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Eichhornia crassipes: Invasive weed to source for Biochar

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Abstract

Biochar is a form of charcoal produced by the thermal breakdown of biomass without using oxygen. It's utilised as a soil conditioner for boosting soil carbon, nutrients, and organic matter, as well as improving soil microbial population, soil retention, and aeration capacity. Agriculture wastes, plant biomass, and animal waste can all be used to make biochar. Eichhornia crassipes is an aquatic plant that produces a lot of biomass and is used for a number of things all over the world . Biochar made from *E. crassipes* biomass has high nutritional value, and its use in the soil improves agricultural crop productivity while also improving soil health. The conversion of *E. crassipes* biomass to biochar is not only a superior alternative to chemical fertilisers, but it is also a long-term management strategy for this invasive plant species.

Keyword- Biochar, invasive weed

The growing population has resulted in the depletion of natural resources as a result of increased demand. This combined effect may have a negative impact on long-term agricultural production and food security. Crop yields have been increased using a range of chemical synthetic fertilizers, insecticides, and other items. Nonetheless, these chemical fertilisers include hazardous metals that undermine soil health through a series of antagonistic interactions, resulting in soil degradation and stressful conditions for plants. As a result of the overuse of chemical and inorganic fertilizers, agricultural yield and soil fertility have decreased.

Natural substances or products produced from them have been shown to be both economically and environmentally viable for improving agricultural output as well as soil fertility. biochar, a carbonaceous solid substance, is one of the products with a high proportion of aromatization and significant anti-decomposition properties. It can also be made from weeds, food wastes, lumber debris, straw, rice shell, crop residues, and other

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materials . Biochar made from organic biomass is an innovative way to boost soil fertility, agricultural productivity, and organic matter while also preventing soil degradation .

Biochar is utilised as a soil amendment in various nations, including India, Europe, China, Japan, and the United States . Utilization of weeds especially high biomass producing species for production of biochar has become a novel tool due to its easy availability and cost-effective nature.

Water hyacinth (*Eichhornia crassipes*) is a prominent alien weed. It's well-known for its stubborn growth near water bodies. *Eichhornia crassipes*, popularly known as the "terror of Bengal" or common water hyacinth, is an aquatic plant native to the Amazon basin that is often an extremely problematic invasive species outside of its native region. The exotic free-floating perennial vascular aquatic plant E. crassipes (water hyacinth) is notorious for its rapid growth all over the world, which has resulted in major ecological and socioeconomic changes to the ecosystem . It is native to the Amazon basin of tropical and sub-tropical South America and belongs to the "Pontederiaceae" family. It reproduces both sexually and asexually , but high nutrient concentrations and ideal temperature are thought to be the most important elements in water hyacinth growth and reproduction. Because of its free-floating root system, water hyacinth is not restricted to shallow water like other emergent macrophytes. It has nearly encroached on over 50 countries across several continents, and it may spread to higher latitudes as temperatures rise as a result of increased greenhouse gas emissions and climate change.

The rapid growth of water hyacinth affects drainage systems and irrigation patterns, spreads pathogens, alters water quality and hydropower and water supply routes, sabotages water transport, obstructs canals and rivers, lowers dissolved oxygen in water, and lowers the aesthetic value of tourist destinations. Despite the negative consequences, water hyacinth has some advantages. It can be used in traditional medicines, biogas production, mushroom bedding material, carbon black production, rope production, fibreboard production, animal fodder and fish feed, green manure, compost, biochar, and as an ornamental plant.

Biochar has a lot of active organic clusters and aromatic structures, as well as a good cation exchange capacity, a good pH, a lot of surface area, and a negative surface charge. Biochar application improves soil organic matter and enzymes, stimulates soil microbial population, aids in improved water holding capacity, limits leaching behavior of chemically derived

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fertilisers, promotes soil aeration, extends nutrient retention time, and increases soil stress tolerance capacity, among other things.

Pyrolysis and hydrothermal carbonization are most suitable and practical Methods for the extraction of biochar.

Pyrolysis

Pyrolysis is the most promising method for converting waste into valuable biochar, liquid, or gas. The quality of the biochar and the surface structure of the particles may be affected as the temperature rises in this process. Pyrolysis can be divided into two types: slow pyrolysis and fast pyrolysis.

The waste materials are easily decomposed by the fast pyrolysis, which results in gases, aerosol particles, and biochar. High heating, short reaction times, temperatures of 500°C or higher, quick char product removal, and rapid vapour cooling are all part of this process. Aside from these, bio-oil derived from dry biomass, as well as charcoal and gas, are constituent products. It's a quick process that takes only a few seconds to complete. The yield in this method is 60 percent bio-oil, 20 percent biogas, and 20 percent.

Slow pyrolysis, on the other hand, is defined by slower heating rates, more solid materials, and lower temperatures (400°C or less) than fast pyrolysis. Biochar is the most important product (35–45%) in slow pyrolysis, followed by bio-oil (25–35%) and syngas (20–30%).

Hydrothermal carbonization

The hydrothermal carbonization (HTC) process, which uses water as a reaction medium above saturation pressure and operates at temperatures ranging from 180 to 350°C , is a cost-effective and environmentally beneficial method. Due to the use of water as the individual reaction medium under pressure and heat, the HTC process is a cleaner and risk-free approach. The HTC is a cost-effective process since it is run in highly sophisticated pressurised rotary drums, kilns, and stoves. HTC creates biochar that retains nutrients like nitrogen and phosphorus, which can help restore soil fertility.

Biochar production from E. crassipes biomass

E. crassipes is a nitrogen-rich plant (up to 3.2 percent dry matter) with a C/N ratio of 1:5, indicating that the plant has a high level of organic matter. It's also a good source of minerals and can be used as a cost-effective feed for making biochar. The dry matter of water hyacinth

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contains 5.2 percent nitrogen, 0.22 percent phosphorus, 2.3 percent potassium, 0.36 percent calcium, 280 parts per million of iron, 45 parts per million of zinc, 2 parts per million of copper, and 332 parts per million of manganese. Biochar made from water hyacinth improves the soil's carbon, organic matter, and water-holding ability. Given the foregoing qualities, water hyacinth stands out as an excellent candidate for biochar production. Biochar made from water hyacinth biomass pyrolysis effectively takes carbon from the atmosphere's carbon cycle and transfers it to long-term soil storage, resulting in increased carbon-nitrogen percentages in plants.

Effects of water hyacinth biochar on soil and plant productivity

Biochar made from Eichhornia biomass has proven to be a low-cost and environmentally friendly biotechnological application. Biochar is used for a variety of applications, including soil enhancement, wastewater treatment, climate change mitigation, waste minimization, and waste management. Biochar, on the other hand, can improve soil qualities as well as soil fertility and nutrient content, particularly by reducing nitrate, phosphate, and other anionic nutrient leaching, improving soil structure and soil–water capacity, and boosting soil microbiological properties. Water hyacinth biomass contains up to 75.8% organic matter, 1.5 percent nitrogen, and 24.2 percent ash, as well as 28.7% K2O, 1.8 percent Na2O, 12.8 percent CaO, 21.0 percent Cl, and 7.0 percent P2O5. Biochar increased crop yield, improved water quality, reduced nutrient leaching rates, decreased soil acidity, increased water retention capacity, and reduced fertiliser consumption. Because of its high surface area, broad surface functional group, and interlocking patterns, Eichhornia biochar can be utilised as a soil amendment to minimise heavy metal and phytotoxicity.

Biochar made from *E. crassipes* (water hyacinth) biomass could be an effective way to manage and use the biomass of this invasive weed.

Because of its high C-N concentration and abundance of minerals including Fe, Cu, Mn, K, P, Zn, and others, water hyacinth is an excellent option for biochar production. The conversion of water hyacinth biomass into biochar and its use in agricultural environments has various advantages and enhances the economy over time. This invasive plant is also commonly used for biochar production and soil quality management in numerous places of the world.

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