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Effects of Termites on Clay Minerals in Lateritic Soils Used For Road Construction in Ado-Ekiti, South Western Nigeria

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ABSTRACT: *The assessment of the effects of activities of termites on clay minerals in termite reworked soils and non-reworked surrounding soils was carried out. Two termite hills from two locations were chosen. Twenty bulk representative soil samples depicting twelve termite reworked sols and eight non-reworked surrounding lateritic soils samples were collected. These samples were subjected to clay mineralogical analysis using X-ray diffraction method. The results showed that kaolinite, quartz, illite, halloysite, chlorite and feldspar were confirmed to be present in both termite reworked soils and non-reworked surrounding soils. It was further confirmed that termite reworked soil contain more kaolinite than the non-reworked surrounding soil which indicates that activities of termite increased the mineralogy of lateritic soil.*

Keywords: *assessment, termites, clay minerals, lateritic soil, X-ray diffraction.*

I. INTRODUCTION

Termites are social insects numbering about 3000 known species, from which approximately 75% are classified as soil-feeding termites. The diet of soil-feeding termites consists of non cellular organic material mixed with clay minerals. Their gut is formed by five compartments that present rising gradients of pH, up to 12.5, and different status of oxygen and hydrogen (Brune et al., 1995; Brune and Kühl, 1996; Donavan et al., 2001). These characteristics are certainly important and may effectively contribute to soil chemical and physical modifications.

Termites are recognized as “ecosystem engineers” (Dangerfield et al., 1998) because they promote soil transformations by disturbance processes. Termites collect organic matter and mineral particles from different depths and deposit them in mounds, enhancing the content of organic, clay and nutrients. Also, pH and microbial population are higher in termite mounds than in adjacent soils (Lal, 1988; Black and Okwakol, 1997; Holt et al., 1998).

The physical, chemical and biological alteration of soils caused by the nest-building or soil-feeding of termites have been extensively explored (Lobry de Bruyn and Conacher, 1990; Black and Okwakol, 1997). However, much less attention has been paid to soil mineralogical alteration. Leprum and Roy-Noel (1976) reported that mound distribution of Macrotermes spp was substantially influenced by soils clay mineralogy. Boyer (1982) and Mahaney et al. (1999) found that the clay mineralogical composition of termite (Macro termitinae) mounds was somewhat different from that of adjacent surface soils.

Experience with the tropical late rites has shown that climate, topography and vegetation, determine if the weathering system and drainage conditions favour the development of kaolinites (kaolinite, halloysite), micas (illite) and smectites (Montmorillonite) minerals. Obviously, the mineral status of laterite soils appears to be a function of weathering conditions. The mineralogy of laterite soils and the relationship of the mineralogy of their clay contents, to that of the prevailing weather conditions have shed some light, on the conditions which enable the development of particular types of minerals. This information is useful to engineers in helping them to make inferences as to when and where to expect the occurrence of similar minerals. Clay mineralogical compositions and clay fractions are therefore very important and may be used as a means of soil classification (Osinubi, 2004).

The crystalline mineralogical components of clay fraction of soils are most readily identified by the powder method of x-ray diffraction analysis (Harris and White, 2007; Shrivastava, 2009).

X-ray diffraction is one of the continuing challenges in the study of clay rich minerals, which is a mineral assemblage. X-rays are one of the several types of waves in the electromagnetic spectrum and have wavelengths in the range of 0.01 to 100A^0 (Ola, 2013). It is because wavelengths of above 1A^0 are of the same order as the spacing of atomic planes in crystalline materials that make x-rays useful for analysis of crystal structures. The principle of x-ray diffraction by planes of atom is that a parallel beam of x-rays of wavelength, λ, will strike a crystal at an angle θ to parallel atomic planes spaced at distance 'd' where $n\lambda = 2d\sin\theta$ and n is the order of diffraction. Each mineral will produce a characteristic set of reflections at values of θ corresponding to the spacings of the prominent planes (Mitchell, 2005).

II. MATERIALS AND METHODS

Bulk samples of termite reworked soils and non-reworked soils were obtained. Twenty samples were taken altogether from two different locations that is, ten samples from each location. In each location, two samples were taken from the upper part of the termitarium after the outer surface has been scrapped off with cutlass, then another two samples were taken from where the queen of the termites was found after the termitarium has been broken and two samples were taken from the bottom of the termitarium. Four different samples were taken from the surrounding of the termitarium and this was done by measuring 4m (four meters) away from the 4-cardinal points of the termitarium. The same process was repeated in the second location.

The samples were washed, oven-dried at 40^0C to a constant weight, and then ground into fine powder using a hand mill. The powdered specimen was mounted on a small pedestal connected with a continuously rotating base. The X-rays were permitted to hit the specimen and be diffracted upon a film.

III. RESULTS AND ANALYSIS

Minerals in the clay fractions were identified from the oriented and random powder diffraction pattern following the procedures given by Brown and Brindley (1980). Identification of the minerals present in the soil samples was based on X-Ray Powder data for minerals (George Brown, 1961) as shown in table 4. The following symbols were used to designate soil samples:

NRS - Non-Reworked Soil
TRS - Termite Reworked Soil

From the result of X-ray diffraction analysis, the following conclusions were arrived at regarding the mineralogy of the soil samples. It can be noted that kaolinite is prominent in the termite reworked samples than the non-reworked samples with some quartz, chlorite, illite, halloysite minerals.

In location 1, (see figs. 1a , 1b and Table 1), the presence of kaolinite was confirmed by the following characteristic peaks; 7.08A^0, 4.24A^0, 3.71A^0, 3.43A^0, 2.28A^0, 1.825A^0, 1.542A^0, 1.36A^0, 1.175A^0, 1.006A^0. The presence of quartz was likewise confirmed by the following reflections; 4.24A^0, 3.43A^0, 1.542A^0, 1.379A^0, 2.28A^0, 1.67A^0, 1.252A^0, 1.175A^0 and 1.071A^0. Furthermore, the presence of illite was confirmed by characteristic peaks 2.368A^0, 1.542A^0, 2.43A^0, 1.67A^0 and Halloysite by 3.43A^0, 1.67A^0 while chlorite and feldspar were confirmed by 7.08A^0 and 0.914A^0 respectively.

In location 2 (see figs. 2a , 2b and Table 2), the presence of Kaolinite was confirmed by the following characteristics peaks; 7.37A^0, 7.08A^0, 7.07A^0, 4.04A^0, 1.93A^0, 1.82A^0, 1.59A^0, 1.54A^0, 1.50A^0, 1.48A^0, 1.36A^0, 1.25A^0, 1.22A^0, and 1.05A^0.

The presence of quartz was also confirmed by the following reflections 3.3A^0, 3.31A^0, 1.82A^0, 1.59A^0, 1.54A^0, 1.27A^0, 1.175A^0, 1.22A^0 and 1.05A^0. The presence of illite was confirmed by the following: 3.3A^0, 3.24A^0, 1.59A^0, 1.54A^0, 1.48A^0 and 1.50A^0. Furthermore, halloysite was confirmed by the following reflections, 1.48A^0 and 1.27A^0 and chlorite by 7.08A^0 while felspar was confirmed by 4.04A^0 and 3.24A^0.

Table 3 shows that termite activities increased the quantities of minerals in the soil samples. For non-reworked soils in location 1, the quantities of kaolinite, quartz, illite and chlorite are 17.47, 31.37, 2.05 and 2.92 respectively, while for termite reworked soils, the values are 44.76, 33.76, 2.61 and 6.95 respectively.

Also, for non-reworked soils in location 2, quantities of kaolinite, quartz, illite and chlorite are 28.5, 18.5, 8.0, 0 respectively while for termite reworked soils, the values are 29.5, 27.0, 14.5 and 2.0 respectively.

Table 1: Results of X-Ray Analysis on Sample from Location 1

NRS				TRS		
Interval of Angles of Reflection $^0 2\theta$	No. of Characteristic Peaks	Wave lengths (A^0)	Identified Minerals	No. of Characteristic Peaks	Wave lengths (A^0)	Identified Minerals
≤ 20	2	4.24-7.08	Kaoline, Chlorite, Quartz	2	4.23-7.07	Kaoline
21-40	2	2.368-3.43	Kaoline, Quartz, Illite, Halloysite	3	2.28-3.71	Kaoline,Chlorite, Quartz, illite.
41-60	2	1.542-1.875	Kaoline, Quartz	4	1.542-2.01	Kaoline, Quartz, Chlorite, illite, Halloysite
61-80	2	1.257-1.379	Quartz, Chlorite	3	1.36-1.75	Kaoline, Quartz
81-100	2	1.071-1.175	Quartz	2	1.006-1.07	Kaoline, Quartz
>100	1	0.914	Felspar	-	-	-

Table 2: Results of X-Ray Analysis on Sample from Location 2

NRS				TRS		
Interval of Angles of Reflection $^{0}2\theta$	No. of Characteristic Peaks	Wave lengths (A^{0})	Identified Minerals	No. of Characteristic Peaks	Wave lengths (A^{0})	Identified Minerals
$\leq$ 20	1	7.37	Kaoline,	2	4.04-7.08	Kaoline, Chlorite, Feldspar
21-40	2	3.24-4.42	Kaoline, Felspar Illite,	2	2.31-3.30	Kaoline, Quartz, illite
41-60	1	1.59	Illite, Kaoline, Quartz	3	1.542-1.93	Kaoline, Quartz, Illite.
61-80	3	1.22-1.48	Kaoline, Halloysite, Illite, Quartz	3	1.25-1.50	Kaoline, Quartz, Illite.
81-100	2	1.05-1.18	Quartz, Kaoline	2	1.08-1.175	Kaoline, Quartz
>100	-	-	-	-	-	-

Table 3: Relative Percentages of Quantities of Minerals in the Studied Soils

	Location 1				Location 2			
Minerals	**NRS**		**TRS**		**NRS**		**TRS**	
Chlorite	2.92	4.68	6.95	7.81	-	-	2.0	2.63
Feldspar	7.16	11.47	-	-	13.0	18.3	3.0	3.95
Halloysite	1.46	2.34	0.95	1.07	3.0	4.23	-	-
Illite	2.05	3.28	2.61	2.93	8.0	11.27	14.5	19.08
Kaolinite	17.47	27.98	44.76	50.28	28.5	40.14	29.5	38.82
Quartz	31.37	50.25	33.76	37.92	18.5	26.06	27.0	35.53

Table 4: X-Ray Powder Data for Minerals (George Brown. 1961)

Quartz		Kaolinite		Kaolinite		Illite		Felspar		Chlorite		Halloysite	
d(A^{0})	I	d(A^{0})	I	d(A^{0})	I	d(A^{0})	I	d(A^{0})	I	d(A^{0})	I	d(A^{0})	I
4.26	35	7.16	10+	1.619	6	10.0	10	6.44	2	14.2	10	10.1	10
3.343	100	4.46	4	1.584	4	4.94	2	6.35	<1	7.08	4	4.46	8
2.458	12	4.36	5	1.542	5B	4.47	9	5.84	<1	4.71	6	3.40	5
2.282	12	4.18	5	1.489	8	3.68	2b	5.65	<1	3.534	6	2.56	5
2.237	6	4.13	3	1.467	2	3.32	9	4.04	9	2.829	9	2.37	3
2.128	9	3.845	4	1.452	4B	3.16	½	3.89	2	2.604	2	2.23	3
1.980	6	3.741	2	1.429	4	2.86	1	3.75	7	2.567	2	1.67	3
1.817	17	3.573	10+	1.403	2	2.60	6	3.64	4	2.458	3	1.48	5
1.801	<1	3.372	4	1.390	2	2.50	1	3.48	1	2.273	3	1.28	1
1.672	7	3.144	3	1.371	2	2.41	4	3.37	1	2.013	2	1.23	1
1.659	3	3.097	3	1.338	4	2.158	2	3.210	>15	1.886	2		
1.608	<1	2.753	3	1.305	6B	1.982	1	3.178	10	1.717	3		
1.541	15	2.558	6	1.292	2	1.689 1.639	3	3.021	3	1.567	3		
1.453	3	2.526	4	1.282	5	1.53	6	2.953 2.920	1	1.549	3		
1.418	<1	2.91	8	1.264	3			2.833 2.826	2	1.392	2		
1.382	7	2.370	6	1.246	3			0.982	1				
1.375	11	2.338	9	1.235	3			0.913	2				
1.372	9	2.288	8	1.217	1								
1.288	3	2.247	2	1.200	3								
1.256	4	2.186	3	1.190	3								
1.228	2	2.	3	1.168	2								
1.1997	5	2.061	2	1.124	1								
1.973	2	1.989	6	1.094	3								
1.838	4	1.939	4	1.082	2								
1.1802	4	1.896	3	1.057	1								
1.1530	2	1.869	2	1.049	2								
1.1408	<1	1.839	4	1.039	2								
1.1144	<1	1.809	2	1.021	2								
1.0816	4	1.781	4	1.013	2								
1.0636	1	1.707	2										
1.0477	2	1.685	2										
1.0437	2	1.662	7										
1.0346	2												

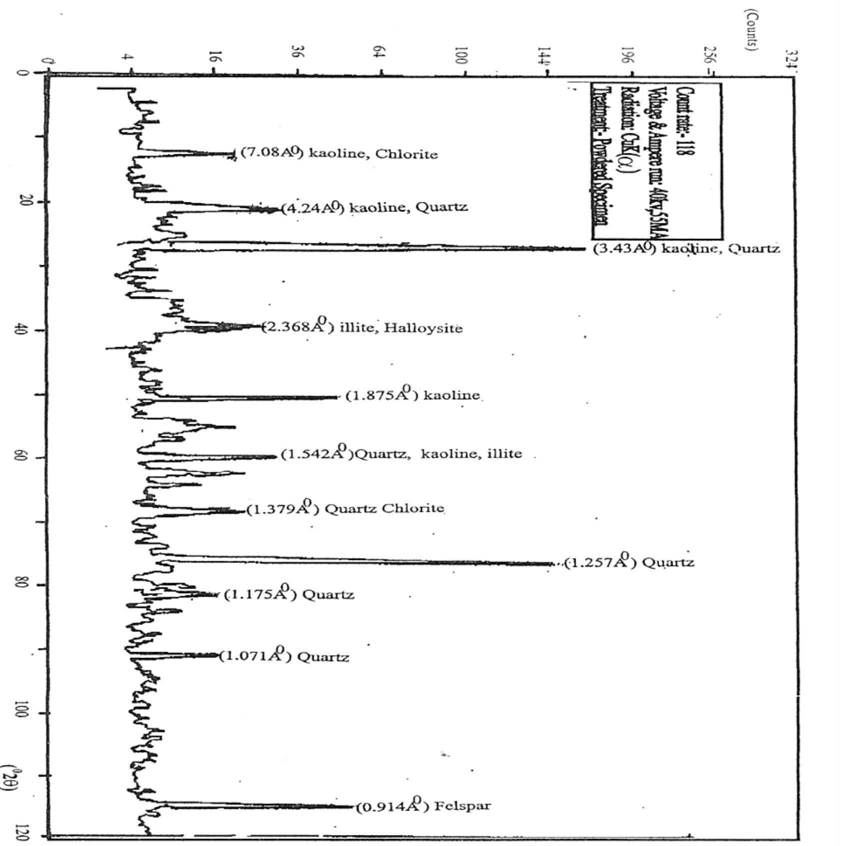

Fig 1a: X-Ray Diffraction for Location 1, NRS

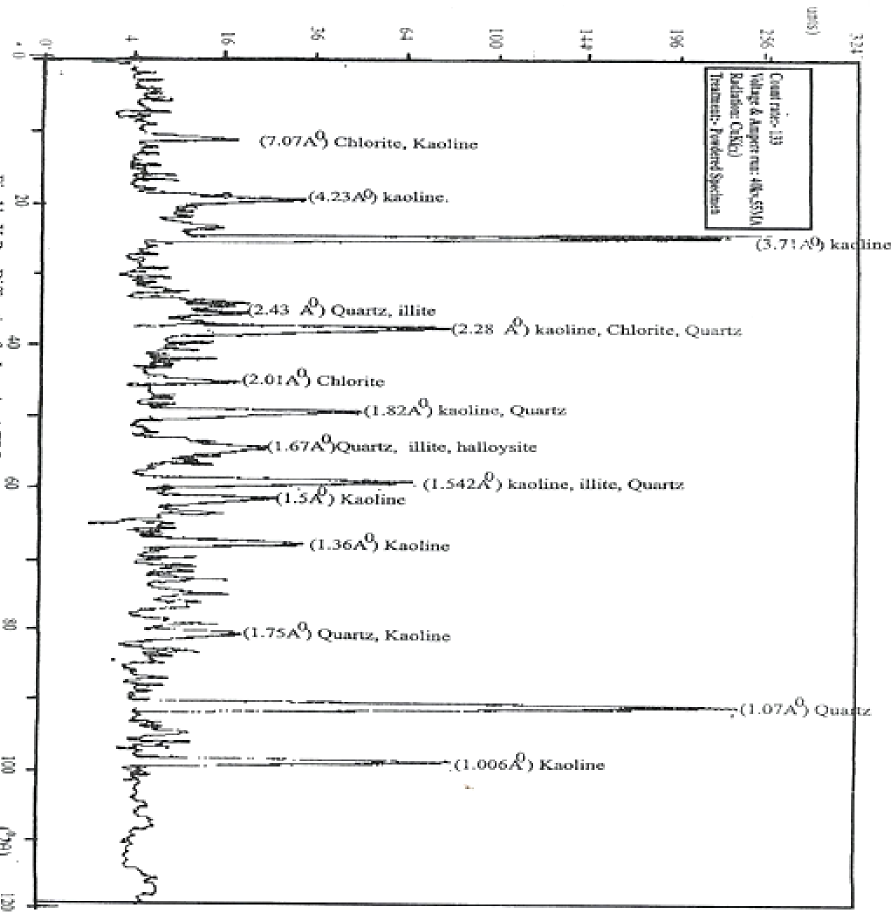

Fig 1b: X-Ray Diffraction for Location 1, TRS

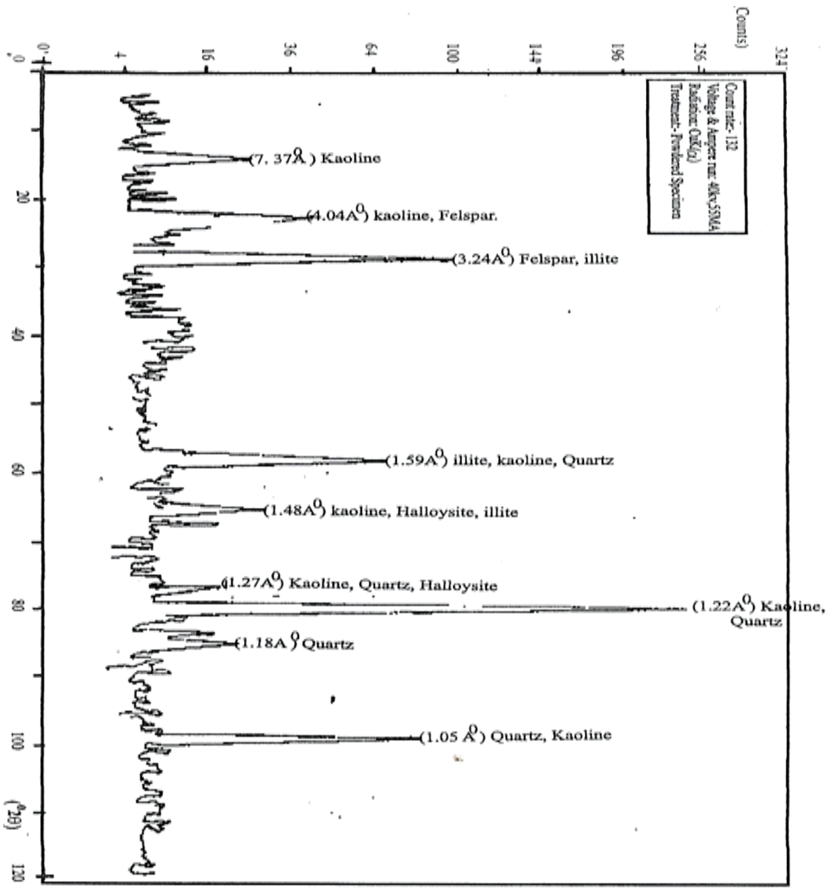

Fig 2a: X-Ray Diffraction for Location 2, NRS

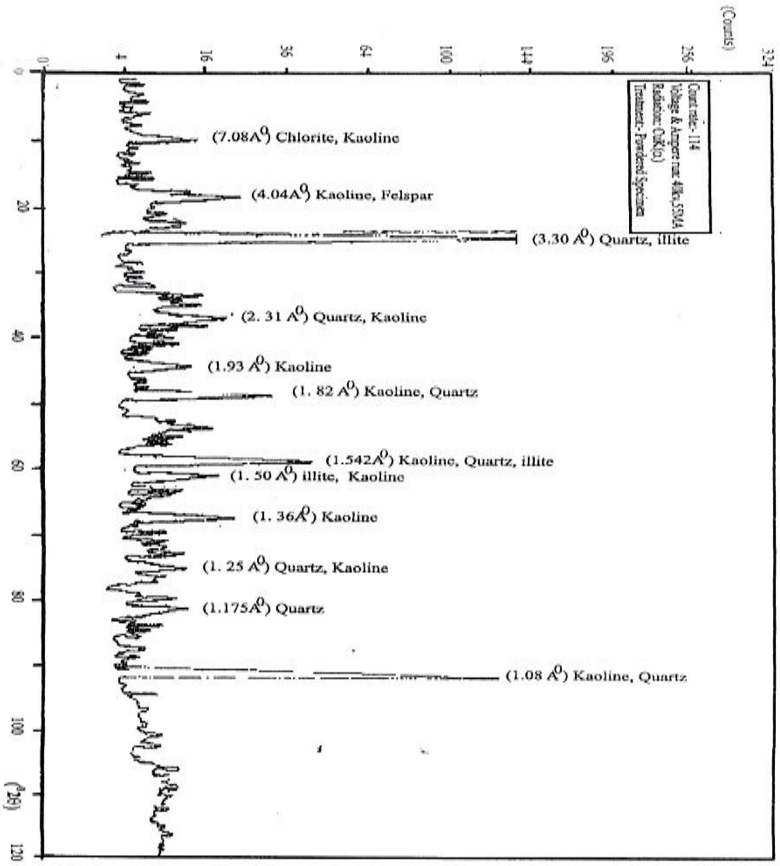

Fig 2b: X-Ray Diffraction for Location 2, TRS

IV. CONCLUSION

The X-ray analysis of the soil showed that termite reworked soils contain more kaolinite as their main clay mineral (a non-swelling clay mineral good for road construction) than the surrounding non-reworked soils.

It can therefore be inferred that this research illustrates a possible mineralogical alteration of the soils mediated by termites.

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