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Influence of *Odontotermes spp*. on soil mineralogy of the biogenic mound Materials

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ABSTRACT

This work highlights the interactions between fungus-growing termites (Isoptera, Termitidae), and mound building components. As major eco-engineers in tropical ecosystems, termites create biogenic structures with galleries, sheeting's, fungus-comb chambers where the exosymbiotic interaction between termites and the fungus is well documented. Odontotermes spp. a fungus cultivator build mounds of different dimension that strongly influence the physical and chemical properties of soils there by clay mineralogy and SOM gets altered. In dry land ecosystems, termite mounds are often hotspots of primary production.

Introduction

Termite nest are found to be in abundance in Dindigul district of Tamilnadu. The densities of these mounds in some part of the location are high. They are occupying a vast area of farmers' fields, and influence a significant role on the surrounding soils. These soil inhabiting - arthropods create chaff - frash piles around the nest perimeter that increase the organic content of the soil using the ejected material .The influence of Odontotermes spp. on SOM and clay has mainly been related to above-ground mound materials built by these species. These termites significantly modify their environment by increasing the clay and SOM contents in order to ensure the structural stability of their nest structures (Holt and Lepage, 2000; Jouquet et al., 2004). Besides this, termite mound soil can be used as organic resources to improve soil productivity. It can also counteract land degradation through their soil borrowing and feeding activities.

Materials and methods

Termite mounds and surrounding soils were sampled from 10 different sites in the Dindigul district of Tamilnadu , India . Geologically Dindigul District receives an average rainfall of 700 mm and the average temperature is relatively high varying from 26 degree celsius to 38 degree celsius. A typical OM was identified at each site, the vegetation and associated land use around the mound were also noted .The types of mound selected at each of the sites were of the Odontotermes spp. *[odontotermes* mound (OM)]. Samples were taken from the top to the base of the OM and a composite of these samples was taken as the mound soil. A major part of the soils of this district are classified as black and red loam soils. Soil textural and chemical analyses were performed according to methodology described in the soil analysis manual of EMBRAPA. The soil and mound samples were air dried, crushed to pass through a 2-mm sieve and analysed as follows: Particle size by the hydrometer method, Organic matter was determined by the Walkley-Black method. Total nitrogen amount of the mound material was measured following the Modified Kjeldhal method.. Carbon content in the soil was estimated by oxidising the carbon and measuring either the amount of oxidant used (wet oxidation, usually using dichromate). Soil organic matter have usually measured in terms of carbon and converted to organic matter by multiplying 1.72 value .

Results and discussion

Soil dwellers are also able to act as weathering agents, modifying clay properties in a significant manner (Landeweert et al., 2001). Termites are traditionally considered to have significant effects on clay mineralogy and fertility through the decomposition process and the production of acids .In tropical soils, odontotermes sp. play an important role in soil bioturbation because of their considerable impact on soil conditions A large number of mound-builders forage on the soil surface and, in order to protect themselves from desiccation and predation, construct extensive surfaces of protective soil sheetings with their saliva which upturn the peodology parameters. Mounds have extensive underground galleries which have significant effects on the porosity and hydrological properties of the soil (Wood .,1988)

While termites were able to use both clay and sand for nest construction they forage more on clay and bring it up . This clay was used with a high preference for covering and reinforcing their constructions. This behaviour underlines the importance of termites in the dynamics, not only in transformation but also of translocation, of clays in tropical ecosystems. Odontotermes spp. in savannas appear to import coarse particles (sand) in the construction of their mounds, improving water infiltration, reducing water-logging, and lowering wilting point in these heavy clay soils (Brady and Weil 2002) .By binding soil particles together with saliva and fecal material, termites create soil aggregates (Arshad., 1981), which increase pore space within the soil profile. Especially in sandy soils, a small but localized increase of clay could be of major importance in term of soil fertility. The process of soil transportation for mound building promote pedobioperturbation, and nutrient cycling.

Soil texture and structure were strongly modified on the termite mound as compared to the surrounding control soil. The soil on termite mound exhibited a higher proportion of fine particles (Table 1 and Figure 1). In particular, two fold increase

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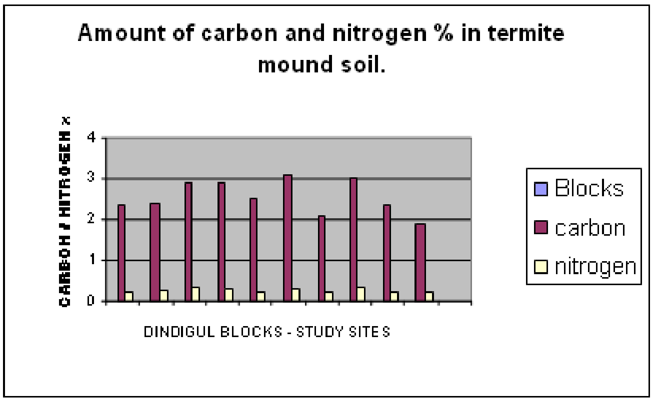
in clay content was observed in the site 3 and 8, respectively. Clay content varied from 280 to 435 g kg-1, silt 175 to 255 g kg_1, and sand 319to 550 g kg_1 (Table 1). Average values of 10 samples were 325gkg_1 clay, 200 g kg_1 silt, and 475 g kg_1 sand .compared to control parameters there was significant increase in soil textural content . Such an enrichment in fine soil particles on mounds has been reported in other tropical savanna environments (Abbadie et al., 1992;) .

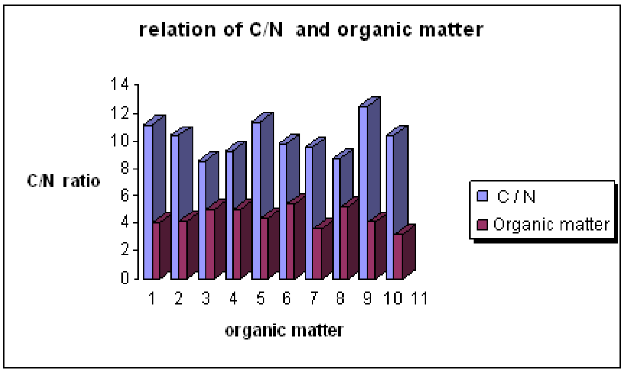
Fig .1 Amount of carbon and nitrogen percentage in termite soil in 10 study blocks



This indicates that termite action increased silt content of mounds and probably increased the nutrient-supplying capacity of the soil. This may happen because termites generally select the smaller particles from within the profile; material brought to the surface are commonly finer in texture and may have different clay mineral composition than those of the original surface. Lavelle et al .,(1995) also reported that the epigeal mounds built by termites are usually fine textured and have cemented hard and massive structures that shed almost all the water that impinges on them.

Most farmers in this region are resource-poor. In most of the arid ecosystem , the increased rate of decomposition associated with cultivation, combined with the low rates of crop residue addition associated with crop-fallow rotations has caused a fairly rapid decline in soil organic matter. Organic matter can be considered a pivotal component of the soil because of its role in physical, chemical and biological processes (Table 2). The high cation exchange properties of organic matter are a major means by which organic matter is able to bind soil particles together in a more stable structure. The reactive regions present in humus are numerous, and give these molecules a capacity to bind to each other and to mineral soil particles, and also to react with cations in the soil solution. A high proportion of organic matter was recorded in site 8, 6 and 3. This was due to the termite activity on carbon sequestration by incorporation of carbon and nitrogen .

Fig 2. Effect of C/N ratio and organic load in termite soil



A high proportion of organic matter was recorded in site 8, 6and 3 .this was due to the incorporation of carbon and nitrogen .Termite activity increases the content of organic matter in the soils that they use for the construction of their nests and also modifies the mineral composition of the soil materials (Mahaney *et al*., 1999). While a high CEC is an important attribute of SOM which is a substantial reservoir for phosphorus and sulphur, as well as nitrogen. These elements are bound within the organic structure, and are released to the soil solution when microbes like termites break down organic matter. These materials modify the soil profile and may lead to changes in the soil physical and chemical properties.

To be attractive, the use of chemical fertilizers are cost effective given for the poor and deteriorate physicochemical conditions of the land cultivated . As demonstrated by Jouquet et al. (2004a), termites modulate the incorporation of supplementary material (i.e., saliva) according to the type of the soil used. The more termites prefer a substrate, the less they must incorporate C and N. Clay-soil is probably a better substrate in term of both stability and economy for maintaining the organic constituents. (less C and N were incorporated).Clay protect organic matter from breakdown, either by binding organic matter strongly or by forming a physical barrier which limits microbial access. Clay soils in the same area under similar management will tend to retain more carbon than sandy soils.

Under the dry conditions and low rainfall, most of the manure would be lost. Despite large nutrient loss high termite activity at the arid sites would equalize the organic loads on selected spots of croplands. More attention should be paid to the fertile soil accumulated near mounds built by termites in Dindigul District. The exploitation of this improved soil with high fertility is possible for eco- production by reducing costs of inorganic sources More research should be conducted to evaluate feasibility of such practices on a larger scale in future.

Conclusion

In conclusion, termite mounds appear as a major source of functional heterogeneity in the dry land ecosystem. Due to their specific soil texture and structure, they represent sites of high water and possibly nutrient availability for plants which can deeply influence directly or indirectly the vegetative function, and productivity .

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Table 1. Textural properties of termitaria soil analyzed in 10 different sites in Dindigul district

Site	Clay (gkg^{-1})	Silt (gkg^{-1})	Sand (gkg^{-1})
TMS 1	310	200	490
TMS 2	305	215	480
TMS 3	435	255	310
TMS 4	360	205	435
TMS 5	290	190	520
TMS 6	280	195	525
TMS 7	275	175	550
TMS 8	410	205	385
TMS 9	285	180	535
TMS 10	300	180	520
mean	325	200	475
control	260	170	570

TMS- Termite mound sites (1-10)

Table 2. Ratio of carbon to nitrogen and its proportionate organic load in 10 different study sites in Dindigul district

Study sites	Carbon (%)	Nitrogen(%)	C / N	Organic matter
TMS 1	2.33	0.21	11.09	4.0076
TMS 2	2.38	0.23	10.34	4.0936
TMS 3	2.91	0.34	8.55	5.0052
TMS 4	2.88	0.31	9.29	4.9536
TMS 5	2.50	0.22	11.36	4.3008
TMS 6	3.12	0.32	9.75	5.3664
TMS 7	2.11	0.22	9.59	3.6292
TMS 8	2.98	0.34	8.76	5.1256
TMS 9	2.37	0.19	12.47	4.0764
TMS 10	1.88	0.18	10.44	3.2336

TMS- Termite mound sites (1-10)