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COMPARATIVE STUDY OF SOME CHEMICAL CHARACTERISTICS OF MOUND MATERIALS AND SURROUNDING SOILS OF DIFFERENT HABITATS OF TWO TERMITE SPECIES IN NIGERIAN SAVANNAS

Etude comparative, pour deux espèces de termite,
de certaines caractéristiques chimiques des sols de termitière
dans différents sites de savane du Nigéria.

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RESUME

Les tertres édifiés par deux espèces de termite des savanes du Nigeria (Macrotermes bellicosus et Trinervitermes geminatus) ont été étudiés du point de vue de leur composition chimique. Les sols des termitières de Trinervitermes sp. (herbivore) contiennent de façon significative une proportion plus élevée de substances nutritives que les sols voisins et que les monticules dus à Macrotermes sp. Ces derniers sont également plus pauvres en substances chimiques que les sols voisins.

Les teneurs plus élevées du tertre de Trinervitermes tend à prouver que l'abondance et la voracité de ces termites non seulement hâte l'évolution des matières organiques mais favorise également une concentration sélective dans leurs nids. Les tertres sont aisément détruits par les cultures ou érodés par le ruissellement et la qualité des sols en est ainsi améliorée. Bien que les termites soient une nuisance pour les récoltes et même pour pas mal de constructions, ils peuvent être considérés d'un autre côté comme des agents de l'amélioration des sols.

ABSTRACT

Some chemical characteristics of the crusts of the mounds of two termite species (Macrotermes bellicosus and Trinervitermes geminatus) of Nigerian Savannas and the surrounding soils were studied. It was found that the mound crust of Trinervitermes sp. (grass harvesting termites) contained significantly higher nutrients than both the surrounding soils and the mound crust of Macrotermes sp. It was also found that the mound crust of Macrotermes species was poorer in most of the chemical constituents that the surrounding soils.

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The significantly higher nutrient content in the mound crust of Trinervitermes goes to prove that the abundance and voracious feeding habits of the termites 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. Although certain termites are serious crop pests and those feeding on wood cause damage to buildings, fences ..., the majority of termites might be regarded as beneficial agents in improving the nutrient status of the soils.

INTRODUCTION

One feature which distinguishes what we call soil from the decomposing rock fragments which are its precursors is the presence of living organisms. The role that these organisms, the flora and fauna of the soil, play in the transformation of soil organic matter, in amending the conditions in which the mineral particles exist, and in altering the manner in which the ultimate physical particles are organized into structures is only just being appreciated.

Termites, commonly called (biologically inaccurately) "white ants", belong to the order Isoptera. They quantitatively dominate the macrofauna of tropical and subtropical soils, extending to latitudes 45° N and S in the way that earthworms dominate temperate soils (LEE & WOOD, 1971 a).

The termites of West African Savannas belong to some eleven recognizable genera with many species. The most important are :

- *Macrotermes bellicosus* which builds cathedrallike mounds, up to 8 m tall and feeds on wood, is not considered a serious pest of crops,
- *Trinervitermes sp.* particularly *T. geminatus* (grass eating termites) which are widely distributed throughout the savanna. They construct small domed mounds as their nests. These species are considered as one of the most important natural modifiers of soil physical and chemical properties (LEE & WOOD, 1971 a). The mounds are easily destroyed by cultivation but are extensive in their number.

It is estimated that under natural conditions of the Northern Guinea Savanna of Nigeria, the average density of mounds is about 143/ha with a termite population of between 2 and 10 millions per hectare (KOWAL & KASSAN, 1978).

SANDS (1965) estimated mound density of *T. geminatus* in an area near Zaria at 753/ha. MURRAY (1938) estimated mound density of about 534/ha and OHIAGU (1976) recorded 317/ha at Mokwa in the Southern Guinea Savanna.

The termites travel from their mounds through subterranian network of galleries and emerge from foraging holes at the soil surface. Up to 2,500 holes per hectare may be opened when foraging is active. The termites climb up standing grass which is cut down into small pieces and carried back to the nest. On average, about 0.4 kg/ha per day of grass is stored in the nests. WATSON *et al.* (1970) estimated about 200-500 g of dry grass and leaf litter when foraging ceased in early winter in Australia. The effect 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 excreta is therefore apparent.

A number of authors (MALDAGUE, 1959; BURGES & RAW, 1967; MADGE & SHARMA, 1969; LEE & WOOD, 1971 a, 1971 b; and YOUNG, 1976) have reported that termites were helpful in relation to the fertility of tropical soils. YOUNG (1976) indicates that the soil within a termite mound shows substantial differences from the surrounding, although the nature and extent of these differences vary owing to the habits of different species. He also concluded that the pH is nearly always higher within the mound, often by one unit, and that carbon, nitrogen and exchangeable bases, especially calcium are usually higher. SYS (1955) and WATSON (1962, 1974) indicate that a peculiarity of Macrotermes mounds in some parts of Africa is the presence of calcium carbonate in concentrations of several percent, forming concretions. PATHAK & LEHRI (1959) examined microbial activity in mounds in India and reported that rates of nitrification and nitrogen fixation were higher than in adjacent soils. Fungus gardens were also found to be a specialized nitrogen fixing flora.

Most of termites energy is derived from the digestion of polysaccharides (especially cellulose and hemicelluloses); some species are also apparently able to digest lignin. The ability to digest these materials, which are principal structural components of plant tissue, sets termites apart as a specially significant group of soil animals (LEE & WOOD, 1971). 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). YOUNG (1976) comments that in some areas of ferrallitic soils in Africa, maize is grown only on the richer soils of degraded mounds. Sisal grows better on termite mounds than elsewhere in Tanzania (HESSE, 1955).

Not much work has been done on chemical effects of termites on soils of the Nigerian savannas. The objective of this study therefore is to examine some chemical characteristics of mound materials and surrounding soils of different habitats of *Macrotermes* and *Trinervitermes* in Nigerian Savannas.

Study area

The samples were collected from three locations in the Nigerian Savannas namely, Mokwa in the Southern Guinea Savanna, Afaka in the Northern Guinea Savanna and Jere in Jos Plateau type of vegetation. The details of the climate and vegetation zones have been well described by KEAY (1953) but are not given in this paper.

The soils of Mokwa are derived from the Turonian - Senonian Cretaceous sandstone and are reddish brown to red in colour with some variation in texture (loamy sand to sandy loam). They are generally very deep and well drained. The clay fraction is of the 1:1 lattice type and there is very little reserve of weatherable minerals (BARRERA, 1971). These soils are grouped under ferralitic soils (D'HOORE, 1964).

The soils of Afaka are developed from Basement Complex and are dominated by 1:1 latice type of clay and usually show iron accumulation in some parts of the profile. There is a textural and structural B horizon with an appreciable reserve of weatherable minerals. The cation exchange capacity (CEC) has an average of 6.2 me/100 g for the A horizon and 5.2 me/100 g for the B horizon (BARRERA, 1971). These soils are grouped under ferrugenous tropical soils (D'HOORE, 1964).

The soils of Jere are formed from granite and are light textured. The cation exchange capacity (CEC) ranges from 5 to 8 me/100 g for the A horizon and from 6 to 14 me/100 g for the B horizon. These soils are also grouped under ferruginous tropical soils (D'HOORE, 1964).

METHODS

Mound materials of two termite species and their surrounding soils were collected from three different areas in Nigerian Savannas namely Mokwa, Jere and Afaka, and analysed in order to compare the chemical composition of termite mound materials with those of unmodified, surrounding soils.

Mound materials were broken with a spade, and placed in polythene bags. At a distance of about 150 cm from the mounds, soil samples were also collected from topsoil and subsoil and put into containers similar to those used for the mound materials. The termite species in the study were *Macrotermes bellicosus*, a wood harvester and fungus grower, and *Trinervitermes geminatus*, a grass harvester. For each termite species, samples were collected from a total of ten sites in each of the three areas.

All samples were dried and ground to pass through 2.0 mm sieve. The pH was determined with a glass electrode in a 1:2.5 soil-water mixture. The organic matter was determined using the Walkey Black method (JACKSON, 1958) and phosphorus by extraction with 0.2 N sulphuric acid and determined colourimetrically (SCHUTTE & OLSEN, 1970). The cation exchange capacity was determined by the PEECH *et al.* (1947) method and total nitrogen was determined by the Kjeldahl method (BRUMNER, 1965).

RESULTS

The mound materials of *Trinervitermes geminatus* have significantly higher values of pH, organic carbon, sodium, potassium, magnesium, nitrogen, C/N ratio, cation exchange capacity and base saturation percentage than the surrounding unmodified soils. (Tab. I A). The available phosphorus content of the mound material is significantly higher than the surrounding subsoil but not the topsoil.

The mound materials of *Macrotermes bellicosus* have significantly lower values of sodium, phosphorus, and nitrogen (but higher values for only pH and potassium) than the surrounding unmodified topsoil (Tab. I B).

The mound materials of *Trinervitermes geminatus* have significantly higher values of organic carbon, sodium, magnesium, nitrogen, base saturation percentage, C.E.C. and C/N ratio than the adjacent mound materials of *Macrotermes bellicosus*.

DISCUSSION

The chemical characteristics of the mound materials of these two species of termite are directly related to their building habits. Particle size analyses of mounds of *Macrotermes spp.* in Africa show that their composition is close to that of subsoil (HESSE, 1955; NYE, 1955; HARRIS, 1956; MALDAGUE, 1959; STOOPS , 1964), but there is some selection in favour of the finer size fraction in soils that are not rich in clay, or against the finer fractions in soils rich in clay (NYE, 1955;

	CC	A	B	A–B	TV	C	A–C	TV	D	A–D	TV
	pH.	6.3	5.8	0.5	3.903**	5.7	0.6	2.433*	5.8	0.5	2.861*
	Org. C	1.39	0.74	0.65	4.437**	0.87	0.52	3.910**	0.79	0.6	5.590**
Exch.	Na+	0.19	0.08	0.11	5.729**	0.06	0.13	5.029**	0.07	0.12	4.867**
"	K+	0.86	0.30	0.56	9.598**	0.30	0.56	7.928**	0.30	0.56	8.724**
"	Ca^{2+}	0.22	0.30	- 0.08	1.4636	0.29	- 0.07	- 1.7827	0.30	- 0.8	- 2.1571*
"	Mg^{2+}	0.20	0.11	0.09	1.6166	0.06	0.14	2.3041*	0.08	0.12	2.1461*
	CEC	5.47	4.25	1.22	3.0963**	4.42	1.05	2.5056*	4.45	1.02	2.8067*
	BSP	27.26	18.41	8.85	2.4145*	17.0	10.26	2.609*	17.54	9.72	2.7118*
Avail.	P	5.56	6.3	- 0.74	-0.7045	2.67	2.89	2.3491*	4.22	1.34	1.1121
Total	N	0.08	0.07	0.01	1.6180	0.06	0.02	3.1623**	0.07	0.01	2.2295
	C/N	17.00	10.11	6.89	3.6014**	15.99	1.01	0.3815	12.83	4.17	2.1542*

Tab. I : Chemical characteristics of *Trinervitermes* mound materials, the surrounding soils and their paired t - values. A : mean for *Trinervitermes*; B : Mean for topsoil; C : mean for subsoil; D : Mean for top + subsoil; TV : pared t - value; CC : chemical characteristics. * Significant at 5 percent level; ** significant at 1 percent level.

	CC	A	B	A–B	TV	C	A–C	TV	D	A–D	TV	E	A–E	TV
	pH.	6.30	6.3	0.0	–	5.8	0.5	2.603*	5.7	0.6	4.465**	5.8	0.5	3.304*
	Org. C	0.65	1.39	0.74	–16.482**	0.74	–0.09	–	0.87	0.23	1.892*	0.79	0.15	1.719
Exch.	Na^+	0.07	0.19	0.12	6.164**	0.08	–0.01	–0.885*	0.06	0.01	1.440	0.07	0.00	–
"	K^+	0.57	0.86	0.29	1.640	0.30	0.27	1.442	0.30	0.30	1.376	0.30	0.30	1.4244
"	Ca^{2+}	0.32	0.22	0.10	1.571	0.30	0.02	0.209	0.29	0.03	0.5484	0.30	0.02	0.3451
"	Hg^{2+}	0.07	0.20	0.12	–2.4405*	0.11	0.04	–2.7975*	0.06	0.01	–0.4531	0.08	–0.01	–1.3791
	CEC	4.25	5.47	1.22	2.8207*	4.25	0.0	–	4.42	0.48	–0.1114	4.45	–0.08	–0.2339
	BSP	23.30	27.26	3.96	–3.4142**	18.41	4.89	0.7514	17.0	6.27	1.3703	17.54	5.73	1.3703
Avail.	P	3.0	5.56	2.4	–1.5906	6.3	–3.3	–2.2736*	2.67	0.61	0.62027	4.22	–0.94	0.7668
Total	N	0.06	0.08	0.05	–4.2632**	0.07	–0.01	–2.9406**	0.06	0.0	–0.2294	0.07	–0.01	–2.8737*
	C/N	11.24	17.00	5.76	–3.4176**	10.11	1.13	0.6516	15.99	–4.86	–1.7568	12.83	–1.53	–1.2005

Tab. II : Chemical characteristics of *Macrotermes* mound materials, the surrounding soils and their paired t – values. CC : chemical characteristics; A : mean for *Macrotermes*; B : mean for *Trinervitermes*; C : mean for top-soil; D : mean for subsoil; E : mean for top + subsoil; TV : paired t – values. * significant at 5 percent level; ** significant at 1 percent level.

STOOPS, 1964). HARRIS (1961) also indicates that *M. bellicosus* builds mounds of pure sand cemented with saliva.

These findings explain why the mound material of *M. bellicosus* was lower in most of the chemical constituents than the surrounding unmodified soils. *Trinervitermes spp.* use partially digested organic materials in mound construction, hence their mound materials are higher in chemical constituents than the surrounding unmodified soils. The data from the chemical analyses of the termite mound materials in Savanna areas of Nigeria generally agree with the observations made by KEMP (1955), LEE & WOOD (1971 b), SYS (1955)and others. The low values of calcium in the mound materials of both *Macrotermes* and *Trinervitermes* indicate the absence of accumulated calcium carbonate in the mounds and this disagrees with what was reported by some workers (HESSE, 1955 and WILD, 1952).

From the foregoing, it is clear that termites influence the nutrient status of the soil, through their effect on organic materials. In the absence of termites, one can only speculate on the possible fate of the organic matter in our forest stands. In some Savanna areas where earthworms and millepedes are scarce and the termites are the dominant group of soils animals, forest litter would possibly accumulate undecomposed and become a fire hazard.

The grass harvesting termites (especially *T. geminatus*) have been observed defecating while foraging on grass resulting a recycling of ingested materials, a situation akin to earthworm activity (OHIAGU, 1976). The dispersal of bodies of alates and their wings after the 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 in the mound crust of *Trinervitermes* goes to prove that the abundance and voracious feeding habits of the termites not only speed the breakdown of plant material but selectively concentrate it 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.

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