Engineered Black Carbon Pertinence for Environmental Remediation

P. Vijetha, T. Subbaiah, K. Bhuvaneswari, M. Ramesh Naidu, A. Ranganadha Reddy, K. Naresh Katari

Abstract: ***It is acknowledged that biochar is a considerable tool for soil prolificacy and seclusion of carbon. Water bodies affected by toxins can be treated with biochar, which acts as a good adsorbent. It is necessary to perceive its physical and chemical properties, which are firmly associated to the kind of feed stock and environment, is important to detect the purposeful biochar employment in soil. In order to make an effective use of biochar as a soil amendment, biochar is prepared by pyrolysis of different types of agricultural wastes at different temperatures (300, 400, and 500). Biochars produced at elevated temperatures gives good results for adsorption compared to the biochar produced at low temperatures. The components present on the biochar surface determine its contaminant removal capacity.***

Key words; Soil Prolificacy, Carbon, Toxins, Pyrolysis

I. INTRODUCTION

The use of biochar in reducing the global warming effects is gaining huge interest. Numbers of studies have concentrated not only on the application of biochar for carbon sequestration, but also focused on the revolutionary applications of biochar in the neutralization of contaminants such as pesticides, plant growth, soil fertility enhancement [1][2]. The pyrolysis environment and the type of feed stock determine the properties of biochar, which are responsible for its wide range of applications [3]. The major point in determining the most suitable use of biochar is to know about its overall production process. The overall characteristics of biochar can induce modifications in the soil environment and carbon existence and protect microorganisms which modify the assortment of microorganisms and characterization of soil [4]. The plant growth takes place by easily decomposable substrates present in the volatile matter, whereas biochar obtained from least pyrolysis is classified [5][6]. The biochar prepared at elevated temperatures is specified by elevated surface area, which increases the capacity of adsorption. The biochar employment and its uses on soil depend on the original feed stock, because the characteristics of the feed stock greatly affect its properties. For example, manure-based biochar when compared to wood biochar has high soil cation exchange capacity whereas the action of woodchip biochar towards soil gives more conductivity values compared to manure-based biochar prepared from animal dung.

Revised Manuscript Received on January 10, 2020.

***** Correspondence Author

P. Vijetha*, Department of chemical engineering, VFSTR (deemed to be university), Andhra Prasdesh, 522213, India.

E-mail; vijetha.ponnam@gmail.com

T. Subbaiah, Department of chemical engineering, VFSTR (deemed to be university), Andhra Prasdesh, 522213, India.

K. Bhuvaneswari, Department of chemical engineering, VFSTR (deemed to be university), Andhra Prasdesh, 522213, India.

M. Ramesh Naidu, Department of chemical engineering, VFSTR (deemed to be university), Andhra Prasdesh, 522213, India.

A. Ranganadha Reddy, Department of biotechnology, VFSTR (deemed to be university), Andhra Prasdesh, 522213, rraluru_bt@vignanuniversity.org

K. Naresh Katari, Department of Chemistry, GEETHAM (deemed to be university), Hyderabad,Telangana, India. nareshkumar.katari@gitam.edu

To make the best use of physical and chemical properties of black carbon to apply in agriculture by examining dissimilar pyrolysis temperatures and agro based scrap recycled as starting material is the objective of this study. The thermo chemical characteristics of the adsorbent produced at non-identical temperatures (400–800 C) were analysed to achieve the aim of this study. Orange Peel (OP) and Lemon Peel (LP) were used as the starting materials. In literature many people worked on TG/DTG analysis but few reported on complete kinetic parameters.

II. MATERIALS AND PREPARATION METHODS

2.1 Preparation methods of biochar

The raw materials employed in biochar production are two fruit peels, orange and lemon peels. The peels are cleaned and dried and then reduced in size. The materials were weighed and inserted into ceramic vessels and kept in a muffle furnace. The prepared material was undergone heating under controlled oxygen conditions for about 3 to 4 hrs (from 300 to 500 C) with heating at a constant rate of 10° C min $^{-1}$.

2.2 Compositional analysis

The products obtained from pyrolysis method were powdered and reduced to 0.5mm diameter. The yield of the biochar was calculated based on the weights of the initial biomass and the char product. Ash content and volatile matter were determined .Volatile matter and ash content were estimated at 950 °C and 750°C respectively by using the standard methods.

2.2.1 Ultimate and proximate Analysis

Ultimate analyses of samples were carried out using CHNS Elemental analyzer and the composition of C, H, N, S elements was resolved. The fuels produced from the biomass are analysed by finding their content of moisture, volatile matter and the free carbon, the ash in the sample using muffle furnace and the high heating value (HHV) using differential scanning calorimeter.

2.3 FTIR Spectroscopy

Using the pellet technique, functional groups were analysed by adding 1mg of char with 300mg and crumbled dispersive KBr .The high speed bandwidth assignment was used ,and the peaks at 3400 to 3410 cm^{-1} represents stretching vibrations, and the peaks at 2000 to 3000` cm^{-1} resembles C–H, peaks at 1620 to 1650 cm^{-1} depicts vibrations, peaks at 1580-1590 cm^{-1} shows the existence of COO asymmetric stretching,peak at 1460 cm^{-1} resembles the existence of C–H deformation of CH_3 group,peaks observed in the range of 1280 to 1270 cm^{-1} shows the phenolic compounds stretching of O-H and bending of Si-O stretching.

2.4 Thermal Analysis

Thermal analysis is carried by using TG analyzer for all the biochar samples at different temperatures. Pyrolysis process gives the products which act as energy carriers with high heating vailue and low water content by converting the biomass using thermal heating process. The Wt. loss studies of various biomass feedstocks can be studied by using Weight loss data due to decomposition of lignin, cellulose and hemi cellulosic contents with temperature can be obtained . TG and DTG give the data of various feedstocks and their decomposition and degradation temperatures. Major advantages of TGA include authenticity, fewer data, non interrupting data and exceptional command over the heating rate.

III. RESULTS AND DISCUSSION

3.1 Biochar Physical and Chemical Properties

The biochars obtained from different agricultural wastes have different characteristics which are tabulated above. High yield of product and enhanced % of volatile matter are seen in biochar produced from low temperature pyrolysis compared to high temperature pyrolysis. As the pyrolysis temperature increases there is a gradual decrease of biochar yields and volatile contents. Besides, the biochar yield and volatile matter are also affected by the type of agricultural waste used.

Table 1: Properties of biochar derived from different agriculture wastes; Orange Peel (OP), Lemon Peel (LP).

Samples	Temperature (°C)	Biochar yield (%)	Volatile content (%)	pH	BET surface area
OP	300	26.1	30.13 ± 0.05	5.1 ± 0.02	12.03
	400	14.3	16.13 ± 0.12	6.2 ± 0.12	56.23
	500	13.9	11.1 ± 0.1	10.2 ± 0.01	98.16
LP	300	32.3	31.21 ± 0.12	6.4 ± 0.021	9.23
	400	28.3	22.12 ± 0.05	7.6 ± 0.01	44.56
	500	24.6	19.16 ± 0.07	9.2 ± 0.02	89.28

With increase in temperature the pH value of biochar also increases, due to the presence of unconvertible biomass in to biochar present. The properties of soil such as soil water retention ability and adsorption capacity an be enhanced greatly by some critical physical properties represented by surface area and porosity.

3.2 Elemental Composition of Biochar

The characteristics of biochar depend on elements present in it and the ration of H/C and O/C. With temperature carbon content increases. As a result of thermal induction, dehydrogenation of CH_3 takes place, which resembles a modification in biochar recalcitrance. Biomass feedstock generally composed of unstable and oxygen traces; the first part is ended after heating, whereas the remaining is conserved in the biochar of the end. The ratios H/C and O/C reduced for the reason of high temperature of charring process, as a result of due to degradation reactions. TGA is the most effective analysis to investigate about various biochars . Thermal-degradation profile is shown similar for the two biochar samples, with increase in temperature of pyrolysis the weight loss increases proportionally. The O/C ratios of OP and LP in the range of 300-500°C are OP<LP. Since the volatile matter is almost lost at elevated tmperatures ,the O/C and H/C ratios steadily diminish. In the same way at higher temperature the O/C ratio is lower which specifies a proper alignment of aromatic rings, that leads to the formation of crytalline graphite structures.

The complete elemental compostion of biochar prepared from orange peel and lemon peel at 300,400 and 500 °C was shown in table 2.

Table-2: Elemental Composition of biochar

Samples	Temperature	C (%)	H (%)	N (%)	O (%)	O/C	H/C
OP	300	69.23 ± 0.05	5.3 ± 0.01	0.74 ± 0.01	20.62 ± 0.01	0.21	0.70
	400	78.21 ± 0.12	2.13 ± 0.09	0.35 ± 0.02	12.13 ± 0.05	0.10	0.39
	500	80.64 ± 0.16	1.9 ± 0.05	0.21 ± 0.03	11.26 ± 0.12	0.11	0.28
LP	300	71.13 ± 0.05	4.3 ± 0.02	0.68 ± 0.05	21.23 ± 0.15	0.22	0.62
	400	73.16 ± 0.12	2.51 ± 0.16	0.5 ± 0.03	17.56 ± 0.05	0.16	0.38
	500	80.16 ± 0.01	1.16 ± 0.06	0.4 ± 0.03	15.23 ± 0.01	0.14	0.27

3.3 FTIR Spectroscopy:

To analyse the chemical composition of a sample FTIR Spectroscopy is the best method. The band of FTIR C-H stretching(2950–2850 cm^{-1}) represents the aliphatic carbon loss with increase in temperature; at the same time the aromatic C-H stretching is visible more clearly which shows the aromatic carbon increases with temperature. As the charring temperature increases the aliphatic carbon decreases and the aromatic carbon increases, thus shown by the infrared spectroscopy, the modification of functional group takes place with charring temperature. Various elements existing in orange peel biochar produced at individual temperatures are shown in the figure 1.various elements present in the lemon peel biochar at individual temperatures are shown in figure 2.

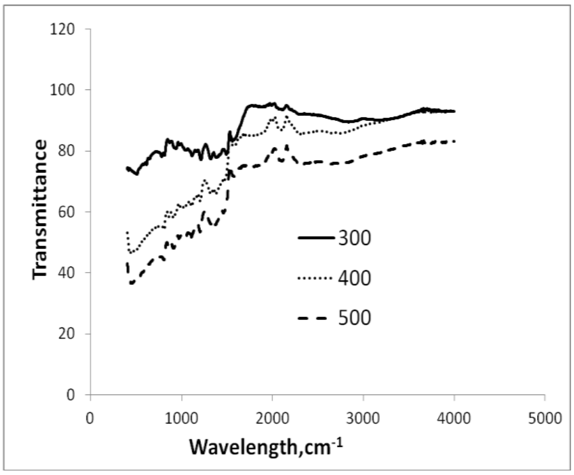

Figure 1 FTIR spectra of orange peel biochar at different temperatures of 300,400 and 500°C

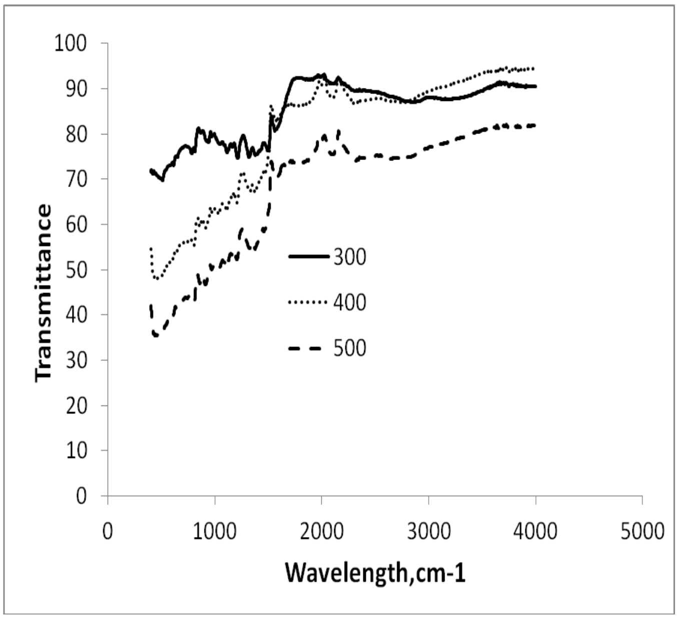

Figure 2 FTIR spectra of Lemon peel biochar at different temperatures of 300,400 and 500°C

3.4 TG/DTG analysis:

TG/DTG analysis was carried out for both OP and LP and were shown in the figure .From thermo gravimetric analysis ,weight loss of 37.1% during Initial stages occurs for OP in the temperature range of 212 to 324 °C and in the second phase the weight loss of 55.20% occurs in the range of 435 to 590 °C.

For LP, weight loss of 39.2% during Initial stages occurs for LP in the temperature range of 220 to 320 °C and in the second phase the weight loss of 58.35% happens from 437 to 589 °C. The weight loss percentage and differential thermogravimetry data w.r.t temperature for the orange peel is given in the Figure 3. The weight loss percentage and differential thermogravimetry data w.r.t temperature for the lemon peel is given in the Figure 3.

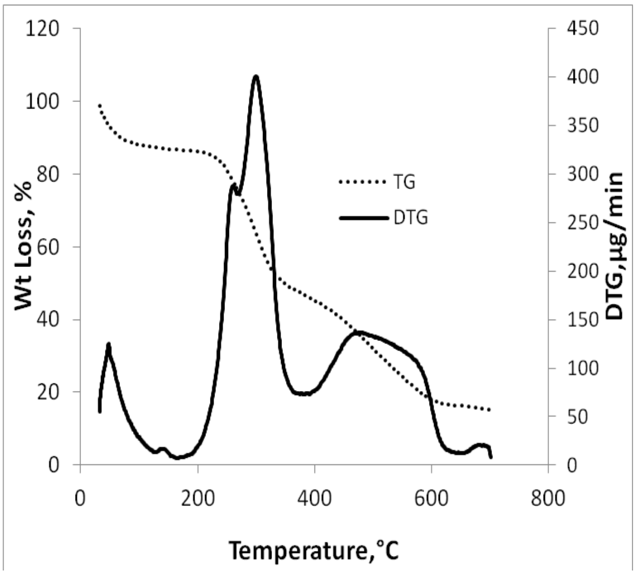

Figure 3 TG and DTG vs temperature graph of orange peel

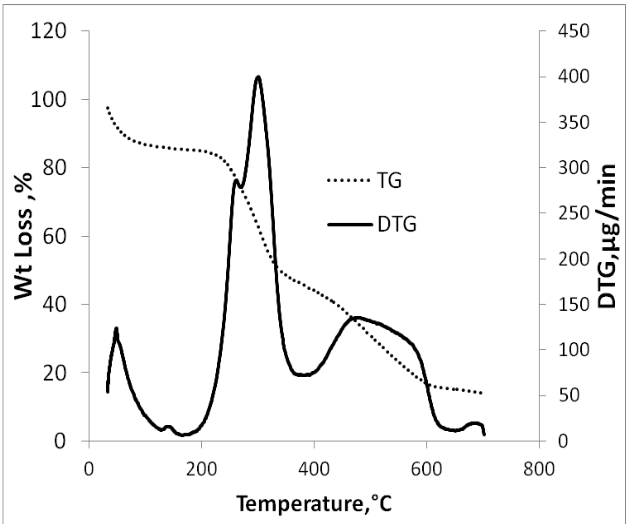

Figure 4 TG and DTG vs temperature graph of lemon peel

IV. CONCLUSION

The properties were influenced by both the pyrolysis temperature and the original feed stock, which has been evident from the data presented. With increase in pyrolysis temperature there is an improvement in adsorption properties like porosity, recalcitrant pH and surface area is observed; and at the same time deterioration of biochar formed and volatile matter is seen. The functional group decomposition takes place as temperature rises through heat degradation.

REFERENCES

1. P. R. Kumar,V. Madhusudhanrao, B. N. Rao,M. Venkateswarlu, and N. Satyanarayana "Enhanced electrochemical performance of carbon-coated $LiMPO_4$ (M = Co and Ni) nanoparticles as cathodes for high-voltage lithium-ion battery", *Journal of Solid State Electrochemistry*,vol.2016, 20, pp. 1855–1863
2. Narsimulu, B.N. Rao, M. Venkateswarlu, E.S Srinadhu, N. Satyanarayana. "Electrical and electrochemical studies of nanocrystalline mesoporous $MgFe_2O_4$ as anode material for lithium battery applications", *Ceramics International*, 2016, vol. 42(15), pp 16789- 16797
3. K. Hari Prasad, N. Naresh, Nageswara Rao, M. Venkateswarlu, N. Satyanarayana. "Preparation of $LiMn_2O_4$ Nanorods and Nanoparticles for Lithium-ion Battery Applications",2016 *Materials Today: Proceedings*, vol. 3(10),pp 4040-4045
4. M.S. Sudhir, P.M Mohan, R.V. Nadh. "Simple and validated ultraviolet spectrophotometric method for the estimation of Febuxostat in bulk and pharmaceutical dosage forms", *Oriental Journal of Chemistry*,2013, vol. 29(1), pp 235-240
5. G. Suresh G., R. Venkata Nadh, N. Srinivasu N, K. Kaushal. "Novel coumarin isoxazoline derivatives: Synthesis and study of antibacterial activities", *Synthetic Communications*,,2016,46(24), pp 1972-1980.

AUTHORS PROFILE

P. Vijetha Mtech , Jntu Hyd,22 no of publications in repute journals, IICHE life membership, Star performer award.

Tondepu Subbaiah Ph.D from Andhra University, Retired Chief Scientist, CSIR-IMMT, with a 40years of R&D experience. Currently working as a research advisor in chemical department at VFSTR, 125 paper publications, 10 patents.

K. Bhuvaneswar,Student,VFSTR (deemed to be university)

R. Mandapati Ph.D from Indian Institute Of Technology-Bombay, Associate Professor, HOD Chemical at VFSTR with 10 SCI Publications.

Dr. A. RanganathReddy, PhD in Microbial Biotechnology from VFSTR University, Life Member in "Society for Biotechnologists (India)" with membership number L575.

Dr. Naresh Katari phD,Jntu Hyd,25 Publications