Frontiers in Environmental Research
ISSN: 2960-026X
DOI: 10.61784/fer240116

RESEARCH AND APPLICATION PROGRESS OF BIOCHAR IN THE ENVIRONMENTAL FIELD

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Abstract: Biochar is a new type of environmental functional material. It has become a research hotspot in the fields of environmental science and other fields because of its excellent ecological and environmental effects. The composition and basic characteristics of biochar are introduced, and the application of biochar in the environmental field is explained. This paper discusses and looks forward to the current research status of biochar in the environmental field at home and abroad, summarizes the existing problems and deficiencies in the field of biochar research, and provides some new ideas for future research on biochar.
Keywords: Biochar; Environmental science; Basic properties

1 INTRODUCTION

In recent years, as global climate warming caused by carbon dioxide and other greenhouse gases and the growing population have led to dual challenges of food security, biochar has received increasing attention because it can increase the organic matter content in soil [1]. Biochar as a soil conditioner is different from traditional charcoal that is generally used for fuel. It not only helps plants grow, but can also be used in agriculture to reduce the use of chemical fertilizers and carbon capture and storage, thereby mitigating climate change and food Security Question.

Biochar is a stable carbon-rich product formed after incomplete combustion and thermal cracking of biomass through high-temperature pyrolysis and carbonization in the absence of oxygen [2]. Biochar is defined as "biochar" in relevant foreign research, which usually refers to biomass such as wood, crop waste, plant tissue and animal bones or other biomass waste in the absence of oxygen and "low" relative temperature (<700 °C).) products formed by pyrolysis under conditions [2].

In addition to being rich in carbon (70% to 80%), biochar also contains H, O, N, S and a small amount of trace elements, a small amount of minerals and volatile organic compounds. Biochar is a mixture of organic carbon, mainly aromatic hydrocarbons and elemental carbon or carbon with a graphite structure. Most of the carbon exists in irregular stacks of stable aromatic rings [3]. Biochar mainly contains highly carboxylic acid esterification, aromatization, aliphatic chain structure, and main functional groups such as carboxyl, phenolic hydroxyl, hydroxyl, carbonyl, aliphatic double bonds, and benzene rings. Biochar also has larger porosity and specific surface area. These basic structures determine that biochar has strong antioxidant power, strong adsorption capacity, and large ion exchange capacity [4]. The highly aromatized and hydrophobic aliphatic chain structure allows biochar to be retained for a long time and difficult to decompose after being applied to the soil. Biochar has low bulk density and low viscosity, so biochar can reduce the bulk density and hardness of clay soil, thereby improving soil texture and farming performance. Biochar can increase the specific surface area of the soil, increase the water holding capacity of the soil, delay the release of fertilizers, increase the adsorption and exchange of soil nutrients, reduce soil nutrient losses, and reduce eutrophication of the water environment [5]. Research has found that the application of biochar can significantly increase the water holding capacity and specific surface area of soil, and effectively improve the properties of sandy soil with poor water holding capacity. The large specific surface area and cation exchange capacity of biochar are largely determined by the raw materials and pyrolysis temperature, which can enhance the adsorption of organic and inorganic pollutants on its surface and reduce the mobility of pollutants when amending contaminated soil [6]. Biochar can enhance soil water retention performance, improve soil porosity and aeration, promote the formation of soil aggregates, thereby improving the physical properties of soil. Biochar promotes the infection and activity of soil microorganisms (especially fungi), which may increase the decomposition of minerals and the secretion of polysaccharides by microorganisms. Polysaccharides are important substances for the formation and stability of soil aggregates, so biochar has the ability to stabilize or increase soil The role of agglomerates [7]. In the short term, the release of various organic molecules from fresh biochar may in some cases influence increases or decreases in soil biological abundance and activity.

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2.1 Biochar Remediation of Acidic Soil

Soil acidification refers to the process in which the soil absorptive complex accepts a certain amount of exchangeable hydrogen ions or aluminum ions, causing the alkaline (basic) ions in the soil to leach out. It is a continuous process [8]. The natural acid formation process in soil is originally very slow, but human influence has greatly accelerated this process. There are two main human factors that affect soil acidification. One is the large emission of acidic gases, which leads to an increase in acid deposition. Some of the SO_2 and NOX emitted into the air directly penetrate into the ground surface to form dry deposition, and the other part undergoes a series of chemical processes. The reaction forms H_2SO_4 and HNO_3, and the pH of the rainwater subsequently drops to form acid rain; the second is inappropriate agricultural measures, such as the use of a large amount of chemical fertilizers, especially ammonium nitrogen fertilizers, the planting of leguminous crops, improper fertilization amounts and fertilization methods, etc. [8].

The microporous structure and strong adsorption force of biochar itself make it a good habitat for soil microorganisms, providing protection for beneficial soil microorganisms, especially mycorrhizal fungi, promoting the reproduction and activity of beneficial microorganisms, and enhancing vesicle arbuscules. Infection of plants by mycorrhizal fungi [9]. Biochar can be used as a carrier for microbial fertilizer inoculum to increase the survival rate of the inoculum in the soil and the infection of plants. After biochar is applied to the soil, it is easier to form large aggregates, which can enhance the adsorption and retention of nutrient molecules in the soil, making it less likely to be lost with water washing. Most of the N in the soil is stored in various complex organic matter. Only Only when ammonia is converted into NH_4^+ and nitrified into NO_3^- can it be absorbed and utilized by plants. Ammonia is converted into biological communities, which leads to changes in soil nitrogen cycle and thus changes in soil pH [9]. Studies have shown that after rice husk biochar and paper fiber sludge biochar are mixed with compost at a ratio of 1%, 0.5% (w/w), the experimental soil can be better than untreated acidic sandy soil. Plants and animals provide more habitable habitats. Some scholars have found that adding the same biochar to different soils has different impact rates on crop production efficiency. The largest (positive) impact occurs in acidic (14%) and neutral pH soils (13%), and coarse (10 %) or medium texture (13%) soil [10]. The benefit of increasing soil biochar is usually increased crop yield. However, experimental results are variable, depending on the experimental setting, soil properties and conditions. Most conclusions are limited to short-term studies within 1 to 2 years, and the mechanism of action is not yet complete. clarify.

2.2 Adsorption of Organic Pollutants by Biochar

High and increased agricultural yields are inseparable from chemical fertilizers, but the absorption and utilization rate of chemical fertilizers by crops is limited. After biochar and chemical fertilizer are mixed and granulated, the two are closely combined, which can reduce the loss of chemical fertilizer and slow-release fertilizer efficiency, thus improving the utilization rate of chemical fertilizer and reducing the amount of chemical fertilizer [11]. Field experiments in many farmland areas have shown that when the application of biochar in farmland soil reaches 20 t/hm2, the amount of chemical fertilizer application can be reduced by approximately 10%; in farmland soil with a large amount of residual chemical fertilizers, chemical fertilizers may not even be used in the season, and only Biochar can achieve high yields. The adsorption capacity of biochar for pesticides depends on its physical and chemical properties, such as organic carbon content, specific surface area (SSA) and porous structure [12]. Sopena et al. found that the adsorption capacity of 2% (W/W) Eucalyptus dunensis biochar to isoproturon was nearly 5 times higher than that of soil without application. Wood chip biochar can absorb almost all herbicides and bentazone in silt loam soil. Studies have shown that the application of biochar not only improves the adsorption of different pesticides, but also reduces the bioavailability of residual pesticides to organisms [13]. In addition, applying biochar to agricultural soil near lakes or water bodies can effectively reduce pesticide leaching to reduce groundwater pollution. The new synthetic zero-valent iron biochar can fix and transform organic pollutants that are sensitive to redox in the natural environment, thereby removing organic pollutants in natural water bodies and soil [14]. Some scholars conducted a farmland experiment for 851 days. In the first 105 days, compared with the control group and the original state, the free dissolved polycyclic aromatic hydrocarbons in the soil with biochar added decreased significantly. From 106 days to 851 days, the levels of different amounts of biochar added There was no significant decrease in the free dissolved polycyclic aromatic hydrocarbons in the soil. The research results showed that adding biochar led to the reduction of the free dissolved polycyclic aromatic hydrocarbons in the soil. Soil amendments containing a small amount of biochar have high adsorption capacity for pollutants and at the same time reduce the bioavailability of pollutants to microbial communities, plants, earthworms and other organisms in the soil. Plants grown in soil amended with biochar have Lower pesticide absorption rate [15]. Studies have found that applying biochar to agricultural soil near lakes or water bodies can effectively reduce pesticide leaching to reduce groundwater pollution.

2.3 Adsorption of Heavy Metals by Biochar

Common heavy metal pollution in the environment is mostly lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), arsenic (As), copper (Cu), zinc (Zn) and other pollution [16]. The sources of heavy metal pollution are very wide. In addition to emissions from industrial and agricultural production, urban pollution and major pollution incidents are also important sources. The non-biodegradable properties of heavy metals allow them to accumulate in the food chain, and their bioavailability makes them highly toxic and carcinogenic to organisms, which not only endangers the health of humans and animals, but also creates a series of environmental problems [16]. Due to the rapid development of my country's industry, sewage from industrial and mining enterprises is discharged into sewers without diversion treatment, and then mixed with domestic sewage for discharge, resulting in an increase in the content of heavy metals such as mercury, lead, cadmium, chromium, etc. in soil in sewage irrigation areas year by year. According to statistics, there are tens of millions of hectares of soil contaminated by heavy metals in our country, and among all heavy metals, cadmium pollution has the highest rate of exceeding standards. Among the seven major river systems in my country, heavy metal pollution in the waters of the Huaihe

River, Haihe River, Yangtze River and Pearl River is more serious. Heavy metal pollution also exists abroad. "Minamata disease" in Kumamoto Prefecture and "bone pain disease" in Toyama Prefecture, Japan, are caused by mercury pollution and cadmium pollution respectively. Heavy metal pollution has become a global environmental problem that requires sufficient attention, and its serious pollution status urgently needs to be solved.
Currently, there are two main solutions to heavy metal pollution in water and soil: one is to completely remove heavy metals from water and soil; the other is to reduce the mobility and bioavailability of heavy metals in water and soil. Compared with the treatment of heavy metal-contaminated water bodies, the remediation of heavy metal-contaminated soil is more complex and difficult [17]. The porous structure and high specific surface area of biochar make it an excellent heavy metal adsorbent. Research shows that the application of biochar can increase soil pH, thereby reducing the exchangeable content of heavy metals, improving the utilization of plant nutrients and promoting plant growth. Studies have shown that the release of arsenic (III) in sediments amended with biochar for 49 days (656.35±89.25 mg/L) was significantly higher than that in sediments without biochar amendment (98. 06±19.38 mg/L), the study also found that the reduction of 87% to 90% arsenic (V) and 83% to 88% iron (III) is because biochar stimulates biological reduction, and biochar increases dissolved organic matter. (DOM) bioavailability.

2.4 Biochar's Contribution to Carbon Sinks and Emission Reduction

The production of biochar and its storage in soil is considered an effective way to reduce atmospheric carbon dioxide concentrations. The California Energy Commission's Public Interest Energy Research Project believes that biochar projects can offset greenhouse gases because biochar can effectively trade the carbon sink in the carbon dioxide emissions generated by fossil fuels. The Climate Trust, an American non-profit organization, wrote specifically in "Climate Solutions for Governments, Public Welfare and Large Enterprises" that "at its maximum potential for sustainable development, biochar can reduce annual greenhouse gas emissions by 12%." ", and this estimate is based on the assumption that 80% of biochar will still exist in the soil after 100 years [18]. Woolf et al. assume that biochar is stored in the soil at its maximum potential, and the annual net emissions of carbon dioxide, methane and nitrous oxide can reduce the maximum carbon equivalent equivalent of 180 million tons of carbon dioxide, which is equivalent to the current human emissions of carbon dioxide. 12% of the equivalent, and will not endanger food security and soil protection [19]. Matovic calculates that 10% of global net primary production from landfilling and carbonization each year would offset the increase in carbon dioxide in the atmosphere that year. In my country, more than 50% of straw is discarded and burned, while only 15% is returned to fields. Biochar from different sources has different effects on the soil after being applied to the land. Compared with other biochars (rice husk biochar, poultry manure biochar, sheep manure biochar, farm manure biochar and wood biochar), soils with sheep manure biochar have higher organic matter content and carbon percentage [20]. Optimistic statements about the environmental benefits of biochar actually lack strong evidence. For example, there is insufficient experience and evidence to prove that the use of biochar can significantly mitigate climate change [21]. Biochar can reduce
Slow atmospheric change stems from the argument that biochar can exist in soil for hundreds or thousands of years. The main evidence for its long-term persistence in static soil is the existence of ancient biochar in the Amazon basin, but this can only prove that there are ancient organisms. It is just the existence of charcoal, it may also be just a small piece remaining after the degradation of a large volume of biochar.

3 DISCUSSION AND OUTLOOK

As a new type of low-carbon, environmentally friendly and renewable energy, biochar can replace non-renewable energy sources such as coal for daily life and power supply and heating, reducing carbon emissions, mitigating air pollution and improving the current environmental situation. Biochar is considered a unique adsorbent due to its high specific surface area and high carbon content. Bamboo charcoal in biochar has the function of absorbing dust, adsorbing odors and harmful gases. It can be used as an air purifier to eliminate odors in the room and has now become a daily necessity.. As a new environmental material, biochar can be combined with other fields to make new discoveries while undergoing in-depth research [22]. Biochar-based nanocomposites combine the advantages of biochar and nanomaterials, have excellent abilities, and can adsorb aqueous solutions [3] Ahmad M, Rajapaksha AU, Lim JE. a range of pollutants. Citrus peel has an inhibitory effect on anaerobic digestion. Some scholars have found that as the proportion of biochar increases, the lag phase of microorganisms decreases from the longest lag phase of 9.4 d (orange peel to biochar 2:1) to the shortest 7.5 days (1:3). Utilizing the excellent characteristics of biochar, combined with other sewage treatment methods, it can well meet the treatment requirements of industrial sewage and urban sewage. Biochar may also be the best option for poor soils and areas cleared for farmland by burning.
However, there are also limitations and problems in current related research. Research on the behavior of biochar in soil is a very young field, reflected in different, non-standardized terminology and methods, and research on major areas is unevenly distributed. There is also a lack of sufficient field evidence to prove the production and application of biochar. can actually affect the greenhouse gas balance of the entire system. There are many key variables, such as emissions related to biochar production, transportation and application to soil; the extent to which biochar can stimulate the decomposition of soil organic matter; the amount of energy that can be captured during the biochar production process, etc.[23]. The mechanism by which biochar functions in soil is influenced by the specific conditions during its manufacture and the materials from which it is produced. Compared with biochar produced by conventional pyrolysis, biochar produced by microwave catalytic

pyrolysis under the same conditions can more effectively increase soil water-holding capacity due to its high porosity. There are also a few different reports on the impact of biochar on soil [23]. Studies have shown that during the pyrolysis process, the enrichment of total heavy metals in biochar increases and a large amount of heavy metals are discharged into the atmosphere, and this trend becomes more and more obvious as the pyrolysis temperature increases. Some scientific researchers have also warned that biochar may have adverse effects by releasing toxic substances such as heavy metals into the soil or reducing the efficacy of pesticides [24]. Current research on the behavior and effects of biochar is limited, mostly limited to short-term laboratory experiments. In the future, short-term laboratory experiments and long-term field experiments can be combined for research. In the future we also need to systematically study the stability of biochar obtained from different raw materials and production methods under different climate and soil conditions.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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