

Analysis of The Relationship Between Biochar And Soil

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Abstract. Biochar helps plant growth and is commonly used in agriculture as a soil conditioner for charcoal. This paper examines biochar, focusing on its usefulness for soil remediation, production, environmental benefits, and bioeconomic advantages. When comparing biochar with other carbon-rich solids, biochar can reduce greenhouse gas emissions. Biochar is produced using raw materials such as animal manure and waste. The conversion of waste into an adequate carbon-rich solid is an effective way to add value to the material. The sustainability of biochar feedstock can ensure the safety and stability of the food supply when other organic feedstocks are unavailable to ensure food production. Biochar is also a soil amendment that significantly improves the physical, chemical, and biological properties of the soil, and can be used to remove contaminants such as heavy metals and other harmful substances from the soil and reduces the density of the soil so that it can absorb more of the air, water and nutrients that the soil needs. At the same time, reducing the density of the soil provides a more suitable environment for microorganisms to live in. Biochar can be used in industrial, agricultural, and other areas with economic advantages. Therefore, biochar can be a value-added product to sustain the economy. It is a product with economic value and provides additional income.

Keywords: Biochar, Soil Conditioner, Application.

1. Introduction

Biochar is a substance that is very similar in appearance to charcoal. It is a substance made by burning in a controlled pyrolysis process of organic matter from agricultural or industrial waste. Biochar is very similar to charcoal in appearance, but its function is different from charcoal. The unique production process makes its main function to store carbon while reducing pollution. The energy or heat produced during the pyrolysis process of biochar can be easily accessed and used as a renewable source of clean energy. With regard to the physical properties of biochar, biochar has a distinctly black, porous, lightweight, fine-grained appearance and the surface area of biochar is very large. It is composed of approximately 70% carbon [1]. The remaining part is composed of nitrogen, hydrogen, oxygen and other elements. Therefore, biochar is the most efficient and cleanest way to convert carbon into a stable form at the same time. The rational and effective use of biochar is essential to improve the economic viability and environmental sustainability of biomass thermochemical technologies. The application of biochar in agriculture and the environment has been extensively studied [2]. After entering the 21st century, biochar has become a hot spot for multidisciplinary research due to its unique characteristics, wide range of applications and broad development prospects. In the face of food security issues, polluted environment and lack of energy, the prospect of biochar's basis and application in agriculture, environment and energy as well as research investigations have increased dramatically. Biomass inevitably releases large amounts of carbon dioxide gas and methane gas into the earth's atmosphere during the process of combustion and natural degradation. However, while the production process of biochar also inevitably results in the production of carbon dioxide gas. The remaining carbon levels become very stable. Biochar has been in the ground for centuries, slowing the growth of greenhouse gases. At the same time, its presence on earth improves water quality, increases soil fertility, increases agricultural yields, and reduces overexploitation of primary forests. In addition, with the development of technology, the application of biochar is expanding and is no longer limited to soil improvement or environmental enhancement, but can be used as a catalyst, fuel cell gas storage, activated carbon, etc. Biochar is valuable for filtering drinking water in daily life, treating food waste from daily production, and as a composting agent in agricultural fields to improve soil fertility. All of these uses have proven to be

widespread in many different pre-industrial cultures. In contemporary society, its uses have multiplied: adsorbents for functional clothing, insulation for the construction industry, food packaging for supercapacitors for energy management, wastewater remediation and air purification. In the future, biochar will have a much more comprehensive range of applications than it does today, and its uses will increase dramatically.

Biochar has been present in our environment for more than 2,000 years, and the earliest records of biochar come from the early Amazon basin. At that time, the indigenous people gave it a name in Portuguese that translates to “black earth”. The name was given because when biochar was applied, the soil improved, became more nutritious, and crops grew better. Biochar was first discovered in the Amazon rainforest in 1950 by Dutch soil scientist Wim Sombroek, the first modern study of biochar [3]. For biochar to play a valuable role in revitalizing nutrient-poor soils, it should significantly increase the amount of available plant nutrients and nutrient retention capacity. However, improving soil fertility and crop yield is a complex task involving a complex balance of biotic and abiotic processes. The contribution of biochar to soil improvement is significant, but this does not mean that its massive application does not have negative impacts on our environment. Firstly, the massive application of biochar can lower the pH of soil, leading to a decrease in the activity of soil insects such as earthworms; secondly, it has been investigated that the free radicals in biochar can induce oxidative stress after massive application, thus becoming a neurotoxin for soil organisms. Therefore, biochar has both advantages and disadvantages, and we should use biochar in a reasonable way. It should not ignore the drawbacks of applying biochar in large quantities. As a result, this article mainly introduces the relationship between biochar and soil, hoping to provide a new idea for the subsequent application of biochar in soil.

2. The relationship between biochar and soil

Biochar is used in a wide range of applications both in life and in scientific investigations, the first of which is known to be for soil improvement, as shown in Figure 1 [3]. However, it can be used not only for soil improvement, but also for power development and thermal energy development. The focus here is on the benefits of biochar for soil amendment, a method that has been used since the indigenous peoples of the Amazon basin thousands of years ago. Combined with its physical properties as well as its chemical properties, biochar is exceptional for its ability to adsorb and retain water, nutrients and agrochemicals. It can even retain nutrients, such as nitrogen and phosphorus, that are difficult to keep in the soil for long durations. In addition, the large surface area and rich pore structure of biochar provide a safe habitat for microorganisms and fungi. Some of the retained fungi form a symbiotic relationship with the fibers of the plant roots, allowing the plant to absorb more nutrients as it grows, giving the crop safe access to sufficient nutrients as it grows. Therefore, it is clear that soil treated with biochar produces more robust crops and more nutrient-rich crops than regular soil. Another aspect of biochar is that it improves the durability of the soil, which means that biochar lasts longer than any organic material normally applied to the soil.

Due to the physical properties of biochar it allows the soil to retain water or nutrients in the soil for a long and durable period of time. All of the benefits associated with nutrient retention in the soil, moisture retention and soil fertility are longer lasting and more cost effective than if just regular fertilizer is used. There is also a tendency for the acidity of the soil to decrease with the application of biochar, and biochar can reduce the use of lime. Biochar absorbs and retains nutrients in the soil, reducing the need for fertilizer at the time of application in a way that regular fertilizer cannot. It reduces the cost of fertilizer and allows it to stay in the soil longer, reducing the environmental impact of over-fertilization to a certain extent. Finally, the application of biochar results in a significant increase in crop yield in the soil. When biochar is applied to the soil, biochar can significantly improve plant growth and add more crop yield, increasing total food production and sustainability in farmlands where there is a lack of soil nutrients, insufficient organic resources, water or inability to even supplement agricultural fertilizers. Not all soils have the same positive effect when biochar is added,

and it often takes up to a year to see results. Many studies have shown that in soils with low carbon content and lack of nutrients, crop yields can increase up to four times or more when biochar is applied to normal soils [4]. It is important to note that all soils may not have the same improvement effect when biochar is added. The basic chemical and physical characteristics of biochar are influenced by the type of raw material used in the heating and the different conditions in the pyrolysis reaction. For example, biochar made from excrement will have a higher nutritional value when applied to soil than biochar made from leaves. However, biochar made from biochar may contribute significantly to soil persistence when applied to soil [5].

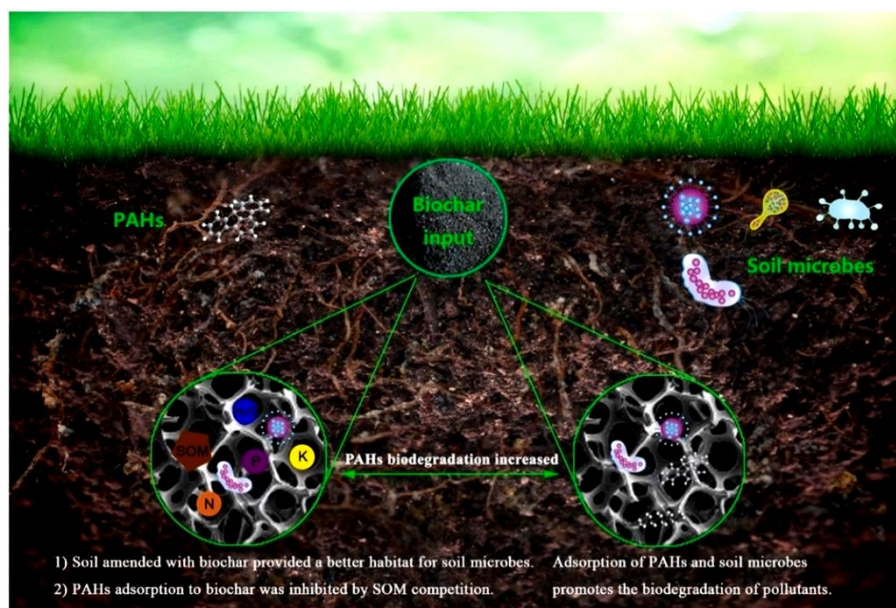


Figure 1. Combined action of biochar and soil microorganism for pollutant removal [3]

In addition, biochar can improve our environment by improving the soil and climate to a great extent. Today, all humans and policies are trying to implement energy saving and emission reduction strategies to help reduce the damage of greenhouse gases to our atmosphere and slow down the global warming problem. While biochar has many different properties and uses, carbon sequestration is a common function of all biochar applications. By immobilizing efficiently degradable plant carbon in durable charcoal, carbon dioxide is slowly but reliably reduced in the amount emitted into the atmosphere. While green plants fix atmospheric carbon dioxide through photosynthesis, organic matter will then be released into the atmosphere through respiratory decomposition. In this process, if biochar is applied to the soil, the decomposition of organic carbon can be indirectly prevented, so that the carbon in organic matter can be stored in a relatively stable form and carbon emissions can be reduced. According to statistics, the global annual carbon emission from industrial waste, forestry waste and residues, and municipal waste is 0.16 Pg C [6].

Biochar production can fix 30.6 kg of carbon for every 1 GJ of bioenergy consumed, and the perimeter of this carbon can offset more than 12% of global carbon emissions. The application of biomass char to soil can significantly reduce carbon monoxide emissions from soil when added at concentrations greater than 20%. It has been found that biochar can adsorb enzymes and other organic materials in the soil, inhibit the mineralization of organic carbon in the soil, and reduce the emission of carbon monoxide from the soil. It is believed that biochar reduces soil carbon monoxide emissions due to the toxic effects of soil microorganisms. When biochar is used in whatever form, it can affect not only carbon emissions, but also other non-CO₂ greenhouse gas emissions in the soil. When biochar is applied to soils in rural or rangeland areas, significant reductions in NO_x emissions can be observed. This is because biochar, when applied to soils, reduces the soil bulk and alters aeration, thereby limiting microbial transformation and denitrification of nitrogen. As a result, nitrogen oxide emissions are reduced. Some researchers also believe that the application of biochar to the soil changes the pH of the soil and that the changes in soil properties caused by biochar lead to the

emission of greenhouse gases such as methane gas and nitrogen oxides into the atmosphere. Biochar can also suppress the emission of greenhouse gases such as methane and nitrogen oxides from the soil by altering the nitrogen fixation of the soil and the activity of microbial colonies. Oxidation reactions on the surface of biochar can also enhance the adsorption of nitrogen and reduce greenhouse gas emissions. In addition, biochar can also reduce GHG emissions by regulating soil temperature. When biochar is applied, its physical properties and chemical reactions with microorganisms can largely reduce the phenomenon of over-emission of greenhouse gases in the atmosphere, helping to improve our climate and reduce global warming. When applied, biomass charcoal may also affect methane emissions in the soil. For example, the content of oxygen radicals in biochar, the content of free radicals in aromatic rings and the presence of toxic substances may reduce methane emissions. At the same time, reducing nitrogen oxides by biochar may increase other forms of nitrogen loss, which may also cause environmental hazards, such as the inhibition of denitrification by biochar and the enhancement of nitrification, which may lead to the accumulation of sulfur oxides. Therefore, the use of biochar to reduce greenhouse gas emissions should consider the overall effect of biochar on the soil nitrogen storage ring, and the application of biochar should be carried out rationally to improve our climate to reduce greenhouse gas emissions in the atmosphere and have a positive impact on our climate [7], as shown in Figure 2.

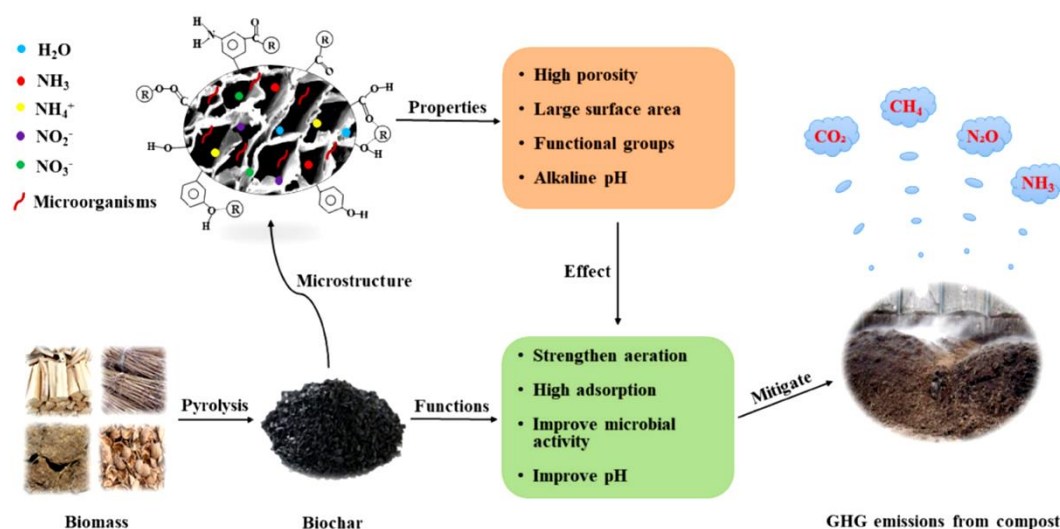


Figure 2. Schematic diagram of the relationship between biocarbon and greenhouse gas emissions [7]

Finally, biochar can also help in the economic development of the agricultural sector, which is conducive to greater profitability. In China, agriculture is one of the least profitable industries in all of China due to the large gap between the east and west of the country and the climate gap between the north and the south. Since the reform and opening up, China has gradually realized the importance of developing the economic and social environment together. Even though the government has promulgated many welfare policies and substantial economic subsidies, the living standards of many farmers have not been significantly improved, and a large proportion of farmers are still living in poverty. Government subsidies do increase the income of farmers in the region to a certain extent. However, they do not lead to sustainable poverty alleviation and an increase in the population's income. Therefore, changing the existing agricultural production model is the primary way to increase farmers' sustainable income and improve the sustainability of future development. Pyrolysis is the main pathway for biomass energy production, while biochar is a by-product of the pyrolysis process. Again, according to current research investigations, biochar is a substance that can achieve very stable carbon storage. Due to the physical effect of biochar, the porous structure of the surface not only helps to fix carbon but also retains a large number of microorganisms in the soil so that when fertilizer is applied, the nutrients of the fertilizer can be preserved for a relatively long period, as well as the water

after irrigation. This physical effect can significantly increase the use of irrigation and fertilizer, which can help farmers' sustainable income in these aspects [8].

Applying biochar reduces the need for water and fertilizer inputs, reducing farmers' investment in planting and reducing costs, allowing them to make more profit. At the same time, the yield of crops will increase significantly with the application of biochar, which will not only help economically but also help to reduce or slow down the degradation of our environment. Using pyrolysis in combination with biochar as a soil amendment will not only increase autonomous energy production but also create a sustainable environmental system for future generations. Fertilizers in our country are mainly nitrogen and phosphorus fertilizers, which are used in large quantities in some areas where the land is infertile, which is undoubtedly harmful to our environment. However, when biochar is applied, the utilization rate of the fertilizer will be improved without the need to apply as much fertilizer as before [9], as shown in Figure 3. This helps not only the environment but also helps farmers to reduce their expenses and increase their profits [10]. In general, the economic advantages of biochar are undeniable, as it reduces farmers' costs, increases profitability, and increases the utilization of fertilizer and water, reducing waste. It also reduces waste by improving the utilization of fertilizer and water and does not have the effect of damaging the environment while bringing economic benefits.

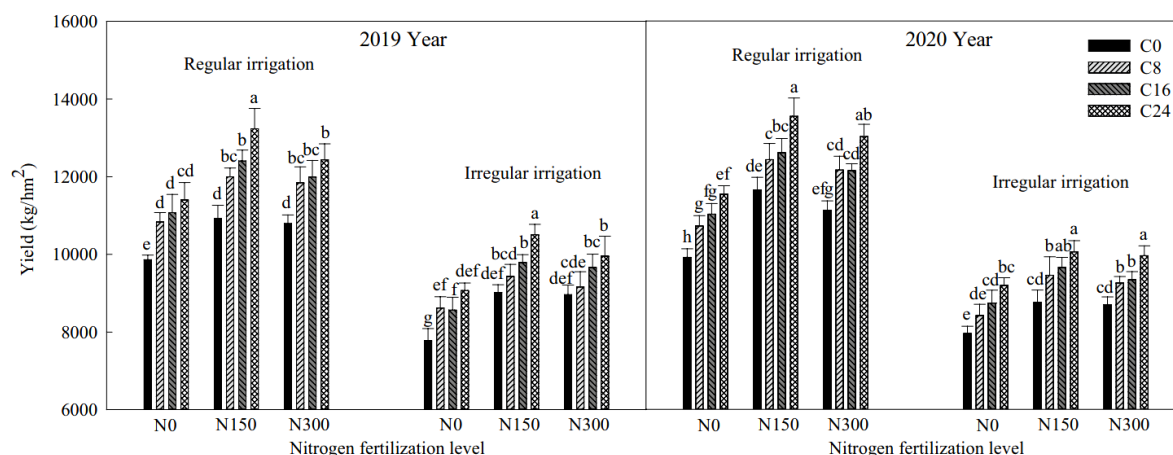


Figure 3. Effects of biochar and nitrogen fertilizer on maize yield [9]

3. Conclusions

In general, the advantages of biochar can be used as a soil conditioner to turn poor soil into fertile soil, remove pollutants from the soil to reduce soil density so that the soil can absorb more nutrients and oxygen water needed by crops. It can increase the yield of crops and bring help the sustainability of the land. It brings more help to our agricultural development. Also, climate help cannot be ignored. Biochar can re-fix carbon emissions by reducing the amount of carbon dioxide absorbed by plants into the atmosphere. This is an essential contribution to improving our climate. It also helps to improve environmental sustainability. At the same time, biochar can also bring economic benefits, increasing crop yields to form sustainable and safe, stable food production, bringing higher economic income to China's agriculture. Of course, if we want biochar to bring more positive effects, we need to pay attention to the amount of biochar application. We cannot ignore the adverse effects of biochar, so when we control the amount of biochar used, we get more help than the disadvantages of biochar itself.

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