# ROLE OF military TERMITES (*Pseudocanthotermes militaris*) IN IMPROVING SOIL PRODUCTIVITY in tropical agroecosystems.

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## ABSTRACT

Military Termites have been considered as a major pest causing significant reduction to crop productivity in tropical regions of the world. The termite destroys many plants [domestic and wild) at any stage of development from the seedlings to maturity. Crops such as cotton, wheat and ground nuts, upper land rice and eucalyptus trees are highly susceptible to termite damage. They destroy huge amounts of organic materials especially those used as mulches in plantation farming. However, there are beneficial termite activities such as organic matter decomposition and nutrient dynamics that are essential components in the soil ecosystem as they aid in maintaining long-term soil productivity and also in restoring barren soils. The review sought to establish the contribution of military termite activities to soil productivity. The result from the review showed that termite activities such as burrowing, chewing of plant litter, excavation activities in search of food, and construction of termitaria leads to improved soil structure, soil aeration, water infiltration via soil porosity, plant nutrient (calcium, nitrogen, phosphorus, potassium, magnesium) and soil organic matter which will eventually result to improved yields of crops. Also, termite mound has been suggested to be very effective for bulking agent for compost preparation and soil amendment.

Keywords: termite, mound, chemical, physical and biological.

## Introduction

Termites are insects classified at the taxonomic rank of infrared Isoptera. They are soil animals since they spend some part of their life cycle in the soil; together with their association with the soil, they have several effects on soil properties (Holt & Lepage, 2000). Termites are among the macrofauna that influence soil physical, chemical and biological properties. They are more active in the semi-arid and arid areas (this is missing in the general topic) (Lal, 1988). According to Moe, (2009), termites account for 40 to 60% of the total soil macrofauna biomass in many tropical ecosystems. Their estimated biomass in African savannas is estimated to be between 70 to 110kg/ha (Moe, 2009). Several studies have shown that termites are able mechanically to chew up plant material with their mandibles and grind it with their gizzard, thereby increasing the surface area accessible to soil microorganisms. However, some termite species are essential in maintaining long-term soil productivity and also in restoring barren soils (Kaiser *et al.*, 2017). Termite accumulate and deposit particles from various soil depths in mounds so that the amount of organic carbon, clay and nutrients, pH and microbial communities is higher in termite mounds than in adjacent termite-free soils(Deke *et al.*, 2016). Termites contribute to the regeneration of crusted soils by creating voids on the sealed surface, resulting in increased potential for infiltration, and ultimately enhanced water quality (Calovi *et al.*, 2019). Hence this review seeks to find out the contribution of termites through their physical, chemical and biological influence on soil and how it enhances soil productivity

**Common termites' families in the tropics**

| Family | HABITAT | source |
|---|---|---|
| Mastotermitidae | Dry forest/savanna | (Wappler and Engel, 2006). |
| Hodotermitidae | Arid grasslands | (Picker *et al.*, 2007) |
| Kalotermitidae | Tropical forest canopies, oceanic islands, coasts | (Desai *et al.*, 2009) |
| Serritermitidae | Tropical forests | (Bourguignon *et al.*, 2009) |
| Rhinotermitidae | Forest edges (and centers) | (Lo *et al.*, 2004) |

| | | |
|---|---|---|
| Macrotermitinae | Forests and savannas | (Jouquet *et al.,* 2004) |
| Apicotermitinae | Tropical forests and savannas | (Costa-Leonardo, 2004) |
| Termitinae | Tropical forest (all tropical areas) | (Bignell *et al.,* 1979) |
| Nasutitermitinae | Tropical forest (all tropical areas) | (Prestwich *et al.*, 1981) |

**Functional activity of termites versus termite mound microorganisms**

Termites feed on plant materials by transportation (Live and dead plants, litter in various stages of decay in dung, soil and specialized food such as lichens in their mound. The chewing of the plant materials aid in rapid decomposition hence contributing to the organic matter in the soil (Enagbonma *et al.*, 2019).The importance of non-mutualistic microorganisms in termite mounds is determined by the variety of organisms' present. The combination of mountain microorganisms and termites was thought to have a positive impact on the decomposition of organic matter and nutrient cycling, particularly in more arid ecosystems (Abe *et al.,* 2000). The microbial biomass present in mound soil exceeds that of the termite population and that the ratio of microbial biomass carbon to termite biomass carbon was approximately 20:31 in an average mound, suggesting a relatively large microbial community(Enagbonma et al., 2019).Cellulose decomposers are a predominant group of bacteria found in termite mound soil, suggesting that cellulosic material degrades more quickly in mound soil than in surface soil unaffected by termites(Mohindra & Muketji, 1982). As early as the 1960s, it was established that large numbers of nitrifying and denitrifying bacteria are found in termite mound soils (Meiklejohn, 1965). The presence and activity of these organisms have also been determined indirectly by assaying end products of both the nitrifying and denitrifying process (nitrate and nitrous oxide respectively) (Abe *et al.,* 2000). Nitrate rates exceeding 100 ppm were measured in the mounds of some termites, and significant $N_2O$ fluxes from termite mounds were also reported (Abe *et al.,*2010). In certain areas of some termite mounds, there are also some records of low microbial activity and the possibility that termite excretions may have bacteriostatic properties (Enagbonma *et al.*, 2019).

**Influence of termites on soil physical properties**

Termites play a major role in the ecosystem which deals with soil loosening (reduction of bulk density) and both vertical and horizontal transport through bioturbation, and subsequent erosions of their constructions Large amounts of soil are translocated from various depths of the profile to the soil surface during mound-, gallery- and sheeting constructions (Jouquet *et al*., 2011). Considering rare earth element (Ni, Cu, and Zn) and the concentration of trace element, the nests of *Macrotermes sp*. are produced through the accumulation of highly weathered soil originating from deeper layers (Sako *et al*., 2009). Termite has the potential for reduction of soil bulk density and influences the translocation of soil either vertical and horizontal transport by bioturbation and erosion of their mound hence, this magnitude and route of soil translocation resulting from termite activity is directly related to their dietary habits (litter feeding and wood chewing) and the properties of the soil they use. Generally, soil transported by termites contains higher proportions of finer particles size and therefore typically demonstrates different clay mineral compositions than those predominating at the original surface (Jouquet *et al*., 2011; Abe & Wakatsuki, 2010).

Effect of termite activities on soil physical properties ranges from micromorphological to soil profile structure and evolution (Holt & Lepage, 2000). Termites are known to be a major contributor to soil turnover and the amount of biomass produced. Termites influence the alteration of the soil profile through; soil turnover and physical disturbance, decomposition of litter and biomass and creating deep galleries and burrows (Mando *et al.*, 1996). Termites affect the soil through their activities search as; burrowing and excavation activities in search of food, or the construction of living spaces or storage chambers in the soil or above-ground (Mando *et al.*, 1997). The burrows in the soil increase soil porosity resulting in high infiltration of the soil and bulk density. Watsonthe (1977), performed experiments on the use of mounds of the termite *macrotermes falciger* (gerstacker) as a soil amendment. The results obtained shows that termite mound had the lowest bulk density as compared to the surrounding soil. Moreover, termites increase water infiltration via porosity and soil structure improvement (de BRUYN & Conacher, 1990). Termite increase water infiltration via porosity through creating tunnels. These tunnels find in the soil improved soil aeration, soil water availability through the macropores and soil turnover (Kaiser 2017). Mando *et al.*,(1996), found out that the termite restored the infiltration capacity of crusted soil through increased porosity, soil water content and less bulk density. Termite also increase soil aggregation by the secretion of substances that aid in biding of the soil particles Also, termite tunnels in the soil allow rainwater to percolate deep hence, reduce run- off and consequent soil erosion, through bioturbation(Moe *et al.*, 2009)

**Influence of termites on soil chemical properties**

Termites alter the chemical properties of the soil by collection and transportation of living and dead, plant and animal materials, in and out of the termitaria. The effects of termite activities depend on soil properties termites' feeding behavior and materials utilized in nest building, termite species, vegetation and land use (Lal, 1988). Termites accumulate organic matter in their hills. This leads to the increase of plant macronutrient such as nitrogen, phosphorus and potassium in the soil as compared to the adjacent soil. According to de BRUYN & Conacher,(1990), the capacity of termites to increase nutrient levels such as nitrogen, phosphorus potassium, calcium and magnesium are dependent on the rate of organic material incorporation and the type of termitaria made by the termites. Termites generally modify the availability of nutrients either directly or indirectly for other organisms in the soil. (Moe *et al.*, 2009) In an experiment performed by Watson (1977), termite mounds were combined with soil. The result showed high percentages of plant nutrient such as Calcium 95%, mineral Nitrogen 81%, extractable Potassium 69% and available Phosphorus 69%. The activities of termite to improve soil nutrient aid in increasing the crops' biomass and grain yield. According to Arshad(1982), the proximity of vegetation's growth and species structure to termites' mounds in semi-arid savannah ecosystem showed that the mounds influence nutrient and water availability, drainage of the soil, which in turn contribute to increased biomass. Besides, termites have been considered as weathering agents due to their ability to transform minerals chemically (Sako *et al.*, 2009) it can be hypothesized that the grinding of soil particles by termite mandibles in the saliva-rich environment of the buccal cavity increases the surface area exposed to the surrounding solution and then releases interlayer K and adsorption of hydrated or polar ions between the layers (Jouquet *et al.*, 2011).

**Influence of termites on soil biological properties**

The termitarium is similar to the soil from which it is made because it normally includes large numbers of micro-organisms. These micro-organisms, mainly fungi and bacteria, have different functions within the process of decomposition of organic matter (Abe *et al.,* 2000). The termite-fungal relationship can be divided into two groups, non-mutualistic and mutualistic. There are usually non-mutualistic interactions between dry wood termites and certain wood-rotting pillows, with evidence suggesting that wood previously attacked by pillows is more favourable to these termites (Arshad, 1981; Becker, 1975). According to Abe *et al.*, (2000) mutualistic relationships between termites and fungi are restricted to termites in the Macrotermitinae and the fungus *Termitomyces* and have been particularly well studied. They further stated that the primary role of this fungus appears to be colony nutrition, which forms an extensive sporulating mycelium on aggregated, partially digested faecal pellets (forming characteristic structures within the mounds known as combs), the fungus has been attributed to other more specific functions. These include the provision of synergistic cellulolytic enzymes to facilitate digestion, decomposition of lignin and the provision of a nitrogen-enriched substrate for termites' ingestion **(**Abe *et al.,* 2000).Certain studies of termite mound soil microbiology have indicated the existence of large numbers of free-living bacteria and fungi not directly related to termite feeding. The found out that bacteria and fungi were more numerous in soil made from mound than in adjacent surface soils (Mohindra & Muketji, 1982). According to Jouquet *et al.,* (2011), several studies suggest that termites and sheets could be microbial diversity sites with a different assembly structure from the parent soil. They stated that increasing evidence suggests that termites are capable of controlling the numbers of microorganisms and probably diversity in selected parts of their mounds, such that the higher abundance of substrates, the nutrient content and the amounts of moisture available promote the growth of a selected and possibly specialized population of commensal bacteria and fungi.in selected parts of their mounds.

**Practical application of termites in agroecology**

Termite activity is of great importance while mulching in crusted soils. The organic matter used for mulching purposes is broken down by the termite especially during the dry periods hence increasing water infiltration(Mando, 1997)Termite mounds have also been suggested to be effective bulking agents for compost preparation. Fungus growing termites (Macroterminitae, Isoptera) are associated with termitomyces mushrooms(Hsieh *et al.,* 2017). Fungus growing termites cultivate fungal crops in farms within their colonies. They are found through-out old world tropics in savannas and rain forests. Fungus growing by termites is ecologically most successful under the unfavourable conditions of the savanna but that seems to have changed under more constant and favourable conditions of the rainforest (Brossard et  2007). There is a symbiotic relationship between the fungus-growing termites (Macroterminitae, Isoptera) and the termitomyces mushrooms whereby the fungus mushroom produces the faecal pallet which come together and form a spongy-like structure called fungus comb. The mushrooms grow on the fungus comb(Ohkuma *et al.*,2001). Fungus growing termites cultivate symbiotic fungi in the nest and feed on the fungus garden/ comb.

**New research viewpoints**

Termite mound has been found to be very effective for soil amendment (Garba et al., 2011) however, its combination with other organic resources such as biochar, compost, manure on soil quality indicators and crop productivity are areas proividingopportunities for further study. Phytotoxicity and compost quality assesment produced from available waste product has been well documented but there is limited information available on compost quality and composting studies during composting of waste materials blended with termite mound

**Conclusion and recommendations**

Termites are among the macrofauna that influence soil physical, chemical and biological properties through their functional activities**.** **Termite activities** aid in the improvement of soil porosity, organic matter through decomposition, water infiltration, availability of soil water, soil aggregation, nitrogen, potassium, calcium, magnesium and phosphorus availability. Composting of crop residues with termite mound and soil amendment has shown to be promising one to improve soil fertility. It is, therefore, necessary for farmers to conserve these mounds on their fields and utilize it beneficial use.

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Ethic: NA

Consent: NA

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