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Determination of nitrogen mineralization in an open dumpsite soil treated with poultry manure in Anyigba, Nigeria.

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Abstract

Nitrogen mineralization is the process of conversion of organic nitrogen to a useful form for plant use. A pot experiment was conducted at Soil and Environmental Management Department of Kogi State University Anyigba to determine nitrogen's mineralization rate in an open dumpsite soil treated with organic manure. About 1.6kg of soil sample was collected from Fallow land where no fertilizer history has been recorded and at three different dumpsite soil (Ate-Iji dumpsite (DS1), Ijebu-Ode dumpsite (DS2) and Iyale road dumpsite (DS3)) in Anyigba at a depth of 0-15cm and was put inside a pot, which was replicated three times. The spacing between pots was 8m×5m range in completely randomized design (CRD). The soil's physicochemical properties were determined, 20g of poultry manure was added to each pot at a constant rate excluding the control pots (fallow land soil). The soil was stirred, and water was added at regular interval. The mineralization rate of nitrogen was determined after 14days, 28days and 56 days of treatment application. Nitrate (NO_3-N), ammonium (NH_4^+–N) and nitrite (NO_2-N) was calculated from total nitrogen. The data was analyzed, and treatments mean separated using Least Significant Difference (LSD). Poultry manure had a significant influence on the mineralization rate of nitrogen. DS3 soil gave the highest mineralization values for all the nitrogen forms. Highest values of 184.5mg/kg of NH_4^+ was recorded after 14days of mineralization in DS3 soil, while the highest value of 470.8mg/kg of $NO_2^-$was recorded after 14days of mineralization in DS3 soil and the highest value of 634.5mg/kg of NO_3^- was recorded after 14days of mineralization compared to other dumpsite soil. The fallow land which serves as control gave the lowest mineralization values for all the nitrogen forms, and this indicated that organic manure has a greater impact in nitrogen mineralization in soil when applied to the soil within 28 days

Keywords: Nitrogen; poultry manure; mineralization; open dumpsite .

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1.0. Introduction

Nitrogen is one of the crucial nutrients that influence plant productivity and the ecosystem's sustainability (Arsian *et al.,* 2010). Nitrogen is required by the plant in a larger amount than other soil- born elements (Marschner, 1995). Nitrogen is vital for normal plant growth, biological processes; nitrogen is a basic constituent of protein, a nucleic acid. Nitrogen also plays significant roles in plant metabolism chlorophyll formation, hormones and vitamins (Marschner, 1995). Nitrogen is obtained from the soil through mineralization of soil organic matter by soil microorganism. Nitrogen mineralization has been defined as converting organic nitrogen to plant the available form of nitrogen, vital for ecosystem productivity. Several researchers have reported nitrogen mineralization to play an essential role in ecosystem productivity and nutrients cycling in soil (Vitousek, 1997; Jordan, 1996).

The dumpsite is a general land disposal area and generally known for its characteristics such as its exposure directly to the atmosphere (Igwe *et al.,* 2002). Dumpsite soil contains solid wastes materials that have been discarded after it has served its purpose or is no longer useful, such wastes comprises of domestic refuse, wood, hospital waste, agricultural waste, polythene bags, plastics, broken glass, abandoned automobiles and parts, demolition wastes, ash, human and animal waste, dust and leaf litters (Awomeso *et al.,*2010). Since people of this region are mainly dependent on agriculture for their livelihood; therefore, open dumpsites waste composition is highly organic. For such waste, optimized biological processes reuse, and recovery would be preferable, the mineralization of nitrogen in open dumpsites soil is essential because, the mineralization processes convert the green waste, agricultural or solid waste in dumpsites soil to organic fertilizers such as compost (Favoino and Hogg, 2008; Hargreaves *et al.,* 2008b; Boldrin *et al.,* 2009, Kumar, 2011)

Therefore, the composted waste's fertilizer value has been extensively studied, but little work was done on livestock waste (Scotti et al., 2015; Rigby et al., 2016; Shah et aal2012, 2013, 2016a, b; Moreno *et al.,* 2017). Thus, understanding the mineralization of nitrogen in dumpsites soil could be an essential means of managing nitrogen in the soil and recycling the dumpsite soil by applying organic manure as a promising option for a healthy environment and sustainable agriculture. This research aimed to determine the nitrogen mineralization rate in an open dumpsite soil treated with poultry manure in Anyigba, Nigeria.

2.0 Material and Method

2.1. Study location

The study was conducted in Anyigba, Kogi State, Nigeria. Anyigba is situated in Dekina Local Government of Area of Kogi State. Anyigba is bordered by Dekina town, which is just about 32km away (Jumiatravels.com, 2018). It is located on Latitude $7^0$15"-$7^0$29" N and Longitude $7^0$11"-$7^0$32" E and on an altitude of 420m above sea level (Department of Geography and planning, KSU, Anyigba). Anyigba is endowed with a hot and humid climate. The climate is characterized by the seasonal alternation of the Tropical Continental (TC) and Tropical Maritime (TM) air masses and all year round high temperature with an annual range of 24.1^0-31.2^0C. It experiences a fairly distinct rainy season (April '3.7mm'-October '4.3mm') and sometimes very little residual rain (SAS publication.com, 2017).

2.2. Soil sample collection and preparation

About 1.6kg of Soil samples were collected from a fallow land where no history of organic and inorganic fertilizer use has been recorded and from three (3) different dumpsites in Anyigba at a depth of 0-15cm with the aid of an auger at three samples location in each dumpsite, 5m×5m from each other. A total of 12 soil samples were collected. The soil was passed through a 4–mm sieve to eliminate coarse rock and plant material, thoroughly mixed to ensure uniformity and was put inside a polythene bag for pot experiment and prepared for analysis.

2.3. Pot experiment

The pots (perforated at the bottom) was filled with soil from each dumpsite location and from fallow land (control land) where no history of organic and inorganic fertilizer use has been recorded, the samples were replicated three times. The spacing between pots were 8m×5m arranged in a completely randomized design (CRD)

2.4. Soil analysis

The physical and chemical properties were determined. A litre of water was added to each pot and mixed properly. This is to supplement the water that would be lost during mineralization days.

2.5. Collection of Poultry Manure

Poultry manure was collected directly from the livestock section of research and demonstration farm of Kogi University, Anyigba, Nigeria. A composite sample of well-rotted Poultry manure was air-dried, crushed into smaller particles by hand pressing, homogenized, and passed through a 1–mm sieve. Poultry manure was analyzed for total N, total carbon (C), P, K and C/N ration. 20g of poultry manure was added to all pots at a constant rate excluding the control pots (soil samples obtained from the fallow land without organic and inorganic fertilizer history). The samples were stirred, and another litre of water was added. The mineralization of nitrogen was determined in the soil sample after 14days, 28days and 56days of treatment application.

2.6. Soil Analysis

After 14days, 28days and 56days, the soil samples were analyzed for total mineral nitrogen (TMN) and ammonium -N (NH_4^+–N), nitrate-N (NO_3-N) and nitrite-N (NO_2-N). The concentration of total mineral nitrogen (TMN) was determined using micro Kjedal and ammonium-N (NH_4^+–N), nitrate-N (NO_3-N) and nitrite-N (NO_2-N) was determined by extracting soil samples with 200 ml of 2 M KCl added directly to the flask. After that, triplicate samples from each treatment were removed randomly at different mineralization days and extracted by shaking for 1 hour with 200 ml of 2 M KCl followed by filtration through Whatman's No.40 filter paper. The extract's mineral N-contents were determined using the steam distillation and titration method (Keeney and Nelson, 1982). NH_4^+–N, NO_3-N and NO_2-N were calculated from total mineral N using a conversion formula/method used by previous researchers who worked on Nitrogen Mineralization of a Loam Soil Supplemented Organic-Inorganic Amendments under Laboratory Incubation. (Abbasi and Adams, 2000; Abbasi et al., 2001; Abbasi and Khizar, 2012).

Statistical analysis

The data collected were subjected to Analysis of Variance (ANOVA). Separating significant means was carried out using the Least Significant Difference (LSD)

Table 1. Physical and chemical properties of the soil used for the experiments at 0-15cm depths

Soil properties	Fallowed land (control)	Ate-Iji dumpsite (DS1)	Ijebu-Ode dumpsite (DS2)	Iyale-road dumpsite (DS3)
%sand	82.36	81.30	85.52	80.36
%silt	0.44	0.50	0.88	0.48
%clay	17.20	18.20	13.60	19.20
pH 1.2	5.3	6.6	6.8	7.1
Organic carbon (%)	1.10	1.86	1.88	2.54
Total nitrogen (%)	0.06	0.09	0.09	0.13
Available P (mg/kg)	8.82	26.43	24.11	20.58
Sodium (Cmol/kg)	0.35	0.56	0.55	0.60
Magnesium (Cmol/kg)	3.03	7.83	7.42	6.65
Potassium (Cmol/kg)	2.72	6.20	5.61	5.02
Calcium (Cmol/kg)	3.67	8.23	8.51	7.94
Exchangeable acidity	1.17	0.84	0.92	1.06
CEC (Cmol/kg)	10.94	23.66	23.01	21.27

Table 2. The nutrient contents of the poultry manure used as treatment.

Sample	N%	OC%	P	K	C/N	NO_3^-	NH_4^+	NO_2^-
Poultry manure	2.89	26.1	2.48	1.42	9.03	12.8	3.72	9.48

Table 3 Mean values of NH_4^+-N (mg/kg) released from the mineralization of dumpsite soils treated with poultry manure at 14 days, 28days and 56 days of mineralization (DOM),

LOCATIONS	14 DOM	28 DOM	56 DOM
Fallowed land (control)	103.0^b	98.7^b	90.1^b
Ate-Iji dumpsite (DS1)	158.7^a	171.6^a	158.2^a
Ijebu-Ode dumpsite (DS2)	154.4^a	158.7^a	150.2^a
Iyale road dumpsite (DS3)	175.9^a	184.5^a	184.0^a
LSD	43.7	46.95	36.11
SEM	12.63	13.57	10.44

LSD=Least Significant Difference; Note: value with the same letter (s) are not significantly different, SEM= Standard Errors of Means, DS= Dumpsite.

Table 4 Mean values of NO2--N (mg/kg) released from the mineralization of dumpsite soils treated with poultry manure at 14 days, 28days and 56 days of mineralization (DAM)

LOCATIONS	14 DAM	28 DAM	56 DAM
Fallowed land (control)	262.8^b	251.8^b	230.0^b
Ate-Iji dumpsite (DS1)	405.2^a	438.0^a	405.2^a
Ijebu-Ode dumpsite (DS2)	394.2^a	405.2^a	383.2^a
Iyale road dumpsite (DS3)	449.0^a	470.8^a	470.0^a
LSD	111.55	119.82	92.17
SEM	32.24	34.63	26.63

LSD=Least Significant Difference; Note: value with the same letter (s) are not significantly different, SEM= Standard Errors of Means, DS= Dumpsite.

Table 5: Mean values of NO3--N (mg/kg) released from the mineralization of dumpsite soils treated with poultry manure at 14 days, 28days and 56 days of mineralization (DAM)

LOCATIONS	14 DAM	28 DAM	56 DAM
Fallowed land (control)	354.2^b	339.4^b	309.9^b
Ate-Iji dumpsite (DS1)	546.0^a	590.3^a	545.9^a
Ijebu-Ode dumpsite (DS2)	531.2^a	546.0^a	516.5^a
Iyale road dumpsite (DS3)	605.0^a	634.5^a	600.0^a
LSD	150.33	161.48	124.21
SEM	43.44	46.66	35.89

LSD=Least Significant Difference; Note: value with the same letter (s) are not significantly different, SEM= Standard Errors of Means, DS= Dumpsite.

3.0. Results

3.1. Soil properties

The soil properties of the soils used for the analysis were shown in Table 1. The % sand ranges from 80.36 to 85.52 while the highest value was recorded in dumpsite soil (DS2) with 85.52%. The % silt range from 0.44 to 0.88, with the highest value recorded in dumpsite soil (DS2) with 0.88%. % clay ranges from 13.60 to 17.20 with the highest value recorded in dumpsite soil (DS3) with 19.20%

Soil pH values range from 5.3 to 7.1; the organic carbon ranges from 1.10 to 2.54%; the highest value was recorded in dumpsite soil (DS3) with 2.54%. The total nitrogen ranges from 0.06 to 0.13Nkg^{-1}. The highest value was recorded in dumpsite soil (DS3) with 0.13 $N\ kg^{-1}$. The available phosphorus ranges from 8.82 to 26.43mg/kg while the highest value was recorded in dumpsite soil (DS1) with 26.43mg/kg.

For the exchangeable bases, the sodium value ranges from 0.35cmol/kg to 0.56cmol/kg, the potassium value ranges from 2.72cmol/kg to 6.20cmol/kg, while the highest sodium and potassium was recorded in dumpsite soil (DS1) with 0.56cmol/kg for sodium and 6.20cmol/kg for potassium. Calcium value range from 3.67cmol/kg to 8.51cmol/kg, highest value was recorded in dumpsite soil (DS2) with 8.51cmol/kg. The exchangeable acidity ranges from 0.84 to 1.17, while the highest was recorded in fallow land (control). The soil's cations exchangeable capacity ranges from 10.94 to 23.66 while the highest was recorded in dumpsite soil (DS1) with 23.66cmol/kg.

Table 2 show the nutrient contents of the poultry manure used as treatment. The range of nitrogen content was 2.89%, % organic carbon was 26.0, and available phosphorus was 2.48mg/kg, potassium content was 1.42mg/kg, and C/N ratio was 9.03, NO_3^- contents were 12.8, NH_4^+ content was 3.72 and NO_2^- the content was 9.48

Table 3 show the Mean values of NH_4^+-N (mg/kg) released from the mineralization of dumpsite soils treated with poultry manure at 14 days, 28days and 56 days of mineralization (DAM). There were no significant differences among the NH_4^+-N (mg/kg) in the soil. The dumpsite soil (DS3) gave the highest mineralization of NH_4^+-N (mg/kg) at 28days with the value 184.5 mg/kg while the lowest value of 90.1 mg/kg was recorded in the fallowed land (control) at 56 days.

Table 4 shows mean values of NO_2^--N (mg/kg) released from the mineralization of dumpsite soils treated with poultry manure at 14 days, 28days and 56 days of mineralization (DAM). The dumpsite soil (DS3) gave the highest mineralization of NO_2^--N (mg/kg) with the value of 470.8 mg/kg at 28days while the lowest value of 230.0 mg/kg was recorded in control at 56days

Table 5 shows Mean values of NO_3^--N (mg/kg) released from the mineralization of dumpsite soils treated with poultry manure at 14 days, 28days and 56 days of mineralization (DAM). It was observed that the value was not significantly different, the dumpsite soil (DS3) gave the highest mineralization of NO_3^--N (mg/kg) and the highest was recorded in a (DS3) with the value of 634.5 mg/kg at 28days of mineralization while the lowest value of 309.9 mg/kg was recorded in control at 56days

4.0. Discussion

The pH of the soil was neutral to basic. Organic carbon and nitrogen were low, and available phosphorus was high, exchangeable potassium, calcium and magnesium were moderate. Exchangeable sodium and exchangeable acidity were low, CEC was high. In general, the selected sites' chemical soil fertility is high due to CEC values; thus, in general, the soil of the selected sites is dominated by the base cation.

The nutrients content of poultry manure varies depending upon the condition under which it is processed. The poultry manure contained medium organic nitrogen contents, and this was in agreement with (Preusch *et al.,* 2002) that reported organic nitrogen fraction in compost and poultry manure.

The mineral nitrogen contents in the poultry manure range from low to medium due to the high activity of microorganism present in the poultry manure due to oxygen availability. This study was in conformation with Mowrer *et al.,* (2013) who found the small mineral nitrogen value in poultry litter samples. The amount of organic carbon, potassium, phosphorus in the poultry manure may be due to the number of flocks produced in the bed and environmental conditions, promoting a decrease in the C/N ration. (Kirchman and Witter, 1992: Nodar *et al.,* 1992: Nicholson *et al.,* 1996)

Due to a small C/N ratio in poultry manure, all its nitrogen is readily available forms with no immobilization by a microorganism. The low C/N of organic materials cause mineralization of nitrogen as they are decomposed, whereas the high C/N of organic materials cause immobilization of mineral nitrogen because available nitrogen is utilized by soil microbial biomass (Mary *et al.*, 1996, Calderon *et al.,* 2004).

In the present study, the lowest mineralization rate of nitrogen forms was recorded in the control land (fallow land), and the highest was recorded in the soils amended with manure; this was likely due to richness of the amended soil in organic matter and its heavier texture which is more favourable for organic matter retention and protection. This study was in agreement with the previous studies conducted by several researchers who reported more significant mineralization potential in soil with amendments and lower ratios in control soil (Kaur et al., 2005; Masto et al., 2006; Liu et al., 2010).

The mineralization of soil organic nitrogen begins with ammonification, the mean values of NH_4^+ concentrations in dumpsite soil reviewed lowest mineralization rates in control soil, at 56days and maximum concentration was recorded at 28 days mineralization days, this research was in agreement with previous researchers that work on organic amendments' mineralization in soil. The researchers reported that using organic amendments without fertilizer addition can decrease nitrification potential due to increased immobilization stimulated by organic manure (Fortuna et al., 2003; Chu et al., 2007).

Alizadeh *et al.* (2012) also showed that poultry manure treated soil had significantly higher total nitrogen mineralization than untreated soil, and this view was confirmed in our results.

It was observed that concentration of NH_4^+-N (ppm), NO_2^--N (ppm) and NO_3^--N (ppm) at 28days gave the highest results, this indicated that organic manure has a more significant impact in nitrogen mineralization in soil when applying to the soil under 28days. The concentration of NH_4^+-N (ppm), NO_2^--N (ppm) and NO_3^--N (ppm) in dumpsite soil treated with poultry manure was higher compared to control (fallow land) due to the available mineral nitrogen, and mineralizable organic nitrogen available in treatment applied. These results were in corroboration with Shah *et al.,* (2013) who worked on compost nitrogen mineralization under aerobic and anaerobic condition.

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