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Ecological effects of clay mining by *Macrotermes* termites

The mounds of *Macrotermes* termites in sandy soils usually have a greater clay content than surrounding topsoils.[1] The origin of the clay used in the construction of the mounds has not been systematically investigated, but could be from the topsoil, subsoil or tens of metres into the regolith.[2] There are a range of potentially positive ecological effects of this clay mining by the termites. Erosion of the mound material (Figure 1) will increase the clay content of topsoils and consequently their nutrient status, water-holding capacity and nutrient-holding capacity. There is, however, a potentially negative effect of increased clay content in sandy topsoils, namely an increased tendency of the surface layer of the soil to seal during rain events, and to reduce infiltration of rainwater as a result.

Figure 1: A *Macrotermes* termite mound in northern Namibia. The direction of soil erosion from the mound is depicted by a black arrow.

Sealing of the soil surface during a rain event can, in many soils, have a large effect on infiltrability of water.[3-7] Such sealing is usually temporary. Raindrop impact disperses clay particles which block the soil pores within the top millimetre of soil.[3,6] This blockage can occur even in sandy soils with small amounts of dispersed clay.[7-9] When the soil dries after a sealing event, whether in a clayey or sandy soil, the clay particles shrink, the thin seal breaks apart, and the seal is no longer easily discernible in the field. Sealing is usually ephemeral, occurring during rain events, as opposed to crusting which may be evident at the timescale of decades.

Although a physical crust several centimetres thick will constrain infiltration, it is often the formation of a thin seal during a rain event at the soil surface that has a greater effect on infiltration.[8,9] The ecological effects of this sealing process can be extreme, with seals of less than 0.1 mm thick reducing the rate of infiltration by a factor of 1800.[3] To investigate the likelihood of this potentially negative effect of sealing being increased as a result of clay mining by termites, we analysed a range of physico-chemical properties of seven termite mounds, constructed by *Macrotermes* species, as well as adjacent topsoils and subsoils in northern Namibia (Figure 2).

The results of these analyses are presented in Table 1. As expected, the mean clay content of mound samples was considerably greater than that of topsoils (23% vs 11%). Surprisingly, this greater clay content did not result in reduced infiltrability. Mean infiltrability of mound samples and topsoils was ~180 mm/h and 115 mm/h, respectively. We attribute this result to the greater electrical conductivity, pH and exchangeable sodium percentage of the mound samples compared with the topsoil. These chemical changes in the soil would be expected to reduce the dispersibility of the clay and consequently reduce the tendency of the soil to seal.[6,8,9,10] This was borne out in the data, with mound samples and topsoils having similar amounts of water-dispersible clay (1–2%). Notably, the percentage of total clay dispersed was three times greater in topsoils than in samples from the top of the mounds (18% versus 6%).

In conclusion, our results show that the mining of clay by *Macrotermes* termites is unlikely to increase sealing and thereby reduce infiltrability of soils during rain events. This is because the mining is also associated with an increase in electrical conductivity, pH and exchangeable sodium percentage, all of which reduce the dispersibility of the clay.

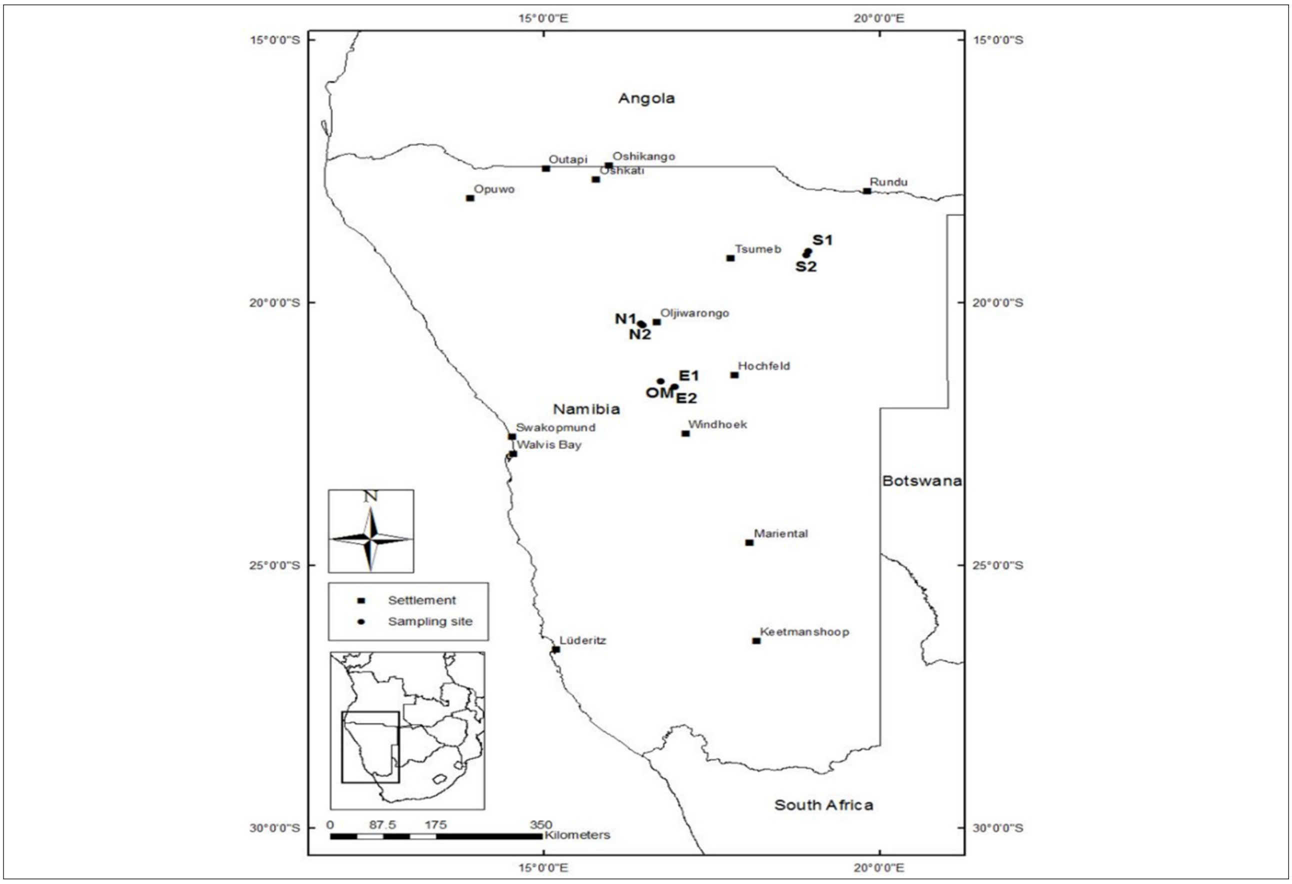

Figure 2: Location of sample sites in northern Namibia.

Table 1: Physical and chemical properties of the mound surface, mound interior, topsoils and subsoils. Values are presented as means and standard errors ($n=7$). Letters (a,b,c) indicate significant differences between values in a row ($p<0.05$). Statistical analyses were conducted as follows: linear mixed models using the 'lme4' package[11] in R[12]; sampling site was assigned as a random intercept to test the differences in soil properties within and not across sites; model residuals were inspected for normality and plotted against independent variables to test for linearity, ensuring no violation of linear mixed model assumptions; and Tukey's post-hoc tests were applied to identify significant differences between treatment means.

		Mound		**Topsoil**	**Subsoil**
		Surface	**Interior**		
Soil texture[i]	Clay	23 (3.8) a	23 (3.9) a	11 (3.8) b	18 (3.3) ab
	Silt	8 (1.1) a	9 (1.4) a	11 (3.6) a	8 (1.6) a
	Clay + fine silt	28 (4.7) a	27 (4.6) a	17 (5.5) a	21 (4.3) a
	Sand	67 (5) a	66 (5) a	77 (7) b	73 (5) ab
Infiltrability (mm/h)[ii]		176 (27) a	179 (38) a	115 (20) a	180 (25) a
Water-dispersible clay and fine silt (WD, %)[iii]	Clay	1.1 (0.3) a	2.5 (0.5) b	1.7 (0.4) ab	1.1 (0.2) a
	Clay + fine silt	7.3 (1.5) a	8.9 (1.4) a	6.5 (1.7) a	6.4 (1.1) a
WD clay as a percentage of total clay (%)		6.4 (3.4) a	13.2 (4.3) ab	18.2 (6.1) b	7.5 (1.9) a
WD clay + fine silt as a percentage of total clay + fine silt (%)		30.5 (6.6) a	36.9 (5.9) ab	45.4 (5.4) b	36.9 (7.7) ab
EC (Sm^{-1})[iv]		164 (23) bc	234 (60) c	48 (13) a	73 (19) ab
pH (KCl)[iv]		6.7 (0.2) a	6.7 (0.2) a	5.6 (0.3) b	6.2 (0.4) ab
OC (%)[v]		0.36 (0.1) a	0.4 (0.1) a	0.5 (0.1) a	0.27 (0.1) a
Exchangeable cations (Cmol$_c$/kg)[vi]	Sum	19 (4) a	18 (4) a	8 (3) b	15 (4) a
	Ca	15 (3) a	15 (4) a	5 (2) b	13 (4) a
	Na	0.24 (0.02) a	0.3 (0.01) b	0.24 (0.02) a	0.23 (0.02) a
	Mg	2.4 (0.3) a	2.3 (0.3) a	1.5(0.3) c	1.9 (0.2) b
	K	0.7 (0.1) a	0.8 (0.1) a	0.7 (0.2) ab	0.4 (0.1) b
Exchangeable sodium percentage (%)[vii]		1.7 (0.4) a	2.3 (0.6) a	5.2 (1.2) b	2.9 (0.8) a

[i] *Total calgon-dispersible particle size distribution*[13]

[ii] *Laboratory infiltration method*[9]

[iii] *Pipette method*[13]

[iv] *1:5 soil:water suspensions*[14]

[v] *Walkley-Black method*[15]

[vi] *Thomas*[16]

[vii] *ESP = Exchangeable {(Na)/(Ca + Mg + K + Na)} x 100*

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