PHYSICOCHEMICAL PROPERTIES OF WILDLIFE GEOPHAGIC SOIL: A PRELIMINARYASSESSMENT FOR POSSIBLE UTILIZATION IN PHARMACEUTICAL INDUSTRIES

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ABSTRACT

The act of consuming soil (geophagy) has been reported both in man and wildlife. Most previous studies have concentrated more on various type of geophagic soilswith less attention on termite mounds (TMs), thus limiting our understanding the cause(s) of geophagy. This study investigated the physico-chemical constituents of wildlife geophagic TMsincomparison with non-geophagic forest soil (FS). Composite soil samples were collected each from four different TMs and a FS. Samples were analyzed for pH, texture, electrical conductivity (EC), water retention capacity (WRC), moisture content (MC) and colour.Soils were analyzed in triplicates following standard methods. Datagenerated were analyzed statisticallywith SPSS version 17.Theresult indicated acidic pH for both TMs(strongly to slightly acidic) and FS (slightly acidic). Clay content, EC, WRC and MC were significantly higher in TMs than FS.The colour of TMs ranged from reddish brown(4R 4/5) to dark brown (2.5R 5/7 or 5R 6/8) as against that of FS which was black (2R 2/4). Wildlife may be consuming TMs in preference to FS for; detoxification (high clay content), ant-diarrhea (high WRC and MC), Fe-supplement (brown colour of TMs) and dissolved salt content (high EC). Detailed studies intomineralogical and microbiological compositions of TMs may be needed to further justify the rolesof geophagy in wildlife.

Keywords: Geophagy, Detoxification, Electrical conductivity, Water retention capacity

INTRODUCTION

Earth rich in minerals are often employed by wildlife as mineral licks, clay licks or natural salt licks [1]. These licks may include rock surface [2, 3], excavated land [4], termite mounds [5] and mineral springs [6]. Records of animals of different taxa's visiting such places to ingest soil (geophagy) for purpose(s) that are yet to be fully understood are abounds. However, lick are thought to be utilized for minerals that may be deficient in their diets [7, 8].Other speculated existing hypotheses on wildlife geophagy include but not limited to detoxification, buffering of stomach pH, mechanical grinding, ant-parasitic and ant-diarrhea [8, 9, 10]. Many of these hypotheses have been evaluated more often for soils other than termite mounds.Termite mounds (TMs) are nest built above the earth by the termites. They are found almost all around the world, most especially in the tropical region like Nigeria. Unlike sub-surface natural licks (SNL) that is constantly evacuated by geophagic animals without replacement, consumed TMs stand a better chance of rebuilt by termites after consumption. Apart from this, the conspicuous nature of TMs as well as its availability in urban setting can place it in greater advantage over SNL, most especially for domestic utilization. They can urgently be employed in preference to SNL when needed for

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management of zoological wildlife or for treatment of human ailments [11].

Termite mounds are made from several different soils and dung/grass/wood mixed with termite saliva to form next. They have been documented to contain constituents like; minerals (kaolinite, quartz and smectite) and elements (sodium, potassium, calcium, magnesium, iron, zinc) [12,13, 14]. The most important part of their constituents seems to be clay. From their appearance, it is obvious that TMs contain clay of high plasticity employed by termite for molding their next[5].Details of several of such physicochemical properties of TMs are rarely evaluated in relation to geophagy. Based on the physical properties, [15]has defined clay soil as any soil that are capable of expansion or contraction, water holding or poor drainage, sticky or hard, crust or crack, depending on its changing water content. As a result of high clay content, the physical properties exhibited by TMs have placed it in advantage over all other types of soil, most especially because of its numerous uses in agriculture and pharmaceutical industries. With several roles played by TMs in industries, little have been done to evaluate their physico-chemical constituents as a probable reason for geophagy in wildlife. Few of the examined studies have concentrated on the elemental constituents of the licked soil [16,17], with less detail on the physico-chemicals (pH, texture, electrical conductivity, water retention capacity, water content and colour). This inadequate information has limited our understanding of the important stimuli for geophagy**.** The present study therefore aimed at investigating the physico-chemical constituents of TMs eaten by wildlife in comparison with non-geophagic soil at the College of Agricultural Sciences (CAS).

MATERIALS AND METHODS

Study Area

The College of Agricultural Sciences of Olabisi Onabanjo University is in Yewa North local government of Ogun State, Southwest Nigeria. It occupies an area of 1.54km^2 with latitude 7°13.30´ to 7°14.30´N and longitude 3°3.10´E to 3°4.30´E. The college is surrounded by arable farmlands with some pockets of forest, inhabited by some wildlife like duiker, giant rat, cane rat, squirrel, rabbit and rat, that are sometimes encounter accidentally (Adewale, pers. obs.).

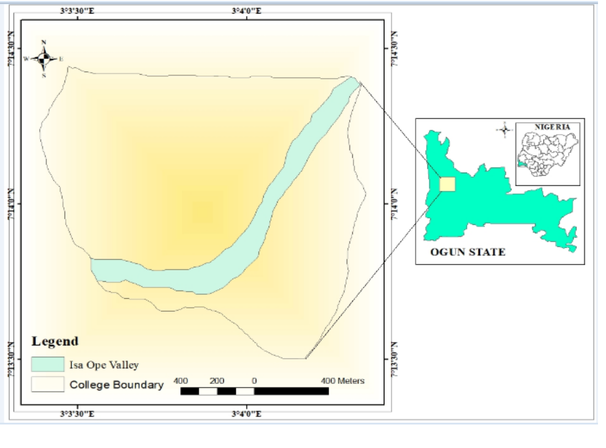

Figure 1: Map of College of Agricultural Sciences, Ayetoro Campus, Olabisi Onabanjo University.

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Soil Sampling and Sample Preparation

The soil sample collection was grouped into two. First from termite mound soil (TM) and then from forest soil (FS). Of all the existing termite mounds found in the study area (identified during reconnaissance survey), four termite mounds (TM1-4), showing sign of geophagy (i.e visual sign of scratching by wildlife) were selected for sample collection. Forest soils (about 1km away) of size 400m^2 (20m x 20m) with no sign of geophagy was also strategically sampled as control.With the use of sterilized spatula and/ or hand trowel, four composite soil samples approximately 300g of soil samples were collected at the depth of 10-15cm (from each of the selected TMs and FS)and were stored in a Ziploc bag for laboratory analysis. The FSs were bulked from 10 core samples to form a composite sample. Samples were collected in triplicate for analysis. Prior to analysis, all soil samples collected were first air dried for 7 days at room temperature and later crushed and sieved with 2mm before subjecting them to physico-chemical analysis.

Physico-chemical Analysis of Soil

Soil colour was recorded using Munsell soil colour chart [18]. Particle size analysis was carried out using the hydrometer method [19]. Soil pH was measured by mixing soil: distilled water (1:1) and thereafter measured with pH meter. All analyses, including Electrical conductivity, water retention capacity and moisture content of the sample soils were done following the procedure of[20] and [21].

Data Analysis

One-way analysis of variance was used to calculate the mean and standard deviation of each sample, while post hoc analysis was done with Turkeys test to compare the sample mean of both the TMs and FS.

RESULTS AND DISCUSSION

Particle Size Distribution

The results of the particle size distribution of both the TM sand control (FS) are presented in Table 1 and Figure 1. In TMs, the clay content, silt and sand ranged from (11.50 - 34.60%), (16.50 - 26.26%) and (44.04 - 50.33%) respectively, while in the control (FS), the clay, silt and sand were 3.90%, 8.60%and sand 87.50% respectively. The clay content of the control (FS) was significantly lower than that of the TMs (at $p<0.05$). Apart from the control (FS) which is predominantly sandy, the texture of TMs 1-4 was sandy clay loam, sandy loam, clay loam and sandy clay loam respectively (Figure 2). This result is similar to that conducted by [5] on termite mounds in Tanzania. Studies have shown that lick rich in clay are generally employed by both wildlife and man for the purpose of detoxification [7], since termite mound are very rich in clay, it is not unexpected to be utilized by wildlife. The high clay content of termite mounds utilized by wildlife of this study also suggests similar assertion. Clay soils have been found to help in the detoxification of dietary toxins (e.g alkaloid) ingested by wildlife. Plant secondary metabolites are unescapable in the diets of wildlife and once consumed, may cause stomach up-set[5].In various studies on geophagy, the consumption of highly rich-clay lick has been found to ameliorate gastrointestinal malady. These properties of clay together with other characteristics have been employed by the pharmaceutical companies for the production of anti-diarrhea drugs such as Kaopectate™[5,9, 22]. Also, the textural characteristics of clay containing Fe or Na have also been known to provide tactile, visual and proximal stimuli for the consumers [23, 24].

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Table 1: Particle size distribution of termite mound and forest soil

Soil Sample	Sand (%)	Silt (%)	Clay (%)
TM 1	50.33 ± 0.8[c]	16.50 ± 0.50[b]	33.00 ± 0.20[d]
TM 2	68.80 ± 1.00[d]	26.26 ± 1.00[c]	11.50 ± 0.70[b]
TM 3	44.04 ± 1.20[a]	21.00 ± 1.00[b]	34.60 ± 0.20[e]
TM 4	47.40 ± 0.20[b]	23.80 ± 0.80[c]	28.80 ± 0.60[c]
FS	87.50 ± 0.30[e]	8.60 ± 0.60[a]	3.90 ± 0.30[a]

Means in the same row with different superscript letters are significantlydifferent at p<0.05 in accordance with Turkey HSD test.

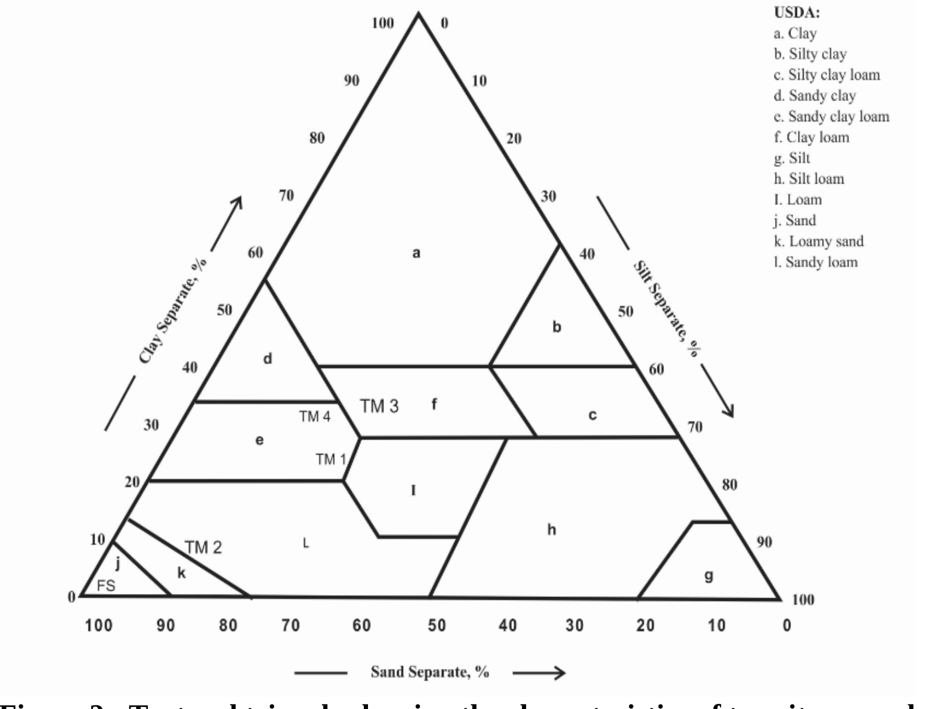

Figure 2: Textural triangle showing the characteristics of termite mounds and forest soil

Colour of Sample Soil

Table 3 indicates the soil colours and hue values for TMS 1-4 as well as that of the control (FS). TM 1 showed a dark brown with hue value of 2.5R 5/7, while TM 2 showed a chocolate brown colour with hue value of 5R 3/5. Both TM 3 and TM 4 showed a dark brown colour and a reddish brown colour with corresponding hue values of 5R 6/8 and 4R 4/5 respectively. This range of colours (brown to red) in TM 1-4 suggests presence of Iron (Fe) which is an important component of blood [25]. The colours of TMswere distinctively different from the colour of the control, which is blackish (with a hue value of 2R 2/4). The idea of red/brown soil signifying presence of Fe has been suggested by [26]. [2] identified the eaten soil of hybrid macaques to be red or orange in colour and that of the uneaten soil to be grey in colour. The chimpanzees of Mahale Mountains National Park, Tanzania also prefer light brown coloured termite mounds to very dark

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brown soil for consumption [5]. The importance of Iron and other physic-chemical constituents in the healing of wildlife diseases cannot be overemphasized. For instance, the use of iron rich clay (French green clay) for curing of Buruli ulcer has been investigated by [32].

Table 2: Hue value, chroma and colour of termite mound and forest soil

Soil Sample	Hue value and Chroma	Colour
TMS 1	2.5R 5/7	Dark Brown
TMS 2	5R 3/5	Chocolate Brown
TMS 3	5R 6/8	Dark Brown
TMS 4	4R 4/5	Reddish Brown
FS	2R 2/4	Blackish

pH of Sample Soil

The pH of the TMs ranged from 5.40±0.00 to 6.13 ± 0.05 and were not significantly different (at $p>0.05$) from that of the control soil (FS = 6.13±0.31), except for TM1 (5.60 ± 0.00) and TM3 (5.40 ± 0.10) as shown in Table 3. However, the pH of all soil samples (TMs 1-4 and FS) indicated slightly to strongly acidic nature. The consumption of termite mound soils by wildlife has been associated with balancing the alkaline pH of their stomach walls [18]. It is therefore evident in this study that the strongly acidic nature of TMs was a reason why wildlife prefers TMs over FS. Since acid has a sour taste, the sour taste of the TMs may be the motivation for ingestion by wildlife [26]. Hence, TMs in this study may not only have acted as antacid agents but may also give a special taste preferred by the wildlife. This may require an investigation in another study.

Electrical Conductivity (EC) of Sample Soil

All TMs 1-4 had a very high EC values ranging from 147.23 – 459.90µS/cmin Table 3. This indicated high amount of dissolved salt in the termite soil compared with FS. The significantly lowest value of EC in the FS reflected the low salt content in the soil.Although, this result is contrary to the report of [5], which showed no distinction in EC concentration of both the termite mounds and that of the control. Previous studies have shown the importance of EC in wildlife nutrition; for instance, EC can be used as a measure of dissolved salt content in the soil[5, 28]. Thus, suggesting that TMs may be an important source of both micro and macro nutrients for wildlife. It appears that wildlife selects soil relatively high in EC for mineral supplementation. Hence, TMs may be employed as mineral rich clay for both agricultural and pharmaceutical purposes. This calls for the elemental composition of the geophagic TMs, which is currently being investigated.

Water Retention Capacity and Moisture Content (MC) of Soil

The values of WRC for the termite soil samples (TMs1-4) ranges from 74.25 to 80.2% with a relatively high significant difference (at $p<0.05$) when compared with control (Table 3). This result agrees with the study of [29] that the surrounding soils have less WRC in relation to the various termite mounds examined. Similarly, the moisture content (MC) for TMs 1-4 also showed a significant higher value ranging from 4 -10% when compared to the control, indicating that FS has a low MC. Water retention capacity is the ability of soils to process and hold large amount of water [30]. The high content of clay in the TMs than the FS is likely

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responsible for their increased WRC and MC, since clay is generally known for their water- retaining capacity [31].Also, since the TMs in this study are clay-like in nature and most clay comprises of important minerals (e.g kaolinite, illite, vermiculite) which are known to have water-holding properties [32]. It is therefore not surprising that most of the TMs in this study exhibited significant greater WRC and WC than the control (FS). This result therefore is in support of the hypothesis that says, geophagic soil absorbs large quantity of water in the digestive track of animals to produce less watery stool, thus preventing diarrhea. This property of clay has also been employed in the making of the antidiarrheal medicine known as Kaopectate^{TM} in the treatment of human [17].

Table 3: The pH, electrical conductivity, moisture content and water retention capacity of termite mound and forest soil

Soil Sample	pH	EC (μS/cm)	MC (%)	WRC (%)
TMS 1	5.60 ± 0.00^a	236.50 ± 1.60^d	9.00 ± 0.21^e	76.00 ± 0.20^d
TMS	5.90 ± 0.10^b	147.23 ± 0.55^b	5.20 ± 0.02^c	71.10 ± 0.70^b
TMS 3	5.40 ± 0.10^a	228.23 ± 0.57^e	8.18 ± 0.03^d	80.20 ± 0.60^e
TMS 4	6.13 ± 0.05^b	459.90 ± 4.20^c	4.08 ± 0.04^b	74.25 ± 0.25^c
FS	6.13 ± 0.31^b	3.90 ± 0.30^a	2.42 ± 0.05^a	9.00 ± 0.40^a

Means in the same row with different superscript letters are significantly different at p<0.05 in accordance with Turkey HSD test.

CONCLUSION

In this study, it appears that wildlife consumes termite mounds (TMs) in preference to the forest soil (FS). This might be for detoxification (high clay content), ant-diarrhea (high WRC and MC), Fe-supplement (brown colour of TMs) and dissolved salt content (high EC).Further investigation may be needed to test for the healing and antibacterial nature of the clay lick soils.

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