

AGRICULTURE FORUM FOR TECHNICAL EDUCATION OF FARMING SOCIETY

Kota, Rajasthan



Turning Forest Fire Waste into Biochar: A Climate-Smart Solution for Carbon Credits

Authors

**Adarsh Umrao¹, Anil Kumar Sharma²,
Jyoti Pandey³, Santhosh B.L⁴, Samar Thakuria⁵**

¹M.Sc. Scholar, Department of Forestry (Silviculture & Agroforestry), PGCA, Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Samastipur, Bihar.

²Ph.D Scholar, Department of Agronomy, College of Agriculture Ummedganj-Kota, Agriculture University Kota.

³Ph.D, Department of Forestry and Environmental Science, DSB Campus, Kumaun University, Nainital.

⁴Agriculture Officer, Raitha Samparka Kendra, Singatagere, Office of Assistant Director of Agriculture Kadur, Department of Agriculture, Karnataka, India.

⁵Ph.D Research Scholar, Department of Agricultural Extension Education, School of Agricultural Sciences, Medziphema Campus, Nagaland University.

INTRODUCTION

Why This Matters

Fires in the forest are becoming more frequent and intense as the result of climate change, lengthy droughts, and higher temperatures, producing large amounts of biomass, including dry leaves, pine needles, shrubs, grasses, fell branches, and deadwood. This biomass, when unchecked or burned in wildfires, emits substantial greenhouse gases and air pollutants and leads to catastrophic ecological damage. The production of biochar from forest fire residues via oxygen-starved pyrolysis provides a green alternative, in that it converts biomass into a stable, carbon dense material that can reside in soils for hundreds of years. In addition to reducing greenhouse gas emissions and wildfire hazards, biochar enhances soil quality, increases crop yield, promotes long-term carbon sequestration, and provides a means for farmers to capture carbon credits. To that end, the waste from the forest fire is not a disposal problem to be solved, but rather a climate-smart asset that can support environmental recovery, sustainable farming, and rural livelihoods.

What is Biochar

Biochar is a carbonaceous material that derives from pyrolysis of biomass and possesses inherent porosity and a high specific surface area. While open burning of biomass liberates its carbon content into the atmosphere in the forms of CO₂ and other Greenhouse Gas (GHGs), pyrolysis locks down most of the biomass carbon in a solid form, biochar. Biochar can

be produced from a variety of feedstocks such as pine needles, dry leaves, branches, wood residues, shrubs, forest litter, bamboo residues and agrobased residues collected from the fringes of forests. Since it has superior chemical stability, biochar not only provides a long-term carbon solution but also improves soil quality, increases nutrient and water holding capacity, and promotes sustainable agriculture production.

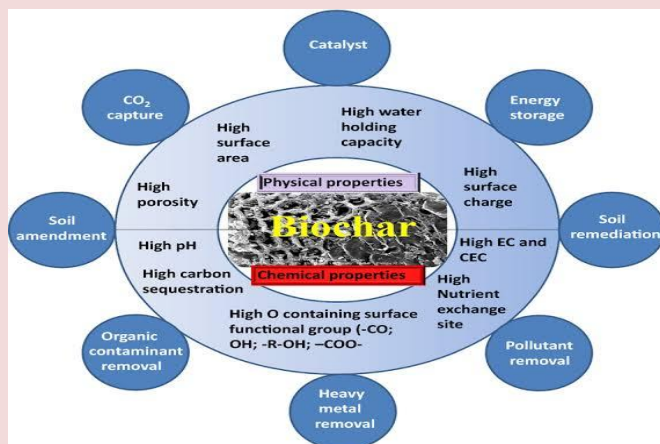
Why Use Forest Fire Waste

Environmental Benefits

Using forest fire debris for biochar production has multiple environmental advantages as it mitigates the fire risk by decreasing the buildup of flammable biomass that contributes to catastrophic wildfires. It contributes to reducing greenhouse gas emissions, to limiting smoke and air pollution, to preserving forest biodiversity, and to the development of a circular bio-based economy through the sustainable use of forest biomass that would have been considered as waste or been discarded by burning.

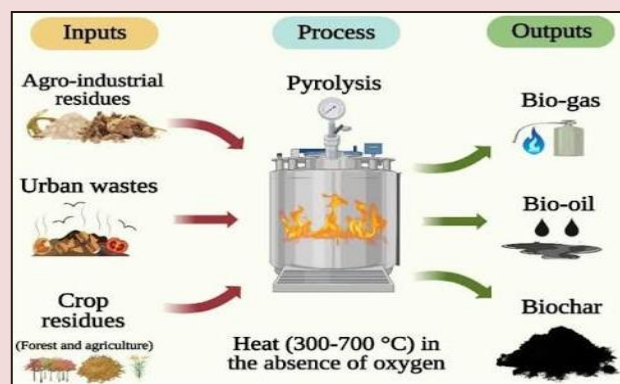
Agricultural Benefits

The use of biochar improves soil quality through better soil aggregation, water retention, nutrient retention, and activity of beneficial microbes, leading to improved efficiency of fertilizer use and decreased nutrient leaching. These positive attributes improve the drought resilience of crops and have been reported for higher productivity in cereals, vegetables, fruit crops, pulses, oilseeds and plantation crops, positioning biochar as promising amendment for climate-smart and sustainable agriculture.



How is Biochar Produced

The biochar production takes place along with the gathering of forest debris including pine needles, dry twigs, dead branches, shrubs and forest floor litter in the aftermath of fires or during the routine forest management, steering clear of biomass tainted with plastics, metals, paints, or chemicals. The harvested biomass is dried to moisture about 10-20% for increasing the biochars quality and pyrolysis efficiency, then size reduction is performed by chipping or cutting to get the uniform heating. The processed biomass is slow pyrolyzed in either a kiln or reactor under limited oxygen at 350-600°C for 30-90 min to yield biochar in addition to bio-oil and syngas, which also can be recovered as renewable energies. After pyrolysis, the biochar is cooled in an oxygen-depleted environment to avoid combustion, crushed and sieved to the required particle size according to different application, and finally stored in a dry place for application.



How Biochar Stores Carbon

Unstable organic carbon in forest biomass is converted to highly stable aromatic carbon during pyrolysis, which resists degradation for hundreds of years. This carbon, when added to the soil, remains locked up rather than being emitted back into the atmosphere in the form of carbon dioxide (CO₂), a phenomenon known as carbon sequestration. Each tonne of biochar you apply can sequester a substantial quantity of carbon in the atmosphere while you improve soil fertility, water retention, and crop production. Therefore, biochar is a potent long-term climate solution which addresses climate change mitigation as well as agricultural sustainability and productivity.

Biochar and Carbon Credits

What are Carbon Credits

A carbon credit is the equivalent of a verified removal or avoidance of one tonne of carbon dioxide equivalent and it can be traded as a commodity to enable people, industries and governments to compensate for their greenhouse gas emissions.

Projects that produce biochar are eligible for carbon credits, since they remove atmospheric carbon in a stable form and sequester it in soils for centuries, while also preventing emissions due to wildfires and open biomass burning. With biochar-based carbon sequestration in the long term and supportive services such as ecosystem restoration, sustainable biomass management and climate change mitigation, biochar ranks as a compelling nature-based solution for simultaneously achieving carbon, environmental and economic returns.

How Can Biochar Projects Earn Carbon Credits

Biochar projects produce carbon credits inside a process-biochar production begins with the sustainable harvesting of forest biomass, followed by the manipulative production of biochar, and then the quantification of biochar quantity and quality. The biochar's amount of sequestered carbon is rigorously accounted for and independently verified by third party accredited bodies. Upon successful verification, the project is registered with recognized carbon credit standards that allow for the issuance and trading of carbon credits on a voluntary or a compliance market. Proceeds from these credits can then be reinvested in forest rehabilitation, community development, sustainable biomass management, and scaling-up climate-smart agriculture practices.

Additional Climate Benefits

In addition to long-term storage of carbon, biochar has a number of other climate change mitigation benefits, including reduction of methane and nitrous oxide emissions from soils, increase in soil organic carbon,

improvement of fertilizer-use efficiency, enhancement of drought resilience, and facilitation of regenerative agriculture. The cumulative effect of these benefits is to reduce the environmental burden of agriculture while supporting sustainable and climate-resilient farming systems.

Benefits for Farmers

The effects of biochar on seed germination and root elongation, increase in water holding capacity, and provision of nutrients to the plants, and on the efficiencies of water and nutrient usage for plants are well documented. It also has persistent benefits for soil fertility, allowing farmers to build long-lasting improvements in productivity and resilience to drought and climate variability, particularly in degraded, acidic, sandy, and low-organic-carbon soils.

Benefits for Forest Departments

The use of forest debris to make biochar offers a means for forest agencies to reduce wildfire risks by decreasing flammable fuel loads, while advancing sustainable biomass management and rehabilitating compromised forest landscapes. Beyond increased carbon sequestration and alignment with national climate action goals, the biochar program could turn forest biomass from a fire hazard into an economic resource, opening up potential livelihood opportunities for rural communities.

Benefits for Rural Communities

Enterprises based on biochar offer new avenues for rural employment, such as biomass collection, operation of pyrolysis units, processing and packaging of biochar for a variety of uses, production of soil amendments, management of carbon projects, and

green entrepreneurship. Community involvement in all these activities is vital not only as a source of complementary income during the off-seasons but also in consolidating forest protection, sustainable resource management and rural livelihood.

Challenges and Future Prospects

Although there are many prospects for application, biochar has to overcome the barriers of high initial investment, lack of standardized protocols for production and quality assurance, limited awareness by stakeholders, costs for certification in the carbon market, logistics of biomass collection and transportation, and a need for stronger policy and institutional support in order to be widely implemented. Mitigating these limitations through research, capacity development, financial support and enabling policies will help to promote the uptake of biochar as a climate-smart option for sustainable forestry and agriculture.

Best Practices for Biochar Production and Application

Sustainable biochar production is the collection of forest biomass done in a sustainable manner without cutting of live trees. The production of good quality biochar may be accomplished by using suitable pyrolysis temperature, avoiding contamination in the production process, and analyze the final product prior to application in the field. For improving soil health and crop growth, biochar application could be more effective if coapplied with compost or organic manure. Keeping good records makes it easier to get carbon credits, and following local environmental regulations will allow production and use of biochar in a manner that is environmentally safe, sustainable and responsible.



CONCLUSION

Forest fires are now being considered as one of the big challenges for the environment in the twenty-first century. Nevertheless, the residual biomass after such events constitutes a challenge, but also a resource and not exclusively a source of waste. Forest fire residues to biochar presents a novel route for prevention of wildfires, reduction of greenhouse gas emissions, soil quality enhancement and agricultural productivity, as well as generation of carbon credits. Combining science with sustainable forestry and community involvement, biochar can turn disaster tree waste into a valuable long-term environmental and economic resource. Increased usage of biochar solutions, enabled by the right policies, quality standards, and carbon finance mechanisms, will be key to driving progress in climate-smart agriculture and the realization of global carbon neutrality targets.