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Research Paper

Comparative Analysis of Biochar with Co-composting of Organic Manure

Kirthana, R.[1], S. Ivo Romauld[1], Akila, S.[2*], Varsha, K.[1], Bhuvaneswari, S.[1], Sinduja, M.[2] and Kalpana, P.[2]

[1]Department of Bioengineering, School of Engineering, Vels Institute of Science Technology and Advanced Studies (VISTAS) Pallavaram, Tamil Nadu, India
[2]National Agro Foundation, Taramani, Chennai, Tamil Nadu, India

*Corresponding author: akila.s.agri@gmail.com (**ORCID ID:** 0009-0007-3577-4339)

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ABSTRACT

The composting is one of the pre-eminent recycling technologies of biodegradable waste that produces an augmented nutrient source of manure. Further, a carbon-rich product, the biochar, amended in composting with agricultural wastes aids in nutrient enhancement of soil health and microbial taxa in soil. This process is potentially a cost effective, eco-friendly technique that degrades the organic wastes and transform to valuable manure which is used in soil application and thereby a soil nutrient enhancer. In this study, initially the potential Biochar Amended Compost (BAC) was evaluated from various compost treatments. The fungal species, *Pleurotus ostreatus* stimulated the lignin degradation of the organic wastes which is used in all the treatments throughout compost progression. Among them, the wood biochar compost (Compost bed A) treatment was characterised to be potentially best with nutrients during the initial and final stages of composting followed by Coconut shell biochar compost (Compost bed B) and rice husk biochar compost (Compost bed C). Moreover, the metagenomic study revealed the microbial taxa of the treatment with wood biochar compost with a higher diversity of species in the final compost which extracted the most promising strains of microbial communities that is responsible for the plant growth, plant growth promoting hormones, anti pathogenitic, heavy metal resistance, lignin degradation, degradation of aromatic compounds, biochemical functions (Photosynthesis, nitrogen fixation, symbiosis, denitrification etc.,) soil rhizosphere colonisers and other enzymes responsible for soil health and plant growth. Thus, BAC is an appropriately valuable and cost effective approach for soil reclamation and health. Besides, metagenomic study is a unique approach for the study of microbial strains which is the most effective system of studying microbial community.

HIGHLIGHTS

- The addition of biochar improves the microbial taxonomy and soil health by providing nutrients.
- The wood biochar compost (Compost bed A) treatment provided the most nutrients during the phases of composting.
- The most promising strains of microbial communities were recovered from the final compost by the metagenomic analysis.
- The microbial taxa of wood biochar compost with a greater diversity of species through metagenomic study.

Keywords: Wood biochar, Biochar Amended Compost, Metagenomic study and Microbial profiles

The solid waste disposal is major threat to soil in both developed and developing countries throughout the world. Biodegradable waste is commonly found in solid waste as green waste, food

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waste, paper waste, wood waste and biodegradable plastics. Among various method of sustainably recycled organic wastes, composting brings out the digestate disposal since it is an environmentally benign technology that converts the phytotoxic digestate into a safer product called compost which can be used as a soil amendment, nourishing for plants and also as a substrate and nutrient source for plant growth or as a conditioner to improve soil properties (Li *et al.* 2023), through which it is generally mediated by indigenous microbial communities under the aerobic conditions. Most of the previous research has given that composts sustain an immense diversity of microbes for the efficient degradation of lignocellulosic biomass (Adebayo, E. A & Martinez-Carrera, D, 2015). Moreover, Co-composting process of organic waste and biochar (COMBI), not only simultaneously disposes of different organic wastes but can also enhance compost quality by the comprehensive use of diversified waste properties (Paredes *et al.* 2002). In addition, the fermentation period can be shorter when two or more organic wastes are composted together rather than separately (Das *et al.* 2011).

Among the several types of additives of composting, Biochar-Amended Composting (BAC) plays an integral role in sustainable agricultural practices due to its multiple benefits in crop production, soil nutrient retention, soil microbial activity, carbon sequestration and environmental protection. Biochar, a stable form of carbon, is produced from pyrolysis of biological materials. It is attracting growing interest because of its potential to improve soil nutrients status, increase crop yield and sequester carbon (C) in the soil. Biochar (BC) has been demonstrated to be a superior amendment and is characterized by a large surface area, high sorption capacity, cationic exchange capacity, and higher pore volume which significantly enhances the composting performance by improving aeration and microbial proliferation was expressed in previous studies (Akdeniz, 2019). It also serves as a source of reduced carbon compounds (organic molecules adsorbed to the particle's matrix) for any biochar colonizing soil bacteria. However, the biochar properties are highly dependent on the feedstock and the pyrolytic temperature used for the biochar production which eventually imposes varied impacts on the composting process (Xiao *et al.* 2017). Thus, also showed in researches that biochar is more likely to be useful in sandy soils with low physical properties as an amendment to soil. Hence, many types of biochar (coconut) Being two carbon-based entities with plentiful nutrients and surface activity, biochar and compost find application in agricultural fields together or separately for improving the soil properties and crop productivity. It have been used for many years as natural soil amendments to improve the yield of crops (Jiang *et al.* 2021) also stimulate the activity of microorganisms and soil enzymes responsible for the immobilization of nutrients (Bedada *et al.* 2014).

The supplementary benefit to the co-composting can be affected more rapidly with the help of lignin degradation fungi, *P. ostreatus* which is a genus of gilled mushrooms that includes *P. ostreatus*, one of the most commonly consumed mushrooms, also known as oyster, abalone, or tree mushrooms (Mahari *et al.* 2020). It helps in degradation of lignin in compost and hence it enhances the compost formation. *P. ostreatus* are efficient colonisers and degraders of lignocelluloses (Malik *et al.* 2021) and the fungus accomplishes enzymatic degradation of the lignocellulosic portion of substrates by using enzymes such as endoglucanase, β-glucosidase, xylase, laminarinase, laccase and polyphenol oxidase that are involved in the degradation of lignocellulose (Grimm *et al.* 2019). They have the ability to immobilize pollutants, slow down/regulate the release of nutrients, and improve soil properties (Rombel *et al.* 2020). Henceforth, Co-composting of agricultural waste and biochar along with the fungi can be considered to investigate the potentials of organic matter rich-biochar to improve soil fertility and plant biomass production. Thus, the combination of BC and compost seems to be a stimulating solution for soil health. To recycle organic waste sustainably, composting is generally mediated by indigenous microbial communities under the aerobic conditions and in the solid state.

Metagenomic methods have accessed to distinguish further on microorganisms. Aggregate considerations have been presumed to the integration of the microbial genetic taxonomic and functional diversity as dynamic features that affect soil nutrient cycling in different ecosystems (Guo *et al.* 2016). The microbial community structures and functions form a dynamic principal that determines the decomposition, mineralization of plant residues that affect cycling and storage of carbon and nitrogen (Zhong *et al.* 2018). Metagenomics has risen as resilient mobilisation to study microbial communities regardless of the ability of member organisms to be cultured in the laboratory using conventional isolation and also has offered the opportunity to describe the microbial diversity in environment. Metagenomic represents a strategic concept that includes investigations at three major interconnected levels, sample processing, DNA sequencing and functional analysis, with an ultimate goal of getting a global view of the functioning of the microbial world, DNA sequencing and functional analysis, with an ultimate objective of getting a comprehensive observation of the functioning of the microbial world in a particular place (Eldridge *et al.* 2018).

In contrast to the well-documented positive effects of biochar on soil, there is scarce information about the impact of biochar on the quality of composts. Composting is an organic waste treatment technology having the capacity to transform organic wastes into well-stabilised products that can be beneficial to agriculture (Tayyab *et al.* 2018) have recently shown reduced losses of nitrogen and other nutrients from compost mixtures upon addition of biochar and attributed this effect to enhanced cation exchange capacity and an increased surface and nano-porosity of the compost matrix. Besides effects on nutrient cycling, biochar can also affect OM humification, proliferation of composting microorganisms and structure of microbial community in composts which can subsequently affect soil fertility (Dias *et al.* 2010). Thus, The aim of the present work was to investigate the effects of biochar on the quality of various composts with wood biochar, wheat husk and coconut shell and to investigate the comparative potentials of organic rich co-composting of Biochar Amended Compost (BAC) with various agricultural wastes which benefits the soil for its fertility, nutrients and health and to study the strains of enriched microbial community in the potential BAC among various agricultural waste through metagenomic analysis (Fig. 1.).

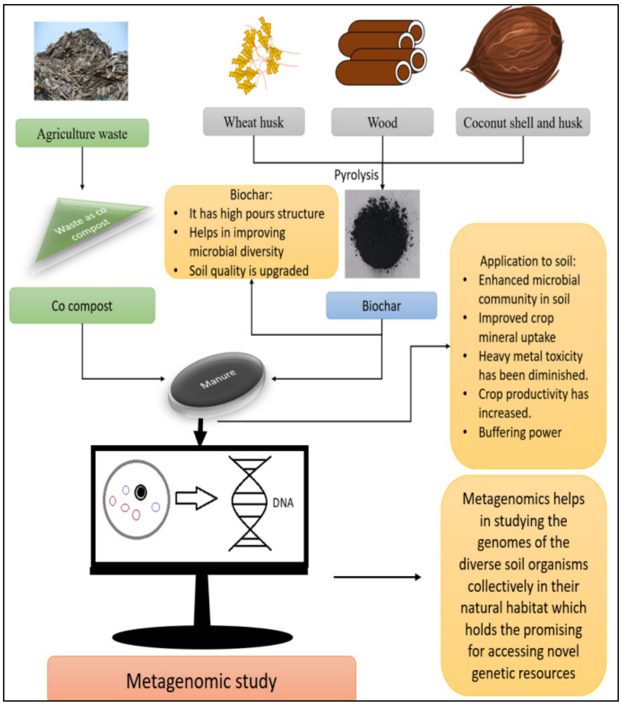

Fig. 1: Graphical abstract of the study

MATERIALS AND METHODS

Soil sample collection & analysis

The experimental soil sample was taken from a farm in Iledu, Pondicherry, India (12°.04′63.05″N, 79°.84′84.95″E) and the collected samples were processed stored for further analysis. Soil samples were collected and dried for 2-3 days, ground, sieved (2 mm sieve), packed in polyethylene cover, and used for further analysis. pH was measured with a pH meter (Jackson 1973), EC with a conductivity meter (Jackson 1973), organic carbon with a wet digestion method (Walkley and Black, 1934), Diacid extract (5:2 - $H2SO_4$: $HClO_4$) - semi automatic kjeldahl distillation method and (Piper, 1966) Triacid extract (9:2:1- HNO_3: $H2SO_4$: $HClO_4$) Vanadomolybdate yellow colour method were used for NPK analysis (Jackson, 1973). The estimation of Available Sulphur and Exchangable Calcium and Magnesium was performed using the following methods: 0.15 per cent $CaCl_2$-Turbidimetry method Williams and Steinbergs (1959), Neutral normal ammonium extract- Versenate titration method.

Collection of materials and process of biochar

Biochar samples were prepared from the pyrolysis of various biological materials viz., wood biochar, coconut shell biochar, and rice husk biochar, in a slow pyrolysis unit at the Department of Bioenergy, TNAU Coimbatore.

Process and characterization of biochar

The reactor where pyrolysis happens has two chambers: the combustion chamber and the pyrolysis chamber. The pyrolysis chamber was filled with 20 kg of wood, wheat husk, coconut shell, and other biomass. The biological waste raw material was placed in the gasifier space (space between combustion chamber and outer chamber). The process began when charcoal was burned in the combustion chamber. A rag soaked with kerosene was used as a fire starter. The unit was set to 450°C. The lid was placed on the stove, when the fire was started burning. After 10 - 15 min the fuel material was burnt hotter, which showed the flame in yellow colour whereas; the waste biomass in the outer chamber began to burn after 30 min. At that time it released gases and the flame was turned blue with little smoke. The reactor is turned off right away because the process needs an area without air. After that, the biochar was left to cool to room temperature. With a conversion efficiency of 21.5 per cent, 4.3 kg of crushed and sieved biochar were made (Desirablesize).

Preparation of compost bed

The compost bed was prepared at National Agro Foundation, Taramani campus, Chennai, Tamil Nadu, India with a latitude and longitude of 12°.04′63.05″N, 79°.84′84.95″E (Fig. 2).

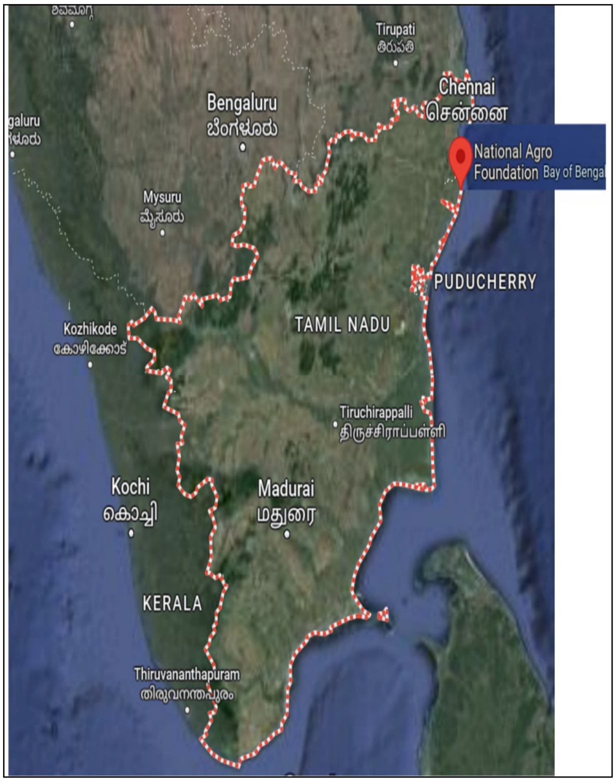

Fig. 2: Study area

The compost was prepared in three beds (A, B, and C) The first layer was a slurry of cow dung, followed by a 6″ layer of organic waste made up of plant remnants, dried plant stalks, leaves, etc. Cow dung was layered as the third layer and then the next layer was the lignolytic fungi *Pleurotus ostreatus* and finally soil. The experiment was carried with three different composting beds, viz., Compost bed A - wood biochar + biomass+ *Pleurotus ostreatus* + soil. Compost bed B - biochar + coconut shells +

T_1 - Compost bed A *T_2 - Compost bed B* *T_3 - Compost bed C*

Fig. 3: Preparation of Compost bed

biomass + *Pleurotus ostreatus* + soil and Compost bed C - rice husk biochar, + biomass+ *Pleurotus ostreatus* + soil (Fig. 3.)

Compost analysis

The compost beds were left aerobically for the decomposition of the organic materials to undergo various stages viz., initial mesophilic phase, then thermophilic phase and finally maturation phase for about 60 days. Once the compost bed reaches the harvesting stage, the harvest of the matured compost was done at the day of sixty in all the 3 beds. Then the compost samples from both the initial (21. 08.2022) and final stages (21.10.2022) of the beds were collected and assessed for physiochemical parameters for potentiality comparison and metagenomic analysis for further microbial community study of the potential compost.

Metagenomic analysis

The Metagenomics analysis on microbial taxanomy was anaysed at Yaazh Xenomics, Coimbatore.

RESULTS AND DISCUSSION

Characteristics of the experimental soil

The pH of the experimental soil was 7.26 with an EC of 0.421 dS m^{-1} and other parameters are given in Table 1.

Table 1: Characteristics of the experimental soil

Parameter	Unit	Value
pH	—	7.26
Electrical conductivity	dSm^{-1}	0.421
Organic matter	%	0.82
Nitrate Nitrogen	mg kg^{-1}	60.8
Available Phosphorus	mg kg^{-1}	21.28
Exchangeable potassium	mg kg^{-1}	412
Exchangeable calcium	mg kg^{-1}	2482
Exchangeable Magnesium	mg kg^{-1}	780
Available Sulfur	mg kg^{-1}	39.8
Available Manganese	mg kg^{-1}	BDL
Available Copper	mg kg^{-1}	BDL
Available Boron	mg kg^{-1}	BDL
Total Chromium	mg kg^{-1}	BDL

BDL below detectable limit (below 0.1 ppm).

Physio-chemical characterisation of biochar

The physio-chemical characterisation of biochar is given in (Table 2) has been analysed and the main changes in the characteristic of biochar along with the compost produces stability in soil due to the chemical recalcitrance of its structure.

Effect of pH and EC in biochar compost

The pH and conductivity are two properties of biochar that strongly influence soil fertility. The use of biochar during the thermophilic phase, reflecting the positive effect of biochar on the physio-chemical characteristics of compost, as previously observed in soils (Glaser, 2007). The pH increased from 6.04 to 7.0 from initial stage to 6.90 to 7.01 at the final stage of experimented composts. The pH was found to be almost neutral in all the treatments T_1, T_2 and T_3 at the final stage of compost samples (Table 2) which correlated with the findings of A. A. Ansari and S. Jaikishun, 2011 as the pH for all fluctuated between 5 and 8 until it was almost neutral on the day 60, when the compost was harvested (A. A. Ansari and S. Jaikishun, 2011). There is a direct variation of compost pH and pyrolysis temperature as the increase in pH from initial to final stage (Table 2), there is an increase in pyrolysis temperature (Rafq *et al.* 2016) and so the compost becomes neutral to alkaline in turn this helps in the reclaim acidic soil when applied as determined by Jien and Wang, 2013. The pH for end compost was recorded as 7.6 (Table 2). Other researches revealed that the range of pH between 7 and 8 supports the microbial activity for the decomposition of organic matter during composting process (Chandna *et al.*, 2013). Increase in the pH during the final stage of compost process indicates the activity of proteolytic bacteria were in accordance with the work of Jien and Wang, 2013 where the biochar of pH 9.94 produced from wood at 700 °C increases the pH in Paleudults soil from 3.95 to 4.65.

The electrical conductivity of all the treatments T_1, T_2 and T_3 decreased steadily at the final stage of composting. Generally, there was a significant decrease in EC of the initial materials as the composting process proceeded, and the lower EC T_1 (0.123 dSm^{-1}) is ideal for plant growth (Table 2). With a low EC, the organic manures proclaim the mineral salts deliberately, which is appropriate for plant

Table 2: Changes in stages of physio-chemical in biochar compost

Parameters	Initial stage of manure			Final stage of manure		
	T_1	T_2	T_3	T_1	T_2	T_3
pH	6.07	7	6.04	7.0	7.1	6.9
EC	0.157	0.169	0.143	0.123	0.149	0.133
Total Nitrogen (mg/Kg)	4120	3820	2671	4862	3865	3215
Total Phosphorus (mg/Kg)	702	557	678	845	634	948
Total Potassium (mg/Kg)	341	293	318	364	314	326
Sulphur (mg/Kg)	38.01	40.45	39.12	39.12	40.45	41.67
Moisture (%)	59.39	52.17	51.16	46.39	48.17	51.16
Organic carbon (%)	15.57	17.09	12.33	17.57	14.09	16.33
Magnesium (mg/Kg)	621	643	678	890	887	907
Potassium (mg/Kg)	389	390	365	450	456	435
Calcium(mg/Kg)	2210	2209	2213	3456	3231	2344
Zinc(mg/Kg)	1.21	1.83	1.34	2.32	2.54	2.45

growth (A.A. Ansari and S. Jaikishun, 2011) and also elevation in soil pH by alkaline metal oxides (i.e. Ca^{2+}) in wood biochar has a role in controlling the relative abundance of bacteria and fungi, where it is documented that neutral soils favour the growth of bacteria rather than fungi (Rousk *et al.* 2009).

Effect of organic matter in biochar compost

Organic matter (OM) is a dynamic factor of composting. The addition of charred material to soil modifies the chemical composition of the soil OM by adsorption of dissolved organic carbon (Pietikainen *et al.* 2000) and an increase in the number of aromatic and carboxylic groups of soil humic substances extracts (Novak *et al.* 2019). In the present study, the OM ranged from 16.327 per cent to 17.574 per cent and the highest OM is observed with the T_1 wood biochar compost, followed by T_2 and T_3 at initial and at final stage of composting. The OM also increased from initial compost process compared to final compost process that over all increased from 12.33 per cent to 17.57 per cent (Table 2). The addition of charred material to soil modifies the chemical composition of the soil OM by adsorption of dissolved organic carbon (Pietikainen *et al.* 2000; Sinduja *et al.* 2023).

Usually, the OM decreases as the compost processes but in this study the present changes are due to the addition of biochar which reinforce the resistance of soil OM to microbial degradation and mineralisation, consequently favouring the build-up of soil OM with a mean residence time of several hundred to several thousand years (Lehmann *et al.* 2009; Sugumaran *et al.* 2018). Other beneficial effects of biochar application to agricultural soils are related to the improvement of water-holding and cation exchange capacity and to interactions with nutrient cycling through increases in soil pH and reductions in nutrient leaching (Glaser, 2007) and an increase in the number of aromatic and carboxylic groups of soil humic substances extracts (Novak *et al.* 2010).

Effect of macronutrients in biochar compost

There was a sharp increase of nitrogen in T_1 followed by T_2 and T_3 (Table 2). This high level of nitrogen during the process of composting is probably contributed by microbial community through release of ammonia along with reduction of organic waste to nitrogen component. The nitrogen fixation was at the final composting process. The phosphorus content generally increased significantly during the process of composting. There was a fluctuating pattern in per cent from low to high observed for phosphorus (S.A. Ismail, 2005).

The phosphorous content generally rises during the process of composting is probably due to mobilization and mineralization of phosphorus due to microbial activity. The treatment T_1 was found to have the higher P content 845 to 948 mg/L followed by T_3 and T_2 (Table 2). The unique characteristics of wood biochar possibly bring variations in soil microbial communities, which successively drive biotic controls on soil

P availability through microbial solubilization or mineralization that reflects in microbial P gene expression in metagenomic analysis and also wood biochar had a positive effect on surface soil P bioavailability which could help agricultural soil health and ecosystem service in organic agriculture (Si Gao and Thomas H Deluca *et al.* 2018).

Effect of Micronutrients in biochar

The higher amounts of potassium, calcium and magnesium ions were detected in T_1 then in T_3 and T_2 (Table 2) is related with the results of Godlewska and Hans Peter Schmidt, 2017, where the presence of those elements with biochar, and on the other hand it is related with the negatively charged surface of the biochar that attracted K^+, Ca^{2+} and Mg^{2+} cations through electrostatic interactions.

The mineral composition exhibited in the Table 2 of both composting matrices at different stages of the composting process. There was a general increase in the concentration of mineral elements with composting time as a consequence of the concentration effect caused by the degradation of the organic matter.

Metagenomics of microbial profiles of biochar compost

The metagenomics analysis of various its Class (Table 3) order (Table 4), Family (Table 5), Species (Table 6) and Genes (Table 7) has been analysed and studies for the microbial community. The density of microbial profile is documented in Fig. 4.

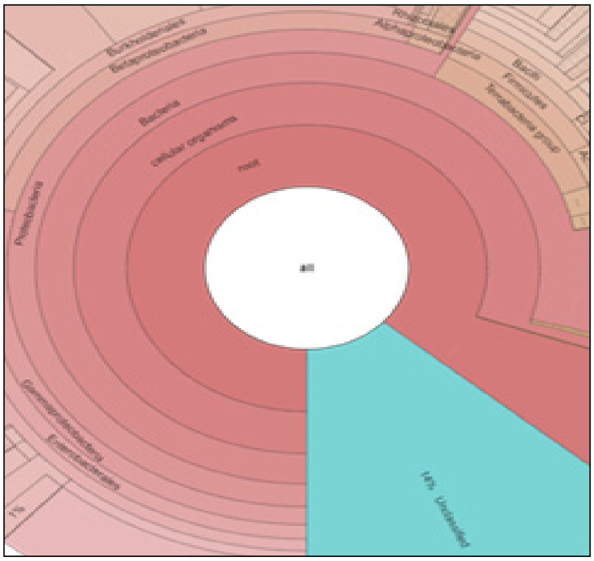

Fig. 4: Krono plot of microbial profile

Influence of microbial profile on nutritional value

Biochar made from these three materials may accommodate several microorganisms. Table 2 demonstrated that wood biochar is more capable of supporting microorganisms which helps in the overall soil health as the wood has a high nutritional value and is rich in lignin, hemicellulose, and cellulose when compared wheat husk and coconut husk. Overall, the results of this study showing that the most abundant phyla (those with an elevated number of reads) throughout the composting process were *Proteobacteria, Firmicutes, Bacteroidetes, Actinobacteria, Tenericutes, Cyanobacteria, Acidobacteria* under which the beneficial species of microbes where in the Table 3, where a similar microbial composition was found in cow manure compost, which was demonstrated while examining the bacterial community structure in wood biochar composting of agricultural waste. In a previous study, (Chandna *et al.* 2013) biochemical analysis of the bacterial diversity during the composting of agricultural by-products revealed distinct taxonomic profiles depending on the composting stage and a higher diversity of species in the finished compost.

Influence of microbial profile on plant growth promoters

The strain of Stenotrophomonas (Table 3) was found to be higher 4.64 per cent in T_1, but found in all other treatments. *Stenotrophomonas maltophilia* (2.58%) (T_1), (Table 6) with a produces plant growth hormone indole-3-acetic acid (IAA), stimulates the oxidation of elemental sulphur to produce sulphate responsible for plant growth and also the strains are *Stenotrophomonas maltophilia* a natural heavy metals resistant is correlated with the study of (Ryan *et al.* 2009).

The order Enterobacteriales (454.37%) (Table 4) Enterobacteriacia (44.61%) (Table 5) and *Enterobacter cloacae* (3.39%) (Table 7) was observed predominantly in T_1 (Table) have been described as plant growth promoters because they exhibit a variety of growth-enhancing properties were in line with the metagenomic findings of Khalifa *et al.* (2016). *Herbaspirillum seropedicae* was found to be of 0.4 per cent (Table 7), is indeed an endophytic bacterium that develops associations with a variety of plants, including rice, corn, and sugarcane, and can significantly enhance plant growth. *H.*

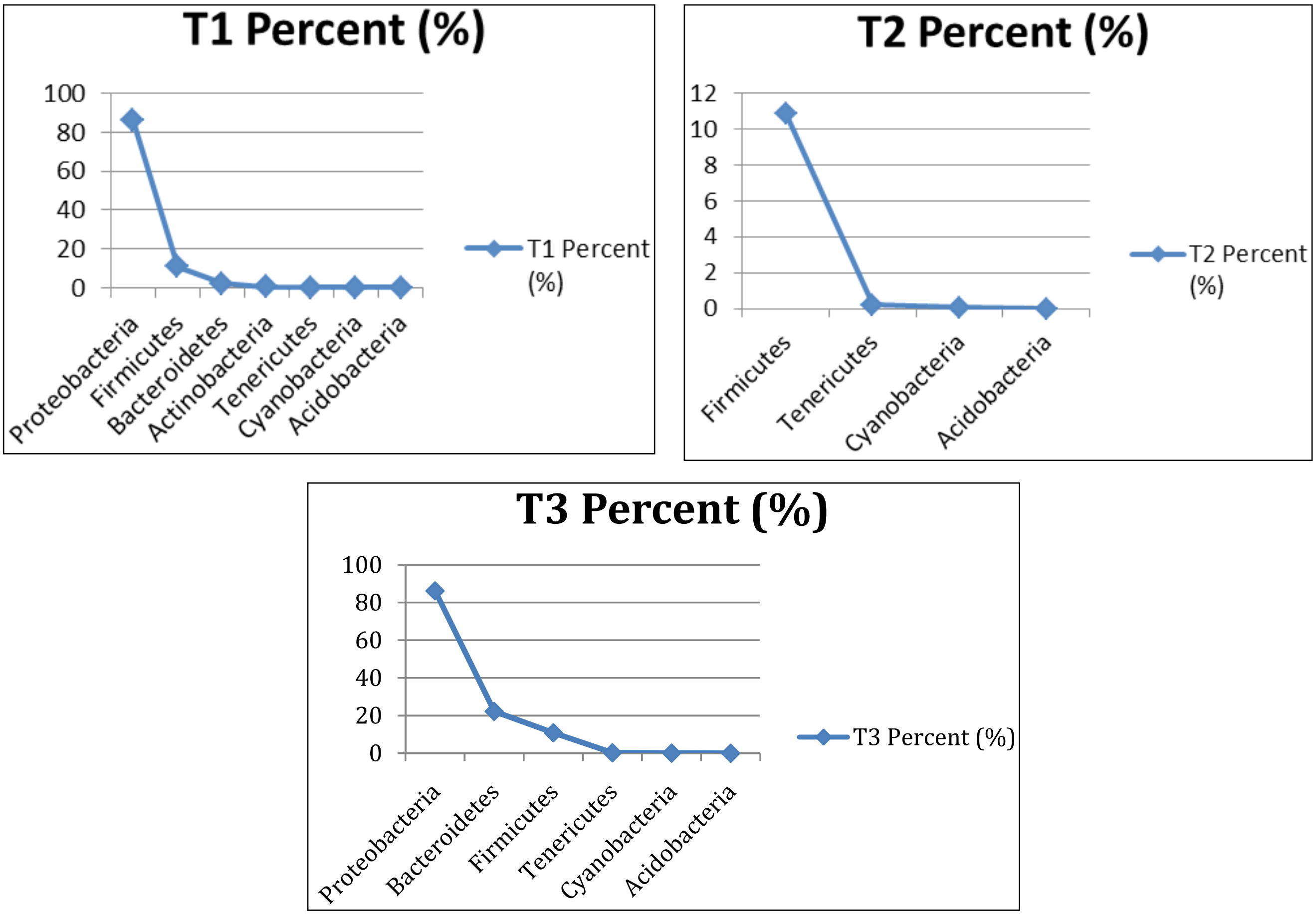

Fig. 5: Microbial phylum percentage

seropedicae tends to produce polyhydroxybutyrate (PHB), which is deposited as insoluble granule was in line with the research of Alves *et al.* (2013).

Influence of microbial proile on biochemical functions

Bradyrhizobium with the highest percentage of 0.55 is found in T_1 and T_3 (Table 3), *Bradyrhizobium pachyrhizi* with a per cent of 0.08 and 0.77 in T_1 and T_3 (Table 7) is highly enriched in soils perform a wide range of biochemical functions such as photosynthesis, nitrogen fixation during symbioses, denitrification, and aromatic compound degradation which is similar to (Jones *et al.* 2016). Acinetobacterin T_1 with a percent of 0.01 per cent (Table 3), *Acinetobacter variabilis, Acinetobacter equi, Acinetobacter marinus, Acinetobacter septicus* (0.08%) (Table 7) observed in T_1, coxidase-negative, have twitching motility, and appear in pairs under magnification. They are significant soil organisms that aid in the mineralization of substances like aromatic compounds, among others, is in accordance with the results of (Santoyo *et al.* 2021; Sinduja *et al.* 2023).

Influence of microbial profile on anti-pathogenic functions

Pseudomonadales with a per cent of 1.79 (Table 4), *Pseudomonas formosensis* (0.77%), *Pseudomonas alcaligenes* (0.77%) *Pseudomonas stutzeri* (0.67%) in T_1 and T_3 as one of the most diverse bacterial species of the genus on the planet, play an important role in soil. Their distribution in soil is critical for promoting plant growth and pathogenicity control as describes by Orozco *et al.* (2012).

Influence of microbial profile on lignin degradation

Marinobacterium stanieri, Acholeplas maparvum, Pelomonaspuraquae, Pelomonas saccharophila, Herbaspirillum seropedicae, Acinetobacter variabilis and *Acinetobacter equi* (Table 7) all play a minor

Table 3: Microbial class percentage

T$_1$		T$_2$		T$_3$	
Class	**Percent (%)**	**Class**	**Percent (%)**	**Class**	**Percent (%)**
Gamma proteobacteria	48.82	*Gamma proteobacteria*	48.82	*Beta proteobacteria*	35.73
Beta proteobacteria	35.73	*Bacilli*	39.62	*Bacilli*	8.62
Bacilli	8.62	*Beta proteobacteria*	35.73	*Bacteroidia*	1.98
Bacteroidia	1.98	—	—	*Clostridia*	1.95
Clostridia	1.95	—	—	*Gamma proteobacteria*	1.32

Table 4: Microbial order percentage

T$_1$		T$_2$		T$_3$	
Order	Percent (%)	Order	Percent (%)	Order	Percent (%)
Enterobacterales	44.37	*Enterobacterales*	54.37	*Enterobacterales*	57.67
Burkholderiales	36.08	*Burkholderiales*	46.08	*Burkholderiales*	36.08
Lactobacillales	7.51	*Lactobacillales*	8.51	*Lactobacillales*	7.51
Clostridiales	1.89	*Bacillales*	0.85	*Clostridiales*	1.89
Pseudomonadales	1.79	*Rhizobiales*	0.65	*Pseudomonadales*	1.79
Marinilabiliales	1.69	*Rhodobacterales*	0.58	*Marinilabiliales*	1.69
Oceanospirillales	1.14	*Bacteroidales*	0.30	*Oceanospirillales*	1.14
Xanthomonadales	0.90	*Alteromonadales*	0.28	*Xanthomonadales*	0.90
Bacillales	0.85			*Bacillales*	0.85
Rhizobiales	0.63			*Rhizobiales*	0.63
Rhodobacterales	0.58			*Rhodobacterales*	0.58
Bacteroidales	0.30				
Alteromonadales	0.28				

Table 5: Microbial family percentage

T$_1$		T$_2$		T$_3$	
Family	**Percent (%)**	**Family**	**Percent (%)**	**Family**	**Percent (%)**
Enterobacteriaceae	44.61	*Bacillaceae*	46.61	*Enterobacteriaceae*	40.61
Alcaligenaceae	22.30	*Oscillospiraceae*	20.30	*Alcaligenaceae*	28.30
Lactobacillaceae	9.24	*Rhodobacteraceae*	9.24	*Lactobacillaceae*	9.24
Comamonadaceae	7.24	*Clostridiaceae*	7.24	*Comamonadaceae*	7.24
Marinilabiliaceae	2.16	*Acholeplasmataceae*	2.16	*Marinilabiliaceae*	2.16
Burkholderiaceae	2.14	*Dysgonamonadaceae*	2.14	*Burkholderiaceae*	2.14
Pseudomonadaceae	1.56	*Oscillospiraceae*	0.59	*Pseudomonadaceae*	1.56
Oceanospirillaceae	1.43	*Rhodobacteraceae*	0.49	*Oceanospirillaceae*	1.43
Xanthomonadaceae	1.15	*Clostridiaceae*	0.33	*Xanthomonadaceae*	1.18
Moraxellaceae	0.73	*Acholeplasmataceae*	0.30	*Moraxellaceae*	0.73
Ruminococcaceae	0.62	*Dysgonamonadaceae*	0.28	*Ruminococcaceae*	0.62
Bacillaceae	0.59	*Shewanellaceae*	0.23	*Bacillaceae*	0.57
Oscillospiraceae	0.59	*Lachnospiraceae*	0.23	*Oscillospiraceae*	0.59
Rhodobacteraceae	0.49	*Erwiniaceae*	0.19	*Rhodobacteraceae*	0.49
Clostridiaceae	0.33	*Caulobacteraceae*	0.15	*Clostridiaceae*	0.33

Table 6: Genus percentage in compost

T_1		T_2		T_3	
Genus	**Percent (%)**	**Genus**	**Percent (%)**	**Genus**	**Percent (%)**
Lactobacillus	24.88	*Stenotrophomonas*	24.88	*Lactobacillus*	24.88
Pelomonas	18.08	*Escherichia*	18.08	*Pelomonas*	18.08
Achromobacter	13.97	*Acinetobacter*	13.97	*Achromobacter*	13.97
Pseudomonas	4.50	*Cupriavidus*	4.50	*Pseudomonas*	4.50
Marinobacterium	4.23	*Paracoccus*	4.23	*Marinobacterium*	4.23
Enterobacter	3.99	*Acholeplasma*	3.99	*Enterobacter*	3.99
Ralstonia	3.33	*Bordetella*	3.33	*Ralstonia*	3.33
Stenotrophomonas	2.46	*Burkholderia*	2.46	*Stenotrophomonas*	2.46
Escherichia	2.39	*Shewanella*	2.39	*Escherichia*	2.39
Acinetobacter	2.07	*Bacillus*	2.07	*Acinetobacter*	2.07
Cupriavidus	1.53	*Bradyrhizobium*	1.53	*Cupriavidus*	1.53
Paracoccus	1.10	*Clostridium*	1.10	*Paracoccus*	1.10
Acholeplasma	0.94	*Lactobacillus*	0.35	*Acholeplasma*	0.94

Table 7: Overall Species found in compost

T_1		T_2		T_3	
Species	**Percent (%)**	**Species**	**Percent (%)**	**Species**	**Percent (%)**
Pelomonas saccharophila	28.62	*Lactobacillus gallinarum*	17.62	*Pelomonassaccharophila*	19.62
Lactobacillus crispatus	9.49	*Lactobacillus gasseri*	8.44	*Lactobacillus crispatus*	9.44
Achromobacter animicus	5.28	*Enterobacter cloacae*	5.28	*Achromobacteranimicus*	6.28
Lactobacillus gallinarum	4.13	*Achromobacter xylosoxidans*	5.13	*Lactobacillus gallinarum*	5.13
Lactobacillus gasseri	4.51	*Marinobacterium maritimum*	4.51	*Lactobacillus gasseri*	4.51
Enterobacter cloacae	3.39	*Achromobacter insuavis*	3.39	*Enterobacter cloacae*	3.39
Achromobacter xylosoxidans	3.32	*Ralstoniasyzygii*	3.32	*Achromobacter xylosoxidans*	3.32
Marinobacterium maritimum	2.58	*Stenotrophomonas maltophilia*	2.58	*Marinobacterium maritimum*	2.58
Achromobacter insuavis	2.31	*Escherichia fergusonii*	1.77	*Achromobacter insuavis*	2.31

role in plant growth. Additionally, we discovered various taxonomic profiles in which some orders predominated over others responsible for plant growth and lignin degradation. The composting period has influenced these variations in wood biochar compost. This conclusion is in line with what Li *et al.* (2019) previously reported. Moreover, the current work is in accordance with the study Li *et al.* (2019), that claimed, as the compost metabolised with wood biochar, the abundance of some microflora increased. Firmicutes and Actinomycetes were the dominant phyla at the start of the process, whereas Proteobacteria, Bacteroidetes, Firmicutes, and Chloroflexi but not Actinomycetes were identified at maturity stage. The same author also demonstrated that some lignocellulose-degrading bacteria, including Streptomyces, Rhodococcus, and Mycobacterium in wood biochar compost were found to be more prevalent during the matured stage of composting with the study (Table 3). Overall, the wood biochar compost has plenty of microbial community with high nutritional value, lignin degradation capacity, more of biochemical functions and anti- pathogenic properties that help in the overall soil health and plant growth and the study can be further researched for the field trail.

CONCLUSION

The use of a small amount of biochar in the starting composting mixture had a positive effect on the chemical and biochemical characteristics of mature compost. The chemical and biochemical changes observed by the addition of biochar can be affected by the variability in the quality of the starting materials and the specific experimental conditions; hence a validation for a wide range of organic wastes and composting operations may be valuable. The agricultural utilisation of charred materials (charcoal, biochar, and activated carbon) to maintain soil fertility, has been suggested as an additional strategy for increasing soil organic matter (OM) and reducing greenhouse gas (GHG) emissions (Lehmann, 2007). The use of a small amount of biochar in the starting composting mixture had a positive effect on the physio-chemical and biochemical characteristics of mature compost. The physio-chemical and biochemical changes observed by the addition of biochar can be affected by the variability in the quality of the starting materials and the specific experimental conditions; hence a validation for a wide range of organic wastes and composting operations may be valuable. As a result, the biochemical analysis of the microbial diversity during the composting featured higher diversity of species in the final stage of composting of wood waste biochar (T_1) (Compost bed A). The liable factors for plant growth viz., Plant growth regulating hormones, heavy metal resistant strains, anti- pathogenic microbes, beneficial endophytic bacteria, different representatives performing a wide range of biochemical functions such as photosynthesis, nitrogen fixation during symbioses, denitrification, and aromatic compound degradation from the extracted obliging microbial strains was a prospective element of the research findings. Furthermore, this study emanate that the application of BAC benefits in retrieval of the poor- nutrient soils into an enriched soil and also proliferated soil microflora and an augmented rhizosphere soil that affords an upright soil fertility, soil organic carbon, improved progression in plant growth and in turn yield. More over the BAC can also be used as a substitute for the fertilizer applied soil to evade soil nutrient degradation through top soil deprivation. This biochar infused manure could be a breath-taking opportunity to reclaim the soil health. In future, the BAC can be investigated in crop field to evaluate the growth with comparison to fertilizer applied soils.

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