

Research progress of biochar for soil heavy metal pollution remediation

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Abstract: Biochar is a low-value material that is produced from agricultural waste under oxygen-limited conditions and is commonly used in sewage treatment and soil improvement. The main purpose of this paper is to analyze the strong adsorption of heavy metals by biochar and the improvement of soil physical and chemical properties, the feasibility of its application in soil heavy metal pollution remediation is clarified.

Keywords: biochar, soil, heavy metal, pollution remediation.

1. INTRODUCTION

Biochar products are obtained by an pyrolysis of biomass energy materials at high temperature (300-900 °C) in the environment with limited oxygen content [1], and have been used for soil improvement in agriculture previously. Depending on porous structure, it can be considered as adsorbent and water-retaining admixture material. A large amount of material from agricultural production and processing industry can be used as biochar raw stock due to its abundance and low cost [2]. Especially in the harvest season and crop processing, a lot of agricultural residues are produced such as rice, wheat, corn and peanut. Processing abundant biomass into biochar under pyrolysis and anaerobic conditions not only greatly reduces the volume, but also improves the value [3].

Researchers found that biochars produced by anaerobic digestion of biomass has higher adsorption capacity to heavy metal [4]. Cellulosic biomass wastes from agricultural and forestry production are

usually used as raw materials of biochar processing. In view of the research results of the application of biochar, multiaperture, specific surface area, cationic exchange ability, high stability and other characteristics, biochar as an adsorbent for metal contaminated water treatment has important application prospects.

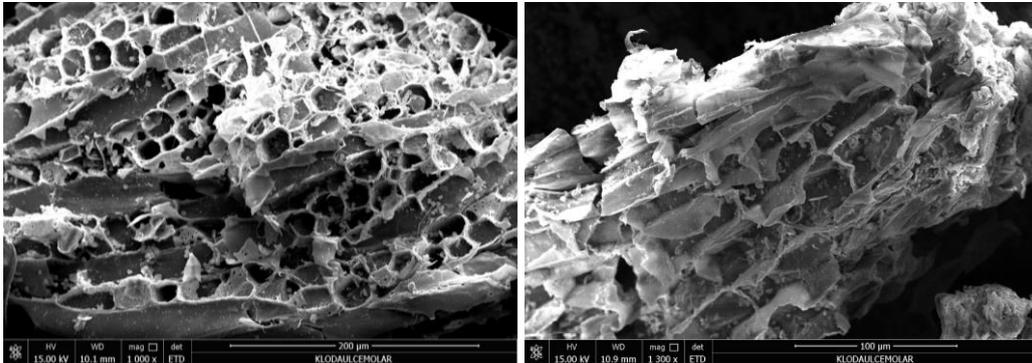


Fig. 1 Scanning electron microscope images of biochar

2. SOIL POLLUTION BY HEAVY METALS

Soil resources are natural resources necessary for the survival of humans, animals and plants, and have non-renewable characteristics. However, with the development of the world's industrial technology, people's living standards have improved, and at the same time, the toxic and harmful substances discharged by industry have also caused harm to the environment, especially the soil. Among all kinds of pollutants, heavy metal pollution is the most common and the most difficult to control, and it has become the most pressing problem facing people. Once soil is polluted by heavy metals, it not only reduces crop yield and quality by affecting the physical and chemical properties of the soil and toxic to plants, but also pollutes the water environment through rainwater washing and surface runoff. Heavy metals are more stable than other pollutants in the soil, and are not easily transformed and used by microorganisms, forming their characteristics of accumulation in the soil. However, heavy metals exist in the soil in different forms. Among them, the available heavy metals can be absorbed by plants and accumulated in the human body through the food chain. When they accumulate to a certain level, they will seriously threaten human health.

Many countries in the world have farmland soil pollution problems, especially heavy metal pollution. According to reports, there are more than 10 million polluted areas in the world, and more than 50% of them are heavy metal pollution. In the United States, there are approximately 600,000 sites contaminated with heavy metals. In Western European countries, this number has reached 1400,000. Georgia Agricultural irrigation water has been polluted by heavy metals from tailings waste for many years.

With the advancement of my country's industrialization process and economic development, heavy metal pollution in my country's cultivated soil has shown an increasingly serious trend, and reports on human health problems caused by heavy metal pollution are not uncommon. The direct economic loss caused by the reduction of grain production due to heavy metal pollution of arable soil amounts to more than 20 billion yuan. According to data, 24 provinces (cities) in my country have been polluted by heavy metals in the soil to varying degrees, mainly cadmium, zinc, lead, mercury and so on. The "National Survey Bulletin of Soil Pollution Status" issued in 2014 (Ministry of

Environmental Protection and Ministry of Land and Resources 2014) pointed out that in my country's soil-contaminated farmland, the number of excess heavy metals accounted for 82.8% of the total number of exceedance points, which is national farmland. 19.4% of the area. The light pollution point was 14.65%, the light pollution point was 2.23, the moderate and severe pollution points were 1.24% and 0.88%, respectively. Among them, cadmium pollution is the most serious, with an excess of 7.0%, nickel comes next with 4.8%, and zinc has the lowest excess rate. In terms of distribution, soil heavy metals in southern my country are more serious than those in northern China, and heavy metals in eastern China are more serious than those in western China. Some typical industrial areas, such as the Northeast, the Yangtze River Delta, and the Pearl River Delta, have more serious pollution than other places. In addition, the land used by heavily polluted enterprises, industrial wasteland and mining areas have become the most severely polluted areas by heavy metals in the soil, with the exceeding rates of 36.3%, 34.9%, and 33% respectively. It can be seen that the main source of heavy metal pollution in soil is from industrial production activities.

3. BIOCHAR'S REMEDIATION OF HEAVY METALS IN SOIL

3.1 Biochar has an adsorption effect on soil heavy metals

Some recent publications have provided the excellent ability of biochar to fix organic matter and inorganic pollutants in the soil and water system. Although most organic pollutants are biodegradable, inorganic pollutants, mainly heavy metals, are not biodegradable and can form a food chain through bioaccumulation. Biochar is increasingly recognized as a substitute for metal removal agents in water treatment technology. The development of biochar technology provides an opportunity for water-based heavy metal adsorbents to meet low-cost requirements. Chen et al. reported that biochar is made of wood or corn stalks that can effectively adsorb copper and zinc in aqueous solutions [5]. Similarly, Kong et al. reported that the removal rate of mercury in aqueous solution by soybean straw was 75-87% biochar [6]. In addition, the application of different engineering methods in biochar production, such as pretreatment of raw materials or surface modification of coal char, has produced many high-efficiency and cost-effective engineered biochars whose adsorption capacity can be equal to or even comparable. For example, previous studies have shown that biochar is produced from anaerobic digested biomass and has a higher lead adsorption capacity than commercial activated carbon. Physical therapy crushes the raw materials and then pyrolyzes them, which can also greatly increase the adsorption capacity of biochar on copper in the aqueous solution [7].

Biochar may also affects the bioavailability of heavy metals in soil and the accumulation of heavy metals in soil-growing plants. However, previous studies have not provided much information on the effects of biocarbon on heavy metals in soil [5]. Unlike most biodegradable organic and inorganic pollutants, especially heavy metals could not be biodegraded and accumulated through the food chain [2]. In recent years, biological carbon has been paid more attention because of its functions such as carbon sequestration, soil fertility improvement and soil restoration. Recent literature provides evidence of the ability of biochar can hold organic and inorganic pollutants in soil [2]. Therefore, biochar is considered to be a new type of remediation agent that can repair heavy metal pollution in soil [8].

3.2 The effect of biochar on the improvement of soil physical and chemical properties

Studies have shown that adding a certain amount of biochar to soil contaminated by heavy metals usually has the effect of improving acidic soil pH and increasing soil nutrient content and its effectiveness. Biochar itself is alkaline (pH 8~12). It can increase the pH value of acidic soil by increasing the alkaline saturation of the soil, reducing the reduction of aluminum content and the consumption of soil factors, thereby reducing the content of transportable forms of heavy metal ions. The typical biological carbon has high cation exchange ability and alkalinity. With the increasing of soil biological activity, biochar improves the soil properties. The increase in biological carbon in the soil has led to changes in soil quality, which has the potential to increase agricultural yield. Adding biochar can increase the available phosphorus, available potassium, organic matter, total nitrogen, total phosphorus and total potassium in the soil to varying degrees. First, biochar contains mineral nutrients, such as N, P, K, etc., which can be directly used to increase soil nutrient content. Secondly, biochar can also significantly increase the effective content of potassium, magnesium, calcium and other major cations in the soil, improve the availability of soil nutrients, and provide necessary nutrients for plant growth. Third, the strong adsorption and structural characteristics of biochar can retain water-soluble nutrient isolates in the soil, effectively reduce soil nutrient leaching, release nutrient isolates slowly and continuously, and increase soil effective nutrient content. In short, the application of straw-based biochar can be used in the remediation of contaminated land. Biomass waste is not only effectively used, but can also achieve carbon sequestration, improve soil structure, improve soil fertility, and open up new ways for the restoration of contaminated land and the intensive use of agricultural waste.

4. CONCLUSION

Biochar is a low-value material that is produced from agricultural waste under oxygen-limited conditions and is commonly used in sewage treatment and soil improvement.

The main purpose of this paper is to analyze the strong adsorption of heavy metals by biochar and the improvement of soil physical and chemical properties, the feasibility of its application in soil heavy metal pollution remediation is clarified.

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