Biomass for Bioenergy and Biochar Applications – 15653

Presented at

2015 Waste Management Symposia (WM2015)
March 15-19, 2015
Phoenix, Arizona

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Objectives

Review and evaluate existed studies that assess the application of biochar as a medium for soil and environmental remediation and pollution mitigation.

Utilization of biochar in nanotechnology applications is also explored.

Biochar

Biochar is a by-product of biomass pyrolysis. Although biochar has been applied as a soil amendment for a long time, there are many other applications that need to be explored.

Biochar properties are greatly affected by choice of , pyrolysis temperature, particle size, and residence time. These properties affect the interactions of biochar within the environment as well as its fate.

Biochar Stability

Some studies indicate millennial-scale stability. However, it is difficult to establish the half-life of modern biochar products using short experiments due to the presence of small amounts of labile components, partial oxidation and biotic or abiotic surface reactions.

Biochar Safety

Analysis of a limited number of biochar samples has indicated that biochar can be toxic i.e. in a combustion form such as polycyclic aromatic hydrocarbons.

However, a more systematic evaluation for a more complete range of other potentially harmful chemical contaminants associated with combustion, as well as toxic substances within feedstocks, has not been made.

Given the stability of biochar, a safe rates of its applications need to be determined to avoid possible detrimental effects due to excessive use of in different applications (e.g. reduction in soil productivity).

Biochar Performance

The predictive capacity for biochar 'performance' and the use optimization has not been concluded yet due to insufficient number of studies.

Biochar Economic Value

The economic value of sequestered carbon will be determined within complex carbon markets that are influenced by energy supplies and demand, the supply and demand for low emissions technologies, the availability of alternative carbon sequestration technologies and global policy responses to climate change.

The growing price of waste disposal is likely to make the production and application of biochar for electricity and waste management economically viable.

Carbon offsets will have a greater role once biochar is certified under the Clean Development Mechanism (CDM) of the Kyoto Protocol.

Biochar Agricultural Benefits

A large number of studies have been conducted where biochar application has shown significant agronomic benefits with a minor number of studies showing opposite results

This suggests that the extent of the effect of biochar on crop productivity is variable, due to the different bio- physical interactions and processes that occur when biochar is applied to soil, which are not yet fully understood.

Biochar Interaction with Soil Microbial and Plants

The physical, biological and chemical processes that biochar may exert on microbial communities and their symbiotic interaction with plants, and possibly enhanced nutrient use efficiency, are not yet understood.

The apparent contradiction between the high stability of biochar, soil organic matter accumulation and apparent enhancement of soil microbial activity needs to be resolved.

Biochar can complex the carbon from dead micro-organisms.

Further research work is required to determine under what conditions this complexation takes place

Biochar and Greenhouse Gases

It is generally accepted that biochar is a highly stable form of carbon and as such has the potential to form an effective C sink, therefore sequestering atmospheric CO_2.

The mitigation potential of biochar with regard to other greenhouse gases, such as N_2O and CH_4, through its application to soil is less well established and requires further research.

The currently available data on the effect of biochar additions on trace gas emission is very limited, but has a potentially great impact on the net benefit of biochar application.

Biochar Cation Exchange Capacity (CEC)

Biochar that has resided in soil for hundreds of years has been shown to have much higher CECs, comparable to those of zeolites.

However, several studies have reported an increase in soil CEC after the application of fresh biochar.

Thus, the processes that are instrumental in developing CEC over time as well as the effects that lead to an increase in CEC by addition of fresh (low CEC) biochar require detailed understanding.

Biochar and Water Holding Capacity

While some studies report positive effects of biochar application on water-holding capacity, the specific mechanism that biochar exerts on water retention, macroaggregation and soil stability are poorly understood – yet should be of critical importance in climate change adaptation, where mitigating drought, nutrient loss and erosion are critical.

Biochar Vs Erosion, Transport and Fate

The loss of biochar through vertical or lateral flow is not quantified, and only recently have studies been initiated to examine movement through soil profiles and into waterways.

These processes complicate the task of confining the range of current estimates (from hundreds of years to millennia) of the mean residence time of biochar in soil. Long-term monitoring research stations are required to adequately assess the long-term stability and dynamics of biochar in soil.

Biochar Vs Soil Carbon Modeling

Modeling of the linked carbon and nitrogen cycles in soil with and without application of biochar is essential to understanding the fundamental mechanisms referred to above and the impact on soil-based emissions of greenhouse gases.

Biochar Life Cycle Assessment (LCA)

The total environmental LCA has been conducted for some biochar case studies. Greenhouse balances, for example, are very project specific and hence there is opportunity to assess the benefits over a large range of feedstock, process and biochar application scenarios.

Biochar in Environmental Remediation and Pollution Mitigation

Limited research has been published on the environmental uses of biochar, particularly in the field of air pollution, wastewater treatment and groundwater remediation.

Biochar and Solar Energy Applications

There is no researches (data) have been published on the environmental uses of biochar in the solar energy applications, specially (photovoltaic cells).

Industrial scale production is still in its infancy, with research currently ongoing within the scientific and technological communities focusing on the most effective method of producing it on a large scale.

Conclusion

The results of this research: (1) summarizes the main keystones of biochar applications; (2) define the research gaps and the major research needs to design and evaluate innovative materials and environmental systems that utilize biochar.

References

Berger, C. (2012), Biochar and activated carbon filters for greywater treatment comparison of organic matter and nutrients removal. Master Thesis, Swedish University of Agricultural Sciences.

Dowine, A. (2011), Biochar production and use: environmental risks and rewards. Doctoral Dissertation, School of Materials Science and Engineering, The University of New South Wales.

Brick, S. (2010), Biochar: assessing the promise and risks to guide U.S. policy. Natural Resources Defense Council.

Marschner, B., S. Werner, K. Alfes, and M. Lubken, (2013), Potential dual use of biochar for wastewater treatment and soil amelioration. Geophysical Research, Vol. 15, EGU2013-11260, 2013, EGU General Assembly 2013