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Mineralization of fresh and dry cow dung bioslurry for improved soil fertility

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Abstract

Microbial mineralization of organic amendment is important for the availability of nutrient elements in amended soil. The use of bioslurry as an amendment for improvement of soil fertility in the Southern Guinea Savanna zone of Nigeria is new, therefore is a need to ascertain the effectiveness of this amendment as a biofertilizer. The objective of this study was to evaluate carbon and nitrogen mineralization of fresh and dry cow dung bioslurry for the improvement of soil fertility. The laboratory study was carried out under an anaerobic condition, 1% and2 % of fresh and dry cowdung bioslurry in soil were used. The carbon and nitrogen released were estimated by the measurement of CO_2, NO_3-N and NH_4-N for 85days. During the incubation, both fresh and dry cowdung bioslurry released CO_2, NO_3-N and NH_4-N. The relationships between carbon and nitrogen mineralization and chemical properties were analyzed by the Pearson correlation coefficient. Results obtained show that the fresh cow dung bioslurry released higher CO_2, NO_3-N and NH_4-N than dry cowdung bioslurry. There was a positive correlation between nitrate mineralization and ammonium mineralization. The predominant bacteria and fungi species identified were *Providencia sp* and *Aspergillius sp* . It was concluded that drying the bioslurry before use will not be necessary since the fresh cow dung bioslurry releases higher nutrient levels than dry cowdung bioslurry.

Keywords: Carbon, Nitrogen, Mineralization, Microorganisms, Soil fertility.
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1.0 Introduction

There is an inherent problem of poor soil fertility in soils of Southern Guinea Savanna (SGS) agro-ecological zone of Nigeria, which has resulted in the following problems: poor soil productivity, food security threatened, poverty of subsistence farmers etc. Attempts have been made to solve the problem of soil fertility to some extent by the use of chemical fertilizer and organic manures. The use of chemical fertilizer and organic manures has both positive and negative effects on plant growth, yield and soil quality .

Bioslurry has been used in other countries as an organic amendment to improve plant growth, yield and soil fertility. It has many benefits compared to other soil amendments. Bioslurry, a product of anaerobic fermentation of animal excrements in a biogas digester, is an excellent organic fertilizer that can make an important contribution to better crop yields and lasting soil fertility. Bioslurry, released from the hydraulic chamber is anaerobically decomposed organic material of cow dung to cow dung bioslurry, poultry manure to poultry bioslurry etc (Sehanabish, 2013). Bioslurry has been reported to consist of 93% water and 7% of dry matter, of which 4.5% is organic matter and 2.5% inorganic matter. Bioslurry can also be used to build up healthy fertile soil for crop production. According to Ishikawa *et al*., (2006) bioslurry contains easily available plant nutrients than composted manure and farmyard manure.

Soil microorganisms are the agents of the transformation of soil organic matter, nutrients and of most key soil processes. Their activities are much influenced by soil physicochemical and ecological interactions (Powlson *et al*., 2001). It is well known that soil microbes are unable to directly assimilate complex and solid soil organic matter, but rather simple and dissolved compounds for growth and metabolisms. As a consequence, soil microbes must produce extracellular enzymes, to catalyze the breakdown and depolymerization of soil organic matter and to make readily usable dissolved compounds (Merino *et al*., 2016).

Soil organic matter (SOM) undergoes mineralization and releases substantial quantities of N, P, S and a smaller amount of micronutrients. Soil fertility and nutrient availability are closely connected to the soil organic matter content and its mineralization (Zech and Kogel-Kanabner, 1996).

Coffee beans were grown by Nasiri Mukasa using bioslurry with a loamy soil type. He used liquid and composted bioslurry during the two rainy seasons in Uganda (March-May and August – November). He used one jerrycan (20 litres) per plant twice a year, around the roots. The bean yields were increased by around 50%. It was also reported that the crops showed resistance to disease, especially Coffee Wilt Disease (CWD), and there was additional control of insect pests like small black ants and mealybugs (Warnars and Oppenoorth, 2014). There is a dearth of information on the use of cow dung bioslurry in the southern guinea savanna of Nigeria.

The objective of this study was therefore to assess the microbial mineralization of fresh and dry cow dung bioslurry in a selected soil of the Southern Guinea Savanna zone of Nigeria.

2.0 Materials and methods

Collection of soil samples

Random soil samples were collected from the depths of 0-15cm at selected points in the Teaching and Research Farm of University of Ilorin (latitude 9º 29°N and longitude 4º 35° E), Southern Guinea Savannah agro-ecological zone of Nigeria. The soil samples were air-dried and sieved (2 mm mesh) to remove roots and other debris (Haney *et al*., 2004). All samples were stored in a cool and dry place until the start of the experiment. The soil samples were composited.

2.1 Analyses of Physico-chemical properties of the soil

Bulk density and moisture content were determined following Anderson and Ingram (1993). The particle size distribution was carried out using the hydrometer method as described by Okalebo *et al*. (2002). Soil pH was also determined by the method outlined by Okalebo *et al*. (2002) using an electronic pH meter at a ratio of 1:2.5 soil/water or KCl. The total organic carbon in the soil was determined using the wet oxidation method of Walkley and Black (1934) as described by Jackson (1996). Total Nitrogen was determined using Kjelhdal distillation method as described by Bremmer and Mulvancy (1982). The exchangeable acidity of the soil was determined by titration method using 1N KCl extract as described by Rhoades (1982). Cation Exchangeable Capacity (CEC) was determined following Anderson and Ingram (1993) method. Effective cation exchange capacity (ECEC) was calculated by the summation of cation exchangeable capacity (Ca, Mg, K, Na) and exchangeable acidity (Juo *et al.*, 1976). Available phosphorus was determined using Bray 1 (Bray and Kurtz, 1945; Okalebo *et al*., 2002) method

2.2 Microbiological Analyses of soil and organic amendment

Isolation of fungi

The fungi were isolated following the dilution plating technique. Tenfold serial dilution of samples in sterile distilled water was carried out. Potato dextrose agar supplemented with 1% chloramphenicol was be used to isolate fungi from 10^{-3} dilutions of soil. Plates were incubated at 28℃ for 3-5 days. Inoculated plates were incubated at 37℃ for 24hrs . The number of colonies for both fungi that developed on the plate were counted and expressed in cfu/g (Johnson and Case, 2007).

Identification of fungi

The colonies on plates counted were identified using the cultural features and microscopic morphology (presence of hyphae, colour of spore, size of hyphae, presence of conidia, colour, size, pigmentation etc) (Navi, 1999).

Collection and Preparation of Organic Materials

The organic amendment used for this research was cow dung bioslurry; it was collected from Kwara State Polytechnic (Engineering section). The complete randomized design made up of 2 treatments (fresh and dry cow dung bioslurry) with 3 levels (control, 1% and 2% fresh and dry cow dung bioslurry in soil) in three replications was adopted. The dry cow dung bioslurry was sun-dried for 3 weeks and grounded. The bioslurry was applied to the soil and mixed thoroughly. Two hundred(200) grams of the sieved and ground soil sample, two levels of manure samples were mixed thoroughly before placing in 12 cm long PVC tubes with an inner diameter of 7 cm and water was added to an equivalent of 50% water-filled pore space and maintained throughout the incubation period with the addition of water at 2-week intervals. The tubes were placed inside jars with an inner diameter of approximately 0.1 m.

Some Carbon and Nitrogen properties were determined at days 0, 3, 6, 9, 12, 15, 29, 43, 57, 71 and 85. For CO_2 determinations, small vials containing 10 ml 0.25M NaOH solution were also placed in the jars to trap the evolved CO_2. The jars were made air-tight with seals and incubated at 25°C temperature for 85 days.

CO_2 evolution: was determined by pipetting 5 ml of the C-containing NaOH and auto-titrating with 0.15M HCl after precipitation of carbonates with 8 ml of 3M $BaCl_2$ (Anderson, 1982; Khali *et al*., 2005). CO_2 evolved from the soil was calculated using the formula proposed by Anderson and Ingram (1993). The CO_2 evolved was expressed as

V x N mg where V= volume of HCl and N= normality of HCl

NO_3-N and NH_4-N: were measured for determining N mineralization of inherent soil organic matter and applied manure. Both NO_3-N and NH_4-N were extracted from the soil with 0.5M K_2SO_4. Fifty (50) ml of 0.5M K_2SO_4 was added to 10g of moist soil sample and shaken for 1 hour. Then, filtered with Whatman filter paper no 42. NO_3-N and NH_4-N were determined using the colourimetric method (Okalebo *et al.*, 2002).

Statistical Analysis

The data collected from the incubation experiment were analyzed using the statistical program GENSTAT package version 17 at $P \leq 0.05$. The relationships between carbon and nitrogen mineralization and chemical properties were analyzed by the Pearson correlation and regression coefficient (r) with the help of GENSTAT package version 17 at $P \leq 0.05$ (Nelder, 2017).

3.0 Results and discussion

3.1 Characterization of soil and organic amendment

The values of the physical and chemical properties of the initial soil used for the study are presented in Tables 1 and 2. The particle size distribution of the soil is sandy clay. The bulk density and moisture content were 5.02 gcm^{-3} and 8.56% respectively. The soil pH in water is 6.8 (neutral) and pH in KCl is 6.4 (slightly acidic). The pH in water suspension is higher than the corresponding value in KCl solution, indicating that the soil in the natural state is negatively charged (Villapando and Greatz, 2001). Organic carbon and organic matter of the soil were 0.85% and 1.47% respectively. The organic carbon observed in this soil is rated low. A low level of organic carbon (< 1%) may be associated with high rate of organic matter decomposition and burning of organic residues (Adamu *et al*., 2015). The total nitrogen (0.11%) content of the soil; available phosphorus (7.58ppm) and exchangeable bases were also low. The low level of organic carbon, nitrogen and exchangeable bases may be attributed to the rapid decomposition and mineralization of organic matter. Adebayo *et al*. (2009) also reported that organic matter is the main agent for building particles and stabilizing soil aggregates in soils of both humid and sub-humid tropics and organic matter is the sole source of N in the soil. Organic matter is a vital indicator of soil health because it provides the energy source for micro-organisms in the soil (Line-kelly, 1994).

Table 3 shows the microbiological enumeration of the soil and cow dung bioslurry used for the study. Bacterial population is

Table 1: Physical characteristics of the soil sample

Physical characteristics	Values/ Results
Moisture content (%)	8.56
Bulk density (g cm^{-3})	5.02
Particle size distribution	Sand: 50%
	Silt: 10%
	Clay: 40%
Textural class	Sandy clay

Table 2: Chemical characteristics of the soil and cow dung bioslurry used as soil amendment

Chemical characteristics	Soil	Fresh Cow dung bioslurry	Dry Cow dung bioslurry
pH (H_2O)	6.8	7.8	8.2
pH (KCl)	6.4	7.4	7.7
Organic carbon (%)	0.85	10.02	9.80
Organic matter (%)	1.47	17.70	17.00
Total Nitrogen (%)	0.11	1.8	1.2
C:N	7.73	5.57	8.17
Available Phosphorus (ppm)	7.58	18	22
NH_4-N (µg kg^{-1})	3.45	ND	ND
NO_3-N (µg kg^{-1})	5.87	ND	ND
Exchangeable acidity (cmol/kg)	0.31	ND	ND
Calcium (c mol/kg)	3.48	10.58	9.8
Potassium (c mol/kg)	0.4	0.61	0.76
Sodium (c mol/kg)	1.08	1.12	1.23
Magnesium (c mol/kg)	1.55	5.2	3.2
Cation Exchange Capacity	5.51	17.51	14.99

ND = Not determined

higher than fungal population in soil and in the bioslurries may be due to the pH of soil and cow dung bioslurries which were near neutral to slight alkaline. These most probably favored more bacteria growth. Bacterial growth increased fourfold between pH 4 and 8 according to Fernandez-Calvino and Baath (2010). Also, the microbiological population was comparatively higher in fresh cow dung bioslurry compared to dry cow dung bioslurry and soil.

Table 4 shows the population of bacteria and fungi in soils amended with different levels of cow dung bioslurry. Bacterial population was also higher than fungal population in soils amended with different levels of cow dung bioslurry. These could also be a result of the pH of amended soil which were neutral to slight alkaline . Among all the treatments BF2 (2% amendment) showed significantly higher fungal population. The microbial population showed the trend in decreasing order as BF2>BD2>BF1>BD1>B0.

The cultural and microscopic features of fungi isolated from bioslurry amended soils are shown in Tables 6. Five strains of bacteria and eight strains of fungi were encountered in the soils amended with cow dung bioslurry.

Table 3: Microbiological enumeration of the soil and cow dung bioslurry used for the study

Source of isolates	Fungal population (cfu/g) $\times 10^4$	Bacterial population (cfu/g) $\times 10^6$
Soil sample	2.00	2.33
Fresh cowdung bioslurry	3.67	5.33
Dry cow dung bioslurry	2.67	3.33

Table 4: Population of fungi and bacteria in soils amended with different forms and levels of cow dung bioslurry at 85 days of incubation

Source of isolates	Fungal population (cfu/g) $\times 10^5$	Bacterial population (cfu/g) $\times 10^6$
B0 (Control)	2.57	6.27
BD1 (1% amendment)	3.73	6.00
BD2(2% amendment)	4.57	8.33
BF1(1% amendment)	4.43	6.67
BF2 (2% amendment)	5.23	9.33

B0= Unamended soil, BD1= Soil amended with 1% of dry cow dung bioslurry, BD2= Soil amended with 2% of dry cow dung bioslurry, BF1= Soil amended with 1% of fresh cow dung bioslurry, BF2= Soil amended with 2% of fresh cow dung bioslurry.

Table 5: Microorganisms isolated from soil and cow dung bioslurry used for the study

Source of isolates	Organism name (Fungi)	Organism name (Bacteria)
SS	Aspergillus niger	Providencia sp
	Fusarium oxysporum	Staphylococcus sciuri
	Aspergillu s parasiticus	
FCB	Cladosporium sp	Providencia sp
	Penicillium sp	Providencia vermicola
	Aspergillus flavus	Bacillus subtillis
DCB	Phoma sp	Providencia sp
	Penicillium sp	Bacillus subtillis
	Aspergillus flavus	

SS= Soil Sample, FCB= Fresh cow dung bioslurry, DCB= Dry cow dung bioslurry

Table 6: Microorganisms isolated from soil amended with different forms and levels of cow dung bioslurry at 85 days of incubation

Source of isolates	Organism name (Fungi)	Organism name (Bacteria)
B0 (Control)	Aspergillus niger	Staphylococcus sciuri
	Aspergillus parasitcus	Bacillus safensis
	Fusarium oxysporum	
BD1	Aspergillus flavus	Providencia sp
	Penicillium sp	Providencia vermicola
	Phoma sp	
BD2	Phoma sp	Providencia sp
	Cladosporium sp	Providencia vermicola
	Aspergillus niger	
BF1	Cladosporium sp	Providencia sp
	Aspergillus niger	Providencia vermicola
	Penicillium sp	Bacillus subtilis
	Aspergillus flavus	
BF2	Cladosporium sp	Providencia sp
	Aspergillus flavus	Providencia vermicola
	Fusarium solani	Bacillus subtilis
	Aspergillus parasitcus	

B0= Unamended soil, BD1= Soil amended with 1% of dry cow dung bioslurry
BD2= Soil amended with 2% of dry cow dung bioslurry, BF1= Soil amended with 1% of fresh cow dung bioslurry, BF2= Soil amended with 2% of fresh cow dung bioslurry.

Carbon mineralization pattern of fresh and dry cow dung bioslurry from the soil

The carbon mineralization pattern of fresh and dry cow dung bioslurry from the soils is shown in Figure 1. In an absolute basis, carbon mineralization from cow dung bioslurry of the soil were 17.82, 33.33 and 36.85 mg C 200 g soil^{-1} 85 days from the different treatments respectively. The carbon mineralization rate for all the selected soils increased slowly. At the 43rd day of incubation there was a high increase of carbon mineralization rate of 41.25 mg C/200g soil for the fresh cow dung bioslurry compared to other treatments. On the 71st day of incubation, the highest carbon mineralization rate was obtained from the fresh cow dung bioslurry and then falls on the 85th day of incubation in the treatments.

Carbon mineralization pattern of the different forms and levels cow dung bioslurry from the soil

Figure 2 shows the carbon mineralization patterns of the different forms and levels cow dung bioslurry from the soil at 2g/ 200g (1%) soil and 4g/ 200g (2%) respectively. It is seen that carbon mineralization of different levels of dry cow dung slurry started exponentially and continued up to 71st day of incubation and then fell at 85th day of incubation.

There was increased carbon mineralization rate in the two levels of fresh cow dung bioslurry between 0day and 9th day of incubation. On the 12th day of incubation, there was an increase at 2g/ 200g (1%) soil and 4g/ 200g (2%) of fresh cow dung bioslurry amend soil. On the 71st day of incubation the two levels of fresh cow dung bioslurry reached its highest peak and fell after 2 weeks (85th day of incubation).

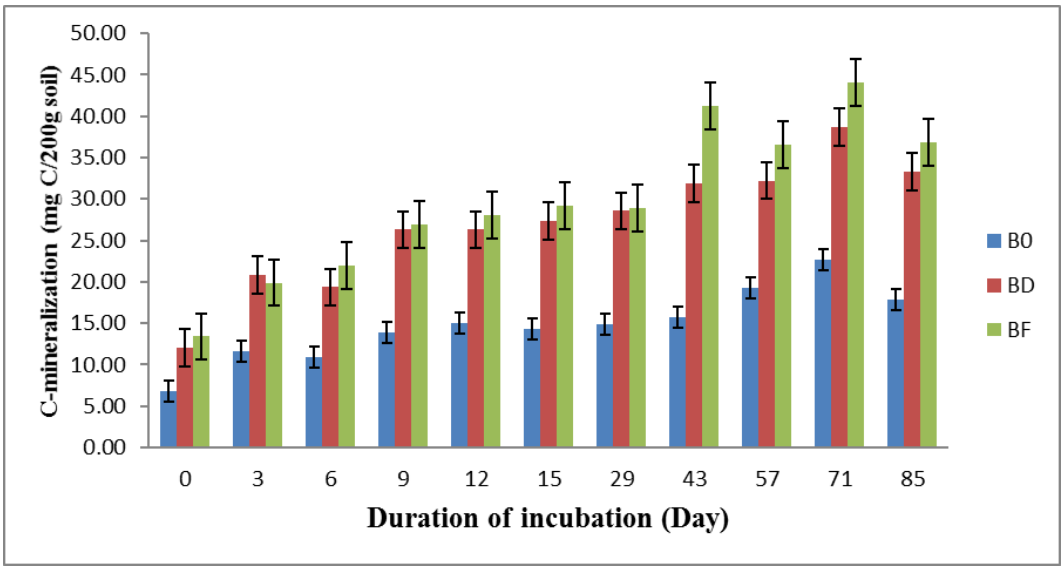

Figure 1: Carbon mineralization pattern of fresh and dry cow dung bioslurry in the soil.
B0: control; BD: dry cow dung bioslurry; BF: fresh cow dung bioslurry

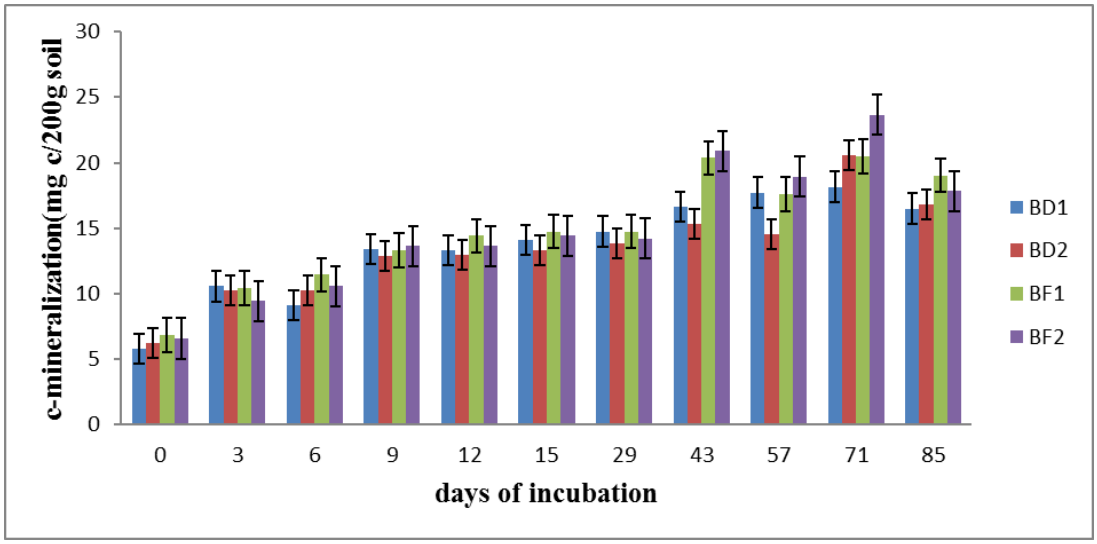

Figure 2: Carbon mineralization pattern of the different forms and levels cow dung bioslurry from the soil.
BD1: 2g of dry cow dung bioslurry; BD2: 4g of dry cow dung bioslurry
BF1: 2g of fresh cow dung bioslurry; BF2: 4g of fresh cow dung bioslurry

NH_4-N mineralization of fresh and dry cow dung bio-slurry

The NH_4-N mineralization was varied by forms (fresh and dry cow dung bioslurry) and incubation time. The extent of NH_4-N mineralization of treatments under anaerobic conditions is presented in Figure 3. Fresh cowdung bioslurry had the highest release of NH_4-N followed dry cow dung bioslurry and least release is the control.

Comparing the NH_4-N mineralization between 2g and 4g of both fresh and dry cow dung bioslurry (Figure 4), higher NH_4-N mineralization was observed at 4g of fresh and dry cow dung bioslurry application rates than 2g of fresh and dry cow dung bioslurry. The NH_4-N mineralization increased progressively and reached its peak within 15th to 29th day of incubation, and then it decreased gradually from 43rd day of incubation. Similar results were also described by Walpola and Arunakumara (2010) that the NH_4-N content reached its peak at day-14 followed by gradual reductions in all the animal manure (poultry manure, goat manure and cowdung) treatments. NH_4-N is therefore found as the dominant form of N under anaerobic soil condition. Maithani *et al.* (1998) and Calderon *et al.* (2004) also observed NH_4-N as the dominant form of inorganic N in anaerobic soils.

NO_3-N mineralization of fresh and dry cow dung bio-slurry

The trend of NO_3-N mineralization under anaerobic conditions is shown in Figure 5. Across the treatments the highest NO_3-N mineralization rate was from 4g of dry cow dung bioslurry compared to other treatments.

Comparing the NO_3-N mineralization between 2g and 4g of both fresh and dry cow dung bioslurry (figure 6), it was observed that 4g of dry cow dung bioslurry application rates releases higher NO_3-N mineralization between 15th and 29th days of incubation over 2g of dry cow dung bioslurry, while 2g of fresh cow dung bioslurry. application rates releases higher NO_3-N mineralization between 15th and 29th days of incubation over 4g of dry cow dung bioslurry.

The NO_3-N mineralization increased progressively and reached its peak within 15th to 29th day of incubation, then it decreased gradually from 43rd day of incubation.

The NO_3-N mineralization was also strongly influenced by incubation period. Anaerobic condition has been reported that not favorable for NO_3-N availability in the soil (Haque *et al.*, 2015).

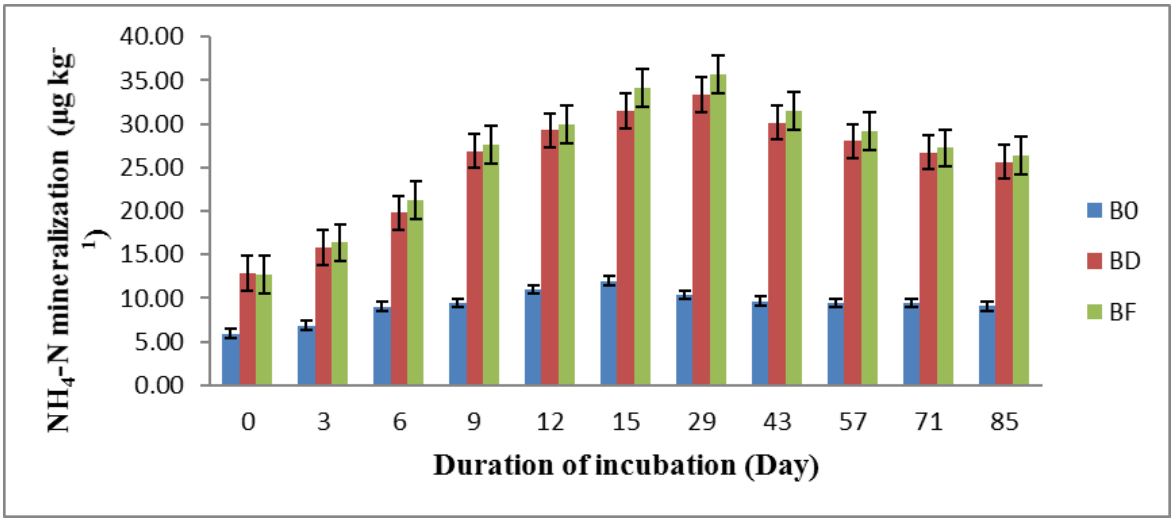

Figure 3: NH_4-N mineralization pattern of fresh and dry cow dung bioslurry in the soil.
B0: control; BD: dry cow dung bioslurry; BF: fresh cow dung bioslurry

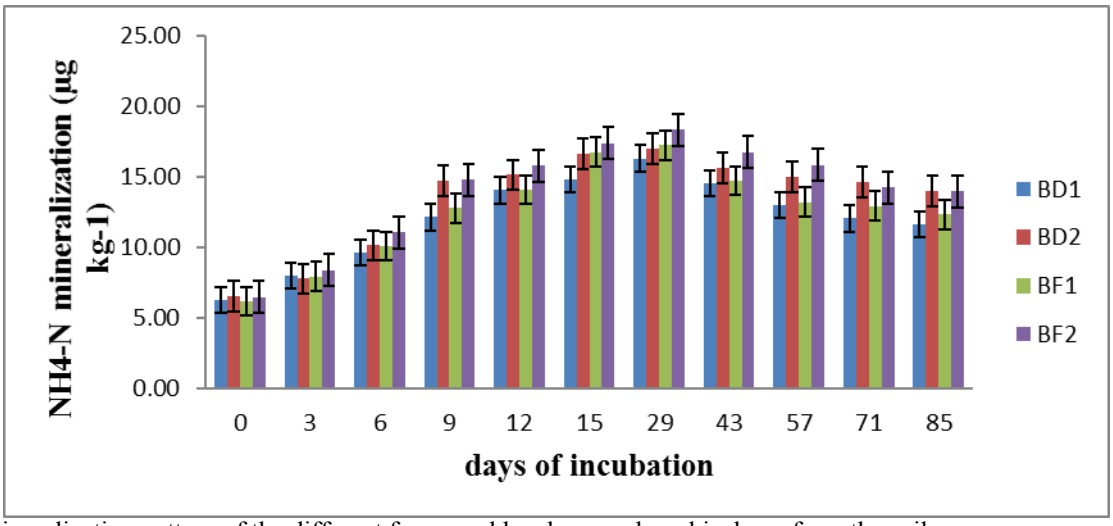

Figure 4: NH_4-N mineralization pattern of the different forms and levels cow dung bioslurry from the soil.
BD1: 2g of dry cow dung bioslurry; BD2: 4g of dry cow dung bioslurry
BF1: 2g of fresh cow dung bioslurry; BF2: 4g of fresh cow dung bioslurry

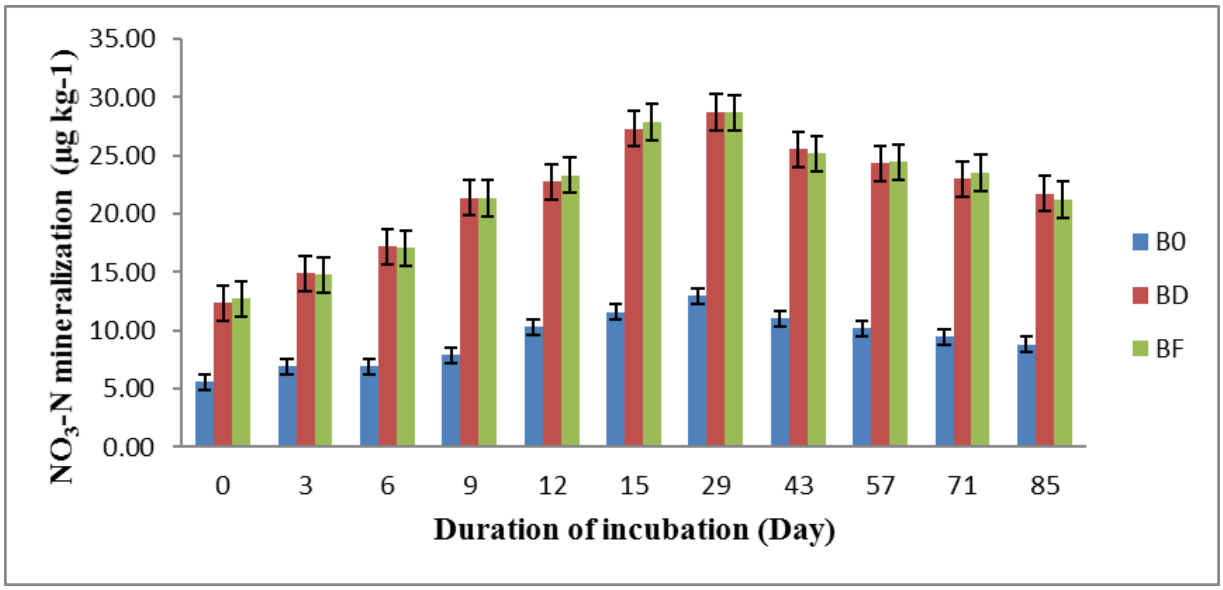

Figure 5: NO_3-N mineralization pattern of fresh and dry cow dung bioslurry in the soil
B0: control; BD: dry cow dung bioslurry; BF: fresh cow dung bioslurry

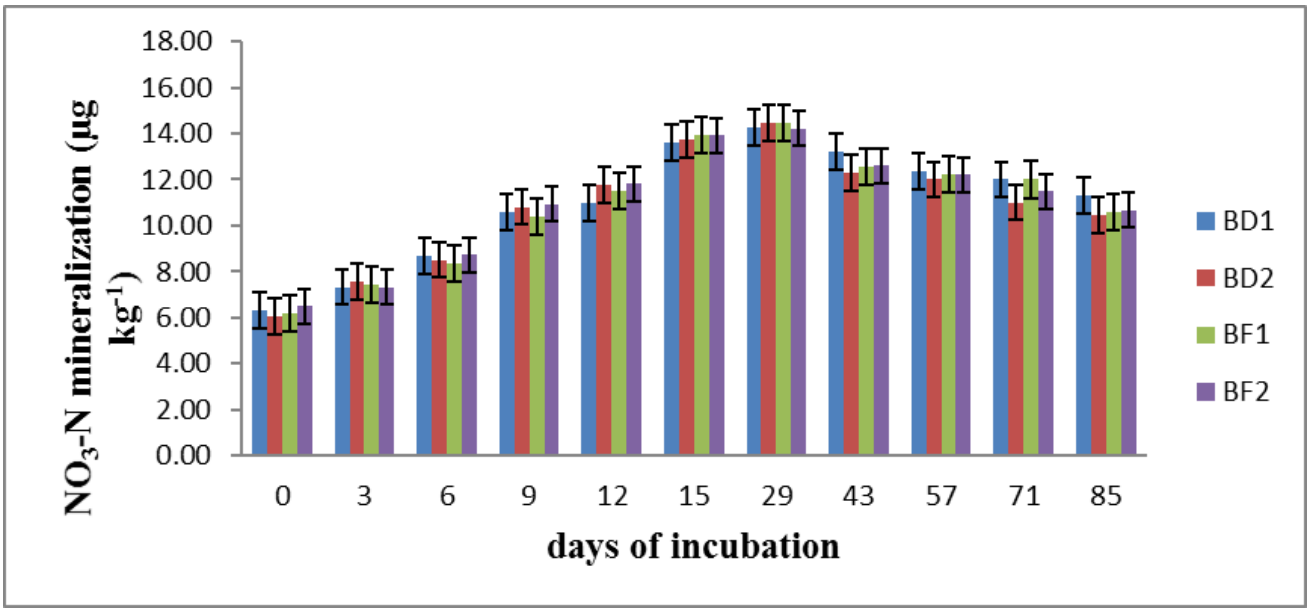

Figure 6: NO_3-N mineralization pattern of the different forms and levels cow dung bioslurry from the soil.
BD1: 2g of dry cow dung bioslurry; BD2: 4g of dry cow dung bioslurry
BF1: 2g of fresh cow dung bioslurry; BF2: 4g of fresh cow dung bioslurry

Net-N mineralization of fresh and dry cow dung bioslurry
Net-N mineralization (calculated by addition of NH_4-N and NO_3-N) of fresh and dry cow dung bioslurry is presented in Figure 7. Among the treatments under this study, fresh cowdung bioslurry showed the highest Net-N mineralization throughout the incubation period. The Net-N mineralization was varied by forms (fresh and dry cow dung bioslurry) and incubation time. Fresh cowdung bioslurry had the highest release of Net-N followed by dry cow dung bioslurry and least release is the control.

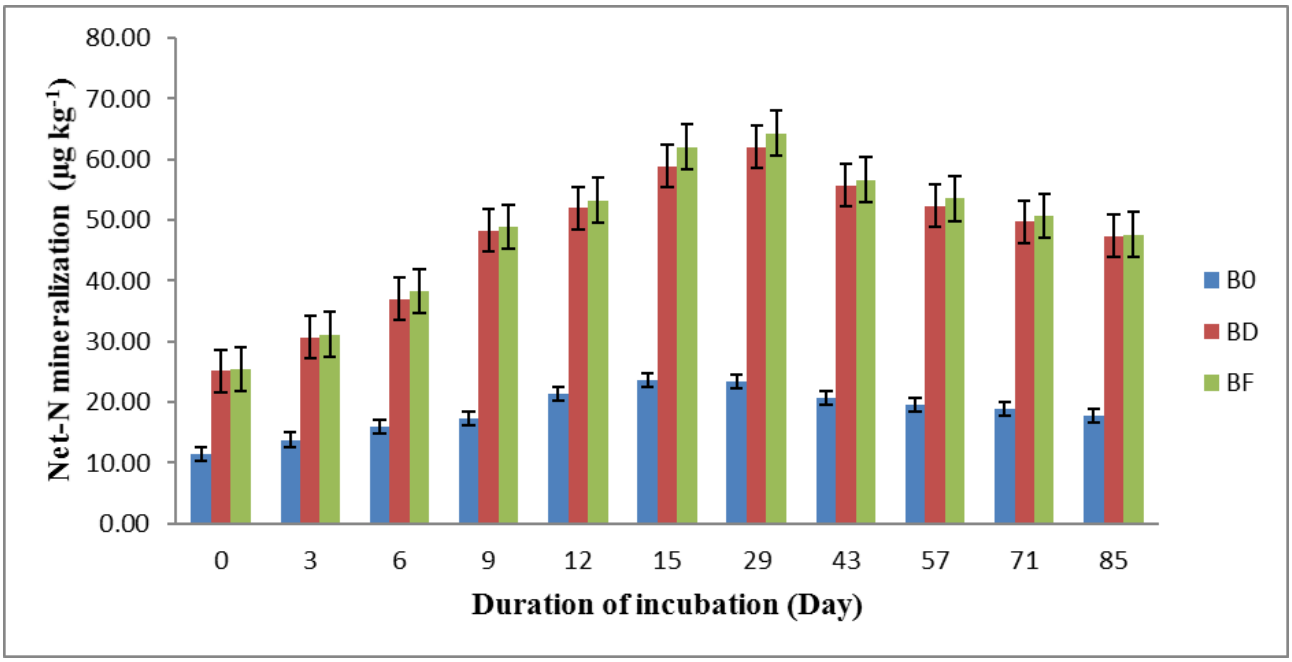

Figure 7: Net-N mineralization pattern of fresh and dry cow dung bioslurry in the soil
B0: control; BD: dry cow dung bioslurry; BF: fresh cow dung bioslurry

Relationships between the Carbon and Nitrogen mineralization and chemical properties of the amended soil
Correlation analysis was carried out between the carbon and nitrogen mineralization and chemical properties of the amended soil (Table 7). Carbon mineralization was not significant correlated with chemical properties of the amended soil. There was significant ($P<0.05$) negative correlation between the nitrogen mineralization and some chemical properties of the amended soil: organic carbon, organic matter, carbon and nitrogen ratio and pH in both H_2O and in KCl. While the total nitrogen, available phosphorus, cation exchangeable capacity and effective cation exchange capacity significantly and positively correlated with nitrogen mineralization.

Table 7: Pearson correlation of carbon and nitrogen mineralization and chemical properties of the amended soil

	C-min	**NH_4-N**	**NO_3-N**	**pH H_2O**	**pH KCl**	**OC**	**OM**	**E.A**	**T.N**	**C:N**	**Avail.P**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ECEC**
C- min	1.00																
NH_4-N	-0.14	1.00															
NO_3-N	-0.28	0.90**	1.00														
pH H_2O	-0.40	-0.67*	-0.57*	1.00													
pH KCl	-0.23	-0.73*	-0.68*	0.84**	1.00												
OC	-0.13	-0.63	-0.62*	0.66*	0.84**	1.00											
OM	-0.13	-0.63*	-0.62*	0.66*	0.84**	0.99**	1.00										
E.A	-0.21	-0.30	-0.23	0.48	0.22	0.30	0.30	1.00									
T.N	0.16	0.72*	0.62*	-0.62*	-0.64*	-0.34	-0.34	-0.33	1.00								
C:N	-0.08	-0.86**	-0.82**	0.79**	0.90**	0.87**	0.87**	0.35	-0.68*	1.00							
Avail.P	-0.12	0.82**	0.74*	-0.66*	-0.68*	-0.57*	-0.57	-0.14	0.67*	-0.74*	1.00						
Ca	0.16	0.83**	0.74*	-0.82**	-0.89**	-0.79**	-0.79**	-0.46	0.71*	-0.89**	0.78**	1.00					
Mg	0.10	0.88	0.85**	-0.76**	-0.86**	-0.80**	-0.79**	-0.26	0.73*	-0.92**	0.87**	0.91**	1.00				
Na	-0.16	0.09	0.06	-0.11	0.05	0.39	0.39	-0.07	0.31	0.08	0.25	0.14	-0.01	1.00			
K	-0.10	0.27	0.39	0.14	0.02	-0.001	0.002	0.08	0.15	-0.10	0.09	0.04	0.28	-0.21	1.00		
CEC	0.10	0.89**	0.83**	-0.76**	-0.85**	-0.78**	-0.78**	-0.37	0.75*	-0.92**	0.86**	0.96**	0.98**	0.08	0.23	1.00	
ECEC	0.07	0.88**	0.83**	-0.71*	-0.85**	-0.77**	-0.77**	-0.20	0.73*	-0.91**	0.88**	0.92**	0.98**	0.07	0.25	0.99**	1.00

** =0.01, *=0.05. C-min=Carbon mineralization, NO_3-N-=Nitrate mineralization, NH_4-N=ammonium mineralization, OC=organic carbon, OM=organic matter, Ex.A= Exchangeable acidity, Avail.P= Available Phosphorus, T.N= Total nitrogen, C.N=Carbon- Nitrogen ratio, K= Potassium, Ca= Calcium, Mg= Magnesium, Na=Sodium, CEC= Cation Exchange Capacity, ECEC=Effective cation exchange capacity.

4.0 Conclusion and Recommendation

The findings from this study led to the conclusions that the application of fresh and dry cow dung bio-slurry to the selected soils resulted in the release of CO_2, NO_3-N and NH_4-N.The mineralization of CO_2, NH_4-N and NO_3–N were higher in the fresh cow dung bioslurry than dry cow dung bioslurry. Drying will therefore not be necessary. NH_4-N mineralization was higher than NO_3-N mineralization due to the anaerobic condition.. Apart from improving soil fertility, addition of organic amendment is important in the release of nutrients for plant use.

In order to derive more benefits from this types of research work, I recommend that cow dung at 1% and 2% levels for use in this agro ecology to increase soil nutrient levels . Future work is needed to test the effects of the crop productivity.

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