Persistence and Distribution of Chlordane and Dieldrin Applied as Termiticides[1]

by
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The persistence and movement of many chlorinated hydrocarbon insecticides in soils have been found to be dependent upon the chemical formulation used, the method of application, and especially the environmental conditions (weathering) to which they are exposed (CARTER and STRINGER 1970a, 1970b, LICHTENSTEIN 1966, LICHTENSTEIN et al. 1960, 1962, 1964, 1971, SMITH 1968). Soil type, the amount of organic matter in a particular soil type, and soil moisture are major factors affecting persistence and distribution. Other climatic conditions and the chemical and microorganismic composition of the soil are less influential. Most of the organochlorine compounds studied as soil insecticides have been reported to be relatively persistent. Fifteen or more years after being applied, aldrin and DDT have been found to move vertically and horizontally only very slightly unless the treated soil is physically moved (LICHTENSTEIN et al. 1971, SMITH 1968). HERMANSON et al. (1971) reported measurable enduring insecticide residues in soil treated with DDT, toxaphene, chlordane, dieldrin, endrin, heptachlor, and aldrin 11 years after application.

Some chlorinated hydrocarbon compounds applied to soil under and around buildings are very effective for subterranean termite prevention and control (JOHNSTON 1960, JOHNSTON et al. 1971). However, these termiticides and their effects on the environment are being closely reviewed by the Environmental Protection Agency. Two reports (LICHTENSTEIN et al. 1971, SMITH 1968) have indicated that termiticides, when applied in field plots, show a negligible movement through the soil. We hypothesized that (a) other termiticides would behave in a similar manner in soil beneath and around treated structures so as to be of no environmental concern, and that (b) those termiticides previously reviewed in field experiments would behave even more favorably from an environmental standpoint when applied under and around structures where weathering is less severe. This study reports our investigation of hypothesis (a).

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MATERIALS AND METHODS

Soil Treatment and Sampling. - Post-construction insecticide applications of chlordane and dieldrin were made to two homes, both of basement type construction. One building was treated in 1950 with 2.0% chlordane emulsion at the rate of 4 gal/5 linear ft around the outer perimeter of the foundation. The second structure was treated in 1956 with 0.5% dieldrin emulsion at the rate of 4 gal/10 linear ft around the foundation. These materials were applied in accordance with established termite control procedures.

Samples for residue analysis were collected using two different samplers. Soil samples (cores) were taken beneath the hollow chlordane-treated porch using an 18 in long X 12 in diameter hand sampler. Four cores were taken along the inside of each of the three walls. Each core was divided into four equal segments (A-D). The four A segments along the front wall were combined for analysis. Each of the segments along the three walls were handled in this manner.

All soil samples taken around the treated structures involved the use of a metal tube (36 in long and 1 in diameter) cut in half longitudinally. A heavier metal tube served as a sleeve to hold the two halves securely together, and attached to a heavier metal driver. Each soil core was divided and combined for analysis as described above. Samples were taken from all sides of the treated structures where construction details did not interfere.

Sample Extraction

All soil samples were prepared for extraction as follows: the soil cores were air dried, ground in a disc mill, sieved through a No. 16 standard sieve screen, mixed, and stored in plastic bags at -15°C until analysis. Soil samples were extracted by placing a 10-g aliquot in a 500-ml erlenmeyer flask and shaking for 15 min on a wrist shaker with 5 ml deionized water and 50 ml isopropyl alcohol. One hundred milliliters hexane was then added and the shaking continued for 2 hr. The flask contents were allowed to set overnight and then were filtered through filter paper into a 500-ml separatory funnel. Two hundred milliliters deionized water was added to the separatory funnel and the contents shaken hard for 1 min. The layers were allowed to separate and the lower layer (containing water and isopropyl alcohol) discarded. The washing process was repeated twice. The hexane portion was then stored over anhydrous sodium sulfate (heated at 175°C for 10 hr) until analysis.

The dieldrin samples were analyzed using an Aerograph Model 1200 gas chromatograph equipped with an electron capture detector operated at -90V. A 5 ft X 1/8 in stainless steel column containing a 1+1 mix of 5% QF-1 and 2% Reoplex 400 on Gas Chrom Q was operated at 160°C, while the injector and detector temperatures were 230°C and 220°C, respectively. Nitrogen (carrier gas) was used at a flow rate of 50 ml/min.

The hexane extract was analyzed directly or concentrated to an appropriate volume for most of the samples. Some of the dieldrin samples showed interfering peaks on the gas chromatograph which necessitated using a column cleanup procedure. A glass column, 22 mm (id) X 210 mm with a 200-ml reservoir, was packed, bottom to top, with 1 cm sodium sulfate, 10 cm Florsil (as received), and 1 cm sodium sulfate. The column was washed with 50 ml hexane just prior to use. A 20-ml aliquot of the soil extract (2 g soil equivalent) was placed on the column and the interfering impurities eluted by rinsing with 100 ml hexane followed by 100 ml of 6% ethyl ether in hexane. Dieldrin was then eluted with 100 ml of 25% ethyl ether in hexane. The eluate containing dieldrin was then evaporated on a rotary evaporator and brought to an appropriate volume in hexane for analysis by gas chromatography. Recoveries of dieldrin averaged 85-90% through the entire procedure.

In the chlordane analyses, gamma chlordane was separated using column chromatography so that an isolated, identifiable peak could be used for quantitation. A 7 mm (id) glass tube was closed enough at one end to hold a glass wool plug and then packed, bottom to top, with 1 g sodium sulfate, 15 g Florsil (as received), and 1 g sodium sulfate. The column was washed with 30 ml hexane just prior to use. A 10-ml aliquot of the original sample was concentrated to 1 ml and quantitatively transferred to the column, and the early eluting part of chlordane removed by rinsing with 130 ml hexane. Gamma chlordane was then eluted with 80 ml hexane. The eluate containing gamma chlordane was then evaporated on a rotary evaporator and brought to an appropriate volume in hexane for analysis by gas chromatography. Isolation and recovery of the gamma chlordane isomer by the above method was 95%.

The gamma chlordane samples were analyzed using an Aerograph Model 1200 gas chromatograph equipped with an electron capture detector operated at -90V. A 5 ft X 1/8 in stainless steel column containing 5% SE-30 on 60/80 mesh chromosorb W was operated at 180°C, while the injector and detector temperatures were 230°C and 220°C, respectively. Nitrogen (carrier gas) was used at a flow rate of 50 ml/min.

RESULTS AND DISCUSSION

Table 1 shows that gamma chlordane residues are concentrated in the upper layers of soil with significantly lower residues in the lower core segments. Since the termiticides were applied to the top 6-8 in of soil around the foundation walls, it is apparent that most of the insecticide remained in the layers of soil in which it was initially applied. The construction of the porch was such that all four sides were enclosed and essentially no air, light, nor moisture had penetrated the treated area. Upon entering the hollow porch, the odor was that of a recently treated area although 21 years had elapsed since the application was made.

TABLE 1

Vertical Distribution of Gamma Chlordane Residues in Treated Soil Beneath a Hollow Porch.[a]

Core Segment[b]	Segment Depth (in)[c]	Residues (PPM) Perimeter Positions South	East	West
A	0 - 3.25	15.00	4.35	13.92
B	3.26 - 6.50	8.35	1.16	10.00
C	6.51 - 9.75	4.05	0.31	3.28
D	9.76 -13.00	5.20	0.47	4.05

a - samples taken six inches from inside porch wall.

b - each core segment represents the combination of four samples.

c - calculated by averaging the core lengths of all soil cores taken and dividing the average by four.

In perimeter soil samples, gamma chlordane and dieldrin residues were concentrated in the upper 6 in of soil in all areas sampled (Table 2). This lack of downward movement next to the foundation was surprising since the general opinion of pest control specialists has been that insecticides will move down along basement walls (this hypothesis, however, has never been substantiated).

TABLE 2

Vertical Distribution of Gamma Chlordane and Dieldrin Residues in Soil Samples.[a]

Core Segment[b]	Segment Depth (in)[c]	Residues (PPM) Perimeter Positions			
		North	South	East	West
Gamma Chlordane					
A	0 - 5	6.65			8.69
B	6 - 10	0.20			4.95
C	11 - 15	0.01			0.19
D	16 - 20	0.01			0.17
Dieldrin					
A	0 - 6.25	9.75	3.53	3.40	
B	6.26 - 12.50	3.70	0.58	0.09	
C	12.51 - 18.75	0.71	0.01	0.05	
D	18.76 - 25.00	0.19	0.01	0.02	

a - samples taken six inches from perimeter of building.

b - each core segment represents the combination of four samples.

c - calculated by averaging the core lengths of all soil cores taken and dividing the average by four.

In another series of experiments, the vertical as well as the lateral movement of gamma chlordane and dieldrin from the areas of initial application were studied (Table 3). Decreasing residues outward and downward from the treatment area were noted. In the dieldrin treated building, high residues in the A core segment 4 and 10 ft from the foundation could be attributed to extensive sheet erosion at two of the four sampling sites. The insignificant lateral movement of the termiticides except where soil particles with absorbed insecticide molecules eroded is consistent with the findings of DDT movement in open field tests (SMITH 1968).

Twenty-one years after treatment, as much as 15% of the gamma isomer of chlordane remained in treated soil while as much as 10% of the dieldrin remained.[3] In both cases, the greatest amounts of the residues remained in the immediate treatment area. Under a build-

[3]Based on theoretical residues present immediately after treatment.

TABLE 3

Horizontal and Vertical Distribution of Gamma Chlordane and Dieldrin Residues in Treated Soil Around a Building.

Core Segment	Segment Depth (in)[a]	Residues (PPM)[b] Distance from Building (ft) .5	1	2	4	10
Gamma Chlordane						
A	0 - 5	0.83	0.39	0.42	0.34	0.07
B	6 - 10	0.04	0.01	0.01	<0.01	<0.01
C	11 - 15	<0.01	<0.01	<0.01	<0.01	<0.01
D	16 - 20	0.01	<0.01	0.03	<0.01	<0.01
Dieldrin						
A	0 - 7	5.38	2.88	0.78	1.71	0.94
B	8 - 14	0.27	0.09	0.04	<0.01	<0.01
C	15 - 21	0.39	0.05	<0.01	<0.01	<0.01
D	22 - 28	0.08	0.08	<0.01	<0.01	<0.01

a - calculated by averaging the core lengths of all soil cores taken and dividing the average by four.

b - mean residues of the four core segments.

ing, even less movement would occur. Therefore, chlordane and dieldrin are persistent as termiticides, but their horizontal and vertical movement is restricted so that any form of environmental contamination is remote.

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