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Movement of Aldicarb in Different Soil Types

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The detection of the pesticide "aldicarb" in groundwater in various sections of the country (Anon., 1979; Rothschild et al., 1982; Anon., 1982; Anon., 1983) has increased our awareness about the movement of chemicals in soil. According to Sepak et al. (1978), movement of pesticides in soil depends on the amounts applied, on soil conditions, on various ecological determinants, and on the pesticide's physical and chemical properties.

When applied to potatoes grown in Long Island, N.Y. aldicarb was subsequently found in well water at levels as high as 180 ppb, which according to EPA officials, could be toxic to babies and infants (Anon., 1979). Rothschild et al. (1982) considered 10 ppb aldicarb in water to be the maximum permissible level.

Past studies on the fate of aldicarb in soil have been focused mostly on its chemical changes, on its degradation rate and on its metabolism in closed systems representing actual field conditions. As a result, various investigators have found that the initial step in the breakdown of aldicarb in soil is a rapid conversion by oxidation to aldicarb sulfoxide. Aldicarb sulfoxide is subsequently degraded by hydrolysis and after a further oxidation is converted to aldicarb sulfone (Smelt et al., 1978).

Our major objectives in this study were to determine the movement of aldicarb in different soil types under laboratory conditions and to measure what effects large volumes of water would have on such movement. Information of this type is important in gaining a better understanding of the downward movement of aldicarb in soil when applied as a pesticide.

MATERIAL AND METHODS

Preparation of soil column: Thirty-five g of 8 different but well defined soils (NASCO West, Modesto, CA) were packed in individual glass columns (20 x 350 mm) and tapped lightly. Twenty-five mg of aldicarb active ingredient in formulated form were added to the top of the column and mixed thoroughly with the top inch of soil. Three aliquots of 50 mL each of distilled water were then added to the top of the soil columns. Eluted water was collected as fractions after the addition of each aliquot and analyzed for aldicarb. At the end of the holding period (5 days), soil was taken from each glass column and sectioned into three parts. Each part was analyzed separately to determine the movement of aldicarb.

Analytical procedure: Ten g of each air-dried soil sample or 20 mL of each water fraction were analyzed for aldicarb using the procedure by Maitlen et al., 1969. Briefly, the soil was extracted by shaking for 6 hr on a wrist-action shaker with 100 mL acetonitrile/dichloromethane mixture (1:3) to which 2 drops of phosphoric acid were added. Water samples were extracted directly with chloroform. Extracts were evaporated to small volumes in a rotary evaporator. Final evaporation to dryness was accomplished by using a gentle stream of nitrogen. Residues of aldicarb were oxidized to aldicarb sulfone by adding 10 mL of (1:1) mixture of hydrogen peroxide and glacial acetic acid and heating at 90°C in oil bath for 1/2 hr. After cooling to room temperature, 1/2 g Celite 545 and 50 mL of H_2O were added and the aqueous solutions were then extracted with methylene chloride. The solvent, which contained the residue, was evaporated under vacuum to a small volume and then to dryness again using a gentle stream of nitrogen. The remaining residues were dissolved in 10 mL of acetone-hexane mixture (1:1) and analyzed by gas chromatography.

GC conditions: Quantification of aldicarb in the form of aldicarb sulfone was accomplished with a Tracor 222 gas chromatograph equipped with a flame photometric detector and operated in the sulfur mode. The glass GC column was packed with 5% OV-225 on chrom Q 80/100. Temperatures were 185, 190, and 210°C for column, detector, and injector, respectively. Recovery studies using fortified control samples were conducted by adding 100 ppb of aldicarb to the soil samples and analyzing for aldicarb sulfone following oxidation. Recovery studies averaged 96%, with a standard deviation of ±1.0.

RESULTS AND DISCUSSION

In these experiments, the persistence and movement of aldicarb in different types of soil were studied under laboratory conditions. In order to simulate a flooded condition and to measure its subsequent effect on aldicarb distribution in soil, the amount of water applied and the amount of aldicarb used were more than would normally be experienced under field conditions.

Fig. 1 shows the amount of water which leached through columns packed with different types of soil containing aldicarb after the addition of the first aliquot (50 mL) of distilled water. As expected the results show that water movement differed drastically with respect to soil type, being quite fast in sandy soil and very slow in clay soil. The volume of water leached through the columns after 24 hr ranged from 10-70% of the volume of water added initially. Table 1 shows the percentages of aldicarb residues recovered in the drainage water from the different types of soil

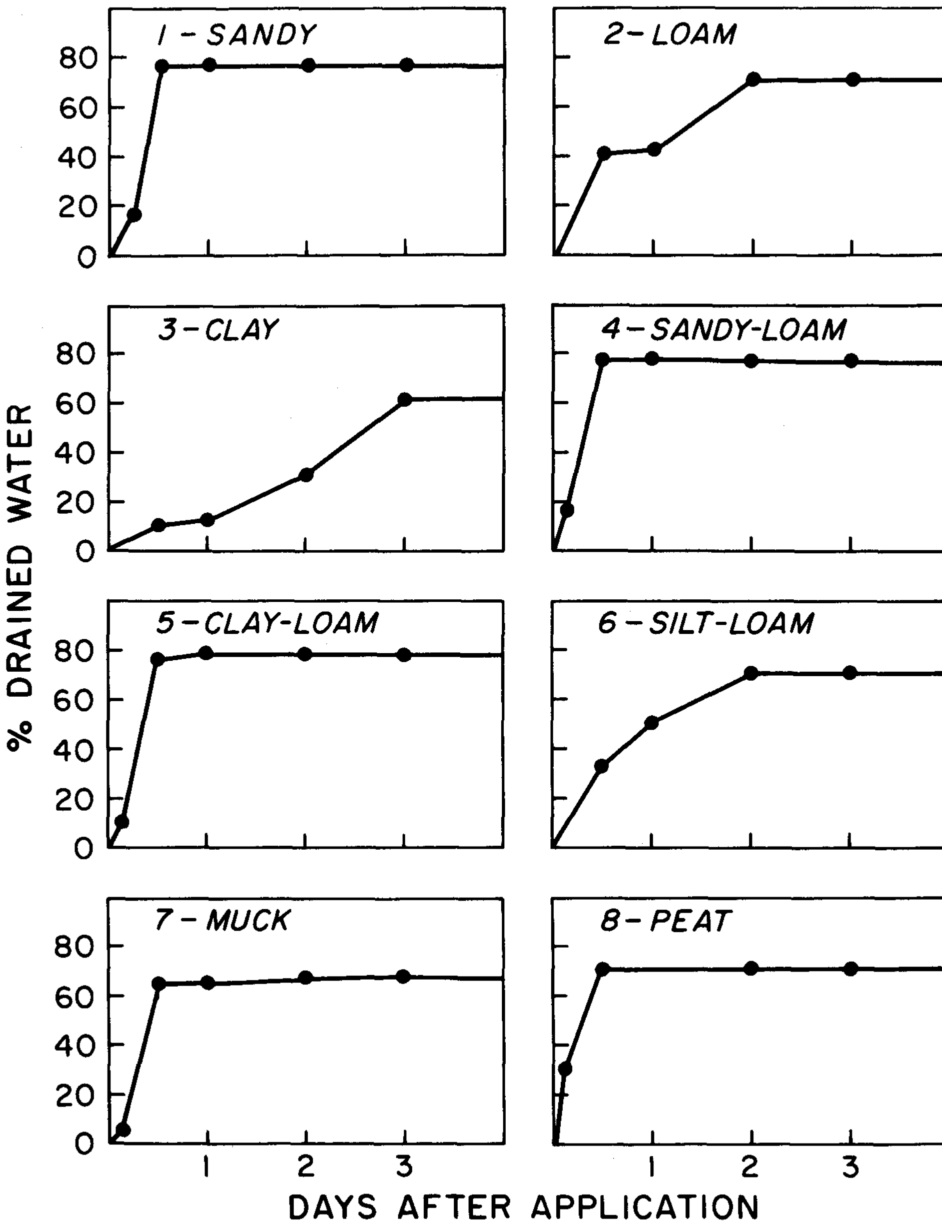

Figure 1. Percentage of total volume of water which percolated through various soil types containing aldicarb.

Table 1. Percentages of aldicarb recovered from different effluents and from soil sections taken from different soil columns.

Soil type	% Aldicarb recovered in effluents				% Aldicarb recovered from soil sections				% Total Aldicarb Recovered
	1st Effluent	2nd Effluent	3rd Effluent	Total	Top Section	Middle Section	Bottom Section	Total	
Sand	72.51	0.002	0.009	72.52	25.55	0.010	0.001	25.56	98.08
Loam	38.62	0.425	0.002	39.05	56.96	0.007	0.000	56.97	96.02
Clay	32.81	0.554	0.025	33.39	61.44	0.118	0.380	61.94	95.33
Sandy-loam	72.94	0.036	0.038	73.01	24.84	0.131	0.138	25.11	98.12
Clay-loam	69.06	0.248	0.014	69.32	26.46	0.166	2.285	28.91	98.23
Silt-loam	67.19	*	*	67.19	30.18	0.356	0.150	30.69	97.88
Muck	60.83	2.329	0.002	63.16	36.05	0.266	0.343	36.66	99.82
Peat	73.46	0.419	0.330	74.21	23.40	0.508	0.790	24.70	98.91

*No effluent was recovered.

after elution with the three-50 mL aliquots of water. The results indicate that 33-74% of the added amounts of aldicarb were leached from the treated soils at the end of the experiment. The highest levels of aldicarb residues were found in water leached from sandy, sandy-loam and peat soils, whereas the lowest levels of aldicarb residues were found in water collected from clay and loam soils. From these experiments, it is evident that the majority of the leachable aldicarb residues were present in the first effluent.

These results are in agreement with those of Coppedge et al. (1977) who also found that the movement of aldicarb residue was restricted in clay and loam soils. However, in field studies, Bull et al. (1970) found that under wet conditions all radioactivity from both loam and sandy soils treated with S^{35} labeled aldicarb was lost in a few hours.

The amounts of aldicarb residues retained in the various soils are also given in Table 1. These data clearly show that clay soil retains the highest amount of aldicarb residues, followed by loam soil. However, none of the second or the third aliquots of water passed through the clay soil column. This suggests that the apparent retention of aldicarb residues by loam and clay soils may be a function of water flow as well as with some type of physical binding to the soil particles (Table 2). The lowest amounts of aldicarb residues were found in sandy, sandy-loam and peat soils. These results are in agreement with the findings of Bramilow and Leistra (1980) who recovered only 1% of a dose of aldicarb 11 days after it had been applied to sandy-loam soil.

Table 2. Amount of aldicarb per milliliter of drained water in different types of soil.

Soil Type	*Water effluent (mL)	Aldicarb leached (mg)	Aldicarb/mL H_2O (mg/mL)
Sandy	38.0	18.13	0.477
Loam	35.0	9.7	0.277
Clay	30.0	8.35	0.278
Sandy-loam	38.5	18.25	0.474
Clay-loam	39.0	17.32	0.444
Silt-loam	35.0	16.80	0.480
Muck	34.0	15.79	0.464
Peat	35.0	18.55	0.530

*Refer to amount of water collected from the first 50 mL water aliquot.

Coopedge et al. (1977) have reported that most insecticides are retained in soils high in organic content. However, this does not appear to be the case in our experiments, as sandy and peat soils retained low, and almost equal amounts of aldicarb residues. This suggests that if some soil types do retain aldicarb residues the presence of organic matter may not be an important factor. It also suggests that many more studies are needed in this very complex field.

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