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The effect of post application of biochar on compost manure

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Abstract: Composting is a reliable technology to treat food wastes (FW) and produce high quality compost. In recent years, considerable studies have been devoted to investigating the effect of biochar application on organic solid waste composting. This study investigated the performance of mature compost when biochar is applied after composting processes and compost quality. Biochar characteristics and its application coupled with the basic concepts of composting are briefly introduced before detailing the effects of biochar addition on composting. According to recent studies, biochar has exhibited great potential for enhancing composting. It is evident that biochar addition in composting can: (1) improve compost mixture physicochemical properties, (2) enhance microbial activities and promote organic matter decomposition, (3) reduce ammonia (NH_3) and greenhouse gas (GHG) emissions, and (4) upgrade compost quality by increasing the total/available nutrient content, enhancing maturity, and decreasing phytotoxicity. Despite that, this research explored the mechanism of biochar addition on composting after composting to discover any effect. From the results, there was virtually no difference in the results and the already established ones.

Keywords: Biochar, Composting, Emission, Greenhouse, Microbial activities

1. INTRODUCTION

Industrialization Soil fertility issues are of particularly serious concern in Sub-Saharan Africa due to inherently low nutrient levels caused by the weathered nature of soil parent materials (Nisha, Barnali, Shabana, Meena and Shah, 2017). Africa has high yield variety of crops (Dimkpa *et al.,* 2019). The use of high-yielding crop varieties and their associated high Nitrogen (N) needs have led to significant stripping of the soil of micronutrients (Saalah, Rajin, Yaser, Azmi. and Mohammad, 2020; Shi *et al.,* 2016). According to Dimkpa *et al.* (2015) these reasons and the inadequate, non-amendment of agricultural soils with mineral fertilizers, African soils have been rendered less productive (Nisha *et al.,* 2017). Of the five African countries recently studied for crop responses to nutrients in multiple locations, only Malawi showed available P median level, averaging 33.6 mg/kg, that was above the critical level of 15 mg/kg needed for good maize productivity. The rest, including Nigeria, Tanzania, Kenya and Mali, had available phosphorus, P median values of between 3.6 mg/kg and 9.9 mg/kg (Kihara *et al*., 2016; Shuhaimi, Kanakarajuand Nori, 2019). Ironically it is in these same regions of the world with low soil fertility that farmers especially small holders have the most limited access to standard soil analysis infrastructure and accompanying appropriate fertilizers (Abdullah *et al.,* 2021; Abu-Samah *et al.,* 2020; Bocchini *et al.,* 2015; Chung *et al.,* 2021; Crohn, 2016). Given these scenarios, fertilizers should be effective for crop production (Dotaniya and Meena, 2015; Singh and Kalamdhad, 2016).

Fertilizers may be made up of one or more essential nutrients, It is required to be applied to the soil to replace the nutrients taken up by crop from the land with the primary goal of maximizing productivity and economic returns (Ding *et al.,* 2016). Nitrogen, phosphorus, and potassium (NPK) are the major nutrients required by plants. Fertilizers can be grouped into organic or inorganic fertilizer according to their source of production (Wang *et al.,* 2017). Organic fertilizer is a fertilizer that is produced from organic substances or materials which could be biofertilizers or composts, while inorganic fertilizer is made from synthetic or inorganic raw materials. The application of chemical fertilizers enhances crop growth and good yield thereby meeting the food security (Alshehrei and Ameen, 2021; Antonangelo, Sun and Zhang, 2021; Chen *et al.,* 2018a; Yang *et al.,* 2016). However, the improper use of chemical fertilizers has resulted in pollution of soil, water and air, thereby raising important questions regarding food quality and environmental safety (Agapios, Andreas, Marinos, Katerina and Antonis, 2020; Kolbe, Aira, Gómez-Brandón, Pérez-Losada and Domínguez, (2019). According to Rai, Ashiya, and Rathore (2014) chemical fertilizers have been said to be toxic to soil organisms such as earthworms. The deleterious \effect caused by the chemical fertilizers on the environment through chemical toxicity and leaching into the waterways thereby affecting aquatic life directly or indirectly has necessitated the need for safer alternatives. To overcome this, the use of organic materials may play a good role. Organic material in municipal waste is rich in nutrients: proteins, cellulose and lignin (Das, Huque, Amanullah, Dharmapuri and Makkar, 2018; Zheng *et al*., 2017). Some alternatives have been proposed such as the use of microorganisms, composting, among others.

2.0 COMPOSTING

Composting is a means of transforming different degradable wastes into products that can be used safely and beneficially as biofertilizers and soil amendments (Paul, Kauser, Jain, Khwairakpam, Kalamdhad, 2020; Pudełko, Postawa, Stachowiak, Malińska and Dróżdż, 2021; Rathore, Sarmah, 2020; Rehman et al.. 2020). Awasthi *et al.* (2017) asserted that composting is an effective technique to convert organic wastes into the final product called "mature compost" through various metabolisms (Agyarko-Mintah *et al.*, 2017; Janczak *et al.*, 2017; Sánchez-Monedero *et al.*, 2018). It transforms waste into stable humus-like substances in aerobic biodegradation (Awasthi, Wang, Chen and Wang, 2016; Gong *et al.*, 2019; Wang and Zeng, 2018). It is a safe method of waste management. Composting increases soil biodiversity and reduces environmental risks associated with synthetic fertilizer (Bahçelioğlu et al., 2020); increases agricultural productivity and organic matter content of the soil (Al-Harbi, Obadi, Al-Omran, Abdel-Razzak, 2020), owing to the sufficient nutrient in the composted materials and the presence of plant growth-promoting organisms (Antonangelo., Sun and Zhang, 2020). It can be interpreted as the sum of complex metabolic process performed by different microorganisms that, in the presence of oxygen, use nitrogen (N) and carbon (C) available to produce their own biomass (Azim *et al.*, 2018; Van, Lee, Klemeš, Bong and Ho, 2016).

According to Pandey, Cao, Biswas and Vaddella (2016) composting is an aerobic process where complex degradable materials are degraded and transformed by microorganisms into organic and inorganic by-products that can be used safely and beneficially as biofertilizers on soil (Al-Kutti *et al.,* 2018; He *et al.*, 2018; Jarboui, Dhouib and Ammar, 2021). Compost aids soil properties in agricultural fields (Godlewska, Schmidt, Ok. and Oleszczuk, 2017; Guo, Liu and Zhang, 2020) or as an alternative to peat as a potting substrate (Chen, Zhang and Yuan, 2020; Chung *et al.*, 2021; Czekala *et al.*, 2016; Xie, Qiu and Wang, 2017). The compost byproducts contain 'humic-like' compounds that differentiate them from those found in native soil, coals, and peats (Abu-Tayeh, Azaizeh and Gerchman, 2020).

Aside usage as fertilizer, compost is useful in bioremediation (Cao *et al.*, 2020; Cao, Mukhtar, Yu, Bui and Pan, 2022); plant disease control (Boostani, Hardie, Najafi-Ghiri and Khalili, 2021); weed control (Budroni et al., 2020**);** pollution prevention (Bui, Tsai, Tseng and Ali, 2020.); erosion control, landscaping and wetland restoration. Sometimes activators like worm or biochars are added into the compost. Its incorporation into soil increases the supply of valuable nutrients including nitrogen (N), phosphorus (P), and carbon (C) (Bhave and Kulkarni, 2019; Chifari, Piano, Matsumoto and Tasaki, 2017).

2.1 Effect of biochar in composting

Biochar, a type of charcoal produced in the slow pyrolysis of organic materials, is a porous carbonaceous material produced by heating various biomass feedstocks under high temperatures in an oxygen-limited environment (Aziz *et al.,* 2023; Fan *et al.,* 2023; He *et* *al.,* 2023; Layek *et al.,* 2022; Qayyum *et al.,* 2017; Rawat *et al*., 2019; Raza, Wu, Rene, Ali and Chen, 2022; Wang *et al*., 2023;). Biochar is applied to soil as a soil supplement to increase soil fertility and production (Khedulkar et al., 2023). Biochaar can be added to compost as a co-composting agent. Co-composting is the addition of materials together during composting. This is done majorly to bring about an optimum C:N, to hasten the composting process and also to improve the fertilizer quality **(**Arumugam, Renganathan, Babalola and Muthunarayanan, 2018; Limaye, Patil, Ranadive and Kamath, 2017**).** They are activators. When highly nutritious substrates are added to composts, microorganisms become more available, and the composting process is hastened (Sharma, Saha, Arora, Shah, Nain, 2017). According to Ding *et al.* (2016), the strategy behind addition of biochar is to improve the composting process by enhancing aeration (Liao, Li, Yao, 2019; Liao *et al.,* 2020; and sorption of available carbon compounds (Ding *et al.,* 2016; Liu, Yang, Gao, Li and Wam, 2017b; Zoghi, Hosseini, Kouchaksaraei, Kooch and Guidi, 2019). A proper amount of biochar improves the effective conversion of waste into beneficial products (Alshehrei and Ameen, 2021; Lee and Shin, 2021; Malińska, Zabochnicka-Świątek, Cáceres and Marfà, 2016). Sanchez-Monedero *et al*. (2018) indicated that as an additive, biochar enhanced the composting performance and humification process, resulting in enhanced quality and maturity of the compost mixture. Earlier on, Sánchez-García *et al*. (2015) showed that biochar enhances the degradation rate of organic matter during composting process (Sharma and Garg, 2018), increasing agronomical value of compost (Gong *et al.,* 2019; Jain, Jambhulkar and Kalamdhad, 2018b; Wang *et al.,* 2021).

Using biochar in composting mitigates the harmful effects of the final compost in agriculture and increases the pH of soil (Chen *et al.,* 2018b; Soobhany, Mohee and Garg, 2017), adsorbs harmful metals for a long time (Agegnehu, Srivastava and Bird, 2017; Ghazi and Karnwal, 2017; Lin *et al*., 2023; Waqas *et al*., 2017); nutrient use efficiency (NUE) and nutrient uptake at certain application rate (Jambhulkar, Shaikh and Kumar, 2018; Jatav *et al*., 2020; Liu *et al.*, 2017a; Zhang, Q. Xiao, Xue and Zhang, L. 2020); and by improving soil WHC especially in sandy soils, and drainage in clayey soils (Jia, Wang, Yuan, Ju and Yang 2016; Sengupta, Mukherjee and Halder, 2020; Shikha, Rahman, Sultana, Mottalib and Yasmin, 2023). Zheng *et al*. (2017), stated that Biochar alone or co-applied with fertilizer promotes halophyte growth in coastal soil, resulting in improved soil health (Hussain *et al*., 2016c; Rehman and Razzaq, 2017; Zhou *et al.,* 2019).

2.2 Plant growth promotion

When applied to soil, biochar has various positive effects on plants. First and foremost, it can enhance soil fertility increases the availability of nutrients in the soil, which will boost plant development and increase agricultural yields (Goyal *et al.,* 2023; Jasim *et al.,* 2022; Kaushal and Singh, 2022; Kumar, 2022; Ottani *et al.,* 2023). Additionally, the biochar's porous structure can enhance soil aeration and water penetration, supporting strong root development and enhancing plant water usage efficiency (Liu et al., 2022). Due to high phosphorus (P) reserves in the biochar there is improvement of phosphate content in compost with biochar (Singh, Kaur and Vig, 2014). The reduction of orthophosphate after biochar amendment was mainly attributed to mineralization and microbial utilization of organic P compounds (Vandecasteele, Sinicco, D'Hose, Vanden Nest and Mondini, 2016; Wang, Zhang, Zhao, Shi and Liu, 2022; Yang *et al.*, 2020). Another study reported an enhanced plant total N, P, K, Ca uptake, and biomass upon biochar application (Yan *et al.*, 2023). Some nutrients such as potassium (K^+), Ca^{2+}, and Mg^{2+} showed improved retention with biochar amendment which was due to their adsorption by negatively charged biochar surface (Yeboah, Oteng-Darko, Adomako and Malimanga, 2020; Yuan *et al*., 2017). Other elements such as Na^+ didn't show much change after biochar amendment which was considered favorable as Na^+ accumulation can cause deterioration of soil structure (Srivastava *et al.*, 2020; Zhang, Chen, Sun, Zhou and Zou, 2016).

2.3 Biochar and heavy metal uptake cum greengas effect

A number of recent researches have analyzed the significance of biochar for removing the heavy metals (Fan et al., 2023; He et al., 2023; Huang et al., 2023; Lin et al., 2023; Manikandan et al., 2023). Biochar has been shown to have a high adsorption capacity for a wide range of contaminants, including heavy metals, organic pollutants, and other toxins (Ahmad et al., 2021). This makes biochar an effective tool for remediation of contaminated soils, helping to reduce the risk of environmental pollution and improve the health of ecosystems (Ajala et al., 2023). Biochar contributes significantly to the world's greenhouse gas emissions because it decreases the quantity of carbon dioxide (CO_2) in the atmosphere and lessens the consequences of climate change. This is possible because it has the capacity to trap carbon in soil. Composting with biochar typically showed lower emission of NH^3 and a higher concentration of NO^{3-} compared to that without biochar (Gul and Whalen, 2016; Wu *et al.*, 2017). With biochar addition, the nitrification process where NH^3/NH^{4+} is converted to NO^{3-} by nitrifying bacteria was enhanced, while the ammonification process (the reverse route) was suppressed (Archanjo *et al*., 2017; Daliakopoulos *et al.*, 2016; López-Cano, Roig, Cayuela, Alburquerque and Sanchez-Monedero, 2016). Therefore, biochar amended compost usually shows higher total nitrogen (N) than it without biochar (He *et al.*, 2016; Xiao *et al.*, 2016).

3.0: MATERIALS AND METHOD

3.1: Materials

Humid Soil, Greenish fleshy Kitchen wastes, Brownish Waste from the compound, Used cartons and paper, Pig dung, Earthworms, Biodigester, and Water

3.2 Method

3.2.1Practical Composting

Vermi-Vessel composting was used. Biodigester was constructed. Humous sand was first fed into the biodigester as underlayer. Greenish (fleshy wastes from the kitchen) and Brownish putrescibles (dried leaves from trees, banana leaves and old paper wastes) were added alternatively into the biodigester in two layers of 100cm each. Thereafter, handful of pig dungs was sparingly and evenly sprayed on it and earthworms were added on top of the wastes. This was done to enable the earthworm to act on the waste. Other layers of the green and brown wastes in three alternative layers was followed. Clean water was sprinkled on top of the compost to keep it moist. The whole setup was turned by stirring every week to make it homogenous for every part of the compost feel the activities of the worm. The turning enhanced aeration . The wastes was composted to maturity in 42 days. At the end of the composting, the waste was brought out of the digester and thoroughly and homogenously mixed together in preparation for drying.

Plate 1 Biodigester

3.2.2 Drying

The compost was dried at room temperature of 37^{o}C to retain the nutruents. Again it was mixed together to make sure that homogeneity was achieved. Thereafter, it was spread out and allowed to cool.

3.2.3 Determination of the nutrients:

A desired quantity was taken to the Ahmadu Bello University (ABU) laboratory, Zaria for characterization and determination of the percentages of the major elements of Nitrogen, Phosphorus, Potassium, Carbon and other minor elements. A portion was taken to the unizik laboratory for the physico- chemical analyses.

3.3 Characterization of the dry manure

The characterization was done by the use of SEM and EDX techniques to confirm the rapid decomposition and mineralization by the earthworms. The physico-chemical parameters were also used to confirm the rapid decomposition and mineralization by the earthworms.

3.3.1 SEM analysis

SEM analysis provided essential information on surface morphology of the compost and control samples. The morphology of the composted samples was observed using a scanning electron microscope JEOL JSM 6360 operated at 20 keV. The samples were coated with gold prior the analysis. The final dried composted sample was fixed on a circular metallic sample holder by using double-sided adhesive tape and then the samples was coated with gold using sputter coater for clear visibility of picture, followed by micrographs of surface texture.

3.4 Physiochemical analysis of the dry manure

About 25 g of the sample was used to perform different physico-chemical analysis after composting. The samples were air dried and crushed to fine powder by a grinder and stored in airtight plastic packets. The powdered samples were subjected to physico-chemical parameters as follows:

3.4.1 Determination of Sulphur Content

Fusian: 1.0gm of finely powdered sample was mixed with 5.0g of $NaCO_3$ a –d $NaNo_3$, in a crucible. The mixture was preheated at 400^0c for 30 mins in an electric furnance, and the fused at 600^{0C}. After the fusion, the crucible was allowed to cool and was placed in a 150cm^3 beaker. Enough deionized water barely to cover the contents of the crucible was added and the beaker was heated at a temperature just below boiling on a hot plate, until the melt was thoroughly designated. The crucible was then removed and washed with deionized water. At this point 20cm^3 of 6m HCL was added to neutralize the $NaCO_3$ and to make the solution slightly acidic. This was filtered into a 100cm^3 volumetric flask and the volume made up to the mark with deionized water.

Precipitation of $BaSO_4$: The solution was brought to boilinig and 10cm^3 of 10% $BaCl_2$ $2H_20$ was slowly added to precipitate the sulphate. The solution was allowed to cool and was filtered. The residue was washed with deionized water.

Ignition of $BaSO_4$: The ashless filter paper was ignited at low temperature (40^0c) and the precipitate weighed. The percentage sulphur in the precipitate was calculated from the expression below,

% Sulphur = $\frac{BaS0_4}{wt\ of\ sample\ in\ gram} \times 100$

3.4.2 Nitrogen (N) Determination

N was determined by micro-Kjeldhal method (Bremner and Mulvaney, 1982).

Principle: the method was the digestion of sample with hot concentrated sulphuric acid in the presence of a Kjedahl catalyst. Air dried sample (0.5 g) was taken into 100-ml digestion flask along with 10 ml of digestion acid mixture (1 g digestion mixture (K_2SO_4: $CuSO_4$ and SeO_2 in the ratio of 10:4:1) in 10 ml concentrated sulphuric acid). Initially this flask was heated at low temperature for about 30 min until the contents became light yellow green. The digest was cooled and the final volume was made 50 ml with distilled water. An aliquot of 10 ml was taken from the digested sample and reacted in micro Kjeldhal apparatus with 10 ml of 40% NaOH to produce ammonia. (This action reduced the organic nitrogen in the sample to ammonia). Boric acid indicator (5 ml) was taken into a flask and placed below the condenser of Kjeldhal apparatus so that the tip of the condenser dipped into the boric acid indicator to absorb liberated ammonia. The ammonia was trapped in dilute acid. The condensate was titrated with 0.01 N HCl using a burette. The colour change at end point was from greenish-blue to permanent light pink.

Calculation $\% N = (a - b) \times N \ \times 1.4S\%$

Where: *a:* sample titrate (ml), *b*: blank titrate (ml), *N:* Normality of HCl used, 1.4: multiplication factor, *S*: weight of sample (g)**.**

3.4.3 Phosphorus (P) Determination of phosphorus:

The phosphorus status was determined colorimetrically (AOAC, 1984). 0.5 g of the slurry sample was weighed into a well washed and dried crucible. The sample was ashed in muffle furnace at 500 Â°C for 3 h and then allowed to cool. It was digested with 5 mL of HNO_3 and the volume made up to 50 mL with distilled water. Approximately 5 mL of the diluted sample was pipetted into a test tube and 2 mL ammonium molybdate and 10N sulphuric acid solution was added. The mixture was swirled and allowed for 10 min. The absorbance was read at 420 nm using distilled water as blank. The standard solutions were treated as test sample. The calibration graph for the phosphate standard was used to read off the concentration of the phosphate:

$$C_p = A_b \times G_{spg}$$

Where C_p is the concentration of the phosphate, Ab is the absorbance and G_{spg} is the gradient from the standard plot of the phosphate concentration.

3.4.4 Determination of carbon content

Procedure

Two (2) gm of sample was weighed in a crucible (w_1). Sample was spread with a brush. Then the crucible was kept inside a muffle furnace and the temperature was gradually raised up to 600°C. At 800°C the temperature was kept constant and the incineration of sample was completed by heating the sample at that temperature. After incineration, the crucible was allowed to cool and transferred to a desiccator. After cooling the crucible was re-weighed (W_2). Deduction of w_1 (weight of the crucible) from W_2 (weight of the crucible + ash) gives the amount of carbon in the sample. Carbon content is expressed in per cent of sample.carbon content = $\frac{W2-W1\times 100}{Weight\ of\ sample}$

3.4.5 Methods for the Heavy mental analysis

Heavy metal analysis was conducted using Agilent FS240AA Atomic Absorption Spectrophometer according to the method of American Public Health Association (APHA, 1998).

Working principle: Atomic absorption spectrometer's working principle was based on the sample being aspirated into the flame and atomized when the AAS's light beam was directed through the flame into the monochromator and onto the detector that measured the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelength, a source lamp composed of that element was used, making the method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame was proportional to the concentration of the element in the sample.

Sample Digestion Adrian Method was adpted: Five gram (5g) of the dried sample was weighed and transferred into a digestion flask and 20ml of the acid mixture (650ml conc HNO_3; 80ml perchloric acid; 20ml conc H_2SO_4) was added. The mixture was heated in a digesting flask until a clear digest was obtained. It was diluted with distilled water to the 50ml mark.

Stock Standard Solution 1000 mg/l, of stock metal solution was dissolved in a minimum volume of (1+1) HNO_3. Diluted to 1 liter with 1% (v/v) HCL, appropriate dilution was carried out to produce 2, 4 and 6ppm working solution.

3.4.6 pH and electrical conductivity (EC)

A suspension was made in a flask by mixing sample with double distilled water (1:10 *w*/*v*). The suspension was shaken over a shaker for 40 min. The supernatant was taken out and analyzed for pH and EC. The pH meter and EC meter were calibrated prior to its use. (Composts of pH 6–8.5 and EC value of below 4.0 $mScm^{-1}$ are excellent for agricultural soils).

3.5 Grinding and "Biocharation":

The whole dried compost was finely grounded. Locally purchased Biochar from wood (another kitchen waste) was also grounded. The biochar was added to the dried and grounded compost in the ratio of 1:4. (Biochar is usually added to vermicompost during composting and not after. But in this project, it was added after composting.

Second characterization.

A portion of the mixed dried sample of compost and biochar was taken to the laboratory for another characterization. This helped to determine the effect of the biochar on the dried compost (manure)

4.0: RESULTS

4.1 SEM analysis

The maturity of vermicompost process involves changes in texture and structure which can be determined through scanning electron microscopy (SEM). SEM analysis provided essential information on surface morphology and numerous surface irregularities in the vermicomposted mixtures that confirms the maturity and degradation of waste by earthworms. Earthworms ground the feed mixtures, and further action by microbes and enzymes in the earthworm gut disaggregates the substrates (Wang, Xiong and Kuzyakov, 2016).

The scanning electron micrograph of final vermicomposted mixtures of the final is shown in figure 4.1. The compost revealled the presence of greater number of surface changes indicating that it consists largely of solid or hollow spherical particles of variable size with small bulgings of homogenous elements. This also indicated the biodegradation and mineralization of waste by the earthworms. The photomicrograph also indicated that dark areas are organic material, and light areas are mineral matter. Moreover, the SEM investigation definitively validated the successful integration of wastes within the composite materials.

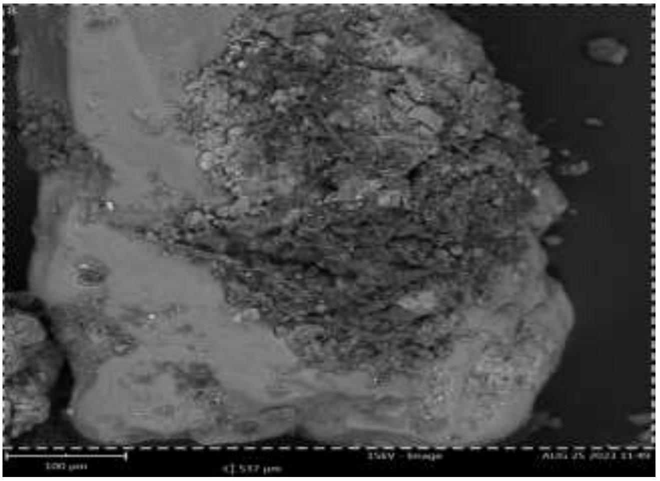

Fig 2 SEM micrographs

4.2 Energy-dispersive X-ray spectroscopy (EDX) analysis

Energy-dispersive X-ray spectroscopy (EDX) is an important instrumental technique used for the elemental or chemical analysis of a sample. The EDX analysis results of compost sample is represented in Table 1

Table 1 EDX Results

Element Number	Element Symbol	Element name	Atomic Conc.	Weight Conc.
6	C	Carbon	68.24	64.65
14	Si	Silicon	10.68	20.01
7	N	Nitrogen	16.63	15.53
13	Al	Aluminum	2.02	3.64
26	Fe	Iron	0.48	1.80
20	Ca	Calcium	0.61	1.62
19	K	Potassium	0.20	0.53
12	Mg	Magnesium	0.31	0.50
15	P	Phosphorus	0.20	0.42
11	Na	Sodium	0.26	0.39
16	S	Sulfur	0.16	0.33
22	Ti	Titanium	0.10	0.33

17	Cl	Chlorine	0.10	0.24

The EDX of compost sample suggested the presence of carbon, silicon, nitrogen, aluminum, iron and calcium as the primary elements and other trace elements. EDX provided detailed imaging information about the morphology and surface texture of individual particles while SEM provided the elemental composition of compost sample which also confirmed the earlier physio-chemical analyses findings.

4.3 Analysing the differences in pre and post addition of Biochar

Table 2 Physico-chemical analyses results

Parameters	Composition ppm
Iron	5.566
Calcium	14.407
Sodium	18.187
Magnesium	5.784
Potassium	10.002
Manganese	2.893
Aluminum	0.965
Nitrogen %	3.984
Total organic Carbon %	16.559
Phosphorus	21.432
pH	7.33
EC	3.5mS/cm

Table 3 Physico-chemical analyses after adding Biochar

Parameters	Composition ppm	Remark
Iron	3.66	
Calcium	14.79	Appreciated
Sodium	10.79	
Magnesium	6.49	Appreciated
Potassium	5.66	Appreciated
Manganese	0.034	
Nitrogen %	7.17	Appreciated
Carbon %	5.47	
Phosphorus	23.11	Appreciated
pH	7.89	Appreciated
EC	56.56 µsm/cm	Appreciated

Table 3 shows that there were appreciation in the calcium, magnesium, potassium, nitrogen phosphorus pH and EC contents. The results shows that the addition of the biochar to the compost during composting or after the composting made no difference because the result obtained is in agreement with the results obtained by the following researchers who added Biochar during composting : Chen *et al.* (2018b); Soobhany *et al*. (2017) and Yang *et al.* (2020). That of nitrogen is in agreement with the results of Liu *et al.* (2019) Sengupta, Mukherjee, Halder, (2020) and Wang *et al.* (2022). The appreciation of the phosphorus is in agreement with the results of Guo *et al.* (2020); Liao *et al.* (2019); Raza *et al.* (2022). Again the findings in the pH and phosphorus of the results agreed with those of the following researchers like Chen *et al.* (2018b); Soobhany *et al*. (2017) asserted that using biochar in vermicomposting increased the pH of soil. Guo *et al.* (2020); Raza *et al.* (2022) declared that phosphorus availability was enhanced in the vermicomposting product when biochar was added. All these are in line with the findings of Mulakkal *et al.* (2021) who asserted that biochar is made up of C content of 42.6%, total N of 0.75%, total P of 0.15%, total K of 1.06%. Other elements such as Na^+ did not show any increase rather it depreciated after biochar amendment which was considered favorable as Na^+ accumulation can cause deterioration of soil structure as stipulated by Srivastava *et al.* (2020); Zhang, Chen, Sun, Zhou and Zou, (2016). However, the result of carbon content showed that the carbon content also depreciated. This contracdicted the results gotten by Liu *et al.*, (2019) and Sengupta, Mukherjee and, S. Halder, (2020). They stated that biochar-based fertilizer increases the microbial biomasses of Carbon.

4.3 Organic carbon to nitrogen (C: N) ratio

The C: N ratio is an important parameter used for determining the vermicompost maturity and stability. It indicates rapid mineralization and decomposition of the initial raw material and is mostly used parameter for stability and maturity of organic wastes (Singh, Kaur and Vig, 2014). C: N ratio of <20 confirms organic waste mineralization which indicates compost maturity; however, a C:N ratio of <12 is also preferred for agricultural purpose (Ling *et al.*, 2022). From the above results of the EDX the C:N ratio was 4,16 <12 and the physiochemical was 1.06 and 3.62 <12. This showed that the C: N ratios fall within the normal range. Also from the results, it was observed that there was no difference between when Biochar was added to the compost during posting and when it was added after composting.

5.0: CONCLUSION AND RECOMMENDATION

The research has revealed that the addition of biochar to compost after composting is a sustainable tool to restore the degraded soil ecosystems. It has not only proved effective in management of soil but also is considered as eco friendly technique as compared to synthetic fertilizers. With the upsurging population growth in developing nations, there is a huge demand for plant nutrition supplements for the soil fertility. The usage of the effective composting system will reduce the uncontrolled use of chemical fertilizers which ultimately reduces the cost of cultivation. The addition of biochar in organic solid waste composting would be a potential method for the successful management of organic waste. However, further research is needed to fulfill our understanding of the mechanisms of biochars' effect on composting and to explore the relationship between biochar, the microorganisms, and composting processes at both the pilot scale and large scale. A comparison of biochar with other additives influences on composting processes and compost.

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