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Waste recycling through biochar- a sustainable approach

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Carbon dioxide is the most commonly produced greenhouse gas. There has been a steady increase in the CO_2 levels in the atmosphere since the Industrial revolution. The Earth System Research Laboratory has been measuring carbon dioxide and other greenhouse gases for several decades.According to the global monitoring division of National Oceanic and Atmospheric Administration (NOAA), it is reported that the mean CO_2 recorded during the month of February 2021 was 415.88 ppm[1]. Atmospheric carbon can be removed and trapped in soil for a long term by a process known as carbon sequestration.Carbon can be sequestered by a number of ways.One of the ways to sequester carbonfor a long term is by converting the biowastes to biochar. The estimated residence time of carbon in biochar is in the range of hundreds to thousands of years. Thus, there is reducedrelease of CO_2 back to the atmosphere as it is sequestered as carbon in soil. The nutrient content in biochar varies with the feed stock used, temperatureand the method used to pyrolysis. Hence the prepared biochar can be used as a soil ameliorant or with manures depending on the nutrient content present in it. Biochar has multiple benefits ranging from waste management to carbon sequestration.

What is biochar?

Biochar is simply charred organic matter. It is a stable carbon compound produced when biomass (agro-waste) is heated to temperatures between 300 ^{0}C to 1000 ^{0}C, under low or no oxygen concentration. The carbon in biochar resist decay and degradationand can storecarbon in soils for thousands of years.Biochar is not simply pure carbon, but is a mix of carbon,hydrogen, oxygen,nitrogen and sulphurin different proportions.

Materials that can be made to biochar

Theoretically, any organic feedstock can be pyrolyzed. Each year, a significant amount of agricultural waste is being generated in the form of crop residues.The use of these crop residues as a feed stock for production of biochar is slowly finding its place in India. Industrial wastes like lumber, peelings, scrapes of fruits and vegetables, wood waste, and forest residue like dead wood can be used for production of biochar. Even animal wastes like poultry litter, swine litter and municipal solid wastes can be converted to biochar. Thus, this serves as an efficient waste disposal system which is sustainable, cost effective and curbs environmental pollution.

How is it made?

During photosynthesis, plants use carbon dioxide from the atmosphere and water from soil to produce carbohydrates or sugar and is used up forbuilding plant biomass. This plant biomass is subjected to 'pyrolysis' to produce biochar. The word 'pyrolysis' is derived from the Greek words 'pyro' meaning fire and 'lysis' meaning decomposition. In short, the biomass is burned by heating at high temperature in the presence of low or no oxygen. The solid component which remains after pyrolysis is referred to as biochar.Biochar can even be produced in households at a very low cost. Pits of suitable length and breadth with a depth of upto 30cm are made on the ground. The materials that are to be made biochar is put inside this pitand is torched. Ensure that whole of the biomassstarted to burn. After some time, the fire is just doused off and the pit is covered using a metal plate.Mud is distributed equally over the metal plate and let to burn overnight. Next day plate is removed and the biochar produced can be dug out.

If biochar is made in a burner, a portion of the carbon from the plant biomass returns to the atmosphere as $CO_2$and only about 60% of the carbon will remain as biochar. This process of pyrolysis isused by various chemical industries for producing a range of compounds like charcoal, activated carbon, methanol etc. On an average, one ton of dry biomass can create about 400 kg of biochar containing 80 to 90% pure carbon[2].The weight and volume of initial feedstock is reduced, thereby reducing the space required for its disposal.

How to apply in soil?

Biochar is applied to soil either by mixing with top soil or along with organic manures. When biochar is mixed with top soil during conventional tillage systems,because of its lower density it may get eroded along with soil particles by wind and water. This risk is reduced when biochar is mixed along with organic manures and incorporated into the soil.

Deep placement of biochar in the rhizosphere is more beneficial for crop growth as it is less susceptible for erosion. During conservation tillage, application of biochar is less advised as the incorporation depth is less leading to a greater erosion loss. In areas where incorporation of biochar in soil is not possible like forests, pastures etc., top dressing biochar to the surface of soil can be done. Apart from erosion, inhalation by humans and animals may lead to respiratory issues. Biochar, when blended with

compost and manures is said to improve microbial diversity and shorten the crop response time. Biochar's capacity to hold water and nutrients make it an excellent addition in grow bags.The frequency of application of biochar depends on several factors like soil, crop, feed stock used,land, labour etc.Based on all these factors, application one-time to applying every year can be considered.In sandy loam soils, where there is continuous cropping, biochar can be applied once a year or in alternate years. A more frequent application can also be done if the biochar is enriched.

Advantages

Apart from sequestering carbon, incorporation of biochar in soil, improves the soil structure, providing more aeration and increased water penetration resulting in an overall improvement in soil fertility. The use of synthetic fertilizers can be brought down. Since biochar can be produced from unutilized agro-wastes, there is considerable potential to convert green and brown agro-wastes to biochar.Incorporation of biochar in soil increases water retention, microbial activity and thereby plant yield. Due to the porous nature of biochar, nutrients, water and other soil inhabitants are adsorbed in biochar for a longer period.Moreover, biochar can also be used as a bio-adsorbent in treating water to remediate contaminants.Biochar is also capable of absorbing metals such as lead and several other toxic organics that contaminate soils. Since the production of biochar is a low-cost procedure with low-environmental-impact, there are high prospects in the present and future.

Disadvantages

Biochar as a dust pose respiration difficulties at all stages *viz*. handling, storage and field application. During soil incorporation, if heavy machinery is used, there is a chance of sub soil compaction. Since freshly prepared biochar quickly sorbs oxygen and moisture which being an exothermic process, makes it flammable. The dust particles of biochar can form explosive mixtures with air in confined spaces. Chemicals like boric acid and ferrous sulphate when added to biochar decreases its flammability. Mixtures with composts or manures yield products which are much less flammable.Since studies on using biochar in agriculture is in the initial stages, research reports available are meagre. Based on the availablereports, the advantages of using biochar far outweighs the disadvantages.

Conclusion

Biochar has the potential to resolve some of the most vital environmental issues of the present world. Biochar with its multiple functions can address problems like sustainable waste management and problems related with environment degradation.The use of biochar in agriculture is cost effective as it cut down the amount of fertilizer required andcan reduce the frequency of irrigation.Since it adsorbs nutrients, it helps in preventing nutrient loss from soil. Apart from agricultural benefits, biochar also poses someenvironment benefits like mitigation of greenhouse gases, remediation of polluted soil and carbon sequestration. Thus, biochar production and its application can be regarded as a viable solution to an array of modern-day problems.

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