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Advances in Research on Rehabilitation of Plants on Petroleum Pollution Soil

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Abstract

In the process of oil extraction, refining, transportation and use, there is a chance of entering the soil environment. If its quantity and speed exceed the range of soil self-purification ability, it will have a serious impact on the structure and function of the soil, resulting in the decline of soil quality, affecting the normal development of plants grown in the soil, even enriching in crops, and ultimately affecting human health through the food chain. Therefore, it is urgent to repair the soil contaminated by oil. Among the many repair methods, phytoremediation has the advantages of high efficiency, safety, low cost and environmental friendliness. This paper mainly introduces the mechanism of phytoremediation of oil-contaminated soil, plant species for remediation and some methods to improve efficiency of phytoremediation.

Keywords

Oil pollution; Soil pollution remediation; Phytoremediation.

1. INTRODUCTION

According to a large amount of relevant data, the pollution of oil to soil mainly comes from the application process of oil spill, leakage, sewage irrigation, oil shale slag stacking, atmospheric deposition, medicament and so on. According to statistics, about 1×10^9 t per year worldwide petroleum and its petroleum products enter surface water, groundwater and soil in various ways, of which China has 600000 t, while some petrochemical areas in China contain as much as 1×10^4 mg/kg, newly contaminated soil 1×10^8 kg per year. The area of contaminated soil per oil well is 200~500 m^2, China owns about 2×10^5 t oil wells, can cause soil pollution area is 8×10^7 m^2, and that number is growing. After the petroleum material enters the soil, it will first cause the soil blockage, make it salinization, asphaltization, encrustation, water permeability decrease. Then, because the reaction group in petroleum hydrocarbon material binds with inorganic nitrogen and phosphorus in soil and limits nitrification and dephosphorylation, it will reduce the available phosphorus and nitrogen content of soil, and will also cause the decrease of soil microbial quantity and soil activity [1]. The petroleum pollutants in soil are mainly hydrocarbons, halogenated hydrocarbons and other inorganic components, which are mostly carcinogenic, teratogenic and mutagenic. Once humans eat crops produced on contaminated soil, their health will be threatened.

The remediation methods of petroleum contaminated soil mainly include chemical method, physical method, microbial method and phytoremediation method. The treatment of soil organic matter pollution by physical method and chemical method is expensive, the process is very complicated, and it may cause secondary pollution. Phytoremediation is a remediation method that uses plants to transform, transfer and accommodate heavy metal pollutants, thus reducing their content and concentration. It belongs to in-situ remediation technology and has low cost and almost no secondary pollution, so it has been widely used in recent years.

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2. MECHANISM AND METHODS OF PLANT RESTORATION OF OIL-COTAMNINATED SOIL

2.1. Plant Fixation

Plant fixation refers to the absorption and adsorption of pollutants by the root surface of plants, thus preventing the migration of pollutants in soil through diffusion, infiltration and so on. The cell wall of plant roots binds to pollutants under the action of related enzymes and proteins, so that they are fixed outside the cell membrane. Some enzymes can also promote pollutants through the cell wall and cell membrane into the vacuole. It can also play a fixed role. The use of plant fixation does not remove pollutants, but temporarily immobilizes them so that they do not damage the environment.

2.2. Plant Degradation

The mechanism of plant degradation is that pollutants are absorbed by the roots of plants and degraded by the transport of plant tissues, which participate in the metabolic process of plants or by the action of compounds secreted by plants, eventually transformed into an intermediate metabolite of carbon dioxide, water, less toxic, or essentially nontoxic, that is readily absorbed and emitted by plants [2].

2.3. Plant Volatilization

Plant volatilization refers to the release of volatile components and some metabolites into the atmosphere through transpiration of plant stems and leaves after pollutants are absorbed by plants, thus effectively preventing the invasion and pollution of soil by organic pollutants. Hydroxyl is an oxidant formed in photochemical cycle. Many difficult pollutants in underground environment react with them quickly after entering the atmosphere, so that the pollutants can be degraded.

2.4. Rhizosphere Degradation

Rhizosphere degradation is the degradation of auxiliary microorganisms in plant roots, which can significantly reduce the persistence and toxicity of petroleum pollutants. First, the non-root part of plants provides nutrients to the roots of plants, promotes their growth and secretion of related organic substances, and increases the availability of petroleum pollutants. Finally, the roots create a multi-nutrient environment to enhance the metabolic activities of the surrounding microbial communities. This is the most important way for plants to degrade organic matter, promote the growth and reproduction of root microbes through the action of root exudates, and plant planting can also promote the oxygen supply of root soil. These are beneficial to the degradation of organic pollutants [3].

2.5. Plant Extraction

Plants absorb pollutants from the soil to the harvested parts of the root and the stems and leaves of the plant, and when the plants are harvested, the pollutants will be taken away, thus avoiding the invasion of the soil. Plant extraction is more efficient for pollutant removal, Ling Wanting and others [4] studied the absorption of PAHs and pyrene in soil by 20 plant roots, and concluded that the contents of phenanthrene and pyrene in different plant roots were positively correlated with the fat content of roots.

2.6. Plant Extraction

Rhizosphere filtration is the absorption, adsorption and precipitation of pollutants by plant roots, forming a root filtration system to remove pollutants, and generally using plants with developed roots.

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3. MAJOR CATEGORIES OF PLANTS FOR REMEDIATION OF SOIL OIL POLLUTION

Generally speaking, plants that can be used for petroleum hydrocarbon contaminated soil remediation should have the characteristics of high pollution concentration and developed root system. At present, there are more than 400 kinds of plants found in the world that can be used for soil remediation [5].

3.1. Herbs

Herbaceous plants refer to a plant with underdeveloped xylem, less lignified cells and weak support. Herbaceous plants are generally very short, short life, weak stem, most of the end of the growing season on the ground or the whole plant body died. According to the length of life completed, divided into annual, biennial and perennial herb [6]. Herbaceous plants are the most used plants to repair petroleum hydrocarbon pollution in soil.

There are many species of herbs that repair oil pollution, the repair effect is relatively good. Guo Junquan [7] studied on the remediation of oil contaminated soil by forage plants, Five herbage plants, planted in oil - contaminated farmland, by measuring the change of petroleum hydrocarbon content, plant germination rate and biomass, therefore, the soil remediation ability of several forage plants is as follows: Medicago sativa > Astragalus adsurgens > Trifolium pratense > Trifolium repens > Puccinellia distans. Jing Mingbo, Zhou Tianlin et al. [8] selected four native plants on the Loess Plateau as experimental materials, determination of total petroleum hydrocarbon (TPH) degradation rate, number of degraded bacteria and response of some growth indexes in rhizosphere soil of tested plants under different oil pollution concentration stress. It turns out, degradation rates of rhizosphere THP Medicago satiua and Calendula officinalis were higher in mild contamination, when heavily contaminated, compositae plants were significantly higher than leguminous plant. Yu Yilei et al. [9] used outdoor potted plants to carry out experiments on Suaeda glauca remediation of crude oil pollution, the results showed that the degradation efficiency of Suaeda glauca for low pollution level crude oil is higher than other treatments. Guo Junquan et al. [10] to study the effect of wild plants on the remediation of oil-contaminated soil, take the abandoned oil well area, ten kinds of wild plants as the research object. It turns out, when soil oil is low, Chloris virgata, Agropyron cristatum, Bothriochloa ischaemum have a higher concentration of petroleum hydrocarbons, when the oil content is high, Artemisia gmelinii, Artemisia scoparia have a higher concentration of petroleum hydrocarbons.

Herbaceous plants have simple planting methods, low planting costs, fast early growth, large roots, and a wide variety of species. It is proved that many varieties have good effect on the remediation of petroleum contaminated soil. Therefore, it has great research potential.

3.2. Vines

Xylophytes are strong plants whose roots and stems grow thicker to form a large number of xylem, and the cell wall is also mostly lignified. The xylem of plants is developed, and the stems of plants are more developed and perennial. Woody plants are divided into trees, shrubs and semi-shrubs because of plant height and branching position. Woody plants are not widely used in the remediation of petroleum contaminated soil, and the remediation effect is slightly higher than that of herbaceous plants.

Dong Yaming et al. [11] show that, Elaeagnus angustifolia and Tamarix chinensis remediate contaminated soil for 80 d, Petroleum hydrocarbon removal rate can reach 26.50%~31.27%, The remediation of saturated hydrocarbons is the best, can reach 39.34%~46.18%. Yu Qi et al. [12] evaluated the degradation ability of petroleum hydrocarbons in soil with different litter leaves, The results showed that the best remediation effect of soil oil pollution was Melia

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azedarach and Amygdalus persica, the better order is Morus alba, Sophora japonica, Salix babylonica, Acer mono and Prunus Cerasifera. Ucisik et al. [13] studies show, for phenol contamination (concentration not exceeding 250 mg ·L-1) of Artemisia annua, the soil and water body have good remediation effect. Corseuil et al. [14] tests found that Salix babylonica can withstand up to 2 000 mg·L-1 of ethanol, within 7 d, from 1% in hydroponics 360 mg·L-1Down to 9 mg·L-1, the concentration of benzene also decreased by 99%, and its purification efficiency was related to transpiration rate. Da Cunha et al. [15] studies have found that Salix babylonica can reduce the concentration of pyrene in soil from 23.06 to 0.1μg·kg-1.

According to various studies, there are few species of xylophytes used to repair petroleum contaminated soil, and Salix babylonica are widely used.

3.3. Vines

Vine is a plant whose stems are long and can not grow upright and must cling to other objects and climb upward. According to the texture of their stems, they are divided into grass vines and wood vines. Vines save energy used to grow and support tissues, can effectively absorb sunlight, vines are widely distributed, most of them have developed roots and strong germination power. Less vines are used to repair petroleum pollution.

Jiao Chunhua et al. [16] studied the effect of Pharbitis nil on soil microorganisms and petroleum hydrocarbon degradation in oil-polluted saline-alkali soils. The results show, the degradation rate of petroleum hydrocarbons in different seasons of Pharbitis nil was significantly different, with 22.3% in spring, 51.8% in summer and 38.0% in autumn. Peng Shengwei [2] found that the planting of Pharbitis nil had a significant effect on the degradation of petroleum hydrocarbons, and the degradation rate reached 1.9~2.7 times of natural degradation. However, the multiple relationship between planting Pharbitis nil and natural degradation did not decrease, but slightly increased.

There are few studies on the degradation of petroleum hydrocarbon pollution by vines. At present, Pharbitis nil has a good ability to degrade petroleum.

4. METHODS AND TECHNIQUES TO IMPROVE THE EFFICIENCY OF PHYTOREMEDIATION TECHNOLOGY

The phytoremediation is green and environmentally friendly, does not produce secondary pollution, and has been widely used in soil remediation. However, the main problem of phytoremediation is its low remediation efficiency. Phytoremediation should not only select plants with high remediation ability, but also improve plant remediation efficiency, including the following aspects.

4.1. Genetically Modified Engineering Technology

Genetic conversion technology can improve the biomass of Hyperaccumulator, or clone Hyperaccumulator and plants that secrete biodegradable enzymes to promote the efficiency [17] of phytoremediation. This method has great prospect, but its application is limited at present.

4.2. Genetically Modified Engineering Technology

By improving agricultural tillage technology, plant restoration efficiency can also be improved. Reasonable fertilization and addition of organic carbon sources can promote plant growth and microbial activity, thus improving phytoremediation efficiency.

4.3. Plant-Microbial Combined Restoration System

Combined plant-microbial remediation technology refers to the technical of enriching, fixing and degrading organic pollutants in soil by using plant-microbial composite system [18]. Plants and microorganisms are mutually beneficial in the process of growth. Microorganisms can

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secrete organic acids, iron carriers and other substances to change the state of pollutants in the environment, thus reducing their toxicity, reducing the invasion of organic pollutants on plants, improving plant tolerance and promoting the absorption, transfer and enrichment of organic matter plants [19]. At the same time, plants also promote the activity of microorganisms and improve the ability of microorganisms to repair organic matter. Combined plant-microbial repair technology mainly includes the combined repair technology of plant and rhizosphere microorganism, the combined repair technology of plant and mycorrhizal bacteria, the combined repair technology of plant and endophytic bacteria and the combined repair technology of plant and specific degrading bacteria, etc .[20] A large number of studies have shown that plant-microbial combined remediation technology is the most effective technology to repair organic pollution at present, and the remediation effect is obviously better than that of single phytoremediation.

5. CONCLUDING REMARKS

Nowadays, the use of oil in the world is increasing year by year, which will inevitably cause soil pollution in the process of oil exploitation and use. Therefore, it is urgent to repair soil oil pollution. Among the many remediation techniques, phytoremediation is more advantageous than physical and chemical remediation because of its low price and no secondary pollution. Improving the efficiency of phytoremediation is the focus of research. A large number of experiments show that microbial-plant combined remediation is more efficient than single phytoremediation, which is worth studying and popularizing.

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