Variability in Geochemical Properties of Termitaria: University of Ibadan Case Study.

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ABSTRACT

The study of geochemical properties of eight termitaria within three geological zones of the University of Ibadan was carried out for this paper. The geotechnical properties performed were Atterberg limits, shear strength, California bearing ratio (CBR), specific gravity, and coefficient of permeability. Chemical properties like organic carbon (OC), organic matter (OM), nitrate (NO_3), pH, and exchangeable sodium, etc. were examined. The results revealed that within and from one geological zone to another, the geotechnical and chemical properties of termitaria differed.

(Keywords: geotechnical properties, chemical properties, termitaria, geological zones, shear strength)

INTRODUCTION

Termitaria are edifices built by tropical termites. Construction of termitarium entails excavation in soil and mass shifting of the excavated soils to the surface. The soils are cemented together with chewed up, partially digested wood, saliva, and feces to produce a more durable building material (Longair, 2004). Reworked soils are stable than surrounding ground mass because of the saliva added when building the structures by worker termites. A termitarium, which may be up to 7.0 metres may weigh up to two and half tonnes (Atkins, 1980).

Within the Savannah ecosystem, termites impact an important change on the soil environment and can occupy a large portion of land (Lee and Wood, 1971). Termites play integral roles in soil development, as they are one of the primary soil producers in arid and semi-arid systems (Holt and Leepage, 2000). Therefore, the association of termite populations with soil processes has recently prompted Levelle et al (1997) to designate them as "soil ecosystem engineers".

According to Hole (1981), a cemented surface on a termitarium may serve to reduce erosion. Animal activities such as that of termites may lower soil pH and rejuvenate soils as they concentrate calcium and other nutrients in soils. In part of East Africa, termitaria are used by farmers as soil amendments (Watson, 1977).

Termitaria have higher levels of total nitrogen, acid-extractable phosphorus and cations than their surroundings due to both the concentration in, and subsequent decomposition of, organic matter within the moulds (Jones, 1990). Marais (1989) opined that the presence of termites may bring about an increase in ground cover density, plant height, organic carbon, mineral salts and pH towards termitaria centers as well as deep store-free top soil.

Some geotechnical properties of two termite reworked lateritic soils from Ago-Iwoye Nigeria were investigated by Adeyemi and Salami (2004). The specific gravity of grains and the California bearing ratio (CBR) were higher than those of the nearby soils. However, the plasticity indices and linear shrinkages of the reworked earths were significantly lower than those of the nearby soils. The unconfined compressive strength was significantly higher than those of the neighbouring soils.

In Nigeria, with recent rapid development in building and construction industries, civil engineers have found termitaria tool for locating borrow pit because their occurrence indicates that the surrounding soil is riched in clay material or laterites. This study centered on ascertaining if there is significant difference in the geotechnical and chemical properties of termitaria within and from one geological location to another.

MATERIALS AND METHOD

The study area is the University of Ibadan Campus located in Ibadan Oyo State, Nigeria. The basement complex rocks in Ibadan are mainly metamorphic rock type of Precambrian age but with few intrusions of granites and porphyrics of Jurassic age.

The geological map (Figure 1) shows that there are four different rock types found in the University. These are quartzite, quartz schist, granite gneiss and augen gneiss. Augen gneiss constitutes the majority of basement complex followed by quartzite. The termitaria for the study were randomly selected as follows. Two were selected at quartzite zone, two picked from granite gneiss and the remaining four picked from augen gneiss zone as shown in Figure 1. A typical example of termitarium before samples were taken for laboratory analysis Is displayed in Figure 2.

Eight termitaria were selected at random as shown in Figure 1. At each location, the exposed layer of termitarium was scrapped off and enough samples were taken for the laboratory analysis. The materials taken were stored in labeled bags.

Altogether, about 30 kg of soil sample was taken at each location and transported to laboratory. The soil sampling work was done at the peak of dry season. In addition, representative sample from each location was stored in small container and taken to soil chemistry laboratory for its chemical constituents determination.

Geotechnical properties of each selected termitarium such as particle size analysis, liquid limit, and plastic limit, California bearing ratio (CBR), compaction test, permeability test, specific gravity and shear strength were carried out. These properties were done in accordance with BS 1377 1991. The compaction test was carried out prior to the CBR and shear strength tests. The values of optimum moisture content obtained during the compaction test were used to prepared soil samples for CBR and shear strength tests. Only unsoaked CBR test was carried out. Also, the permeability test was done with the aid of constant head permeameter.

The chemical constituents of termitaria determined in the laboratory were percentages of organic carbon (OC) and organic matter (OM) present. Also levels of mineral elements such as iron (Fe), potassium (K), calcium (Ca), aluminum (Al), magnesium (Mg), soil pH, and nitrate (NO_3) level were examined.

The organic carbon in the soil samples was determined by infrared Fourier transform spectroscopy method. Furthermore, the level of organic matter was achieved through the reduction of potassium dichromate by OC compounds and subsequent determination of the unreduced dichromate by oxidation-reduction titration with ferrous ammonium sulphate.

The level of nitrate present was measured by ultraviolet spectrophotometers. The exchangeable cations such as Ca, Mg, and Al were determined by atomic absorption spectrophotometer. The level of K was determined using ion – selective electrode method, while Na level was obtained through flame atomic absorption spectrometry method.

RESULTS AND DISCUSSIONS

The particle size distributions for termitaria at locations 1 and 2 were in the range of 0.075 to 1.18mm. The size of particles of termitaria from locations 3 to 8 was in the range of 0.075 to 2.36mm. The distribution curves of termitaria were displayed in Figure 3. Both the liquid and plastic limits of termitaria at locations 1 and 2 were higher than those of the remaining termitaria as shown in Table 1. The variations between the liquid and plastic limits of termitaria at locations 1 and 2 were 0.4 and 0.3 respectively. These termitaria were from granite gneiss zone. Also, variations occurred in the values of liquid and plastic limits of termitaria found at other zones. For instance, those of quartzite zone were 2.5 and 1.3 respectively. Likewise, the variations observed at locations 5 to 8 were in the range of 0.2 to 1.2 and 0.3 to 0.6 respectively. The percentage variation from one termitarium to another was very small; the highest being 4.17% for liquid limit and 2.86% for plastic limit.

Compaction test was carried out to determine both the maximum dry density (MDD) and optimum moisture content (OMC). Both OMC and MDD values were not uniform for all termitaria as shown in Table 1. Variations in values occurred from one termitarium to the next in all the zones considered. The values of OMC obtained were used to prepared samples for shear strength and CBR tests.

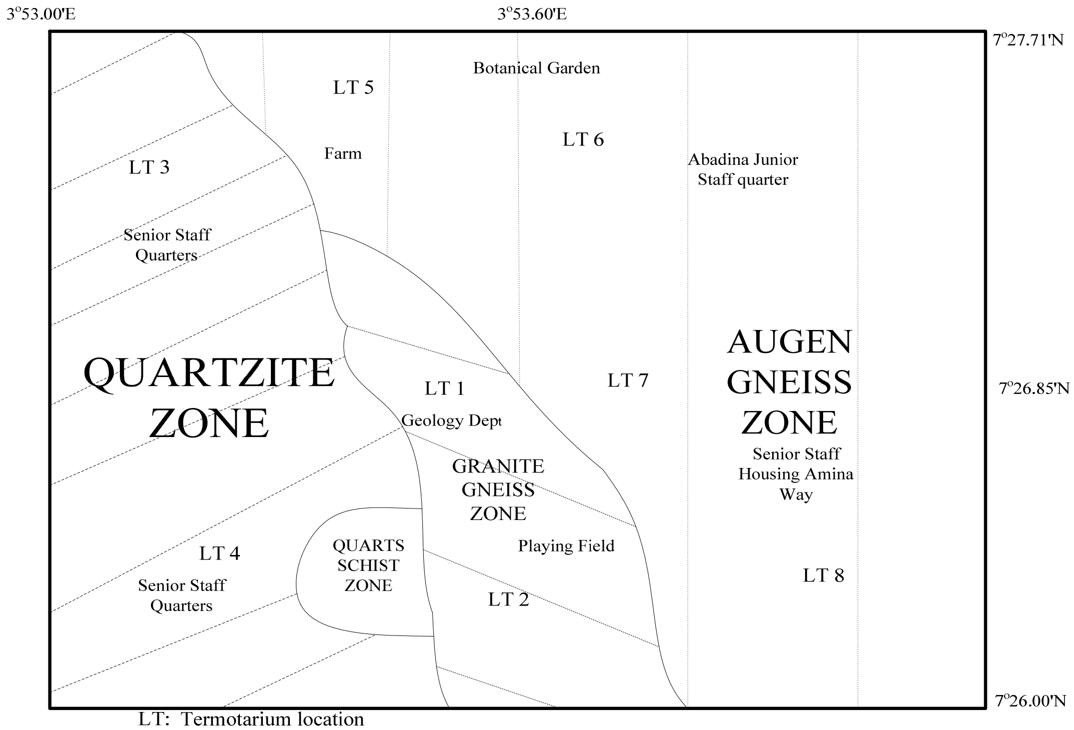

Figure 1: Geological map of the University of Ibadan, Ibadan, Nigeria
Courtesy: Department of Geology University of Ibadan

Figure 2: One of the Termitaria Prior to Sampling.

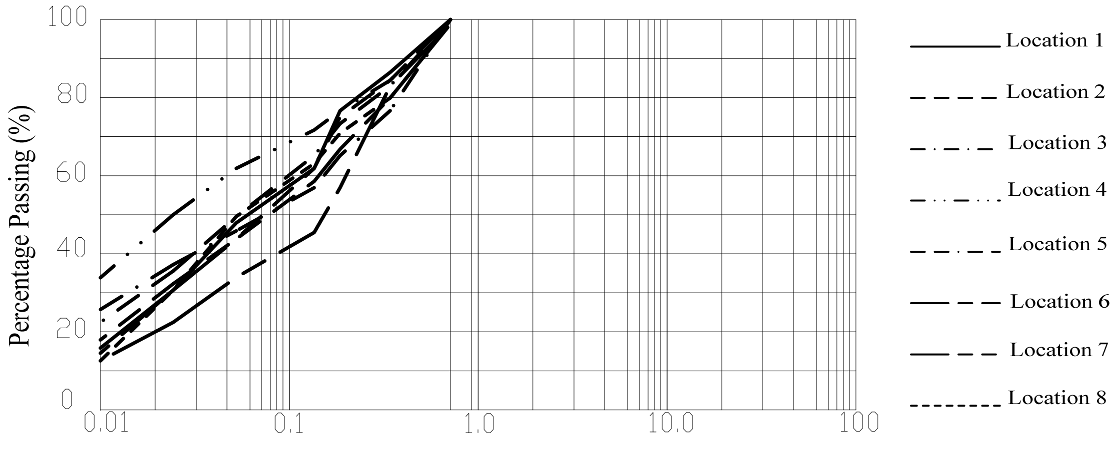

Figure 3: Particle size distribution curves of termitaria

Table 1: Results of Atterberg limits, compaction and CBR tests of termitaria

Termitarium Location	Liquid limit %	Plastic limit %	MDD kg/m^3	OMC %	CBR %
1	32.10	19.60	2.02	10.6	26.00
2	31.50	19.30	2.00	10.4	25.00
3	29.00	18.60	1.68	11.2	25.00
4	26.50	17.30	1.90	10.9	27.00
5	27.60	17.50	1.85	11.4	29.00
6	28.80	16.90	2.03	10.8	27.00
7	28.20	17.20	1.97	11.1	26.00
8	27.80	17.00	1.95	11.0	25.00

MDD: maximum dry density; OMC: optimum moisture content

CBR tests were conducted to assess the resistance value of termitaria to cone plunger penetration which governs their suitability as flexible pavement elements in road construction. The results showed that the CBR values were not uniform within rock zone and fell in the range of 25 and 29%. The differences recorded from one termitarium to another were highest at augen gneiss zone of order 13.8%. But in quartzite and granite gneiss zones, the percentage variations were 7.4 and 6.3, respectively, as shown in Table 1.

The ability of termitaria soils to withstand external stress was also measured using a triaxial cell. The compression drained test yielded the results shown in Table 2. The values of cohesion c' were very high for all the termitaria in the range of 42.5 to 50.5kN/m^2. There were significant variations in the values within rock zone. For instance, the values of c' of termitaria at locations 5 to 8 differed from one to another with highest percentage variation of 11.88%. In addition, at locations 3 and 4 of quartzite zone, the percentage variation was 7.22% which is of great significant.

The angle of friction φ' values of termitaria differed from one to another and were in the range of 14 and 19°. Variations occurred both within a basement zone and from one to another.

Table 2 revealed that there were variations in the values of specific gravity of termitaria within and from one basement to another. The highest variation recorded for termitaria was at augen gneiss zone that was of order 3.60%. The ability of termitaria soils to resist passage of water was measured. The values of coefficient of permeability obtained were very low as shown in Table 2. These values were not uniform but varied from one termitarium to another. At augen gneiss zone, the highest percentage variation was recorded of order 42.96%. On the other hand, at quartzite and granite gneiss zones, the variations were 22.20 and 9.29%, respectively and were of great significant.

The results of chemical properties of the selected termitaria were displayed in Table 3. The pH values indicated that the termitaria from granite gneiss and quartzite zones tend to be alkaline in nature. On the other hand, those from augen gneiss were acidic. The percentages of organic carbon and organic matter varied from one termitarium to another within and outside basement rock zone. The nitrate levels in all termitaria were not uniform. These values varied from one reworked earth to another. Variations were observed in the levels of metallic ions present. Mg and Fe levels were very high on comparing with other ions in all the termitaria analyzed.

Table 2: Results of Shear Strength, Permeability. and Specific Gravity Tests of Termitaria.

Termitarium Location	cohesion kN/m^2	Angle of friction degrees	Coeff. of permeability $X\ 10^{-4}$ mm/s	Specific gravity
1	43.50	19.00	7.86	2.66
2	42.50	18.00	7.13	2.61
3	45.00	15.00	6.73	2.67
4	48.50	14.00	8.65	2.73
5	46.00	16.00	9.52	2.68
6	44.50	18.00	7.60	2.78
7	47.00	17.00	5.43	2.74
8	50.50	15.00	6.59	2.73

Table 3: Results of Chemical Properties of Termitaria.

Termitarium Location	pH	OC %	OM %	NO_3^*	Mg^*	Fe^* (cmol / g)	Ca^*	K^*	Si^*	Al^*
1	7.3	0.13	0.22	0.013	1.30	1.41	0.40	0.46	0.12	0.50
2	7.4	0.14	0.24	0.015	1.20	1.43	0.41	0.48	0.13	0.56
3	7.5	0.23	0.42	0.016	1.42	1.35	0.42	0.48	0.13	0.57
4	7.4	0.25	0.38	0.018	1.46	1.33	0.36	0.51	0.12	0.59
5	6.6	0.30	0.50	0.036	1.26	1.40	0.38	0.53	0.13	0.56
6	6.7	0.33	0.50	0.040	1.28	1.43	0.41	0.56	0.14	0.57
7	6.5	0.40	0.60	0.038	1.30	1.50	0.45	0.60	0.12	0.60
8	6.3	0.42	0.65	0.041	1.24	1.47	0.44	0.58	0.13	0.61

** measured in cmol / g*

CONCLUSIONS

An in-depth study of the geotechnical and chemical properties of eight termitaria selected at random from three rock zones from the University of Ibadan have been done. The outcomes revealed the following:

- Within and from one geological zone to the other, variation in the monitored properties of termitaria occurred. The properties were not uniform in values. This implies that each parent rock has influence on the resulted reworked earth.

- Variations in monitored geotechnical properties were highly significant in soil cohesion, coefficient of permeability, liquid limit and plastic limit of order 2.86 to 42.96%.

Variations in monitored properties of termitaria were highest in augen gneiss zone.

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