Research Article

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Environmental Implications of Municipal Dump Site on Soil Nitrogen in Calabar Metropolis, Nigeria

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Abstract

Organic matter exhibit strong variations in nitrogen retention and transformation cycle in soil. However, nitrogen could be altered by seasonal variations, leading us to hypothesize that the open municipal waste dump site in Calabar exposed to dry and wet season could alter nitrogen dynamics in that soil. A total of sixty (60) composite soil samples were collected at different landscape positions (summit crest, shoulder slope, toe slope, interfluve slope, valley floor) of a municipal dump site and a control (no refuse area) during the dry and wet seasons in Calabar and analyzed to ascertain the effects on forms and status of soil nitrogen. The soils were loamy sand across the study location with pH values of 4.50, 7.00, 6.70, 7.30, 5.00, 7.30 (dry season) and 5.00. 7.30, 7.00, 7.40, 5.90, 7.40 (wet season) for the control, summit crest, shoulder slope, toe slope, interfluve slope and valley floor accordingly. Values obtained for total nitrogen (N) from the study site were generally low (<0.21 %), with values for dry season slightly higher than the wet season. NH_4^+ recorded higher content in wet than in dry season with values ranging between 12.11-14.11 mg/kg (control), 14.60 - 15.90 mg/kg (Summit crest); 18.25 - 20.05 mg/kg (Shoulder slope), 18.30 - 20.20 mg/kg (Toe slope), 12.30 - 14.00 mg/kg (Interfluve slope) and 9.24 -11.07 mg/kg (Valley floor). The Shoulder and toe slopes recorded the highest NH_4^+ concentration in the wet season. No_2^- contents documented for the control site were within the ranges of 2.78- 3.20 and 3.22-3.62 mg/kg while the dumpsite had values between 2.49-3.45 and 2.98 -3.22 mg/kg was observed for the shoulder position, the toe slope contained between 2.30-2.75 and 2.70 -2.82 mg/kg, the inter fluve slope had similar ranges of 2.32-2.90 and 2.70-3.08 mg/kg, and the valley floor 2.45-2.60 and 2.78-2.98 mg/kg. No_2^- values were higher for the wet than dry season. NO_3^- nitrogen was observed to be excessive across the dumpsite with the highest values > 80 mg/kg obtained at the valley floor. The NO_3^- values were higher in dry season across the all the landscape positions than in the wet season. The values were equally higher for the dumpsite than the control. It was observed that the dumpsite soils contend excessive NO_3^- which could be converted to nitrous oxide (N_2O) thus contributing to green house (GHG) emissions. It was also noted that seasonal variation did not significantly affect the N content at the different landscape positions of the municipal dumpsite in Calabar. It is highly recommended that municipal waste be sorted and the organic materials composted to harness the rich NO_3^- content as observed in this research.

Keywords: *nitrogen distribution, dry and wet season, landscape positions, municipal dumpsite*

1. Introduction

Nitrogen (N) is a vital element in crop production and ironically, often the most limiting nutrient in plant nutrition (Krivtsov et al 2011). This is partly attributed to the ease in which nitrate (NO_3) and NH_4^+ forms of nitrogen are removed from soil. Nitrate (NO_3) nitrogen is readily soluble in water thus being leached away under heavy rainfall or excessive irrigation, particularly in coarse textured soils while the NH_4^+ form is readily volatilized and fixed by clay and soil organic matter (Paul and Clark, 1989).

Organic materials of plant and animal origins exhibit strong variations in nitrogen content and contribute about 90 % of soil's total nitrogen, thus playing a key role in the retention and transformation of N (Kelley and Stevenson 1995, Schulten and Schnitzer 1997). Nitrogen availability, is closely linked with the decomposition of organic matter, mineralization of organic nitrogen and the de-amination of the N-containing amino acid and amino sugar (Chu H, Grogan, 2010, Schimel and Bennett 2003). Soil organic matter though a key contributor to soil N, its decomposition process equally depletes significantly soil supplies of available NH_4^+ and O_2 for use by micro-organisms thus becoming temporarily unavailable for plant uptake (Ferrari, 1999; Miller and Donahue, 1995). Some researchers have documented that nitrogen dynamics in soils is largely dependent on soil-plant interactions (Paul and Clark, 1989) while others are of the opinion that nitrogen content of the soil could also be altered by seasonal variations in precipitation/water content of the soil (Öquist et al., 2009; Ågren and Wetterstedt 2007). The changes in soil nitrogen forms and availability have also been attributed to other processes that portray a high level of heterogeneity. Morris and Boerner (1998) found land scape positions and variation in patterns of soil moisture to control soil nitrogen dynamics while Ferrari (1999) observed variability of N forms and status in soil to be associated with leaf litter. Municipal waste trends across the globe generally, have depicted high organic matter (50-90 %) contents (Asomani-Boateng and Haight, 1999) leaving us to hypothesize that it may alter the N content of soil.

In Calabar, municipal wastes from medical facilities, residential and commercial areas are collected from designated dumping locations within the metropolis and deposited in an open dump overlaying a large expanse of an undulating landscape in Ikot Effanga Mkpa (Fig 1). Wastes at the dump site are exposed to the prevalent climatic conditions and are intermittently subjected to open burning to decrease its bulkiness. This research aims at evaluating the seasonal variation in soil nitrogen forms and status on an undulating landscape along a municipal dump site in Calabar municipality.

2. Materials and Methods

2.1 Location, climate and vegetation of the area

This experiment was carried out on different landscape positions at the municipal dump site located in Ikot Effanga Mkpa, Calabar municipality of Cross River State in Nigeria (figure 1). The area is a municipal dumpsite used by Calabar Urban evelopment Authority (CUDA) for municipal waste disposal and maintained by the Environmental Sanitation Authority (ESA). The waste dump spans over an area of 2,355 sq m. At the bottom of the slope is a stream where locals use for drinking and irrigation of their crops in dry season. The waste composition at the dump is not homogenous but a collection of different materials mainly domestic-household waste, hospital waste, industrial waste, faecal waste etc. with, organic waste fraction making up the largest proportion of it. The volume and composition of Calabar municipal waste is subject to seasonal variations.

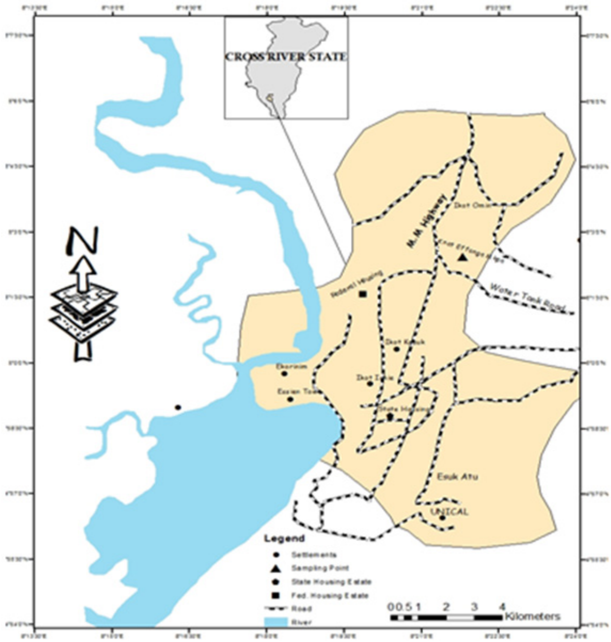

Figure 1: Map of the study area

Calabar lies between latitude 040 57" and 050 05" N and longitude 080 19" and 080 25"E. The study location falls within the lowland rainforest ecological zone with large areas of undisturbed forests (FAN, 2018). The study area is characterized with a mean annual rainfall of 2360 mm (range 2290-2680 mm) and a bi-modal distribution pattern with peaks in June to July and September to October. In August, the rainy season is intercepted by a short dry spell referred to as "August Break". Calabar observes a distinct dry season of 3-4 months (December to March) and wet seasons of 8- 9 months (March to November) with high ambient temperature and relative humidity throughout the year. The mean daily minimum temperature ranges from 21 to 25 o C while the mean maximum temperature varies from 27 to 30 o C. The mean relative humidity is between 82 - 87 % with tropical maritime winds of 60 - 70 % (FAN, 2018). Calabar is a semi- industrial and residential area.

2.2 Soil sampling procedure and preparation

The sampling location consisted of an undulating landscape located within latitude 050 02' N and longitude 0080 21'E in Calabar. Sampling points were established along the different land scape positions.Global positioning system (GPS) (Etrex 20) was used to determine the latitude, longitude and elevation of each slope position. Samples taken from the opposite plot near to the dump site served as control.

Five composite soil samples from each of the five identified landscape positions (Summit crest, Shoulder slope, Toe slope, Interfluve slope, Valley floor) and a control site were collected at a depth of 0-45 cm, with the aid of an auger. Eight samples were taken in each location and mixed thoroughly to represent a composite sample. A total of thirty ((30) composite samples were collected for each season (dry and wet) giving a total of 60 samples. Samples were collected in dry and wet seasons, representing dry and wet seasons, respectively. The soil samples collected were put in well labeled sampling bags and taken to the laboratory for analysis. The soil samples were air dried, ground, and passed through a 2-mm size sieve to remove materials greater than 2 mm in diameter.

2.3 Laboratory analysis

The prepared soil samples were subjected to analysis using standard procedures as outlined by Udo et al. (2009). Particle size distribution: Particle size distribution was determined by the Bouyoucos hydrometer method using sodium hexametaphosphate as a dispersant.

Soil pH: The pH of the soil was determined in a 1:2.5 soil/distilled water suspension using a glass electrode pH meter (Model No 7020. Electronic instrument limited, Kent). Organic carbon: Soil organic carbon was determined by the Walkley and Black wet oxidation method.

2.4 Forms of Nitrogen (N)

Total nitrogen (N): This was determined by the modified macro-Kjeldahl digestion method of Black et al. (1965) as outlined by Udo et al. (2009).Ammonium nitrogen (NH_4) - N: This was determined by Richardson's (1938) method as outlined by Udo et al. (2009). Ten (10) grams of soil sample was weighed into 250 - ml shaker bottle then 100 ml of 2 M KCl solution was added and shaken for I hour with the aid of a mechanical shaker. The supernatants were filtered using Whatman (No 42) filter papers. Five (5) ml of the extractant was used to develop the colour and readings were done at 636 nm using a spectrophotometer.

Nitrite (NO_2)-N : From the same extract above, 10 m1 aliquot from each sample were pipetted into 50 m1 volumetric flask and Two (2) m1 of 2 M HC1 added and made up-to 30 m1 with distilled water. Two milliliters (2 ml) Sulphanilic acid solution was also added, stirred and allowed to stand for 5 minutes. Alpha –naphthy lamine solution (10 m1) was added to the flask and made up to mark with distilled water. Five minutes was allowed for colour development. The absorbance was read at 520 nmand NO_2 - N was extrapolated using standard curve concentration (Udo et al., 2009) .

Nitrate (NO_3): Thenitrate nitrogen was determined by weighing into the shaking bottles, 20 g of the experimental soil sample and 100 ml solution of 0.25 M K_2So_4 was added and shaken for 30 minutes. The mixture was flittered through a Whatman No 42 filter paper. Colour was developed by Brucine Colorimetric method. 10 ml aliquot of the experimental soil was transferred into 25 ml volumetric flask and 10 ml of concentrated K_2So_4 was rapidly added to 2 ml of brucine reagent. It was mixed for 30 seconds and allowed to stand for 5 minutes 5 seconds. It was allowed to cool for 15 minutes and made up to mark with distilled water. The absorbance of the solution was read at 470 nm. Using appropriate dilution factor the concentration of Nitrate was computed (Udo et al., 2009).

2.5 Statistical Analysis

Descriptive analysis was used to calculate the variation between the different nitrogen compounds (NH_4)- N; NO_2-N and NO_3) for dry and wetseasons on the different landscape positions of the dump site. Calculations were done using Statview statistics software.

3. Results and Discussion

Impact of seasonal variations and landscape position on particle size distribution of soil at the municipal waste dump site in Calabar

The sand contents in soils of the study sites were greater than 75 %, with silt < 19 % and clay < 7 % (Table 1) in both seasons irrespective of the landscape positions of the dump-site giving a loamy sand texture. The texture of the soils at the control site did not differ from that of the dumpsite for both in both dry and wet seasons..The sandy nature of the soils is not unconnected with the sand stone parent material underlying the study area.

Table 1: Mean physicochemical properties of the municipal waste dump site in Calabar for dry and wet seasons

Parameters	Season	Control	Summit crest	Shoulder slope	Toe slope	Interfluve slope	Valley floor
Latitude		05°02'09 N	05°02'03 N	05°02'05 N	05°02'08 N	05°02'02 N	05°02'01 N
Longitude		008°21' 51E	008° 21'54E	008°21'52E	008°21'50E	008°21'50E	008°21'50E
Attitude (m)		28.0	25.0	23.0	22.0	20.0	14.0
Soil Temp. (°C)	Dry	30.0	39.0	39.0	38.0	36.0	29.0
	Wet	33.0	35.0	33.0	32.0	32.0	27.0
Sand (g/Kg)	Dry.	79.0	78.0	78.0	77.0	87.0	75.0
	Wet	78.0	78.0	78.0	77.0	88.0	76.0
Silt (g/Kg)	Dry.	15.0	16.0	18.0	18.0	8.0	18.0
	Wet	15.0	17.0	17.0	19.0	8.0	18.0
Clay (g/Kg)	Dry.	6.0	6.0	4.0	5.0	5.0	7.0
	Wet	7.0	5.0 .	5.0	4.0	6.0	6.0
Texture	Dry.	LS	LS	LS	LS	LS	LS
	Wet	LS	LS	LS	LS	LS	LS
pH	Dry.	5.6	7.0	6.7	7.4	5.9	7.4
	Wet	5.0	7.3	7.3	7.3	5.0	7.3
Organic matter	Dry	0.09	3.21	3.31	3.99	1.51	2.37
(%)	Wet	1.15	2.7	3.66	4.28	1.03	2.2 6

Impact of seasonal variations and landscape position on soil pH and organic matter at the municipal waste dump site in Calabar

The soils at the study location during the dry season had mean pH values ranging from 5.6--7.4 while during the wet season (wet season) the values ranged from 5.0 – 7.3. The lowest pH values were recorded in control soils in both seasons and were strongly acid in reaction, while soils at the different landscape positions of the dump site were slightly acid to very slightly alkaline with highest values obtained at Toe slope and Valley floor (Table 1). The strongly acid pH observed for the control soil is typical of the soils in Calabar (Ediene et al., 2016). Lower pH values were observed during the wet season across the different landscape positions when compared with values obtained during the dry season. The seasonal differences in pH could be attributed to the moisture regime tenable in the study location characterized by high rainfall in the wet season and also to the sandy nature of these soils which enhanced the leaching of basic cations across the different locations.

The increased pH observed in dry and rainy seasons at the dump site over the control could be attributed to the various stages of decomposition of the different organic material deposit. The pH values observed for the dump-site were in line with the 5.4 - 7.0 value range documented by Hargety et al. (1973) and 5.0 - 8.5 or less by Pavoni et al. (1975) for organic matter at different stages of decomposition in aerobic conditions. These suggest that the slightly acid to very slightly Alkaline observed for the dump-site is influenced by decomposition of organic wastes.

Results for the organic matter content of the studied soils were quite revealing. For the wet season, soils at the control site were medium (1.0 -1.5 %) in organic matter while the dumpsite positions were very high in organic matter (>2.0 %) with the Toe slope recording the highest (3.99 %) content. The interfluve slope position was however, medium in OM content for both seasons. This is not unconnected with the fact that the position was by the entrace to the dumpsite as such did not have much waste deposits. Generally, organic matter contents were higher in the various landscape positions of the dump-site in both seasons (dry and wet) with the highest recorded during the rainy season when compared with the control across the study sites. The high organic matter content observed for the dump-site could be attributed to the high quantities of organic materials deposited and the high amount of moisture resulting in a slow rate of decomposition.

Effects of seasonal variations and landscape position on forms of soil nitrogen at the municipal waste dump site in Calabar

3.1 Total Nitrogen (N)

The mean values of total nitrogen in the soil during the dry season ranged from 0.05 -0.30 % with the lowest value obtained in the control and the highest at the Toe slope position while values ranged from 0.01 – 0.20 % in wet season (Fig 2). The lowest total nitrogen value in the soil during the wet season was at the interfluve slope position while the highest content was from the Toe slope position of the dump site. Coefficient of variation values of .0.1964 %, 0.1065 %, 0.0784 %, 0.2191 %, 0.7536 % and 0.2512 % (Table 2) were recorded for total nitrogen content of the soils at the control, summit crest, shoulder slope, toe slope, interfluve slope and valley floor positions correspondingly. The highest nitrogen content for both seasons were recorded at the toe slope (Fig. 2).

Total nitrogen in a given soil measures the organic and inorganic N content of that soil. This is because about 98 percent of the soil nitrogen is stabilized in organic matter as reported by Bationo et al. (2003).Soil N content is reported to increase as soil moisture increases (Paul and Clark, 1989), however, the soil of the study area was loamy sand with a reputed low water holding capacity which could account for the low N mineralization. The N values obtained were within the range reported for soils in Calabar by Akpan-Idiok (2012).

The values for total nitrogen were slightly higher in dry season than in wet season (Fig 2). Despite the high organic matter deposit in the dump site, the percentage nitrogen content in these soils were low (< 0.2) following the rating of Landon (1991). The low nitrogen contents observed across the different sampling points during the dry and wet seasons could be as a result of organic matter decomposition which requires high amounts of inorganic nitrogen (N) and oxygen (O_2) (Ferrari, 1999). It could also be due to hydrolysis and fermentation of nitrogenous fractions of biodegradable refuse substrates of which ammonium nitrogen represents the major proportion of total nitrogen.

3.2 Ammonium nitrogen (NH_4^+ -N)

The values for NH_4^+ in soils of the study area ranged between 11.44 - 13.38 and 12.11-14.11 mg/kg (control); 14.91 - 15.88 and 14.60 - 15.90 mg/kg (Summit crest); 18.43 - 19.38, 18.25 - 20.05 mg/kg (Shoulder slope); 12.40 - 13.42, 18.30 - 20.20 mg/kg (Toe slope); 8.20 - 9.05 and 12.30 - 14.00 mg/kg (Interfluve slope) and 7.90 - 9.59 and 9.24 -11.07 mg/kg (Valley floor) for dry and wet seasons respectively. The means for the control, summit crest, shoulder slope, toe slope, interfluve slope and valley floor toposequences had coefficient variabilities of 0.06 %,

Table 2: Descriptive statistics for Total Nitrogen (N) in soil on different landscapes positions of an open municipal dump site in Calabar for dry and wet seasons

Descriptive Statistics	Control	Summit	Shoulder	Toe slope	Interfluve slope	Valley floor
Mean	.0550	.1400	.1700	.2500	.0300	.0900
Std. Dev.	.0108	.0149	.0133	.0548	.0226	.0226
Std. Error	.0034	.0047	.0042	.0173	.0071	.0071
Count	10	10	10	10	10	10
Minimum	.0400	.1200	.1500	.1800	.0100	.0600
Maximum	.0700	.1700	.1900	.3200	.0600	.1200
# Missing	0	0	0	0	0	0
Variance	.0001	.0002	.0002	.0030	.0005	.0005
Coef. Var.	.1964	.1065	.0784	.2191	.7536	.2512
Range	.0300	.0500	.0400	.1400	.0500	.0600
Sum	.5500	1.4000	1.7000	2.5000	.3000	.9000
Sum Squares	.0313	.1980	.2906	.6520	.0136	.0856
Geom. Mean	.0540	.1393	.1695	.2445	.0220	.0873
Harm. Mean	.0530	.1386	.1690	.2391	.0165	.0846
Skewness	-1.023E-15	.4243	-.2965	3.864E-17	.3041	-.1216
Kurtosis	-1.1293	-.1000	-.9687	-1.7218	-1.7051	-1.5350
Median	.0550	.1400	.1700	.2500	.0200	.0900
IQR	.0100	.0200	.0200	.1000	.0400	.0400
Mode	•	.1400	•	•	.0100	.1100
10% Tr. Mean	.0550	.1388	.1700	.2500	.0288	.0900
MAD	.0050	.0100	.0100	.0500	.0100	.0200

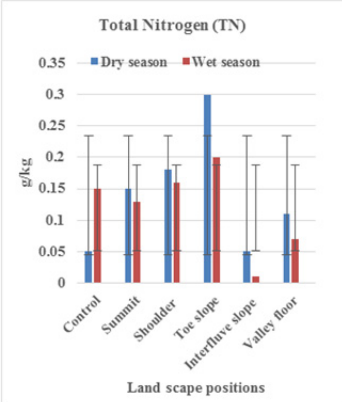

Figure 2: Mean seasonal variation of Total Nitrogen (N) in soils on different landscapes positions of an open municipal dump site in Calabar

Table 3: Descriptive statistics for NH4+ -Nin soil on different landscapes positions of an open municipal dump site in Calabar for dry and wet seasons

Descriptive Statistics	Control	Summit	Shoulder	Toe slope	Interfluve slope	Valley floor
Mean	12.765	15.065	18.840	15.866	10.700	9.530
Std. Dev.	.849	.583	.770	3.716	2.669	.900
Std. Error	.268	.185	.243	1.175	.844	.285
Count	10	10	10	10	10	10
Minimum	11.440	13.930	17.460	11.440	7.400	7.900
Maximum	14.110	15.900	20.050	20.200	14.000	11.070
# Missing	0	0	0	0	0	0
Variance	.721	.340	.592	13.811	7.126	.810
Coef. Var.	.066	.039	.041	.234	.249	.094
Range	2.670	1.970	2.590	8.760	6.600	3.170
Sum	127.650	150.650	188.400	158.660	107.000	95.300
Sum Squares	1635.937	2272.606	3554.786	2641.603	1209.035	915.499
Geom. Mean	12.740	15.055	18.826	15.470	10.397	9.491
Harm. Mean	12.715	15.044	18.811	15.082	10.101	9.452
Skewness	.336	-.253	-.150	.031	.063	-.052
Kurtosis	-.839	-.185	-.753	-1.843	-1.750	-.453
Median	12.430	14.985	18.730	15.860	10.675	9.415
IQR	1.050	.440	1.030	7.200	4.750	1.210
Mode	12.430	15.300	•	12.400	•	•
10% Tr. Mean	12.762	15.102	18.861	15.878	10.700	9.541
MAD	.445	.315	.565	3.460	2.375	.550

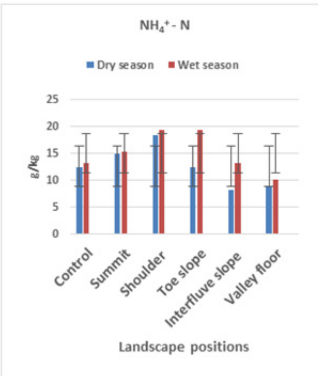

Figure 3: Mean seasonal variation of NH4+ -N in soils on different landscapes positions of an open municipal dump site in Calabar

Results in Table 3 indicate 0.03 %, 0.04 %, 0.2 %, 0.2% and 0.09 % accordingly. Ammonium content was higher during wet season than in dry season. The Shoulder and toe slopes had the highest concentration of NH_4^+ in wet season while the lowest concentration was observed on the valley floor (Fig 3). NH_4^+-N does not accumulate in soil owing to soil moisture and temperature regimes which enables the easy conversion of NH_4^+ to NO_2^- and then NO_3^-. This is because any ecosystem alteration that increases soil NH_4^+ availability usually accelerates nitrification.

The values obtained for NH_4^+-N in dry and wet seasons from the different landscape positions were relatively high, above the ammonium nitrogen typical concentrations of 2-10 mg/kg for soils as documented by Marx et al. (1999). This could be due to the assertion that the concentration of ammonia nitrogen increases with the increase in age of the dump-site (Korniawan et al., 2006). These high levels of ammonium nitrogen could be toxic to soil organisms.

NH_4^+-N is ranked a major toxicant to living organisms, and has been validated by various toxicity analyses using bioassays and various bio-indicators such as Salmo gairdnieri and Oncorhynchus nerka (Korniawan et al., 2006). Higher concentrations of NH_4^+-N have also been documented to enhance algal growth (as was visibly observed at the toe slope and valley floor) and promote eutrophication due to decreased dissolved oxygen (Deng and Englehardt, 2007).

3.3 Nitrite nitrogen (NO_2^- - N)

Values for NO_2^- obtained from the control plot were within the ranges of 2.78 - 3.20 and 3.22 -3.62 mg/kg, 2.49 - 3.45 and 2.98 - 3.22 mg/kg was documented for the shoulder, the toe slope contained between 2.30-2.75 and 2.70 -2.82 mg/kg, the inter fluve slope had similar ranges of 2.32 - 2.90 and 2.70 - 3.08 mg/kg, and the valley floor 2.45 - 2.60 and 2.78 - 2.98 mg/kg for the dry and wet seasons in the given order. Standard deviations of 0.26, 0.26, 0.24, 0.17, 0.24, 0.18 were recorded for the means of the control, summit crest, shoulder slope, toe slope, interfluve slope and valley floor indicating that the means for dry seasondid not differ from that of the wet season. The means were negatively skewed except for the control (Table 4).

The NO_2^- values obtained for the dump site were lower than the values from the control for both seasons (Fig 4). The NO_2^- values were generally lower than values obtained for other forms of nitrogen. This could be attributed to the rapid oxidation of NO_2^- to NO_3¬- in soil when formed. Paul and Clark (1989), noted that nitrite (NO_2^-) is rapidly oxidized in soil at temperatures between 400C to 600C. This phenomenon is actually fortunate because nitrite nitrogen is toxic to living organisms (Miller and Donahue 1995).The results observed in this study has confirmed reports by these authors however, the soil temperatures reported by Paul and Clark, (1989) were substantially higher than the temperature that was observed at the dump site as recoreded in Table 1.

3.4 Nitrate nitrogen (NO_3^- - N)

Nitrate (NO_3^-) nitrogen had values ranging from 58.20 - 62.10 and 57.36 - 59.40 mg/kg for the control; 52.80 - 55.46 and 48.79 - 50.86 mg/kg; 57.04 - 59.22 and 54.80 - 56.50 mg/kg; 52.06 -56.00 and 50.26 - 54.00 mg/kg; 50.80 - 68.86 and 56.06 - 57.60 mg/kg; 75.20 - 84.40 and 71.22 - 79.00 mg/kg for the summit crest, shoulder slope, toe slope, interfluve slope and valley floor, for the dry and wet seasons sequentially. The means had coefficient of variations of 0.02 %, 0.05.

Table 4: Descriptive statistics for NO2- -N in soil on different landscapes positions of an open municipal dump site in Calabar for dry and wet seasons.

Descriptive Statistics	Control	Summit	Shoulder	Toe slope	Interfluve slope	Valley floor
Mean	3.210	2.610	3.035	2.705	2.750	2.715
Std. Dev.	.265	.266	.248	.174	.243	.188
Std. Error	.084	.084	.078	.055	.077	.059
Count	10	10	10	10	10	10
Minimum	2.780	2.140	2.490	2.300	2.320	2.450
Maximum	3.620	2.950	3.450	2.950	3.080	2.980
# Missing	0	0	0	0	0	0
Variance	.070	.071	.062	.030	.059	.035
Coef. Var.	.083	.102	.082	.064	.089	.069
Range	.840	.810	.960	.650	.760	.530
Sum	32.100	26.100	30.350	27.050	27.500	27.150
Sum Squares	103.673	68.756	92.666	73.443	76.158	74.030
Geom. Mean	3.200	2.597	3.025	2.700	2.740	2.709
Harm. Mean	3.190	2.584	3.016	2.694	2.729	2.703
Skewness	.030	-.533	-.619	-1.184	-.567	-.037
Kurtosis	-1.031	-.920	.912	1.210	-.715	-1.487
Median	3.210	2.685	3.000	2.750	2.800	2.715
IQR	.460	.400	.230	.070	.270	.330
Mode	3.000	•	3.000	•	2.800	•
10% Tr. Mean	3.212	2.626	3.051	2.725	2.762	2.715
MAD	.210	.160	.080	.050	.135	.165

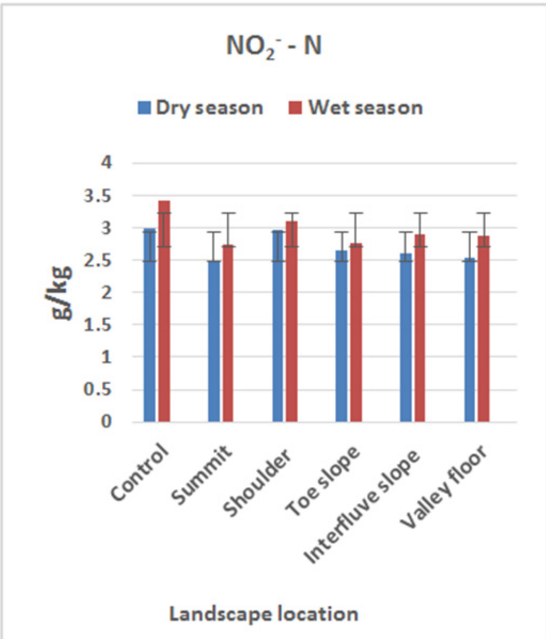

Figure 4: Mean seasonal variation of NO2- -N in soils on different landscapes positions of an open municipal dump site in Calabar

Table 5: Descriptive statistics for NO3- -N in soil on different landscapes positions of an open municipal dump site in Calabar for dry and wet seasons.

Descriptive Statistics	Control	Summit	Shoulder	Toe slope	Interfluve slope	Valley floor
Mean	59.190	52.105	56.920	53.090	58.330	78.655
Std. Dev.	1.477	2.599	1.424	1.728	4.568	3.760
Std. Error	.467	.822	.450	.547	1.445	1.189
Count	10	10	10	10	10	10
Minimum	57.360	48.790	54.800	50.260	50.800	71.220
Maximum	62.100	55.460	59.220	56.000	68.860	84.400
# Missing	0	0	0	0	0	0
Variance	2.183	6.756	2.028	2.987	20.871	14.136
Coef. Var.	.025	.050	.025	.033	.078	.048
Range	4.740	6.670	4.420	5.740	18.060	13.180
Sum	591.900	521.050	569.200	530.900	583.300	786.550
Sum Squares	35054.204	27210.115	32417.117	28212.364	34211.724	61993.317
Geom. Mean	59.174	52.047	56.904	53.065	58.174	78.573
Harm. Mean	59.157	51.989	56.888	53.039	58.024	78.490
Skewness	.770	.098	.126	.071	.890	-.376
Kurtosis	-.465	-1.661	-1.207	-.751	1.416	-.101
Median	58.740	51.830	56.770	53.045	57.550	78.500
IQR	1.800	4.730	2.340	1.940	3.840	2.970
Mode	58.200	•	•	54.000	•	78.000
10% Tr. Mean	59.055	52.100	56.898	53.080	57.955	78.866
MAD	.620	2.195	1.150	.970	1.780	1.650

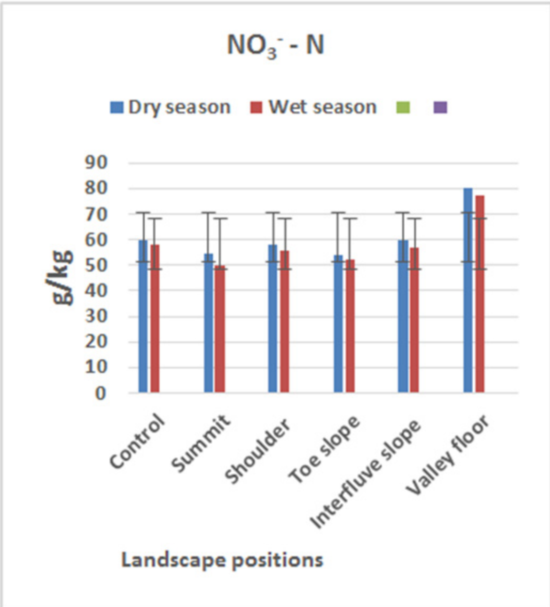

Figure 5: Mean seasonal variation of NO3- -N in soils on different landscapes positions of an open municipal dump site in Calabar

Percentage representation for the control was 0.02 %, 0.03 %, 0.07 % and 0.04 % at the different topo-positions accordingly. The data were positively skewed (Table 5). The valley floor recorded the highest content of NO_3^- -N (Fig 5). Despite the high rate of leaching and solubilization of NO_3^-, its content in the study soils were excessive (> 30 mg/kg). Nitrate has been reported to be high in soils, marine environments and manure piles and during sewage processing (Hirobe et al., 2003). Nitrate is reported to be deficient in soils with low pH (<5.5) such as soils in the study area, this is because of reduced nitrification.

However, organic matter (organic waste) is an important source of NO_3^- and nitrate accumulation may correlate with organic matter deposits patterns across landscapes. These excessive values of NO_3^- are worrisome as nitrate nitrogen could be converted into nitrous oxide (N_2O), which could increase the atmospheric green house (GHG). NO_3^- could also be converted to nitrogen dioxide (NO_2) and nitrogen gas (N_2) under waterlogged condition.

4. Conclusion and Recommendation

The study was to assess the seasonal variation in nitrogen distribution at a municipal dumpsite following the different landscape positions. The soils at the study location were loamy sand in texture with mean pH values of 4.50 and 5.00 for the control, and 5.9 -7.47 and 5.80 - 7.30 (dumpsite) for both dry and wet seasons. Total nitrogen from the study site were rated low for both seasons, with values for the dry season being slightly higher than the wet season. NH_4^+ was equally low with means of both seasons varying with a coefficient of 0.06 %, 0.03 %, 0.04 %, 0.2 %, 0.2% and 0.09 % for the control, summit crest, shoulder slope, toe slope, interfluve slope and valley floor toposequeces accordingly.

The NH_4^+ values were slightly higher in the wet than in dry season with the shoulder and toe slopes recording the highest concentration. Values obtained for No_2^- from the control plot were within the ranges of 2.78- 3.20 and 3.22-3.62 mg/kg while 2.49-3.45 and 2.98 -3.22 mg/kg was documented for the shoulder, the toe slope contained between 2.30-2.75 and 2.70 -2.82 mg/kg, the inter fluve slope had similar ranges of 2.32-2.90 and 2.70-3.08 mg/kg, and the valley floor 2.45-2.60 and 2.78-2.98 mg/kg for the dry and wet seasons in the given order.

Nitrate (NO_3^-) nitrogen was excessively high across the dumpsite for both seasons with values greater than 48.79 mg/kg; in dry season and > 50.26 mg/kg in the wet season. The excessive NO_3^- could be leached down the profile or washed off with eroded soil particles. NO_3^- could equally be converted to nitrous oxide (N_2O), a green house (GHG) that could increase the atmospheric content. It is observed that seasonal variation did not significantly affect the N content at the different landscape positions of the municipal dumpsite in Calabar. It is highly recommended that municipal waste be sorted at source and the organic component composted to harness the rich N content.

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