

Review Article

Simple Technology to Convert Coconut Shell Waste into Biochar: A Green Leap Towards Achieving Environmental Sustainability

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Received 29/07/2019, last revised 16/08/2019, accepted 19/08/2019, available online 01/09/2019

Abstract

Pyrolysis is a technology to convert biomass into high-value product such as biochar. Biochar is a bio-based material as well as char that can maintain soil, water and air quality. Biochar can produced by all of plant parts and generated directly from pyrolysis for a few hours in a certain temperature. The quality of biochar production is highly dependent on the pyrolysis temperature, heating rate, particle size, type, and composition of feedstock and reactor conditions. Several study inform that biochar produced by high temperature such as furnace. Application of biochar in soil can solve contaminated soil from pollutants such as toxic metals contamination, low pH issues and degradable soil caused by industrial activities. Therefore, the application of biochar in water ecosystem can solve some problems such as reduce toxic metals content in wastewater. Biochar known can give significant impact to reduce global warming through the reduction of greenhouse gas emissions and the sequestering of atmospheric carbon into soil. This condition is a problem for several areas especially rural area in developing countries. This paper will describe clearly how to produce biochar use simple technology. Thus, this paper will provide useful information for reducing environmental problems especially on rural areas.

Keywords: coconut shell, biochar, environment, environmental sustainability

1. Introduction

Environmental damage is a global issue since recent decades made industrial activity being grow up and generate more waste. These was made problems such as water pollution by the existence of plastic industry which caused macro- and microplastic in marine environment (Wibowo, et al., 2019). Therefore, air and soil pollution from fly and bottom ash of power plant, added by the increasing of population growth forced more energy consumption and lead to environmental degradation by its industrial activities (Winarno et al., 2019). Population growth was also lead to the increase of food needs that will give an impact for environment caused by waste such as coconut and waste palm mill (Naswir et al., 2019)

Production of coconut shell has been growing steadily in recent decades (Global Cement Magazine, 2012), coconut shell waste will give impact for environmental such as bad smell, air pollution and if this waste burned will give an impact for ozone especially on developing countries. This condition

will give negative impacts for human activity. They were work a day full to fulfill their life needs. They were doing monotone activities, this condition will give impact for their health (Wibowo, 2019; Wibowo & Indrayana, 2019). Coconut shell waste need some treatment to provide sustainable added value. Coconut shell waste could be a biochar, which has various functional groups and contain polycyclic aromatic hydrocarbons (Wibowo & Naswir, 2019; Wibowo et al., 2019). Several study informs that biochar has been creating by pyrolysis (Tareq et al., 2018; You & Wang, 2016) used different time and temperature with advanced technologies (Vithanage et al., 2016). Biochar has been utilized to reducing environmental damage such as toxic metals content on wastewater (Wibowo al., 2019), soil remediation (Wibowo & Sadikin, 2019), air pollution and solid waste (Sahoo et al., 2019). Biochar is not only environmentally, but also give positive impact for economy and social development (Ji et al., 2018). **Figure 1** shows the schematic process of biochar production and application.

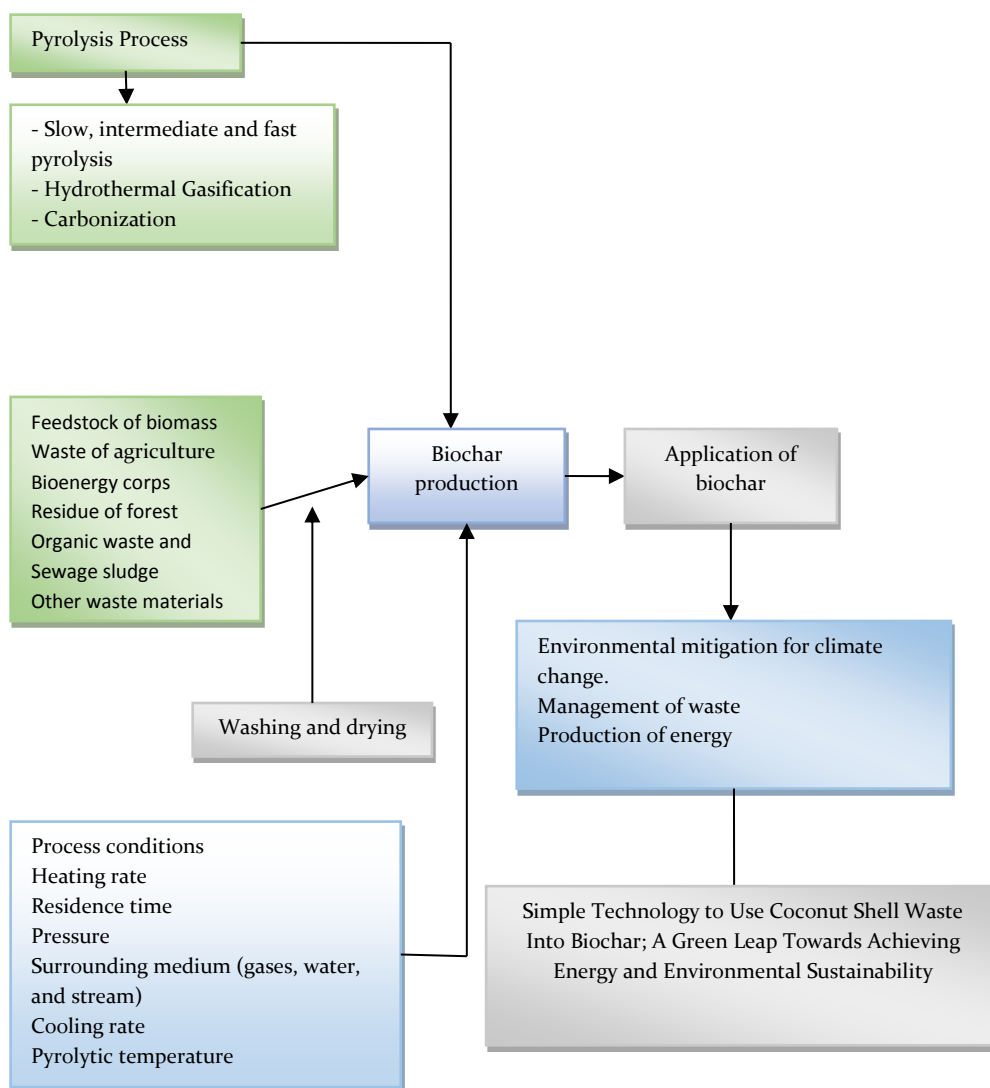


Figure 1. Schematic process of biochar production and application

Biochar have many benefits to environment, economy and social aspect but still have problems especially on technology to create this biomaterial. Several study that inform used furnace to created biochar (Zhu, Qiao, & Yan, 2019). Advanced technology made this biomaterial could not possibly be created by traditional treatment especially on rural areas. This paper will give clear information to create biochar by simple technology. Thus, this technology is acceptable for everyone as a green leap towards achieving energy and environmental sustainability.

2. Biochar Preparation

Several study informs that biochar created by furnace, this paper will describe how to create biochar use a simple technology. Biochar created by coconut shell waste that dried for two days to remove water content, then coconut shell waste burned with pan using unused firewood during four hours (**Figure 2**) at 400 °C. Biochar has burned four hours removed and cooled before using to utilize as a biomaterial that could reducing heavy metals content on water, soil remediation and reducing air pollution. Biochar made from physic and chemical properties. Biochar is different with activated carbon, it caused by biochar do not need activators. Biochar have chemical and physical characterization such as BET, pH, FTIR/FTIS, elemental analysis, Boehm titration, bulk density, CEC analysis, C-NMR, gas chromatography, zeta potential of biochar colloids, particle size distribution, x-ray absorption near-edge structure, SEM/TEM, moisture content, ash content, pores volume (**Figure 3**) (Nartey & Zhao, 2014). Biochar can produced by microalgae, wood, solid waste and all of organic matter. Recent study showed that biochar production by microalgae use slow and fast pyrolysis (between 200-750 °C), another study reported that yield of biochar has decreased from 48% to 24% when pyrolysis temperature increased from 300 to 700 °C. Low temperature range (200-750 °C) of biochar pyrolyzed from microalgae produced high carbon (J.-S. Chang et al., 2017) and optimum production of biochar is at 500 °C (Y. Chang et al., 2014).



Figure 1. Simple technology to create biochar

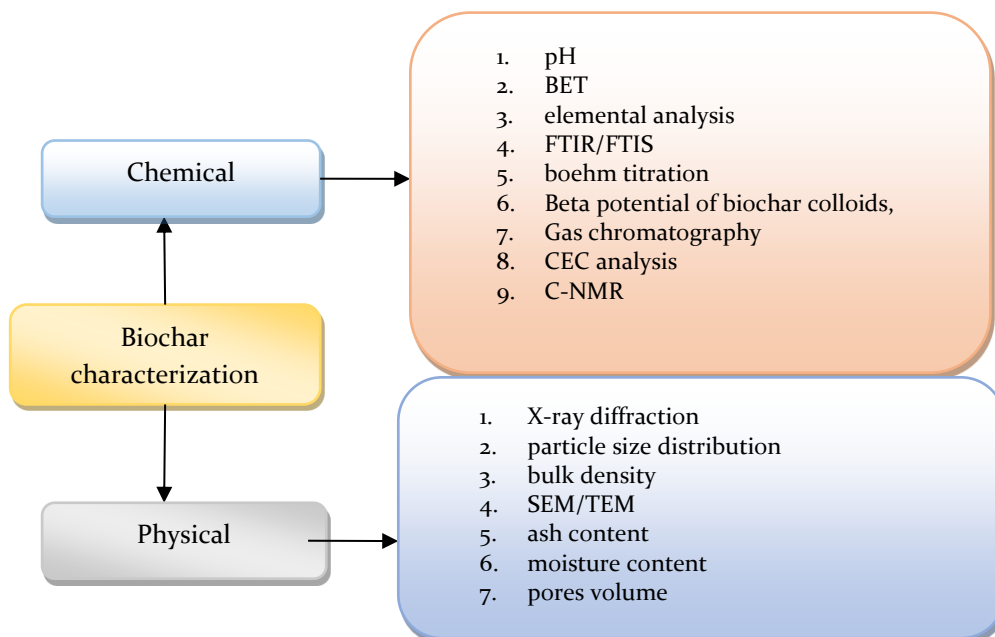


Figure 2. Biochar Characterization

3. How can Biochar Support Environmental Sustainability?

Biomaterial-biochar is a good material for environmental sustainability for environmental remediation such as climate change mitigations, reduce organic pollutant, high metal reduction and immobilization, high complexation and soil amelioration include slow nutrient release, microbial abundance (efficient nutrient transfer), better O₂ and moisture level. The physical properties of biochar include physical and chemical properties, physical properties of biochar are high surface area and porosity, high surface charge and high holding water capacity and chemical properties include high pH, high carbon sequestration high nutrient exchange and high -COO⁻;OH⁻;CO⁻,-R-OH group (**Figure 4**), biochar is a potential sorptive media for removal of hazardous benzene in air (Khan et al., 2018), soil nutrients (Gaskin et al., 2010) and reducing wastewater pollution (S. Wang & Wang, 2019). Biochar has been developing as a green energy as catalyst in energy recovery technologies and fuel. Green energy from biochar has created by agriculture waste and showed high porosity, a wide range of mineralogical composition and pH and biochar has found suitable for improvement of waste to energy technologies (Bhowmick et al., 2019). Several study about biochar affected for environmental could see in **Table 1**. Biochar can decreased heavy metals in soil and water, several study showed that biochar can neutralize pH values of soil. Application biochar in environment can reduce the global warming effect include acidification, eutrophication, ozone layers and else. **Tabel 1** informs that biochar can support the sustainability of environment.

Table 1. Biochar impacts on environmental sustainability

Statement	Descriptions
Biochar effect of organic pollutants and heavy metals on soil	Biochar decreased the concentration of Cu, As and Cd in maize shoots, which depended upon amount of biochar addition, pH values of soils, and ability of metal to adsorb on biochar (Nartey & Zhao, 2014)
Biochar can reduce environmental damage and climate change	Applied biochar for environment that give reducing global warming effect, acidification, eutrophication, ozone layer depletion, summer smog, winter smog, pesticides, airborne heavy metals, waterborne heavy metals, and carcinogenic substance (Ning et al., 2013).
Desorption of atrazine in biochar-amended soils	Biochar can significantly decrease the desorption of atrazine from soil, root exudates and the aging interactions between biochar and soil can enhance the desorption of atrazine (Ren, Wang, Cao, Guo, & Sun, 2018)
Biochar role in microbial proliferation and pollutant biodegradation	Biological attributes of biochar related to pollutants removal however develops later phase of the soil application (Oliveira et al., 2017)
Effects of biochar materials on arsenic and heavy metals under water and soils	Biomaterial-biochar (using softwood) could reducing arsenic and heavy metals content underwater, status of nitrogen species and elements of potential toxicity in soils (Heaney, Tahir, Al-gharib, & Lin, 2018)
Site energy distribution consideration by tetracycline adsorption of biochar	Biochar can reduce tetracycline, biochar can sorption 86% from a solution at initial concentration 200 mg/L. Freundlich-Langmuir was used as an isotherm adsorption.

Statement	Descriptions
Pyrolysis of switchgrass in auger reactor for biochar production	Biochar can reduce emission N_2O and sorption of carbon. Biochar was produced by auger reactor, this treatment can reduce greenhouses gases and make energy balance (Brassard et al., 2018)
Utilization of acid mine drainage sludge and coal fly ash for phosphate removal from dairy wastewater	Acid mine drainage sludge and coal fly ash can be combined to reduce phosphate from wastewater. Acid mine drainage sludge can utilize to biochar to reduce phosphate (Y. R. Wang et al., 2013)
Removal heavy metals from contaminated soil	Biochar was pyrolyzed at $350^\circ C$ for a hour under $0.1\text{ m}^3\text{ h}^{-1}$ nitrogen flow, after this treatment biochar was prepared by steam activation at $800^\circ C$ for 45 min in an atmosphere with 71% water vapor in nitrogen. Biochar can remove heavy metals content such as Cu(II), Cd(II), and Ni(II) in soil polluted (Uchimiya et al., 2010)
Effect of cassava waste biochar on sorption and release behavior of atrazine in soil	Biochar was used to sorption and desorption test to remove atrazine in latosol. Biochar produced by cassava. Results indicate that the addition of 0.1%–5% (w/w) biochar in latosol inform atrazine adsorption by 1.7- to 36-fold as compared with the natural soil control, after 60 days.

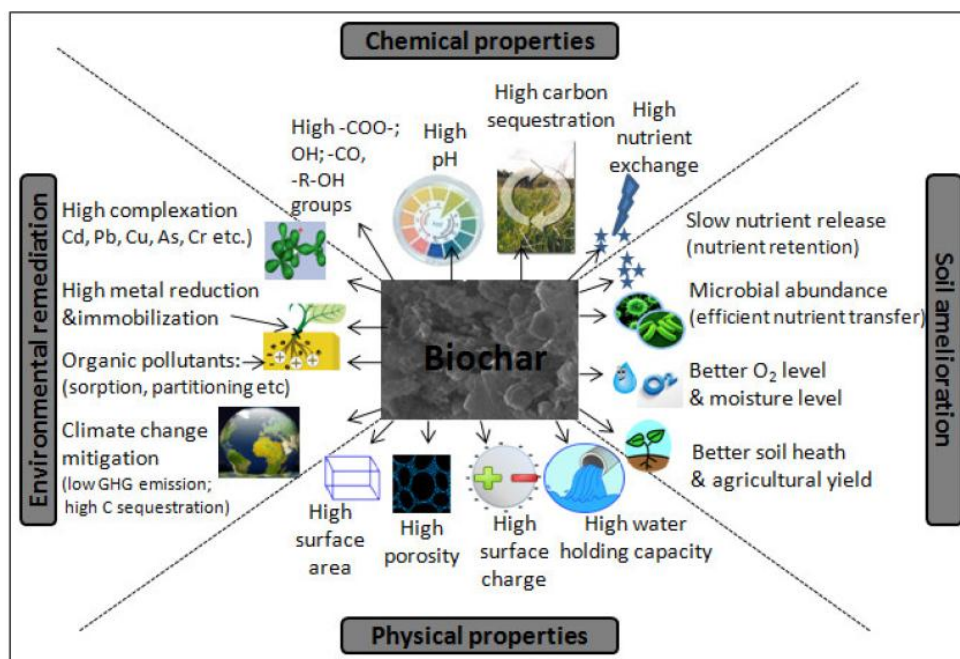


Figure 4. Biochar utilization

4. Conclusion

High production of coconut shell is not be a solid waste again, coconut shell could though to be a biochar. Biochar is a biomaterial that give positive impact for environment sustainability. Biochar will be give positive impact on soil remediation, reducing wastewater and air pollution. Simple technology on this paper could implemented on everywhere especially rural areas have many coconut resources.

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