IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

BIOCHAR Making Process and its Utilization for Agriculture

Dolika. N. Patel*, Mihir. B. Prajapati*, Dr. Dhara O. Bhavsar and Dr. ArchanaU. Mankad

Department of Botany, Bio-informatics and Climate change Impacts Management, School of Science, Gujarat University, Ahmedabad, Gujarat. 380009

ABSTRACT

Biochar is charcoal used as a soil amendment for both carbon sequestration and soil health benefits. **Biochar** is a stable solid, rich in carbon, and can endure in soil for thousands of years. Like most charcoal,

Biochar is a solid residue produced from burning organic material from agricultural and forestry wastes (also called biomass)in a controlled process called pyrolysis. The use of biochar can potentially aid in mitigating climate change through carbon sequestration and improve soil quality by the addition of nutrients, increased water holding capacity and providing a liming effect in soils. The physical and chemical properties of biochar can vary depending on pyrolysis conditions and feedstocks used.Biochar is a promising alternative to remedy the soils contaminated with heavy metals and organic compounds through adsorption and immobilization due to its large surface area, charged surface, and functional groups. Overall, the bioavailability of heavy metals and organic compounds decreases when biochar is amended into soils.This paper is mainly focused on the production of biochar with the use of castor stock and the pyrolysis.

KEY WORDS: Biochar, Pyrolysis, Biomass, Heavy metals, Feedstock, Soil, Castor stock.

INTRODUCTION

Biochar is the carbonaceous solid residue which is obtained after heating biomass under oxygen deficient conditions. It is regarded as a nutrient recycler, soil conditioner, Agri-waste recycler optionthat additionallyhas potential for long-term, healthy and economical carbon sequestration.(Brewer, 2012).Biochar has been proved to be effective in improving soil properties and increasing crop biomass. It has also been suggested that it can even enhance crop resistance to disease. Biochar has recently been used to remediate soil with both heavy metal and organic pollutants(JingchunTang, 2013).

ORIGIN OF BIOCHAR AND ARCHAEOLOGY

Biochar research began by attempting to understand the secrets of dark, permanently fertile soils in the central Amazon called terra pretta. In central Amazon, up to 350 ha wide patches of a pre-Columbian black earth-like anthropogenic soil exist, very well known as terra pretta characterized by a sustainable enhanced fertility due to high levels of SOM and nutrients such as N, P and Ca (Glaser, B., 2007), (Glaser, B. & Birk, J. J. , 2011).

The key to terra pretta formation, however, is the tremendous input of carbonated organic materials, known as Biochar, which comprise up to 35% of SOM and 50 Mg/ha on average (Glaser, Haumaier, & Guggenberger, 2001). Biochar acts as a stable C compound that is only slowly degraded in the millennial time scale, with a mean residence time. Biochar has a high specific surface area (400 – 800 m^2/g), providing soil microorganisms with a habitat which can degrade more labile SOMs. Additionally, higher microbial activity speeds up soil stability. Furthermore, higher mineralization of labile SOM and Biochar itself provided important nutrients for plant growth (Daniel Fischer,Bruno Glaser, 2012).

SOIL IMPROVEMENT BY BIOCHAR

Biochar have attracted tremendous attention due to their effects on soil improvement, they enhance carbon storage, soil fertility and soil quality. Soil mineral depletion is a major issue due mainly to soil erosion and nutrient leaching. The addition of Biochar is a solution becauseit has been shown to improve soil fertility,promote plant growth, increase crop yield, and reduce contaminations.

Biochar produced from wide range of organic materials by pyrolysis and improve soil physical fertility and crop productivity.Biocharamendment improves soil quality by increasing soil pH, water-holding capacity.

The addition of Biochar increase in availability of basic cations as well as in concentration of phosphorus and total nitrogen. As a compost additive Biochar, provide multiple benefits including improving composting performance and humification process, enhancing microbial activities, reducing greenhouse gas and NH_4 emissions, immobilization heavy metal and organic pollutants. As a soil improvementBiochar shows good performance in improving soil properties and plant growth, alleviating drought and salinity stresses.

Composting with Biochar improve in soil,

- Better humification process
- Better nitrogen retention
- GHGs and NH_4 emissions are controlled
- Heavy metal and organic pollutants are inactivated
- Better water holding capacity
- Better nutrients retention

Pollutants are immobilized plot-scale evaluation of Biochar application to agricultural soils was conducted in Tirunelveli, Tamil Nadu, India, to investigate the potential of Biochar to improve soil fertility and moisture content. The Biocharfeedstockwere sourced sustainably and locally. Several locally available feedstock's (rice husk, cassia stems, palm leaves and sawdust) were analyzed as proposed soil amendments so that no single biomass material is depleted to maintain Biochar addition. The biochar's from different biomass feedstock contained >20% C and were high in macro- and micronutrients. The results suggested that an application rate of 6.6 metric tones/ha cassia Biochar was enough to initiate C-accumulation, which is reflected in an increase in OM and a net reduction in soil bulk density. (Utra Mankasingh, 2011).

The role of Biocharin agriculture and environment is depicted in fig.1.1. Biochar has gradually been linked to soil management, sustainable agriculture development. It is a solid product obtained by thermochemical conversation of biomass with the pyrolysis all the environmental pollution, and reduce greenhouse gas emissions.

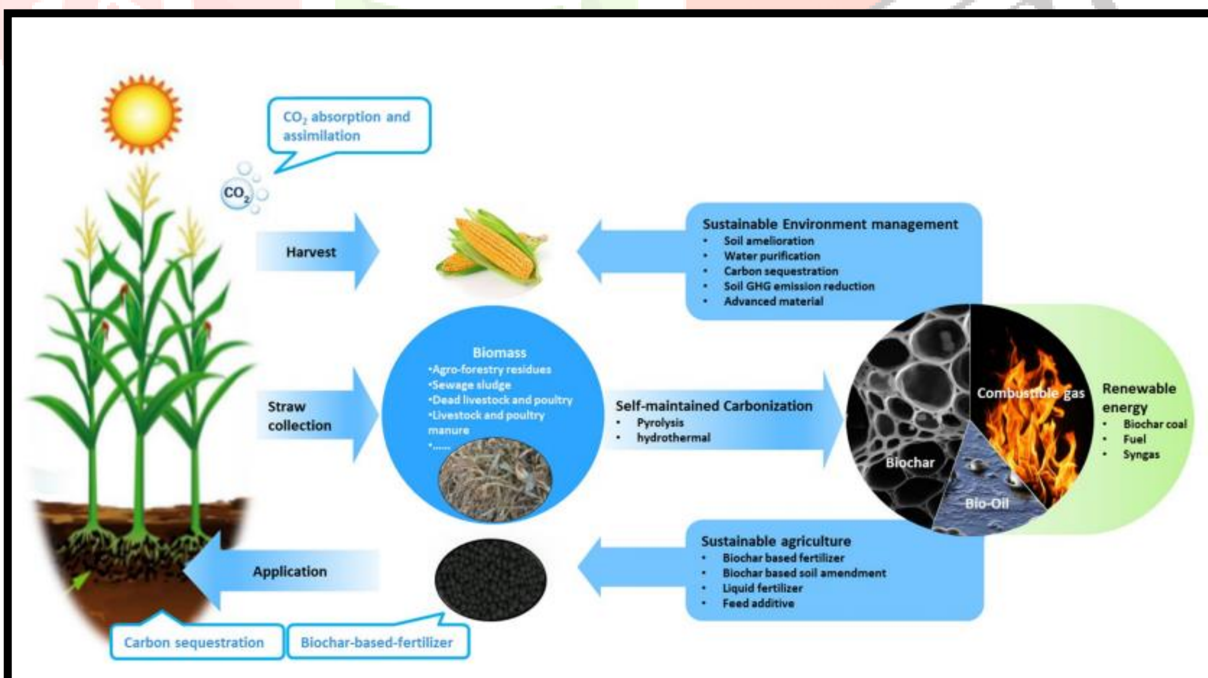


Fig. 1.1 Framework of Biochar Applications(Wenfu Chen, 2019).

THE ROLE OF SOIL ORGANISMS

The researchers find carbon-dating charcoals in terra pretta soils hundreds to thousands of years ago, indicating that carbon was extracted from the plant biomass many years ago as a stable solid.(lehmann, J.; Gaunt, J.:Rondon,M., 2006).According to Ogawa, 1994Biochar is generally characterized by a proliferation effect for many microorganisms of symbiosis due to its porous structure that provides a suitable habitat for soil microbes (Steiner & Teixeira, 2004). Furthermore, an increase of soil microbial biomass and a changed composition of soil microbial community were also observed after Biochar amendments (Birk, Steiner, Teixiera, & Zech, 2009).

While microbial reproduction rates after glucose addition in soils amended with Biochar increased, soil respiration rates were not higher (Steiner, C.; Teixeira, W. & Zech, W, 2011). One of the characteristics of terra pretta is this difference between low soil respiration and high potential for population growth in microbial population. These results show that a low biodegradable SOM together with a sufficient content of soil nutrients can support the growth of the microbial population.

According to Birk et.al., 2009,these effects can be ascribed in the porous structure of Biochar to different habitat properties. The following factors could be the reason why currently available evidence supports them in decreasing order:

- High surface area and porous Biochar structure ideal for several forms of microbes as habitat and retreats
- Increased water and nutrient retention capability, resulting in microbe stimulation
- Formation of 'active' surfaces covered by water film, dissolved nutrients and substances providing an optimal habitat for microorganisms; these specific surfaces serve as interaction matrix for storage and exchange processes of water and substances between soil fauna, microorganisms and root hairs
- weak alkalinity
- Maintaining character against decay possibly resulting in (partial) inhibition of some 'destructive' and pathogenic species while promoting beneficial microbes simultaneously.

Biochar promotes the spread of useful microorganisms, such as free-living nitrogen fixing bacteria, based on these possible stimulating factors (Tryon, 1948) (Ogawa, M., 1994) (Rondon, Lehmann, & Ramirez, 2007). Fig. 1.2 b show that the basic process of how Biochar becomes a safe habitat for micro-organisms and storage of nutrients and moisture, the symbiotic relationship between plants, fungus and micro-organisms, how plants feed this micro-life carbohydrates in return for moisture and nutrients.

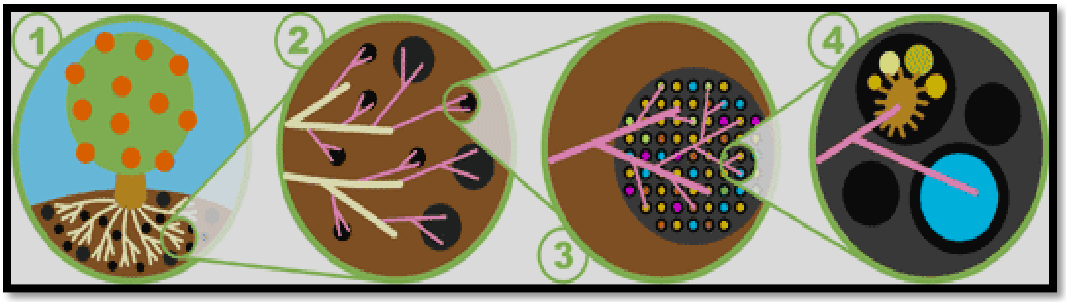


Fig. 1.2 Biochar as a habitat of a microorganism (The Biochar Factory, 2013).

Steps of microorganism process in the soil improvement,

1. Biochar applied around a trees root zone or drip line.

2. Plant roots (white) linking up with common stringy soil fungus (pink). The plant carbohydrates produced from photosynthesis are shared with the fungus in return for nutrients and moisture.

3. Fungus linking up with Biochar full of moisture, nutrients and micro-organisms

4. Micro-organisms embedded into the porous structure of Biochar share nutrients with fungus in return for plant produced carbohydrates

BIOCHAR COMPOSITION

The Biochar composition is highly heterogeneous and has both stable and labile components. The Carbon, reactive material, mineral matter (ash), and moisture are widely known as its main constituents. The relative proportion of Biochar components determines the chemical and physical behavior and function as a whole; Which in turn determines its suitability for a site-specific application.Another essential component of the Biochar is moisture, with higher moisture content the cost of Biochar development and transport to be changeable. Biochar is black, extremely porous, lightweight, fine-grained and has a large area of surface. Approximately 70 % of its composition is carbon. Among other elements the remaining percentage is nitrogen, hydrogen, and oxygen. The chemical composition varies according to the feedstock used for making and the methods for heating. In an oxygen-limited environment, it produced during pyrolysis and a thermal decomposition of biomass.Table.1.1 describes the Thermochemical processes, their representative reaction conditions, particle residence times, and primary products (brewer, catherine Elizabeth, 2012).

Sr.No.	Thermo chemical Process	Temperature range (°C)	Heating Rate Residence	Pressure	Residence Time	Primary Product
1	Slow Pyrolysis	350-800	slow (<10°C/min)	Atmospheric	Hours- Days	Char
2	Torre faction	200-300	slow (<10°C/min)	Atmospheric	minute-Hours	Stabilized,friab le,biomass
3	Fast Pyrolysis	400-600	Very Fast(~1000°C/s ec)	Vacuum-Atmospheric	Seconds	Bio-oil
4	Flash Pyrolysis	300-800	Fast	Elevated	Minutes	Bio carbon/Char
5	Gasification	700-1500	Moderate-very fast	Atmospheric-elevated	Seconds-Minutes	Syngas/Produc er

Table.1.1Thermochemical processes, their representative reaction conditions, particle residence times, and primary products (brewer, catherine Elizabeth, 2012).

BIOCHAR PROPERTIES

Biochar properties can be defined more easily if char is viewed as having two Fractions; the fraction "carbon," and the fraction of inorganic ash. The fraction on "carbon" Includes carbon-bonded hydrogen, oxygen and other elements, which is most impacted fraction by conditions of the reaction. Reaction time, heating rate, temperature, etc. To some extent, convert the mostly organic carbohydrate components into a Characteristic of Char condensed aromatic structures. The amount of inorganic ash is in the fraction most affected by feedstock properties; conditions for the reaction Some influence on the char's ash properties and ash-to-carbon ratio but in general, no matter what mineral components are in the biomass become concentrated in the ash(Brewer, 2012).

Methodology of Making Biochar

The typical process for making Biocharare listed in following steps,

1. Biomass dried
2. Biomass fed into pyrolysis kiln
3. Pyrolysis kiln heats biomass without oxygen
4. Biomass converts into Biocharin a period of 4-6 hours
5. Biochar removed from pyrolysis kiln
6. Biochar stored for soil applications.

- Biochar is prepared from pyrolysis process of organic feedstocks.
- Pyrolysis is the chemical decomposition of an organic material by heating in the absence of oxygen. The term is derived from the Greek word 'pyro' meaning fire and 'lysis' meaning decomposition or breakdown into component parts.
- Nevertheless, as compared to combustion where almost complete oxidation of organic matter occurs, the degree of oxidation of the organic matter is comparatively high, and as such a considerably greater proportion of the carbon remains in the feedstock and is not emitted as carbon.
- The pyrolysis process converts organic materials into three different elements, being gas, liquid or solid in various amounts depending on the conditions used for both the feedstock and pyrolysis.
- the remaining solid component after pyrolysis is charcoal, called biochar when it is generated with the purpose of adding it to the soil in order to improve it.

PROCESS / METHODOLOGY

In a modified method char production done using a pyrolysis kiln.

1. The SET-UP

a. A cylindrical metal drum (capacity 200 L) with both sides intact was procured from local market and modified for use as charring kiln.

b. A square shaped hole of 10 cm × 10 cm was made at the bottom side of the drum for loading the fuel wood.

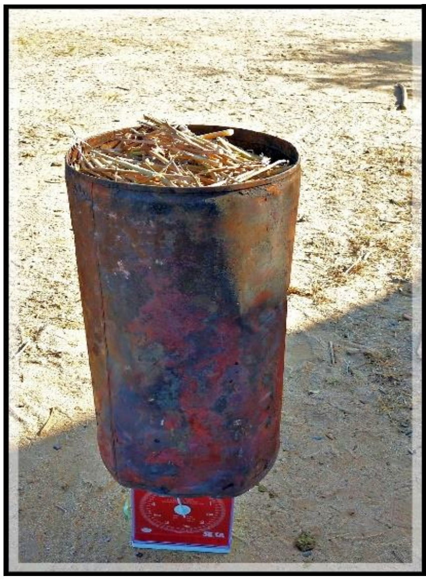
c. Another small metal cylindrical drum (capacity 30 L) was used for the loading crop residue and prepare the proper seal lid.

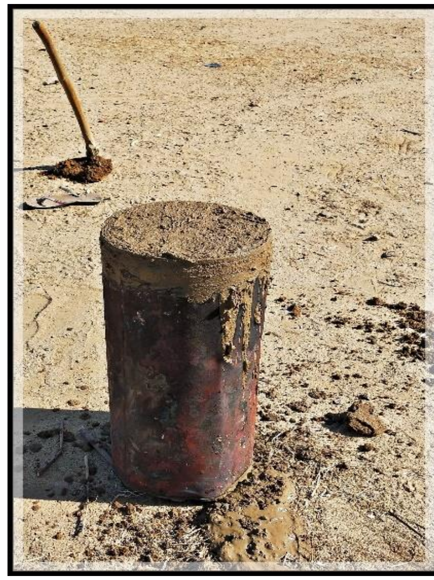
d. Drum same square shaped hole of 10 cm × 10 cm was made on the center of the top side to facilitate uniform circulation of the air.

After making the modification inner side of charring kilns where measured and prepare the proper seal lock lid with exhaust facility. The upper surface of the drum will help to uniform circulation of air. Another metal sheet measuring the 5 cm× 5 cm was made ready to cover the top square hole at the end of the burning process to stop the circulation of air. Sufficient amount of clay soil was collected for sealing purpose. The details of the study and measure finding are presented below.

2. Loading the charring kiln

Before loading the modified kiln with the Castrol stalk initial weigh of the charring kiln was recorded using a platform balance (fig. A). The dried castor stalk was loaded in a small kiln. Castor stalk added in 3 to 5 cm diameter and stalk were loaded in thekiln at 3.300 kg quantities and the weight of the loaded kiln was recorded using platform balance and the using clay to seal this small drum with the lid (fig. B).

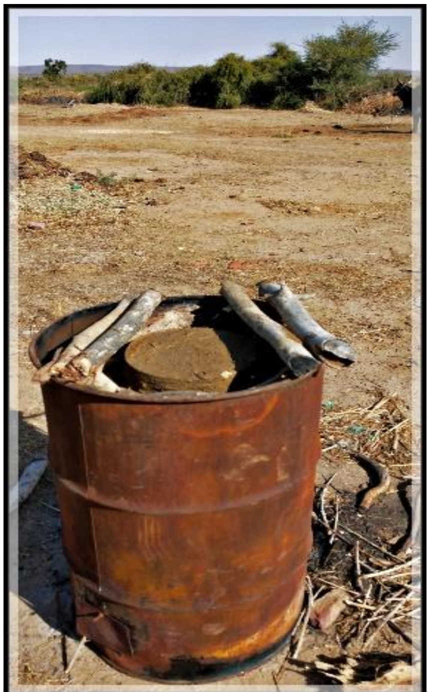

A


B

Sealing and firing charring kiln

Before initiating the burning process adjust the big drum and add the fuel wood through the initial weigh and set up the straight layer of the wood so the loaded small drum was placed on three stones (about 10 cm height) to facilitate airflow the holes at the bottom side (fig. D). After the set up the small drum cover the whole side through neem wood or any heating wood through initial weigh and lock the big drum with the lid and seal with the metal lock ring (fig. C). The wood where ignited through the bottom hole after the reduction in thickness of a smoke the metal sheet was placed partially on the top hole of the Kiln to slow down the flow of the air into the drum this was to reduce the flow of oxygen so that the stalk were burn properly. Whenever the amount of smoke increased the cover was opened to allow more air flow. The sealing of the drum and also along with the edge of the metal sheet used for covering the top and bottom hole (fig. E).

C



D

E

3. Biochar Output

F

G

The charring was done for four hours under controlled anaerobic condition. After the burning process is over, cooling of drum takes place in sealed conditions. After overnight cooling of the kiln, the small drum is taken out and the seal clay is removed. The Biochar thus formed is taken out from the kiln and weighted (fig. F-G). It is stored in air tight condition for use by the farmer for soil application.

CONCLUSION

Biochar's application to agricultural soils has the ability to significantly improve physical, chemical, and biological conditions in soil.The impact of Biochar in the soil is long-term soil improvement phenomena, which particularly improve the organic carbon, pH, nitrogen, potassium, phosphorus, as well as holding soil moisture for longer period, despite hot and dry condition as well as hot and dry climate. Biochar application has show a remarkable improvement in tropical soils, which has positive effects on soil fertility and disease resistance. Biomass processing to produce biofuels and Biochar for carbon sequestration in the soil is a carbon-negative process, i.e. more CO_2 is extracted from the atmosphere than emitted, thereby allowing long-term sequestration. Agriculture waste materials are rather resistant to decomposition and require long composting times and additional N fertilization. Therefore, many a times agriculture waste is frequently burned open by on the farm (for no other use than to get rid of it) or is deposited at landfills. These biomass sources are ideally suited for Biochar production and can either be mixed with compost or used for direct application to soil.

Bibliography

Government of India. (2011). Provisional Population Totals, Office of the Registrar General and Census. New Delhi.: State of Gujarat Agriculture .

Birk, j. J., Steiner, C., Teixiera, W. c., & Zech, w. (2009). Microbial Response To Charcoal Amendments And Fertilization Of A Highly Weathered Tropical Soil, In: Amazonian Dark Earths: Wim Sombroek's Vision, Woods, W. I.; Teixeira, W. G.; Lehmann, J.; Steiner, C.; Winklerprins A. And Rebellato, L. (Eds.). *pp. 309-324. Springer*, ISBN 978-1-4020-9030-1 .

Brewer, C. E. (2012). Biochar Characteristics And Engeneering.

Brewer, Catherine Elizabeth. (2012). Biochar Characterisartion And Engineering.

Daniel Fischer,Bruno Glaser. (2012). Synergisms Between Compost And Biochar For Sustainable Soil Amelioration. *Management of organic waste,* 1.

Glaser, B. & Birk, J. J. (2011). State Of The Scientific Knowledge On Properties And Genesis Of Anthropogenic Dark Earths In Central Amazonia (terra preta de Índio). . *Geochimica Et Cosmochimica* Acta doi:10.1016/j.gca.2010.11.029.

Glaser, B. (2007). Prehistorically Modified Soils Of Central Amazonia: A Model For Sustainable Agriculture In The Twenty-First Century. *Philosophical Transactions of the Royal Society B-Biological Sciences* 362, pp 187-196.

Glaser, B., Haumaier, L., & Guggenberger, G. &. (2001). The Terra Preta Phenomenon:A Model For Sustainable Agriculture In The Humid Tropics. *Naturwissenschaften* pp 88, 37.

India State Of Forest Report, E. 1. (2019). India State Of Forest Report. *Forest Survey of India.*

Jingchuntang, W. R. (2013). Characteristics Of Biochar And Its Application In Remediation Of Contaminated Soil. Japan: *Journal Of Bioscience And Bioengineering*.

Lehmann, J.; Gaunt, J.:Rondon,M. (2006). Bio-Char Sequestration In Terrestrial.

Ministry Of Environment, Forest And Climate Change. (2018). India Second Biennial Update Report To The United Nations Framework Convention On Climate Change. *Ministry of Environment, Forest and Climate Change, Government of India*.

Mrutyunjay Swain, S. S. (2012). State Of Gujarat Agriculture . Anand: Agro-Economic Research Centre.

Ogawa, M. (1994). Symbiosis Of People And Nature In The Tropics. *Farming Japan 28 (5)*, pp. 10–30.

Rondon, M. A., Lehmann, J., & Ramirez, J. &. (2007). Biological Nitrogen Fixation By Common Beans (Phaseolus Vulgaris L.) Increases With Bio-Char Additions. *Biology and Fertility of Soils* 43, pp 699-708.

Steiner, C., & Teixeira, W. &. (2004). Slash And Char - An Alternative To Slash And Burn Practiced In The Amazon Basin. In "Amazonian Dark Earths" (B. Glaser And W. Woods, Eds.). pp. 182-193. *Springer, Heidelberg*.

The Biochar Factory. (2013) Biochar Nutrient Content - The Biochar Factory. Retrieved June 22, 2020, from https://www.blackearthproducts.com.au/about-biochar/: http://doctor-biochar.blogspot.com/2013/11/biochar-nutrient-content.html

Tryon, E. H. (1948). Effect Of Charcoal On Certain Physical, Chemical, And Biological Properties Of Forest Soils. . *Ecological Monographs 18*, pp 81-115.

Utra Mankasingh, P.-C. C. (2011). Biochar Application In A Tropical,Agriculture Region: A Plot Scale Study In Tamil Nadu,India. *elsevier* , pp s 218-s 221.

Vimala D. Nair, P. K. (2017). Biochar In The Agroecosystem–Climate-Change–Sustainability Nexus. *frontiers in plant science* .

Wenfu Chen, J. M. (2019). Past, Present, And Future Of Biochar. *Shenyang Agricultre University* , p 13.