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Production and characterization of coconut shell and mesquite wood biochar

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Abstract
Biochar derived from Coconut shell and Mesquite wood had. A significant variation was observed in pH and EC. Coconut shell biochar had higher cation exchange capacity of 11.93 cmol(p^+)kg^{-1}, zeta potential of -42.2mV compared to mesquite wood biochar. At low magnification (1000 x), the size of the pores diameter varied from 7.26 µm to 10.00µm and length is varied from12.95 µm to 15.69µm. It is a highest pore diameter and length compared to mesquite wood biochar. Particle size of the coconut shell (56.4nm) is lower compared to mesquite wood biochar (87.4nm). Functional properties of amines, allenes, ketones, amides, alcohols, aldehydes and aromatics groups are present in coconut shell biochar. Mesquite wood biochar had alkanes, amines, alkynes, alcohols and aromatics. These biochar were subsequently characterized regarding their main properties, in order to evaluate their potential use in soil and waste water remediation.

Keywords: Coconut shell, Mesquite wood, Biochar, SEM, FTIR

1. Introduction
South and Central America was introduced to (*Prosopis juliflora)* in India to meet the fuel-wood requirements of the rural poor and to restore degraded lands. It is fast growing and tolerant to arid and saline soils conditions. Now it has become an aggressive weed in several parts of the country and poses a serious threat to native biodiversity (Chandrasekaran and Swamy 2011) [8]. It is available in large quantities in many parts of Tamil Nadu, particularly in wastelands of drought prone area. The cheapest biomaterial are selected for my research and the production cost also inexpensive. Many researchers have studied for various agricultural biomass and woody material used as a low cost sorbent for heavy metal removal in waste water (Beesley and Marmiroli, 2011) [4].
Major coconut (*Cocos nucifera*) growing States and union territories of India like Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Goa, Orissa, Assam, Andaman and Nicobar, Lakshwadeep and Pondicherry. The total area of the coconut cultivation in Tamil Nadu is 357100 hectares and production is 3243.50 million and the productivity is 9083 nuts per hectare which surpasses the all India average productivity of 6632 nuts per hectare. In Tamil Nadu, coconut is mainly produced in Pollachi taluk of Coimbatore district, Kanyakumari and Nagarkovil districts due to its large area under cultivation of coconut which is due to suitable climatic mainly conditions available in these regions for coconut production. The component of cellulose, hemicelluloses and lignin content are present in coconut shell and mesquite wood waste not easily degraded.
Biochar can be produced from various feedstock materials or waste, such as agricultural residues, manures, industrial wastes etc., providing an alternative option for waste management (Yao *et al.,* 2011) [31]. Biochar refers to charcoal materials generated from incomplete combustion of carbon rich biomass with heat treatment and oxygen-limited conditions (Beesley *et al.,* 2011) [3]. Biochar has attracted widespread attention because of its potential use as a soil amendment to improve soil quality, sequester carbon (Awad *et al.,* 2012) [2] and enhance immobilization of potentially hazardous chemicals (Beesley and Marmiroli, 2011; Borchard *et al*., 2012; Sun *et al.*, 2014) [4, 6, 27]. After pyrolysis of biochar were found to contain many functional groups of hydroxyl and carboxyl, which improve the cation exchange capacity and make a potential adsorbent in aqueous solution (Li *et al*., 2008; Liang *et al*., 2010) [15, 16].

2. Material and methods

2.1 Preparation of Biochar

Coconut shell and mesquite wood were collected from different localities such as Pollachi in Coimbatore district and Paramakudi in Ramnathapuram district. The collected samples were air dried at room temperature for 2-3 days then converted into biochar through pyrolysis at 450 ˚C for 2-3 hours. The resulting biochar was crushed and sieved into less than 2.0mm size. Then the sieved biochar of coconut shell (CSB) and mesquite wood (MWB) was kept in oven at 60 ºC for 48 h to reduce the moisture content. After air dried CSB and MWB were stored in air tight container for further analysis.

2.2 Characteristics of coconut shell and mesquite wood biochar

The physical and chemical properties of the coconut shell biochar are summarized in Table 2. The physical properties of coconut shell biochar such as bulk density particle density and Pore space were measured using Keen Raczkowski brass cup method suggested by Richards (1954) [24]. The pH and Electrical conductivity of the biochar were measured in 1:10 ratio (samples: distilled water) using a EC meter and pH meter, respectively (Jackson, 1973) [10]. Total Organic Carbon was determined using muffle furnace method (Mitchell, 1932) [18] and Cation exchange capacity analysed by ammonium acetate method (Gupta, 2007) [9]. The zeta potential of supernatant solution were identified using Particle size analyser (Horbia scientific Nanopartica SZ-100, Japan) Ucar *et al.*, 2014) [29]. Functional groups were identified by the Fourier transform infrared spectroscopy (Model 8400S of Shimadzu, Japan). The FTIR spectra were collected with a spectrometer using potassium bromide (KBr) pellets and the wave number ranging from 400 to 4000 cm^{-1} (Trakal *et al*., 2014) [28]. Surface morphology character was identified by scanning electron microscopy (M/s. FEI - Quanta 250, Czech Republic) (Ucar *et al.*, 2014) [29].

3. Result and Discussion

3.1 Characterization of coconut shell and mesquite wood biochar

The measured results showed different characteristics between the two types of biochar (Table 1). The pH of the CSB and MWB was alkaline pH 8.66 and pH 8.73 with an EC of 0.98 and 2.2 dSm $^{-1}$ respectively. A significant variation was observed in physical and chemical characteristics of both the biochar. The physical properties of bulk density, particle density, moisture and ash content of CSB (0.54, 0.25, 0.43 and 1.46%) were higher compared to MWB (0.34, 0.23, 0.35 1.29 %) but pore space were lower (31.01%) in comparison with the CSB (37.3%). The chemical characters of total organic carbon content 9.52% was more in CSB compared to MWB (8.90%). These values are closely related to coconut shell and prosopis wood biochar reported by Shenbagavalli and Mahimairaja (2012) [26]. In MWB and CSB had cation exchange capacity (CEC) value ranged from 9.76 -11.93. In general, the (CEC) of most biochars is relatively high, in part due to their negative surface charge and resultant affinity for cations, including most heavy metals ($Pb^{2+,}$ Ni^{2+})$^{.}$ For this reason, several studies have been conducted investigating the adsorption of cations onto biochar (Cao *et al.*, 2010 and Jiang *et al.*, 2012) [7, 11], which is the primary mechanism by which biochar can be used for remediation of heavy metal contamination. CEC varies significantly between terrestrial derived biomass from different feedstocks, ranging from 4.5 to 40 cmol (p^+) kg $^{-1}$ (Bird *et al.*, 2011 and Uzoma *et al.*, 2011) [5, 30]. The zeta potential of the CSB was more -46.2mV and less in MWB (-26.1mV). The negative values of the zeta potentials of both biochar suggest that the surfaces of both biochar are negatively charged. The CSB were more negatively charged than MWB due to the presence of higher amount of functional groups in the CSB than the MWB. Similar trends was recorded by Samsuri *et al.* (2014) [25] in empty fruit bunches biochar and rice husks biochar. Lower particle size of 56.4nm noticed in CSB for compared to MWB (87.4nm). For decreasing particle size to increase the surface area of the biochar. Kannan and Veemaraj (2010) [12] resulted that the removal of Cd^{+2} increased from 10.07% to 53.16% with decreasing particle size of Jackfruit seed carbon from 250 to 90µm. They attributed this to the increase in the available surface area (Nguyen *et al.*, 2013) [19].

Table 1: Characterization of coconut shell and mesquite wood biochar

S. No	Parameter	Coconut shell biochar	Mesquite wood biochar
1	pH	8.66	8.73
2	EC (dSm^{-1})	0.98	2.2
3	Bulk density (g cm^{-3})	0.54	0.34
4	Particle density (g cm^{-3})	0.25	0.23
5	Pore space (%)	31.01	37.3
6	Moisture content (%)	0.43	0.35
7	Ash content (%)	1.46	1.29
8	Total organic carbon (%)	9.52	8.9
9	Cation exchange capacity (cmol (p^+) kg $^{-1}$)	11.93	9.76
10	Zeta potential (mV)	- 42.1	-26.2
11	Particle size (nm)	56.4	87.4

3.2 Surface morphology structure of coconut shell and mesquite wood biochar

The surface morphology structure of the CSB and MWB was analyzed by SEM before adsorption of metal ions. The textural and morphological structure examination of CSB and MWB particles can be observed from the SEM photographs at 1000 x magnification. Surface features of the biochar as depicted by SEM micrographs reveal that coconut shell biochar is fish net like structure but not uniform. At low magnification (1000 x), the size of the pores diameter varied from 7.26 µm to 10.00µm and length is varied from12.95 µm to 15.69µm (Fig 1).

The mesquite wood biochar surface morphology structure was different. They are irregular elongated shape at low magnification 1000 x with a pore size varying from 1.29 µm to 1.70 µm diameter and length was 4.69 µm to 8.51 µm (Fig 2). Mathew (2017) [17] has registered by 1.614 µm pore diameter of Cocoa pod waste biochar and Coconut tree saw dust, Egg shell and Sugarcane bagasse were 1.9, 11.4 and 7.2 nm, respectively (Putra *et al.,* 2014) [22]. Scanning electron microscopy proves to be a powerful method in understanding different associations between heavy metal and its carrier phase (Priadi *et al.,* 2011) [21].

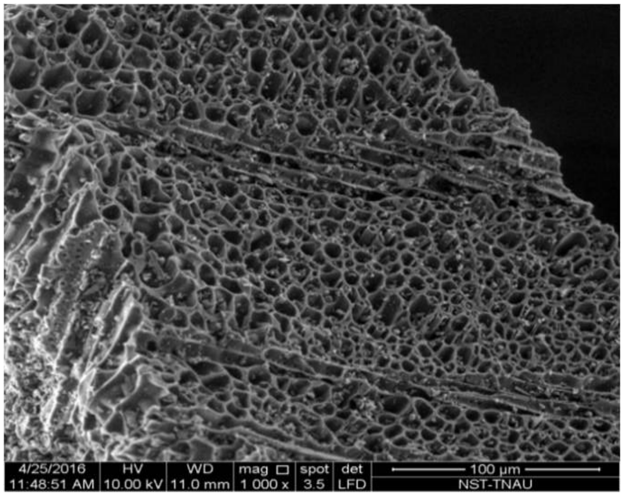

Fig 1: Scanning Electron Microscope of coconut shell biochar

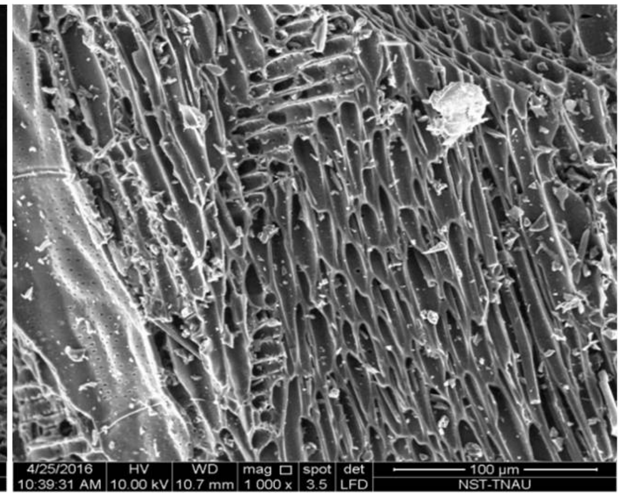

Fig 2: Scanning Electron Microscope of mesquite wood biochar

3.3 Functional groups of coconut shell and mesquite wood biochar

FTIR spectra for the CSB the values of FTIR spectra of CSB (Fig 3) showed the bands located at 2317.1, 2083.7, 1988.2, 1576.5, 1407.8, 1285.3, 1169.6, 875.5 and 806.1 cm^{-1} which correspond mainly to the presence of amine (NH) bonded medium intensity stretching mode (2317.1 and 2083.7 cm^{-1}), Strong stretching mode of Allenes (C=C=C) and Ketones (C=O) (Regmi *et al.,* 2012) [23], medium intensity stretching mode of amides (C-N), Strong intensity of alcohols (C-O), medium intensity stretching mode of aldehydes (C-C) (Regmi *et al.,* 2012) [23] and aromatics (CH) functional groups present in coconut shell biochar. Kumar *et al.* (2011) [14] that confirmed the presence of several oxygen functional groups (carboxylic, hydroxyl/phenolic, carbonyl) on the surface of the biochars. Functional groups, such as (C=O) demonstrated high coordination with heavy metals (Prapagdee *et al*., 2014) [20].

FTIR spectroscopy revealed that the result of MWB are presented in Fig 4. The peak as observed at 2901.4 and 2318.0 cm^{-1} is medium intensity of CH bonding of alkanes and NH bonding of amine salts functional groups. The variable intensity peak at 2108.8 $cm^{-1}$and 1591.9 is due to the alkynes (C≡C) and ring bonding of aromatics stretching mode. The medium and strong intensity peak at 1441.5 and 1314.3 cm^{-1} represents the deformation mode of alcohols (OH) and alkanes (CH) functional groups. A strong intensity peak at 1173.5 and 875.5 cm^{-1} skeletal deformation mode of alkanes (CC) and aromatics (CH) functional groups are exhibited in PWB. Similar type of functional groups of CH, OH and NH bond are documented by Mathew, 2017 in Cocoa Pod waste biochar **a**nd C=C (aromatic conjucation) and OH bonded of alcoholic functional groups are founded in *Prosopis juliflora* park biochar (Kumar and Tamilarasan, 2013) [13].

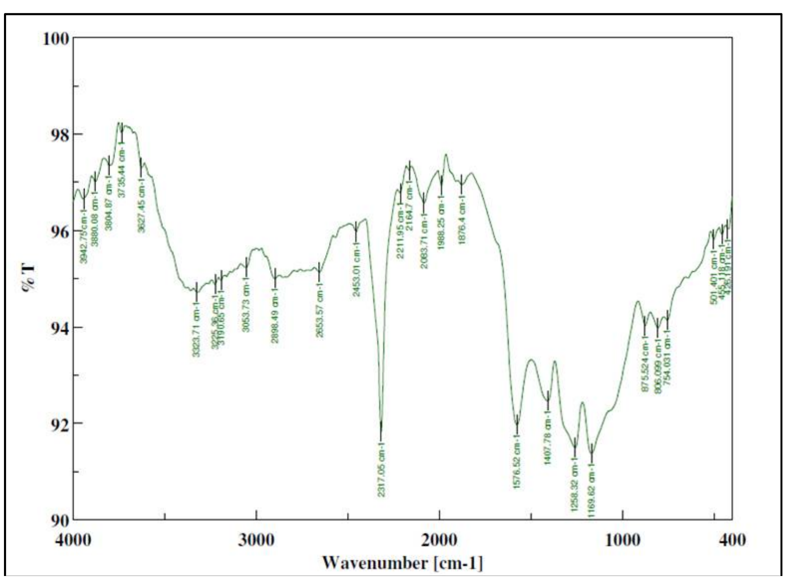

Fig 3: FTIR spectra of coconut shell biochar

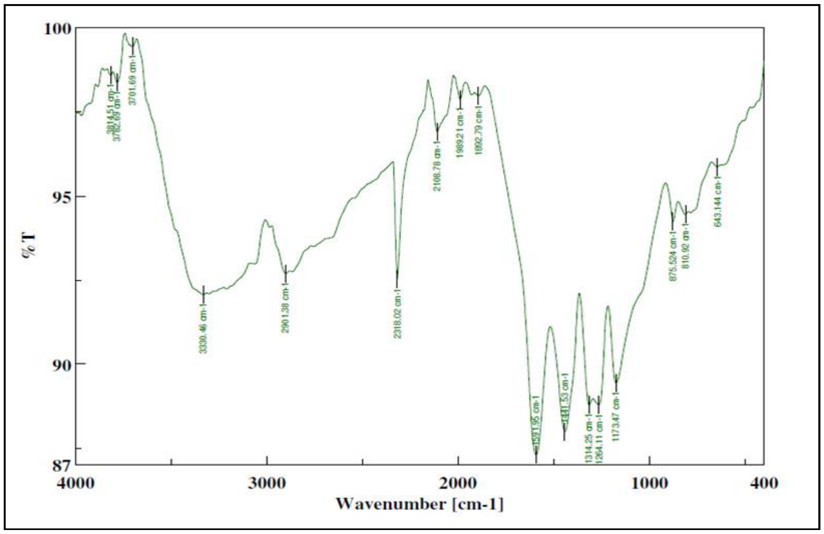

Fig 4: FTIR spectra of mesquite woo biochar

4. Conclusion

The coconut shell biochar was comprises of higher cation exchange capacity (11.93 cmol (p^+) kg $^{-1}$), total organic carbon (9.52%), negatively charged zeta potential (-42.1 mV), surface area diameter of.26 µm to 10.00µm and length is varied from12.95 µm to 15.69µm compared to mesquite wood biochar. More functional groups become deprotonated and the biochar surfaces become more negatively charged. This study was carried out to provide basic information as to the possibility of reuse of biochar derived from different biomass. Biochar production is a viable waste management option and coconut shell and mesquite wood seems like a suitable feedstock that can be provided in great quantities. The biochar production from biomass such as coconut shell and mesquite wood may be an effective way for recycling the waste resources.

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