Research progress on contaminated soil remediation materials based on soil organic reconstruction

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Abstract. Soil pollution is cumulative, hysteretic, concealed and irreversible, and it is generally difficult to recover and control soil pollution. According to many years of engineering practice, Shaanxi Provincial Land Engineering Construction Group put forward the core idea of land engineering--organic reconstruction, which provides new ideas and methods for the study of soil restoration. The core of land organic reconstruction lies in material and structure reconstruction. According to local conditions, organic reconstitution can achieve good results in contaminated land restoration.

1. Introduction

As the general reservoir of material, biological and geochemical cycles, soil is the most important resource for economic development and agriculture. It is extremely sensitive to the environment. Although China has a vast territory, with the rapid development of China's economy and a huge population base, the per capita cultivated land is much lower than the world average. With the deepening of urbanization and industrialization, the exploitation of mineral resources, metal smelting, sewage irrigation, and the large-scale use of chemical fertilizers and pesticides have caused various pollutants to enter the soil through various channels, causing serious soil pollution, resulting in soil degradation and ecological damage. And through the geochemical chain, food chain, etc. into the organism and endanger human health and life safety. The status quo of heavy metals and persistent organic pollution is particularly prominent. The area of soil contaminated by heavy metals in China is about 20 million hm², accounting for 1/5 of the total area of cultivated land, and the annual economic loss exceeds 20 billion [1].

The agricultural land in South China is mainly polluted by toxic heavy metals such as Cd, and Hg, and petroleum hydrocarbons. The suburban farmland in the Yangtze River Delta is mainly contaminated by various heavy metals such as Cd, Pb, As, Cu and Zn, which makes the ecological environment and
agricultural production. Greatly damaged [2]. With the rapid development of the economy and society, the problem of soil pollution has become increasingly prominent. It is the key to solve this problem to find a repair technology that can effectively remove soil pollutants without destroying the ecological environment. At home and abroad, there have been many researches on heavy metal contaminated soil remediation technologies, mainly physicochemical remediation technologies based on methods such as soil turnover, passivation, leaching, electrochemical repair, and chemical fixation, and plants, microorganisms, and Animal-based bioremediation technology, however, currently lacks cost-effective and environmentally friendly technologies to remove heavy metal pollution. The treatment of soil organic pollution is mainly reflected in three directions: (1) chemical methods, mainly including leaching, redox and electro kinetic repair; (2) physical methods, mainly through heat treatment, solidification/stabilization, etc. The volatile organic pollutants can be removed from the soil; (3) biological methods, mainly through the biological metabolism, the organic pollutants in the soil are absorbed, transformed or decomposed and removed from the soil, mainly including microbial methods, plants Methods and mycorrhiza methods. However, due to the high operating costs, combined with the specific requirements of biological methods for pollutants and repairing the environment, it is often difficult to obtain a wide range of applications. Therefore, new theoretical methods are urgently needed to solve the problem of current degraded land restoration.

Through years of engineering practice, Shaanxi Provincial Land Engineering Group has profoundly realized that it is necessary to solve problems such as soil pollution, and established the organic remodelling of soil as the core technology for degraded land restoration, fundamentally solving the problem of soil pollution, its essence. It is to use engineering techniques to solve land problems, reconstruct and reconstruct unused land, degraded land, defaced land, and harmful land, fully apply new materials, and provide technical means for carrying life with replacement, compounding and reconstruction. Necessary conditions. In this process, the pressure on soil pollution problems will be reduced.

2. Physical reconstruction material
The main principle of physical materials to solve soil pollution problems is to remove pollutants from the soil, block, etc., select materials that are suitable for local conditions and have high economic benefits and are easily available, and solve soil pollution through means of soil, soil replacement and soil layer reconstruction problem.

For example, for a landfill that has reached the storage capacity, covering the soil and planting plants for ecological restoration will not only reduce soil pollution, achieve sustainable use of land resources, but also provide a beautiful landscape environment and space for residents’ production and life. Landfill is a special secondary pollution bare land. Landfill settlement is one of the main factors affecting soil stability. Its stability is in addition to landfill and accumulation, as well as landfill and surrounding soil environment. Stabilization problems, the stability of landfill deposits is a complex and lengthy process of simultaneous physical, chemical and biochemical reactions. The coverage of the landfill should be composed of composite layers. The whole system can be divided into five layers. From top to bottom, it is the vegetation layer, the nutrient layer, the drainage layer, the barrier layer and the foundation layer. The base layer is the garbage accumulation body [3]. The use of covering soil, compaction, and reconstruction methods to construct a barrier layer is a typical method for soil pollution control using physical materials. This method of sealing and fixing soil contaminants through profile level reconstruction can effectively reduce the cost of landfill disposal.

Clay minerals represented by vermiculite and diatomaceous earth mainly fix heavy metals in the soil by adsorption, thereby reducing their mobility and bioavailability. Clay minerals have a large number of micropores, numerous surface hydroxy groups and a certain amount of negative charges, and have large surface energy and adsorption potential energy. These characteristics make clay minerals have strong adsorption capacity, and can be effectively adsorbed and fixed in heavy metals. There are three main types of clay minerals adsorbing heavy metals in soil [4, 5]: (1) physical adsorption by Coulomb force and van der Waals force; (2) chemical adsorption by hydrogen bonding with surface hydroxyl
groups (3) ion exchange adsorption with cations such as Ca\textsuperscript{2+}, Mg\textsuperscript{2+}, Na\textsuperscript{+}, and K\textsuperscript{+} in the micropores. Clay minerals are capable of adsorbing most heavy metals, but there is a large difference in adsorption capacity. In addition, studies have shown that only the part of the heavy metal adsorbed by the surface of the clay mineral will return to the soil and enter the micropores, and the heavy metals deep into the lattice layer will hardly return to the soil [6].

3. Chemically reconstituted material
The soil is a solid, liquid and gas three-phase composite with many biological and chemical components and complex nature. In the organic remodeling of soil, the soil composition should be controlled within the life safety threshold. The biological and chemical properties of the soil itself must be considered, and the soil material should be reconstructed by chemical materials to control soil pollution. For example, the colloid has a large surface energy and a two-electron structural layer that can adsorb ions, perform ion exchange, and finally solidify the toxic and harmful heavy metal ions in the soil. On the basis of understanding these characteristics, the organic reconstitution of soil and non-agricultural land should be based on the understanding of these characteristics, and the selection of suitable chemical materials to control the toxic and harmful pollutants in the soil within a certain range. The basic principles of chemical materials for reconstitution mainly include adsorption-degradation, oxidation-reduction, complexation-chelation, dissolution-precipitation, etc. to achieve the purpose of reducing the concentration of heavy metals in the soil.

3.1. Application of clay mineral materials
Clay minerals are a kind of naturally occurring secondary silicate minerals containing Fe, Al, Mg and other metal elements. Most of them have a layered structure with small particles, many micropores, large specific surface area and a certain amount of negative charge. Such as vermiculite, zeolite, montmorillonite, sepiolite, etc., a large number of studies have shown that clay minerals have a good adsorption of heavy metals [7-11], often used as in situ repair materials for heavy metal contaminated soil. Zhu Jian et al showed that diatomaceous earth can significantly reduce the exchangeable Pb content in soil, and the application of diatomite has little effect on soil pH and organic matter. Zeng Hui et al [12] used zeolite, sepiolite, bentonite, diatomite and limestone to form in-situ immobilization of heavy metal contaminated soil in the mining area. The results showed that diatomite and limestone were mass ratio 1:2. The immobilization effect of heavy metals in the paired soil was the best. Compared with the control ratio, the contents of heavy metals Pb, Cd, Cu and Zn in the soil extract were reduced by 54.3%, 99.0%, 27.2% and 63.8%, respectively. Lin Dasong et al [13] studied the immobilization effect of sepiolite on soil Cd and Zn pollution. It was found that the addition of sepiolite can significantly reduce the content of extractable and water-soluble Cd and Zn in soil. When the addition amount reached 4% of the soil sample, the content of water-soluble Cd and Zn in the soil decreased by 57.3% and 41.4%, respectively, while the content of extractable Cd and Zn decreased by 42.8% and 24.7%, respectively. Chen Bingrui et al [14] showed that zeolite can effectively fix heavy metals Pb, Cd, Cu and Zn in soil. When the addition amount is 8g/kg, the exchangeable content of heavy metals decreases by 26.4%, 40.1%, 49.0% and 12.2, respectively. %, the amount of leaching decreased by 17.3%, 17.7%, 29.3% and 11.2%, respectively. Du Zhimin et al [15] showed that the addition of montmorillonite can significantly increase the pH value of soil solution and significantly reduce the content of exchangeable Cu and Cd in soil. Wang Yizhen et al [16] used diatomite, attapulgite, peat, humic acid and other four modifiers to passivate soil heavy metals. The results show that the passivation effect of diatomite and attapulgite is not as good as peat and rot. Acid. Yang Xiuhong et al [17] studied the repair of Cu-contaminated soil by attapulgite. The results show that the addition of attapulgite can significantly reduce the bioavailability of Cu in soil. When the addition amount is 5 g/kg, the corn plants of the tested crops The heavy metal content in the aboveground part decreased by 29.8%, and the underground part decreased by 30.0%. Kumpiene et al. [18] used montmorillonite to repair as contaminated soil. The results showed that applying 10% montmorillonite reduced the leaching amount of as in the soil by 50%.
3.2. Inorganic chemical materials
Limestone, phosphate, fly ash, red mud, cement, iron-containing materials, etc. These materials can change the pH value of the soil and chemically react with heavy metals in the soil, thereby changing the form of heavy metals in the soil and reducing the migration of heavy metals. Sexual and biologically effective, often used as a repair of low-concentration large-area heavy-metal contaminated soil. Wang Biling et al. [19] used the three kinds of phosphate fertilizers, such as superphosphate, calcium magnesium phosphate and phosphate rock, to repair the soil Pb pollution. It was found that the phosphate fertilizer can significantly reduce the content of non-residual Pb in the soil. The repair mechanism is phosphate and soil. Pb in each form of the residue reacts to form a poorly soluble substance and precipitates. Du Zhimin et al. [20] studied the effects of apatite and other modifiers on Cu behavior in soil-Ryegrass system. The results showed that apatite and other modifiers can significantly increase soil pH and reduce the bioavailability of Cu in soil. Useability to reduce the toxicity of Cu to ryegrass. Liu Yonghong et al. [21] compared the repair effects of phosphate rock and activated phosphate rock on Cu-contaminated soil. It was found that both phosphate rock powders can significantly increase the residual Cu content in soil and reduce the activity of Cu. In other words, the repair effect of activated phosphate rock powder is better. Su Dechun et al. [22] studied the effects of fly ash passivation sludge on the bioavailability and physicochemical properties of heavy metals in soils. It was concluded that adding appropriate fly ash passivation sludge can significantly increase soil pH and increase soil Mg and Ca. And the content of B, reducing the bioavailability of heavy metals in the soil. Luo Tao et al. [23] screened the passivation agent for heavy metal pollution in soil for the production of pollution-free vegetables. Salt-based phosphorus and solid sulfides can reduce the bioavailability of Pb and Cd in soil and reduce Pb and Cd on vegetables. The pollution coefficients of pollution, Pb and Cd decreased from 0.89 and 1.36 to 0.11 and 0.02, respectively. Bolan et al. [24] used quicklime to improve heavy metal contaminated soil. It was found that the leaching and migration of heavy metals Cd, Cu and Ni in soil was significantly reduced, and the toxic effect on organisms was significantly weakened. Lau et al. [25] used fly ash to improve heavy metal contaminated soil. Studies have shown that fly ash can reduce the concentration of Pb, Cd, Cu and Zn in soil leaching solution. Lombi et al. [26] showed that red mud can effectively reduce the bioavailability, migration and bio toxicity of heavy metals in soil, and also pointed out that iron-aluminum compounds can stably place heavy metals in the oxide lattice layer for a long time.

3.3. Organic chemical materials
Organic chemical materials mainly form complex or insoluble organic complexes with pollutants through complexation, chelation, coordination, etc., and increase the ion exchange capacity of the soil, thereby reducing the mobility and biology of heavy metals in the soil. Effectiveness. Organic materials commonly used for the improvement of heavy metal contaminated soil include livestock manure, organic compost, activated sludge, and humic acid. Wang Jing et al. [27] studied the effect of humic acid on soil Cd morphology, and proposed that humic acid can significantly reduce the content of soluble Cd in soil, indicating that humic acid can be used as a heavy metal pollution improver. Yang Haizheng et al. [28] studied the effects of compost on the occurrence of Cd and Cu in heavy metal pollution. The results showed that the amount of Cd in the soil decreased significantly while the amount of compost increased, while the content of Cu increased significantly. Composting is only suitable for the repair of Cd contaminated soil. Chen Shizhen [29] studied the effects of adding peat and compost on the morphology and chemical activity of Cu in contaminated soil. The results showed that the addition of 2.5% peat and compost, the morphology and chemical activity of Cu in the soil changed significantly. The content of Cu decreased significantly, and the chemical activity of Cu also decreased. As the amount of addition increased, the repair effect of peat and compost increased and then weakened. Huang Qifei et al. [30] used urban waste compost to repair Cr-contaminated soil and studied the remediation effect. The results show that the waste compost mainly affects the content of available Cr in the soil through organic matter, oxidation-reduction potential and pH value. The application of waste compost can reduce the mobility and bioavailability of Cr in soil. Brown et al. [31] used compost and activated sludge
to repair heavy metal contaminated soil. The study found that compost and activated sludge can significantly reduce the exchangeable Zn content in the soil and ensure the safety of vegetable production in the mining area. Hashimoto et al. [32] conducted in-situ passivation studies on Pb-contaminated soil using livestock manure. The results showed that poultry manure could significantly reduce the exchangeable Pb content in the soil, and the residual Pb content increased significantly, reducing the soil. The mobility and bioavailability of Pb.

4. Bio reconstruction material

The application of biological materials such as plants, animals and microorganisms for soil organic reconstitution is a means to accelerate the rapid circulation of toxic and hazardous substances in the soil and to change the structure and physical and chemical properties of the soil. The method has the advantages of low processing cost and little impact on the environment. Phytoremediation refers to the measures to purify heavy metals in the soil by planting highly enriched and high-tolerance plants; animal restoration and microbial remediation are achieved by the adsorption, absorption, accumulation and transformation of heavy metals by animals and microorganisms in the soil. Measures for heavy metal activity and toxicity [33, 34]. However, the phytoremediation cycle is long, resulting in reduced repair efficiency.

"Super-enrichment" stems from Reeves' report on the super-accumulated absorption of nickel by a plant in the New Caledonian genus, and the super-accumulated plant was first proposed by Brooks et al in 1977 and used to describe the dry The leaf tissue absorbs more than 1000 μg/g of nickel and is a plant that grows 100 to 1000 times in other common plants in non-contaminated soil [35]. So far, there is no clear mechanism for the absorption and enrichment of heavy metals by super-enriched plants, but it has been common in various soil pollution remediation research and application practices, and has achieved certain effects, but the efficiency is low and the repair cycle is too long.

There are many kinds of microorganisms in the soil, which can not only eliminate the pollution of infectious microbial organisms in the soil and rebuild the healthy ecosystem. The use of microorganisms for organic reconstitution of soils plays an extremely important role in improving soil fertility, enhancing soil structural bearing capacity, improving ecological environment, and improving crop yield and quality [36]. For agricultural land, the use of microbial life activities and their metabolites can improve soil fertility and reduce soil pollution, thereby improving crop nutrient supply, providing nutrients to crops, improving yield and quality, and reducing fertilizer use. For non-agricultural land, the use of microorganisms can be used to modify the soil in the porous medium for growth, migration and reproduction, improve the macroscopic mechanical properties such as strength, stiffness and permeability of the soil, and realize the process of soil modification through technological innovation. Pollution repair.

5. Conclusion

Soil pollution has a wide range of sources and is highly harmful. It will remain an important environmental problem facing China for a long time to come. It is urgent to solve it. The organic remodeling of soil provides another way of thinking for the restoration of contaminated land. The engineering and technical means of material structure reduces the engineering cost on the one hand and reduces the secondary harm to the environment on the other hand. As the research on soil organic remodeling is still in its infancy, the future should focus on two aspects: material selection and structural law research. The choice of materials should follow the principles of easy access, low cost, resource recycling and environmental friendliness. The study of soil structure should be in-depth, systematically study the mechanics of soil organic remodeling, grain size requirements, level reconstruction characteristics, Biochemical needs and nutritional support, etc., and gradually introduce new materials such as nanomaterials into the research system of soil organic remodeling.
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