# In-situ microbial remediation of organic contaminated soil

Lirong He[1,2,3,4 a], Yingying Sun[1,2,3,4 b]

[1]Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Xi'an, Shaanxi,710075, China;

[2]Institute of Land Engineering Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an, Shaanxi,710075, China;

[3]Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, Xian, Shaanxi, 710075, China;

[4]Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an, Shaanxi, 710075, China.

[a]156144982@qq.com, [b]sunyy526@163.com.

## Abstract

**The problem of organic soil pollution in China is becoming increasingly prominent, and is widespread, diverse, complex and persistent, posing a great threat to human health and the safety of the ecological environment. Commonly used degradation methods include physical remediation, chemical degradation, bioremediation and combined chemical-biological remediation, among which bioremediation mainly refers to microbial remediation, which has now given rise to a series of bioremediation techniques such as on-site treatment, in-situ treatment, composting and bioreactors. The main body of these remediation techniques is microorganisms, and the application of these techniques to treat organic pollutant-contaminated soil has been widely studied. With the development of genetic, genomic, proteomic and metabolomic technologies and their application in the field of bioremediation of organic pollutants, knowledge on various aspects of physiology, ecology, biochemistry and regulatory mechanisms of microbial metabolic pathways has been greatly enriched. In the future, the composition of soil microbial communities, as well as community functions and metabolic pathways, can be studied through macro-genetic sequencing, providing data and theoretical basis for the degradation of complex organic pollutants under natural environmental conditions.**

## Keywords

**Microbial remediation; Organic pollution; In-situ remediation.**

## 1. Introduction

Soil is the basic natural resource on which human beings depend for survival, and is the basis for plant growth and reproduction. The state of the soil environment is closely related to the survival and reproduction of human society. Soil pollution refers to the phenomenon that pollutants generated by human activities enter the soil through a variety of ways, and their quantity and speed exceed the environmental capacity and self-purification capacity of the soil, and the accumulation of pollutants gradually takes over, leading to the dysfunction of the natural functions of the soil, the decline of soil quality, affecting the growth and development of crops [1], and ultimately endangering human health.

Soil compound pollution refers to the joint action of two or more pollutants of different nature in the soil environment, and the concentration of each pollutant exceeds the soil concentration standard, resulting in a significant decline in soil quality and function. According to the nature of pollutants, soil composite pollution is divided into organic composite pollution, inorganic composite pollution and inorganic-organic composite pollution. According to the source of pollutants in the soil, soil composite pollution is divided into homogenous composite pollution and heterogenous composite pollution. Compared with soil and water pollution, soil pollution is hidden and lagging, so it is called

the "invisible pollution". Soil is a source and sink of pollutants, and 90% of all pollution, including air and water pollution, eventually enters the soil, so soil pollution is a microcosm of ecological deterioration. At the same time, pollutants in contaminated soil can, under certain circumstances, enter surface water or groundwater through rainfall, polluting the water environment; or enter the food chain through plant growth, endangering the safety of organisms and even humans.

## 2. The Current State of Organic Pollution and the Problems that Exist

With the growth of population and rapid economic development, the discharge of industrial "three wastes" (waste gas, waste water and waste residue) has been increasing, while the influence of long-term unreasonable sewage irrigation, as well as the pollution of chemical substances such as excessive use of chemical fertilizers, pesticides and agricultural films in the process of modern agricultural production, resulting in the long-term superposition and accumulation of various new and old pollutants in the soil environment. In 2014, the Ministry of Environmental Protection and the Ministry of Land and Resources jointly released the "National Soil Pollution Survey Bulletin", which pointed out that the overall soil environmental situation is not optimistic, and the quality of soil environment in arable land is worrying, with The total exceedance rate of pollutants in soil was 16.1%, among which the exceedance rate of arable soil points was 19.4% [4]. On the one hand, soil pollution affects the quality of agricultural products and exacerbates the contradiction between China's population and the scarcity of land; on the other hand, soil pollution directly leads to excessive residues of pollutants in agricultural products, decreases the quality of agricultural products, affects the export trade of agricultural products, and even endangers human health and ecological safety through the enrichment of pollutants in the food chain. Soil pollution has become one of the major environmental problems that restrict sustainable development and are related to the people's livelihood [5].

At present, the common forms of soil compound pollution are heavy metal compound pollution, organic pollutant compound pollution, heavy metal-organic pollutant compound pollution; among them, soil organic compound pollution is mainly related to the production and use of organic pesticides and industrial "three wastes" emissions, the more common pollutants are organic chlorine pesticides (OCPs ), polycyclic aromatic hydrocarbons (PAHs), and other organic pollutants. The more common pollutants are organic chlorine pesticides (OCPs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and petroleum hydrocarbons (TPHs). According to statistics, at least 36 million hectares of soil in China are currently contaminated with organic compounds such as pesticides, petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) [6]. Compared with heavy metal compound pollution, soil organic compound pollution is more extensive and complex, and its results are more unpredictable. At present, soil organic compound pollution has been extended from local to regional, from urban to suburban and rural areas, forming the coexistence of point source and surface source pollution, superposition of domestic pollution, agricultural pollution and industrial pollution, and various kinds of old and new pollution and secondary pollution compounding or mixing with each other [7].

## 3. The Dangers of Organic Pollution

Petroleum hydrocarbons (TPHs) consist of complex mixtures of non-aqueous and hydrophobic compounds such as n-alkanes, aromatic hydrocarbons, etc. These chemicals accumulate by transport through the food chain, exhibit long-term toxicity and have a greater or lesser impact on the wider environment of the planet as a whole. Polycyclic aromatic hydrocarbons (PAHs) are persistent organic pollutants that are widely distributed in air, soil and water, are teratogenic, carcinogenic and mutagenic, and have high bioconcentration rates and low bioavailability, posing a great threat to human health and ecological safety, and are of great concern in the soil environment as toxic organic pollutants of priority control [8-10]. All halogenated hydrocarbons (VCHs) substances have acute or chronic, direct or indirect pathogenic effects on humans, and some accumulate inside human tissues, altering the structure of cellular DNA and causing carcinogenic, teratogenic and mutagenic changes in human tissues.

## 4. Microbial Remediation Techniques

Commonly used degradation methods include physical remediation, chemical degradation, bioremediation and combined chemical-biological remediation, among which bioremediation has been regarded as the preferred method for degrading organic pollutants due to its low cost, no secondary pollution and easy operation.

Early bioremediation mainly refers to microbial remediation, which is also the earliest, most intensively researched and most widely used bioremediation method. A range of bioremediation technologies have been developed, including on-site treatment, in-situ treatment, composting and bioreactors. These remediation techniques are all based on microorganisms and have been extensively studied in the application of these techniques to organic pollutant-contaminated soils. Studies have shown[11] that microbial degradation is one of the main ways to remove organic pollutants, and other bioremediation techniques are also inseparable from the role of microorganisms. As microorganisms have strong adaptability and variability to the environment, they can differentiate a variety of metabolic types in the process of survival, and can adapt to the living environment. In organic pollutant-contaminated soil, through natural domestication, a variety of microbial species or strains capable of degrading organic pollutants are gradually formed. The degradation pathways of organic pollutants in the environment may be different for different microbial species and objects being degraded.

With the development of genetic, genomic, proteomic and metabolomic technologies and their application in the field of bioremediation of organic pollutants, knowledge on various aspects of physiology, ecology, biochemistry and regulatory mechanisms of microbial metabolic pathways has been greatly enriched. In particular, the evolutionary characteristics of microbial populations in a given environment can be predicted on the basis of 16S rRNA and 18S rRNA genes.

## 5. Summary

In the future, the degradation capacity of the dominant degrading bacteria and their adaptation mechanism to pollutants can be studied experimentally to improve the degradation efficiency of strains of bacteria on petroleum hydrocarbons, polycyclic aromatic hydrocarbons and halogenated hydrocarbons, and to clarify the influence of environmental factors on the biological properties of organic polluted soil microorganisms. At the same time, the composition of the soil microbial community as well as the community functions and metabolic pathways will be studied by macro-genetic sequencing. This study will provide data and theoretical basis for the degradation of complex organic pollutants under natural environmental conditions.

## Acknowledgements

The project was supported by Natural Science Basic Research Plan in Shaanxi Province of China (2021JQ-960) and the projects of Land Engineering Construction Group of Shaanxi Provincial (DJNY2020-19 and DJNY2021-27).

## References

[1] Li Xuemei, Han Yang, ShaoShuang. Environmental pollution and phytoremediation [M]. Beijing:Chemical Industry Press.2017.

[2] Zhou Qixing, Gao Zhengmin. Study on the composite pollution of Cd-Zn in soil-rice system and its measurement index[J]. Journal of Soil Science,2004,32(4):430-436.

[3] Zhang Baojie, Dou Lilong, Chi Xiaode, et al. Theory and technology of bioremediation of typical soil pollution [M]. Beijing:Electronic Industry Press,2014.

[4] Ministry of Environmental Protection of the People's Republic of China. National soil pollution survey report [EB/OL].

[5] Gao Yanzheng, Liu Juan, Zhu Xuezhu. Plant PAH pollution control technology and principles-using functional endophytic bacteria [M]. Beijing:Science Press:2016.

[6] Zhou QX, Song YF. Principles and methods of contaminated soil remediation [M]. Beijing:Science Press:2004.

[7] Zhu LZ. Modulation technology of organic pollutant interface behavior and its application[[J]. Journal of Environmental Science, 32(11): 2641-2649.

[8] Venier M, Hues R A. DDT and HCH, two discontinued organochlorine insecticides in the Great Lakes region: Isomer trends and sources[J]. Environment International, 2014,69:159-165.

[9] Menzie CA,Potoki BB. Exposure to carcinogenic PAHs in the environment. Environ Sci Technol, 1992, 26(7):1278-1284.

[10] Wilson SC, Joins KC. Bioremedialion of soil contaminanted with polycyclic aromatic(PAHs): a review. Environ Pollut, 1993, 81:229-249.

[11] Liu S-L, Luo S-M, Cao Z-H, et al. Advances in combined microbial and phytoremediation of cyclic aromatic hydrocarbon contaminated soils. Soil, 2002, 5: 257- 265.