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Comparative effects of poultry and cow dung-based composts on soil pH, organic matter, and macronutrient dynamics in a tropical sandy loam

Folasade Oluwafisayo Adeyemi *

Department of Soil Resources and Environmental Management, Ekiti State University, Ado-Ekiti, Nigeria

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Author(s)

F.O.Adeyemi *

* Corresponding author

Abstract

Luxuriant crop development, especially in leafy vegetables, is strongly influenced by soil pH, organic matter, and macronutrients (N, P, K, Ca, and Mg). However, tropical soils are often deficient in these fertility indicators due to repeated cultivation without proper soil management or restoration. To maintain adequate organic matter content and improve soil nutrient status, research into organic soil fertility restoration strategies has become essential, particularly since inorganic fertilizers are often expensive, scarce, hazardous, and environmentally unfriendly. Cow dung/sawdust (CDS) and poultry dung/sawdust (PDS) have been the primary composting materials used. Therefore, this study aimed to investigate the effects of CDS and PDS composting on their chemical properties, as well as their impact on selected soil chemical properties. The compost mixtures were separately prepared and composted for 22 weeks at an ambient temperature of 24°C. Temperature changes were recorded fortnightly before watering. Samples from the compost heaps were chemically analyzed at the second and twenty-second weeks. Subsequently, the composts were incubated with soil at a rate of 30 t/ha for 16 weeks under room temperature. Soil pH, organic matter, and macronutrients (N, P, K, Ca, and Mg) were evaluated at 4, 8, 12, and 16 weeks of incubation. Temperature profiles showed higher readings in the CDS heap, suggesting faster composting. At 22 weeks, both composts showed improved chemical properties, with CDS recording higher values across most parameters. During incubation, soil pH, organic matter, N, P, and K increased steadily, indicating ongoing mineralization, whereas Ca and Mg contents declined. Both composts demonstrated potential to increase soil pH, organic matter, and macronutrient levels. However, PDS-treated soils showed greater mineralization of organic matter and macronutrients, making poultry dung/sawdust compost more effective for soil maintenance, fertility restoration, and sustainable crop production.

Keywords: Composts, macro nutrients, management techniques, organic matter, soil fertility restoration.

Introduction

Soil pH and macronutrients are important indicators of soil fertility (MohammedZein et al., 2023). Adequate levels of macronutrients are required for crops to complete their life cycle without interruption. A deficiency or absence of any of these essential elements can hinder crop development and even lead to plant mortality. Unfortunately, most tropical soils lack these critical fertility components, thereby necessitating appropriate soil maintenance, restoration, and management practices (Amer, 2019). Sustainable soil management enhances agricultural productivity, improves environmental conditions, and promotes overall soil health. A healthy soil is characterized by balanced nutrient availability, high humus content, and a diverse population of soil organisms. The primary cause of declining soil fertility in tropical regions is the continuous removal of nutrients through crop harvest without sufficient replenishment (Isitekhale and Osemwota, 2010). This

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situation has led to the increasing use of both organic and inorganic external inputs to restore nutrient balance and sustain productivity.

In Nigeria, the use of inorganic fertilizers has become a common strategy to offset the negative nutrient budgets in crop production systems (Kekong et al., 2010). While these fertilizers can significantly increase crop yields depending on management practices and environmental conditions, they are often expensive, difficult to obtain, and unaffordable for smallholder farmers (Tesfaye et al., 2011). As a result, researchers have shifted their focus to promoting organic fertilizers that are inexpensive and locally available. Improved crop production practices now emphasize nutrient management through the use of organic fertilizers, which have shown more beneficial effects on tropical soils compared to synthetic nutrient sources. Consequently, organic farming practices that rely on natural nutrient cycles are increasingly being encouraged (Amgai et al., 2018).

The numerous documented benefits of organic wastes on soil properties and productivity have contributed to the growing acceptance and application of composts (Omolayo et al., 2011; Fawole, 2015; Adeyemi, 2025). While mineral fertilizers may initially boost yields, they can eventually lead to soil acidification and nutrient imbalance. In contrast, composts enhance the chemical, physical, and biological properties of soils by increasing organic matter and fostering greater microbial diversity and activity (Amgai et al., 2018). Additionally, using organic wastes from farms and animal industries helps mitigate environmental hazards by converting waste into valuable soil amendments (Adeleye and Ayeni, 2010). In Nigeria, compost materials such as poultry and cattle dung are abundant, making composting a practical and increasingly preferred method among farmers.

Compost also acts as a natural pesticide, soil conditioner, and a rich source of humus and humic acids. Research shows that adding organic matter to soil increases microbial populations, which in turn helps suppress root diseases (Talat et al., 2020). Microorganisms in compost produce esters that enhance soil aggregation, creating a friable and well-structured texture (Chotte, 2005). Compost is a porous, moisture-retentive medium that holds soluble nutrients and provides support for healthy plant growth. When applied directly to soil or growing media, compost enhances organic matter content and improves fertility. Regular application leads to long-term productivity and sustainability in crop and vegetable production. Thus, compost is a reliable means of maintaining long-term soil fertility while reducing the need for synthetic fertilizers.

Cattle dung consists of fibrous and liquid materials derived from the digestive tract of the animal, including substances such as cellulose, lignin, hemicellulose, urea, and various minerals. This makes it a nutrient-rich, environmentally sustainable input for enhancing crop production. It can be used as an alternative to synthetic fertilizers. However, if not incorporated into the soil by earthworms or dung beetles, cow dung can dry on the surface, negatively affecting grazing (Thomas, 2020). Cattle manure improves soil structure, organic matter content, water infiltration, and tilth (Bakayoko et al., 2009; Mosebi et al., 2015; Rayne and Aula, 2020). Although the benefits may not be immediate, long-term application leads to enhanced yields and soil quality (Reddy et al., 2000). The nutrient value of cattle manure varies based on factors such as animal type, diet, storage, and handling. Composting manure stabilizes nutrients, reduces volume, minimizes odor, and eliminates weed seeds and pathogens (Zublena et al., 1986). Therefore, composted cattle manure is considered more effective than fresh manure for agricultural use (Kekong et al., 2010; Fawole et al., 2019, 2021; Adeyemi, 2024, 2025).

Poultry manure is considered the most nutrient-rich among livestock manures, containing significant amounts of N, P, K, and Ca (Mitchell and Donald, 1999). It serves as a concentrated source of readily available nutrients for soil improvement and crop production (Azad et al., 2022). Poultry manure can be applied directly to fields without composting, making it convenient for farmers (Prabu, 2009; Adeyemi et al., 2021). However, its composition varies based on poultry species, feed, litter type, and handling methods (Zublena et al., 2012). Nitrogen in poultry manure is mainly in the form of uric acid, which can convert to ammonia and be lost through volatilization if improperly stored. As the manure mineralizes, the nitrogen becomes available to plants, with mineralization rates ranging from 40–90% depending on conditions (Mitchell and Donald, 1999). Poultry manure is used at various stages—before planting, during sowing, and as a top dressing (Adeyemi et al., 2021). Like cattle manure, it can either supplement or replace commercial fertilizers, and it has been used both alone and in combination with other materials (Omolayo et al., 2011; Fawole, 2015; Adeyemi et al., 2021; Fawole et al., 2019, 2021).

Sawdust, a carbon-rich organic material, is produced as a byproduct of wood processing in sawmills and carpentry workshops. Although it contains little in the way of nutrients essential for microbial activity, its high lignin, cellulose, and pectin content makes it suitable for composting. Nitrogen must be available for microbial decomposition of sawdust to occur (Rudiger et al., 2018). Initially, microbes may immobilize nitrogen, limiting plant uptake. However, once decomposition is complete, nutrients become available to crops. Sawdust is widely used as mulch, litter, or soil amendment, and its high moisture-absorbing capacity supports the composting process by balancing the carbon-to-nitrogen ratio (Rhoades, 2022). Sawdust from all tree types can be used, though material from chemically treated wood should be pre-soaked to remove harmful substances. When used in appropriate amounts, sawdust helps create favorable conditions for compost maturation (Qasim et al., 2018).

Cow dung and poultry manure are widely used in composting, often in combination with sawdust as a carbon source (Fawole et al., 2019, 2021). In Nigeria, large amounts of organic waste are generated and often discarded improperly, posing environmental risks. Composting is a sustainable solution for converting these wastes into nutrient-rich inputs for crop production (Adeleye and Ayeni, 2010). It facilitates the breakdown of organic matter by soil organisms and helps restore humus and essential nutrients (Loughrey, 2024).

Soil productivity in tropical systems depends heavily on pH, organic matter, and macronutrient availability. However, due to ongoing cultivation and poor management, these fertility indicators are frequently depleted. Organic nutrient sources have emerged as viable alternatives to inorganic fertilizers, which are costly, scarce, and environmentally hazardous (Adeyemi and Omotoso, 2023; Adeyemi, 2024). Meanwhile, organic farm wastes are often discarded unsustainably. When managed properly, these wastes can support soil fertility and crop productivity (Adeyemi, 2022). In Nigeria, cow dung–sawdust (CDS) and poultry dung–sawdust (PDS) composts are commonly used. Therefore, this study aimed to compare the effects of composting on the chemical properties of CDS and PDS, and to evaluate their respective impacts on soil pH, organic matter, and macronutrients (N, P, K, Ca, Mg) over time. The findings will inform sustainable soil management strategies and provide evidence-based recommendations for compost use in agricultural systems.

Material and Methods

Experimental site

The research was conducted at the Teaching and Research Farm of Ekiti State University, located along Iworoko-Ekiti Road, Ado-Ekiti, Nigeria. The site lies between latitudes 7°15′ and 8°5′ N and longitudes 4°45′ and 5°13′ E, within the rainforest zone of southwestern Nigeria. The average annual temperatures for February and March—the presumed hottest months—are 28 °C and 27 °C, respectively. Average daily sunshine is approximately 5 hours, with a mean annual solar radiation of 130 kcal/cm^2/year.

Chemical analysis of organic wastes

The organic wastes were air-dried, milled, and chemically analyzed. The pH of each sample was determined electrometrically in a 1:2 (w/v) sample-to-water ratio (IITA, 1982). Organic carbon content was measured using the dry ashing method (Nelson and Sommers, 1996), and total nitrogen was assessed by the micro-Kjeldahl method (Bremner, 1996). Samples were digested using a perchloric-nitric acid mixture, and phosphorus was determined using the vanadomolybdate yellow color method (Olsen and Dean, 1965). Potassium and sodium were measured with a flame photometer, while calcium, magnesium, manganese, iron, zinc, copper, and lead were quantified using atomic absorption spectrophotometry (AAS).

Experiment 1: Composting Effects on Compost Properties

The heap method was employed for composting. Cattle dung mixed with sawdust (CD + S) and poultry dung mixed with sawdust (PD + S) at a 1:1 ratio were heaped separately. Each heap measured 1.5 m in width and 1 m in height. The heaps were turned fortnightly to ensure aeration, and equal amounts of water were added to maintain moisture. Ambient and internal heap temperatures were recorded prior to each watering and turning. Temperature trends during the composting period were analyzed descriptively. Samples were collected at weeks 2 and 22—when heap temperatures had stabilized and composts had darkened, indicating maturity. These samples were analyzed for non-synthetic carbon, nitrogen, phosphorus, calcium, magnesium, potassium, sodium, manganese, iron, zinc, copper, and lead. The analytical methods used were the same as described above (Olsen and Dean, 1965; Nelson and Sommers, 1996; Bremner, 1996).

Determination of Soil Properties at the Study Site

Surface soils (0–15 cm) were randomly collected from the Teaching and Research Farm. The samples were air-dried, sieved (2 mm), and analyzed for particle size distribution, pH, total nitrogen, organic matter, available phosphorus, potassium, sodium, calcium, and magnesium. Particle size was determined by the hydrometer method (Sheldrick and Hand Wang, 1993), and pH was measured in a 1:2 soil-to-water ratio using the electrometric method (IITA, 1982). Total nitrogen was estimated using the macro-Kjeldahl digestion method (Bremner, 1996), while organic matter was determined by wet oxidation (Nelson and Sommers, 1996). Available phosphorus was analyzed using Bray's method (IITA, 1982). Exchangeable cations (K, Ca, Mg, Na) were extracted with 1 N NH_4OAc (Hendershot and Lalande, 1993). Potassium and sodium were quantified using a flame photometer, while calcium and magnesium were measured with AAS. Effective acidity was extracted using 1 N KCl and titrated with 0.05 N NaOH using phenolphthalein as an indicator (Thomas, 1982). The sum of exchangeable bases and acidity was used to calculate the effective cation exchange capacity (ECEC).

Experiment 2: Dynamics of soil reaction (pH), organic matter, N, P, K, Ca and Mg in composts-treated soils through Incubation Studies

Two (2) kilogrammes (kg) samples of soils from the study site were weighed into pots. Each enriched compost was used; by properly mixing with the soils at 30 t/ha. Properly mixed substances were dampened, covered and stored in a cool environment. Thorough mixing of pots' contents was done at weeks 4, 8, 12 and 16 of incubation and thereafter, total N, accessible phosphorus and inter-exchangeable potassium, calcium and magnesium, contained in sampled soils from the pots were measured. Each treated soil was replicated four times, making a total of 12 pots, arranged in a complete randomized design (CRD). The macro-Kjeldahl method was adopted for N determination, while the Bray P-1 method was involved in available P calculation and exchangeable K quantified by flame photometer after extraction with neutral normal NH_4OAc, while Ca and Mg contained in filtrates were quantified with atomic absorption spectrophotometer. Data generated were analyzed with anova, at 5%, and were described with charts.

Results

The chemical properties of the organic wastes

Table 1 shows the chemical properties of the compost materials i.e. the organic wastes used in the study. The compost materials (poultry droppings, cow dung and sawdust) had pH values of 8.4, 8.0 and 8.4 respectively. The poultry droppings gave the highest N (79.2 g/kg) value, followed by cow dung (53.9 g/kg N) while the least value was in saw dust, which contained 1.5 g/kg of N. Total P in cow dung was 26.8 g/kg while the other two compost materials-poultry manure and sawdust contained 8.6 and 0.2 g/kg P respectively. The Ca content of poultry manure (13.1 g/kg) was the highest amongst the organic wastes and followed by saw dust with 10.4 g/kg while cow dung gave the least value (9.5 g/kg). Total Mg was highest in poultry droppings (6.7 g/kg) followed by sawdust (6.4 g/kg) which was slightly higher than cow dung (6.0 g/kg). Total K was 5.2, 4.8 and 4.4 g/kg for poultry droppings, cow dung and saw dust respectively while Na content was 0.8 g/kg for cow dung and poultry droppings and 0.5 g/kg for sawdust. Poultry droppings contained 0.3 g/kg Mn while the content in cow dung and sawdust was the same at 0.2 g/kg. The Fe content was the same for cow dung and poultry droppings (0.5 g/kg) but 0.3 g/kg in sawdust. The Zn content was higher in cow dung (0.2 g/kg) than in poultry droppings and saw dust with 0.1 g/kg. The Cu values ranged from 0.03 to 0.1 g/kg while Pb was below detectable levels in the compost materials.

Table 1. Nutrient composition of compost materials

Parameters	Cow dung	Poultry dung	Sawdust
pH (H_2O)	8.0	8.4	8.4
Total N (g/kg)	53.9	79.2	0.9
Organic C (g/kg)	222.9	327.2	334.3
Total P (g/kg)	26.8	8.6	0.2
Calcium (g/kg)	9.5	13.1	10.4
Magnesium (g/kg)	6.0	6.7	6.4
Potassium (g/kg)	4.4	5.2	4.8
Sodium (g/kg)	0.8	0.8	0.5
Manganese (g/kg)	0.2	0.3	0.2
Iron (g/kg)	0.5	0.5	0.3
Zinc (g/kg)	0.2	0.1	0.1
Copper (g/kg)	0.1	0.03	0.03
Lead (g/kg)	ND	ND	ND

Physical and chemical characteristics of composts as affected by weeks of composting

Figure 1 shows the trend of changes in temperature during composting. The two main temperature ranges: mesophilic with optimum growth temperature range of between 20-45°C and thermophilic with optimum growth temperature range of between 50-70°C, often encountered in aerobic composting, were observed. At the first turning (2 weeks into composting), the temperature was 40 and 42°C which increased to 53 and 56°C for PDS and CDS respectively at the second turning (4 weeks into composting). At the third turning (6 weeks into composting), the temperatures of the materials increased to 62 and 66°C but decreased to 58 and 56°C for PDS and CDS respectively at 8 weeks and to 50°C for both heaps at 10 weeks. The decrease in temperature continued till 42 and 40°C at 12 weeks, 30°C at 14 weeks and to 24°C for PDS and 25°C for CDS at 16 weeks into composting. At 18 weeks, the temperature remained constant at 24 and 25°C in the PDS and CDS heaps respectively. At 20 weeks, the temperature on both heaps was observed to remain at 24°C and turning no longer reheated the piles; an indication that the piles have attained the curing stage. The temperatures for the heaps remained constant till 22 weeks. The composts had become brown/black in colour. These all indicate the maturity of the composts.

The chemical properties of compost samples taken at 2 and 22 weeks are shown in Table 2. At 2 weeks into composting, the pH values in the two composts were 8.0, for PDS and 8.3, for CDS; an indication that the two composts were basic. The values obtained for Total N, organic carbon and all the exchangeable cations were higher in the CDS based composts at 2 weeks into composting while total P was higher in PDS. The Pb content of the two composts was not detectable.

At 22 weeks into composting (Table 2), the pH of the two composts increased becoming more basic with pH values 8.2 for PDS and 8.4 for CDS. Also, there was an increase in total N, organic carbon, total P and exchangeable cations of the two composts except in Fe, where a reduction in the initially recorded values was observed. The particles had reduced in size and became consistent and soil-like in texture. It was also observed that the C: N for both compost samples got reduced at 22 weeks into composting.

Table 2. Chemical properties of the composts at 2 and 22 weeks into composting

Parameters	PDS		CDS	
	2 weeks	22 weeks	2 weeks	22 weeks
pH (H_2O)	8.0	8.2	8.3	8.4
Total N (g/kg)	3.91	4.22	6.02	6.40
Organic C (g/kg)	161.2	158.0	249.0	243.0
Total P (g/kg)	19.7	23.0	5.5	10.0
Calcium (g/kg)	9.0	11.5	11.2	13.0
Magnesium (g/kg)	5.3	6.2	6.3	6.8
Potassium (g/kg)	4.2	5.4	5.0	6.1
Sodium (g/kg)	0.04	0.04	0.11	0.13
Manganese (g/kg)	0.2	0.3	0.3	0.4
Iron (g/kg)	0.3	0.2	0.5	0.4
Zinc (g/kg)	0.2	0.3	0.2	0.5
Copper (g/kg)	0.1	0.2	0.1	0.3
Lead (g/kg)	ND	ND	ND	ND

Chemical properties and particle size distribution of soils used for incubation

The properties of the soil used for the incubation studies are shown in Table 3. The soil was a slightly acidic (pH 5.8 in KCl and 6.6 in water) sandy loam with organic matter content at 14.6 g/kg. Total N in soil was 0.8 g/kg; available P was 13.0 mg/kg while the exchangeable cations; K, Ca, Mg and Na were 0.3, 7.0, 1.8 and 0.1 cmol/kg respectively.

Table 3. Chemical properties and particle size distribution of experimental soils

Parameters	Values
pH (1:1 KCl)	5.8
pH (H_2O)	6.6
Total Nitrogen (g/kg)	0.8
Organic matter (g/kg)	14.6
Available P (mg/kg)	13.0
Exchangeable cations	
Calcium (cmol/kg)	2.8
Magnesium (cmol/kg)	1.8
Potassium (cmol/kg)	0.3
Sodium (cmol/kg)	0.1
Exchangeable Acidity	0.6
ECEC	5.6
Base saturation (g/kg)	893.0
Particle Size Analysis	
Sand (g/kg)	799.0
Silt (g/kg)	132.0
Clay (g/kg)	69.0
Textural Class (USDA)	Loamy sand

Dynamics of soil reaction (pH), organic matter, N, P, K, Ca and Mg in composts-treated soils through Incubation Studies.

Effects of PDS and CDS on soil reaction (pH)

Figure 2 shows the pH values of the composts-treated soils obtained during incubation study. The experimental soil was slightly acidic, having great impact on the soil reaction values of the treated soils. The pH values of samples reduced through week 12 of soil incubation. The trend of soil pH reduction was similar, for all treatments in the treated, soils. However, soil acidity reduced after 12 weeks of incubation, as the pH values of all treated soils, including the control (soil alone) increased at 16 weeks of incubation. Though there were no significant differences among the treatments, but CDS treated soils gave the lowest pH values. The pH at 16 weeks of incubation ranged from 5.9 (CDS), through 6.0 (control) to 6.05 (PDS).

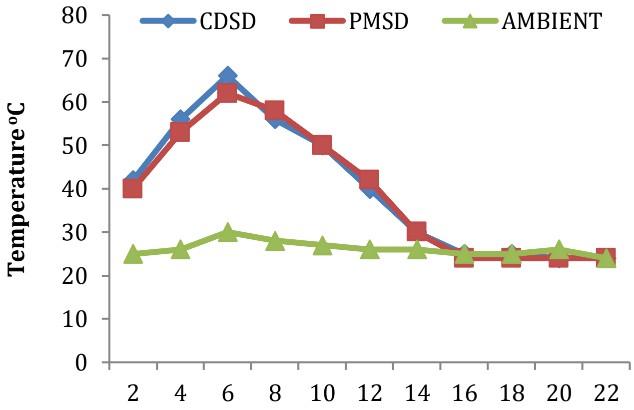

Figure 1. Temperature changes during composting

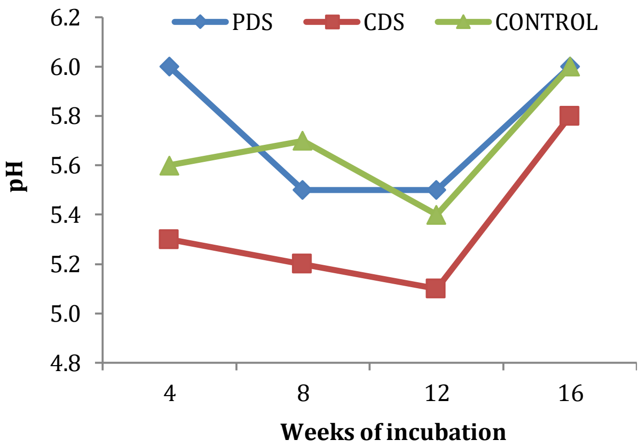

Figure 2. pH of the composts-treated soils obtained during incubation study

Effects of PDS and CDS on soil organic matter (SOM)

Soil organic matter (SOM) dynamics, as recorded from this study (Figure 3), showed that SOM at in the control (4.35 g/kg) was the highest at week 4, and it was significantly different from the least SOM value (2.65 g/kg), which was recorded from soils treated with PDS. The SOM recorded from soils treated with CDS (3.81 g/kg), also differed significantly from SOM value for PDS-treated soils. The organic matter contents of the treated soils decreased at week 8, with the control still having the highest SOM content (2.34 g/kg), followed by PDS (2.22 g/kg) and PDS giving the least SOM content (1.8 g//kg). However, there were no significant differences among the values obtained for the treated soils. There were no significant differences in the values of SOM recorded for the treatments at 12 weeks of incubation, but the CDS treated soils gave the highest SOM value (1.84 g/kg), followed by the control (1.75 g/kg). The PDS-treated soil gave the lowest SOM value of 1.61 g/kg. The SOM values (g/kg) recorded for the treatments at 16 weeks of incubation were in the order: PDS (2.8)> Control (2.3)> CDS (1.8). The PDS gave a SOM value significantly different from the CDS which gave the lowest SOM value.

Effects of PDS and CDS on total N in soil

Total N contents of the treated soils were greatly influenced by the addition of composts (Figure 4). Both compost types were effective in soil N enrichment, as N values recorded for soils treated with the two composts were significantly higher than N values in the control soil. The N values (g/kg) at 4 weeks of incubation were: 5.1, 4.1 and 0.6, recorded for PDS, CDS and control, respectively. Nitrogen dynamics in the treated soils followed the same pattern as in the SOM contents, as a reduction in N values was recorded at 8 weeks of incubation. There were no significant differences in the N values recorded from CDS and PDS-treated soil through the period of incubation. However, PDS has the highest values of N at all weeks in the incubation studies and the highest N overall (5.1 g/kg) at 4 and 16 weeks of incubation. Total N increased from 8 weeks into incubation, all through the 16 weeks of incubation.

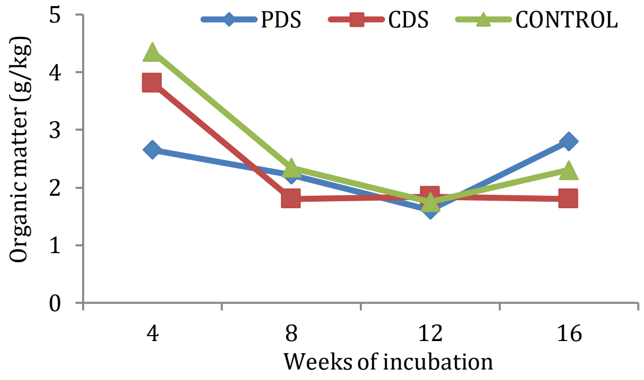

Figure 3. Organic matter contents (g/kg) values of the composts-treated soils obtained during incubation study

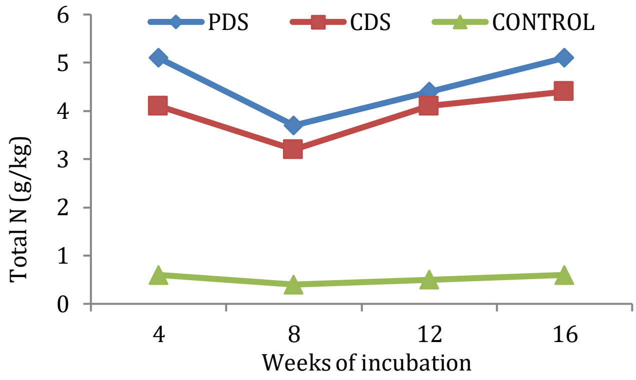

Figure 4. Total N contents (g/kg) of the composts-treated soils obtained during incubation study

Effects of PDS and CDS on soil available P

Though CD gave higher P value of 26.8 g/kg than 8.6 g/kg given by PD in their nutrient compositions analysis, the analysis of the resultant composts indicated that the available P content of PDS at 22 weeks into composting (23.0 g/kg) became higher than the available P content of CDS (10.0 g/kg). From the study, available P values obtained from the organically-treated soils significantly differed from the control soils (Figure 5). The PDS- treated soils gave the highest available P value (9.1 mg/kg) at 4 weeks of incubation, though not significantly different from the CDS-treated soils (8.4 mg/kg). Soils treated with CDS had continuous increase in available P all through the period of incubation, while a slight decrease was observed in PDS at 8 weeks of incubation (Figure 5). The PDS-treated soils also had the highest available P value (16.8 mg/kg) at 12 weeks of incubation and it differed significantly from the available P content of the CDS-treated soils (12.4 mg/kg). The highest available P value overall (19.0 mg/kg), was recorded from CDS at 16 weeks, though not significantly different from the available P value obtained from the PDS-treated soils (18.5 mg/kg). The lowest available P value was recorded from Control at 8 weeks of incubation (2.1 mg/kg). However, available P quantities of soils treated with CDS and PDS were greatly increased.

Effects of PDS and CDS on exchangeable K contents of the treated soils

The exchangeable K contents in soils treated with both composts increased continuously through the weeks of incubation (Figure 6). Up to 400% increase was recorded in the exchangeable K contents of treated soils compared to the exchangeable K contents of the control samples. The highest exchangeable K value at 4 weeks (0.47 cmol/kg) was recorded from the CDS-treated soils and was significantly higher than the PDS-treated soils (0.37 cmol/kg) and the control soils (0.13 cmol/kg). An increase in exchangeable K content was recorded for all treatments, including the Control all through the study, with no significant differences between the PDS-treated soils and the CDS-treated soils. The highest exchangeable K value recorded from the study (0.65 cmol/kg), which differed significantly from other treated soils, was however recorded from PDS at 16 weeks of incubation, and the least exchangeable K value (0.13 cmol/kg), which also differed significantly from others, was recorded from control at 4 weeks of incubation.

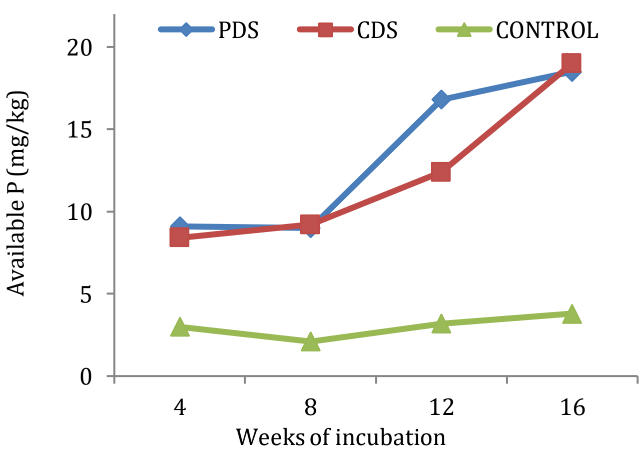

Figure 5. Acailable P contents (mg/kg) of the composts-treated soils obtained during incubation study

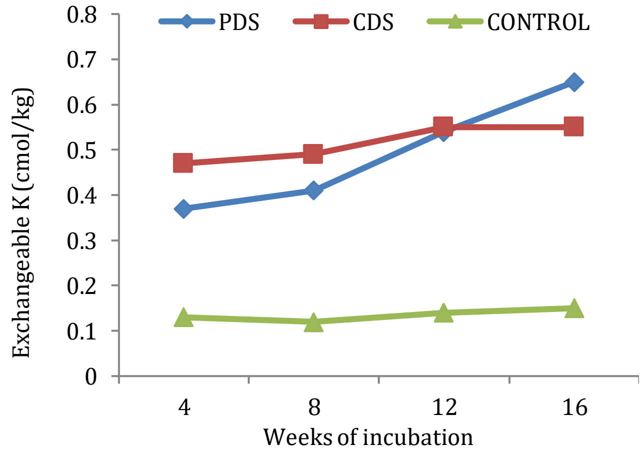

Figure 6. Exchangeable K contents (cmol/kg) of the composts-treated soils obtained during incubation study

Effects of PDS and CDS on exchangeable Ca contents of treated soils

Figure 7 shows that the exchangeable Ca content of the treated soils reduced with weeks of incubation. A noticeable reduction in exchangeable Ca content was observed from 8 weeks of incubation. The PDS gave significantly higher exchangeable Ca values than CDS-treated soils all through the period of incubation. The PDS recorded the highest exchangeable Ca value (8.4 cmol/kg) at the 16th week of incubation whereas the exchangeable Ca values obtained for CDS throughout the incubation period were the lowest (2.5, 10.5, 9.5 and 1.6 cmol/kg at 4, 8, 12 and 16 weeks respectively), conspicuously lower than the exchangeable Ca values obtained in the control soil.

Effects of PDS and CDS on exchangeable Mg contents of treated soils

The same trend as in exchangeable Ca was observed in the values of exchangeable Mg obtained in the incubation studies (Figure 8). The exchangeable Mg contents of soils treated with PDS and CDS composts reduced with weeks of incubation. Unlike in Ca where an increase in the recorded values experienced an increase till 8 weeks of incubation, a continuous decrease was recorded for exchangeable Mg values. The PDS-treated soils were significantly the highest in exchangeable Mg values recorded at all weeks. The highest exchangeable Mg value of 7.9 cmol/kg was recorded from PDS at week 4 while the CDS was the lowest in exchangeable Mg values (1.7 cmol/kg), lower than the control sample, at week 16 of the study.

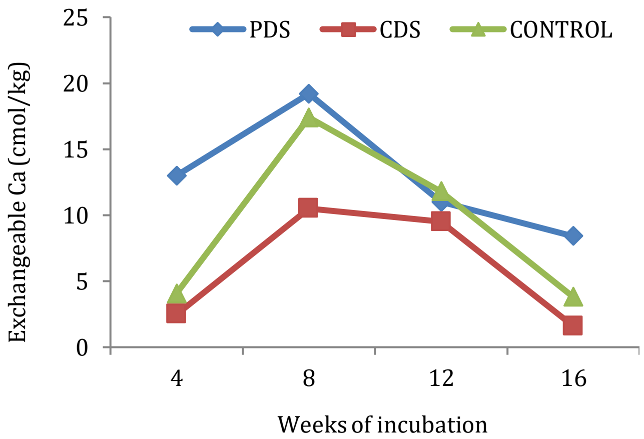

Figure 7. Exchangeable Ca contents (cmol/kg) of the composts-treated soils obtained during incubation study

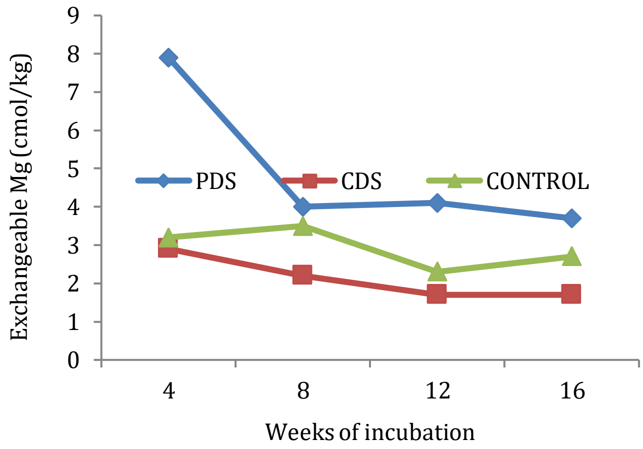

Figure 8. Exchangeable Mg contents (cmol/kg) of the composts-treated soils obtained during incubation study

Discussion

In this study, the two composts—PDS and CDS—attained the thermophilic stage by the third turning (6 weeks into composting), reaching temperatures of 62 °C and 66 °C for PDS and CDS, respectively. This increase in temperature signifies intense microbial activity within both compost heaps (Nemet et al., 2021). The thermophilic stage is crucial for compost quality enhancement, as it ensures the destruction of pathogens and weed seeds (Muller-Samann and Kotschi, 1994; Ryckeboer, 2001). From weeks 18 to 22, the constant and lower temperatures (24–25 °C) without any reheating upon turning indicated that the piles had entered the curing stage. Curing is associated with reduced microbial activity and the stabilization of the end products of composting (Fuchs, 2010; Nemet et al., 2021). Moreover, curing allows the growth of certain fungi and enhances the disease-suppressive potential of composts (Muller-Samann and Kotschi, 1994). However, proper management of the curing stage is essential to prevent recontamination with weed seeds (Nemet et al., 2021).

The slightly higher temperature and more rapid reactions observed in the CDS heap may be attributed to more vigorous microbial activity driven by the higher C:N ratio in cattle dung, which reflects greater lignin content. Orlando and Borja (2020) reported lignin contents of 11.48% in cow dung and 4.17% in poultry dung. This implies that nutrients in poultry dung are released more rapidly than those in cow dung. The dark brown to black color of the composts at 22 weeks is a recognized indicator of compost maturity (EPA, 1994). At this stage, a reduced C:N ratio was also observed, suggesting increased decomposition and mineralization resulting from microbial activity (Nemet et al., 2021).

The observed increase in pH was related to elevated levels of exchangeable bases. Muller-Samann and Kotschi (1994) reported that increased cation exchange capacity and alkalinity often occur by week 22 of composting. This is likely due to microbial breakdown of organic matter, leading to the release of exchangeable cations. The improved nutrient status of the composts may be attributed to the decomposition of waste materials by a wide range of microorganisms, including bacteria and fungi, generating essential soil nutrients. The consistently higher nutrient values recorded in CDS composts at both 2 and 22 weeks may be linked to the more intensive microbial activity driven by the higher C:N ratio in cattle dung.

In the early stages of compost application, a slight increase in soil acidity was observed. This suggests that soil reactions may become more acidic during the initial weeks of incubation. Regardless of treatment, soil pH decreased with incubation time, in agreement with the findings of Roy and Abdul Kashem (2014). Similarly, Gogoi et al. (2021) reported decreasing pH values in compost-treated soils. However, after 12 weeks of incubation, pH increased again, supporting a more favorable environment for plant growth. This pH increase may be associated with the rising levels of exchangeable potassium in the treated soils.

The initial decline in soil organic matter (SOM) across all treatments, including the control, aligns with the findings of Roy and Abdul Kashem (2014), who reported an initial increase followed by a gradual decrease in SOM content with extended incubation.

Nitrogen immobilization observed at week 8 in both compost treatments may have resulted from nitrogen fixation by the expanding microbial population actively decomposing the organic materials (Lim et al., 2018; Nahm, 2023). This pattern of N release may also be influenced by the quality and composition of the compost materials (Rayne and Aula, 2020). Abbasi et al. (2015) stated that the rate of nitrogen release or immobilization from organic sources is dependent on their nitrogen content. They noted that materials with less than 24 g N/kg tend to immobilize nitrogen. Since the N content of the composts in this study was below this threshold, immobilization likely dominated during early incubation stages, particularly around week 8. Eghball et al. (2002) and Shin et al. (2006) emphasized that nutrient mineralization varies depending on the type and composition of organic amendments. Ribeiro et al. (2010) also found that nitrogen release depends on the carbon structure of compost materials. This supports the finding that nitrogen in PDS compost may be mineralized more quickly than in CDS compost. Chadwick et al. (2000) and Fangueiro et al. (2010) further established that the C:N ratio is a key determinant of nitrogen mineralization. Fawole et al. (2019) observed a decrease in compost nitrogen content at week 8, followed by increases at weeks 12 and 16, a pattern consistent with our findings. These trends suggest that PDS and CDS composts are better suited for long-term crops, as some fast-growing vegetables like Amaranthus may mature before nutrient release peaks. Therefore, the application of these composts is more profitable for long-term vegetable and crop production.

The increase in available phosphorus (P) across all treatments during incubation indicates substantial mineralization of organic P in the composts. This supports the suitability of both composts for improving P availability in soils. Fawole et al. (2021) reported similar findings, highlighting the suitability of composts for both short- and long-term vegetable production. Distinct peaks in phosphorus availability observed between the two composts suggest that nutrient release varies depending on compost composition and maturity (Bakayoko et al., 2009).

Exchangeable potassium (K) also increased throughout the incubation period, though with different peak times for each compost. This indicates that the nutrient release dynamics are influenced by the specific composition of the composts. According to Rayne and Aula (2020), nutrient release from livestock manures depends on their physical and chemical characteristics. In this study, up to a 400% increase in soil K was observed in treated soils compared to the control. While there is no clearly defined upper limit for soil K levels, excessive K can lead to luxury consumption by plants and may interfere with the uptake of other nutrients. High soil K levels may result in K/Ca and K/Mg antagonism, reducing calcium and magnesium uptake (Xie et al., 2021). Moreover, elevated K can negatively affect boron, iron, and molybdenum availability, though it may enhance copper, manganese, and zinc uptake (Nguyen et al., 2017).

The compost treatments improved the NPK content of soils compared to the untreated control. This is consistent with the findings of Gogoi et al. (2021), who reported increased NPK levels in compost-amended soils. A decline in calcium and magnesium content was observed with increasing incubation time, in agreement with Tito et al. (2020), who also noted a decrease in calcium, although magnesium increased in their study.

Soils treated with PDS recorded higher values for pH, SOM, N, P, K, Ca, and Mg throughout the incubation study. This indicates that PDS compost facilitated greater nutrient mineralization and may support improved and sustainable crop yields. Azad et al. (2022) similarly reported that poultry manure improved SOM, cation exchange capacity, base saturation, and yield output more effectively than cow dung compost.

Conclusion

This study was conducted in three phases to achieve the following objectives: (i) to determine the nutrient compositions of poultry droppings, cow dung, and sawdust; (ii) to characterize the two composts produced from these materials; and (iii) to investigate the dynamics of soil reaction (pH), organic matter, and macronutrients (nitrogen, phosphorus, potassium, calcium, and magnesium) following the addition of these composts through incubation studies.

The results of the study revealed that composting effectively reduced the particle size of raw materials, converting them into a soil-like substance with a lower carbon-to-nitrogen (C:N) ratio, increased pH, enhanced cation exchange capacity (CEC), and reduced heavy metal content. The compost produced from poultry dung and sawdust (PDS) demonstrated faster nutrient mineralization compared to cow dung and sawdust (CDS), due to the lower C:N ratio in poultry dung.

A temporary decline in nitrogen content was observed between weeks 4 and 8 of incubation, followed by a stabilization from week 12 onward. The application of both composts significantly improved the availability of major macronutrients, particularly nitrogen, phosphorus, and potassium, in the treated soils. These values were notably higher than those in the untreated control soils. However, a gradual decline in calcium and magnesium contents was observed over the incubation period.

Among the treatments, PDS consistently resulted in higher values of soil pH, organic matter, nitrogen, phosphorus, potassium, calcium, and magnesium. Therefore, composted poultry dung with sawdust is recommended as an effective organic amendment for improving soil fertility, particularly in terms of pH regulation, organic matter enrichment, and macronutrient supply. Cow dung composted with sawdust may serve as a suitable alternative when poultry dung is not readily available.

Finally, it is recommended that the study be extended for a longer incubation period to further explore the long-term effects of these organic nutrient sources on soil chemical properties and nutrient dynamics.

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