make it widely used, it is necessary to strengthen research from the following aspects:

(1) The petroleum degradation effect of exogenous strains is often affected by indigenous strains, resulting in poor results, and the compounding mechanism between compound strains is not clear, resulting in the exploration stage of a large number of attempts to deal with compound strains. Therefore, on the basis of discussing the mechanism of petroleum degradation by various microorganisms, the antagonism and synergy mechanism between various microorganisms should be deeply explored to provide a theoretical basis for the compounding and application of strains.

(2) The microbial remediation of petroleum-contaminated soil is greatly restricted by the petroleum properties and the environment, and it is difficult to remediate under certain special geographical conditions, so further research is needed to improve the effectiveness of bioremediation, such as heavy petroleum-polluted soil, aging petroleum-polluted soil, and petroleum-polluted arid and saline-alkali land.

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(3) Bioremediation requires continuous addition of nutrients and biosurfactants, and the preparation of fungi agents is also more complicated and relatively expensive. how to effectively reduce the cost of remediation is also an inevitable problem.

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