Comparative study of clay and organic matter content of termite mounds and the surrounding soils

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Abstract The clay and organic matter content of three randomly selected termite mounds (termitaria) were compared with the surrounding soils, in a study conducted in a fifty hectare farmland in Akure (7°15’N, 5°15’E) Nigeria in May to June 2008. The coordinates of each termite mound were taken using an Global Positioning System (GPS) receiver (Garmin etrex model). The data were put in the ArcView GIS software as point features. Each termite mound coordinate as a point was buffered at 10 meters, 20 meters and 30 meters and each buffered zone polygonized to create a polygonal buffered areas of 0 to 10 meters (Buffered Zone 1), 10 to 20 meters (Buffered Zone 2) and 20 to 30 meters (Buffered Zone 3) away from the termitarium. Points for soil sampling pits were indicated in each buffered zone. The field work entailed locating on the ground, with the GPS receiver the sampling pits already indicated on the digital map. Soil samples were taken at the surface (0 to 15 cm) and subsoil (15 to 60 cm) for determination of clay and organic matter content. The mean values were compared using the Duncan Multiple Range Text (DMRT) at 5 % probability. The clay content of the termite mound was significantly high compared to the surrounding surface soils (0 to 15 cm) with the mean values in a decreasing order as 65, 23, 21 and 18% in termite mound, Buffered Zone 1, Buffered Zone 2 and Buffered Zone 3, respectively. The organic matter content in the subsoil (15 to 60cm) of the surrounding soils was lower than in the termite mound with mean values of 1.65%, 0.30%, 0.27% and 0.25% in the termite mound, Buffered Zone 1, Buffered Zone 2 and Buffered Zone 3 respectively. The lower clay and organic matter content of soils around termite mounds showed that termite activities could lower soil nutrient availability to plants.

Key words: GIS buffering technique, Termitaria

Introduction

Termites are social insects that build nests in soil or wood and the type of nest can be associated with the species of termites with such nests classified as ground mound, subterranean, pole and tree wood nests (Nyamapfene, 1986; Eggleton et al., 2002; Sileshi et al., 2009). The genus Macrotermes in Africa had been identified to have the 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. This genus was reported to be responsible for over 90% of termite damage in agriculture, forestry and urban settings (Mitchell, 2002).

The mounds are features built from subsoil taken from as much as a depth of 3 meters, indicating the composition of mound soils to be closely related to the nature of the adjacent subsoil. Such correlation of termite mound and the adjacent subsoil was confirmed in the analysis of termite mound soils for gold prospering in Mali. Termite which could dig up to 10 meters below the surface bring up mineral grains which had been used to confirm the deposit of gold in many areas in Mali (Afrol News, 2008). The process of soil transportation for mound building had been reported to cause modification of soil characteristics which had been observed to promote pedobioperturbation and nutrient cycling. Termites as major bioturbators, created biogenic structures (galleries, nests, mounds, fungus unit chambers) that strongly influenced the physical and chemical properties of soils (Kaschuk et al., 2006; Jouquet et al., 2007).

Comparative studies of termite mound and the adjacent soils had been carried out in previous research. Kaschuk et al. (2006) in a study collected soil samples from top, middle and bottom of termite mounds and of the adjacent areas and observed a greater content of potassium, phosphorus, calcium, magnesium, organic carbon and lower pH in the inner part of termite mounds in relation to soil of the adjacent area. Ilse et al. (2007) in the study of the impact of mound building termites on surface soil properties in a secondary forest reported termite activities in a landscape to constrain re-colonization of the landscape by vegetation. Lopez-Hernandez et al. (2006) in the study of phosphorus forms and associated properties in fourteen mounds and adjacent soils observed mounds to contain higher total phosphorus and organic matter than the surrounding soils.

The degradative and the redeeming effects of termite activities on surrounding soils physical and chemical properties had also been reported in previous studies (Logan, 1992; Mando et al., 1999) On the consideration of the degradative effects, it had been observed that areas where active mound building macrotermes were common could be difficult to cultivate because the mounds themselves would be difficult to cultivate and if knocked down with a bulldozer, might be built up again quickly. When forests were cleared, termites could attack the annual crops planted causing a great decline in crop yield. Termite attack on plant residues could denude the crop land of surface mulch thus, making it difficult to provide protective crop residue mulch (Evans, 2004; Obi et al., 2008). The
destruction effects of termite on arable crops Mitchell (2002), Sekammatte et al. (2003), Silesi et al. (2005) and on forest economic trees Apolinario and Martins (2004) were also reported in previous investigation. The bacteria metabolism in the guts of termites had been reported to account for a substantial fraction of production of methane an important green house gas that trap outgoing radiation leading to global warming (Rowland et al., 1993)

The redeeming value on soils of termite activities, was discussed in previous work. Their excrements which were rich in nitrogen and which accumulated in certain areas of the nest would be occasionally pushed out through holes made specially for that purpose. This nitrogen rich excrement could add to nitrogen content of soils around the nest (Russel, 1973). Other agriculturally beneficial roles of termites reported were rather adoptable in peasant farming which essentially were the use of termite mound soils as soil amendment (Siame, 2005; Adamou et al., 2007).

The planting of crops and specifically edible mushroom on termite mounds was also reported (Kabasa et al., 2006). The industrial benefit of termite activities was also highlighted as it was revealed in the analysis of termite mound being used to indicate the contents of deeper laying levels of soil and rock. This formed the principle of using termite mound for gold prospecting in Mali (Afrol News, 2008).

The study of termite activities in a landscape carried out in the past was by cadastral study to locate termite nests while the current use of geospatial technology had provided more detailed precision investigation. Jones (1990) using aerial photographs reported a rather consistent 200 macrotermite mounds per square kilometer of a contiguous region in Tanzania while Verlinden et al. (2006) using aerial photographs, maps of indigenous land units (ILUs), geographic information systems (GIS) analysis and field observations in assessing the role of termites in agriculture, confirmed the degradative effects of termite activities in a farmland.

The high population of termite estimated at about 16 million per hectare and surpassing earthworm in dominating the soil fauna Pomeroy (1978), Brady & Weil (1999), Evans (2004) and the activities of termites in denuding the farmland of surface plant residues thereby reducing the soil organic matter content and also predisposing the farmland to accelerated erosion had made this investigation desirable.

The objective of this research was to use GIS buffering technique to carry out a precision study of soil fertility as measured in the clay and organic matter content at known distances from termite mounds.

### Materials and methods

**Physical setting.** The research was conducted on a 50 hectare farmland in Akure (7°15’N, 5°15’E) Nigeria in May to June 2008. The farmland had been cleared of forest and used for arable crop cultivation continuously for three years before the start of the experiment. The three termite mounds studied were the three out of the several spotted in the farmland.

**Preliminary computer analysis.** The coordinates of the entire 50 hectare farmland were taken with the use of the Global Positioning System (GPS) receiver (Garmin etrex model) and input into the computer as a polygon feature to generate the farm boundary using GIS ArcView 3.3 software. The coordinates of the three termite mounds located at over 100 meters apart were also taken and input as point features. Each termite mound was buffered at 10 meters, 20 meters and 30 meters away and each buffered zone polygonized to create polygonal buffered areas of 0 to 10 meters (Buffered Zone 1), 10 to 20 meters (Buffered Zone 2) and 20 to 30 meters (Buffered Zone 3). Soil sampling pits were indicated on the digital map for soil sample collections for laboratory analysis.

**Field work.** Soil sampling pits identified on the digital map were located in the field with the use of the GPS receiver. Soil samples were taken from the termite mounds and from the surrounding buffered zones 1, 2 and 3 specifying distances of 10 meters, 20 meters and 30 meters respectively away from the termite mound. Soil samples were taken at depth of 0 to 15 cm and 15 to 60 cm and the samples analyzed for clay and organic matter content.

**Laboratory analysis.** The laboratory analyses of soil samples were carried out following the laboratory procedures of Canadian Society of Soil Science (Carter, 1993). The particle size distribution analysis was performed using 50 g of soil in 0.1M NaOH as dispersing agent. Hydrometer ASTM 1524 readings were taken at 40 seconds to read the percentage sand while at 2 hours to read the percentage clay. Organic carbon was determined by oxidising soil sample with dichromate solution and later titrated with ferrous sulphate [Iron II tetra oxosulphate (VI)] solution.

**Statistical analysis.** The three termite mounds were taken as replicates and the mean values statistically analyzed using the Statistical Package for the Social Sciences (SPSS) computer soft ware and the means of data compared using the Duncan Multiple Range Test (DMRT) at 5% probability.

### Results

Figure 1 shows one of the termite mounds under investigation. The mound was about three meters high actively occupied by termites. The vegetation near the mound was being eaten up and some that were transported were observed scattered on the mound. Figure 2 showed the boundary of the farmland with the locations of the three termite mounds under investigation. The locations on the digital map were identified on the ground with the use of the global positioning system receiver. Figure 3 showed the termite mounds buffered with the buffered zones showing the distance of the zone from the mound. The buffered zones were at distances of 10m, 20m and 30m from the mound.

Table 1 and Figures 4a and 4b showed the mean values of the percentage clay and organic matter content of the termite mound and the surrounding soils. The surrounding
Clay and organic matter content of termite mounds

Figure 1. One of the termite mounds under investigation.

Figure 2. The locations of the three termite mounds A, B and C. TM = Termite Mound.

Figure 3. The three termite mounds with a typical one buffered at 10m, 20m and 30m away. TM = Termite Mound.
Table 1. The mean values of clay and organic matter content of termite mounds and the surrounding soils.

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance from termite mound in meters</th>
<th>Distance from termite mound in meters</th>
<th>% clay of surface soil (0 – 15cm)</th>
<th>% clay of subsoil (15 – 60cm)</th>
<th>% organic matter of surface soil (0 – 15cm)</th>
<th>% organic matter of subsoil (15 – 60cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termite Mound</td>
<td>0</td>
<td>0</td>
<td>65a</td>
<td>65a</td>
<td>1.65c</td>
<td>1.65a</td>
</tr>
<tr>
<td>Buffered Zone 1 at 10 m radius from mound</td>
<td>0 – 10</td>
<td>0 – 10</td>
<td>23b</td>
<td>32b</td>
<td>2.17b</td>
<td>0.30b</td>
</tr>
<tr>
<td>Buffered Zone 2 at 20 m radius from mound</td>
<td>10 – 20</td>
<td>10 – 20</td>
<td>21b</td>
<td>34b</td>
<td>2.28b</td>
<td>0.27b</td>
</tr>
<tr>
<td>Buffered Zone 3 at 30 m radius from mound</td>
<td>20 – 30</td>
<td>20 – 30</td>
<td>18c</td>
<td>33b</td>
<td>2.62a</td>
<td>0.25b</td>
</tr>
</tbody>
</table>

Means followed by the same letters were not significant using Duncan Multiple Range Test at 5% probability.

Figure 4(a). The percentage clay and organic matter of termite mound and surrounding surface soils.

Figure 4(b). The percentage clay and organic matter of termite mound and surrounding subsoil.

Discussion

The termite mound showed in figure 1 was a type of nest constructed by termite especially by the genus macrotermes (Nyamapfene 1986; Mitchell, 2002). Russel (1973), 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) using aerial photographs to detect a consistently 200 macrotermes moulds per square kilometer in Tanzanian landscape. Sileshi et al. (2009) also reported the rating by local farmers based on the mound shape the species Macrotermes bellicosus and M. subhyallinus as the most abundant in the Tororo district in Uganda.

The digital map of farm boundary with the locations of termite mounds under investigation in Figure 2 had been generated by the Global Positioning System (GPS) and...
the Geographic Information Systems (GIS) technology using the ArcView 3.3 software. The principle applied had been the geospatial technique of data acquisition, manipulation, pre-processing, management and analysis (Brady & Weil, 1999). The data acquisition entailed the use of the GPS receiver to record the coordinates of the farm boundary and the locations of the termite mounds. The coordinates were the Eastings and Northings (UTM system) corresponding to Latitudes and Longitudes (Geodetic system). The data were entered into the computer Notepad software as polygons to generate the farm boundary while the data were entered as point features to locate the termite mounds. This was based on the principle in previous research on soil variability studies Bakhsh et al. (2000) and also in the digital mapping of landscape (Akingbade, 2006) and the mapping of a crop type museum (Adekayode, 2008).

The buffered zones generated around each termite mound in Figure 3 was performed using GIS buffering technique. Buffering is a geospatial technology employed to create a zone of a specified width around a point, line or polygonal area and the resulting buffer becoming a new polygon. The illustration of buffering technique in proximity analysis had been demonstrated in previous studies by which on a map of land parcels, all parcels that were within a specific distance from a point on the map could be selected. (Environmental Systems Research Institute, 1996; Ikhuoria, 1998; Uluocha, 2007).

The significantly higher clay content of the soils in termite mounds compared with the surrounding soils confirmed previous findings that soils had been transported from deep subsoil with a high clay content to the termite mound compared with the surrounding top soil (0-15cm) was an indication that the termite mound was built with subsoil (Brady & Weil, 1999; Sileshi et al., 2009). The distribution of organic matter in the surrounding soils which showed area closer to the termite mound (0 to 10cm and 10 to 20cm) to have lower organic matter content than area further away (20cm to 30cm) was as a result of the activities of termite in denuding the surrounding area of surface residue. The decomposition and mineralization of the plant residue would have increased the organic matter content in the surrounding soils. This corroborated the earlier research finding of a high nutrient content of termite mound soils (Masanori & Tootou, 2004; Chikuvire et al., 2007) and the use as soil amendment (Siame, 2005).

References


