

Biochar: Harnessing Nature's Charcoal for Sustainability

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Abstract

As we all know, CO₂ is a greenhouse gas that traps the largest amount of heat from the air, thus causing our planet Earth to get warmer and warmer. Humans raised CO₂ levels over the last two centuries years, leading to climate change. India, ranked fourth globally in emitting greenhouse gases (GHGs), sees a significant portion of emissions from the agriculture sector. Burning crop stubble in states like Punjab and Haryana worsens air pollution. Transitioning to cleaner practices like biochar is vital to reduce carbon emissions. Researchers are keen on biochar recently for its agricultural and environmental advantages. It enhances soil fertility, boosts crop productivity, and acts as a valuable tool for climate mitigation by capturing carbon in the soil. Even though scientists have studied the chemical, biological, and technical parts of biochar, using it effectively in real life is still far away. To make biochar work, we need to pay more attention to how people and organizations use it, not just the science stuff. This Paper Continues to debate about the benefits of biochar and the production of biochar using IOT sensors.

Keywords: Biochar, thermocouple, pyrolysis, charcoal, environmental

INTRODUCTION

In a report sent to the United Nations in 2021, India said that around 14% of all the greenhouse gases it produces come from farming. That makes farming the third-biggest source of these gases, after factories and energy plants. One big reason for air pollution in India is when farmers burn leftover bits of plants after harvesting, especially in the northern states like Punjab and Haryana.

The burning of crop stubble releases harmful pollutants such as particulate matter, carbon monoxide, and nitrogen oxide into the atmosphere, which can cause respiratory problems and other health issues [1]. To combat this issue, the government has banned the practice, imposed fines, and suggested alternate uses for the straw and other crop residue.

However, farmers continue to burn stubble due to various reasons, including the lack of affordable alternatives, the short time between harvests, and the high cost of manual labor. This is where biochar

can step in and make a big difference in farming. Biochar, a soil amendment, offers a dual advantage of mitigating greenhouse gas emissions and enhancing soil fertility. Despite considerable attention from researchers, its widespread adoption remains limited.

The practice of using biochar to improve soil isn't a recent discovery. It dates back around 2000 years ago to the Amazon region, where indigenous communities added biochar to their soils. They did this because they noticed it helped make the soil better and increased the number of crops they could grow.

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This historical use of biochar highlights its long-standing positive effects on soil quality and agricultural productivity [2-5].

Biochar is a substance like charcoal, created by heating organic materials like agricultural leftovers or forestry waste. This is done in a controlled setting, where there's either very little oxygen or none. This process is known as pyrolysis.

Pyrolysis is a controlled process used to convert organic materials such as wood chips or dead plants into biochar. It involves heating these materials in an environment with minimal oxygen, which prevents them from fully combusting. As a result, only small amounts of harmful fumes are released into the atmosphere.

Through pyrolysis, the organic matter undergoes transformation, yielding biochar—a stable form of carbon that remains trapped within the material matrix. This process not only helps to reduce waste but also produces a valuable product that can enhance soil health and mitigate carbon emissions.

Pyrolysis generates heat that can be harnessed as clean energy. Biochar is highly efficient in converting carbon into a stable form and is a cleaner alternative to other forms of charcoal [6].

OBJECTIVES

Achieve Net-zero Carbon Emission

As the world continues to advance technologically, achieving zero carbon emissions becomes a formidable challenge. Carbon emissions persist not only from traditional fuel sources but also from modern facilities such as data centers, planes, rockets, ships, and more.

However, a promising solution lies in the utilization of biochar. Biochar has the potential to facilitate net-zero carbon emissions by effectively absorbing the released carbon and securely storing it in the ground for thousands of years [7].

Increase the Production of Biochar Using IOT Sensors

As different material requires different temperature to cook to make biochar e.g. - rice straws 400c to 500 and pine chips, peanut hulls, saw dust etc. 300c to, therefore IOT sensors will play a key role in producing biochar.

Biochar Awareness Among Farmers

To achieve net-zero carbon emission, creating awareness among the farmlands on the benefits of biochar for carbon absorbing farming is necessary.

BIOCHAR

Biochar is a substance similar to charcoal, formed through a controlled process called pyrolysis. In pyrolysis, organic materials like agricultural and forestry waste are heated with limited or no oxygen. This controlled environment prevents the materials from fully burning and instead transforms them into biochar [8].

Biochar is produced using specific material and specific process to reduce contamination and produce high quality of biochar. Like sawdust, dead plants, wooden chips, rice straws etc.

Biochar helps in absorbing carbon dioxide for the air and storing them into the ground. This means carbon will go from where it came from. It help's in storing carbon for 1000's of years without letting it out.

The burning of biochar releases flammable gases which is in turn used to heat the reactor where biochar is produced, and the remaining gas will be used to create heat or renewable electricity [9].

The process releases Flammable gas or syngas which can be used to produce heat and renewable energy (Figure 1). Syngas can also be used to produce biofuels.

Biochar is then cooled with water and mixed with soil to form a composite mixture, this mixture is then used in agricultural fields to grow crops at a faster rate because biochar helps the crops to extract nutrients from the soil effectively [10].

The composite mixture of biochar mixture looks like this:

These chambers also help in storing water for long periods of time which can be used by crops (Figure 2). The biggest advantage of biochar is that it stores carbon (CO₂) from the atmosphere for 2000 years approx. Biochar can store about 0.5-2 tons of CO₂ per year depending on how much of biochar is used.

Advantages of using biochar in agriculture

- Increase soil structure.
- Increase water storing capacity of soil.
- Makes soil highly fertile.
- Ability to hold on nutrients.
- Ability to absorb 'CARBON' from the atmosphere.

PRODUCTION OF BIOCHAR

Biochar can be derived from diverse sources of agricultural and forest waste. Among these sources are peanut hulls and pine chips, which contribute to the production of approximately 78% of biochar. Additionally, wooden waste, deceased plants, sawdust, and similar materials can yield biochar at even higher percentages [11].

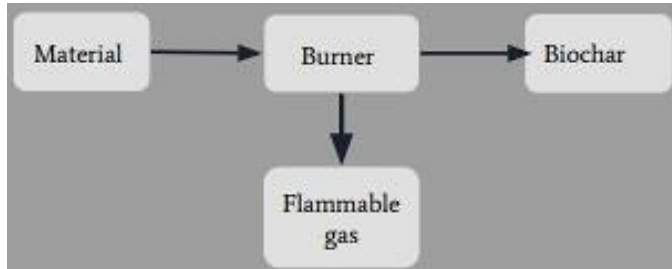


Figure 1. Process releases flammable gas.

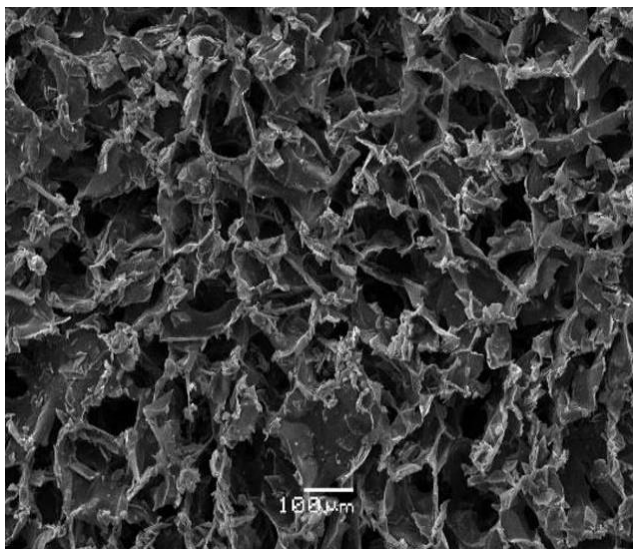


Figure 2. Composite mixture of biochar mixture.

The waste materials undergo heating within the range of 400°C to 500°C or higher, a temperature determined by the specific material being processed. This occurs in a controlled environment with limited oxygen or in the absence of oxygen, and without interaction with any other oxidants. This thermal decomposition process is commonly known as pyrolysis.

As different material requires different temperature to cook to make biochar e.g. - rice straws of 400°C to 500°C and pine chips, peanut hulls saw dust etc. 300°C to 400°C.

Some scholars have found that biochar prepared at different temperature are significantly different and different addition of materials can cause differences in soil environmental effects. Hence, it's crucial to regulate the temperature during the biochar production process. To solve this issue there are different IOT temperature sensing device called thermocouple.

- K-type thermocouple, range 0c - 1300c, 2 O/P
- PT-100 thermocouple, range -200c to 850c, 3 outlets

A thermocouple is a temperature-sensing device made up of two or three different metal wires connected to create a junction. When this junction is either heated or cooled, a small voltage is produced in the thermocouple's electrical circuit. The voltage can be measured, indicating the temperature of the surrounding environment.

To gather temperature data, various data acquisition models or systems are utilized. One of these devices is the thermocouple input model, specifically designed to collect data from the thermocouple (Figure 3).

This method will help us to control temperature at which Biochar is prepared, thus producing high-quality of biochar on a larger scale. This approach helps us manage the temperature during biochar preparation. For instance, if the temperature goes beyond the set limit, the thermocouple will sense the increase and alert us. This way, we can take action, like turning off the blower or heat source, to keep the temperature in check.

For effective monitoring and optimization of the pyrolysis process, it is essential to install sensors within the equipment. These sensors need to measure important factors like temperature, humidity, and other relevant parameters. This setup enables continuous surveillance of the process, empowering you to make real-time adjustments as necessary for optimal performance.

Using a data logging system is crucial for analyzing the data gathered by the sensors. This system records the readings over time, enabling a comprehensive analysis. By identifying trends and patterns within the data, you gain valuable insights that can be instrumental in optimizing the pyrolysis process.

Once you have collected sufficient data, you can use it to identify opportunities for improvement in the pyrolysis process. For example, you may find that certain temperature or humidity ranges are associated with higher biochar yields or better quality. You can then adjust the process accordingly to optimize the production of biochar.

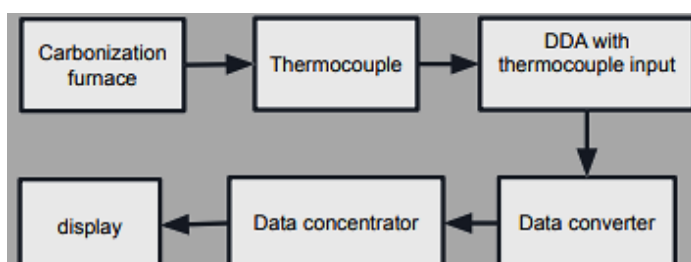


Figure 3. Thermocouple input model.

To maintain optimal conditions for biochar production, you will need to continuously monitor the process and make adjustments as needed. This may involve adjusting the temperature, humidity, or feed rate, or making other process changes as required.

CONCLUSION

The report highlights the pivotal role of biochar in attaining net-zero carbon emissions. Integrating IoT sensors into the biochar production process can substantially enhance the production of high-quality biochar. Given that biochar is environmentally friendly and an effective carbon absorber, it has the capacity to store large amounts of carbon in the ground for thousands of years or more. This implies that increasing the use of biochar in agriculture can result in the absorption of more carbon each year, contributing to a positive environmental impact.

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