Report No. 03

FIELD EVALUATION OF TERMITICIDE MOVEMENT

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Grant Number: 14-08-0001-G-1572
U.S. Geological Survey
U.S. Department of the Interior

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The research on which this report is based was financed in part by the Department of the Interior, U.S. Geological Survey, through the Missouri Water Resources Research Center.

Introduction

In recent years, chlordane has been found in fish in Missouri at high levels. The Missouri Department of Health has issued advisories against fish consumption in a number of lakes and rivers because of chlordane contamination, and the commercial sale of fish from the Missouri and Mississippi Rivers within the State of Missouri has recently been banned. These events cause concern about the impacts of chlordane and speculation as to the source of the chlordane in water. One possible route of chlordane movement is by subsurface leaching from soil around building foundations treated for termite control and subsequent discharge from foundation drain pipes into sewers or streams. This study evaluated the fate of two termiticides applied along the outside of foundation walls constructed with drain pipes resting on foundation footings. The termiticides were chlordane and chlorpyrifos. The objective was to quantify the mass of termiticide leaching from treated soil through the foundation drain. Although chlordane is now banned, it might still be leaching. Therefore, the results of this study provide a basis for evaluating the importance of this source of chlordane contamination of urban lakes and streams and for evaluating the leaching potential of chlorpyrifos, a termiticide currently used for termite control.

Review of Literature

There is no evidence in the literature of field monitoring of termiticide concentrations from foundation drains subsequent to termiticide application. However, several reports describe termiticide residues in surface soils following treatment. Beal and Carter (1968) measured the depth of initial penetration of chlordane poured on the soil surface as a termiticide to be 2 inches. Bess and Hylin (1970) reported that after 7 years of exposure in Hawaii, 2 to 3% of the original chlordane applied as a termiticide remained in sandy loam and clay soils. Bennett, et al. (1974) found that 21% of gamma chlordane remained in treated soil around building foundations 21 years after application. Leidy, et al. (1985) reported average chlordane residues of 1052 and 1475 ppm in sandy and clay soils, respectively, around North Carolina homes. Numerous reports describe chlordane and chlorpyrifos residues in field soils from applications not necessarily related to termite control (Carey, et al., 1979; Crockett, et al., 1974; Fleming and Maines, 1954; Pike and Getzin, 1981; Sears and Chapman, 1979; Werner, et al., 1984).

Materials and Methods

Two full-scale model wall structures were constructed. Each structure consisted of four walls. The walls were 8-ft long and intersected at right angles forming an 8-ft square in plan view. The two structures were located approximately 25 ft apart. The walls were constructed on concrete footings to simulate basement construction. The walls were 8 ft high and consisted of 4 ft by 8 ft by 3/4 in. plywood connected to 2 in. by 6 in. by 8 ft vertical studs. All wood had been commercially pressure treated with wood preservative. The concrete footings were 18 in. wide and 6 in. deep and were centered directly underneath the walls. Soil was backfilled on the outside of each wall up to a line 2 ft. below the top of the wall. Thus, the top of the foundation footing was 6 ft. below the final ground surface.

A PVC drain pipe was placed on top of the concrete footing flush with the exterior wall. A separate pipe was used to drain each wall. The pipe was perforated, and the pipe diameter was 4 in. The pipe extended along the entire length of the 8-ft-long wall and was sealed on both ends. A tee connection installed at the midpoint of the pipe directed drainage through the wall to the inside of the structure where drainage samples were collected.

A 1-ft thick layer of 1/2-in. diameter crushed limestone rock was placed on top of the drain pipe. Soil was backfilled on top of the rock. Soil backfilling occurred in 3-in. thick lifts. Each lift was compacted with a compaction roller. Both structures were backfilled to within 1 ft of the wall with the on-site native soil which was Weller silt loam (fine, mesic, Aquic Hapludalf). The soil that was located adjacent to the wall and that extended outward from the wall for 1 ft was Sarpy loamy sand (mixed, mesic, Typic Udipsamment) for one structure and Menfro silt loam (fine silty, mixed, mesic, Typic Hapludalf) for the other structure. The backfilling procedure resulted in a bulk density of sample cores of approximately 1.5 g/cm^3 for the loamy sand and 1.3 g/cm^3 for the silt loam.

At each structure, a licensed applicator injected the east and west walls with chlordane (Goldcrest C-100) and the north and south walls with chlorpyrifos (Dursban TC) according to label directions using a 1% termiticide solution. Injection holes were spaced at 1-ft intervals along the length of each wall. Therefore, 8 injections were made along each 8-ft length of wall. Each injection hole was located approximately 3 in. away from the wall. Termiticide injection was accomplished using a 3/4" B&G Versatool subsoil injection rod with void tip. The rod was 6-ft long. One end of the rod was attached to a pressure hose through which the termiticide solution entered the rod under pressure. The pressure at the rod inlet was approximately 20 psi. The discharge end of the rod was slowly pressed into the ground with the rod aligned vertically. As termiticide solution discharged from the rod, the force of the discharging solution eroded away the soil directly underneath the rod and allowed the rod to move downward. During many injections, a small amount of solution moved up through the injection hole along the outside of the rod and discharged at the ground surface.

Drainage from each pipe was collected in a 5-gallon bucket placed beneath the pipe outlet. Intermittently during the study period, samples were collected from the buckets, and the buckets were then emptied and returned to their original position beneath the pipe outlet.

The extraction of chlordane and chlorpyrifos from leachate samples was accomplished as follows. The samples were transferred to a flask along with dichloromethane sample jar rinse and were shaken. The dichloromethane fraction in a separatory funnel was passed through anhydrous sodium sulfate and concentrated along with dichloromethane funnel rinse in a rotary evaporator. The concentrated extract was passed through Florisil in a chromatographic column, was eluted with hexane/ethyl ether solution and was concentrated in a rotary evaporator. The sample was injected into a Perkins Elmer Sigma 3B gas chromatograph equipped with a 30-m-long capillary column and ^{63}Ni electron capture detector and coupled to a Finnigan mass spectrometer. Total technical chlordane concentration was assumed to be the sum of the concentrations of trans-chlordane, cis-chlordane and trans-nonachlor.

Results

Prior to the termiticide injections along the walls, the applicator was informed of the depth to the layer of crushed rock surrounding the drain pipe and was cautioned to avoid injecting termiticide solution directly into this crushed rock layer. However, the first injection resulted in a discharge of termiticide into the rock in quantities large enough to flow through the drain pipe holes (located approximately 1/2 in. above the bottom of the pipe), through the drain pipe and into the drainage collection bucket. Approximately two liters of termiticide solution was collected in the bucket from the first injection hole. The applicator reduced the depth of rod penetration in subsequent injection holes to further avoid injecting into the crushed rock. Subsequently, approximately 10 percent of the rod injections resulted in termiticide discharge through the drain pipes. These subsequent injections averaged approximately 100 ml of termiticide discharge per 8-ft length of wall. Assuming the concentration of this discharge was equal to the concentration of the injected solution (1% solution), the mass of termiticide discharged during injections per 8-ft length of wall was approximately 1g.

Two pressure transducers were installed along the pressure hose between the pump and the injection rod to measure pressure loss due to friction through a 30-ft length of hose. The pressure loss versus time was recorded on a strip chart recorder during each injection. The flow rates had been previously calibrated to pressure loss. The flow rates were then computed as a function of time for each injection. For the chlordane injections, the depth of the rod was also recorded versus time during each injection. The mass of chlordane injected at each 1-ft-depth interval was then computed. Figures 1 and 2 show the resulting computed distribution of chlordane mass with depth. The length of each bar (solid line) represents the mean injected mass within that depth interval. The ends of the small cross-hatched bars represent one standard deviation above and below the mean. These measurements were not made for chlorpyrifos; however, the results for the chlordane solution should be typical of the chlorpyrifos solution since the same concentrations and same injection equipment, personnel and techniques were used. For both termiticides in both soils, it was found that the total volume of termiticide solution injected was less than 50 percent of the volume specified on the termiticide label.

Termiticide injection occurred in October 1988. Drainage was first detected approximately two months after injection. Drainage samples were collected through June 1989. The leachate concentration, leachate volume and mass of termiticide measured from each wall during the study period is presented in Tables 1 and 2. Figures 3 through 6 plot daily rainfall, termiticide concentration and total termiticide mass as a function of time. Daily rainfall was taken from a National Oceanic and Atmospheric Administration rain gage located approximately 10 miles from the experimental site.

The volume of drainage was highly variable. More drainage occurred from the walls backfilled with the silt loam than the walls backfilled with the loamy sand. For this reason, more termiticide mass was lost from the Menfro silt loam than the Sarpy loamy sand. Three factors contributed to the larger drainage from the silt loam. First, settling occurred to a much larger extent surrounding the silt loam structure than the loamy sand structure. This settling redirected surface runoff toward the walls, thus increasing infiltration. Second, shrinkage cracks formed between the wall and the silt loam backfill. By the end of the study period, these surface cracks had enlarged in local areas from erosion by the downward movement of water. Third, the silt loam structure was located slightly downhill from the other structure so that following heavy rainfalls, any temporarily perched water table intersected the drain pipes from the silt loam prior to intersecting the drain pipes from the loamy sand.

The drainage concentrations were also highly variable. Technical chlordane concentrations ranged between <5 and 660 µg/L from the silt loam and between <5 and 170 µg/L from the loamy sand, while chlorpyrifos concentrations ranged between 90 and 3300 µg/L from the silt loam and between 43 and 230 µg/L from the loamy sand. Although wing walls were constructed along the outside corners of each structure to block termiticide migration to adjacent walls, significant migration was detected. Concentrations of technical chlordane up to 130 µg/L were measured in the drainage of walls treated only with chlorpyrifos, while concentrations of chlorpyrifos of up to 1100 µg/L were measured in the drainage of walls treated only with chlordane.

The mass of technical chlordane lost in the drainage from a single drainage event ranged between 2.9 and 11,000 µg from the silt loam and between 2.4 and 650 µg from the loamy sand, while mass of chlorpyrifos lost in the drainage from a single drainage event ranged between 8.1 and 54,000 µg from the silt loam and between 18 and 800 µg from the loamy sand. Total mass lost from all measured drainage events during the 8-month study period (excluding mass that drained during injection) was 15 mg technical chlordane and 150 mg chlorpyrifos from the silt loam and 2.0 mg technical chlordane and 1.9 mg chlorpyrifos from the loamy sand. It should be noted that not all drainage events during the study period were measured.

Conclusions

Termiticide can discharge into foundation drain pipes during rod injection. In this study, approximately 1g of termiticide was discharged per 8-ft length of wall. Also, termiticide can be leached from soil surrounding a foundation wall and discharged through foundation drain pipes. In this study, a total of 1 to 7.5 mg of technical chlordane was discharged per 8-ft length of wall during measured drainage events over an 8-month period of time compared to a total of 1 to 75 mg of chlorpyrifos. The mass of termiticide lost during injection was a large amount compared to that lost by leaching. The mass of termiticide injected per foot depth of soil was relatively uniform with a mean rate of approximately 4.7 g per foot depth per injection hole. The largest amount injected was in the one-foot depth increment directly above the layer of crushed rock surrounding the drain pipe where the rate averaged 5.9 g per foot depth per injection hole. The drainage volume and termiticide mass that discharged from the drain pipes in this study were highly variable from wall to wall. The variability in drainage volume and termiticide mass lost due to soil type was confounded by several factors which could not be controlled in the field.

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TABLE 1
Termiticide Measurements from Menfro Silt Loam[1]

	Wall M1 (Chlorpyrifos Applied)					Wall M2 (Chlordane Applied)					Wall M3 (Chlorpyrifos Applied)					Wall M4 (Chlordane Applied)				
		Chlordane		Chlorpyr			Chlordane		Chlorpyr			Chlordane		Chlorpyr			Chlordane		Chlorpyr.	
Date	V	C	M	C	M	V	C	M	C	M	V	C	M	C	M	V	C	M	C	M.
12/22	15.	11.	170.	730	11000	5.7*	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
12/31	>18.	<5	-	190	3600	>18.	140	>2500	72	>1300	11.*	-	-	-	-	0.00	-	-	-	-
2/15	17	8	140.	2900	49000	1.9	12	23.0	160	300	0.00	-	-	-	-	0.00	-	-	-	-
2/21	>18.	10	180.	3000	54000	0.14	660	92.0	460	64.	*	-	-	-	-	*	-	-	-	-
3/15	*	-	-	-	-	*	-	-	-	-	0.10	<5	-	*	-	0.10	22	2.2	*	-
4/22	7.6	<5	-	750	5700	0.12	31	3.6	61	7.3	0.12	11	1.3	160	19.	0.13	22	2.9	150	19.
4/24	7.6	<5	-	980	7400	*	-	-	-	-	0.11	15	1.7	280	31.	*	-	-	-	-
5/4	0.20	<5	-	1500	300	1.9	300	560	580	1100	1.9	13	25.	240	460.	1.9	*	-	*	-
5/9	0.06	<5	-	3300	200	0.08	190	15	1100	85	0.08	<5	-	280	22.	0.08	17	1.4	420	33.
5/19	0.12	<5	-	170	20	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
5/26	0.09	<5	-	2700	240	16.	660	11000	180	2900	0.09	<5	-	90	8.1	0.10	<5	-	57	5.7
5/27	0.14	<5	-	800	110	*	-	-	-	-	0.09	<5	-	130	12.	*	-	-	-	-
5/30	0.10	16	1.6	180	18	0.00	-	-	-	-	0.04	<5	-	320	13.	0.00	-	-	-	-
6/1	15.	<5	-	330	5000	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
6/15	0.10	<5	-	120	12	0.00	-	-	-	-	*	-	-	-	-	0.00	-	-	-	-
6/19	>18.*	-	-	-	-	0.00	-	-	-	-	4.7	<5	-	200	940.	0.00	-	-	-	-
6/27	1.9	<5	-	3300	6300	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-

[1] All values are rounded to two significant figures. The following abbreviations are used:

S = Sarpy loamy sand
1 = North wall
2 = West wall
3 = South wall
4 = East wall
V = Leachate volume (L)
C = Concentration of technical chlordane or chlorpyrifos (µg/L)
M = Mass of technical chlordane or chlorpyrifos (µg)
* = Sample was not collected or was not analyzed.

TABLE 2
Termiticide Measurements from Sarpy Loamy Sand[1]

	Wall S1 (Chlorpyrifos Applied)					Wall S2 (Chlordane Applied)					Wall S3 (Chlorpyrifos Applied)					Wall S4 (Chlordane Applied)				
		Chlordane		Chlorpyr			Chlordane		Chlorpyr			Chlordane		Chlorpyr			Chlordane		Chlorpyr	
Date	V	C	M	C	M	V	C	M	C	M	V	C	M	C	M	V	C	M	C	M
12/22	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
12/31	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
2/15	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
2/21	0.00	-	-	-	-	0.14	17	2.4	<5	-	0.00	-	-	-	-	0.14	17	2.4	<5	-
3/15	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
4/23	9.5	13	120	84	800	15.	12	180.	14	210.	*	-	-	-	-	15.	17	260.	<5	-
4/27	1.9	<5	-	130	240	9.5	5	48.	11	110.	*	-	-	-	-	3.8	170	650.	16	61.
5/4	1.4	120	170	150	210	5.3	35	190.	8	42.	2.7	18	49	43	120	2.6	150	390.	18	47.
5/9	0.08	<5	-	230	18	0.13	<5	-	13	1.7	0.00	-	-	-	-	0.11	77	8.5	11	1.2
5/19	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
5/26	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
5/27	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
5/30	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
6/1	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
6/15	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
6/19	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
6/27	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-

[1] All values are rounded to two significant figures. The following abbreviations are used:

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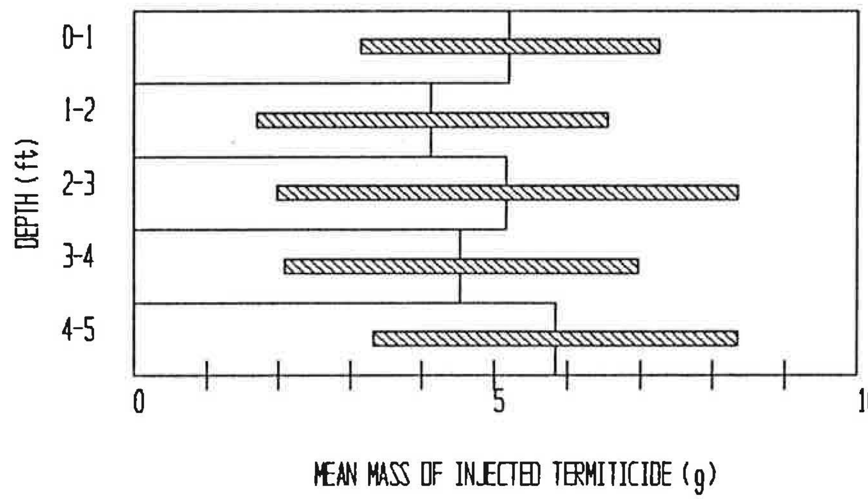

Figure 1. Distribution of Chlordane Mass with Depth for Silt Loam

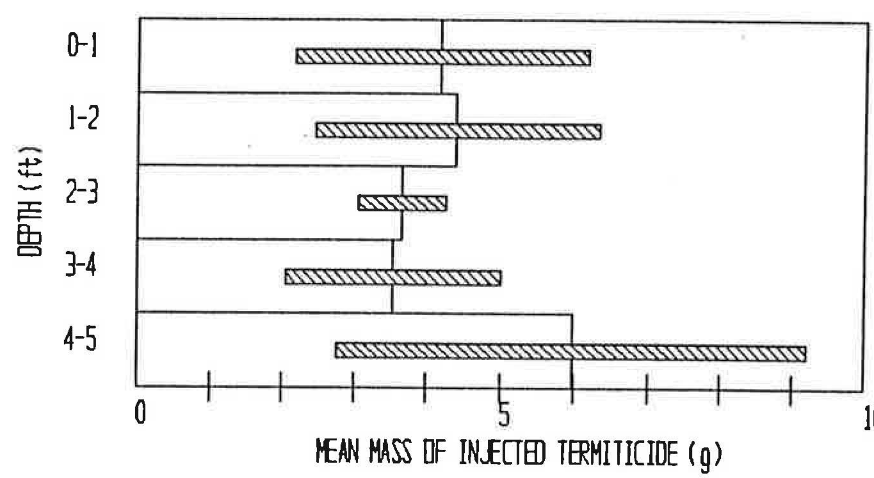

Figure 2. Distribution of Chlordane Mass with Depth for Loamy Sand

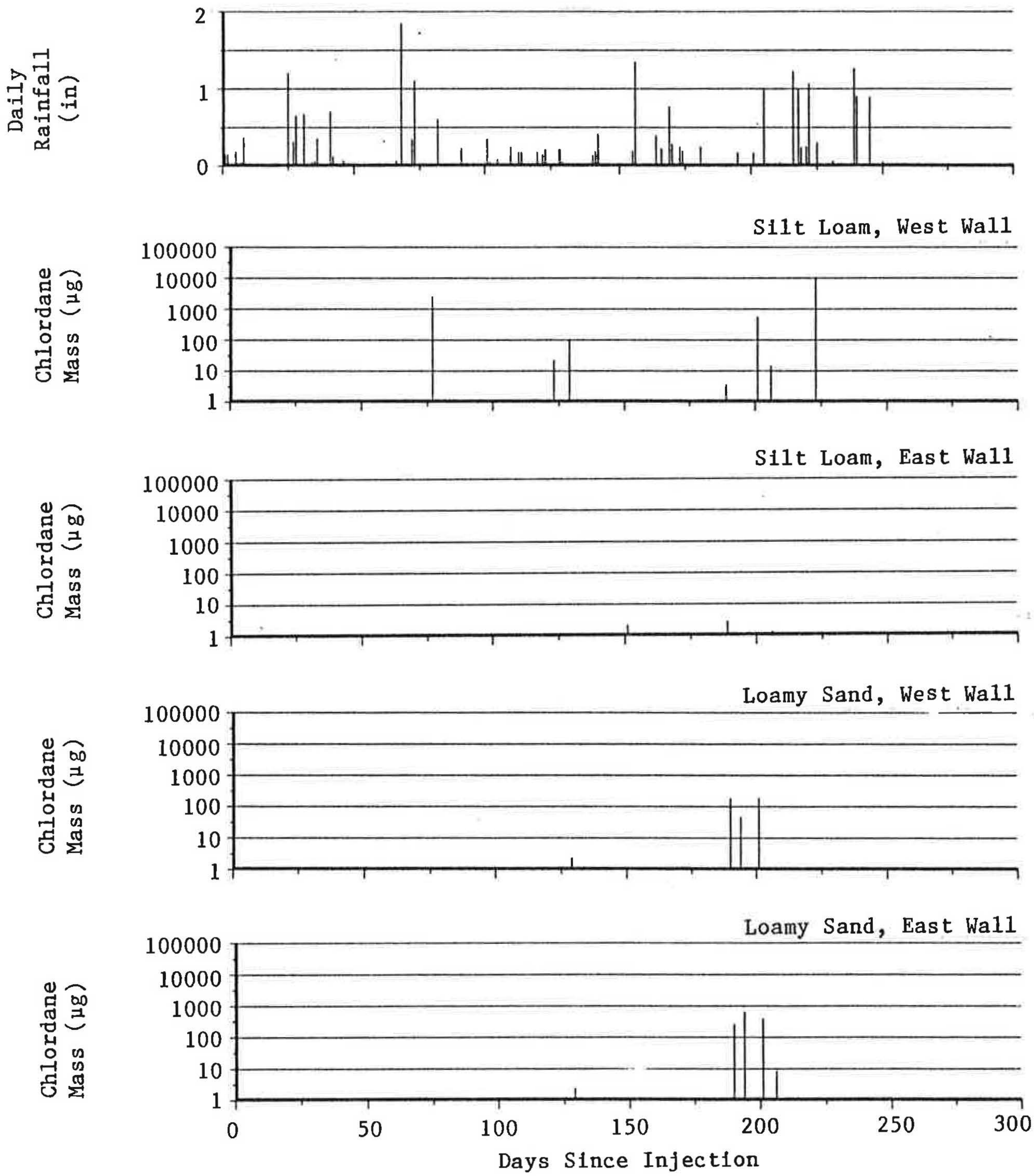

Figure 3. Chlordane Mass Versus Time

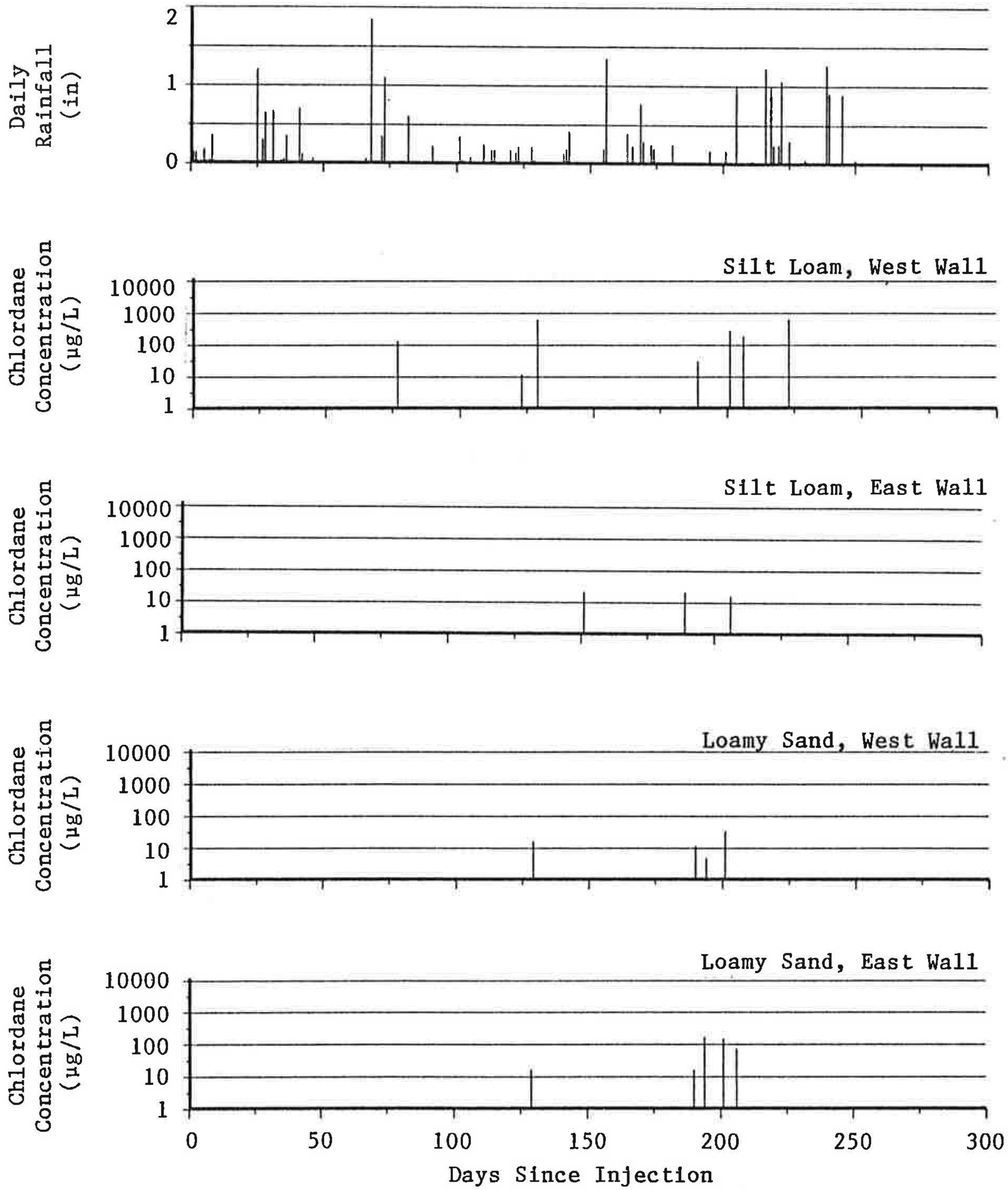

Figure 4. Chlordane Concentration Versus Time

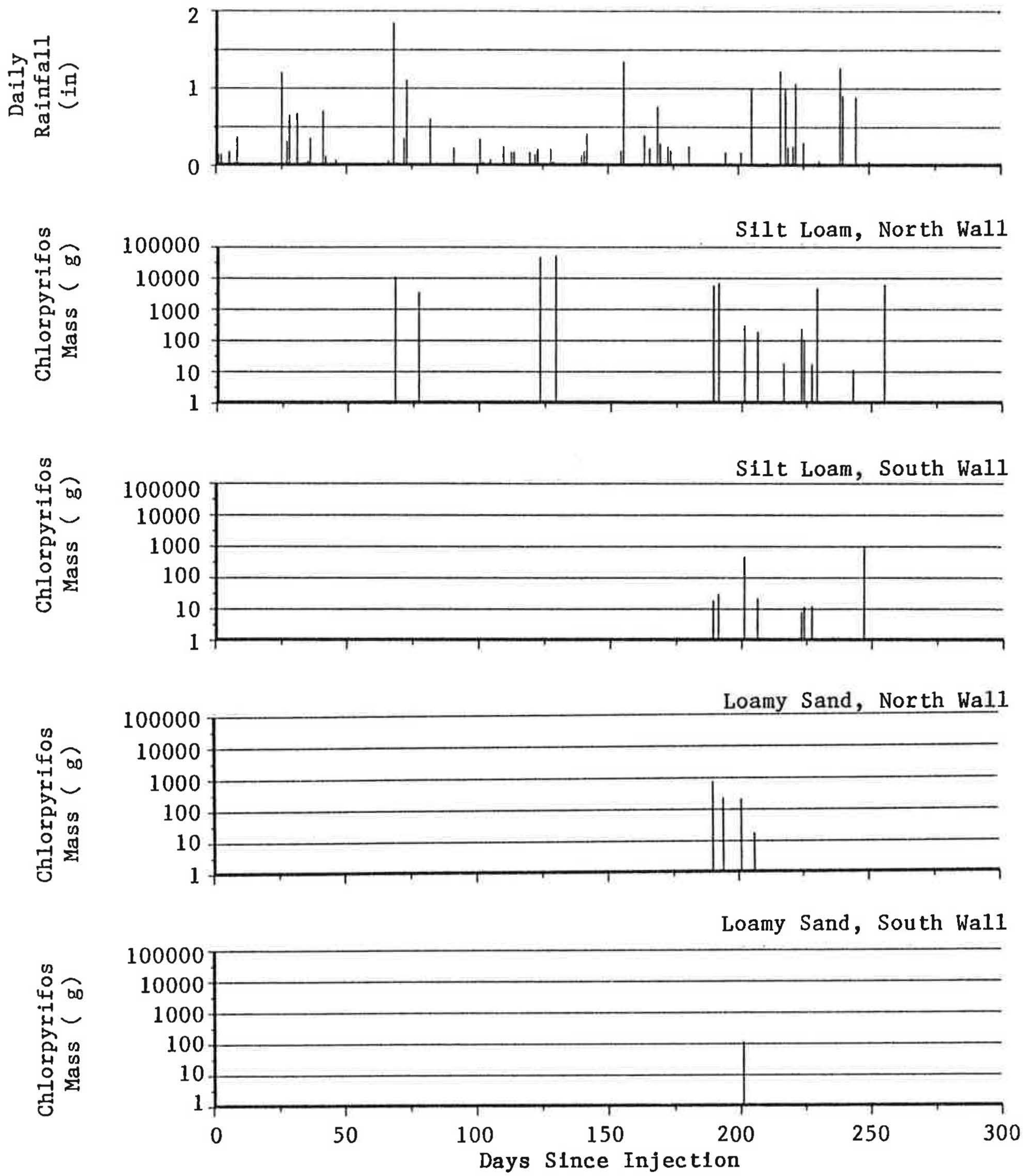

Figure 5. Chlorpyrifos Mass Versus Time

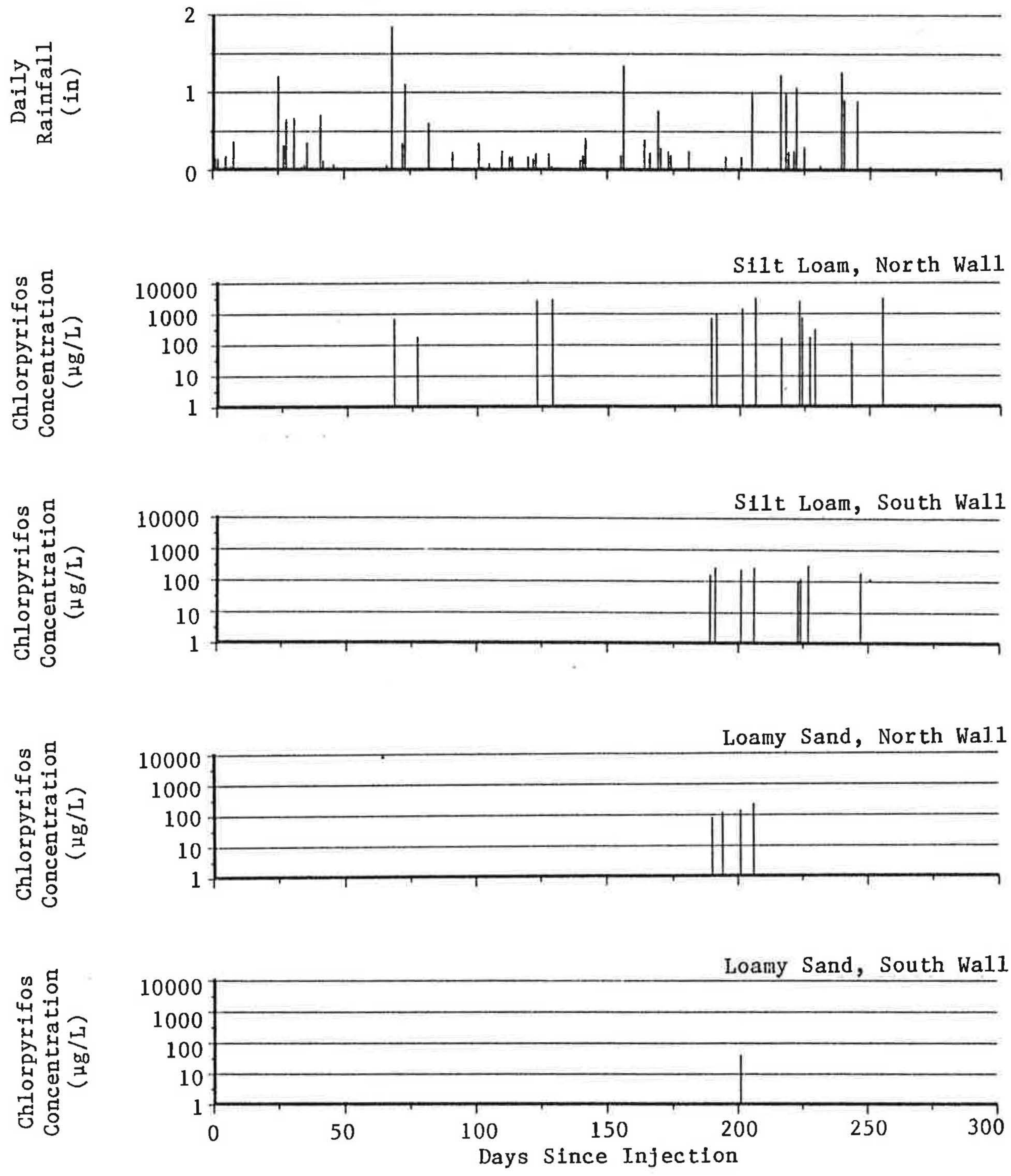

Figure 6. Chlorpyrifos Concentration Versus Time