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REVIEW ARTICLE

Biochar and forests: A green solution to sustainability

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Abstract

Biochar is a carbon-rich product that is produced by pyrolysis of organic biomass like forestry waste, animal manure and crop residues in low oxygen conditions using thermochemical processes like pyrolysis, torrefaction, gasification. Slow pyrolysis is most widely utilized among them due to its increased yield and carbon stability. Properties of biochar such as pH, surface area, porosity and nutrient content depend on the feedstock and production conditions. As a green and sustainable solution, biochar finds applications across multiple sectors. In forestry, it enhances soil porosity, water retention capacity, nutrient supply and microbial activity, which stimulates forest regeneration and reduces forest fire risks. In agriculture, biochar enhances soil fertility, agricultural yields, minimizes fertilizer use and leaching of nutrients. Biochar also plays a significant role in climate change mitigation by sequestering carbon in soils for long periods and reducing greenhouse gas emissions such as methane and nitrous oxide. In environmental remediation, its porous structure allows for the adsorption of heavy metals and organic pollutants from soil and water. In the energy industry, biochar is used as a solid renewable fuel or as a byproduct of syngas-producing or bio-oil producing systems. All these multi-variant uses make biochar a powerful instrument for circular economy initiatives, sustainable land management and climate action. With continued research and policy support, biochar presents a potential route toward ecological restoration and stable ecological conditions.

Keywords: biochar; carbon sequestration; climate change mitigation; soil health; sustainable forestry management

Introduction

Biochar is a carbonaceous substance resulting from the heat breakdown of organic materials, that includes agricultural waste, wood, or manure in an oxygen-limited condition (1). Pyrolyzed biomass at low temperatures (<700 °C) is similarly made into biochar, as is done during traditional charcoal production. Finally, this process has been altered to generate biochar dedicated to soil augmentation and carbon sequestration (2). The large surface area and high porosity as well as stable structure of biochar makes it good for such applications as soil remediation and carbon sequestration (3). Biochar is produced using pyrolysis, gasification and hydrothermal carbonization, depending on feedstock type and according to specific circumstances, the biochar yield and properties vary greatly (1). Boosting soil fertility, reducing greenhouse gas emissions and storing carbon are the ways in which biochar is used presently. In addition, it aids in water filtering as well as supporting material for enzyme immobilization (1, 3). Finally, biochar is a commercial bio product, a bioeconomy product that contributes to generate new revenue streams, as well as Sustainable Development Goals (SDGs) (1).

Sustainable Forest Management (SFM) is a multi-faceted process of managing environmental, economic and social functions of forest ecosystems. Its final objective is to sustain the long-term health and development of the forests for current and future generations. Sustainable forestry has developed as a holistic approach involving environmental, ergonomic, economic, quality of product and societal factors. It seeks to attain maximum income and wood quality and create environmental advantages, put an end to climate change and promote the safety of workers in forest stewardship (4). SFM legislation and policies that cover 97 % of the global forest area are globally recognized. However, difficulties continue to exist within low-resource countries where only 37 % of the forests are delineated. Over the past decade, though, greater certification and planning for sustainability have not yet come close to meeting the pressing imperative to establish enabling conditions for SFM (5). Forestry sustainability has evolved from sustained-yield principle through to the general SFM concept over the past 200 years because of changing social values and to reconcile ecosystem constraints with social dynamics (6). SFM principles are to be re-examined in the context of increasing pressures for mitigation of forest climate change, biodiversity protection and supply of bio-renewable products. The objectives are to be met by forest management tools within guidelines (7). In the context of the Sustainable Development Goals (SDGs), forestry has a twofold function of supplying both desired and undesired ecological impacts that need combined estimates of forest policies and contributing to sustainable development (8).

The longer forest ecosystems can last, the more soil quality is a concern. Soil quality affects forest ecological processes like carbon sequestration, nutrient cycling and support for biodiversity and plays a pivotal role in management and restoration. Nutrients carbon, nitrogen and phosphorus play a critical role in sustaining forest life, with soil bacteria and other microorganisms serving to cycle nutrients and decompose organic matter (9, 10). By their natural function, these microbes promote plant growth and ecosystem process (9). Healthy soils also serve as carbon sinks, storing atmospheric CO_2 and preventing climate change. Increased soil fertility and structure-two measures vital to sustained forest health-successfully facilitates this role (11). Forest restoration activities increasingly track soil health indicators like soil carbon, nitrogen and pH for intervention effectiveness assessment as well as for SFM practice regulation (12). Microbial communities are the core of soil multifunctionality, upon which forest ecosystem stability rests.

Climate change mitigation is an international problem and the most efficient way to cut atmospheric CO_2 is one of the promising carbon sequestration measures. It is the sequestration of carbon into natural reservoirs such as soils, forests and oceans. Soils contain more terrestrial carbon than any other pool and thus carbon management is of the highest priority for them. Land-use management restoration can potentially enhance Soil Organic Carbon (SOC) and potentially balance significant amounts of annual CO_2 emissions (13). However, precise definitions and assessments must exist to keep soil carbon sequestration effective and avoid overoptimism, particularly since non-CO_2 greenhouse gases can offset some gains (14). Though macroalgal forests promise carbon removal, they are not yet appropriately integrated into policy and research strategies (15). Agroforestry systems-agriculture plus tree planting-can sequester carbon while providing food, fuel and biodiversity benefits. Despite this, their carbon impacts are occasionally hard to discern because of concurrent emission from other land use. The systems are particularly useful in semi-arid climates if used with strategic planting and management (16). Climatic impacts of carbon sequestration are not only a function of how much carbon is sequestered, but also duration of storage, influencing radiative impacts and guiding comparisons across varied carbon management practices (17).

In this context, biochar presents itself as a valuable and versatile tool for advancing SFM and addressing the challenges highlighted above. Biochar is a stable, carbon-rich material known for its ability to enhance soil structure, increase water retention and support microbial activity and those factors are critical for forest regeneration, productivity and resilience. In both forestry and agroforestry systems, biochar improves soil fertility, reduces nutrient leaching and boosts crop performance, making it especially useful in degraded and nutrient-deficient soils. Moreover, due to its long-term carbon stability, biochar serves as a nature-based carbon sequestration solution, helping reduce greenhouse gas concentrations in the atmosphere. These characteristics make biochar a multifunctional tool that supports not only forest ecosystem restoration and climate mitigation but also rural livelihoods and sustainable agriculture. Importantly, biochar contributes to the achievement of several Sustainable Development Goals, including SDG 13 (Climate Action), SDG 15 (Life on Land), SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production). Thus, integrating biochar into land and forest management strategies aligns with global sustainability efforts and offers a pathway toward resilient and productive ecosystems.

Biochar technology: Transforming waste into a valuable resource

Pyrolysis of biomass to produce biochar means heating organic material in an oxygen deficient atmosphere. For the environment and agricultural purposes, the research has been drawn because of the unusual features possessed by it. It has been known that biochar is rich in carbon and it is chemically stable enough to be considered as a potential carbon sequestration and reducing greenhouse gas emissions (18). It has an increased porosity and an extensive specific surface area and that makes it excellent as an adsorbent (19). Biochar has a high cation exchange capacity that improves ability to store nutrients and improve soil fertility (18). Biochar is created through major method called pyrolysis. In other words, it is the heat degradation of biomass without oxygen (Fig. 1). Different feedstock types such as agricultural waste, sewage sludge and forestry residues can be used to produce biochar and the characteristics vary. In addition to pyrolysis, other thermochemical methods like gasification and torrefaction are also used for biochar production. Gasification is a partial oxidation of biomass at high temperature (usually >800 °C), with less biochar but the byproduct syngas and thus more energy focused. Torrefaction is a less severe process at 200-300 °C under inert conditions, yielding a solid, energy-rich product with enhanced fuel characteristics. Both yields less biochar than pyrolysis, yet both have different physicochemical properties based on feedstock and end use (20).

Types of feedstocks used for biochar

The range of feedstocks used to make biochar results in a wide range of properties finally provided. Vine pruning, orange pomace, wheat straw, canola straw and rice straw are common feedstocks. These feedstocks are used widely as a result of having a ready supply and improving soil conditions (Fig. 2). Because they are all rich in nutrients, one reason for the use of poultry litter, cow dung and pig manure for culturing biochar is that they can enhance the nutrient content of biochar (21). As forest byproducts such as sawdust and pine wood have high carbon content and high stability, they are used because they are suitable for a long-time carbon sequestration (22). Biochar is also made from seaweed, sewage sludge and other plant wastes, such as tomato and cucumber plant waste, each with different chemical and structural properties. Other notable feedstocks include coconut shells, bamboo, sugarcane bagasse, corn cobs, coffee husks and nutshells. Among these, woody biomass and lignocellulosic materials such as coconut shells and hardwoods are considered more suitable for long-term carbon storage due to their high carbon stability, while animal-based residues and manures are preferred for soil nutrient enhancement. Pyrolysis at elevated temperatures (higher than 500 °C) improves the stability, carbon content and surface area of biochar and diminishes volatiles and yields. As a result, both biochar obtained with increased recalcitrance and the carbon could be sequestered during a substantially longer period (23).

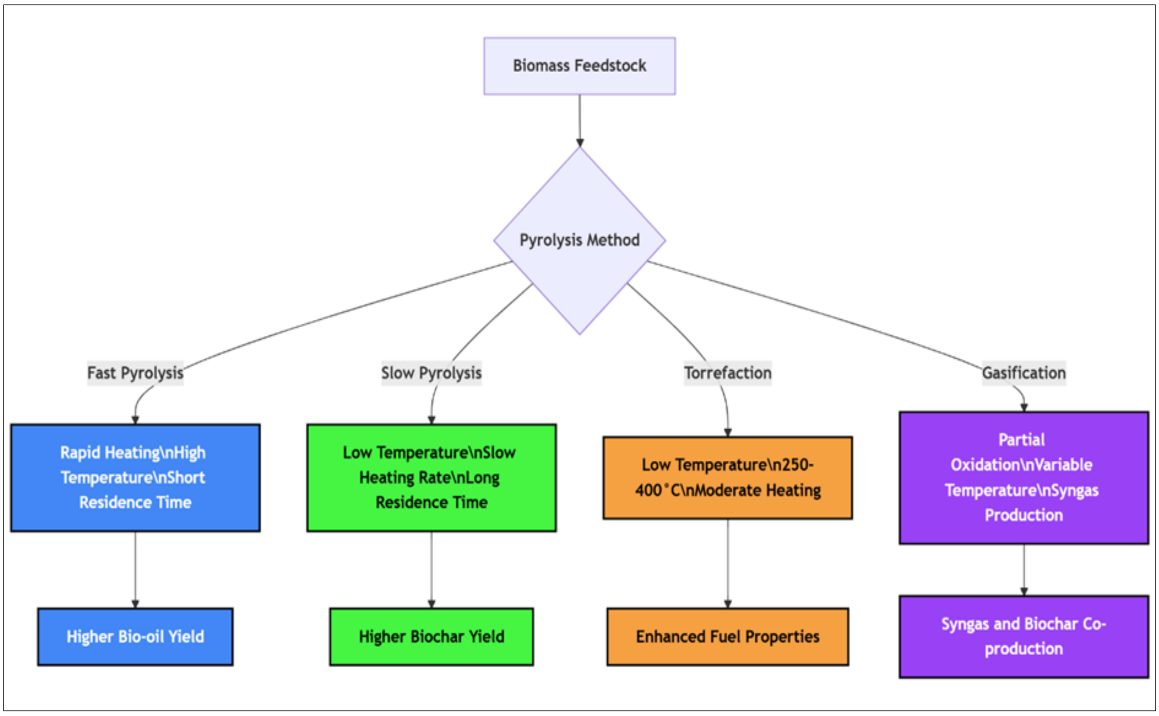

Fig. 1. Biochar production methods.

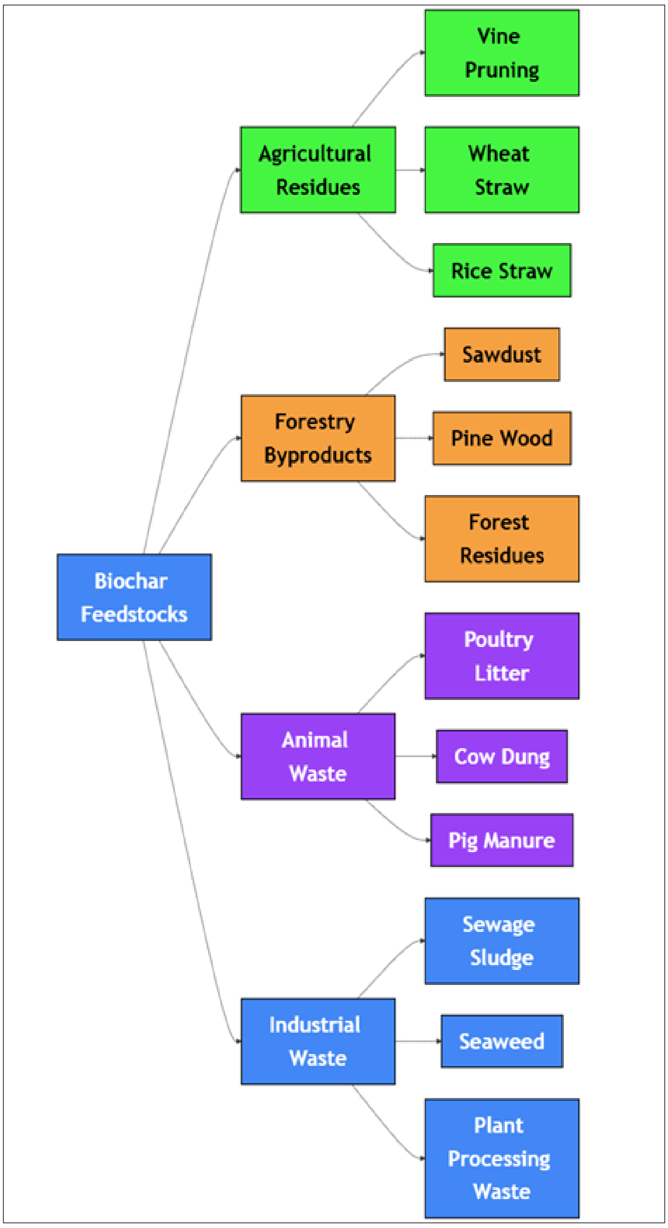

Fig. 2. Feedstock diversity.

However, the ash content, pH and hydrophobicity of biochar tend to increase with increased temperature of pyrolysis, but hydrophilicity and labile carbon concentration tend to decrease. As such, these alterations may enhance biochar's ability to absorb organic pollutants and heavy metals (24). We demonstrate that pyrolysis of blended feedstocks can produce biochar with higher quality attributes and higher yield than individual feedstocks with less waste and pollution (25).

Understanding biochar's physical and chemical properties

The feedstock and pyrolysis conditions affect biochar's high porosity and surface area. These attributes increase biochar's capability to capture nutrients, organic pollutants and gasses, making it a useful material for environmental applications (26). For soil application, the porosity holds nutrients such as phosphorus, potassium and nitrogen, minimizing leaching loss and fertilizer efficiency. Additionally, biochar can adsorb ammonium and nitrate ions on its surface and thereby minimize loss of nitrogen by volatilization or leaching (27). Biochar ability to amend soil and sequester carbon depend largely on its skeleton and envelope densities as well as the volume of its pores. Such qualities may change with exposure to the environment altering water retention and hydraulic conductivity (28) (Fig. 3). On low-water-holding soils such as in sandy soils, biochar enhances water storage since it is porous and contributing to improved better plant growth in arid areas. Conversely, in soils with high clay content, biochar could enhance aeration and decrease compaction. Low CEC tropical soils have been found by evidence to have the CEC increased tremendously by the application of biochar, enhancing the capability of the soil to hold necessary nutrients (29). The biochar's physical structure is dependent upon the raw material used and the pyrolysis method used. In this, particle size distribution and specific gravity are included. The diversity influences its use in soil and environmental remediation (30). Chemical composition of biochar (carbon, nitrogen and hydrogen content) is dependent on pyrolysis condition and

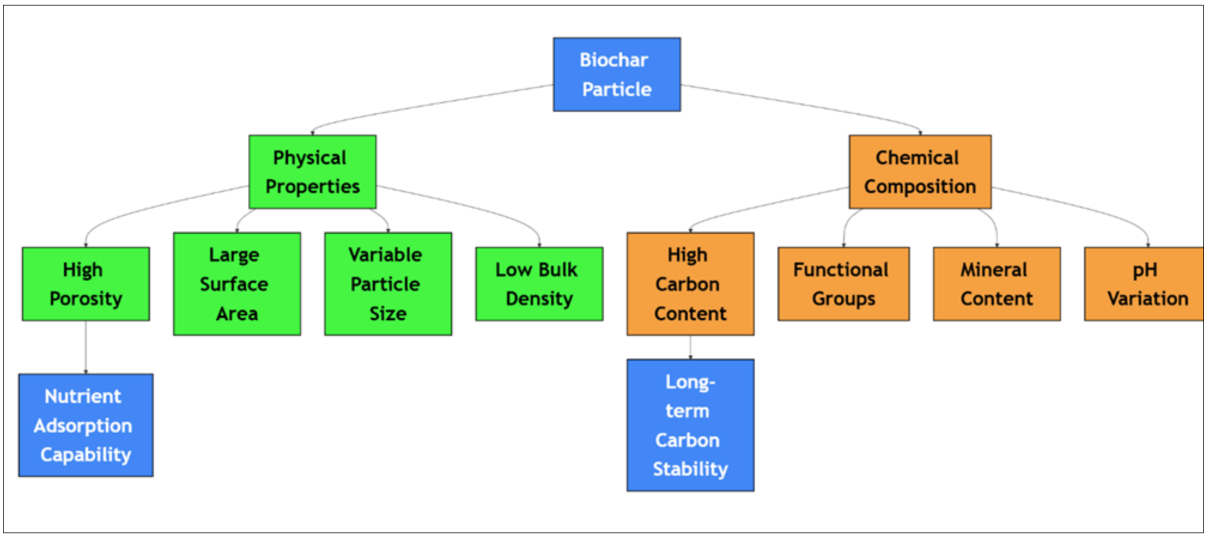

Fig. 3. Biochar's physio-chemical nature.

feedstock. Generally, higher pyrolysis temperatures lead to greater amounts of carbon, higher pH and lower yield, total nitrogen (31). The increased pH of biochar prepared at high temperature will be beneficial in neutralizing acidic soils, enhancing the yield of crops in acidic soils (32). Depending on environment, biochar has various functional groups, such as carboxylate and carbonyl. Internal phenomena induced by these alterations affect the chemical stability and soil and atmospheric CO_2 interactions (33). Pyrolysis temperature and feedstock regulation control ash content and pH. Pyrolysis temperatures and feedstock affect the ash content and pH. Overall, higher temperatures lead to higher ash content and pH; this is also related to higher fertility of the soil, if applied as an amendment.

Different methods of biochar production

Biochar production through fast pyrolysis

Thermochemical fast pyrolysis is a technique that rapidly warms biomass in the absence of oxygen generating charcoal, bio-oil and gas. This method is becoming popular because it is very effective for converting various types of biomasses into valuable commodities. Several types of biomasses ligneous rubberwood and eucalyptus and herbaceous *Phragmites australis* have been used in the fast pyrolysis. And these biomasses can be treated in different reactor designs to get biochar with suitable characteristics (34). A large amount of biochar and bio-oil can be generated from fast pyrolysis of microalgae leftovers, such as *Chlorella vulgaris*. Biochar collected contains different nutrients such as potassium, phosphorus and nitrogen that makes it appropriate for agricultural applications (35). Temperature, as well as heating rate, plays a key role on the characteristics and the output of biochar. However, higher temperatures tend to reduce biochar output and produce more carbonized and stable structure (36).

Biochar production through slow pyrolysis

Slow pyrolysis of biomass serves to convert biomass into biochar thermochemically for a variety of soil and energy production uses. Markus also refers to this process as heating biomass at minimal temperatures and with slow rates under a lack of oxygen process that yields bio-oil, biochar and syngas. Biochar has been formed from pine wood, algae, wheat straw, green garbage, lignin-rich residues and agricultural wastes such as palm oil residues and carob waste. The production and quality of biochar produced from the feedstock are highly dependent on the feedstock, particularly lignin rich material can produce higher carbon content and stability (37). The output and property of biochar are very sensitive to pyrolysis temperature. Often, biochar yield is reduced at higher temperatures and the resulting biochar has increased carbon content, surface area and stability. For example, the yield falls from 400 °C to 800 °C while carbonization and surface modification occurs (38). The periods also matter, as long periods increase the carbon content and stability (39).

Biochar production through torrefaction

In the case of producing biochar, one among the thermal techniques is torrefaction, which includes heating the biomass at decreased temperatures in the absence of oxygen. The properties of biochar are improved by this technique and biochar can now be utilized as a solid fuel and as a means of environmental cleaning. The amount and characteristics of biochar output are largely dependent on the torrefaction temperature. For instance, in heat treating textile fibres in the temperature range of 300 to 400 degrees, biochar's with low ash and sulphur concentration were produced and thus the resulting biochar's are suitable as solid fuel. Other fibres, however, may not be utilised in the future as a fuel because of their high nitrogen content (40). Relatively similarly, biochar was produced from the torrefaction of microalgae with woody biomass at 250 °C with a high output and excellent calorific value. Reduction of the quantity of alkali and alkaline earth metals in biochar affects its gasification behaviour (41). Biochar's extent of pyrolysis and thermal value of can vary with the torrefaction technique used, which although it is usually more thermal value than pyrolysis (42). Torrefaction produced biochar has the potential to act as a high energy solid biofuel. For instance, waste coffee ground biochar, torrefied from them, had a high enough heating value for consideration as a carbon neutral energy production (43).

Biochar production through gasification

The result of biochar production through gasification of biomass offers an alternative to energy generation and environmental applications with a promise of benefits. The approach of this work consists of thermochemical decomposition of organic material under an oxygen limited setting to obtain biochar. This gasification process is a viable technology in creating biochar as well as syngas. Temperature, feedstock type and gasifying agents all influence the features of biochar, notably its porosity and carbon content (44). For instance, biochar from coconut shell gasification in supercritical water exhibits remarkable development in its porous structure, increasing its usefulness in industrial and agricultural fields (45). Higher temperatures often boost syngas generation while lowering charcoal yields. However, appropriate temperatures can improve biochar quality by increasing carbon content and porosity (46) (Fig. 4). The type of biomass employed, notably the lignin level, influences the productivity and reactivity of the biochar produced. High lignin concentration can boost biochar output while decreasing its porous structure (47). The selection of gasifying agent (e.g., air, steam) and their proportions have a considerable influence on the gasification process and the degree of quality of the generated biochar (44).

Each production methods of biochar possess specific advantages based on end use and resources (Table 1). Fast pyrolysis is distinguished by unusually high conversion efficiency and co-production of valuable bio-oil and is therefore optimally suited for integrated biorefineries and energy supply chains. It demands advanced reactor designs and is most appropriately applied at the industrial scale. Slow pyrolysis, however, yields more carbon-stable biochar and is well known to be applied for soil amendment and carbon sequestration, with optimum quality and ease of operation, particularly for decentralized or rural areas. Torrefaction is well suited to improving the fuel quality of biochar and making it more attractive in the energy market; but tends to produce lower surface area and nutrient-rich biochar, restricting its application in agriculture. Gasification, likewise, mainly focused on syngas production, also produces valuable biochar with high porosity and energy characteristics, but could need to be properly controlled to maintain a balance between energy production and quality of biochar. Based on all the considerations, slow pyrolysis is the most appropriate method for large-scale and sustainable production of biochar because it is flexible, easy to operate and produces high-quality biochar that has wide application in agriculture, carbon sequestration and environmental remediation.

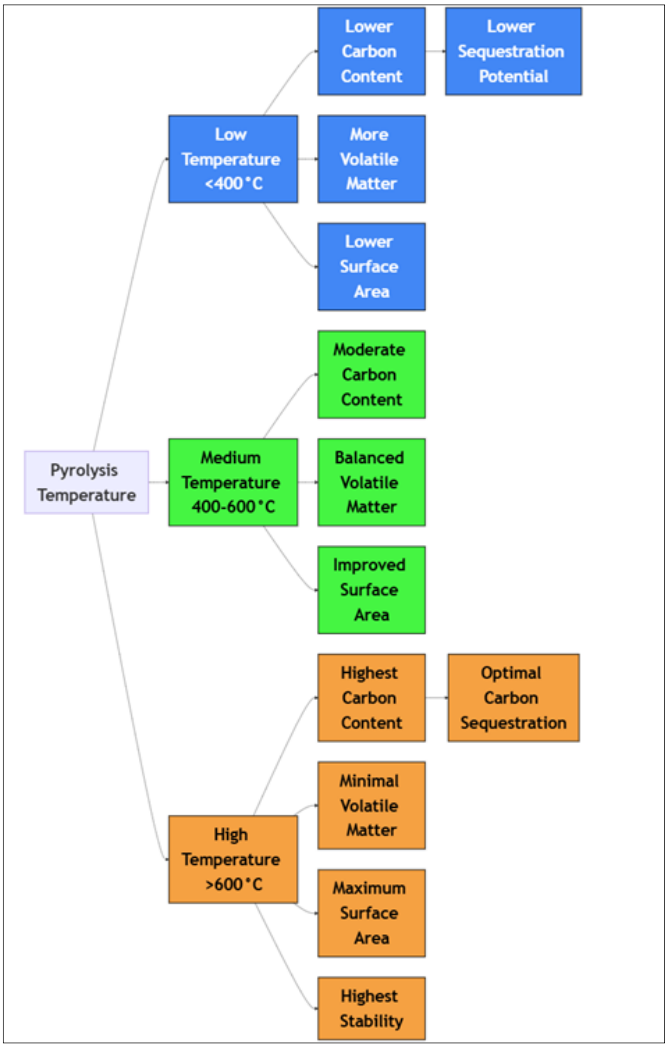

Fig. 4. Pyrolysis temperature effect.

Impact of biochar on soil health in forest ecosystems

Biochar utilization in forest settings has been explored for its ability to promote soil health and mitigate climate change. According to the research, biochar improves soil physiochemical as well as microbiological properties, albeit the benefits differ depending on the circumstances. Biochar generally improves the porosity of soil, retention of moisture also stability of aggregates while decreasing bulk density. It improves soil pH, cation exchange capacity, organic carbon stock and the availability of nutrients such as phosphate as well as potassium. Biochar also affects microbial community structures, resulting in short-term increases in microbial biomass (51). Biochar boosted fungal species richness and variety in boreal forests, with pyrolysis temperature and application rate influencing this effect (52) (Table 2). Biochar can decrease N_2O emissions and boost CH_4 absorption, although its impact on CO_2 emissions varies (54, 55). Biochar application boosted soil respiration in temperate woods but showed little impact in subtropical forests (56). In addition, biochar increases the electrical conductivity of soil, a factor that contributes to nutrient availability and ion exchange processes. It also immobilizes heavy metals and organic pollutants, thus their bioavailability and toxicity in contaminated forest soils. Additionally, it makes forests more drought resistant and inhibits soil pathogens through enhanced microbial interaction and chemical adsorption. Biochar's millennia-long soil persistence makes it especially worthy of carbon sequestration, sequestering atmospheric carbon centuries at a time and thereby contributing to climate mitigation efforts. Such aggregate benefits place biochar as a worthy forest ecosystem amendment for ecological rehabilitation and climate-resilient forestry (57).

Table 1. Biochar production methods and their characteristics

Method	Process description	Yield (%)	Key characteristics	References
Slow pyrolysis	Heating biomass at low temperatures (300-600 °C)	25-35	High biochar yield, stable carbon	(48)
Fast pyrolysis	Rapid heating at 500-1000 °C	10-20	Produces bio-oil, low biochar yield	(49)
Gasification	Partial oxidation of biomass at high temperatures	5-15	Produces syngas, low biochar content	(48)
Torrefaction	Thermal degradation at 200-300 °C	30-40	Improves biomass energy density	(50)

Table 2. Impact of biochar on soil properties in forestry systems

Soil property	Effect of biochar	References
pH adjustment	Increases soil pH, reducing acidity	(53)
Cation exchange capacity (CEC)	Improves availability and retention of nutrient	(48)
Bulk density	Decreases bulk density, improving root penetration	(49)
Microbial activity	Boosts beneficial microbial populations	(50)

Biochar's role in carbon sequestration and climate action

Biochar is now recognized as one of the potentially beneficial methods for carbon sequestration as well as climate change mitigation. Its application in soil not only reduces greenhouse gas emissions but also enhances soil fertility and crop yields. Biochar aids in carbon sequestration primarily via its stable carbon structure, which resists breakdown and can remain in soil for generations (58) (Fig. 5). Biochar's stability is affected by its manufacturing circumstances, which include pyrolysis temperature and feedstock type, with higher temperatures generally increasing its carbon sequestration capability (59). Biochar treatment can drastically decrease CO_2, CH_4 and N_2O emissions from soils. It accomplishes this by modifying soil microbial activity and enhancing soil physical characteristics, which influences the soil's greenhouse gas emissions profile (60). N_2O emissions are highly reduced with the biochar's increased carbon-to-nitrogen (C/N) ratio (61). Biochar is gaining popularity in carbon markets for being a feasible carbon offset alternative. Setting carbon credit standards for biochar is critical for incorporating it into existing carbon trading systems, which can stimulate investment in biochar production and use. This integration is consistent to sustainable development goals and encourages worldwide carbon sequestration methods (62).

Applications of biochar in forestry management

Biochar improves porosity of the soil, retention of moisture and aggregate stability while decreasing bulk density. Biochar improves nutrient availability and soil quality, which leads to better plant growth and survival rates (63). Biochar, made from biomass such as forest leftovers, is being investigated for its ability to minimize wildfire danger and increase soil health. Choosing appropriate locations for biochar production facilities is critical for managing woody biomass and lowering wildfire risk (64). When deciding where to locate these facilities, consider biomass supply, wildfire hazards, markets, soil characteristics and transportation networks (60). Biochar production can help with forest restoration, employment creation, agricultural competitiveness and carbon sequestration (65) (Fig. 6, Table 3). Biochar treatment was recently found in investigations to reduce soil erosion by up to 64 % in severely worn soils and 61 % in sloped farmlands, demonstrating its efficiency over a wide range of soil types and circumstances (66, 67). Biochar is effective at reducing soil erosion because of its potential to improve soil structure and water-holding capacity. Biochar interacts with particulates of soil, increasing their stability and ability to resist erosion. It also reduces horizontal water diffusion, which aids in soil integrity during rainstorm events (68, 69).

Improving productivity in managed forests

Biochar application has been found to improve tree biomass and growth in managed forests. In a boreal forest research, biochar improved *Pinus sylvestris* growth and increased carbon storage in biomass by 19 % (70). Similarly, biochar application in an oak forest boosted canopy tree growth rate while having no significant effect on overall net primary output (71). Biochar enhances soil characteristics by enhancing porosity, retention of moisture and stability of aggregate while decreasing the bulk

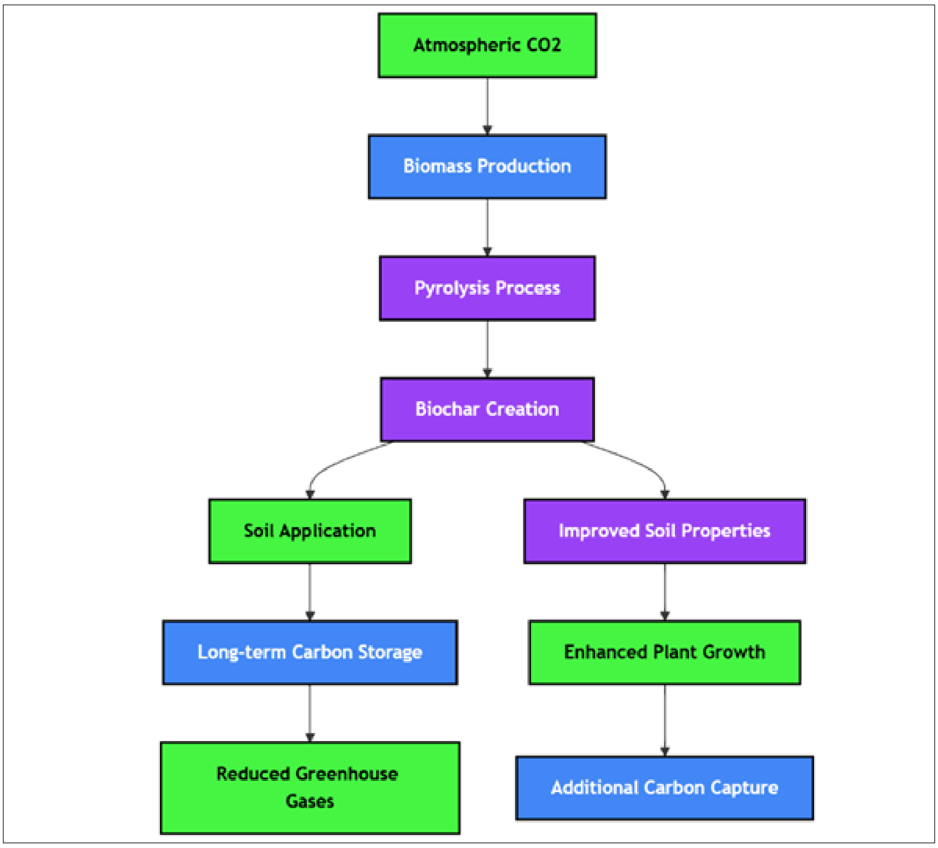

Fig. 5. Carbon sequestration mechanism.

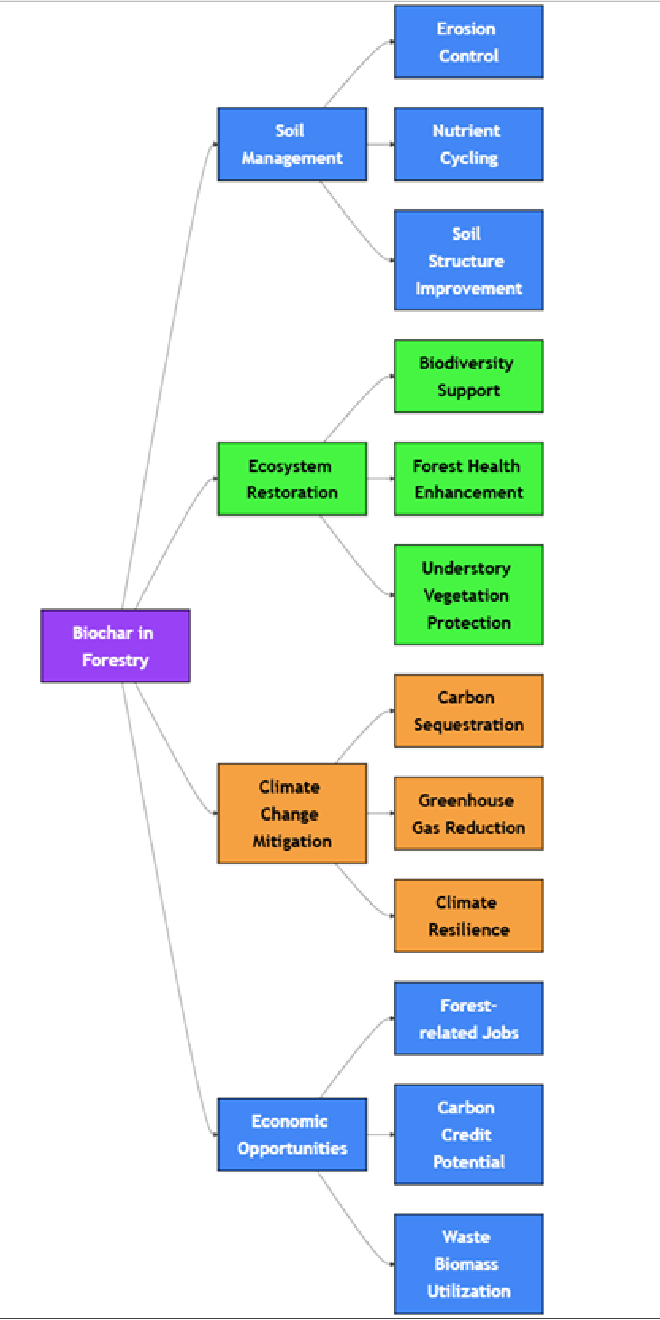

Fig. 6. Biochar in forestry applications.

density. It additionally improves soil chemical properties, especially pH, organic carbon stock and the availability of nutrients like phosphate and potassium (51) (Table 4). In a study of Chinese fir plantations, biochar enhanced availability of soil phosphorus and promoted a more diversified bacterial community, perhaps improving nutrient cycling (72).

Challenges and limitations in forestry

The efficacy of biochar in forestry systems depends largely on its production technique and process factors. Variations in these factors can lead to inconsistent biochar performance and quality, thereby impacting its benefits in health of soil and growth of plant (73). Biochar's impact on agricultural soils is extensively studied, their impact on forest soils is unclear. The influence on soil characteristics and emission of greenhouse gases can differ depending on biochar, soil as well as interactions between plants (51). Biochar can modify microbial community structures in the forest soils, however, microbial biomass gains are often transient. High application rates may even have a negative impact on microbial populations, limiting soil biota (74). Biochar's mitigating capability is restricted by the availability of biomass as feedstock. Sustainable supply chains are required to secure long-term advantages, particularly in areas with major forestry sectors (75). To enhance the efficiency of biochar, post-production techniques like as size reduction and activation are frequently required. These methods can raise prices and complexity, thereby preventing wider adoption (76). High biochar application rates might cause nutrient adsorption, lowering the nutrients available to plants and potentially impeding growth. This needs careful control of frequency of application and circumstances (74).

Table 3. Applications of biochar in forestry management

Application	Description	References
Forest restoration	Enhances tree growth and survival rates	(48)
Agroforestry systems	Improves soil health for sustainable farming	(54)
Wildfire risk reduction	Reduces flammability of forest biomass	(49)
Carbon credits	Contributes to carbon offset programs	(48)

Conclusion

As such, biochar is an excellent alternative to sustained forestry management that promotes soil health, promotes carbon sequestration and reduces climate change. The use is to increase soil fertility, activity of microbes and water retention in forest ecosystems and thereby increase forest production and restoration. Several of the manufacturing methods of biochar affect the physical and chemical characters of biochar, such as pyrolysis, torrefaction and gasification, utilizing biochar as a useful tool for multiple forestry purposes. Nevertheless, there are problems to resolve regarding the unpredictability in quality of the biochar, the sustainability of biomass feedstocks and ecological implications to maximise its benefits. Future study will be needed to improve the biochar properties that can be used for forestry applications and manufacture the biochar more efficiently and integrate biochar into wider environmental and economic policies. If biochar is incorporated into SFM ecosystem resilience will be enhanced, biodiversity will be maintained and climate crisis reduction at the global scale will be facilitated.

Table 4. Benefits of biochar application in forestry

Benefit	Description	References
Soil fertility enhancement	Improves nutrient retention and enhances soil microbial activity	(54)
Carbon sequestration	Increases soil carbon content, reducing atmospheric CO_2 levels	(48)
Retention of water	Improves soil's ability in moisture retention and reducing drought stress	(49)
Erosion control	Improves soil structure, reducing erosion and soil degradation	(50)

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Authors' contributions

KJ and PR involved in choosing the review topic and its overall outline. PK, KTP, IS and KB participated in giving ideas related to the topic and drafted the manuscript. RR and PH offered critical corrections, AR, SN and VK assisted in flowchart related works and corrections. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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