Review Article

A Review on Biochar and Its Application in Agriculture

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Abstract

Biochar, a byproduct of char production, is gaining significant importance for its use in soil health enhancement, scientific waste management, and mitigating global warming. Biochar is largely used to trap carbon to compensate for anthropogenic carbon emissions. Pyrolysis disintegrates organic wastes into a more porous, friable, nutrient-rich humic material. Soil aggregation by biochar helps to improve soil physical properties and increases infiltration rate and water holding capacity as well as used to purify soil water. Biochar application also boosts the microbial population in the soil that makes the soil environment more favorable for crop growth and development. Biochar has a significant ability to improve soil or water ecosystem processes due to its positive properties such as cation exchange capacity, organic carbon content, adsorption capacity, water-holding and nutrient retention capability are all characteristics that make biochar a viable choice for soil remediation and augmentation. In this study focus has been given to mainly technologies involving in biochar production and its beneficial effect in soil, plant and environment.

Keywords: Biochar, carbon sequestration, pyrolysis, climate change, soil health, waste management

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Introduction

Biochar is a carbon-based compound obtained by charring organic matter at low temperatures (<700 °C). Biochar is produced as a by-product during pyrolysis for bioenergy production. There is a lot of interest in using this biochar to trap carbon in soils as a technique towards mitigating manmade carbon dioxide (CO_2) pollution and also as a soil amendment because of its possible agronomic advantages [1]. This biochar production technique is sometimes compared to the manufacturing of coal that is one of humanity's earliest industrial inventions. [2]. Char has been exploited in both industrial and agricultural sectors for ages [3]. Biochar comprises smaller particles unlike charcoal, which is mostly made of solid wood. The feedstock of biochar is mostly post-harvest wastes, sawdust, cutgrass, and other organic wastes [4]. Biochar is developed with the purpose of being utilized in the soil to improve soil health, carbon sequestration, or water filtration (**Figure 1**). Biochar has advocated a solution to improve fertility of the soil and other ecological processes while also sequestering carbon (C) to combat climate change [5-8]. Biochar may also alter emissions potential of other greenhouse gases such as nitrous oxide (N_2O) and methane (CH_4) from the soil [9-15]. Biochar has been found to improve soil microbial biomass [20-21] and may change the composition of the biological community [16-19].

Biochar preparation technology

Thermal decomposition is a common way of making biochar. Thermochemical conversions include pyrolysis, Torrefaction, hydrothermal carbonization and gasification (**Figure 2**) [23, 24].

- **Pyrolysis:** Pyrolysis [25] is the process where organic molecules are thermally degraded in the temperatures ranging between 250 to 900 degrees Celsius in an oxygen-free environment. Pyrolysis can be classified as fast or slow considering the temperature, heating rate, residence time, and pressure.
- **Hydrothermal carbonation:** Since it can be performed at a low temperature of around 180-250 Degrees C, hydrothermal carbonization is a cost-effective way of making biochar.
- **Gasification:** Gasification is a thermochemical mechanism of digesting carbon-based materials into gaseous molecules, such as syngas, which contains CH4, H2, CO, CO2, and traces of hydrocarbons, in the availability of gasification factors such as air, steam, oxygen, and other heat sources.
- **Torrefaction:** Torrefaction is a relatively new process that generates charcoal. Mild pyrolysis is type of pyrolysis that uses a modest heating rate. Various decomposition processes were used to remove the carbon dioxide, oxygen and moisture, present in the biomass using inert ambient air in the absence of oxygen at a temperature of 300 degree C [26].

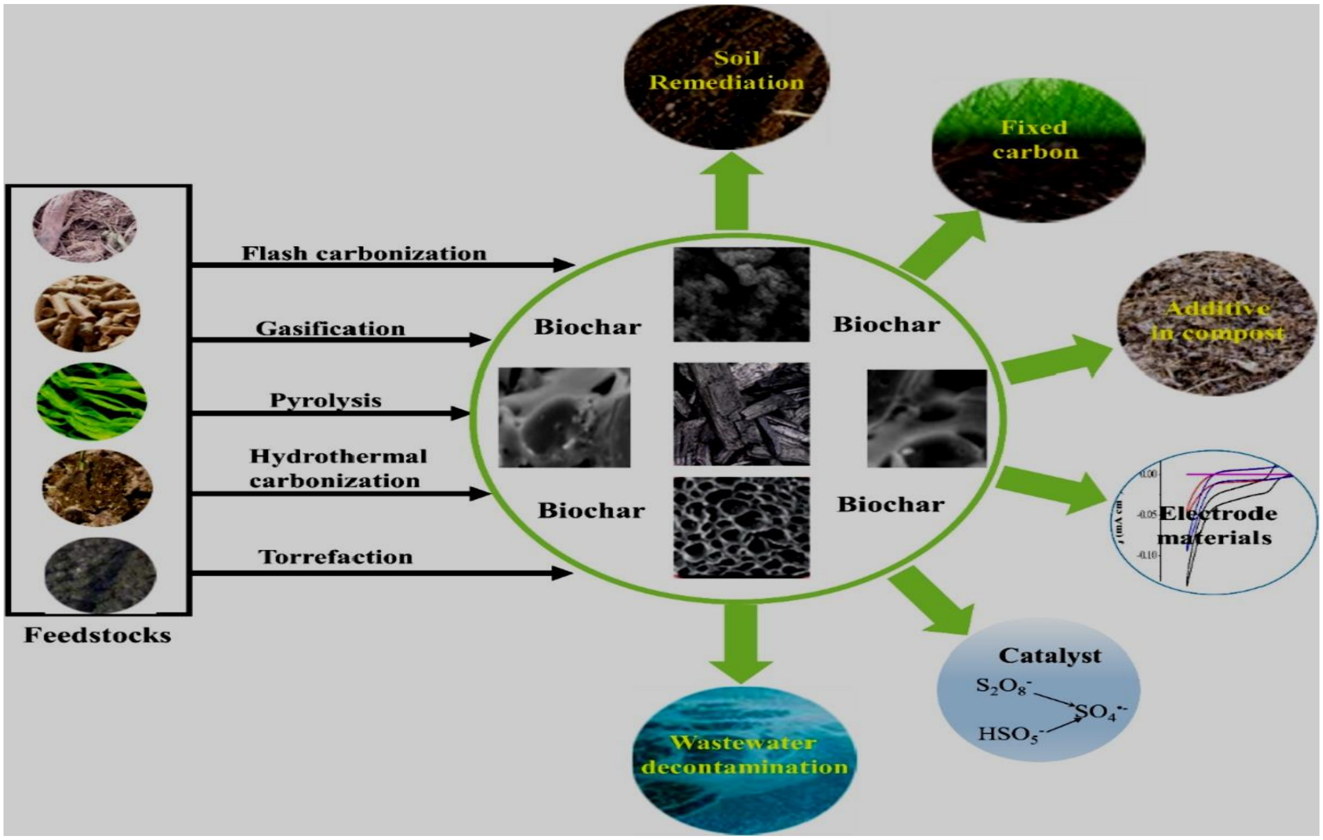

Figure 1 Biochar production and its application in agriculture [22]

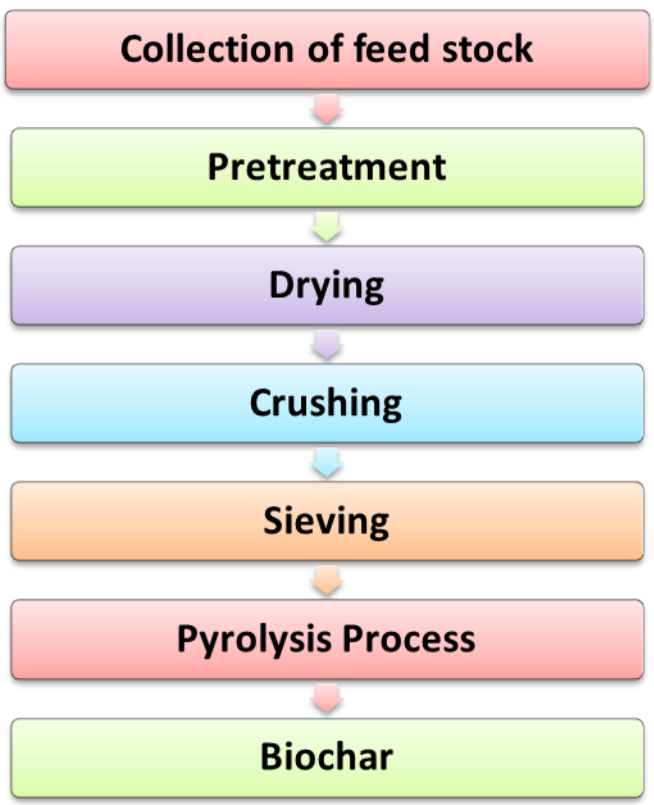

Figure 2 Biochar production process.

Benefits of Biochar

- **Biochar as waste management:** Managing agricultural wastes is a considerable environmental challenge that pollutes ground and surface waters [27, 28]. These wastes, together with other by-products, can be used to generate bioenergy through pyrolysis [29, 30]. This not only provides energy through charring, but it also reduces the volume and, in particular, the weight of the residual material, which is also an important concern in the management of animal wastes. [31].

- **Biochar as to produce energy:** Pyrolysis of organic materials for bioenergy production generates biochar that can be used as soil amendments and also and absorbing energy during biochar production are both beneficial for ensuring the production base for biomass [6] and lowering total emissions. In reality, bioenergy in general, and pyrolysis in particular, could play a key role in ensuring a steady supply of green energy in the future. However, it is unlikely that it would fix the energy crisis and meet expanding global energy demand on its own.
- **Bioenergy as soil amendment:** Biochar itself is a porous, highly variable organic substance with a large surface area that can improve soil water retention, surface sorption capacity, cation exchange capacity (CEC) and base saturation [32]. Biochar has been demonstrated to boost the bioavailability and plant uptake of different nutrients (**Figure 3**) and some trace metals when applied in the soil. Biochar additions to soil have been shown to promote mycorrhizal infection.

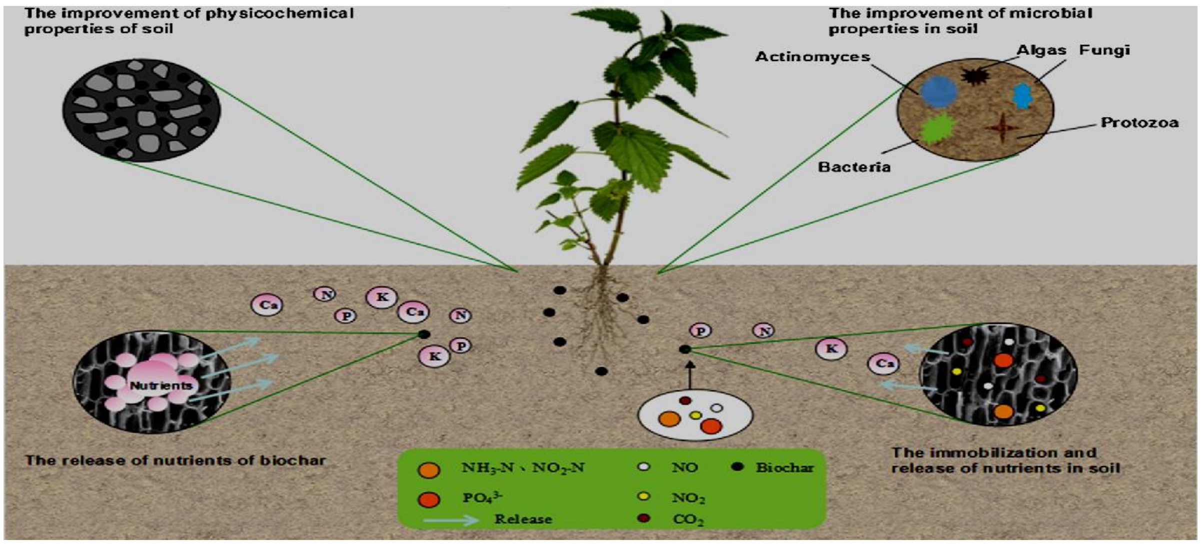

Figure 3 Effects of biochar on soil physiochemical properties [33]

- **Biochar to mitigate climate change**: Climate change induced by increased quantities of greenhouse gases (GHGs) in the atmosphere that incurs the catastrophic consequences for our planet [34]). As biomass decomposes under anoxic conditions, conventional biomass management frequently results in the production of methane (CH4) or nitrous oxide (N2O). Urban green trash (tree trimmings and garden garbage) when put in landfill, for example, emits considerable amounts of CH4, whereas animal manure rich in both C and N frequently decompose to release CH4 and N2O. GHGs such as CH4 and N2O have the potential to cause global warming. Various kinds of biomass waste can be used to generate biochar. The amount of emissions reduced by using waste for biochar would be determined on the properties of the biomass feedstock as well as the management techniques used. Biochar application to soil has been proved to influence the transformation and retention of carbon (C) and nitrogen (N) in soil. These activities, as well as other biochar-influenced processes, have the potential to significantly reduce emissions and increase GHG sink capacity. Biochar has been described as a way to sequester CO2 from the atmosphere by incorporating it into soils. [5]. As a result, rather than just creating energy, a biochar vision is extremely successful in providing environmental solutions.

Conclusion

In the present situation, when global warming is increasing at an alarming rate, use of biochar could be a viable solution to the changing climate. Biochar has a great influence on soil health as well as on the environmental health. Environment is at a risk due to several reasons; one of them is pollution due to residue burning. Therefore, digesting those residues into more useful soil conditioner is another advantage of biochar. Hence, it can be concluded that biochar has a potential to play pivotal role in combating climate change, improving soil fertility and mitigating environmental pollution.

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