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Production Of Biochar From Mustard For Agriculture Use And Carbon Sequestration

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Abstract: Biochar production from slow pyrolysis of biomass removes the net carbon dioxide in the atmosphere act as a potential carbon negative procedure and produce recalcitrant carbon suitable for sequestration in soil. Biochar has been prepared using mustard straw at different temperature 250°C to 500°C in a temperature-controlled oven. The effect of pyrolysis temperature on biochar yield was investigated. The pyrolysis temperature used ranged from 250°C to 500°C .The pH and EC of the biochar was determined. Besides mass recovery, carbon content after each pyrolysis process was determined. The yield of biochar made from mustard stalks with particle size of 0.7-1.4 mm ranged from 66.3% to 30.5% and carbon content ranged from 51.9% to 70.5%. The value of pH and EC varies with increase in pyrolysis temperature. Results suggest that biochar pyrolyzed at high temperature may possess a higher carbon sequestration potential when applied to the soil compared to that obtained at low temperature.
Keywords: Biochar; Pyrolysis temperature; Carbon content and Carbon sequestration.

1. Introduction

Indian agriculture produces 500 million tonnes of crop residues. Various study conducted have shown that 70 million tonnes of crop residues are burnt in the field and making environmental pollution. The crop residues, which are burnt in the field such as wheat straw, paddy straw are due to combine harvesting. The grains are directly collected from field and straw is left and later on burnt in the field .The mustard straw and cotton stalks are burnt largely as these stalks is not used as animal feed. Mustard in the country was estimated at 58.80 lakh tonnes, mustard straw 7.5-lakh tonnes are available in Madhya Pradesh[1]. The straw, which is not being used as animal feed and burnt in field, could be converted in to valuable products like biochar and applied to soil. This approach can be made to clear the mustard field and at the same time preserve the carbon content.

Biochar contains carbon (65-90%), with the balance being volatile matter and ash. Although carbon is the major constituent of charcoal and biochar, the composition and physical properties of char depends on the raw material and temperature at which it is produced[2].

Biochar from wood has very low ash contents less than 2%, whereas the ash content from crop residues varies depending on the mineral matter present in raw material. With increasing temperature, the recovery of biochar commonly decreases, whereas the carbon content increases[3-6]. Biochar with large amount of carbon are obtained in polycondensed aromatic structures at high temperature of 400^{o}C to 700^{o}C[7]. Besides, during the production process, biochar is able to decrease green house gases (GHG) emissions to the air by reducing carbon dioxide, nitrous oxides and sulphur dioxide and act as a potential tool to slow the global warming. Understanding of biochar properties would be beneficial to identify their appropriate applications and for upgrading them. The biochar offers one of the technologies for removing carbon from the atmosphere, making it carbon-negative renewable energy options[8]. The use of biochar allows the total soil organic carbon (SOC) sequestered for several years larger than the naturally decomposition of residues.

The biochar is nothing but charcoal that produces from biomass and it is an excellent material for making poor soil fertile, and storing carbon. It stays for a long time in the soil and difficult to decompose due to its aromatic structure. The conversion of crop residue into biochar and its application in soil would have positive environmental impact as well as improvement in soil health. Considering the importance, study has been conducted to produce the biochar from mustard straw at different temperature and characterize for its application in to soil.

2. Methodology

The mustard straw collected from field was grounded in a hammer mill. The ground straw was sieved to have uniform particle size. The particle size of mustard straw used for production of biochar varied from 0.7-1.4mm. A reactor has been developed to produce the biochar at different pyrolysis temperature with electrical heating arrangements and controller to maintain the desired temperature is shown in figure 1.

The temperature varied during production of biochar ranged from 250^{o}C to 500^{o}C. The reactor consists of a cylindrical drum made up of MS sheet whose thickness is 2.5 mm. The internal diameter of this reactor is 20 cm and it is wrapped with cerablanket for heat insulation. This is kept on a stand with height of 45 cm. In each test biomass was heated within the reactor from ambient temperature to required temperature at heating rate of approximately 10^{o}C min^{-1}. Once the required temperature reached inside the reactor, it was maintained for at least one hour until no further release of gas was observed. The retention time of biomass in a reactor varied from 60 to 120 minutes.

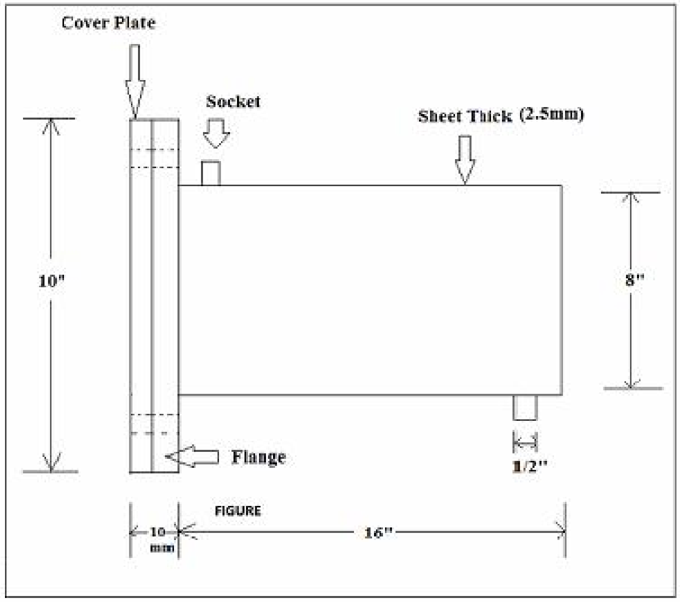

Figure1.Line Diagram of Pyrolysis Reactor

3. Results and Discussion

3.1. Effect of temperature on biochar yield and carbon content

The biochar from mustard straw was prepared at 250°C, 300°C, 350°C, 400°C, 450°C and 500°C. The ground mustard straw was kept in reactor till the volatile matters are released from the biochar. The biochar recovery varied from 30.5 to 66.3% .The biochar recovery decreased with increase in reactor temperature. The effect of temperature on biochar yield is shown in figure 2.

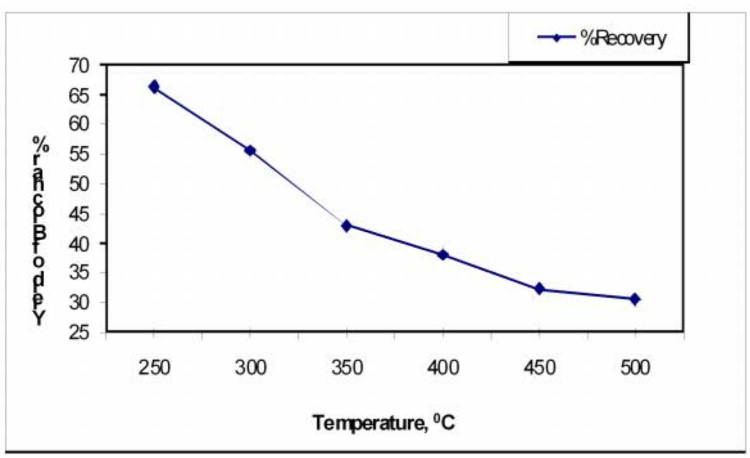

Fig. 2. The effect of temperature on biochar yield from mustard straw

The biochar yield was reduced by 35.2% with increase in temperature from 250°C to 350°C. The reduction in biochar yield was observed by 24.8% with increase in temperature from 350°C to 450°C, where as the reduction of biochar at 500°C was 5.5% as compared to 450°C.The result indicates that beyond 450°C the biochar yield becomes constant.

The carbon content present in biochar produced at different temperature was analyzed. The carbon content in biochar was observed higher as the production temperature increases. The carbon content was 51.9% at 250°C, where as the carbon content increased to 70.5% when biochar production temperature increases from 250°C to 500°C. This shows that the biochar became increasingly carbonaceous at high temperatures, releasing Hydrogen and Oxygen. The variation in carbon content with change in temperature is shown in figure 3.

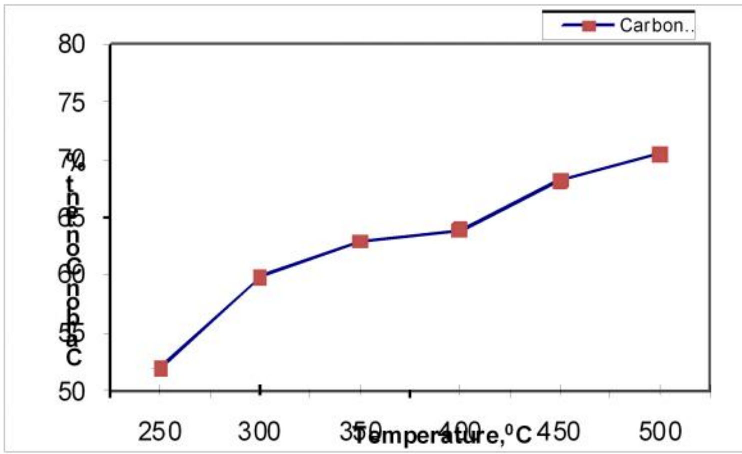

Figure 3. The variation in carbon content, % with change in temperature

3.2. Quality of biochar

The biochar produced at different temperature were analyzed for change in pH value and electrical conductivity. The pH and electrical conductivity (EC) content of samples were analyzed using a pH meter and a conductivity meter by mixing a 1:10 ratio of sample to water. The pH value of biochar was observed to be increasing from 7.26 to 10.02 from the char produced from 250°C to 450°C. The reduction in pH was observed when the temperature of biochar production increases more than 450° C. The reduction in pH was due to formation of metal oxides and release of oxides of Carbon, Nitrogen and Sulphur. Similarly, the EC of biochar was found to be increasing from 8.74 to 10.65 mS cm^{-1} with increase in temperature of biochar from 250°C to 400°C. The reduction in electrical conductivity was observed when temperature of biochar increased more than 450°C. The electrical conductivity (EC) has been used to give an indication for the salinity

3.3 Carbon sequestration

The original carbon present in biomass is retained in biochar by 50% during the conversion process[9]. Estimation showed that worldwide soil hold more organic carbon (1,000Gt) than the atmosphere (750Gt) and the terrestrial biosphere (560Gt). The amount of carbon stored in soils is greater than the amounts found in vegetation or the atmosphere[10]. In India 70 million tonnes crop residues are burnt in the field. The potential of carbon sequestration through crop residues burnt in field is about 20 million tonnes. India has surplus biomass is about 130 million tonnes, which either used inefficiently or burnt in the field could be converted into biochar. Therefore, the crop residue has potential of carbon sequestration when it is altered and used to improve soil as a carbon sink.

4. Conclusion

The mustard straw could be converted into quality biochar at 400^{o}C to 450^{o}C considering the pH and EC of biochar. Pyrolysis study indicated that biochars produced at low temperature have the lowest values of pH and EC and the highest yield having low carbon content as compared with biochar produced at high temperature. The produced biochar from mustard straw could be good source of carbon sink. The use of biochar as a soil supplement would also enhance the input use efficiency costly nutrient used in crop production and thereby reduction in carbon intensity. The use of the biochar for agricultural and environmental purposes should be promoted as carbon sequestration process considering the stability of carbon in soil.

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