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Soil texture, pH, electrical conductivity and some chemical element concentrations of soil samples taken at different heights of a termite mound.

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Abstract

The research was carried out to determine the soil texture, the pH, the electrical conductivity (EC) and some mineral element concentrations of the soil of a termite mound and its surrounding soil with the aim of determining its suitability for crop growth. Soil samples were taken from the mound at 1 metre away from the base (1MA), base (B), 1m up (1MU) and 2 m up (2MU). Standard analytical methods were used to determine the parameters. The results of the analyses gave the soil 1MA as 71% sand, 19.4% silt and 9.4% clay; B, 53.2% sand, 21.4% silt and and 25.4% clay; 1MU, 47.2% sand, 11.4% silt and 41.4% clay and 2MU, 45.2% sand, 11.4% silt and 43.4% clay. The pH values ranged from 6.83 to 7.00, showing that the soil was not acidic or basic and the EC values (in µs/cm) ranged from 206 to 228. The values obtained for exchangeable minerals (in cmol/kg) were Ca, 6.80, 13.78, 8,93, and 11.33; Mg, 1.20, 0.69, 1.07 and 0.77; K, 0.55, 0.60, 0.49 and 0.57 and Na, 0.48, 0.57, 0.57 and 0.66 for 1MA, B, 1MU and 2MU respectively. The values got for micro-elements (in mg/l) were Mn, 68.1, 44.6, 29,0 and 33.7; Fe,15.7, 13.8, 13.5 and 17.5; Cu, 0.97, 1.42, 1.45 and 1.57 and Zn, 5.32, 6.50, 4.55 and 5.36 for 1MA, B, 1MU and 2MU respectively. Nearly all the parameters considered were adequate for proper plant growth

Keywords: Electrical conductivity, mineral elements, pH, soil texture, termite mound

1. Introduction

Soil is an unconsolidated material of the earth's crust on which terrestrial plants grow if water and temperature are adequate with minimum available nutrients (Wagh *et al.,* 2013). It is a natural body of mineral and organic materials differentiated into horizons, which differ among themselves as well as from underlying materials in their morphology, physical make-up, chemical composition and biological activities (Solanki and Chavda, 2012). Many soil organisms modify the environment in which they live, through physical biotic conditioning, in both absolute and relative terms to resources availability (Sarcinelli *et al.,* 2009).

Termites are one of such soil organisms. They are eusocial insects that live in colonies composed of individuals from more than one generation (Dawes, 2010). Termite's colonies are composed of reproductive pair (king and queen) and their offspring of thousands of non-reproductive individuals. This group is divided into workers and soldiers, the workers perform most of the task including foraging and repairing the mounds while the soldiers are responsible for the defense of the kingdom, soldiers fight to defend their territory and to protect every member of the family. Taxonomically, termites belong to the order Isoptera, class Insecta, phylum Arthropoda amd kingdom Animalia and six families are distinguished as follows: *Mastotermitidae, Kalotermitidae, Termopsidae, Hodotermitidae, Rhinotermitidae, and Termitidae* (Krohmer, 2004). The kalotermitidae, termopsidae and rhinotermitidae species live within wood, while the others live inside the soil matrix in nests that are better described as diffuse gallery system. Some of the termitidae build very architecturally complex nests, albeit completely subterranean. Others, while keeping intricate gallery system inside the soil, still build mounds emerging from the soil surface. Termitaria can also shelter other organisms or are important nutrients hot-spots for plants and their associated fauna. These activities influence, to a great extent, the local soil biota (Radojevic *et al*., 2005). Termites can transform clay, k-feldspars into kaollinite, use it as a cementing agent during mound construction and synthesize organo-metal complexes (Adekayode *et al.*, 2009). Mounds are built of subsoil which is not affected in its chemical properties by the termites (Arshad, 1982). Peterson (2010) reports that in certain areas of leveling of termitaria, there is a formation of slicks spots (alkali affected patches).

These slick spots are as a result of termitaria leveling that occurs only in areas with saline ground water. Jouquet (2005) reported that microhabitats are created by termites which are favourable for the development and sustenance of symbiotic micro- organisms, providing them with optimum security from predators and other interferences, minimum or loss extreme fluctuations of wetting and drying cycles, as well as abundant and accessible nutrients. In tropical savannas, trees associated with termites' colonies remained green throughout the year due to the sustenance of water from termite colonies well into the dry season (Turner, 2006). African farmers also collect termite mound soils and apply to cropped fields as it can be rich in available nitrogen, total phosphorus and organic carbon than adjacent soil (Lopez-Hernandez *et al.*, 2001). Among termites, the genus macortermes, in Africa, had been identified to have most spectacular effects on the soil as they build large mounds which can be about 12 to 18 meters in diameter and up to 7 meters high (Mitchell, 2002).

From an ecological point of view, termite mounds are nutrient hotspots. Termites bring the material from diverse soil depths and deposit them in mounds, so that the physico-chemical and biological properties are higher in termite mounds than in the adjacent soils. African subsistence farmers, follow the practice of spreading termite mound materials in their fields to enhance soil physico-chemical properties. Most of the termite mounds are sites of high nutrients contents. Redistribution of this material to the soil surface depends on soil erosion, translocation of nutrients from occupied and unoccupied mounds, and the nature of the species (Holt and Lepage, 2000; Rückamp *et al*., 2009). As long as intact, mounds often have a particularly dense waterproof surface (Jouquet *et al*., 2004). Different parts of the mounds usually have distinct ecological functions. The role of the outer wall is to protect the mounds from rain and predators, while the inner wall has a defense function and is mostly inhabited by soldier termites (Rückamp *et al.,* 2010). Termites play an important ecological role in many ecosystems, particularly in nutrient-poor environments (Avitabile *et al*., 2015).

At the landscape scale, termite activities play a key role in the distribution of resources (Jouquet *et al.*, 2004) through physical changes in biotic or abiotic materials (Ferreira *et al.*, 2011). On a smaller scale, especially in the tropical savannah, termites are known to significantly influence soil properties (Rückamp *et al*., 2012) with the construction of their nests (termite mounds) (Fall *et al*., 2001). Furthermore, termites are known to influence the soil physical, chemical, and biological properties, water dynamics (Jouquet *et al*., 2016) and decomposition of organic matter, accelerating recycling by the facilitation of microbial activity (Jouquet *et al*., 2006). Despite this progress in the knowledge, little has been done to study soil texture, pH, electrical conductivity and and some chemical element concentrations of soil samples taken at different heights of termite mound and the surrounding soil, this study, therefore, sets out to bridge this gap by looking at soil texture, pH, electrical conductivity and and some chemical element concentrations of soil samples taken at different heights of termite mound and the surrounding soil in the premises of Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria.

2. Materials and Methods

Study area: The study was carried out at the Chemistry Department of Oyo State College of Agriculture and Technology, Igboora. Igboora, Ibarapa Central Local Government Area, Oyo State, South Western Nigeria. It is located at Latitude 7°26' and 12°57' N Longitude 3°17' 18, 77°E. It experiences an average annual rainfall of 58 cm. There are several termites mounds in the area. The study area is located in savannah characterized by grasses, shrubs and few trees (Areola, 1983). The soil of the study area is red ferrasols or red- brown gravelly and pale clayey soils derived from shale (Ofomata, 1975).

Samples and sample collection collection

Termite mound soil samples were taken at different heights: Base, 1 metre away from the base, 1 metre and 2 metres up the mound, using digger, hoes and cutlasses. The samples were collected into polythene bags, labelled and taken to the Chemistry laboratory The soil samples were air dried, ground, mixed well and sieved by passing through a 2 mm sieve for analysis.

Chemical analysis of termite mound and adjacent soils

The soil samples were air dried, ground, mixed well and passed through a 2 mm sieve for analysis. Soil pH was measured using pH-meter in a 1:2.5 soil water ratio.

The exchangeable cations were extracted with 1M NH_4OAc at pH 7, Calcium (Ca) and magnesium (Mg) were determined by atomic absorption spectrophotometer, while potassium (K) and sodium (Na) were determined by flame photometry. Micronutrients, i.e., Copper (Cu), Manganese (Mn), Iron (Fe), and Zinc (Zn), were leached with DTPA extractant and their concentrations in leachates were determined by atomic adsorption spectroscopy.

Determination of Heavy metals

About 2.0 g of air-dried soil sample was weighed into a 150 mL beaker and 20 mL of concentrated HNO_3 was added to it and well covered with a glass lid, this mixture was allowed to stand for one hour before the careful addition of 15 mL of concentrated $HClO_4$ acid. It was placed on an electric hot plate and digested at 200 – 250 °C until the mixture turned yellowish in colour in about an hour. The digest was dissolved in 0.1M HCl and filtered into a 250 mL volumetric flask and made up to mark with deionised water used three times in rinsing the digestion container (Radojevic *et al.,* 2005). Finally, the element concentrations were determined by Atomic Absorption Spectrophotometer.

Calculation:

If X = mg of Cu, Fe, Mn, Zn etc were obtained from the standard curve

The soil pH was determined by using the method described by Charman (2000) in which 20 ml of 0.01 M $CaCl_2$ allowed to stand for 30 minutes and later stirred thoroughly with a glass stirring rod. Glass electrodes were then inserted into the suspension for pH measurement.

The electrical conductivity of the soil extract was determined with the Equiptronics digital electrical conductivity bridge for which 20 g soil was added to 40 ml distilled water. The suspension was stirred intermitently for 30 minutes and kept for another 30 minutes without any disturbance for complete dissolution of soluble salts. The soil was allowed to settle down and then the conductivity cell was inserted in the solution to take the readings and record the EC values.

3. Result and Discussion

Table 1 shows the results of the soil texture (sand, silt and clay), pH and electrical conductivity of the surrounding soil (1metre away from the mound) and the soil samples of the termite mound considered in the study. The results show that the soil of the surrounding is made up of 71.2% sand, 19.4% silt and 9.4% clay; the soil of the base of the mound is made up of 53.2% sand, 21.4% silt and 25.4% clay; the soil sample at 1metre up the mound is made up of 47. 3% sand, 11.4% silt and 41.4% clay and the soil sample 2 metres up the mound is made up of 45.2% sand, 11.4% silt and 43.4% clay. This means that the soil surrounding the mound is predominantly sandy with small percentage of silt and clay. As we move up from the base of the mound, the amount of sand decreases. There is an increase in the percentage of silt at the base of the mound. It decreases and remains constant at 1 metre and 2 metre heights of the mound.

There is a progressive increase in the percentage of clay as one move from the surrounding soil to the 2-metre height of the mound. The percentage of sand was higher in all samples than the percentages of silt and clay while the percentage of clay is higher than that of silt in all the samples. This type of situation was also reported by Afolabi *et al.* (2014), in which analyses of chemical and physical characteristics of mound materials and surrounding soils of different habitats of two termite species in Minna, Nigeria were carried out and reported. The report gave the percentage of sand, silt and clay for surrounding soil and mound g/kg for *Macrotermes* as 825 and 873 silt as 58 and 47 and clay as 117 and 80 respectively and for *Trinervterme,* we have for sand as 864 and 878, silt, 60 and 50 and clay as 76 and 72 respectively. The higher values of clay 1 metre up and 2 metre up the mound can be as a result of the fact that the termites have preference for finer particles as cement for building their mounds, the same thing was observe by Lima *et al.* (2018) and Donovan *et al.* (2001)

The pH values for the surrounding soil, base, 1 metre and 2 metre heights of the termite mound are 6.94, 7.0, 6.84 and 6.83 respectively. The pH of the soil at the base of the mound therefore gave higher value of pH followed by the soil samples taken at 1 metre away from the base, 1 metre and 2 metres up the mound. This means that the pH is very close to neutral pH (≈ 7.00). This is in agreement with the study conducted by Deke *et al.* (2016) and Brossard *et al.* (2007). This means that the termite activities did not affect the soil pH as such. The implication of this is that the soil is neutral and so the solubility of the mineral elements will be adequate and so are moderately available for plant growth.

The electrical conductivity (EC) values for soil in the present study, in µs/cm, are as follows: 228, 219, 206 and 210 respectively for soil samples taken at 1 metre away from the base, the base, 1 meter up the mound and 2 meres up the mound. This means that the EC values for the soil under study are very high. EC value is used o estimate the soluble salt concentrations in soil and is used as a measure of

Table 1: Soil texture (sand, silt, clay), pH and Electrical conductivity (EC) of the surrounding soil (1m away from the mound) and the soil sample of termite mound.

Parameter	1m away from base of mound	Base of mound	1m up mound	2m up mound
Sand (%)	71.2	53.2	47.2	45.2
Silt (%)	19.4	21.4	11.4	11.4
Clay (%)	9.4	25.4	41.4	43.4
pH	6.94	7	6.84	6.83
EC (µs/cm)	228	217	206	210

Table 2: Chemical element compositions of the surrounding soil (1metre away from the mound) and soil samples of termite mound

Parameter	1m away from the	Base of mound	1m up mound	2 m up mound
Calcium (cmolkg^{-1})	6.8	13.78	8.93	11.33
Magnesium (cmolkg-1)	1.2	0.69	1.07	0.77
Potassium (cmolkg^{-1})	0.55	0.6	0.49	0.57
Sodium (cmolkg^{-1})	0.48	0.57	0.57	0.66
Manganese (mg/l)	68.1	44.6	29	33.7
Iron (mg/l)	15.7	13.8	13.5	17.5
Copper (mg/l)	0.97	1.42	1.45	1.57
Zinc (mg/l)	5.32	6.5	4.55	5.36
Boron (mg/kg)	0.14	0.14	0.14	0.13
Lead (mg/kg)	19.11	11.5	44.5	53
Chloride (%)	2	1.83	1.63	27.75

salinity. Soils with EC value above 0.8 ms/cm are considered severely saline. Using this standard the soil samples in this study are therefore severely saline and this can also be seen from the pH values of the soils

Table 2 shows the chemical element compositions of the surrounding soil (1metre away from the mound) and soil samples of termite mound. From the table the concentrations of the mineral elements in the surrounding soil and the soil taken at different heights of the termite mounds are as follows. Eleven elements were considered in all. The results show that the base of the mound has highest concentration of exchangeable calcium (13.78 cmol/kg), followed by 2 m height (11.33 cmol/kg), 1 m height (8.93cmol/kg) and 1 m away from the base (6.80 cmol/kg) in that order. The exchangeable magnesium contents in (cmol/kg) are 1.20 for 1 metre away from the base of the mound, 0.69 for the base of the mound, 1.07 for 1 metre height and 0.77 for 2 metre height. With these concentrations, 1metre away from the base has the highest concentration of Mg while the base of the mound has the lowest contents of Mg. The concentrations of exchangeable potassium (in cmol/kg) are as follows in descending order: base of the mound, 0.60; 2 metre height, 0.57; 1 metre away from the base, 0.55 and 1 metre height, 0.49. the concentrations of exchangeable sodium, as determined in the study are in the descending order (cmol/kg): 0.66, 0.57, 0.57and 0.49 for 1 metre height, base, 1 metre height and 1 metre away from the base of the mound. This shows that the height of 1 metre has the highest contents of Na while the 1 metre distance away from the base has the lowest contents.

The following micro-elements were determined to have the following concentrations (in mg/l): Manganese, 68.10 (1 metre away from the base), 44.60 (base), 29. 00 1 metre height of the mound and 33. 70 (2 metre height of the termite mound. This shows that the 1 metre away distance from the base has highest contents of manganese while the 1 metre height has the lowest value. The concentrations of iron (in mg/l) are as follows: 15.70, 13.80 13.5 and 17.8 respectively, with 2 metre height having the highest concentration and 1 metre height having the lowest concentration. Copper concentrations as determined (in mg/l) has the following concentratios: 1 metre away from the base, 0.97; base 1.42; 2 metre height, 1.45 and 2 metre height, 1.57. From the results it could be seen that the termite mound has physicochemical properties that can support the growth of plant without the need to add any inorganic fertilizer

4. Conclusion

The research work studied the soil texture, pH, electrical conductivity and some mineral element concentrations of the surrounding soil, the base and the soil of a termite mound mound in the premises of Oyo State College of Agriculture and Technology, Igboora, Oyo State. It was found that the soil texture of 1 metre away from the base of the mound was predominantly sandy while the soil of the base of the termite mound was a little above average sandy and the soil within the mound had a higher amount of clay, though not as higher as the amount of sand. The pH of the surrounding soil and that of the mound are not too different from one another. The electrical conductivities of the soils were not different from one another, the soil 1 metre away from the mound has the highest value while the soil 2 metre up the termite mound has the lowest value of EC.

The soil of the mound contains varying amounts of mineral elements which are capable of supporting plants growth adequately. The exchangeable mineral elements as well as micro-elements are within the standard limits for plant growth. This agrees with what some other researchers had found out in their various research works. After carefully studying the physicochemical parameters of the termite mound in this work, it can be concluded that: since the termite mounds have physicochemical properties that can adequately support plant growth, the farmer in this neighbourhood can make use of the soils of the termite mounds to enrich the soil on which they plant their crops.

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