Arid Zone Journal of Engineering, Technology and Environment, August, 2017; Vol. 13(4):440-448
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Print ISSN: 1596-2490, Electronic ISSN: 2545-5818, www.azojete.com.ng

A PRELIMINARY STUDY ON TERMITE MOUND SOIL AS AGRICULTURAL SOIL FOR CROP PRODUCTION IN SOUTH WEST, NIGERIA

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Abstract
It is a popular belief of the people in the Southern region of Nigeria that a land infested with termite usually brings prosperity to the land owner regardless of the type of its usage. Therefore, the present study assessed termite mounds soil properties which are important to crop production. Two soil samples were collected and their physical and chemical properties determined in accordance with American Public Health Association (APHA, 2005). Data were analyzed using descriptive statistics. The textural classes showed that the termite mound soil was sand clay loam while the surrounding soil was clay loam. This results revealed that: Termites' activity induced significant chemical changes in the soil possible due to the materials used in building their nests. There was increase the concentrations of nitrogen, phosphorus, Potassium, calcium and magnesium higher in the termite's mounds, while the micro-nutrients (zinc, iron and copper) except sulphur and manganese lower in the soil infested by termites. There were significant differences ($p \geq 0.05$) between termite mound soil and surrounding soil. It showed highly positive correlation between termite mound and surrounding soil (r= 0.92). The concentration of the soil properties around the termite mound are within the range of soil nutrients suitable for arable crop production. Termite mound soil is recommended to be used as an alternative to local farmers who cannot afford to buy expensive inorganic fertilizers.

Keywords: Termite, Mound, Soil properties, Macro-nutrients, Micro-nutrients, Western Nigeria

1. Introduction

Soil is an unconsolidated mineral or organic material that is on the surface of the earth in which we grow plants. It is natural resources which exit on the surface of the earth, made up of macro and micro-organisms, mineral organic matter, air and water. The importance of the soil to life was highlighted by McBratney and De Gruijter (2002).include; food production, water quality and flood control, filtering water and waste and providing a home for plants, animals and micro-organisms. The roles that soil play are as follows:

(1) It provides shelter to creatures, source of food and materials as medium for growth, food and energy crops and the basis for livestock production; it is also served as a source of minerals like peat, as well as a natural reservoir for huge amounts of water and it is a natural seed bank.

(2) It provides water and nutrients for the entire plant kingdom (Brady and Weil, 2006). Termites are social insects of the order Isoptera with about 3,000 known species, of which 75% are classified as soil-feeding termites (Donovan *et al*., 2001).

These insects are not often seen although evidence of their presence is observable in the large mounds they constructed or the damage they do to wood products structures. Anthills are formed on a basis of species of termite which dictate the kind of food they fed upon and the kind of mounds they brought forth (Pathak and Lehri, 2009). The building material for anthill is usually local soil mixed with saliva (Jouquet *et al*., 2002). Termite mounds have been called marvels of engineering because of their wonderful nature and also referring to as "ecosystem engineers" because they promote soil transformations by disturbance processes (Lal, 2008; Senhi *et al*., 2008).Termites are common biological agents that produce significant physical and chemical modifications to tropical and subtropical soils (Black and Okwakol, 2007). The construction of ant nests by termite changes the physical and chemical properties of the soil increasing its drainage and aeration through the formation of underground galleries, and transforming organic matter and incorporating nutrients by food storage (Wood, 2008; Banerjee and Mohan, 2006). Their activities have positive impact on soil's physical and chemical properties, plant distribution and forest health (Holldobler and Wilson, 2010). Researchers have reported that termite activities increase the content of organic matter in the soils due to the construction materials they use in building their nests and also modify the clay mineral composition of this soil (CMahaney *et al*., 2009; Jouquet *et al*., 2002; RooseAmsaleget *et al*., 2004). Researchers highlighted the positive impacts of termites on the physical and chemical properties of soil that are considered to be important for crop production and other human needs (Jouquet *et al*., 2002; Brossard *et al.*, 2007; Hesse, 2000). Termite activity provides channels that increase a soil's porosity, water holding capacity (WHC), and water infiltration (Lopez-Hernandez *et al.*, 2006). They also increase further biotic activity by breaking down large amounts of soil organic matter (SOM) through digestion and supplying nutrient-rich secretions in their casts (Ohkuma, 2003). Some studies have highlighted the role of termite on soil texture and chemical properties improvement (Wood, 2008), soil nutrient cycling and soil metabolism (Menaut *et al.,* 2005; Abbadie and Lepage, 2009. Literature also shows that termite mound soils have high levels of calcium, phosphorus and organic matter, which also contribute to better crop development than immediate surrounding (Rupela et al., 2006; Pathak and Lehri, 2009.

Carter (2002), Brady and Weil (2006) and Gardiner and Miller (2004) reported that agricultural soil is the healthy and high-quality soil that has the following properties:

(1) Good soil tilth,
(2) Sufficient depth,
(3) sufficient, but not excessive, nutrient supply
(4) small population of plant pathogens and insect pests
(5) good soil drainage
(6) large population of beneficial organisms
(7) low weed pressure
(8) no chemicals or toxins that may harm the crop.

A qualitative soil should able to hold water and nutrients like a sponge where they are readily available for plant roots to take them up, suppress pests and weeds that may attack our plants (Magdoff and Van, 2000). Soil quality is used interchangeably to describe soils that are not only fertile but also possess adequate physical and biological properties to "sustain soil productivity, maintain environmental quality and promote plant and animal health" (Nichols, 2004).There are many termite mound soils in the Faculty of Agriculture in Ikole Campus, Federal University Oye-Ekiti and it is a general belief of the people in the South west Nigeria that a land infested with termite (termite mound soil) usually bring prosperity to the ownership regardless of the type of land usage. Therefore, the present study assessed termite mounds soil properties which are important to crop production.

2. Materials and Methods

2.1. Site Description

The study area is Ikole in Ikole Local Government Area of Ekiti States in the South West part of Nigeria. It falls within longitudes 05^{o} 24`E and latitudes 7$^{o}$ 30`N. level. The population of the area is about 414,216. The area is characterized by the tropical rain forest. The temperature ranges from 19^{o}C to 34^{o}C with an annual mean temperature of about 24^{o}C. The average rainfall is about 350 mm. Hydrogeologically, the drainage pattern is dendritic due to clayey weathered overburden overlying the basement complex rock.

2.2 Collection of Samples

The soil samples within 90 cm depth from the termite mound soil (Figure 1) and the soil surrounding termite mound were collected by auger for the experiment within the premises of the Faculty of Agriculture in Ikole Campus of Federal University Oye-Ekiti. The study area was located in Ikole Local Government area of the State. These samples were moved to Soil Testing Laboratory.

Figure 1: Termite Mound Soil in Ikole campus of the Federal University Oye-Ekiti.

2.3 Determination of Soil physical and chemical properties

Soil parameters to be measured include Textural class, Bulk density, pH, electrical conductivity (EC), Water holding capacity (WHC), Porosity, organic carbon, total nitrogen, total phosphorus, potassium, calcium, magnesium, sodium, sulphur, iron, zinc, copper and manganese.

The pH and electrical conductivity: pH and electrical conductivity of the soil were determined with 10 g of air – dried finely powered soil sample put in a beaker and mixed well with 25ml of distilled water and kept for about half an hour with occasional stirring. The electrode of pH meter and electrical conductivity meter were dipped into the solution and the readings were taken in accordance with America Public Health Association (APHA, 2005).

Bulk density of the Soil: Bulk density was determined by gravimetric method. The samplers were weighed empty, and then weighed with the soil. The sample was later placed in an oven at a high temperature of about 105°C for 24 hours and cool in a desiccator.
The bulk density was then determined by the formula.

Bulk density of soil (g/cm^3) = $\frac{Mass\ of\ oven\ dry\ soil\ (g)}{Volume\ of\ core\ (cm3)}$ (FAO/IIASA. 2008)

Porosity (%) = Total pore volume / Bulk soil volume.

pH: the pH of the soil was determined with 10g of air – dried finely powered soil sample put in a beaker and mixed well with 25ml of distilled water and kept for about half an hour with occasional stirring. The electrode of pH meter was dipped into the solution and the reading was taken. (APHA, 2005).

Soil Texture: 100 g of air-dried finely powered soil was put in a 500 ml of conical flask and 15ml of 0.5N sodium oxalate (Na_2SiO_3) was added. 200 ml of distilled water was added to the mixture and shake for 20 minutes. The content was transferred to one litre capacity measuring cylinder and make it up to one litre by adding enough water. Stir the suspension thoroughly, then stop stiring and note the time. Hydrometer was dipped into the suspension after 5 minutes given direct reading of the percentage of Clay + Silt. Hydrometer reading after 5 hours of sedimentation gives percentage of Clay directly. Hydrometer given the reading in g/L. Percentage of sand was determined by deducting the percentage of Clay + Silt from 100. Similarly percentage of Silt was determined by subtracting the hydrometer reading for Clay from Clay + Silt (APHA, 2005).

Total nitrogen (mg/kg): 10 g of air-dried soil was put in Kjehdahl flask. 100 ml of 0.32% potassium permanganate ($KMnO_4$) and 100 ml of 2.5 % Sodium Hydroxide (NaOH) solutions were added to the mixture. The mixture was distilled after adding 2 ml of Paraffin and 10 – 15 ml of glass beads. 75 ml of 0.02 N, Sulphuric acid with a few drop of methyl red indicator were titrated with 0.02 N NaOH to a colorless end point. Nitrogen (mg/l) = (25-no. of 0.02 N NaOH required) × 2.8 (APHA, 2005).

Total Phosphorus (mg/kg): 1.0 g of dried and powered soil sample was put in a glass bottle with a stopper. 200 ml of 0.002 N Sulphuric acid solutions was added and shake for 30 minutes with a mechanical shaker. The mixture was filtered using Whatman no.42 filter paper. 25 ml of the clear filtrate were used to find out the concentration of phosphate in that solution through the standard curve.

Available phosphate (mg/l) = phosphate in solution × 20 (APHA, 2005).

Water Holding Capacity (WHC): Uniform plots of 1m × 1m were selected. The plot were filled with sufficient water to completely saturate the soil and the plot were covered with polythene sheet to check evaporation soil samples were taken after 24 hours of saturation and determined moisture content daily till the values of successive days are nearly equal. Water holding capacity is expressed as follows:

Percentage × moisture in soil = [(Y – Z) ÷ (Z –X) ×100].

Where:

X = weight of empty moisture box

Y = weight of moisture box + moist soil

Z = weight + moisture box + ordinary soil (APHA, 2005).

Organic Carbon (%): 10g of soil samples were placed into vessel and oven dried at 105 ^oC and dried for four days. The soil vessel from the dried oven was removed and placed t in air – dried. When cooled, placed 2 g of soil into furnace and bring temperature to 400 ^oC for four hours.

Percentage of organic Carbon (OC) = [(W_1 – W_2) ÷ (W_1) ×100].

Where: W_1 = weight of soil at 105^oC, W_2 = weight of soil at 400 ^oC (APHA, 2005).

Zinc, sulphur, Copper, Iron and Manganese (mg/kg): 10 g of dried and powdered soil sample was put in a glass bottle with stopper. 200 ml of Zinc sulphate ($ZnSO_4.7H_2O$), ferrous sulphate ($FeSO_4.7H_2O$) and Manganese sulphate ($MnSO_4.H_2O$) solution was added and shake for 30 minutes with a mechanical shaker. Their respectively solutions were flamed using atomic absorption at a wavelength of 213.8 nm photometer which determined the cement atom. (APHA, 2005).

Potassium (mg/kg): .5 g of soil sample dissolved in water and diluted to make up 20 µg K/ml solution. 100 mL of the ammonium acetate was added to the solution

Potassium (ppm): 10A

Where,

A = content of K (µg) in the sample was read from the standard curve/ (APHA, 2005)

Calcium and Magnesium (mg/kg): 5 g air dried soil sample was put in 150 ml conical flask and 25 ml of ammonium acetate was added. The mixture was shaken on mechanical shaker for 5 minutes and then filtered through Whatman filter paper No. 1. 5 crystals of carbamate and 5 ml of ammonium chloride-ammonium hydroxide buffer solution. 4 drops of Eriochrome black T indicator was added to the mixture and then titrated with 0.01N versenate (EDTA) till colour changed from orange red to purple and green to wine red respectively

2.3 Data Analysis

Physical and chemical properties of soil samples were determined in accordance with the American Public Health Association Standards (APHA, 2005). Data were analyzed using descriptive statistics. Each parameter was compared using d-test. The statistical inference was made at 0.05 (5%) level of significance

3 Results and Discussion

3.1: Average Concentration of the Physical and Chemical Properties of the Termite mound and surrounding soils.

The physical and chemical properties of the termite mound soil and surrounding soil is presented in Table 1.

Table 1: The concentration of the Physical and Chemical Properties of the Termite Mound Soil Samples

S/N	Parameter	Termite Mound Soil	Percentage of decrease or increase	Surrounding Soil	Critical Value for Crop Production Nichols, *et al.*, 2004
1	Textural Class	Sand Clay loam		Clay Loam	Sandy Loam
2	Bulk Density (g/cm^3)	1.34	- 44	1.44	1.25 – 1.45
3	Porosity (%)	47.60	46.9	34.36	26.25 – 50.00
4	Soil pH	7.7	8.5	7.1	5.6 – 8.0
5	Electrical condu.(dS/cm)	0.30	33.4	0.22	$<$ 1.0
6	Water holding capacity (%)	67	15.5	58	60 – 80
7	Organic carbon (%)	15	50	10	10 – 20
8	Total Nitrogen (mg/kg)	24	20	20	20 – 30
9	Total Phosphorus (mg/kg)	11.2	69.7	6.6	6.5 – 18
10	Magnesium (mg/kg)	8	33.3	6	6 - 15
11	Potassium (mg/kg)	4	50	2	3 – 6
12	Calcium (mg/kg)	4	-33.3	5	2 – 9
13	Sulphur (mg/kg)	10	-30	13	10 - 20
14	Manganese (mg/kg)	22	-9.1	24	26.- 36
15	Zinc (mg/kg)	7	40	5	3 - 15
16	Iron (mg/kg)	74	27.6	58	50 – 100

17	Copper	7	40	5	3 - 15

The majority (76.5%) of physical and chemical properties of termite mound soil are higher than surrounding soil except calcium, sulphur and manganese that are declined (Table 1).This finding collaborates with Jouquet *et al*. (2002); Brossard *et al.*, (2007); Holldobler and Wilson (2010); Hesse, (2000); Black and Okwakol, 2007) and Wood *et al.*, (2003) that termite activities have impact on physical and chemical soil properties. The soil physical and chemical properties showed significant differences between termite mound soil and surrounding soil. It showed highly positive correlation between termite mound and surrounding soil (r= 0.92) There were significant ($p \geq 0.05$) in concentration values between termite mound soil and surrounding soil

3.2: Textural Class and Bulk Density

The textural classes of the termite mound soil and that of the surrounding soils were and clay loam and clay loam respectively. The bulk density of the termite mound soil was 44 per cent lower than the surrounding soil (Table 1). These two parameters especially textural class reflected the variations in the soil porosity, water holding capacity and carbon content of the termite mound soil in relationship to surrounding soil in the studied areas. This finding reaffirms that Termite activity increases the content of organic matter in the soils; modifies the clay mineral composition of these soil material; it increases the cation exchange capacity and water holding capacity of soil retention (Mahaney *et al*., 2009; Jouquet *et al*., 2002; RooseAmsaleg *et al*., 2004; Wood, 2008).

3.3 pH and Electrical Conductivity of the Soils

The pH and electrical conductivity in termite mound soil were 8.5 and 33.4 per cent higher than the surrounding soil (Table 1). Termite modifies pH (Lal, 2008; Senhi *et al*., 2008). The changes in pH depend upon species to species of termite and soil type. The data in Table 1 indicated that the EC was 0.22dS/m in surrounding soil and 0.30dS/m in termite mound soil. By agricultural point of view soils with an EC greater than 4 dS/cm are considered saline (Brady and Weil, 2006 and Gardiner and Miller, 2004). The mound soil was not saline.The soil chemical properties showed significant differences between termite mound soil and surrounding soil. It showed highly positive correlation between termite mound and surrounding soil (r= 0.92) There were significantly different in concentrations ($p \geq 0.05$) between termite mound soil and surrounding soil. The findings collaborate with Lal (2008); Mahaney et al. (2009) that termite mound soil differed from surrounding soil in terms of physical and chemical properties.

3.4 Organic Soil and Water Holding Capacity.

The table 1 showed that the carbon and water holding capacity contents in termite mound soil were 50.0% and 15.5 % higher than surrounding soil respectively. The acceleration of organic matter decomposition due to termite action can further increase the aggregate stability and soil porosity, which can enhance water retention (Mahaney *et al*., 2009; Jouquet *et al*., 2002). This finding reaffirms that Termite activity increases the content of organic matter in the soils; modifies the clay mineral composition of these soil material; it increases the cation exchange capacity and water holding capacity of soil retention (Mahaney *et al*., 2009; Jouquet *et al*., 2002; RooseAmsaleg *et al*., 2004; Wood, 2008). The improvement of soil carbon content could lead to reduction in green house effects. The soil chemical properties showed significant differences between termite mound soil and surrounding soil. It shows highly positive correlation between termite mound and surrounding soil (r= 0.92) There were significantly ($p \geq$

0.05) difference in values for both physical and chemical properties between termite mound soil and surrounding soil

3.5 Macro-nutrients of the Soil

The data in the Table 1 indicated that the nitrogen; phosphorus, potassium and magnesium contents in termite mound soil were 20 %, 69.1 %, 50 %, and 33.3 % higher than surrounding soil respectively, while sulphur content declined about 30 % than that of the surrounding soil. The availability of sulphur to plants is dependent on the release from soil organic matter. Researchers have shown that net mineralization of soil sulphur is affected by organic matter and plant growth (Magdoff and Van, 2000); besides, temperature, moisture and nutrient supply (Menaut et al., 2005). This finding collaborates with Holldobler and Wilson (2010), Wood, (2008) and Banerjee and Mohan (2006) that termite has positive impact on chemical properties of the soil and increases macro-nutrients of the soil. The soil chemical properties showed variation in the concentrations between termite mound soil and surrounding soil. It shows highly positive correlation between termite mound and surrounding soil (r= 0.92) There were significantly different in concentrations ($p \geq 0.05$) difference in concentrations of the chemical properties between termite mound soil and surrounding soil

3.6 Micro-nutrients of the Soil.

The micro-nutrients are required in smaller quantity by the plants. However, their importance is still great. A shortage of micronutrients can limit plant growth and crop yields. Too great a shortage could even cause plant death, even with all other essential elements fully represented. The data in the Table 1 indicated that the manganese content of the termite mound soil declined than surrounding about 9.1 %. While zinc, iron and copper contents of the termite mound soil increased by about 60 %, 27.6 % and copper 40 % respectively than surrounding soil. There were significantly ($P \geq 0.05$) differences in concentrations of the chemical properties between termite mound soil and surrounding soil. It shows highly positive correlation between termite mound and surrounding soil (r= 0.92)

4 CONCLUSIONS

The present study showed that the relationship between the termite mound soil to those of the surrounding soil are as follows:

1. Textural classes of the termite mound and surrounding soils were sand clay loam and clay loam respectively.
2. Termite mound soil offer diverse range of physical and chemical environment that differ significantly from those present in general soil mass
3. The concentration of the physical and chemical parameters of the termite mound soil were within the recommendation critical values for crop production
4. Termites' activity induced significant chemical changes in the soil that they use in building their nests, increasing the contents of most major elements, i.e. Organic carbon which also includes nitrogen, phosphorus, Potassium and magnesium increases in the soil infested by termites. While the micro-nutrients (Zinc, iron and copper) except calcium, sulphur and manganese decreased in the soil infested by termites

5. Termite soil can be used as an alternative to local farmers who cannot afford to buy expensive inorganic fertilizers. The mound density is very low but soil may be collected, crushed and mixed with top soil for small farming.
6. Effects of termite mound soil as an additive to soil type(s) for crop production should be investigated

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