Analysis of Bio-in-situ Remediation Technology of Petroleum Contaminated Soil Based on Enhanced Electric Power

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Abstract. In order to explore the strengthening effect of the electric field on biodegradable oily soil, through designing 5 gradient electric fields of 0V / m, 50V / m, 100V / m, 200V / m, and 250V / m, the growth and reproduction changes and behavioural dynamics of the electric field on organisms were studied the impact of learning. On this basis, the effects of electric field on the oil-lowering ability of organisms, the accompanying migration characteristics of populations, in situ active replenishment, and the distribution characteristics of nitrate ions and sulphate ions in oily soils were analysed. The results show that when the electric field strength is 100V / m, the biological growth and reproduction rate is the highest, the number of bacteria is the largest, and the loss of nitrogen nutrients is the smallest; the effect on the oil-reducing ability of the oily soil is accordingly coupled effect > single bacteria effect > single electricity effect. It shows that the effect of electric field coupling bioremediation technology on oily soil is remarkable.

1. Introduction
Soil is an important natural resource on which human beings depend for survival and development, but in recent years oil has increasingly polluted the natural environment. Oil pollution mainly comes from accidents such as oilfield exploration, oil and gas extraction, and leakage of petroleum products during transportation and processing. According to statistics, China's petrochemical companies produce 7 million tons of oil per year. The wellhead around the oil refining area is the most polluted area, and the scope of pollution will continue to expand with the accumulation of pollutants and the spread of rainwater. In the past 10 years, PAHs, as the most widely distributed class of polycyclic aromatic hydrocarbon organic compounds, have attracted much attention because of their hydrophobic ester affinity, persistent pollution, stubborn stability, mutagenesis, and carcinogenicity. The US Environmental Protection Agency has listed 16 of these PAHs as priority pollutants. The long-term accumulation of polycyclic aromatic hydrocarbon pollutants in the ecosystem will cause serious harm,
mainly in the following aspects: it will destroy the structure and function of the soil ecosystem, reduce soil permeability and water permeability, and reduce soil compaction and fertility; It will form an oil film on the surface of the water body, causing a large amount of hypoxia of aquatic organisms; it can directly enter and pollute the groundwater source, affecting residential water use and agricultural irrigation; it can seriously harm human health through the bioconcentration of the food chain [1].

2. Bioremediation technology

Bioremediation of contaminated soil refers to the use of specific organisms (plants, microorganisms or protozoa) to absorb, transform, remove or degrade environmental pollutants, to achieve environmental purification, ecological effects recovery biological measures, as shown in Figure 1. Contaminated soil bioremediation is divided into in situ bioremediation and ectopic bioremediation. In situ bioremediation mainly includes bacteriostatic method, biological aeration method and air diffusion method, land cultivation method, plant remediation method and plant-mycorrhizal remediation method; ectopic bioremediation is divided into ectopic solid-phase bioremediation and Ectopic liquid phase bioremediation. Ex-situ solid-phase bioremediation mainly includes composting and biological prefabricated bed methods. Ex-situ liquid-phase bioremediation mainly includes bioreactor method, soil slurry reactor method and anaerobic biological treatment method [2].

The basic principle of bioremediation is to use natural microbial resources in the soil or artificially added strains for the purpose, or even add the constructed specific degrading functional bacteria to each contaminated soil to quickly degrade and convert the remaining pollutants into harmless substances. Restore the soil to its natural function. Since the natural bioremediation process is generally slow and difficult to be practically applied, bioremediation technology is bioremediation under artificially promoted conditions, by changing the soil physical and chemical conditions (temperature, humidity, pH, aeration and nutrition, etc.), or inoculation special Domesticated and constructed engineering microorganisms use the degradation of microorganisms to remove petroleum hydrocarbons and various toxic and harmful organic pollutants in the soil. Because there are many factors that affect the bioremediation technology of petroleum-contaminated soil, which mainly depends on the characteristics of the pollutants themselves, the ecological structure of the soil microbes and the environmental factors in the soil, a series of strengthening measures should be taken in the process of biochemical treatment of petroleum pollution.

![Figure 1. Bioremediation of contaminated soil](image)

2.1. Concept, characteristics and classification of biosurfactants

Surfactant (SAA) is a type of macromolecular substance that can significantly reduce the liquid-liquid and solid-liquid surface tension, and has a certain structure and adsorption characteristics. SAA is amphiphilic: it is both hydrophilic and hydrophobic. SAA can be divided into two categories:
chemical surfactant (CS) and biological surfactant (BS) according to its source. CS is a type of synthetic polymer compound, which can be divided into ionic, non-ionic and other special surfactants. BS is a kind of surface-active metabolites secreted by bacteria, fungi and other organisms during their growth under certain physical and chemical conditions. Common sources and physical and chemical properties of CS and BS are shown in Table 1.

Table 1. Common sources and physical and chemical properties of CS and BS

| Serial number | kind                                | Surface tension (mN / m) |
|---------------|-------------------------------------|--------------------------|
| 1             | Sodium dodecyl sulfonate            | 37                       |
| 2             | Tween -20                           | 30                       |
| 3             | Cetyltrimethylammonium bromide      | 30                       |
| 4             | Linear alkyl benzene sulfonate      | 47                       |
| 5             | Rhamnolipid                         | 25-30                    |
| 6             | Chlorolipid                         | 30-37                    |
| 7             | Trehalas                            | 30-38                    |
| 8             | Subtilisin                           | 27-32                    |

| Serial number | Interfacial tension (mN / m) | CMC (mg/L) |
|---------------|------------------------------|------------|
| 1             | 0.02                         | 2.12       |
| 2             | 4.8                          | 600        |
| 3             | 5                            | 1300       |
| 4             | 1.0                          | 590        |
| 5             | 0.05 to 4.0                  | 5-2000     |
| 6             | 1.0 -2.0                     | 17-82      |
| 7             | 3.5 -17                      | 4-20       |
| 8             | 1                            | 23-160     |

2.2. The mechanism of action of surfactants

The application of SAA technology to the microbial treatment technology for remediation of oil contaminated soil is an engineering technology that has emerged in recent years. SAA can promote the analysis and dissolution of PAHs adsorbed in soil particles, improve bioavailability, and greatly improve the degradation effect of microorganisms on PAHs. SAA is easily adsorbed on the interface of two phases because it contains amphoteric groups, which obviously reduces the interfacial tension between the two phases. When the concentration of SAA in the liquid phase is low, it will exist as a monomer and be adsorbed at the water-gas two-phase interface. As its concentration in the solution continues to increase, its surface tension gradually decreases. When the concentration of SAA increases after reaching a certain critical concentration, the surface tension drops to a minimum, and will not change in the future. Too many SAA molecules or ions form an association from the dispersed state, that is, micelles. The initial concentration of SAA to form micelles in solution is called the critical micelle concentration (CMC). At this concentration, the solution begins to have the ability to dissolve insoluble PAHs [3]. The physical properties of the solution will change with the change of SAA concentration, as shown in Figure 2.
3. Electric power experiment

3.1. Experimental design
The test device is welded by an iron frame of 1.6m × 0.8m × 0.6m, with a wooden baffle inside. The electric field intensity has 5 gradient electric fields of 0 V / m, 50 V / m, 100 V / m, 200 V / m and 250 V / m. Stir the oily soil with sawdust and W-5 in a certain proportion, then put it into the box and insert the graphite electrode and temperature / humidity sensor. Replace the electrode and sensor direction once a day, sample every 3 days, every 5 days turn over the pile once, and perform artificial water replenishment according to the detection condition of the temperature / humidity sensor to keep the water content at about 45%. Each data is measured three times in parallel, and the average value is taken.

3.2. Test index and measuring method
Test indicators: strain growth curve, strain number distribution, strain migration characteristics, nitrate content, sulphate content, oil reduction rate. The growth curve of the strain is measured regularly by the turbidimetric method to determine the optical density OD value of the culture solution, and the growth curve of the bacteria under certain conditions can be obtained; the distribution of the number of bacteria and the migration characteristics are separated and cultured by the coated plate, and the blood count method is used. The determination was carried out; the nitrate content was determined by the phenol disulfonic acid method; the sulphate content was determined by the ICP-AES method; the oil reduction rate was determined by the solvent extraction method [4].

3.3. Results

3.3.1. Effect of electric field on microbial growth and reproduction. As shown in Figure 3, the growth curve of the strain under the effect of the gradient electric field basically conforms to the process from the logarithmic phase to the stable phase. Using the treatment group without electric field as 0V / m as a control, it can be concluded that the electric field intensity is 50, 100, 200V / m, the electric field promotes the growth and metabolism of microorganisms, that is, the growth and metabolism rate of microorganisms is increased, so that the number of microorganisms increases a lot, and the degree of promotion is 100V / m> 200V / m> 50V / m. At 100V / m, the effect of the electric field on promoting microorganisms is more obvious. When the electric field strength is 250V / m, the effect of the electric
field on the growth and reproduction of microorganisms is very small, and its growth curve is almost the same as that without the electric field. Therefore, 100V / m is the best applied electric field strength of W-5.

3.3.2. Effect of electric field on microbial behaviour dynamics. It can be seen from Fig. 4 that different electric field strengths have different effects on the distribution of microorganisms and movement. In the absence of an electric field, the overall number of microorganisms is at a low level, and the distribution of microorganisms at different positions in the electric field has not changed, and there is no directional movement. Under the condition of 50V / m low electric field strength treatment, the number of bacteria was significantly reduced, even lower than that of the group without electric field treatment, while under the conditions of 100V / m and 200V / m electric field strength treatment, the number of microorganisms increased significantly. It shows that the low electric field strength inhibits the growth of microorganisms, and the higher electric field strength promotes the growth of microorganisms. In addition, as can be seen from Figure 3, the microbial content curve under the action of the electric field shows a trend of low on both sides and high in the middle, that is, the number of microorganisms is less at 5 cm away from the anode area and the cathode area, and after 5 cm Areas, the number of microorganisms is rapidly increasing, and basically tends to be consistent.

![Figure 3. Microbial growth curve under the action of electric field](image)

![Figure 4. The influence of electric field on the quantity distribution of petroleum degrading bacteria W-5](image)
4. Microbial degradation pathways of petroleum hydrocarbons

4.1. Aerobic degradation of petroleum hydrocarbons
Aerobic microorganisms and facultative microorganisms need molecular oxygen to participate in the metabolic pathway to degrade hydrocarbon pollutants. If the oxygen content is insufficient, the degradation rate will slow down, and the growth and reproduction of microorganisms will be affected [5]. Microorganisms convert polycyclic aromatic hydrocarbons into CO2 and H2O through aerobic degradation process. Hydrogen receptors of hydrocarbons first combine with oxygen to form hydroxyl groups to form alcohols. The hydroxyl groups are oxidized to aldehyde groups by dehydrogenase to form aldehydes. The aldehyde groups continue to be oxidized to Carboxyl groups form fatty acids or ketones, or generate intermediate products of the tricarboxylic acid cycle, and then enter the tricarboxylic acid cycle through a series of reactions, and finally decompose into CO2 and H2O.

4.2. Dosing and adding bacteria agent
The range of contaminants that can be metabolized by microorganisms is limited. The indigenous microbial populations in contaminated areas may not be able to degrade complex petroleum hydrocarbon mixtures. Therefore, it is necessary to inoculate some degrading microorganisms, including degraded engineering bacteria, into the polluted environment to improve the remediation efficiency. According to different pollutants, highly efficient degrading microorganisms can be inoculated by manual screening and separation, and a single species, multiple species or a degrading bacterial group can be connected. Artificially constructed genetically engineered bacteria are considered to be the preferred inoculated microorganisms. The purpose of inoculating microorganisms is to increase the number of degrading microorganisms and improve the degradation ability.

4.3. Improve soil physical and chemical conditions
Soil properties, such as organic matter content, oxygen content, physical structure, pH value and N, P reserves, etc., can change the biodegradation rate, so improving soil conditions can improve the bioremediation effect of petroleum hydrocarbons. The pH of the soil and the ratio of C, N, and P can be adjusted by adding lime, nutrients and fertilizers, adding soil loosening agents, controlling soil temperature and improving soil texture by finishing and mixing, and adding microbial nutrients to meet Growth, reproduction and degradation activities [6].

5. Conclusion
With the development of the petroleum industry, oil pollution will become increasingly serious. Based on the requirements of environmental protection and the objective reality that China has more people, less land, and declining arable land, if it can successfully deal with China's oil-polluted soil, it will produce huge social and economic benefits. Surfactants have achieved certain effects in bioremediation, promote the microbial degradation process of petroleum pollutants, and greatly improve the degreasing effect of microorganisms. However, the amount of synthetic surfactant sometimes inhibits the activity of microorganisms and may cause secondary pollution. The biosurfactant is non-toxic and biodegradable, will not cause pollution to the environment, and can enhance the hydrophilicity and bioavailability of hydrophobic compounds, increase the number of soil microorganisms, and in turn increase the degradation rate of alkanes. It is an effective means to improve bioremediation technology. In terms of the positive effect of electric field current on microbial degradation of petroleum, perhaps the use of genetically modified technology to develop petroleum-degrading bacteria that can generate electricity can not only improve the degradation rate, but also greatly save repair costs, and research in this area is rarely relevant. Report.

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