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Distribution of Sub-Slab Injected Dursban® TC (Chlorpyrifos) in a Loamy Sand Soil When Used for Subterranean Termite Control

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Creation of continuous soil insecticide barriers is a common method of protecting existing structure from subterranean termite infestations. Previously registered termiticides (aldrin, benzene hexachloride, chlordane, dieldrin and heptachlor) have provided insecticidal activity in the soil for more than 20 years (Johnston et al. 1971; Mauldin et al. 1987). Due to human health and environmental concerns, the U.S. Environmental Protection Agency has canceled these termiticides. Of the currently registered active ingredients (AI) labeled for controlling subterranean termites, chlorpyrifos (Dursban® TC) has been the most widely used by commercial pest control operators (PCO's) (Mix 1988).

The chlorinated hydrocarbon termiticides exhibit minimal soil penetration (O'Brien et al. 1965; Beal and Carter 1968). Bennett et al. (1974) reported that chlordane and dieldrin applied under and around structures displayed negligible movement over time and posed a minimal environmental risk. Published data on the behavior of Dursban TC in soils is lacking. This research was undertaken to test the hypothesis that: a) Dursban TC will provide distribution and penetration patterns adequate to form a continuous barrier when injected beneath a concrete slab, and b) varying insecticide quantities and application pressures will significantly affect termiticide distribution and penetration.

MATERIALS AND METHODS

All treatments included Dursban TC (1% AI chlorpyrifos) and a loamy sand soil. This soil consisted of 80.13% sand, 13.44% silt, 6.43% clay and 0.065% organic matter. The soil pH was 8.25. Treatment variables included, application pressure (0.0, 69.0, 137.9, and 275.8 KPa) and application quantity (0.95, 1.89, and 2.84 L). There were twelve treatments and one untreated control. Each treatment was replicated three times and randomly assigned to the experimental units. Each experimental unit consisted of a plywood box (1.22 X 1.22 X 0.61 m) (Fig. 1). The soil was added to each box in increments of 18 cm. Each layer was hand tamped and lysed before succeeding increments were added. The process was continued until each box was filled to a soil depth of 53 cm. The soil was compacted to ca. 1.4 g/cm^3. After filling, each box was capped with a 7.6 cm #1 grade concrete slab. These conditions were selected to simulate conditions under a basement slab.

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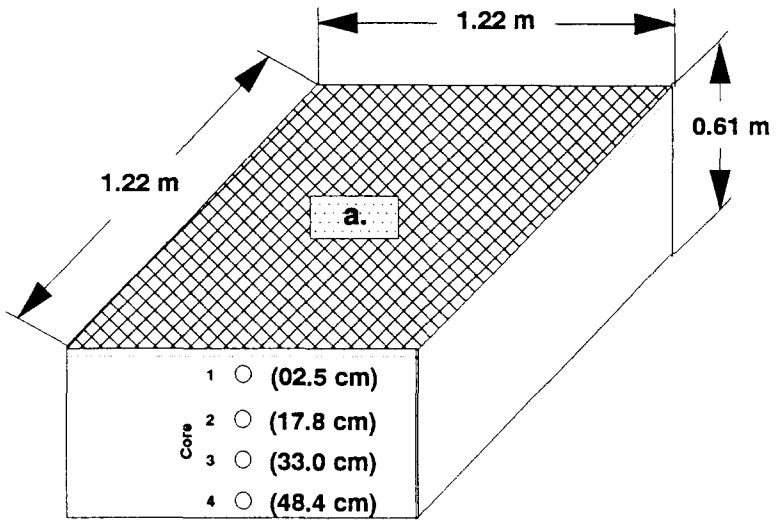

Figure 1. Experimental unit (plywood box) filled with soil, capped with concrete and with core locations specified (a. = injection point).

The soil was treated on 8/4/88. A 1.27 cm entry hole was drilled through the center of the concrete slab of each box. The termiticide was applied to the soil in each box via a B&G® sub-slab injector unit. The application pressure was monitored with a gauge mounted on the injector unit. A B&G®, 11.4 L, stainless steel spray tank was used as the termiticide reservoir. Termiticide quantity was measured with a tank-mounted sight gauge consisting of clear polyvinyl hose. After treatment, the entry holes were sealed with concrete.

Soil samples were collected on 8/8/88-8/11/88. Four, 3.3 cm dia. sampling holes were drilled along a vertical line bisecting one of the plywood side panels of each box. The top hole was positioned 2.5 cm beneath the bottom of the concrete slab. The remaining three holes were located 17.8, 33.0, and 48.4 cm beneath the bottom of the slab. Four soil cores, 60.8 cm long and 2.5 cm in diameter were removed from each box via the sampling holes. The soil cores were removed using stainless steel probes 2.5 cm in diameter. Each soil core was divided into 8 samples, at 7.6 cm intervals with sample 1 located under the injection point and sample 8 proximal to the plywood sideboard. Each sample was placed in a separate, pre-labeled Ziploc® plastic bag and stored in the freezer at -20°C. The probes were triple rinsed with acetone prior to reuse.

Ten grams of soil were removed from each sample and placed in a 250 ml erlenmeyer flask with 50 ml of acetone. The flasks were stoppered, mounted on a wrist action shaker (Burrell® Model 75) and agitated for 45 min. After agitation, the acetone/soil slurry was filtered through #1 Whatman® filter paper into 250 ml boiling flasks. The flasks were mounted on a rotovapor (Buchi® RE110) and the filtrate was evaporated to near dryness. The concentrated residue was redissolved in 10 ml of hexane, decanted into 14 ml glass vials and stored in the freezer at -20°C until analysis. The residues were analyzed with a Varian® 6000 gas chromatograph equipped with a Varian® 4270 integrator, a Varian® 8000 autosampler and a Thermionic Specific Detector (TSD), adjusted for phosphorous

selectivity. A 2 meter, 4% OV 101-6% OV 210 (Chromosorb® W-HP, 80/100 mesh) glass column was used. The oven temperature was stabilized at 210°C for 8 minutes and then increased to 250°C for a total run time of 12 min/sample. The injector and detector temperatures were 200°C and 300°C, respectively. Nitrogen, Hydrogen and air flow rates were set at 30.0, 3.4 and 175.0 ml/min, respectively. The minimum detection limit was 0.05 μg(chlorpyrifos)/g(soil). The residues were analyzed using an external standard method. Analytical standards were provided by the EPA (Research Triangle Park, North Carolina). The insecticide recovery efficiency of this process was 90.9%. Data were analyzed with General Linear Models, Repeated Measures Analysis, SAS Institute 1982.

RESULTS AND DISCUSSION

The chlorpyrifos residues were significantly affected by the interaction of soil sample location, soil core depth, application pressure and quantity ($Pr > F = 0.0437$). The average R^2 for the repeated values was 0.668. Soil samples directly below, (2.5 cm), the injection points in core 1 of all treatments continually exhibited the largest concentrations (Fig. 2). Concentrations adequate for termite control (>5.0 μg/g: *M.P. Tolley, DowElanco Co., St. Louis, MO, personal communication*) were detected horizontally 30.5 cm in core 1 (Fig. 5), and vertically 33.0 cm in core 3 (Fig. 7). Decreasing residues were generally found with increasing depth and horizontal distance (Figs. 2, 3, 4, 5, 6 & 7).

No residues larger than 5.0 μg/g were detected in core 4 (depth = 48.3 cm). The largest horizontal penetration of chlorpyrifos (22.8-30.4 cm) was detected directly

Table 1. Penetration of chlorpyrifos (>5.0 μg/g) in the soil from the injection point.

	Treatment[1]		Distance	
No.	Pressure (KPa)	Quantity (L)	Horizontal[2] (cm)	Vertical[3] (cm)
1	0.0	0.95	7.6-15.2	17.8
2	69.0	0.95	15.2-22.8	2.5
3	137.9	0.95	15.2-22.8	17.8
4	275.8	0.95	0.0-07.6	17.8
5	0.0	1.89	7.6-15.2	17.8
6	69.0	1.89	22.8-30.4	17.8
7	137.9	1.89	7.6-15.2	17.8
8	275.8	1.89	7.6-15.2	17.8
9	0.0	2.84	22.8-30.4	17.8
10	69.0	2.84	15.2-22.8	17.8
11	137.9	2.84	15.2-22.8	17.8
12	275.8	2.84	15.2-22.8	33.0

[1]1% AI chlorpyrifos was used in all treatments.
[2]In core 1 located 2.5 cm below the slab, distances from injection point.
[3]In a vertical line directly below the injection point.

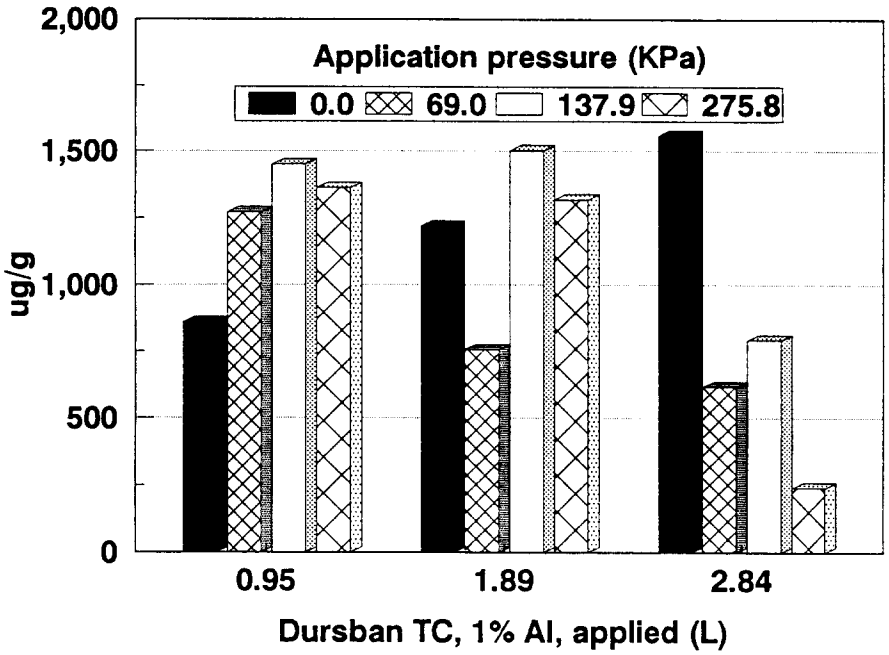

Figure 2. Mean chlorpyrifos residues in soil, 0-7.6 cm from the injection point in core 1 (2.5 cm below the slab) with all treatments.

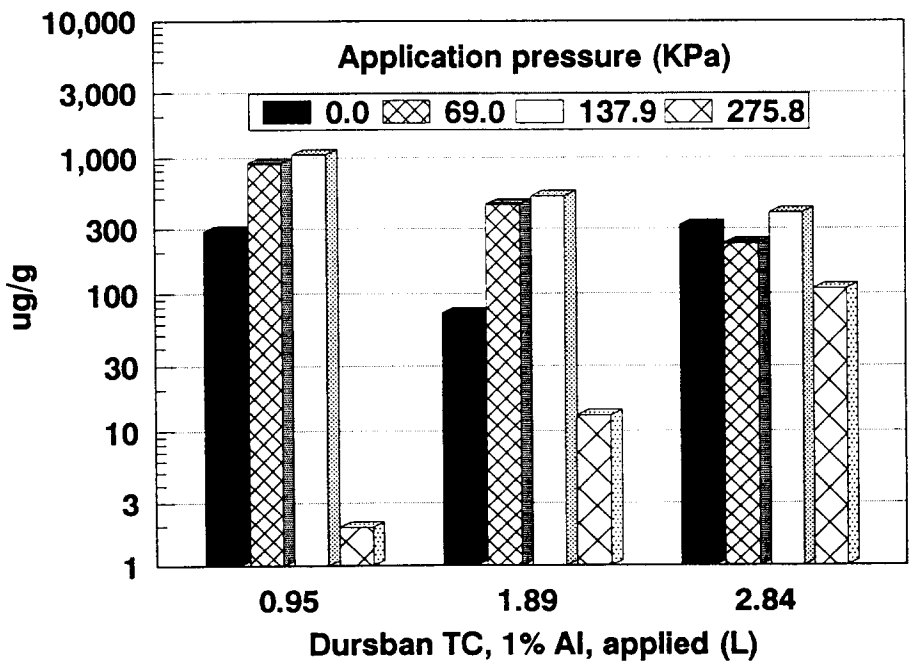

Figure 3. Mean chlorpyrifos residues in soil, 7.6-15.2 cm from the injection point in core 1 (2.5 cm below the slab) with all treatments.

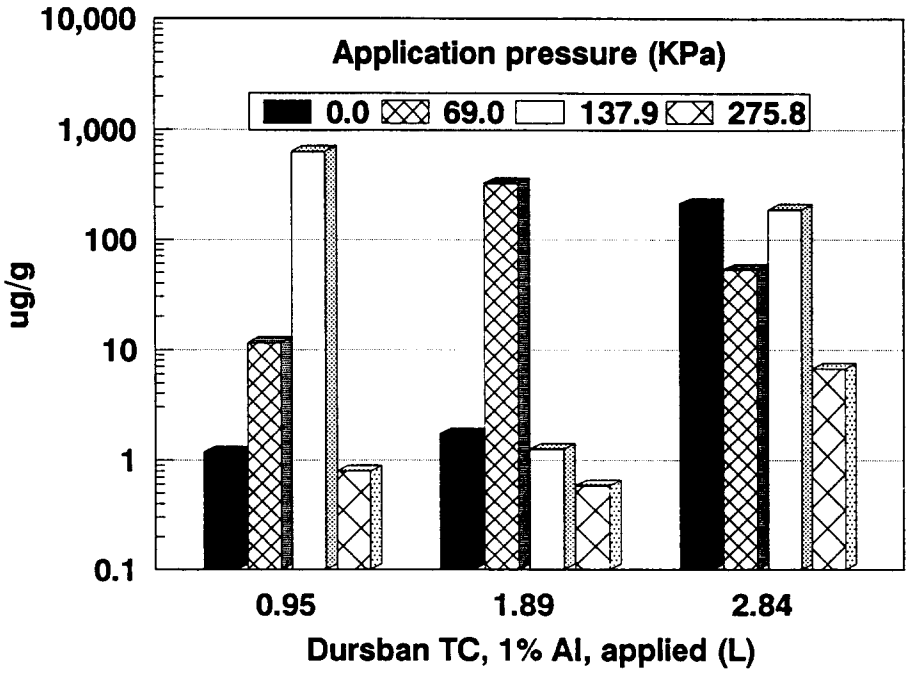

Figure 4. Mean chlorpyrifos residues in soil, 15.2- 22.8 cm from the injection point in core 1 (2.5 cm below the slab) with all treatments.

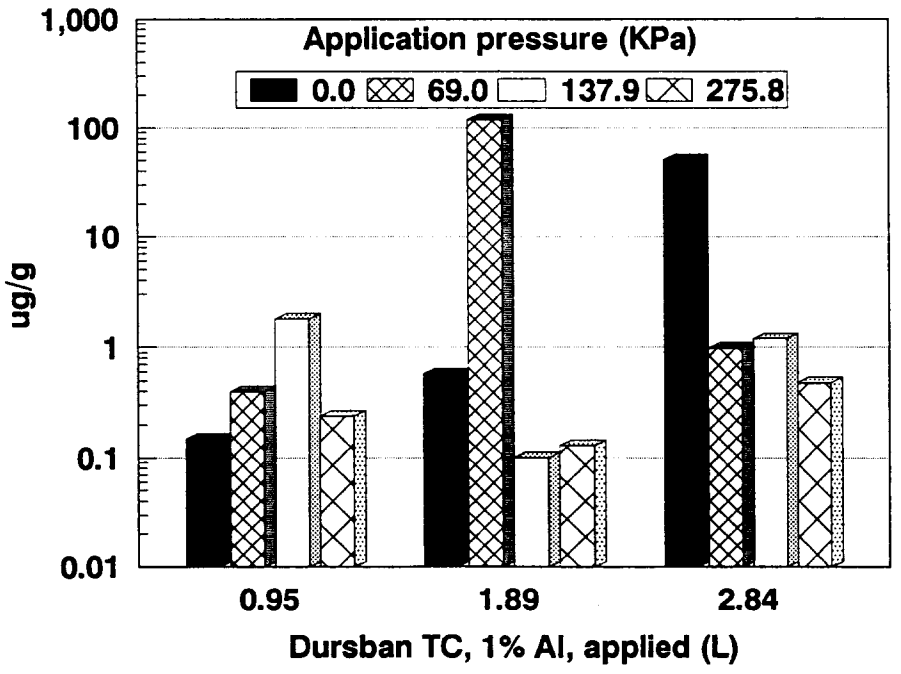

Figure 5. Mean chlorpyrifos residues in soil, 22.8- 30.4 cm from the injection point in core 1 (2.5 cm below the slab) with all treatments.

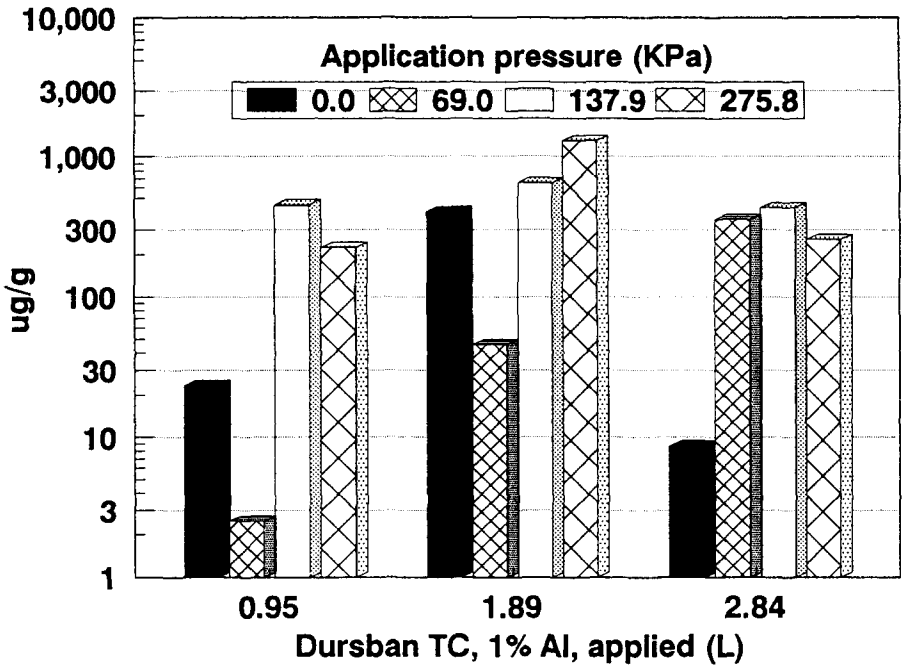

Figure 6. Mean chlorpyrifos residues in soil, 0-7.6 cm from a vertical line beneath the injection point in core 2 (17.8 cm below the slab) with all treatments.

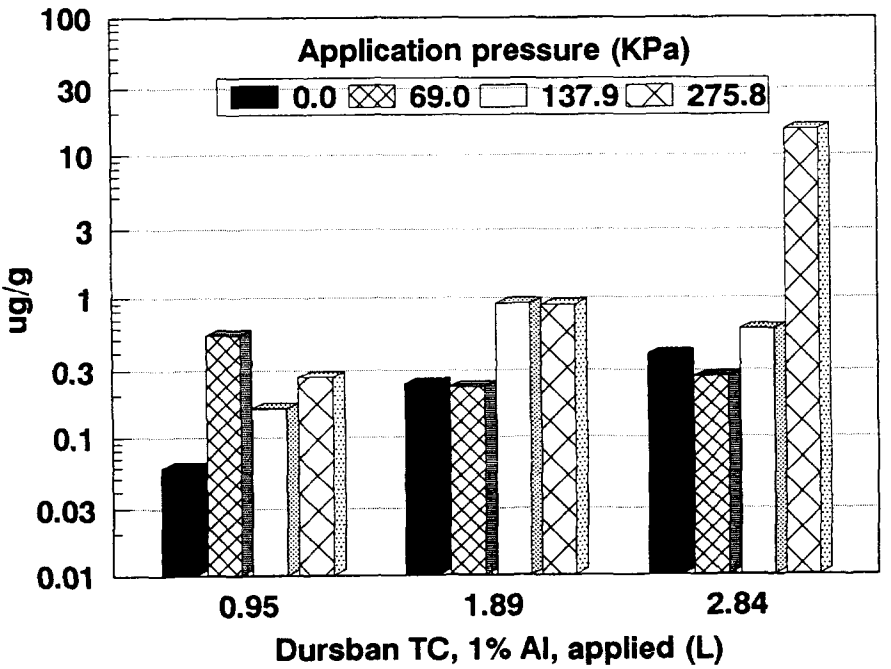

Figure 7. Mean chlorpyrifos residues in soil, 0-7.6 cm from a vertical line beneath the injection point in core 3 (33.0 cm below the slab) with all treatments.

beneath the slab along core 1 in treatments 6 and 9. The largest vertical penetration (33.0 cm) was detected with treatment 12 (Table 1).

Further GLM analysis indicated that insecticide quantity and application pressure were not significant individual factors ($Pr>F = 0.1286$, and $Pr>F = 0.0934$, respectively). However, the interaction of quantity and pressure was significant ($Pr>F = 0.0010$). The largest vertical insecticide penetration was evident with the highest pressure and quantity. The most horizontal penetration was observed with treatments having either 0.0 or 69.0 KPa application pressure and either 1.89 or 2.84 L insecticide quantity (Table 1).

Based on these data, termiticide applicators can be reasonably assured that sub-slab injected Dursban TC will be initially placed 0-18 cm below the concrete slab and that decreasing concentrations will be present vertically and horizontally from the point of injection. This is consistent with reported chlordane and dieldrin distribution patterns (Bennett et al. 1974). The possibility of initial contamination of non-target soil areas is therefore remote. Termiticide applicators can control insecticide placement by varying application pressure and insecticide quantity. Therefore, they can adjust the treatment variables to the requirements of the structure to be protected from subterranean termite infestation.

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