IMPACT OF MOUND-BUILDING TERMITES ON SOIL PROPERTIES IN NORTHERN GUINEA SAVANNAH OF NIGERIA.

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Abstract
Termites are important components of the soils in the tropics and they play a key role in nutrient recycling and transportation of soil material.Several researches on the impact of termites on soil properties and soil formation were conducted. But, in this study, we measured and comparedthe physico-chemical properties of three termite mounds in comparison with the surrounding soils that have no evidence of termite activity in them. Soil samples were collected at the top and bottom of the mounds and were subjected to routine analyses. Results show an increase in clay percent in the soil with the termite activity compared to the surrounding soils. In addition, numerical values of nutrients such as Total Nitrogen content of the soils, exchangeable bases (especially Ca and Mg) and the overall CEC of the soils are higher in the soils with the termite activities.
Keywords: Mound-Building, Termites, Soil, Savannah

Introduction
All over West Africa, termites play a significant role in forming landscapes and the soils. In the savannah region they build huge termite mounds, some of these are several meters high (Awadzi*et al.*, 2004). Termites are common biological agents that produce significant physical and chemical modifications to tropical and subtropical soils (Mando*et al.*, 2006). Nowadays, termites like earthworms are seen as very important soil organisms that effect soil functioning and ecosystem activity. In tropics, termites play an important role in nutrient recycling, transportation of soil material and soil formation (Gholami and Reizi 2012; Lobry de Bruyn, 1999). Termites, particularly fungus-growing species (Termitidae, subfamily Macrotermitinae), are often the dominant invertebrate group in tropical and subtropical habitats (Jouquet*et al.*, 2004). Sileshi*et al.*(2010) outlined several functions of termites in African savannah; among which include nutrient transfer and modification of soil physical and chemical properties.

Although the Macrotermitinae originated in the rainforests of Africa (Aanen andEggleton 2005), there are more species in savannas (94 species) compared with rainforests (44 species). The main genera include *Odontotermes, Macrotermes, Pseudacantotermes,Microtermes, Ancistrotermesand Allodontotermes*(Sileshi*et al.*,2010). Termites can modify soil texture and bulk density through various mechanisms. First, termites translocate large quantities of soil through their foraging (e.g. soil sheeting) and nest-building activities, which involve tunneling and translocating several cubic meters of soil from deep horizons to the surface (Turner *et al.*, 2006). As termites preferentially move fine and medium sized particles, they also contribute to stone line formation. Geological studies (Crossley, 1986) show that *Macrotermesfalciger* transports sediment from beneath and deposits homogeneous red clayey sand sheets of up to 5m thick on the surface. These activities may change the soil bulk density, porosity and other physical properties. The large amounts of soil translocated by termites may also play a role in nutrient transfer. In a South African savanna, *Hodotermesmossambicus* brings to the surface up to 0.70 t ha^{1} of soil annually as soil dumps, which contain about five times as much N as the surrounding soil (Hewitt *et al.*, 1990). In an arid area of northern Kenya, Odontotermes species translocate up to 1.1 t ha^{-1} of soil sheeting annually (Bagine, 1984). In Senegal, *Macrotermessubhyalanus* and *Odontotermesnilensis* bring to the surface 0.70– 0.95 t ha^{-1} of soil sheeting annually,the soil sheeting has higher organic carbon and mineral N than the unmodified soil (Ndiaye*et al.*, 2004).

Termite mounds are common features of agricultural landscape in the tropical regions, however, published scientific research on termite mound soil in relation to surround soil and possible potential of TMS in agricultural production are scarce. The objective of this study therefore was to characterize termite mound soils.

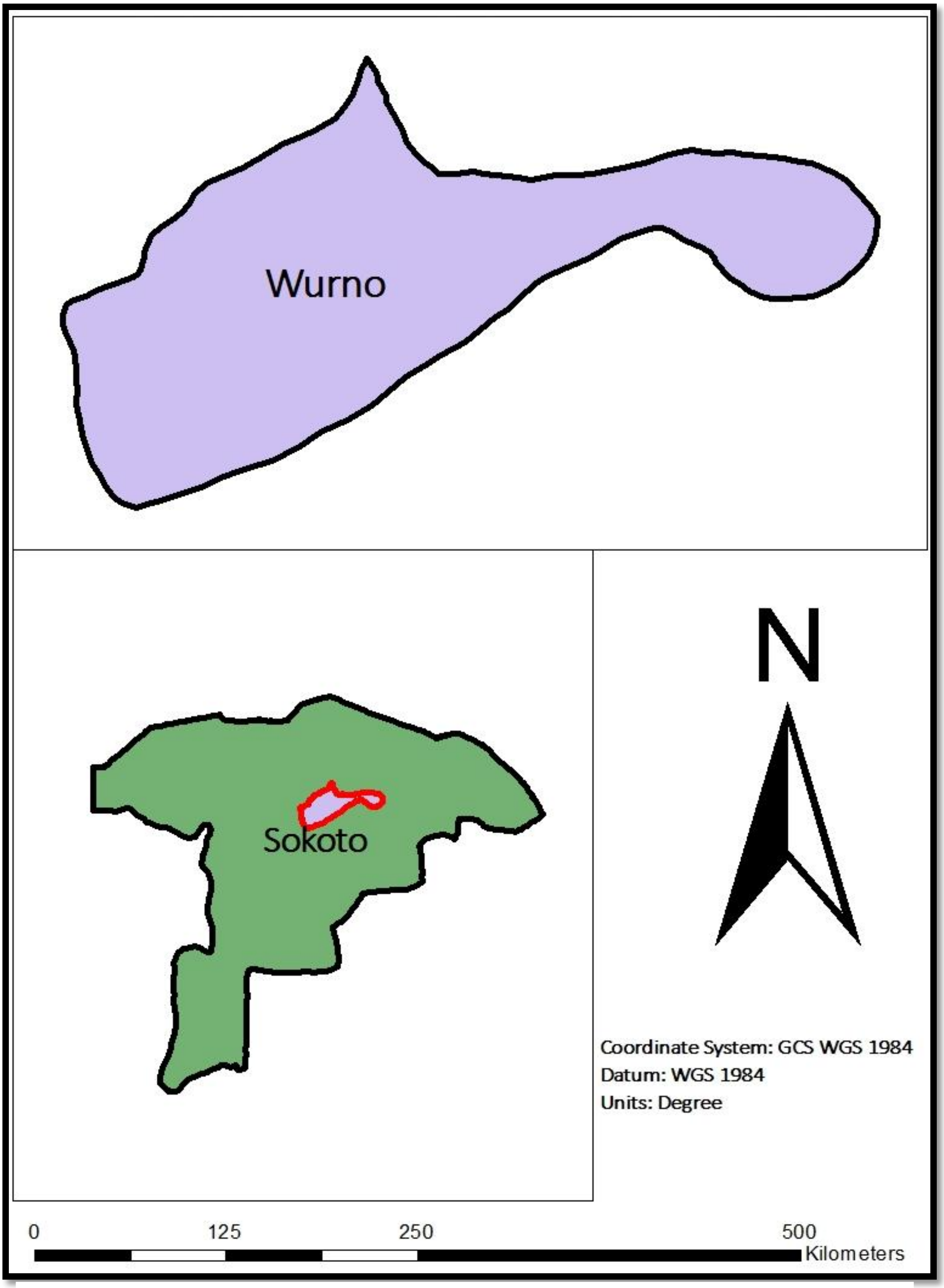

FIGURE 1: MAP OF SOKOTO STATE SHOWING THE STUDY AREA

Materials and methods

Study site

The study was conducted in the dry land farms of Wurno local government area of Sokoto State. Wurno is located 45 km north-east of Sokoto town on latitude 13^0 14^1 N and longitude 5^0 24^1 E (figure 1). The climate of the area is semi-arid with mean annual rainfall of 650 mm. Annual temperature ranges from 38-40^0 C in drier months of March and April with the lowest temperature (26-28^{0}C) in the months of December and January (SARDA, 1991). Natural vegetation observed in the area is Sudan savannah with plant species such as*Balanitesaegyptiaca*, *Bauhinia reticulatum*, *Tamarindus indica*, *Lamneaacida*and*Adamsoniadigitata*. The farm lands are intensively cultivated to arable crops like cereals and legumes.

Soil description and sampling

Soil samples were collected from three different termite mounds located in different farm lands and three surrounding soils as control. Two samples were taken from each termite mound, at the top and the base. Soil samples were also taken from the surrounding soil at the depths of 0-15cm and 15-30cm.

Soil colour was determined at the field using soil Munselcolour chart (1975). The samples were air-dried, gently crushed using a wooden mortar and pestle and then sieved through a 2mm mesh. The sieved samples were stored for chemical and physical analyses. Particle size analysis was undertaken with the Bouyoucos hydrometer method as described by (Gee and Bauder, 1986). Soil pH (1:1) was determined using glass electrode pH meter (Bates, 1954). Organic carbon content of the soils was determined by the modified Walkley-Black method as described by Nelson and Summers (1982). Total nitrogen was determined by the Macro-Kjeldahl digestion and distillation procedures as described by Bremner (1965). Available P was determined by Bray No. 1 Method (Bray and Kurtz, 1954). Exchangeable bases (calcium, magnesium, potassium and sodium) in the soil were determined using the ammonium acetate extract from the CEC determination.

RESULTS AND DISCUSSION

The results of the physical properties of the soils are presented in table 1.

Table 1. Physical properties of the Termite Mound Soils (TMS)

Sample	colour	Sand	Silt	Clay	Texture
		→	%	←	
TMS (LOC.1A)	10YR 6/8	60	18	22	sandy clay loam
TMS (LOC. 1B)	7.5YR 6/6	70	14	16	sandy loam
TMS (LOC. 2A)	10YR 7/8	56	22	22	sandy clay loam
TMS (LOC. 2B)	5YR 6/8	68	18	14	loamy sand
TMS (LOC. 3A)	7.5YR 5/8	40	18	42	sandy clay
TMS (LOC. 3B)	7.5YR 7/8	50	18	32	sandy clay loam

LOC. 1A= TOP, 1B=BOTTOM, 2A= TOP, 2B= BOTTOM, 3A= TOP 3B= BOTTOM

Texturally, the result obtained showed an increase in clay percent in the soil with the termite activity. This could be attributed to the preferred selection of clay particles by termites (Gholami and Rhiazi, 2012). Similar result was reported by Jouquet*et al.;* (2004).

Table 2. Physical properties of the Surrounding Soils (Control)

Sample	Depth	colour (Dry cond.)	Sand	Silt	Clay	Texture
			% →		←	
Control (LOC.1A)	0-15	7.5YR 5/6	84	8	9	Sand
Control (LOC. 1B)	15-30	7.5YR 6/8	86	6	8	Sand
Control (LOC. 2A)	0-15	10YR 5/8	84	8	8	Sand
Control (LOC. 2B)	15-30	7.5YR 7/8	88	6	7	Sand
Control (LOC. 3A)	0-15	5YR 6/8	80	12	8	Sand
Control (LOC. 3B)	15-30	7.5YR5/8	87	10	3	Sand

Based on the standard set by Hazelton and Murphy (2007), the pH value of the termite mound soils (TMS) are within the range of neutral. However, the surrounding soils have a pH value that is slightly acid. This finding disagrees with Manuwa and Olawolu (2013) who reported the total Nitrogen content of the termite mound soil (TMS) is found to be higher than the surrounding soils. According to Semhi*et al.*,(2008), the activity of termites often increases most macro- elements.

Table 3.Chemical Properties of the Termite Mound Soils

Sample	pH	OC	N	P	CEC	Ca	Mg	K	Na
		g/kg	g/kg	Mg/kg		cmol/kg			
TMS (LOC.1A)	6.07	8.6	0.81	0.93	7.90	0.80	0.15	2.49	0.78
TMS (LOC. 1B)	6.99	7.0	0.67	0.88	4.96	0.35	0.25	1.49	0.57
TMS LOC. 2A	5.08	26.3	0.88	0.92	6.38	0.70	0.30	1.97	0.65
TMS LOC. 2B	5.88	10.0	0.60	0.91	4.54	0.40	0.15	1.26	0.61
TMS LOC. 3A	4.91	4.0	0.81	0.86	7.58	0.85	0.15	2.41	0.70
TMS LOC. 3B	5.85	2.0	0.56	0.82	6.60	0.70	0.15	2.13	0.57

The level of exchangeable bases (especially Ca^{2+} and K^{+}) was greater in the termite mound soil. This could be attributed to the process of nutrient transfer by the termites (Sileshi*et al.*,2010).

Cation exchange capacity (CEC) of the termite mound soil is higher than the soils of the surrounding area. Several authors have found that termite mound soils have greater CEC than soils without termite activity (Bremman*et al.;* 2000; Contour-Ansel*et al.;* 2000).

Table 4.Chemical Properties of the Surrounding Soils (Control)

Sample	pH	OC	N	P	CEC	Ca	Mg	K	Na
	%	g/kg	mg/kg		**Cmolkg^{-1}**				
TMS (LOC.1A)	5.60	0.54	0.063	0.98	7.30	0.75	0.15	2.28	0.74
TMS (LOC. 1B)	6.08	0.52	0.039	0.90	5.52	0.55	0.25	1.67	0.52
TMS (LOC. 2A)	5.75	0.08	0.049	0.90	4.16	0.35	0.50	1.18	0.48
TMS (LOC. 2B)	6.56	0.04	0.028	0.83	3.70	0.25	0.30	0.97	0.43
TMS (LOC. 3A)	4.94	0.32	0.056	0.84	3.94	0.45	0.30	1.08	0.52
TMS (LOC. 3B)	6.22	0.12	0.035	0.83	3.28	0.25	0.35	0.90	0.39

Conclusion

From the study itwasrevealed that, the termite mound soil was enriched in clay content as a result of the numerous activities of the termites than the surrounding soil and hence a better soil texture. The texture also varies from top to the bottom of the termite mounds. All the tested soil nutrients are generally found to be on the higher side in the termite mound soil than the soils of the surrounding area. The termite mound soils equally have greater CEC than the corresponding adjacent soils.

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