Climate Change Mitigation by Soil Carbon Sequestration in Tropics—A Review

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ABSTRACT

21st century world is facing the problem of global warming which subsequently has lead to global climate change. The phenomenon of climate change is more evident in tropics as compared to other latitudes. The concentration of carbon dioxide and the other green house gases are increasing and they are set to rise more in the future. Carbon in the atmosphere is increasing by 3.5 Pg per annum. The reasons behind this, broadly goes to excessive use of the fossil fuels and conversion of native forest to agro-ecosystem. Soil Carbon sequestration constitutes a realistic option achievable in many tropical ecosystems. The process of removing the atmospheric carbon to the terrestrial biosphere and storing them in a recalcitrant form can be used as one of the solutions. Soil appears to be a confidential candidate as they can act as a major sink and can absorb large quantities of carbon (Kandji et al., 2003). The production of the biochar and its storage (addition to the soil) can also be used for the abatement of the global climate change, they are preferred due to their recalcitrant nature, potentiality as source of renewable bio energy, their ability to reduce and enhance the loss of the nutrients as well as enhanced the productivity in agriculture specially in low fertile degraded soil respectively and ensure greater water holding capacity (Woolf et al., 2010). Proper management of carbon will help to reduce the GHG emission and lend a hand to the world in its fight against global climate change. Soil Carbon is very important for the growth and development of the plants and they also prevent erosion. Tropical deforestation, intensive farming and monoculture are some of the reasons associated with the degradation of the soil and indirectly they also enhanced climate change and decrease the productivity of the soil. The sustainable production of Bio char has a huge potential in mitigating climate change (Lehmann et al., 2006). Biochar are formed by the pyrolysis of the biomass and they can be formed by fast process and slow process. The slow process is more favourable because they yield about 50% of the biochar as compared to the 20% char produced by fast process (Bractmont, 2010). The biochar are able to sequester approximately around 50–80% of the carbon which is available in the biomass (Lehmann et al., 2007). However, they also have their own drawbacks like, excessive bio char production may lead to decrease in the terrestrial carbon stock and may also lead to enhanced risk of soil erosion (Steiner et al., 2010). Such issues are discussed in detail in this review.

Keywords: Bio Char, Soil Organic Matter, Pyrolysis, Climate Change, Green House Gases, Tropical Agriculture

INTRODUCTION

Climate change is one of the frontline issue, the world is facing in this 21st century, the increasing concentration of the carbon dioxide, methane, nitrous oxide and other green house gases, will one day lead to increase in catastrophic incidents which will have huge impact on the life of Earth. As an inhabitant of this planet our primary concern is to reduce the production as well as remove
the green house gases from the atmosphere up to a minimum threshold level. Carbon sequestration is one of the mechanisms which have been used to offset the emissions of the carbon in the atmosphere. Carbon which is present in a particular area is known as the carbon stock and this can be enhanced by utilising proper management practices and the stock can be converted to sink of carbon. Human being contributes a large portion towards the problem of global climate change by releasing a huge amount of heat absorbing gases like carbon dioxide and methane. The scale in which the human beings are releasing this green house gases is very large however, they have few solutions to cut down emissions. Sequestration of the carbon can be done by using the terrestrial, soil, ocean component of the ecosystem. It can also be done by pumping the carbon dioxide into the geomass however it is a very costly process, they also have problem of impermanence which has its own associated unknown risks.

**CLIMATE CHANGE MITIGATION BY SOIL CARBON SEQUESTRATION IN THE TROPICS**

The agricultural soils in the tropics, they have underwent a massive decline in their carbon content due to the long extractive farming practices. Agriculture contributes a total of 10–12% of the total anthropogenic green house gas emission (Smith *et al.*, 2008). Even though they have lost most of their native carbon they can act as potential sink for the carbon and it is possible by implementing proper management practices. Carbon sequestration has been cited as one of the potential strategy for the removal of the green house gases which are present in the atmosphere. One of the problems the tropical agricultural system is facing is the sharp and the steep decline in the soil fertility, the main reasons behind this being the soil erosion and the loss of the soil organic matter. Moreover the turnover rate of the organic matter is very high in the tropical region (Noble *et al.*, 2013). Majority of the tropical ecosystem they have lost around 30–40t C per ha and thus they have very high potential to sequester carbon. According to recent studies, most of the soils they have the tendency to sequester 20–50 t C per ha which can be in the undisturbed form some 20–50 yrs. In the tropics the land and the land use changes have induce changes in the carbon stock. (Lal, 2006.). Carbon sequestration in the agricultural soil gives a sustainable outcome.

**WHAT IS BIO CHAR AND VARIOUS WAYS IT CAN BE PRODUCE**

Bio char, they are produced by the thermal treatment of the organic matter under the influence of pressure and temperature; it is like a chemical incineration. They are produced under oxygen limited conditions. The process of pyrolysis is utilised in the production of pyrolysis and it can be divided as the fast and slow pyrolysis. The slow pyrolysis is more preferred because it can yield almost about 50% of the bio char but in fast pyrolysis, only about 20% of the bio char and the remaining have underwent the process of gasification. The
process of bio char can be done by local farmers with the help of locally available tools and techniques.

The quality of the Bio char depends upon the process which has been used. Bio char, have been deposited to different type of the soil through different types of natural events like the forest and the grassland fire. Those areas which have high concentration of bio char (naturally occurring) like the North American Prairie are very fertile lands in the world (Hunt et al., 2010). Depending on the kind of input material and the processing condition, the bio char shows a variable range of physical and chemical properties. The alkalinity of the bio char will be increase with the increase in temperature however the availability of the nutrients tends to decrease with the increase in temperature. They also help in the sequestration of the carbon from the atmosphere for long term storage. High temperature will lead to the less production of the charcoal but more production of the ash. They can be applied to the soil in many ways like, 1.applying it to the soil surface and then covering with organic matter, 2.applied with mulch or compost or 3. Apply as liquid slurry by finely grinding. Sometimes they are mixed with the black fill material use for planting plants (Hunt et al., 2010). Biochar increases the soil fertility by escalating the cation exchange capacity of the soil, enhanced the growth of plants by proper nutrient cycling, increases the water retention capacity of the soil, help in the neutralization of acidic soil (Fowles, 2007)

**BIOCHAR AND ITS ROLE IN SOIL CARBON SEQUESTRATION**

Carbon sequestration is the process by which the carbon dioxide which is present in the atmosphere is removed and store in a more stable or recalcitrant pool. Studies have been suggesting they can be use as an excellent source of sequestering carbon, they can retained about 50% of the carbon present in the biomass feedstock depending on the type of the input. It has a very significant stable level; however they also enhanced the stability of the surface soil which is otherwise quite labile in nature. They can be use as a simple yet efficient tool for combating climate change. In most of the cases when the organic matter undergo the decay process, green house gases like carbon dioxide and methane are release to the atmosphere. However the carbon present in the biomass can get fixed by charring of the organic matter and this tie up process has a huge potential to reduce the current global carbon emissions by as must as 10 %. (Woolf et al., 2010). Bio char, have a very high longevity in the forest soil and they raise up to around 10,000 years in some soil. Studies conducted in the terrapreta soils of the Amazonian forest shows the charcoal can persists for an extensive time period of about 500–7000 yrs (Lehmann et al., 2009). When a conservative estimation was done in dry land of Australia for 2 years by using MRT (Mean residence time) it was shown that the longevity of the bio char is 1000 and 2000 however when the same thing was done for the savannah was between 1300 and 2600 years (Lehmann et al., 2008) and half life of the charcoal in the coastal temperate forests of Vancouver is 6633 years (Lehmann et al., 2009). However in some places the turnover period of the charcoal in the
soil is very fast, for example like in the Russian steppes, the reason behind this might be the excessive mineralisation as well as other processes like leaching and soil erosion. The bio char has a very positive impact on the soil. The foremost contribution of bio char to soil is the enhancement of the soil fertility, they increase the water retention capacity, and they also help in the reduction of the runoff from the agricultural input. They are nowadays considered as a potential candidate for the soil carbon sequestration because they help in the reduction of the emission of the green house gas like methane and nitrous oxide. In some of the tropical agro ecosystem they enhanced the crop yield by 2–3 folds and at the same time reduce the application of the field operation which includes decrease in the use of the diesel oil, thus they help in stimulating the overall growth of the organism, primary productivity and at the same time, they are very useful in the net uptake of the carbon (Sohi et al., 2009). The idea of the carbon sequestration by the use of bio char should be put forward because, they provide an opportunity which involves both the farmers and the landowners as participants in the carbon market. Thus they help in the alleviation of the poverty in the developing countries. One of the barrier of using this method is they are very expensive and the lack of the reliable off shelf pyrolysis technique at the reasonable price.

INDIA AND SOIL CARBON SEQUESTRATION BY BIO CHAR

World grain production is annually around 2500 million Mg. More than 54% of the total is produced by the developing countries despite facing the problems like drought, harsh climatic conditions and severe depletion of soil organic carbon pool (Lal, 2010). However, steps should be taken up to enhanced the soil organic carbon as it will increase the quality of the soil as well as the efficiency of the production system (Lal, 2010). The raising of the soil organic carbon is a big challenge (Schlesinger, 1999) which is being faced by all the developing countries due to their harsh climatic conditions, scarcity water. But the carbon pool can be enhanced by effective method of sequestration and by adopting proper recommended management practices. India is a developing country and works need to done in country like this to bridge the gap between the scientific community and the farmers.

CONCLUSION

Soil organic carbon accumulation should be regarded as no regret policy as even if it has a very little role in the mitigation of the climate change, it will have a positive environmental effect like enhancing the soil properties and functioning (Powlson et al., 2011). The bio char studies should also be considered against the other more established techniques. The longevity element which is present in the bio char carbon sequestration made this technique a viable method to mitigate climate change in future. When studies were conducted it is found the sequestration potential of the biomass is more than its use to produce bio energy, however further studies need to be to sharpened the blurred edges of the whole story. Sequestration of the carbon by
bio char is not the ultimate solution and there are still so many blank spaces to be filled regarding the technology and its need however they have potential for the mitigation of the climate change. Stability is one of the most important factor which need to be considered in any process of soil carbon sequestration, therefore future studies need to be focussed to test the level of stability provided by the soil carbon sequestration by using Biochar.

REFERENCES