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"Biochar: Nature's Marvel''

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Abstract—*''Biochar'' is a solid charcoal made by pyrolysis (i: e thermal decomposition in the absence of oxygen) of biomass which can be used as a soil amendment. It is an ancient agricultural practice in which waste is converted into soil enhancer. Structure of biochar is porous carbonaceous solid mass of charcoal. Due to this structure, 1 gram of activated charcoal has surface area of about 500m^2 that is why it acts like great adsorbent. Biochar surface provide a suitable habitat for microbial life and their interaction. It also provide surface for gaseous, water and micro-nutrients storage. Biochar can be called as Nature's Marvel because of its multifarious benefits. It enhances plant growth, prevent fertilizers runoff and leaching. Biochar increases water retention capacity, reduces aluminum toxicity, reduces soil acidity (raises Soil pH). Along with that it increases soil beneficial microbes. Biochar is also known to suppress methane emission, reduces nitrous oxide emission (estimated 50%) and reduces emission of greenhouse gases, therefore helping in environment conservation. Rather than using raw biochar charcoal directly, it is advisable to use activated biochar in fields for better results.*

In soil biochar mineralize slowly and can lock carbon for many years (about 100 years -1,000 years). Biochar can be used for future sustainable development, as it provides holistic solution for increasing energy and food requirements along with emerging need of CO2 level reduction from atmosphere.

Thus biochar is tool for sustainable development and brighter agricultural future.

1. INTRODUCTION'

In today's 21st century, where technology has dominated almost the entire world, we are living lavish lifestyle by exploiting natural resources by burning fossil fuel and generating tremendous waste on plant earth. This is leading to global warming, due to accumulation of carbon dioxide in our atmosphere, which is not being completely utilize by plants through the process of photosynthesis. Along with global warming, increasing population is also becoming major concern for the world. To feed the growing population forests are recklessly cut down for utilizing that area for agriculture purpose. Still it is estimated that one in seven people in the world are considered to be food insecure, that mean they are either currently hungry or living in starvation condition. According to UN DESA report, the current world population is 7.3 billion which is expected to reach 9.7 billion in 2050[i]. From that report it is clear that there are billions of more people demanding more food and billions of more people creating more waste, burning more fossil fuels. Thus leading to more chances of increasing global warming which is a major threat to our plant earth.

To mitigate all these problems scientist around the world are looking for ways to generate energy with renewable sources (such as sunlight, wind, rain, tides, geothermal heat) which are environment friendly also. Along with all those resources, **Biochar** is receiving intense amount of attention of scientist around the world, because biochar too can mitigate above mentioned environment worries.

2. "BIOCHAR''

Biochar is fine grained charcoal(see figure 1), made by pyrolysis (i: e thermal decomposition in the absence of oxygen) of biomass which can be used as a soil amendment. The term "biochar" was coined by Peter Read to describe charcoal used as a soil improvement[ii]. Biochar can be used for a range of applications as an agent for soil improvement, improved resource use efficiency, remediation and/or protection against particular environmental pollution and as an avenue for greenhouse gas (GHG) mitigation. In addition, to be recognized as biochar, the material has to pass a number of material property definitions that relate both to its value (e.g., H/Corg ratios relate to the degree of charring and therefore mineralization in soil) and its safety (e.g., heavy metal content)[iii]. Making and utilization of biochar is not a new research, it is 2,000 years old ancient practice of converting waste into a productive material which can be added to any soil to enhance its fertility. Biochar is becoming latest trend of sustainable agriculture development around the world. It acts as an important tool to increase food supply, which has been experimentally proved.

"Figure 1: Biochar''

3. "HISTORY''

During ancient time, around 2,000 years ago; it is believed that native people of Amazon basin region of African continent had improve their soil quality and enhanced soil productivity by using biochar. Those people used to produce biochar by smoldering agricultural waste (i:e covering of burning biomass with soil) into the trenches or pits. Europian settlers called it *terra preta de Indio.* Following observation and experiments, a research team working in French Guiana hypothesized that the Amazonian earthworm *Pontoscolex corethrurus* was the main agent of fine powdering and incorporation of charcoal debris to the mineral soil[iv] The native Indians of the amazon region would create charcoal and incorporate it in small plots of land from 1 - 80 hectares in size. Terra Preta, means "black soil" in Portuguese, these soils are darker in colour than normal soil. (see figure.2). It is known to remains highly fertile until today, even with little or no application of fertilizers. And this is in a region of the world known for its highly fertile soils. These prehistoric activity of making biochar and using in fields to enhance its productivity, is used as model of sustainable agriculture in twenty first centuary.

"Figure 2. Dark Terra Preta soil of Amazon due to Biochar"

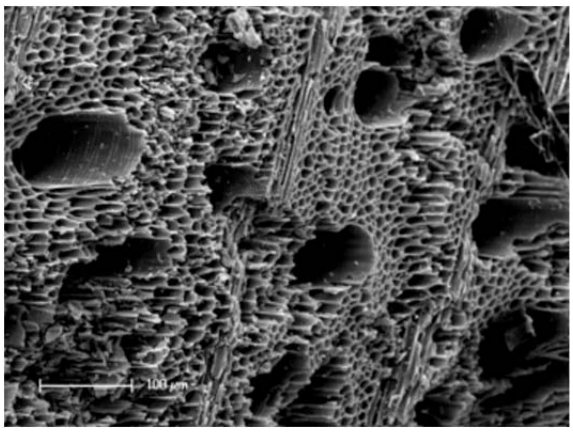
4. "BENEFITS OF BIOCHAR''

There are many direct and indirect benefits of biochar being studied around the world , some of them are mentioned as follows:

- It is known to replenish and retains soil nutrient, such that crops have sufficient nutrient available for their development.
- Biochar can increases microbial population by increasing their retention and reproduction in soil.
- Increasing water holding capacity of the soil.
- Improves resistance to infestation by fungus, nematodes and insects.
- Neutralizes and maintain pH of soil.
- Improves cation exchange capacity for greater mineral delivery to plant roots.
- Neutralizes toxins in the soil.
- Improves germination of seedlings.
- Biochar produces healthy tilth and structure (humus), which can help to reduce compaction, so soil can breath.
- Improves rich source of carbon to build hummus/organic matter and increase productivity[v].
- Biochar heips in sequestration of carbon in the soil that will reduce atmospheric carbon dioxide.
- Biomass production to obtain biofuels and biochar for carbon sequestration in the soil is a carbon-negative process, i.e. more CO 2 is removed from the atmosphere than released, thus enabling long-term sequestration[vi].
- Biochar helps in conservation of environment as it is known to suppress methane emission, reduces nitrous oxide emission (estimated 50%) and reduces emission of greenhouse gases.
- Biochar is also known to reduce aluminum toxicity.
- Biochar can amend soil, it also provide 50% -80% reduction in nitrous oxide emission. Nitrous oxide release from fertilzers is more potent greenhouse gas than CO_2.
- It produces bioenergy in the form of gas and oil, along with the biochar. This energy can be recoverable and used as a renewable fuel.
- Because of its carbonaceous porous structure, biochar acts like a good adsorbant of minerals and water.

5. "STRUCTURE OF BIOCHAR''

Biochar is fine grained charcoal. Under microscope its structure seems to be highly porous, which add to its key feature and is the reason for its high value. Due to very porous structure (see figure.3) it has huge surface area, its estimated that 1 gram of activated charcoal has surface area of about 500m2. This structure make it great adsorbant, thus providing a suitable habitat for microbial life and their interaction. It also provide surface for gaseous, water and micro-nutrients storage. All these factors are important for fertility of soil. What most accounts seem to agree on is that it's not the biochar in itself, but it's combination with organic matter that is critical to soil fertility. A great variety of soil organisms + organic matter & nutrients (food for the organisms) + a rich soil structure (high surface-area environment for the micro-organisms to feel at home in) is the basic combination of good fertile soils[vii].



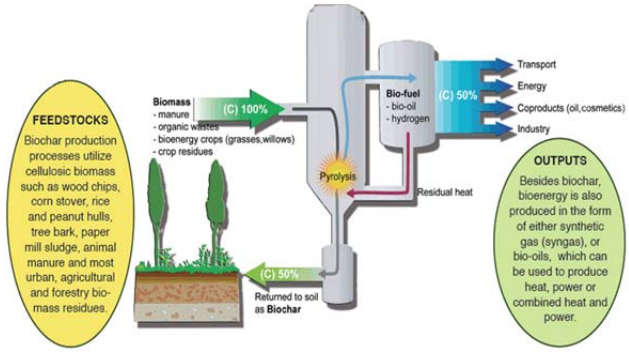
"Figiure 3. Porous structure of Biochar"

6. "PRODUCTION OF BIOCHAR''

The highly porous structure of biocar is produce by the process called **"Pyrolysis''** or "gasification" . Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen [viii]. This process also produces clean energy in the form of gas or oil along with biochar. This energy can be burned to produce heat and can be utilized for other uses. It's one of the few technologies that is relatively inexpensive, widely applicable and quickly scalable.But biochar technology is more than just the equipment needed to produce biochar. Biochar technology necessarily includes entire integrated systems that can contain various components that may or may not be part of any particular system. In general, however, biochar systems should include the following elements:

- Collection, transport and processing of biomass feedstocks
- Characterization and testing of biochar
- Production and utilization of energy co-products: gas, oil or heat
- Biochar transport and handling for soil application
- Monitoring of biochar applications for carbon accounting
- Life Cycle Assessment and full system monitoring for sustainability assessment[ix].

Biochar production diagram courtesy of Johannes Lehmann (see figure.4)



"Figure 4. Biochar Production diagram"

7. "ACTIVATED BIOCHAR

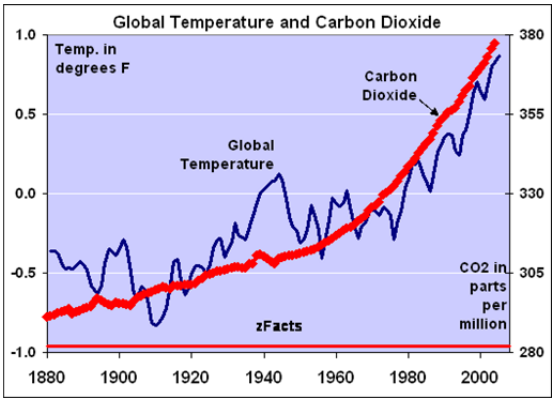
v/s RAW BIOCHAR''

Raw biochar is not fully mature biochar. It is a charcoal, direct product of pyrolysis process. This form of biochar may or may not have good effect on plants. Adding raw biochar directly to fields or garden can stunt plant growth initially as it is pure carbon having high pH. It is always recomended to first activate biochar by adding nitrogenous fertilizer to it. Adding manure, compost, urine, to the biochar counteracts that initial decline in plant growth and may also tempt microorganisms to move into their biochar condos faster[x]. Activated biochar neutralizes soil pH and increases cation exchange process. Adding organic material like urine compost, manure, molasses, flour, vermicompost, rock dust etc. in different recommend proportion helps to increase microorganism population in the soil, as microbes require nutrient or food for breaking down carbon of biochar and making it suitable for soil to increase its fertility.

8. "BIOCHAR IMPACT ON CLIMATE''

As climate is changing dramatically over the past years. Scientists researches have shown imbalance of CO_2 leading to global warming(see Figure 5). This is due to massive industrilization over the past decades and reckless burning of fossil fuels. It has become major threat to earth because of it ozone layer is depleating.

Biochar has proven to be boon for our planet because it can slow climate change, because of the following reasons.



"Figure 5. increasing CO_2 and global temperature"

- Reduces atmospheric CO_2 : The moment of carbon, in its many forms between the biosphere, atmosphere, oceans and earth's crust is called carbon cycle. The active carbon cycle is overwhelmed with much more CO_2 than it can handle from the release of carbon from inactive carbon cycle. Biochar has the ability to capture some of the carbon from the active cycle and return it to the inactive cycle. Thus biochar has potential to reduce atmospheric CO_2.
- CO_2 Sequestration : Sequestration means storage. Carbon or CO2 sequestration means putting carbon into long-term storage to mitigate global warming and dangerous climate change. Biochar technology has potential to increase the rate of natural sequestration and reducing emission of greenhouse gasses.
- Biochar is carbon negative : Biochar is known to have ability to reverse the fossil fuel deposition of CO_2 in the atmosphere by removing carbon from ative cycle and sequestering it in the inactive carbon cycle. Along with increasing soil fertility it also displaces need for fossil-fuel based fertilizers, thereby making biochar process carbon negative.

9. "FUTURE OF FARMING''

In today's world where we are facing major threat to our environment due to depletion and degradation of natural resources, Sustainable agricultural development has become of prime importance at many places around the world. Biochar can be called as Nature's Marvel beacause it has multifarious benefits, and promise to restore depleted nutrients of soil. Biochar is the Future of Farming because it is the emerging trend of agriculture as it offers more reliable source of nutrient to the soil, because it can lock carbon for many years (about 100 years -1,000 years). key benefit of using biochar in agriculture is that being economically accessible, it does not pollute environment. It is a great solution of bio-waste(like sawdust, sewage sludge, agricultural or forest waste, paper, kitchen scrap, cardboard, natural textiles, animal waste, commercial food waste etc.) management as pyrolysis process burn off any kind of bio waste and convert it to usefull product called Biochar.

10. "ACKNOWLEDGEMENT''

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