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Physicochemical Properties and Heavy Metal Content of Termite Mound in Relation to No-Mound and its Implication in Agriculture

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Abstract. Termite can be a major agricultural pest particularly in Africa where crop losses can be severe. This paper investigated the effect of termite mound (TM) and non-termite mound (NTM) on soil physico-chemical properties and heavy metal content of an ultisol in South Eastern Nigeria. Thirty soil samples were collected at 3 depths (0-20, 20-40 and 40-60 cm) from TM and adjacent soil 50 m away (NTM). The samples were analyzed for bulk density (Bd) gcm-^{3}, total porosity (%),OC%, available P, Ph, exchangeable bases, cation exchange capacity (CEC) and heavy metasl (Fe,Zn) . Termite mound (TM) significantly improved soil physico-chemical properties relative to NTM. Soil bulk density significantly ($p<0.05$) decreased in TM relative to NTM. Observed Bd values ranged between 1.12-1.20 gcm^{-3} in TM and 1.30-1.51gcm^{-3} in NTM. Highest OC (2.18%) and CEC (1.72 cmolkg^{-1}) values were observed at 0-20cm depth in TM . These values were 58% (OC%) and 28% (CEC), respectively, higher than OC% and CEC (Cmolkg^{-1}) at same depth in NTM. Termite mound significantly increased heavy metal content (Zn, Fe) relative to NTM but not to Ecotoxological level.

Keywords: agricultural pest, beneficial effect, termite mound, microbial activity, pollution potential

1. Introduction

Micro-organisms can modify the properties of soils either in reversible or irreversible forms. Through their actions they deeply modify their immediate environment by increasing the content of fine particles and organic matter of the soil and consequently stimulate microbial activity.

Termite can be a major agricultural pest, particularly in Africa where crop losses can be severe. Verlinden *et al*.,[1] using aerial photographs, maps of indigenous land units (ILUS), geographic information system (GIS) studied the role of termite in agricultural farm land and reported the degradative effect of termite activities. Mando and Bruss [2] observed that the degradative effect of termites affect the physical and chemical properties of the soil. In a study on the impact of mound building termites [3] reported that there is always the constraint of re-colonization of vegetative land which finally affected the properties of secondary forests. Jauguet *et al.*, [4] reported 20% increase in clay content in termite mound compared to nearby soil. Similarly, [5] showed that the pH and microbial population are higher in termite mound than in clay soils. Watson [6] reported that termite mound has 90% fine material (silt + clay) compared to 52% clay+ silt in adjacent soil in West Africa. Pattak and Lehri [7] noted that mounds of *Odontoterms abscurelops* in India has a water holding capacity about five times than that of adjacent soil.

However, there has been contrasting results on the effect of termite activities on soil exchangeable bases, organic matter, total N, available P and effective cation exchange capacity. In line with this [8] and [9] observed that mound soils of various termites species can have either higher or lower values of organic matter, exchangeable bases (K, Na, Mg, Na) total N. available P, and effective cation exchange capacity. For instance in contrast to higher levels of organic carbon in termite mounds observed by [10], [11] showed low organic carbon content in termite mounds compared to surrounding soil. Researches on termite mounds have concentrated on its beneficial effects with no attention on its possible adverse effect on soil and crop production. Similarly, little or no research on termite mound has been carried out in the study area Abakaliki South Eastern Nigeria. This research is aimed at evaluating the physico-chemical properties and pollution potentials (in terms of heavy metal contents) of termite mounds in an ultisol in Abakaliki South Eastern Nigeria.

2. Material and Methods

This study was carried out in Abakaliki –Ebonyi state Southeastern-Nigeria. Abakaliki (06^0 04^1N, 06^0 65^1E) has a mean annual rainfall of 1700 mm distributed between April and November. The soil is an ultisol and classified as typic Haplustult [12]. Farming is the major activity in the area.

Field Study

Soil samples were collected from termite mound (TM) located at Agbaja Izzi in Abakaliki Urban and non termite mound (NTM) soil 50 m away. Sampling was done at 0-20 cm, 20-40 cm and 40-60 cm depths in the TM and NTM soil. Thirty soil samples were collected from both points. The samples were air dried, sieved with a 2mm sieve and used for determination of soil chemical properties. Similarly ten core samples were collected for determination of soil bulk density.

Laboratory Determinations

Samples were analyzed in the research laboratory of the Department of Soil Science and Environmental Management , Ebonyi State University, Abakaliki, for bulk density, hydraulic conductivity, total nitrogen, organic carbon content, available phosphorus, soil pH, particle size distribution and contents of Zn and fe. Bulk density was analyzed by Core method [13]. Organic carbon was determined by Walkley and Black procedure [14] while total nitrogen was by macro-kjeldahl method [15] .Particle size distribution was determined using the pipette method of [16] whereas soil pH on a saturated sample was determined in soil electrode pH meter (digital pH meter, Accunet model AR15, Fisher Scientific). Total porosity was calculated from bulk density value as follows: $Tp(1-\frac{bd}{Ps})x100$

Where Tp = Total porosity, bd = bulk density and Ps = particle density assumed to be 2.65 gcm^{-3}). Soil and mound contents Fe and Zn were determined using atomic absorption spectrophotometer after digestion with conc. HNO_3 [17]. Exchangeable mg and ca were determined by the method described by [17] while exchangeable Na and k were extracted in neutral NH_4 OAC and measured photo metrically using flame photometer.

Data Analysis

The data obtained from study were analyzed using Duncan Multiple Range Test (DMRT) and means separated using FLSD (0.05)

3. Results and Discussions

Result of the study in Table 1 shows low sand and high silt and clay content in the termite mound (TM) compared to adjacent soil (NTM). Similarly, the sand, silt and clay content were observed to decrease with depth in the Termite mound (TM) compared to the control where it increased with depth.

The table also showed higher moisture content in TM compared to the NTM . At the depth of 0-20 cm in TM moisture content value (38) was 55% higher than moisture content in NTM. Bulk density ranged between 1.10-1.20 gcm^{-3} in TM and 1.30-1.51gcm^{-3}in NTM. At all depths bulk density was lower in TM than that of the NTM. Similarly, total porosity values were higher in TM than in the NTM. Total porosity values of 57%, 60% and 55% were observed in 0-20cm, 20-40cm and 40-60cm depths respectively,in TM as against values of 51%, 45% and 43% observed respectively,at same depths in NTM. The high levels of clay and silt in the TM fraction relative to NTM is in lime with the reports of [19,11, 20 and 8]. The variation in particle size of the soil according to [21] could be as a result of variation in site characteristics, termite species and general land use at the sampling site. Termites modify soil profile by removing soil from various depths and bringing them to the surface. Debrauyn and Conacher [21] reported higher clay content in termite mound relative to the control. The change in texture due to redistribution of mounds and other structures in the surface could lead to change in physical properties like bulk density permeability,and water holding capacity [22]. Pattak and Lehri [7] reported higher water holding capacity in mounds of *odontotermites* at Abscuriceps in India than in adjacent soil. Ghilarvo [23] reported bulk density values of 1.12 gcm^{-3} and 1.22 gcm^{-3} for termite mound and surrounding soils, respectively. Research results by [10, 20] showed higher level of bulk density in surface mound in relation to surrounding soil. .Leonard and

Rajot [24] observed that termite built galleries which increase soil porosity and infilteration which will be filled up with top soil material.

Total N% available P (ppm) and organic carbon values (OC%) were higher in termite mound than in NTM (Table 2). Available P in termite mound ranged from 6.60 (20-40cm) – 11.5 ppm (0-20 cm) and 9-5 (0.20cm) – 10.8 ppm (20-40 cm) in the NTM soil. Total N (%) was observed to decrease with depth in both soils but with higher values in TM. Highest OC% value (6.78) was observed at top 0-20 cm in TM. The value was 58% higher than OC% value in 0-20 cm depth in NTM

Table 1:** Changes in soil physical properties of termite mound and non-termite mound.**

Parameter	Depth (cm)	Sand	Silt	Clay	Bd	TP	HC	GMC
TM	0-20	42.8	31.4	26.8	1.20^{a}	57^{ab}	2.00^{ba}	38^{ba}
	20-40	45.8	30.4	23.8	1.10^{b}	60^{b}	5.20^{aa}	35^{ca}
	40-60	40.8	29.8	29.4	1.07^{a}	50^{ac}	2.00^{bb}	32^{cb}
Mean	-	43.1	30.5	26.4	1.16	57.3	3.07	34
	0-20	60.8	23.4	15.8	1.30^{ab}	51^{c}	18.0^{b}	17^{cc}
	20-40	50.8	31.8	17.9	1.45^{ac}	45^{ab}	14.4^{c}	34^{ca}
	40-60	49.8	34.8	15.4	1.51^{aa}	43^{ca}	7.20^{a}	22^{bc}
^{c}Mean		53.8	29.7	16.7	1.42	46	12.2	24.3

Values with different superscripts are significantly different at ($P \leq .05$).TM=Termite mound, NTM= Non-termite mound

Table 2: Changes in total N avail P, pH and OC (%) of termite mound TM) and non-termite mound (NTM).

Parameter	Soil depth (cm)	Avail P (ppm)	Total N	OC%	pH
TM	0-20	11.5^{b}	0.42^{ab}	2.78^{aa}	3.15^{ac}
	20-40	13.3^{c}	0.05^{ac}	1.26^{bb}	3.67^{ba}
	40-60	6.6^{a}	0.03^{aa}	0.65^{bc}	3.57^{cb}
Mean		10.5	0.17	0.51	3.46
	0-20	10.8^{ab}	0.05^{a}	1.17^{ac}	4.75^{bb}
	20-40	8.9^{ac}	0.04^{abc}	1.22^{ba}	4.30^{bc}
	40-60	9.5^{cc}	0.04^{bb}	0.63^{ac}	4.17^{ab}
Mean		9.7	0.04	1.01	4.41

Values with different superscripts are significantly different at ($P < .05$).TM=Termite mound, NTM= Non-termite mound

P^{h} in TM was more acidic compared to the pH in NTM. Results of the study recorded higher levels of Ca, Mg, K, Na and CEC in TM relative to NTM (Table 3). The table showed mean values of 0.11, 0.73, 4.0 and 0.11 (cmolkg^{-1}) respectively for Na, Mg, Ca and K in TM compared to mean values of 0.05 (Na), 1.13 (Mg), 2.13 (Ca) and 0.09 cmolkg^{-1} (K) in NTM. Highest CEC value of 7.72 (Cmolkg^{-1}) was observed at 0-20 cm depth in TM. The value was 23% higher than CEC value in the NTM. Controversy exists on the actual effect of termite mound on Ca, Mg, total N, cation exchange capacity and available P of termite mound. According [8] and [9] various species of termite can have higher or lower values of OC, total N, available P,exchangeable bases and cation exchange capacity in relation to surrounding soil. Results of the study

Table 3: Effect of termite mound and non-termite mound on exchangeable cations and CEC

Parameter	Soil depth(cm)	Na	Mg	Ca	K	CEC
TM	0-20	0.14^{a}	1.60^{b}	4.80^{c}	0.14^{ac}	7.72^{b}
	20-40	0.09^{b}	2.00^{c}	4.40^{cb}	0.10^{ba}	7.72^{b}
	40-60	0.14^{ab}	1.60^{a}	2.80^{ac}	0.10^{bb}	7.00^{b}
Mean	-	0.11	1.13	4.0	0.11	7.58
	0-20	0.09^{ac}	1.13	3.20^{bc}	0.11^{ca}	5.95^{cb}
	20-40	0.05^{abc}	1.20^{ac}	4.00^{aa}	0.07^{cc}	5.72^{a}
	40-60	0.05^{abc}	1.80^{ca}	1.20^{b}	0.08^{ac}	5.72^{a}
Mean	-	0.05^{abc}	1.13	2.13	0.09	5.72^{a}

Values with different superscripts are significantly different at ($P< .05$). TM=Termite mound, NTM= Non-termite mound

(Table 2 and 3) are in line with that of [25], [26] and [27]. Study by [28] showed that pedogenesis, organic matter decomposition and nutrient cycling are highly influenced by termites. In contrast to the result of this study [11] reported low OC content in termite mound compared to adjacent soil. Kemp [26] using cubi termes mound and [27] using macro terms mound recorded higher OM content, available P, exchangeable cations and pH in termite mound relative to adjacent soil. Holt and Leepage [29] observed increased carbon and nitrogen levels in various termite mounds as compared to surrounding soil. Ellis [30] reported high soil Ca, pH, available P as well as $CaCo_3$ in termite mound of macrihedotermes viator in South Africa.Siame [31] in his investigation concluded that termite mound has higher levels of available P, Ca, as well as higher levels of organic matter than surrounding soil which contribute to better crop development.

Table 4: Changes in contents of selected Heavy metals in termite mound and non-termite mound.

Parameter	Soil depth (cm)	Zn	Fe
NTM	0-20	25.3^{b}	22.2^{ac}
	20-40	20.3^{a}	29.4^{abc}
Mean	-	22.9	25.81
	0-20	368.9^{ab}	415.5^{bc}
	20-40	368.9^{ab}	264.60^{ac}
Mean	-	368.9	340.05

Values with different superscripts are significantly different at ($P< .05$). TM=Termite mound, NTM= Non-termite mound

Table 4 showed higher levels of heavy metal (Zn,,Fe) in TM than in NTM. Observed values of Zn was 378.8 ($mgkg^{-1}$) in top (0-20 cm) of TM as against 35.3($mgkg^{-1}$) observed in NTM. Higher levels of heavy metals (Zn and Fe) observed in top 0-20 cm NTM and TM relative to subsoil is in line with the findings of [32,33] who observed that top soil is better indicator of heavy metals than subsoil. Increase in Zn observed in termite soil is within the normal range in soil which according to [34] is between 1-900 $mgkg^{-1}$. Similarly, observed increase in Fe does not constitute problems to soil and crops.

4. Conclusion

Termite mound improved soil physical and chemical properties relative to non-termite mound. The improvement in soil properties is depth dependent. Termite mound also increased soil heavy metals but not to ecotoxological levels or levels that will constitute problems to soil and crops. Soils from termite mound can be used for increased agricultural crop production without harmful effect on crops and humans.

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