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The Influence of Termites on Desert Soil Properties in Kuwait

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ABSTRACT. The effect of termites on the physical and chemical properties of desert soil in the Kuwait were investigated.

Soil porosity was reduced in absence of termites. More silt and sand were added to the soil in areas where termies were found. More organic carbon and organic matter were available in soils where termites had been active. There was a significant increase ($P = 0.001$) in some exchangable cations such as calcium and magnesium, and slight increases in other cations. The differences in the concentration of potassium was highly significant ($P = 0.002$) between the soils with termites and those without them.

Arthropod responses to perturbances appear to stabilize ecosystem productivity through regulating plant, soil and nutrients (Mattson and Addy 1975). Their regulation of nutrient cycling appears to be a function of the frequency and severity of habitat disturbance (Schowalter 1986).

Most desert termites are subterranean, soil dwellers that have been considered as the "keystone" of the desert system (Elkins *et al.* 1986), because the removal of substerranean termites initiates a series of changes in soil properties that no other soil organisms can compensate for (Elkins *et al.* 1986). Elkins defined the "keystone" as the individuals that maintains both the structural and the functional integrity of the system.

Abushama and Al-Houty (1988) recorded two species of subterranean termites in Kuwait, *Anacanthotermes vagans* (Hagen) and *Psammotermes hybostoma* Desneux. Abushama and Al-Houty (1988), found that *P. hybostoma* prefers soil of high sand content, where it builds deep subterranean nests, but it can survive in soils devoid of vegetation, living on wind-blown debris, animal droppings and subfossil relics. *A. vagans* builds diffuse nests, 15 cm below the surface, composed of irregular tunnels and a number of chambers filled with dry twigs and leaves. The nest may extend horizontally to cover an area of ca. 6 m^2. The latter two authers recorded that there were 2 annual peaks for foraging activity in Kuwait, one in February, following the end of the cold winter weather, the other in September, just after the lapse of hot summer conditions; they also showed that there was a positive correlation between termite activity in the Kuwait desert and soil moisture, and there was a close relationship between the chemical-physical soil properties and termite occurrence. In 1989, Abushama and Al-Houty investigated the diurnal activity rhythms of the subterranean termite, *A. vagans* in the Kuwait desert, and reported that the highest activity was at midnight and during the hours of the early morning in both summer and winter seasons. In spring, the time of highest activity occured at midday and in the afternoon and early evening.

The objective of this work was to determine the impact of subterranean desert termites on the physical and chemical properties of desert soil in Kuwait.

Materials and Methods

Study area

The influence of termites on the physical and chemical properties of Kuwait desert soil was tested in a reserved area about 30 km south west of Kuwait City (29° 10' N and 47° 44' E). The dominant vegetation in this area is the shrub *Rhanterum eppaposium.*

Two plots each of 5 x 20 m were allocated to the experiments. Around each plot, a ditch of 20-25 cm depth was dug. Each ditch before being covered was sprayed with 48.1 of one chosen insecticide. The first plot was sprayed with 0.05% of Dursban 4TC (or chlorpyrefos) which is a broad-spectrum organo-phosphate with commonly used for the control of ornamental plant and turf pests, household pests, and mosquitoes. Its oral LD_{50} for male rats is 163 mg/kg. This first plot was called "the termite free plot". The second plot was sprayed with liquid Marshal (insecticide/miticide) 25 EC, which is a suptenic broad-spectrum carbamate used to combat a wide array of soil and foliar pests. This plot was called the "termite active" plot.

After a year and the establishment of termite galleries in the termite active plot certain physical and chemical characteristics of the soil samples at 20 cm depth were analysed.

Eight replicates of mixed soil samples were used to determine the physical properties of soil from both the termite-active and the termite-free plots.

The water content was determined by the drying method using an electric oven at 105 °C.

Water-holding capacity was determined by Helgard Pan, bulk density (gm/cm^3), and particle density (gm/cm^3) methods. Space or porosity percentage were determined by calculating a measured soil sample dry weight (W), particle volume (PV) and bulk volume (BV) using the following formulae:

Bulk density (B.D.)	= W/BV
Particle density (P.D.)	= W/PV
% porosity	= P.D. - B.D./P.D. x 100

Soil particle fractionation and pH were determined by Bouyoucos soil hydrometer method (Bouyoucos 1951). Organic carbon and organic matter were determined by the Walkly and Black oxidation method (McRae 1988).

Five replicates of soil samples were used to determine the chemical properties of soil collected from the termite-active and termite-free plots.

Twenty gm of oven dried samples were ground in a blender (7012 Model 34 BL 97). The powder was then sieved by 2 mm-mesh sieve and 0.1 gm of the fine powder was taken for further chemical analysis.

Nitrogen content was determined by using Kjeldahl method, while the ultraviolet-visible spectroscopy (UV-Vis-NIR) reaction was used to determine phosphorus content. Atomic absorption spectroscopy (AAS) was used to determine sodium, potassium and magnesium contents. The data obtained were statistically analysed using t-testes.

Results and Discussion

The results shown in Table 1 and Figure 1 indicate that termite presence changes the physical and chemical conditions of the soil.

The physical properties were influenced by the decrease of water content, silt and clay, while sand particles increased in the presence of termites ($P = 0.01$), Archad (1982) found that fine particles are always available in the vicinity of a termite mound; this is due to the demand; by foraging workers establishing the underground galleries that are usually built up by mixing sand particles with saliva.

In the absence of termites, soil porosity is reduced, thus reducing water infiltration (Elkins *et al.* 1986).

The chemical properties of soil were altered in the presence of termites; their activities increased the amount of calcium and magnesium ($P = 0.001$), while potassium was slightly reduced in their absence ($P = 0.002$). A slight increase in nitrogen, sodium and phosphorus (Wood and Sands 1978, Lee and Wood 1971). Higher exchange status contributes to increased nutrient absorption, thus resulting in better plant growth in soil around the termite mound (Archad 1982).

Termites increase the amount of organic carbon ($P = 0.001$) and organic matter ($P = 0.001$) in desert soil of Kuwait. Badawi *et al.* (1983) found the same effect in termites of Saudi Arabia. They found that these organic components increased in termite runways rather than in the surrounding soil. This increase is mainly due to the role of termites in breaking down the cellulosic parts of the plants they collected from the surroundings to stuff their underground chamber and from their excretion of the soil they are living in. These activities increase the fertility of the soil (Lee and Wood 1971 and Elkins *et al.* 1986).

Many authors (Shrikhande and Pathak 1948, Lee and Wood 1971, Lovegrove 1991, Eldridge 1994, Nash and Whitford 1995 and Park *et al.* 1996) have recorded that termite activities change the physical and chemical conditions of the soil in arid and semi-arid ecosystems.

Table 1. Mean percentage ± standard error of soil conditions in the presence and absence of termites, (values in parenthesis are standard deviations of the mean).

Soil condition	Termite-active plot	Termite free plot
Physical		
% Water content	1.05 ± 0.03 (0.08)	1.18 ± 0.18 (0.50)
% Silt	4.13 ± 0.31 (0.89)	3.17 ± 0.37 (1.06)
% Clay	4.59 ± 0.26 (0.72)	9.86 ± 1.19 (3.36)
% Sand	91.28 ± 0.31 (0.87)	86.97 ± 1.23 (3.48)
pH	8.25 ± 0.05 (0.14)	1.45 ± 0.01 (0.02)
Bulk density (gm/cm^3)	1.55 ± 0.01 (0.02)	1.45 ± 0.01 (0.04)
Partial density (gm/cm^3)	2.23 ± 0.05 (0.13)	2.13 ± 0.02 (0.04)
Water holding capacity	22.69 ± 0.05 (4.55)	22.90 ± 1.13 (1.12)
% porosity	29.69 ± 1.61 (3.38)	31.83 ± 0.4 (3.21)
Chemical		
% Nitrogen	0.01 ± 0.002 (0.004)	0.01 ± 0.001 (0.002)
% Phosphorus	0.07 ± 0.002 (0.004)	0.07 ± 0.001 (0.003)
% Sodium	0.08 ± 0.02 (0.03)	0.07 ± 0.002 (0.04)
% Potassium	0.07 ± 0.01 (0.02)	0.14 ± 0.01 (0.03)
% Calcium	2.12 ± 0.12 (0.28)	1.61 ± 0.23 (0.55)
% Magnesium	0.79 ± 0.03 (0.08)	0.52 ± 0.03 (0.07)
% Organic carbon	0.69 ± 0.002 (0.004)	0.29 ± 0.05 (0.10)
% Organic matter	1.19 ± 0.003 (0.01)	0.50 ± 0.08 (0.18)

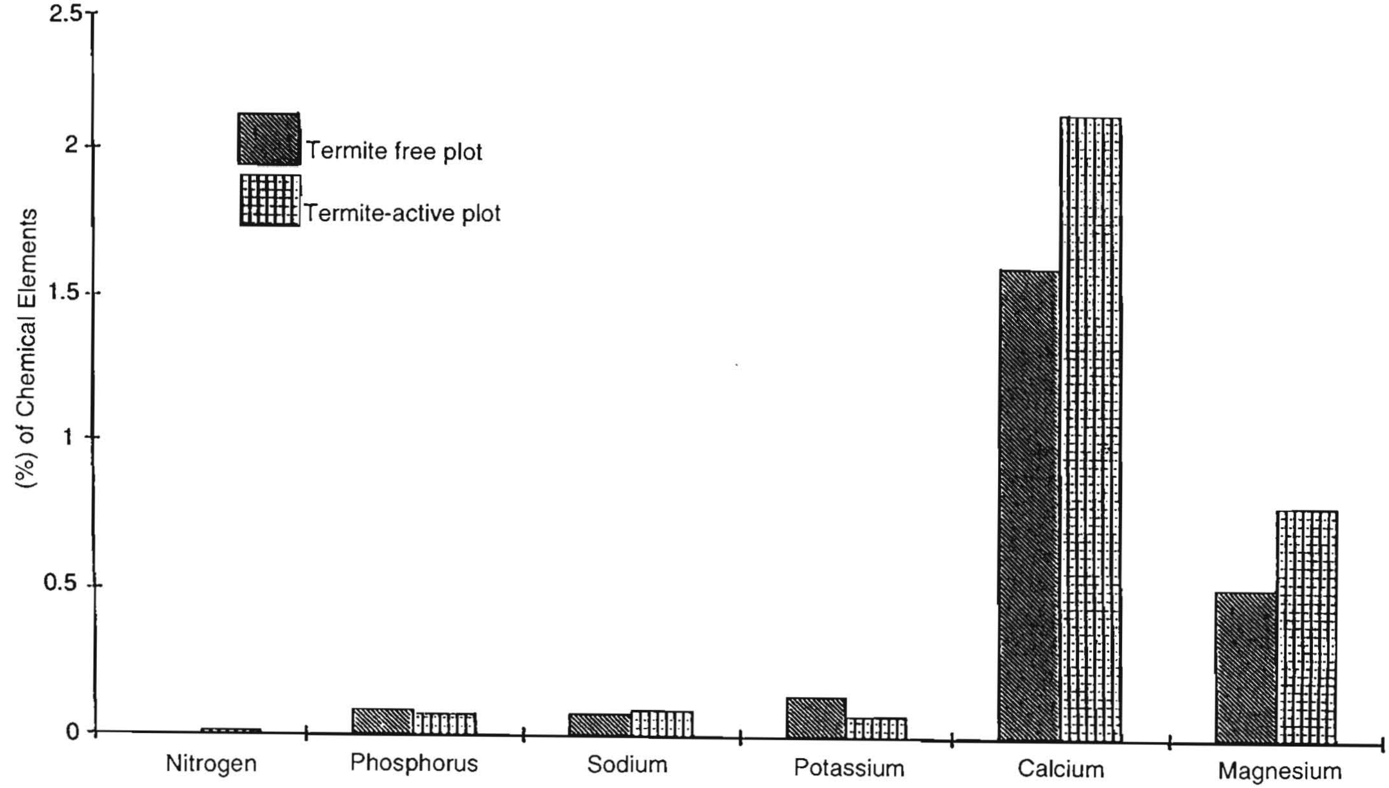

Fig. 1. Percentage of chemical elements in termite-active and termite free plots.

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تأثير حشرة الأرضة على صفات التربة في صحراء الكويت

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تتأثر الصفات الفيزيائية والكيميائية للتربة الصحراوية بنشاط حشرة الأرضة في دولة الكويت .

فالصفات الفيزيائية مثل مسامية التربة ، تقل بعدم تواجد حشرة الأرضة ، مسببة بذلك قلة تسرب المياه السطحية الى طبقات التربة السفلية كما تقل كميات الماء المحمولة بالتربة بوجود حشرة الأرضة مما يعرض تلك التربة للجفاف وذلك إما لاستهلاك الحشرة للمياه أو لتعرضها للعوامل الجوية .

أما الصفات الكيميائية ، فتتضح زيادة معدلات عناصر النيتروجين والكالسيوم والفوسفور والماغنيسيوم ونقصان معدلات عنصر البوتاسيوم ، مما يساعد على خصوبة التربة وتهيئتها لنمو النباتات .

كما أن نشاطات حشرة الأرضة تزيد من معدلات وجود المواد العضوية مثل الكربون ، وذلك نظراً لقيام الحشرة بجمع وتكسير المواد النباتية السيليوزية المحتوية على عنصر الكربون من المنطقة المحيطة بها ، وحشو الأنفاق الأرضية الخاصة بها بتلك المواد التي تستغلها الحشرة كمواد أولية للغذاء . وبذلك تعمل حشرة الأرضة على زيادة تسميد التربة التي عادة ما تتواجد بها مما يجعل تلك التربة صالحة للزراعة .