

## Chemical Composition of Two Termite Mounds (*Coptotermes acinaformis* and *Nasutitermes walkeri*) in Bogoro and Katagum of Bauchi State

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### ABSTRACT

Termite mounds of *Coptotermes acinaformis* and *Nasutitermes walkeri* from two ecological zones (Bogoro and Katagum) and adjacent soils (control) were sampled and analysed for their chemical compositions (oxides) using the X-ray fluorescence spectrophotometer. The results obtained for  $\text{Na}_2\text{O}$ ,  $\text{MgO}$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{SO}_3$ ,  $\text{K}_2\text{O}$ ,  $\text{CaO}$  and  $\text{Fe}_2\text{O}_3$  for the *Nasutitermes walkeri* in Bogoro ranges from 0.07 – 72.66 % while for *Coptotermes acinoformis*, the range is 0.21– 66.22 %. In Katagum, the percentage oxide composition range from 0.000 – 74.517% for *Coptotermes acinoformis* and from 0.000 – 78.877% for *Nasutitermes walkeri*. The percentage of the oxides studied in the mounds within these municipalities did not vary significantly at ( $p < 0.05$ ) from the surrounding soil (or control) sample and generally, the studied chemical composition of the termite mounds followed the order  $\text{SiO}_2 > \text{Al}_2\text{O}_3 > \text{Fe}_2\text{O}_3 > \text{K}_2\text{O} > \text{CaO} > \text{MgO} > \text{SO}_3 > \text{Na}_2\text{O}$ . Silicon and aluminium oxide are amongst the oxide needed in the production of cement, therefore these mounds can be mixed with sand and cement during construction of houses.

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### INTRODUCTION

Termites are common biological agents that produce significant physical and chemical modifications to tropical and sub-tropical soils (Darlington *et al.*, 1987). Termites are small (4 to 15 mm long) and variable in colour from white to tan and even black (Alagappa *et al.*, 2007). They have three-body parts: head, thorax, abdomen, and six legs. They are also social insects and live in colonies. Termites have different looking species (called castes) living together in the colony. The largest individual is the queen. Her job is to lay eggs, sometimes thousands in a single day (Dash, 2004). A king is always by her side. Other individuals have a large head with powerful jaws, or a bulb-like head that squirts liquid. These individuals are called soldiers. But the majority of the termites in the colony are called workers (Alagappa *et al.*, 2007). They toil long hours tending to the queen, building and maintaining the nest, or gathering food, and feeding the young, which are called larvae.

The mound is constructed out of a mixture of soil, termite saliva and dung. Although the mound appears solid, the structure is incredibly porous. Its walls are filled with tiny holes that allow outside air to enter and permeate the entire structure. The top of the mound consist of central chimney surrounded by an intricate network of tunnels and passages. Air travels through the porous walls into a series of small tunnels until it reaches the central chimney and rises up. When fresh air mixes with this warm air, the air cools and

sink down into the nest. This ventilation system constantly circulate the air and ensures that oxygen reaches the lower areas of the mound and keeps the nest from overheating. Iron oxide crystallinity between termite mounds and nearby control soils is most likely due to alternating reducing and oxidizing conditions in themounds, resulting from seasonal water saturation variability. Fe, Mn, oxide concentrations and depletion features are abundant up to considerable height within the termite mound (Mujinya *et al.*, 2011). The variations in average Fe content of epigeous mound materials between sites reflect differences in the abundance of well-crystallized iron oxides (goethite and hematite) as part of the clay fraction. Al is probably mainly derived from Al-substituted iron oxides. The degree of crystallinity of iron oxides decreases with increasing degree of Al for Fe substitution. Mineralogical composition is also a factor, whereby goethite in soils commonly has a greater degree of Al substitution than co-existent hematite. The latter could explain the lower Al content of mound and soil materials at the site containing hematite as the only iron oxide (Mujinya *et al.*, 2011). Cement is a crystalline compound of calcium silicates and other calcium compounds having hydraulic properties (Macfadyen, 2006). Cements are considered hydraulic because of their ability to set and harden under or with excess water through the hydration of the cement's chemical compounds or minerals. Pozzolanic: any siliceous material that develops hydraulic cementitious

properties when interacted with hydrated lime (Macfadyen, 2006). The raw materials for cement production are limestone (calcium), sand or clay (silica), bauxite (aluminium) and iron ore, and may include shells, chalk, marl, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into chemical properties of cement.

#### **Tricalcium Silicate:**

Low content of tricalcium silicate makes the cement sulphate resistant. Gypsum reduces the hydration of tricalcium silicate which liberates a lot of heat in the early stages of hydration. Tricalcium silicate does not provide any more than a little amount of strength. Type I cement: this contains up to 3.5%  $SO_3$  (in cement having more than 8% tricalcium silicate) Type II cement: this contains up to 3%  $SO_3$  (in cement having less than 8% tricalcium silicate) Tricalcium silicate causes rapid hydration as well as hardening and is responsible for the cement's early strength gain are initial setting Alkalis the amount of potassium oxide ( $K_2O$  and sodium oxide  $Na_2O$  determination the alkali content of the cement. Cement containing large amount of alkali can cause some difficulty in regulating the setting time of cement. Low alkali cement when used with calcium in concrete, can cause discoloration in slag-lime cement, ground, granulated blast furnace slag is not hydraulic on its own but is activated by addition of alkalis. (Abiyot et al., 2016) silica fumes is added to cement concrete in order to improve a variety of properties especially compressive strength. Though setting time is prolonged by the addition of silicate fume, it can grant exceptionally high strength. Hence Portland cement containing 5-20% silica fume is usually produced for Portland project that require high strength. Alumina: cement containing high alumina has the ability to withstand frigid temperature since alumina is chemical resistant. It also quickens the setting but weakens the cement. Magnesia: the manufacturing process of Portland cement uses magnesia as a raw material in dry process plant. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement.

Production of MgO base cement also causes less  $CO_2$  emission. All cement is limited to a content of 6% MgO Sulphur trioxide: in excess amount can make cement unsound. Iron oxide/ Ferric oxide: aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the colour of the cement (Macfadyen, 2006).

#### **MATERIALS AND METHODS**

##### **Study area**

The study area was Bogoro and Katagum of Bauchi state

All the reagents were analytical grade chemicals and all the glasswares, containers and tools were washed with liquid detergent first, rinsed with 20% (v/v) nitric acid and finally rinsed with distilled water. The containers and glasswares were kept in the oven until needed. Distilled water was used all through the work.

##### **Sampling**

Soil sample and termite mounds sample of the study area were sampled at all angle, digging deep into a depth of about 30 cm, the soil were thoroughly mixed to obtain a convenient size that was taken to the laboratory. The sample collected was air dried, then ground to break down aggregates, preliminary ground sample was subdivided by using quartering. The sample obtained in such a way was ground again into fine powder to yield an acceptable number of particles of component of the heterogeneous material. The sample were sieved through a sieve of  $60\mu m$  size and then the oversize was ground again until no grains larger than  $60\mu m$  are left. Sieve made of nylon was used to avoid contamination by metals. The sample was taken to the laboratory for measurement to evaluate the homogeneity, which is better than 5% relative soil sample, 1kg mas  $\rightarrow$  Drying and crushing/rolling  $\rightarrow$  Four step quartering  $\rightarrow$  grinding  $\rightarrow$  Sieve  $<60\mu m$   $\rightarrow$  mixing with binder  $\rightarrow$  pellet.

The quantitative Riveted phase analysis of phase composition was performed using x-ray fluorescence spectrophotometer (PAN analytical Empyrean)

## RESULTS AND DISCUSSION

**Table 1:** Percentage Composition of *Nausitetermes walkeri*, *Coptotermes acinoformis*, Termite mounds soil in Bar Community of Bogoro Local Government Area

Compound (Conc. %)	Sample			
	Nausitetermes Walkeri	Coptotermes Acinoformis	Control	Portland Cement
Na <sub>2</sub> O	0.328	0.607	0.521	0.4-1.3
MgO	1.386	0.934	1.268	1.4-4.0
Al <sub>2</sub> O <sub>3</sub>	19.831	19.041	20.681	3.0-8.0
SiO <sub>2</sub>	65.337	67.009	65.322	17-25
SO <sub>3</sub>	0.384	0.305	0.357	1.3-3.0
K <sub>2</sub> O	4.075	4.03	3.835	
CaO	1.5	1.363	0.855	60-70
Fe <sub>2</sub> O <sub>3</sub>	4.891	4.418	4.935	0.5-6.0

**Table 2:** Percentage Composition of *Nausitetermes walkeri*, *Coptotermes acinoformis*, Termite mounds soil in Mwari Community of Bogoro Local Government Area

Compound	Location			
	Nausitetermes Walkeri	Coptotermes Acinoformis	Control	Portland Cement
Na <sub>2</sub> O	0.055	0.147	0.092	0.4-1.3
MgO	0.767	0.404	0.600	1.4-4.0
Al <sub>2</sub> O <sub>3</sub>	21.937	11.903	16.13	3.0-8.0
SiO <sub>2</sub>	66.544	78.474	73.043	17-25
SO <sub>3</sub>	0.317	0.416	0.411	1.3-3.0
K <sub>2</sub> O	2.741	3.665	3.528	
CaO	0.594	0.475	0.542	60-70
Fe <sub>2</sub> O <sub>3</sub>	4.886	2.126	3.517	0.5-6.0

**Table 3:** Percentage Composition of *Nausitetermes walkeri*, *Coptotermes acinoformis*, Termite mounds soil in Mallar Community of Bogoro Local Government Area

Compound	Location			
	Nausitetermes Walkeri	Coptotermes Acinoformis	Control	Portland Cement
Na <sub>2</sub> O	0.877	0.212	0.402	0.4-1.3
MgO	0.775	1.008	1.199	1.4-4.0
Al <sub>2</sub> O <sub>3</sub>	16.418	24.052	22.352	3.0-8.0
SiO <sub>2</sub>	72.654	62.625	63.573	17-25
SO <sub>3</sub>	0.423	0.352	0.318	1.3-3.0
K <sub>2</sub> O	3.877	2.917	3.136	
CaO	1.349	1.314	1.301	60-70
Fe <sub>2</sub> O <sub>3</sub>	1.909	5.705	5.807	0.5-6.0

Table 1 shows the Percentage of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, MgO and CaO with the range of 0.11-63.337% for *Nausitetermes walkeri*, while for *Coptotermes acinoformis* have 0.004-67.009% and for the control soil the range is 0.006-65.32%. In summary, the result showing the combine

Table 2 shows the Percentage of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Mn<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, TiO<sub>2</sub>, MgO and CaO in termite mounds powder having the range of 0.003-66.54% in *Nausitetermes walkeri*, 0-78.474 in *Coptotermes acinoformis* and the control soil is 0-73.043,

**Table 4:** Percentage Composition of *Nasitetermes walkeri*, *Coptotermes acinoformis*, Termite mounds soil in Matsango Community of Katagum Local Government Area

Compound	Loation(%) <i>Nasitetermes Walkeri</i>	<i>Coptotermes Acinoformis</i>	Control	Portland cement
Na <sub>2</sub> O	0.131	0	0	0.4-1.3
MgO	1.07	0.386	0.478	1.4-4.0
Al <sub>2</sub> O <sub>3</sub>	15.857	11.217	23.029	3.0-8.0
SiO <sub>2</sub>	72.365	83.91	70.408	17-25
SO <sub>3</sub>	0.396	0.51	0.368	1.3-3.0
CaO	1.874	0.19	0.201	60-67
Fe <sub>2</sub> O <sub>3</sub>	4.747	1.557	3.147	0.5-6.0

Table 4: shows the Percentage of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Mn<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, TiO<sub>2</sub>, MgO and CaO with the range of 0.005-72.365% for *Nasitetermes walkeri*, while for *Coptotermes acinoformis* have 0-83.91% and for the control soil the range is 0-70.408%. In

summary, the result is showing the order as SiO<sub>2</sub> < Al<sub>2</sub>O<sub>3</sub> < Fe<sub>2</sub>O<sub>3</sub> < SO<sub>3</sub> < Na<sub>2</sub>O, SiO<sub>2</sub> < Al<sub>2</sub>O<sub>3</sub> < SO<sub>3</sub> < Fe<sub>2</sub>O<sub>3</sub> < Na<sub>2</sub>O and SiO<sub>2</sub> < Al<sub>2</sub>O<sub>3</sub> < Fe<sub>2</sub>O<sub>3</sub> < SO<sub>3</sub> < Na<sub>2</sub>O respectively.

**Table 5:** Percentage Composition of *Nasitetermes walkeri*, *Coptotermes acinoformis*, Termite mounds soil in Federal Lowcoast Community of Katagum Local Government Area

Compound	Loation(%) <i>Nasitetermes Walkeri</i>	<i>Coptotermes Acinoformis</i>	Control	Portland cement
Na <sub>2</sub> O	0.131	0	0	0.4-1.3
MgO	1.07	0.386	0.478	1.4-4.0
Al <sub>2</sub> O <sub>3</sub>	15.857	11.217	23.029	3.0-8.0
SiO <sub>2</sub>	72.365	83.91	70.408	17-25
SO <sub>3</sub>	0.396	0.51	0.368	1.3-3.0
CaO	1.874	0.19	0.201	60-67
Fe <sub>2</sub> O <sub>3</sub>	4.747	1.557	3.147	0.5-6.0

Table 5: shows the Percentage of Na<sub>2</sub>O, SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, MgO and CaO with the range of 0-76.348% for *Nasitetermes walkeri*, while for *Coptotermes acinoformis* have 0-76.348% and for the control soil the range is 0.005-74.068%. In

summary, the result is showing the order as SiO<sub>2</sub> < Al<sub>2</sub>O<sub>3</sub> < Fe<sub>2</sub>O<sub>3</sub> < SO<sub>3</sub> < Na<sub>2</sub>O, SiO<sub>2</sub> < Al<sub>2</sub>O<sub>3</sub> < SO<sub>3</sub> < Fe<sub>2</sub>O<sub>3</sub> < Na<sub>2</sub>O and SiO<sub>2</sub> < Al<sub>2</sub>O<sub>3</sub> < Fe<sub>2</sub>O<sub>3</sub> < SO<sub>3</sub> < Na<sub>2</sub>O respectively.

**Table 6:** Percentage Composition of *Nasitetermes walkeri*, *Coptotermes acinoformis*, Termite mounds soil in Tashan Misau Community of Katagum Local Government Area

Compound	Location (%) <i>Nasitetermes Walkeri</i>	<i>Coptotermes Acinoformis</i>	Control	Portland cement
Na <sub>2</sub> O	0	0	0.085	0.4-1.3
MgO	0.478	0.521	1.323	1.4-4.0
Al <sub>2</sub> O <sub>3</sub>	14.898	20.347	14.537	3.0-8.0
SiO <sub>2</sub>	76.348	71.717	74.068	17-25
SO <sub>3</sub>	0.436	0.33	0.438	1.3-3.0
CaO	0.73	0.267	2.476	60-67
Fe <sub>2</sub> O <sub>3</sub>	5.164	4.36	3.997	0.5-6.0

Table 6, shows the Percentage of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Mn<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, TiO<sub>2</sub>, MgO and CaO with the range of 0.07-58.576% for *Nasitetermes walkeri*,

while for *Coptotermes acinoformis* have 0.004-67.009% and for the control soil the range is 0-61.061%. In summary, the result is showing the

order as  $\text{SiO}_2 < \text{Al}_2\text{O}_3 < \text{Fe}_2\text{O}_3 < \text{SO}_3 < \text{Na}_2\text{O}$ ,  $\text{SiO}_2 < \text{Al}_2\text{O}_3 < \text{SO}_3 < \text{Fe}_2\text{O}_3 < \text{Na}_2\text{O}$  and  $\text{SiO}_2 < \text{Al}_2\text{O}_3 < \text{Fe}_2\text{O}_3 < \text{SO}_3 < \text{Na}_2\text{O}$  respective

**Table 7:** Comparative mean concentrations of studied compounds in *Nasitetermes walkeri* termite mounds in the selected communities

Compounds % conc.	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	K <sub>2</sub> O	CaO	Fe <sub>2</sub> O <sub>3</sub>
<b>Bogoro</b>	0.420 <sup>a</sup> ±0.42	0.976 <sup>a</sup> ±0.36	19.395 <sup>a</sup> ±2.79	68.178 <sup>a</sup> ±3.92	0.375 <sup>a</sup> ±0.54	3.560 <sup>a</sup> ±0.72	1.148 <sup>a</sup> ±0.49	3.895 ±1.72
<b>Azare</b>	0.0437 <sup>a</sup> ±0.08	0.732 <sup>a</sup> ±0.31	15.970 <sup>a</sup> ±1.13	74.517 <sup>a</sup> ±2.01	0.445 <sup>a</sup> ±0.05	1.203 <sup>b</sup> ±0.71	0.942 <sup>a</sup> ±0.85	4.579 ±0.69
<b>Portland cement</b>	0.4-1.3	0.1-4.0	3.0-8.0	17-25	1.3-3.0	0.4-1.3	60-70	0.5-6.0

(Values within a column with different superscripts are significantly different (p < 0.05)).

**Table 8:** Comparative mean concentrations of studied compounds in *Coptotermes acinoformis* termite mounds in the selected communities

Compounds % conc.	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	K <sub>2</sub> O	CaO	Fe <sub>2</sub> O <sub>3</sub>
<b>Bogoro</b>	0.32 <sup>a</sup> ±0.25	0.78 <sup>a</sup> ±0.33	18.32 <sup>a</sup> ±6.11	69.37 <sup>a</sup> ±8.18	0.36 <sup>a</sup> ±0.16	3.50 <sup>a</sup> ±0.57	1.05 <sup>a</sup> ±0.50	4.08 <sup>a</sup> ±1.81
<b>Azare</b>	0.00 <sup>a</sup> ±0.00	0.45 <sup>a</sup> ±0.07	14.93 <sup>a</sup> ±4.79	78.88 <sup>a</sup> ±6.37	0.45 <sup>a</sup> ±0.12	0.73 <sup>c</sup> ±0.10	0.21 <sup>a</sup> ±0.05	2.75 <sup>a</sup> ±1.45
<b>Portland cement</b>	0.4-1.3	0.1-4.0	3.0-8.0	17-25	1.3-3.0	0.4-1.3	60-70	0.5-6.0

## DISCUSSION

Table 7 and 8 shows the analysis of variance done on the data collected all the chemical parameters in the two species of termite mounds and the control in each of the two communities shows non-significant difference at p (0.05) difference. Significant levels are found in potassium oxide which is represented by different superscript this is because termites build their mounds by combining polymer from their natural secretions with quartz grains, clay minerals and a feeble amount of vegetable debris. Severe drought conditions though can limit termite activity, as has been observed in New Orleans from October 2005 to June 2006, but once favourable conditions return such as steady rainfall immediately after the drought, they can increase their activities dramatically (Dawes-Gromadzki 2005). The high amount of total nitrogen in the termite mound might be due to the mineralization of soil organic matter by termites as reported by Ackerman *et al.* (2007).

Nyamapfene, (1986) Mitchell and (2002) in the description of termite mound had reported mounds that were up to 7.5 meters high and a diameter of 12 to 18 meters. The mound had been constructed with subsoil brought from a depth of more than 3 meters. Such termite mounds could be

abundant in a landscape as reported by Jones (1990). Sileshi *et al.* (2009) also reported silica fumes is added to cement concrete in order to improve a variety of properties especially compressive strength. Though setting time is prolonged by the addition of silicate fume, it can grant exceptionally high strength. Hence Portland cement containing 5-20% silica fume is usually produced for Portland project that require high strength. Alumina content in cement high has the ability to withstand frigid temperature since alumina is chemical resistant. It also quickens the setting but weakens the cement. Magnesia in the manufacturing process of Portland cement used as a raw material in dry process plant. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement. Production of MgO base cement also causes less CO<sub>2</sub> emission. All cement is limited to a content of 6% MgO.

## CONCLUSION

1. Silica and alumina reduces plasticity and lessens the shrinkages in cement. Alkalis reduces the refractoriness, they combine with alumina and silica to form liquid at low temperatures. Alkalis also impart imperviousness and strength to cement.

- Calcium act as fluxes by combining with alumina and silica to reduce the temperatures and refractoriness of clay
2. The percentage oxides composing in the mound particularly aluminium and silicate are not significantly different at ( $p < 0.05$ ) from the control.
  3. The Sudan savannah (Katagum) termite mounds can be mixed when building or construction is taking place because the secretions give water to the mound and play a role as a plastering agent responsible for good compactness of it building (Jouquet *et al.*, 2004)

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