Application and research progress of environmental mineral materials in soil improvement and soil remediation

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Abstract: Soil remediation is an important support and material guarantee for the completion of the objectives and tasks of soil pollution control in China. The development status and level of the industry directly determine the completion level of the objectives and tasks. Environmental mineral materials have been widely used in organic, heavy metal and virus contaminated soils. In this paper, the application of environmental mineral materials in the soil remediation of heavy metals, organic pollutants and virus-contaminated soil was put forward. Natural porous minerals show obvious particularity and superiority in many aspects such as pore structure, adsorption characteristics, ion exchange characteristics, catalytic characteristics, slightly soluble effect, etc., which can effectively improve soil microenvironment and repair polluted soil. The resource characteristics and environmental attributes of natural porous minerals are very suitable for the application conditions of soil environment improvement and restoration in my country, and have important research and economic significance.

1. Introduction

Soil pollution is one of the three major pollution factors in the world. It is a phenomenon that soil quality is deteriorated due to the change of soil internal structure caused by the infiltration of harmful substances [1]. According to the "national soil pollution survey bulletin" released in 2014, the total amount of soil exceeding the standard nationwide accounted for 16.1% of the total amount investigated. In the central and eastern regions, there are 3.3333 million / hm2 cultivated land with moderate and severe pollution, which is not suitable for the most basic crop cultivation. The exceeding standard rate of heavy polluting enterprises is 36.3%, that of industrial wasteland is 34.9%, and that of industrial parks is 29.4%, The over standard rate of solid waste disposal sites is 21.3% [2]. Relevant statistical research shows that there are about 300,000 ~ 500,000 industrial contaminated sites in China, and the market space is 0.9~1.5 trillion according to the treatment cost of 3 million yuan per site [3]. Remediation and treatment of contaminated soil has become an issue of great concern to all. Applying environmental mineral materials to control soil pollution is one of the important methods of soil remediation. Therefore, the prevention and control of soil pollution, especially the treatment of contaminated soil, and the improvement of soil environmental quality have become an urgent task related to the national economy and people's livelihood [4]. In recent years, scientific and technical personnel at home and abroad have conducted a lot of research on the remediation of contaminated soil and have achieved a number of important results. Among them, some scientific and technical personnel have carried out experimental research on the use of environmental mineral materials to remediate contaminated soil, and have also made gratifying progress [5]. Natural porous minerals show obvious particularity and excellence in pore structure, adsorption characteristics, ion exchange characteristics, catalytic characteristics, sparingly soluble effects, etc., so that they can effectively improve the soil microenvironment and repair contaminated soil. Its research has become In recent years, the scope of hot soil environmental restoration in soil

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environmental science research mainly includes the restoration of contaminated agricultural land and construction land. On this basis, it can be further expanded to the ecological restoration of the mine environment, the restoration of solid waste and ecological garbage dump sites, and the restoration of tailings ponds. Etc. [6].

2. Environmental mineral materials and heavy metal pollution

2.1. Concept of environmental mineral materials

Environmental mineral materials are minerals, rock materials and some industrial wastes used for environmental treatment. Compared with the traditional concept of mineral materials, it emphasizes that materials and technologies should have environmental coordination and compatibility, and be endowed with environmental attributes and environmental functions. According to its characteristics, it can be divided into natural mineral materials, composite and synthetic environmental mineral materials and industrial wastes. Its basic properties include mineral surface adsorption, pore filtration, structural adjustment, ion exchange, chemical activity, physical effect, nano-effect and biological exchange. Environmental mineral materials are abundant in reserves, relatively simple in processing technology and low in price, and have great social and economic benefits for environmental treatment. With the development of science and technology, the demand for environmental mineral materials such as modern high technology and environmental protection is increasing. Therefore, the research on the processing and modification of environmental mineral materials has developed rapidly. In terms of environmental mineral material modification and modification technology, after decades of development, the acid, alkali and high-temperature roasting modification technology of environmental mineral materials has become increasingly mature. Natural minerals can be roasted at high temperature, and the temperature is generally controlled between 350-5800c, which can remove the organic matter in cavities and channels. Therefore, mineral materials with good thermal stability still have pore characteristics at high temperature.

2.2. Heavy metal contamination

Heavy metals are elements that constitute the earth's crust and are widely distributed in the soil environment. Heavy metals mostly exist in various minerals and rocks in the earth crust (Figure1). After rock weathering, volcanic eruption, atmospheric dust fall, water erosion and biological uptake, they constitute their migration cycle in the natural environment, which makes heavy metals spread all over the soil, atmosphere, water and organisms, especially in the soil environment.

Figure 1 Heavy metal pollution of soil in mining area

Therefore, unlike artificially synthesized organic pollutants, heavy metals have background values in the soil environment, and due to the differences in factors such as soil-forming parent rocks, parent materials, and soil-forming processes, there are spatial differences in the background values of heavy metal elements in the soil environment. feature. The organic pollutants in the soil not only come from a wide range of sources, but also have a wide variety of types. Some organic pollutants can remain in the soil for a long time and accumulate in organisms, which are harmful to the soil environment and human health. The remediation of organic contaminated soil by environmental mineral materials is mainly through photocatalysis, oxidation and adsorption. Hyperaccumulators are plants that absorb more than 100 times more heavy metals than common plants. According to the types of accumulated metal elements, hyperaccumulator plants can be divided into Cu hyperaccumulator plants, Ni hyperaccumulator plants, Pb hyperaccumulator plants, Cr hyperaccumulator plants, Zn hyperaccumulator plants and so on(Table 1). In the phytoremediation technology of heavy metal contaminated soil, the characteristics of the plant itself are the key to determining the efficiency of pollution control. Therefore, finding and selecting suitable plants is always an important task of phytoremediation research.

Table 1 Typical heavy metal super-accumulating plants

Element	Super-accumulated plant element content requirements	Typical super-accumulative plant species	
		Plant species name	2900
Cd	>100	Thlaspi caerulescens	11300
Co	>1000	Hericium erinaceus	13400
Cu	>1000	Alpine sweet potato	52900
Mn	>10000	Macadamia nut with thick veins	48600
Ni	>1000	Nine-knot wood genus	9300
Pb	>1000	Blue vegetables with round leaves	52700
Zn	>10000	Thlaspi caerulescens	2900

3. Application of environmental mineral materials in soil improvement and soil environmental remediation

Under the influence of natural and external factors, the aggregate structure is easy to be destroyed, and the environmental mineral materials have large specific surface area and strong electrostatic field, which can absorb the surrounding colloidal clay particles and facilitate the formation of aggregates. Soil organic pollutants not only come from a wide range of sources, but also have a wide range of types. It is one of the important pollutants to reduce soil quality and destroy soil ecosystem, and it is also the main source of groundwater pollution and surface water pollution, which has attracted extensive attention from all walks of life. Environmental mineral materials mainly remediate organic contaminated soil through adsorption, fixation, oxidation and catalytic degradation. Natural porous minerals have different effects on soil aggregation according to their differences in structure and chemical properties. Through their effects on soil aggregation, they can play an active role in regulating soil water content, improving soil drought tolerance, enhancing gas diffusion in soil, and promoting soil respiration. The water absorption rate of bentonite is also very high. The effect of improving soil water retention capacity on sandy soil is particularly obvious. When the amount of bentonite is 20%, the water content of sandy soil can be increased by more than 20%. Due to the structural and chemical properties of silicate porous minerals and the lack of bonding adjacent atoms on the solid surface, the high-energy state of the mineral surface causes the mineral surface structure to reorganize and adsorb foreign molecules or ions to reduce its surface energy. For example, on the surface of kaolinite, there are not only hydroxyl groups of silanol = Si − Oh, but also hydroxyl groups of aluminol = Al oh and acid sites at the edge of the structure. Under certain conditions, the surface has certain polarity and charge, and then has molecular and chemical interaction with inorganic or organic matter to affect the environment around the soil. The surface potential change of natural porous minerals is shown in

Figure 2.

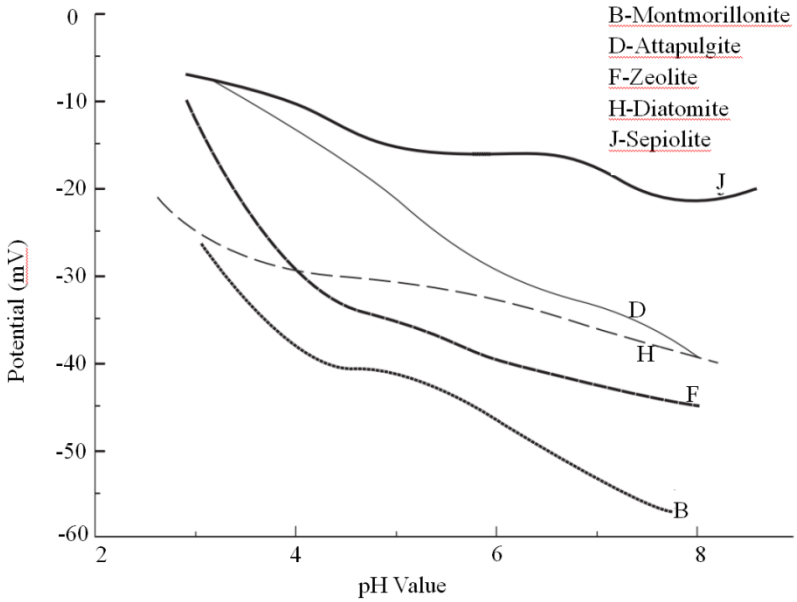

Figure 2 Changes in the surface potential of some natural porous minerals

Soil fertility capacity increases with the increase of zeolite dosage, especially in the soil with low fertility and coarse texture. A1-P, Fe-P and water-soluble phosphorus in soil also increased obviously, which indicated that zeolite could reduce the fixation of available phosphorus and improve the bioavailability of phosphate fertilizer. At present, there are many researches on remediation of heavy metal contaminated soil by silicate minerals. The study found that bentonite has a better remediation effect on the soil contaminated by Pb and Zn. The adsorption capacity for lead is 2 to 3 times greater than the adsorption capacity for calcium. At pH 5, the ratio of bentonite to composite contaminated soil is 1. : At 5 o'clock, the repair effect is best. Due to the existence of hydrophilic inorganic cations in natural silicate minerals, there is a thin water film on the surface of minerals. Therefore, the removal of organic compounds such as phenol, benzene and amine is hindered. In order to adsorb the organic pollutants in the fixed environment, organic cations are introduced into the minerals through certain modification methods, and the water molecules are replaced to form organic silicate minerals. Natural porous minerals and their modified materials can not only adsorb and fix organic pollutants in soil, but also promote their oxidative decomposition on the mineral surface. For example, the combination of montmorillonite and kaolinite with metal oxides in the surface or soil can effectively promote the direct, indirect or photocatalytic degradation of some agricultural chemical organic compounds, and then reduce the content of organic pollutants in the soil.

4. Conclusions

In view of the advantages of environmental mineral materials in the application of soil environmental remediation, such as in-situ, simple operation, quick effect and low cost, my country's natural environmental mineral materials resources are relatively abundant. Therefore, my country's environmental mineral materials have certain development potential and good application prospects in soil environmental remediation. Using environmental mineral materials to improve soil can not only meet the needs of modern agricultural development, but also broaden the application field of environmental mineral materials. In China, there are many kinds of minerals with abundant reserves, wide distribution and low price, which provide better basic conditions for soil improvement research. Environmental mineral materials can fix organic pollutants in soil and reduce their diffusivity, so as to achieve the purpose of purification. Natural environmental mineral materials have relatively weak fixation ability to organic pollutants, and usually need to be modified. At the same time, to further improve the adsorption capacity of natural environmental mineral

materials to heavy metals and pathogenic organisms, effective modification technology is needed to reduce its usage. The resource characteristics and environmental attributes of natural porous minerals are very suitable for the application conditions of soil environment improvement and restoration in my country, and they have also received extensive attention from domestic researchers. However, the selection of natural porous minerals, the modification of mineral materials, the composite of porous minerals and microorganisms There is a lack of in-depth research work in many aspects such as technology. Moreover, the basic theoretical research should be strengthened, especially in the principle and mechanism of remediation of heavy metal contaminated soil by environmental mineral materials, there are still some controversies and lack of theoretical support.

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