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SOME CHARACTERISTICS OF TERMITARIA SOIL OF *MACROTERMES ESTHERAE* (DESNEUX) AND *TRINERVITERMES BIFORMIS* (WASMANN) IN RELATION TO THEIR SURROUNDINGS IN KERALA

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Physical characteristics such as mechanical composition, water holding capacity and chemical parameters like pH, organic matter, total nitrogen, calcium, magnesium, sodium, potassium, iron and phosphorus content of termite soil and surrounding soil was analyzed for *Macrotermes estherae* and *Trinervitermes biformis*-two widely distributed subterranean termites found in Kerala. The nest soil of both the species recorded a higher water holding capacity. Gravel was totally absent in termitaria soil. There was no significant variation in the proportion of coarse sand, fine sand and clay fractions between the nest soil and surrounding soil of *M. estherae* where as the gallery soil of *T. biformis* contained significantly higher proportions of coarse sand, fine sand, silt and clay than the adjacent soil. Most of the chemical parameters tested recorded significantly higher proportions in the termitaria soil of both species. The study indicates that temitaria soil can be used as a cheap and eco-friendly fertilizer.

INTRODUCTION

It is a known fact that termites have important effects on the soil fertility. Soil particles are selected, transported, rearranged, mixed with organic matter and cemented together. Organic debris is collected during foraging, transported to their nests and subjected to intense degradation when it is digested by termites (Lee & Wood, 1971). Drummond (1886) [*c.f. Termites and soil* by Lee & Wood, 1971) considered termites to be the tropical analogue of the earthworm. Joseph (1978) reported termites as predominant soil fauna enhancing fertility.

Considerable work has been carried out both in India and abroad regarding the physico-chemical composition of termite modified soil mainly due its economic consequences. Pomeroy (1976), Arshad (1976), Garnier *et al.* (1988) are some of the workers who have made investigations in this field. In India too, quite a lot of studies have been carried out. Banerjee & Mohan (1976) studied the physico-chemical properties of termitoria soil in Dehra Dun. Basalingappa *et al.* (1978), Rajagopal *et al.* (1982), Mohindra & Mukherjee (1984) and Veeresh *et al.* (1986) have analysed the mound soil of different *Odontotermes* species.

With regard to this important field of termite ecology absolutely no work has been done in Kerala not with standing its rich termite fauna. Moreover, most of the work done in India and abroad is confined to mound building species. Hence a study was planned to unravel the physico-chemical aspects of the nest soil of two important subterrenean termites. a comparison with the surrounding soil was also made to find out whether termite activity enhances soil fertility.

MATERIALS AND METHODS

The study was carried out at the Kerala University Campus, Trivandrum. The termites selected for the study was *M. estherae* and *T. biformis*-two widely distributed subterranean species found in Kerala. The soil samples were collected from two different regions of the nest *viz.* periphery and gallery. In the case of *M. estherae* the characteristic soil clumps over the nest entrance was taken as the peripheral soil. For *T. biformis* soil was collected only from the gallery.

For each species, soil samples were collected from five randomly selected nests. Samples from the adjacent area were collected from the top soil to a depth of 0-15 cm and the subsoil to a depth of 15-30 cm from four different directions at a distance of 100 cm, away from the nest.

All the samples were air dried and then analysed.

Physical properties

- *Mechanical composition* : This was determined by the International Pipette method [Piper, 1944] and the percentages of coarse gravel, fine gravel, coarse sand, fine sand, silt and clay were calculated.
- *Water holding capacity* : This was determined by Keen's cup method as outlined by Piper [1944].

Chemical properties

- *pH [Hydrogen ion concentration]* : The pH was determined by pH meter by preparing the soil suspension in water [1 : 2]. It was stirred intermittently for 11/2 hours and the pH of the supernatant was noted.
- *Organic carbon* : This was measured by Walkley and Black's Rapid Titration method [1934].
- *Organic matter* : This was obtained by multiplying the organic carbon by 1.724.
- *Total nitrogen* : This was determined by Kjeldahl's method as outlined by Vogel [1969]. To estimate calcium, magnesium, sodium and potassium in air dried soil samples, they were first subjected to a preliminary method as follows :

The materials were sieved through a 100 mesh sieve. 1 gm of this soil was then digested for 1 hr with 60% perchloride acid and 3 ml of sulphuric acid. 5 ml more of $HClO_4$ was added and evaporated to dryness. Now 50 ml of 1N HCl was added to the mixture and was boiled for 30 minutes. It was then cooled, and filtered through Whatman No. 40 filter paper. The residue was washed twice with 1N HCl and twice with distilled water. To the filterate two pinches of NH_4Cl and 2 drops of metyl red indicator were added and the solution was heated for 5-10 minutes. Ammonia solution was added till a straw colour developed. It was again heated for 5 min to coagulate the precipitate, which contains Iron and Aluminium. It was cooled and filtered into 250 ml standard flasks. The precipitate was washed twice with distilled water. This is the original solution for the estimation of Calcium, Magnesium, Sodium and Potassium.

- *Calcium and Magnesium* : These were estimated using complexometric titration with EDTA as primary standard [Vogel, 1969].
- *Sodium and Potassium* : These were determined by the Flame Photometer method.
- *Iron* : The residue obtained during the above preliminary procedure was dissolved in 1 N HCl and estimated using standard dichromate [Vogel, 1969].
- *Phosphorous* : This was determined by the titration method [Vogel, 1969].

For each parameter studied the mean value of periphery and gallery soil was taken as the termite modified soil value while the mean value of top soil and subsoil was taken as the surrounding soil value. The student 't' test was employed to compare the termite modified soil and surrounding soil.

RESULTS AND DISCUSSION

The physical properties of the nest soil and surrounding soil of *M. estherae* and *T. biformis* are given in Tables I and II. In *M. estherae* no significant variation in the proportion of coarse

Table I : Physical properties of the nest soil and that of the surrounding soil of the termite *Macrotermes estherae.*

Characteristics		Soil from different parts of the nest		Average of (I) & (II)	Surrounding soil		Average of (III) & (IV)
		Periphery (I)	Gallery (II)		Top soil (III)	Sub soil (IV)	
Coarse gavel	%	-	-	-	5.360 ± 1.15	3.144 ± 1.17	4.252 ± 1.150**
Fine gravel	%	10.156 ± 1.25	11.360 ± 1.73	10.758 ± 0.269*	13.700 ± 2.2	15.0 ± 0.42	14.350 ± 0.900*
Coarse sand	%	50.610 ± 2.28	49.135 ± 1.23	49.873 ± 1.75	46.350 ± 1.82	53.164 ± 0.98	49.760 ± 0.430
Fine sand	%	30.110 ± 2.09	28.350 ± 1.95	29.230 ± 0.27	22.360 ± 2.29	27.141 ± 1.21	24.75 ± 1.750
Silt	%	5.110 ± 1.04	7.155 ± 1.95	6.133 ± 0.42**	2.230 ± 0.39	1.100 ± 0.31	1.665 ± 0.345**
Clay	%	1.014 ± 0.80	4.000 ± 0.43	2.507 ± 0.61	-	0.451 ± 0.17	0.226 ± 0.084
Maximum water holding capacity	%	53.110 ± 2.19	56.320 ± 2.30	54.720 ± 0.13*	46.120 ± 2.23	48.0 ± 1.36	47.060 ± 1.790*

Table II : Physical properties of the nest soil and that of the surrounding soil of the termite *Trinervitermes biformis.*

Characteristics		Soil from the nest	Surrounding soil		Average of (I) & (II)
			Top soil (1)	Sub soil (II)	
Coarse gravel	(%)	-	9.65 ± 1.23	10.14 ± 1.86	9.895 ± 1.54**
Fine gravel	(%)	1.85 ± 0.52**	13.10 ± 2.08	10.64 ± 2.07	11.875 ± 2.05**
Coarse sand	(%)	48.00 ± 1.00*	40.20 ± 1.13	45.30 ± 0.95	42.75 ± 1.025*
Fine sand	(%)	38.10 ± 1.03*	34.40 ± 2.38	31.10 ± 1.30	32.75 ± 0.540*
Silt	(%)	6.25 ± 0.50*	2.65 ± 0.67	2.10 ± 0.46	2.375 ± 0.56*
Clay	(%)	5.80 ± 0.44*	-	0.71 ± 0.10	0.355 ± 0.05*
Maximum water holding capacity	(%)	50.82 ± 1.78*	45.261 ± 2.04	46.132 ± 1.95	45.697 ± 1.99*

* = $P < 0.05$; ** = $P < 0.01$.

Table III : Chemical characteristics of the nest soil and surrounding soil of the termite *Macrotermes estherae.*

Characteristics	Soil from different regions of the nest		Average of (I) & (II)	Surrounding soil		Average of (III) & (IV)
	Periphery (I)	Gallery (II)		Top soil (III)	Sub soil (IV)	
pH	6.5300±0.270	6.0100±0.290	6.2700±0.270*	7.0800±0.430	6.9400±0.080	7.0100±0.180*
Organic carbon (%)	0.8660±0.006	0.7100±0.030	0.7880± 0.012*	0.5720±0.010	0.4010±0.004	0.4870±0.006*
Organic matter (%)	1.4910±0.100	1.2240±0.110	1.3570±0.025*	0.9830±0.020	0.6920±0.006	0.8400±0.010*
Total Nitrogen (%)	0.0081±0.0008	0.0092±0.0006	0.0087±0.0007*	0.0051±0.0003	0.0046±0.0001	0.0049±0.0001*
C/N ratio	106.90±1.040	77.170±0.930	90.570±0.970*	112.16±1.950	87.170±0.930	99.670±1.440*
Exchangeable cations (%)						
Calcium	0.6800±0.100	0.6420±0.090	0.6610±0.07*	0.2700±0.002	0.2500±0.001	0.2600±0.001*
Magnesium	0.2430±0.003	0.2600±0.020	0.2515±0.13*	-	0.1000±0.050	0.0500±0.010*
Sodium	0.0450±0.003	0.0380±0.003	0.0415±0.0009*	0.0150±0.001	0.0120±0.002	0.0135±0.001*
Potassium	0.0210±0.0001	0.034±0.0040	0.027±0.002*	0.0100±0.010	0.0010±0.000	0.0055±0.0008*
Total inorganic elements (%)						
Iron	8.6640±0.340	8.1000±0250	8.3820±0.290*	6.780±0.360	7.2110±0.310	6.9960±0.030*
Phosphorus	0.00098 ±0.00001	0.00084 ±0.00003	0.00091 ±0.00003	0.00095 ±0.000002	0.00095 ±0.00002	0.00088 ±0.00002

* = $P < 0.05$

Table IV : Chemical characteristics of the nest soil and surrounding soil of the termite *Trinervitermes biformis*.

Characteristics	Soil from the nest	Surrounding soil		Average of (I) & (II)
		Top soil	Sub soil (II)	
pH	6.6950±0.280*	7.5800±0.120	7.800±0.360	7.690±0.230*
Organic carbon (%)	0.8540±0.020*	0.2640±0.008	0.191±0.006	0.2275±0.001*
Organic matter (%)	1.4720±0.110*	0.4550±0.110	0.3290±0.08	0.3922±0.006*
Total Nitrogen (%)	0.0970±0.01*	0.0400±0.01	0.0250±0.0005	0.0330±0.005*
C/N ratio	8.9000±0.700*	6.6000±0.20	7.6400±0.350	7.120±0.280
Exchangeable cations (%)				
Calcium	0.2485±0.030	0.2750±0.01	0.2110±0.002	0.2430±0.004
Magnesium	0.0251±0.0007*	0.0110±0.003	0.2110±0.002	0.1110±0.0005*
Sodium	0.0360±0.0030*	0.1200±0.020	0.0170±0.001	0.0680±0.010*
Potassium	0.0050±0.002*	-	0.1700±0.0015	0.008±0.0005*
Total inorganic elements (%)				
Iron	6.3610±0.100*	4.1810±0.850	5.3210±0.210	4.751±0.530*
Phosphorous	0.0042±0.0002	0.0031±0.0003	0.0029±0.0002	0.0030±0.0002

* = $P < 0.05$

sand, fine sand and clay fractions were observed between the nest soil and surrounding soil. However, more silt was recorded in the termite soil ($p<0.01$). Gallery soil of *T. biformis* contained significantly higher proportions of coarse sand, the fine sand, silt and clay than the adjacent soil ($p<0.05$). Gravel was lacking in the nest soil of both species. This is attributed to the fact that maximum size of the particles that can be transported and incorportated in limited by the ability of the workers to carry them (Lee & Wood, 1971). Banerjee & Mohan (1976) and Veeresh et al. (1986) obtained similar results in *O. obesus* and *O. wallonensis.*

The water holding capacity of the mound soil of *O. obscuriceps* was five times greater than the surrounding soils (Pathak & Lehri, 1959). However, Ghilarov (1962) reported a fall of 8% in water holding capacity of the mound soil of *Anacanthotermes* sp. in Central Asia. In the present study the water holding capacity was higher in the termite soil in both species ($p<0.05$). The water holding capacity of the mound soil is related to the content of organic matter which increases the absorption capacity of soil (Pathak & Lehri, 1959).

The chemical parameters of the nest soil and surrounding soil of *M. estherae* and *T. biformis* are given in Table III and IV. Veeresh *et al.* (1986) observed no significant difference in the pH of the mound soil and surrounding soil of *O. obsesus* and *O. wallonensis.* In the present investigation, lower pH values were obtained for nest soil. This may be associated with high organic matter (Shrikande & Pathak, 1948).

The organic matter of the nest soil was higher than the surrounding soil in both the species studied ($p<0.05$). Similar trends were reported by Agarwal (1978). The high organic content in the termite soil must be due to the fact that termites use salivary secretions and faecal matter to cement soil particles during nest construction. Most workers have registered a general increase in the nitrogen content of termite soil than surrounding soil. In the present study too similar trends were recorded.

With regard to the exchangeable cations, the nest soil of *M. estherae* registered almost three times more of calcium than adjacent soil. In many African Macrotermitinae concretions of $CaCO_3$ are occasionally found making the mound soil suitable for agriculture (Lee & Weed, 1971).

However, Shrikhande & Pathak (1948) reported a reduction in the calcium concentration of gallery soil of *Odontotermes* sp. The present investigation reveals a higher magnesium content in the nest soil of *M. estherae* than surrounding soil ($p<0.05$). But in *T. biformis* the nest soil contained less potassium. These results are in conformity with those of Rajagopal *et al.* (1982) for *O. obsesus* and *O. wallonensis.* Calcium, magnesium and potassium being constituents of plant tissue are assimilated during foraging and incorporated into the nest structure through the faecal matter (Mishra, 1976). In *M. estherae* no significant difference was found in the phosphorus content of nest soil and surrounding soil whereas in *T. biformis* similar concentration of phosphorous was recorded in the nest soil and surrounding soil. The proportion of iron in the nest soil of both species recorded significantly higher values.

Thus the study reveals that termite activity enhances water percolation and moisture content of soil helping in the better growth plants, besides increasing the organic matter and mineral content. It can be concluded that termite modify the sub soil used for construction of nests and gallery systems thereby increasing the fertility index of the soil. Hence the soil from termitaria can be used as a cheap and eco-friendly fertilizer. The study also points to the fact that subterranean species are similar to mound building species in promoting soil fertility.

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