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Physical and Chemical Characteristics of Mound Materials and Surrounding Soils of Different Habitats of Two Termite Species In Minna, Nigeria.

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Abstract

Termite mounds are common micro – topographic features of Guinea Savanna area of Nigeria. Samples of soils from mounds of two termite species (Macrotermes bellicosus and Trinervitermes geminatus) and surrounding soils in Gidan Kwano and Gidan Mangoro areas of Niger State were collected, processed and analyzed for their physico-chemical characteristics. It was observed that the mound crust of Trinervitermes geminatus. (grass harvesting termites) contained significantly higher nutrients than both surrounding soils and mound crust of Macrotermes bellicosus. The mound crust of Macrotermes bellicosus was poorer in most of the chemical constituents than the surrounding soils. The significantly higher nutrient content in the mound crust of Trinervitermes geminatus might be as a result of the abundance and voracious feeding habits of the termites which not only speed the breakdown of plant material but selectively concentrate it in the nests. These mounds are easily destroyed by cultivation or washed down by erosion when the mounds are abandoned thereby improving the soil nutrient status. However some of the termite species are destructive but majority of them might be regarded as beneficial agents in improving the nutrient status of the soils.

Keywords: *Termite mounds, Termite Species, Physico-chemical properties, surrounding soils.*

Introduction

Termites are common biological agents that produce significant physical and chemical modifications to tropical and sub-tropical soils (Darlington and Dransfiled 1987). *Trinervitermes spp.* particularly *Trinervitermes geminatus* (grass eating termites) are widely distributed throughout the Nigerian savannas. They construct small domed mounds as their nest, these species are considered as one of the most important natural modifiers of soil physical and chemical properties (Jouquet *et al*., 2011). The mounds are easily destroyed by cultivation but are extensive in their number about 143 ha^{-1} in Guniea Savanna of Nigeria (Ackerman *et al*., 2007).

Termites have a key role in controlling carbon and nitrogen fluxes both in semi and humid ecosystems such as savannas and tropical rain forests. Also their potential impact on agriculture is receiving increasing attention. Different species of a termite consume wood and litters in different stages of decay and humification and more than half of all termites generally are considered humivorous (Martins, 2000). Hyodo (2000) reported that the enzymatic secretors of fungi primarily facilitate the breakdown of lignin and cellulose in the fungus-growing termites.

Termite mounds are among the most conspicuous feature of many tropical ecosystems, strongly influencing the soil properties as compared to surrounding soil. These modifications have a great impact on the vegetation, through spatial and temporal effects, even when the termites' colony is dead and the mound material subjected to erosion. Thus the termites have been referred to as large soil builders and ecosystem engineers (Whiteford and Eldridge 2013). The effects of termites in modifying the soil physical properties by burrowing and nest building and on the soil chemical properties through deposition of organic debris and excretion are therefore apparent. Their ability to mix the soil and organic matter from different horizons and also create tunnels in the soil to enhance aeration may be one of the reasons why many of the trees and shrubs in woodland savanna surround old termite mounds (Owen, 1966).
Land suitable for agriculture is limited by climate, effective soil depth for root growth, drainage conditions, soil erosion, slope and all other profile characteristics in savanna area. Agricultural production which includes wood fiber depends on the soil productive capability but productivity of soils in Nigeria is generally on the decline. The objective of the study is to examine some physic-chemical characteristics of mound materials and surrounding soils of different habitats of *Macrotermes bellicosus* and *Trinervitermes geminatus* in Gidan Kwano and Gidan Mangoro areas of Minna, Nigeria.

Materials and Methods

Study Site

Mound materials of two termite species *Macrotermes bellicosus (*a wood harvester and fungus grower) and *Trinervitermes geminatus* (a grass harvester) and their surrounding soils were collected from two different areas namely Gidan Kwano and Gidan Mangoro in Minna, Nigeria. Minna lies on latitude 9° 49`N and longitude 6° 30`E within the southern Guinea savanna vegetation zone of Nigeria. Climate of Minna is sub – humid with mean annual rainfall of about 1284 mm and a distinct dry season of about 5 months duration occurring from November to March. The mean maximum temperature remains high throughout, about 33.5 ^{o}C, particularly in March and June (Ojanuga, 2006). The physical features around Minna consist of gently undulating high plains developed on basement complex rocks made up of granites, migmatites, gneisses and schists. Inselbergs of "Older Granites" and low hills of schists rise conspicuously above the plains. Beneath the plains, bedrock is deeply weathered and constitutes the major soil parent material (saprolites) (Ojanuga, 2006).

Soil Sampling and Analysis

Mounds materials of two termites species and their surrounding soils were collected from two different areas: Gidan Kwano and Gidan Mangoro in Minna and analyzed. Mound materials were broken with a spade and the surrounding soils were collected from top soil (0-20cm) at a distance of 150cm from the mound. For each termite species samples were collected from a total of twelve sites in each of the two areas. The samples were lightly crushed and sieved with a 2mm sieve to remove contaminants and to obtain a composite sample. Sub sample were taken thereafter for determination of physico-chemical properties by standard methods as described by Agbenin (1995). Soil particle size distribution was determined by the hydrometer method, soil pH was measured by using the pH meter. Organic carbon was determined by Walkley and Black wet oxidation method and organic matter was calculated by multiplying the organic carbon value by 1.734g. Available P was determined colorimetrically after Bray P 1 extraction. Exchangeable bases were extracted with neutral 1N NH_4OAc. Na and K were determined by flame photometry while Ca and Mg were by Na-EDTA titration. Exchangeable acidity was extracted with 1N KCl. ECEC was obtained by summation of the exchangeable cation and the exchangeable. Total N was determined by the micro Kjeldahl method.

Experimental Design

The experimental design was completely randomized design.

Statistical Analysis

Statistical Package for Social Sciences (SPSS, 2010) was used for statistical test. Paired t-test was used to determine significant differences between means of the parameters obtained from soils and mound materials.

Results and Discussion

The physicochemical properties of the mound materials and the surrounding soils are shown in Tables 1, 2 and 3. The sand fractions of both mound materials and surrounding soils ranged from 844.90 to 871.00 g kg^{-1}. The mound materials of the *Trinervitermes geminatus* gave significantly higher values than both *Macrotermes* materials and surroundings soil. The silt contents ranged from 48.76 to 57.10 g kg^{-1}. The clay contents ranged from 74.87 to 98.18 g kg^{-1}. The *Macrotermes bellicosus* materials gave the highest clay content. The pH (H_2O) of both materials and surrounding soils ranged from 6.355 to 6.677 with the *Macroermest bellicosus* materials giving the highest value. Organic carbon contents ranged from 15.342 to 22.458 g kg^{-1}. The *Trinervitermes* material gave the highest value. Total nitrogen ranged from 0.21 to 0.07 %. *Trinervitermes germinatus* materials were significantly higher in organic carbon and organic matter than the surrounding soils with values ranging from 27.75 to 17. 17.16 g kg^{-1} and 47.70 and 29.52 g kg^{-1} respectively. Calcium content ranged from 2.366 to 2.783 cmol kg^{-1} while magnesium contents ranged from 0.982 to 2.78 cmol kg^{-1}. The *Trinerviterme geminatus* materials gave the highest values of Ca^{2+} and Mg^{2+}. Potassium values ranged from 0.754 to 1.444 cmol kg^{-1} and sodium values ranged from 1.239 to 1.525 cmol kg^{-1}. It is generally observed that mound materials of *Trinervitermes geminatus* have significantly higher values of sand fractions and organic carbon and numerically higher calcium, magnesium and potassium than mound materials of *Macrotermes bellicosus*

Table1: Physicochemical composition of *Macrotermes* mound material and the surrounding soil.

PARAMETERS	MM	SS	MM-SS	T-VALUE	REMARKS
Sand (g kg^{-1})	825	873	-48	-8.657	*
Silt (g kg^{-1})	58	47	11	1.445	NS
Clay (g kg^{-1})	117	80	37	4.761	*
Silt:Clay	0.50	0.64	-0.14	-0.784	NS
pH (H_2O)	6.72	6.62	0.10	0.886	NS
pH ($CaCl_2$)	6.11	5.91	0.20	0.813	NS
OC (g kg^{-1})	10.22	20.48	-10.26	-3.035	*
OM (g kg^{-1})	17.43	29.04	-11.61	-2.594	*
TN (g kg^{-1})	0.10	0.08	0.02	1.165	*
AP (mg kg^{-1})	13.08	12.48	1	0.804	NS
Ca^{2+} (cmol kg^{-1})	2.34	2.41	-0.07	-0.186	NS
Mg^{2+} (cmol kg^{-1})	1.09	0.99	0.10	0.759	NS
K^{+} (cmol kg^{-1})	1.23	0.90	0.33	0.733	NS
Na^{+} (cmol kg^{-1})	1.52	1.54	-0.03	-0.134	NS

* Significant at the 5% level ($P \leq 0.05$)

NS: Non Significant at the 5% level (P > 0.05), MM : Mound Material, SS: Surrounding Soil, OC: Organic carbon, OM: Organic Matter, TN: Total nitrogen, AP: Available phosphorous.

Table 2:Physicochemical composition of *Trinerviterme* mound material and the surrounding soil.

PARAMETERS	**MM**	**SS**	**MM-SS**	**T-VALUE**	**REMARKS**
Sand (g kg^{-1})	864	878	-1.32	-1.422	NS
Silt (g kg^{-1})	60	50	10	0.765	NS
Clay (g kg^{-1})	76	72	-58	0.406	NS
Silt:Clay	0.94	0.69	0.25	0.764	NS
pH (H_2O)	6.33	6.33	0	0.025	NS
pH ($CaCl_2$)	5.36	5.32	0.04	0.000	NS
OC (g kg^{-1})	27.75	17.16	10.59	3.031	*
OM (gkg^{-1})	47.70	29.52	18.18	3.031	*
TN (g kg^{-1})	0.070	0.096	-0.026	-0.493	NS
AP (mg kg^{-1})	12	13	-1	1	NS
Ca^{2+} (cmol kg^{-1})	2.82	2.74	0.08	0.233	NS
Mg^{2+} (cmol kg^{-1})	1.00	0.96	0.04	0.196	NS
K^{+} (cmol kg^{-1})	1.65	0.60	1.05	2.340	NS
Na^{+} (cmol kg^{-1})	1.42	1.08	0.34	2.082	NS

* Significant at the 5% level ($P \leq 0.05$)

NS: Non Significant at the 5% level (P > 0.05), MM : Mound Material, SS: Surrounding Soil, OC: Organic carbon, OM: Organic Matter, TN: Total nitrogen, AP: Available phosphorous.

Table 3: Comparison of the Physicochemical Properties of Mound Material between Termite Types.

PARAMETERS	MAR.	TRI.	MAR-TRI	T-VALUE	REMARKS
Sand (g kg^{-1})	825	864	-39	-3.969	*
Silt (g kg^{-1})	58	60	-2	-0.137	NS
Clay (g kg^{-1})	117	74	43	4.833	*
Silt:Clay	0.503	0.949	-0.446	-1.213	NS
pH (H_2O)	6.72	6.33	0.39	2.566	*
pH ($CaCl_2$)	6.117	5.32	0.797	4.397	*
OC (g kg^{-1})	10.21	27.75	-17.54	-3.519	*
OM (g kg^{-1})	17.42	47.70	-30.28	-3.534	*
TN (g kg^{-1})	0.09	0.07	0.02	0.683	NS
AP (mg kg^{-1})	13	12	1	0.635	NS
Ca^{2+} (cmol kg^{-1})	2.33	2.82	-0.49	-1.040	NS
Mg^{2+} (cmol kg^{-1})	1.09	1.00	0.09	0.408	NS
K^+ (cmol kg^{-1})	1.23	1.65	-0.42	-0.676	NS
Na^+ (cmol kg^{-1})	1.51	1.41	0.1	0.744	NS

* Significant at the 5% level ($P \leq 0.05$)
NS: Non Significant at the 5% level ($P > 0.05$), MM : Mound Material, SS: Surrounding Soil, OC: Organic carbon, OM: Organic Matter, TN: Total nitrogen, AP: Available phosphorous, MAR: *Macrotermes* mound material, TRI: *Trinerviterme* Mound material

The chemical characteristics of the mound materials of *Macrotermes bellicosus* shows that the composition is close to that of surrounding soil. These agreed to the findings of Nye 1995 and Ezenwa 1985 that the mound materials of *Macrotermes bellicosus* was lower in most of the chemical constituents than the surrounding soils and mound materials of *Trinerviterme geminates. Trinervitermes spp* use partially decomposed organic materials in mound construction, hence their mound materials are higher in chemical constituents than the surrounding soils. The result obtained from termite mound materials in savanna area of Nigeria generally agree with the observations made by Jouquet *et al*., (2011). From the foregoing, it is clear that termites influence the nutrient status of the soil through effect on organic materials. In the absence of termites, one can only speculate on the possible fate of the organic matter in our wood-lands and forest stands. In some savanna areas where earth-worms and millipedes are scarce and termites are dominant group of soils animals, forest litter would possibly accumulate and decomposed and become a fire hazard. The grass harvesting termites (especially *Trinerviterme geminatus*) have been observed defecating while foraging on grass resulting a recycling of ingested materials, a situation similar to earthworm activity (Ohiagu, 1979). The dispersal of bodies of alates and their wings after mass flight also contributes to the nutrient content of the soil when they decompose as it is realized that the majority of the alates- perish before new colonies are established.

The significantly higher nutrient content of the mound crust of *Trinervitermes* proved that the abundance and voracious feeding habits of the termites not only speed the breakdown of plant material but selectively concentrate in the nests. These elements are released to the soil when the mounds are eroded or destroyed either by trampling and buffeting by cattle or by cultivation, there by ultimately enriching the soil.

Conclusion

The termite mound of *Trinerviterme geminatus* that gave the higher chemical composition than the *Macrotermes bellicosus* mound can be used as soil amendment in low fertile area in southern Guinea savanna of Nigeria.

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