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Physicochemical properties and biochemical activities of Termitaria soil of Odontotermes spp. and surrounding soil in Sambalpur district, Odisha, India

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Abstract
Background: Termitaria of *Odontotermes* spp. are complex biological habitats that originated by the termite activity and have unusual physicochemical and biochemical characteristics. A research gap is realized in works associated with Termitaria soil characterization, particularly in Eastern India. Therefore, the present work was carried out to compare the enzyme activities and physicochemical properties of Termitaria soil and the surrounding soil collected from Sambalpur University Campus, Odisha, India.
Methods: Field and laboratory Study was carried out during 2019. The enzyme activities like cellulase, Xylanase, amylase and phosphatase and different physicochemical properties of soils were studied following standard laboratory protocol.
Result: All the enzyme activities were found to be significantly high in Termitaria soil than in adjacent soil. The enzyme activities showed a significant correlation with most of the physicochemical properties. This particular study has provided important information regarding the contribution of Termitaria soil as the best possible way of managing unfertile soil.

Keywords: Enzyme activities, *Odontotermes* spp, physiochemical properties, Termitaria

Introduction
The soil sustains a wide variety of invertebrate organisms. Some specific groups bring on changes that add a wide range of essential benefits for the sustainability of natural and managed ecosystems [1]. The invertebrate macrofauna such as termites, ants, and worms, the so-called "soil engineers" [2-5] are the most expansively studied, due to their dominant abundance and biomass in temperate and tropical soils [4]. Among these, termites play an important ecological role in many ecosystems, particularly in nutrient-poor environments [6]. They are considering the impact of their activities on the soil, as well as their constructions they have been addressed in studies in different parts of the world. On a larger scale, termite activities play a key role in the distribution of nutrients [7] through physical changes in biotic or abiotic materials [8]. On a smaller scale, as reported in a tropical savanna, termites are known to significantly influence soil properties [9] with the construction of their nests [10]. These nests of a termite colony are referred to as termitaria.
Many termite species build large and complex termitaria, which harbors a rich associated fauna, including other termite species, arthropods, and even vertebrates [11]. The termite species and environmental conditions control the volume and the number of termitaria [12] in a particular area. Most of the termites build termitaria in sites with high nutrient contents. Soil erosion, translocation of nutrients from occupied and unoccupied termitarias, and the nature of the species affect the redistribution of this material to the soil surface [13-14].
Termites build conspicuous earthen termitaria constituting an important feature of the landscape in tropical and subtropical regions. [15] Distinguish the nests into three main categories: subterranean nest (completely below ground level), epigeal nests (protruding above the soil surface) and arboreal nests (built on the trunk or a branch of a tree but always linked with the soil by covered galleries). However, there are many intermediates. Some epigeal nests

are built against tree trunks.
There are reports of higher content of organic matter in the interior of the termitaria than in the surrounding soils [13][16][12]. Increasingly, it is being recognized that termites are important components of agro-ecosystems, particularly in developing countries where termites are alternative to high-priced inputs, but poorly studied particularly in East India. In this context, the present work was done with an aim to distinguish the biochemical and physicochemical parameters of termitaria soil and the surrounding soil in Western Odisha, India.

Materials and Methods

Study sites

This field and laboratory study was conducted inside Sambalpur University Campus, Jyoti Vihar, Sambalpur, Odisha during 2019. The study sites lies between 21°28’41’’N latitude and 83°52’54’’E longitude and 185 meter above sea level. Sambalpur received 1587.9 mm (62.5") of rain throughout the year. The average high temperature of 41.4°C (106.5°F) and an average low temperature of 27°C (80.6°F) and an averarainfallall of 487.5mm (19.2") were recorded in the study area. The soil surface was covered by scattered herbaceous vegetations. The termitaria hosting termites belonged to the genus (*Odontotermis) with* a height ranging from 0.5 to 1 meter (Fig. 1).
Three old but active epigeous termitarias of *Odontotermes spp*. were chosen and soils from epigeal parts of these termitarias/ termitaria (hereafter “TS”) and adjacent surrounding area of each termitarias (hereafter “SS”) were collected for the study of their physicochemical and biochemical activities.

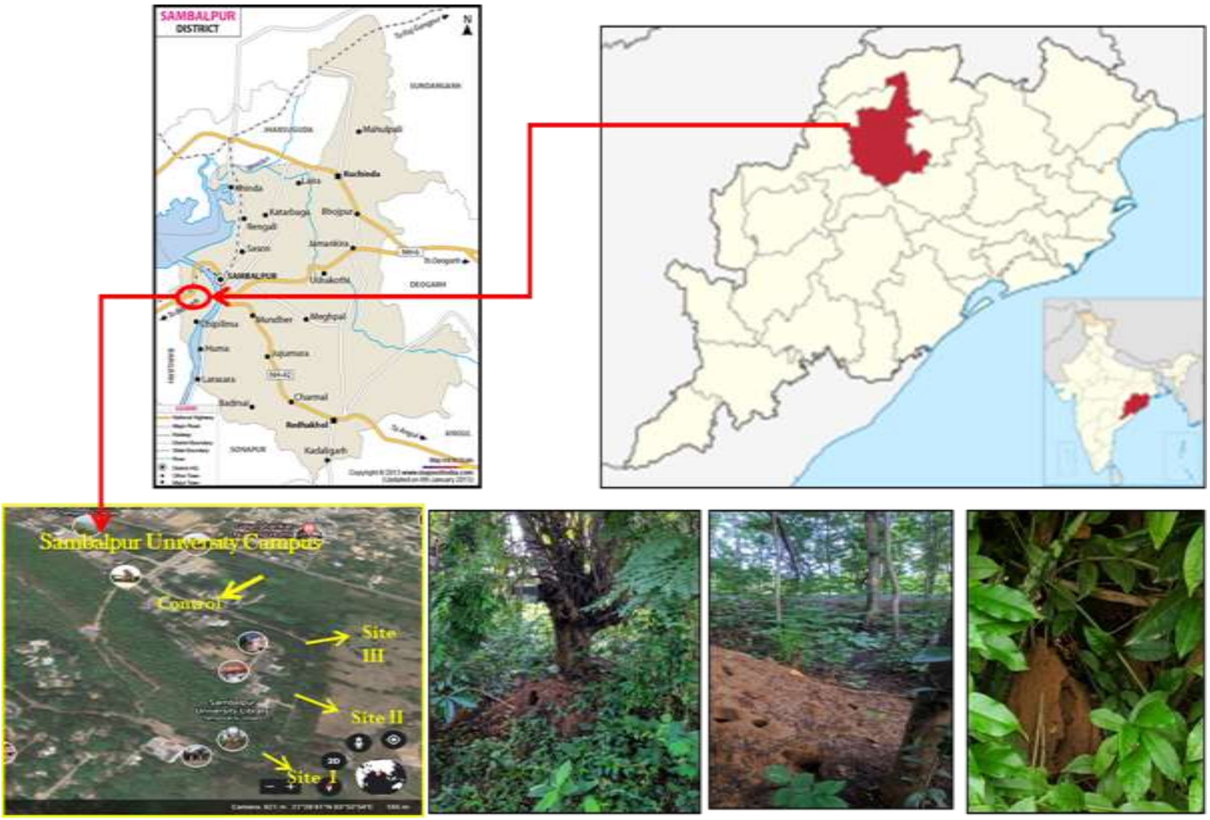

Fig 1: Typical Epigeal Termitaria of site I, II, III and control site inside Sambalpur University Campus, Sambalpur, Odisha

Physicochemical properties of termitaria soil

Soil water holding capacity was determined by the water percolation method, soil pH was measured by using the pH meter, and conductivity was measured by Conductivity Meter (ELECO- CM180). Organic carbon (OC) was determined by the wet oxidation method [17], total N (TN) was determined by the micro Kjeldahl method, available Phosphorus content (AP) was done following the method of [18], available potassium (AK) were determined by flame photometry.

Enzyme activities of termitaria soil

The cellulase, xylanase, amylase activity of freshly collected termitaria soil and the surrounding soil was measured by the dinitrosalicylic acid (DNS) method following [19], and phosphatases activity following [20].

Statistical analysis

Two way ANOVA was conducted to determine significant differences between means of the parameters obtained from soils and termitaria materials using Excel 2007. Multiple correlations and PCA were obtained by Minitab 16.

Results and Discussion

Some of the important physicochemical properties (Mean ± SEM) of the termitaria soils and that of surrounding soils have been presented in Table I. The study indicated a highly significant difference between termitaria soil and surrounding soils in all the parameters studied as shown in Table 1. However, differences between the three sites were not significant for TN and AP.

Table 1: Physicochemical properties of TS and SS

Physicochemical parameters	Termitaria Soil (TS) Avg ± SEM	Surrounding Soil (SS) Avg ± SEM	Two way ANOVA for two soil($F_{1,6}$) types and three sites ($F_{2,6}$)
WHC (%)	24.53± 3.28	10.78±1.128	18.25***, 183.05***
pH	6.48±0.22	7.03±0.056	16.16***, 78.97***
Conductivity (DS/cm)	1.42±0.02	1.318±0.056	28.52***, 150.74***
OC (g%)	0.99±0.003	0.874±0.036	12.28***, 330.28***
TN (g%)	0.215±0.016	0.064±0.002	1.39NS, 132.88***
AP (mg/kg)	0.772±0.007	0.218±0.009	0.212NS, 439.69***
AK(mg/kg)	237.18±17.54	172.24±33.49	4.16*, 8.58**

**p*< 0.05, ***p*< 0.01 ****p*< 0.001, NS Not significant, F_1 and F_2= values of two way ANOVA
(OC: Organic Carbon (g%), TN: Total Nitrogen (g%), AP: Available phosphorus (g%), AK: Available Potassium (g%), WHC: Water Holding Capacity (g%))

Enzyme activities: α-amylase activity, cellulase activity, xylanase activity (µg glucose/g soil/ min) and phosphatase activity (p-nitrophenol/ ml/ min) of three different termitaria soil and that of adjacent soil has been illustrated in Figure 2.

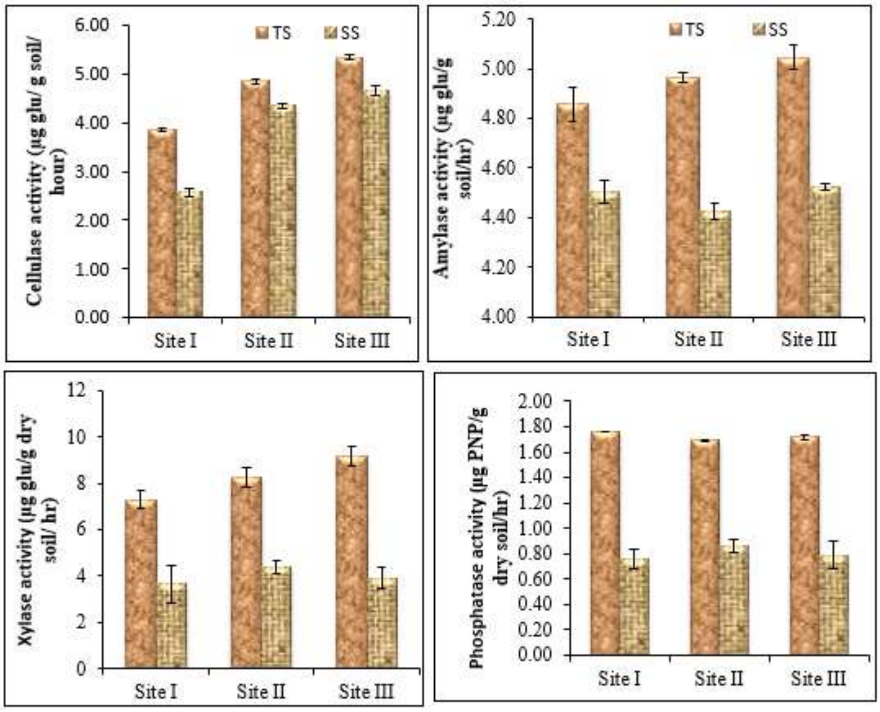

Fig 2: Enzyme activities of termitaria soil and surrounding soil (Cellulase, Xylanase, Amylase activity (µg glucose/ g soil/hr) and Phosphatase (µg of p-nitrophenol/ g soil/hr).

We performed two-way ANOVA to evaluate statistical differences in different enzyme activities between termitaria soils and surrounding soils and between different sites. The enzyme activities showed significant variability among termitaria soils and surrounding soils as revealed from two-way ANOVA ($F_{1,12}$= 742.0213, 340.284, 540.1, and 1072.592, $p< 0.001$ for cellulase, xylanase, amylase, and phosphatase respectively). We also observed significant variations in the enzyme activities in different sites ($F_{2, 12}$ = 1263, 8.04, 10.36, $p< 0.001$ for cellulase, xylanase, amylase activity respectively). However phosphatase did not show any significant variation among the 3 sites but was significantly high in TS than in SS ($F_{1,12}$= 1072.59, $p< 0.001$).

The construction activities of termites play an important role in soil heterogeneity and fertility in tropical ecosystems due to the impact on soil's physical and chemical properties. Results of the physicochemical analyses showed significantly higher WHC, OC, TN, AP, and AK in termitaria soil in comparison to surrounding soil which conforms with the previous reports stating the large capacity of the termites to modify the main soil properties strongly. The results also confirm that termite nests/termitarias are hot spots of nutrients concentration both in the case of soil-feeding and litter-feeding termites [21]. Higher OC and TN content in termite termitaria in relation to the surrounding soil were obtained by [22]. This could be attributed to the foraging behaviour of the worker termites those forage and accumulate organic matters in the termitarias. The P contents were higher in nests and exceeded those of the surrounding soil by up to 71.76% in the present investigation [23]. reported an increased level of organic matter content and available forms of P, especially water-soluble P, several times as a result of termite activity. Soil-feeding termites can increase available P in the nest by two- to five-fold as reported by [24-25].

This study unveiled that the termitaria enzyme activities were significantly more than those of surrounding soil which could be due to high organic materials deposited in the termitaria soil leading to activation of exogenous microflora releasing enzymes to nest soil. This was proved by conducting multiple correlations, which indicated a significantly high correlation between soil enzymes and termitaria soil (Table 2).

Table 2: Correlation between enzyme activities and physicochemical properties of termitaria soil and surrounding soil

	WHC	pH	Conductivity	OC	TN	AP	AK	Cellulase	Xylanase	Amylase	Phosphatase
WHC	1	-.451	.919**	.889**	.867**	.884**	.383	.096	.782**	.805**	.899**
pH	-.451	1	-.464	-.695*	-.704*	-.785**	-.662*	-.678*	-.833**	-.865**	-.741**
Conductivity	.919**	-.464	1	.844**	.793**	.791**	.335	-.080	.648*	.763**	.790**
OC	.889**	-.695*	.844**	1	.891**	.950**	.653*	.436	.893**	.929**	.941**
TN	.867**	-.704*	.793**	.891**	1	.934**	.474	.379	.877**	.879**	.940**
AP	.884**	-.785**	.791**	.950**	.934**	1	.644*	.489	.971**	.969**	.987**
AK	.383	-.662*	.335	.653*	.474	.644*	1	.743**	.638*	.645*	.546
Cellulase	.782**	-.833**	.648*	.893**	.877**	.971**	.638*	.615*	1	.967**	.963**
Xylanase	.805**	-.865**	.763**	.929**	.879**	.969**	.645*	.517	.967**	1	.952**
Amylase	.899**	-.741**	.790**	.941**	.940**	.987**	.546	.450	.963**	.952**	1

** Correlation is significant at the 0.01 levels (2-tailed)
* Correlation is significant at the 0.05 levels (2-tailed)

Further, Principal Component Analysis was carried out considering the data of Amylase, Cellulase, Xylanase, Phosphatase activities of TS and SS along with WHC, pH, Conductivity, OC, TN, AP, AK, of respective TS and SS. (Fig. 3). The analysis discriminate all the variables of TS on the right side and that of SS on the left side with few exceptions. Thus the first component of our data is very effective in separating termitaria soil from surrounding soil. This showed that the termitaria soil and the surrounding soils differed in their physicochemical and biochemical properties which are in conformity with the work of [26] who found a significant difference in chemical and biochemical properties between *Macrotermes* termitaria soil and adjacent soil in Borana District, Ethiopia.

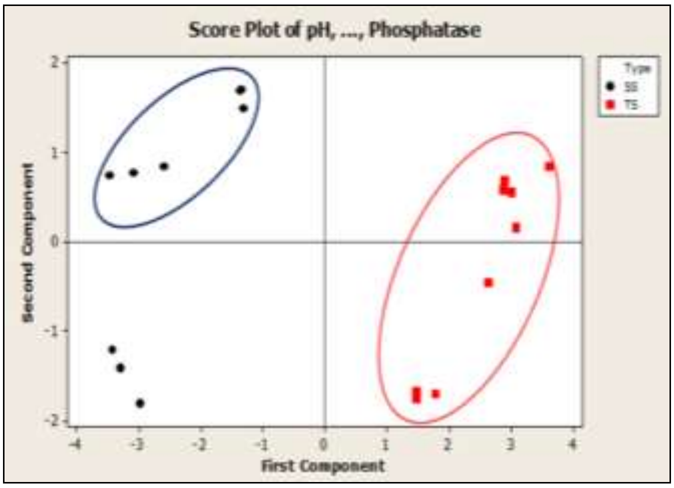

Fig 3: Shows at least two clearly distinguishable clusters. This factoid indicated that the observations in the dataset can be grouped and the clusters represent different soil types i.e. TS and SS.

Conclusion

The current study established the fact that the termitaria soil is comparatively more fertile than surrounding soil and could be further studied for successful utilization of these nest soil for sustainable agriculture in India.

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References

1. Barrios E. Soil biota, ecosystem services and land productivity. Ecological economics. 2007;64(2):269-85.
2. Jones CG, Lawton JH, Shachak M. Positive and negative effects of organisms as physical ecosystem engineers. Ecology. 1997;78(7):1946-57.
3. Jouquet P, Dauber J, Lagerlöf J, Lavelle P, Lepage M. Soil invertebrates as ecosystem engineers: intended and accidental effects on soil and feedback loops. Applied soil ecology. 2006;32(2):153-64.
4. Jouquet P, Blanchart E, Capowiez Y. Utilization of earthworms and termites for the restoration of ecosystem functioning. Applied Soil Ecology. 2014 Jan;73:34-40.
5. Bottinelli N, Jouquet P, Capowiez Y, Podwojewski P, Grimaldi M, Peng X. Why is the influence of soil macrofauna on soil structure only considered by soil ecologists?. Soil and Tillage Research. 2015;146:118-24.
6. Avitabile SC, Nimmo DG, Bennett AF, Clarke MF. Termites are resistant to the effects of fire at multiple spatial scales. PLoS One, 2015, 10(11).
7. Jouquet P, Boulain N, Gignoux J, Lepage M. Association between subterranean termites and grasses in a West African savanna: spatial pattern analysis shows a significant role for Odontotermes n. pauperans. Applied Soil Ecology. 2004;27(2):99-107.
8. Ferreira DO, Martins V, Inda Jr AV, Giasson E, Nascimento PC. Termites action on the soil/Acao dos termitas no solo. Ciencia Rural. 2011;41:804-812.
9. Rückamp D, Martius C, Bornemann L, Kurzatkowski D, Naval LP, Amelung W. Soil genesis and heterogeneity of phosphorus forms and carbon below mounds inhabited by primary and secondary termites. Geoderma. 2012;170:239-50.
10. Fall S, Brauman A, Chotte JL. Comparative distribution of organic matter in particle and aggregate size fractions in the mounds of termites with different feeding habits in Senegal: Cubitermes niokoloensis and Macrotermes bellicosus. Applied Soil Ecology. 2001;17(2):131-40.
11. Constantino R. Chave ilustrada para identificação dos gêneros de cupins (Insecta: Isoptera) que ocorrem no Brasil. Papéis avulsos de Zoologia. 1999;40(25):387-448.
12. Bezerra-Gusmão MA, Barbosa JR, Barbosa MR, Bandeira AG, Sampaio EV. Are nests of Constrictotermes cyphergaster (Isoptera, Termitidae) important in the C cycle in the driest area of semiarid caatinga in northeast Brazil?. Applied Soil Ecology. 2011;47(1):1-5.
13. Holt JA, Lepage M. Termites and soil properties. Termites: evolution, sociality, symbioses, ecology, 2000, 389-407.
14. Rückamp D, Amelung W, de Simone Borma L, Naval LP, Martius C. Carbon and nutrient leaching from termite mounds inhabited by primary and secondary termites. Applied soil ecology. 2009;43(1):159-62.

15. Noirot C, Darlington JP. Termite nests: architecture, regulation and defence. In Termites: evolution, sociality, symbioses, ecology 2000, 121-139.
16. Sarcinelli TS, Schaefer CE, de Souza Lynch L, Arato HD, Viana JH, de Albuquerque Filho MR, Gonçalves TT. Chemical, physical and micro morphological properties of termite mounds and adjacent soils along a to posequence in Zona da Mata, Minas Gerais State, Brazil. Catena. 2009;76(2):107-13.
17. Walkley A, Black IA. An examination of the Degtjareff method for determining organic carbon in soils: Effect of variations in digestion conditions and of inorganic soil constituents. Soil Sci. 1934;63(2):251-63.
18. Bray RH, Kurtz LT. Determination of total, organic, and available forms of phosphorus in soils. Soil science. 1945;59(1):39-46.
19. Ross DJ, Roberts HS. Enzyme activities and oxygen uptakes of soils under pasture in temperature and rainfall sequences. Journal of soil science. 1970;21(2):368-81.
20. Speir TW, Ross DJ. Soil phosphatase and sulphatase. Soil enzymes. 1978;203:197-250.
21. Ndiaye D, Lensi R, Lepage M, Brauman A. The effect of the soil-feeding termite *Cubitermes niokoloensis* on soil microbial activity in a semi-arid savanna in West Africa. Plant and Soil. 2004;259(1):277-86.
22. Ackerman IL, Teixeira WG, Riha SJ, Lehmann J, Fernandes EC. The impact of mound-building termites on surface soil properties in a secondary forest of Central Amazonia. Applied soil ecology. 2007;37(3):267-76.
23. López-Hernández D, Brossard M, Fardeau JC, Lepage M. Effect of different termite feeding groups on P sorption and P availability in African and South American savannas. Biology and fertility of soils. 2006;42(3):207-14.
24. Wood TG, Johnson RA, Anderson JM. Modification of soils in Nigerian savanna by soil-feeding Cubitermes (Isoptera, Termitidae). Soil Biology and Biochemistry. 1983;15(5):575-9.
25. Anderson JM. Mound composition and soil modification by two soil-feeding termites (Termitinae, Termitidae) in a riparian Nigerian forest. Pedobiologia. 1984;26:77-82.
26. Menichetti L, Landi L, Nannipieri P, Katterer T, Kirchmann H, Renella G. Chemical properties and biochemical activity of colonized and abandoned litter-feeding termite (Macrotermes spp.) mounds in chromic Cambisol area on the Borana plateau, Ethiopia. Pedosphere. 2014;24(3):399-407.