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Degradation of Diazinon, Chlorpyrifos, Isofenphos, and Pendimethalin in Grass and Compost

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Mandatory state and municipal recycling regulations are being enacted in Connecticut. Some homeowners compost their own yard wastes, but in many communities this material is sent to recycling centers and made into compost. Recycling of leaves and grass clippings will help relieve overburdened landfills. Many of the grass clippings from lawns, however, are treated with insecticides to reduce turf insects and herbicides to control weeds. The compost made from these clippings may be then used in gardens and around houses and is generally not tested for pesticide residues.

Certain pesticides, such as chlordane, heptachlor and aldrin are persistent in the environment (Lichtenstein and Polivka 1959; Nash and Woolson 1967; Sears and Chapman 1979). These pesticides are no longer in use and have been replaced by newer products, such as chlorpyrifos and isofenphos. Degradation of some of these newer pesticides has been studied under controlled laboratory conditions, (Getzin 1968; Racke and Frink 1989; Petruska et al. 1985), but studies have not been performed under the variable conditions that occur with homeowners' grass and compost.

Our aim was to conduct a study of pesticide persistence using methods of composting as close as possible to those used by homeowners. These methods usually involve placing layers of cut grass and other yard waste in compost bins. Homeowners, however, as compared to controlled studies, rarely turn the materials, monitor the pile temperature, or add water other than rain, to keep the materials moist.

To determine the decomposition of pesticides in grass and compost, we chose four of the most common products used by homeowners; the organophosphorous insecticides chlorpyrifos, isofenphos and diazinon along with a selective pre-emergence herbicide, pendimethalin. Our objective was to test how long residues of these chemicals remained in

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grass clippings and to determine if any residues persisted in the compost made from these clippings.

MATERIALS AND METHODS

During the summer of the 1989, two separate applications of emulsifiable concentrates of diazinon 25E and chlorpyrifos 2E were applied together in the same test plot as per label direction at the rate of 0.75 oz/500 sq ft. Two separate applications of granular isofenphos were applied to one other test plot at the rate of 1.5 lbs/500 sq ft. The two test and one control plot each consisted of 500 square feet.

In 1990, granular formulations of the same three insecticides and the herbicide pendimethalin, were applied together in a new plot area. The applications were made in early, mid, and late summer. This time frame for the applications replicates that used by most homeowners for the control of turf pests. Plot size for the control and the treatment areas were increased to 5000 square feet to obtain greater amounts of grass clippings.

The four chemicals, 5 % diazinon, 2.32 % chlorpyrifos, 1.5% isofenphos, and 1.17% pendimethalin were applied together in the test plot in accordance with label directions. Diazinon and pendimethalin were applied at 10 lbs/5000 sq ft, while isofenphos and chlorpyrifos were used at 15 lbs/5000 sq ft and 12 lbs/5000 sq ft, respectively. The test plot was watered with 0.5 to 1 inch of water, as recommended by label directions after each application. Only water was added to the control plot.

Grass in the plots was initially cut three days after treatment and thereafter on a regular biweekly basis for five weeks depending on weather conditions. The control and test plots were cut on the same days. Grass clippings from the test and control plots were placed into separate, 4 x 4 x 4 ft compost bins constructed as described by Crockett (1977). The bins were designated early, mid, late, and control. The height of the cut grass in the bins varied from 1.5 to 4 inches. After the addition of grass clippings to the compost bins, approximately 1 inch of shredded, partially decomposed compost was added to each bin to cover the grass and enhance microbial activity. This partially decomposed material was a uniform mixture of shredded plant material and potting soil (Pro-Mix BX). This material was tested and contained none of the pesticides used in this study.

After each cutting, and prior to addition to the compost bin, a 50 g sub-sample of grass from the control and treated plots was taken for pesticide residue analysis. In addition, 50 g of the material in the compost bins were also taken and analyzed for pesticide residues.

Pesticide standards were obtained from the EPA Pesticides and Industrial Chemicals Repository, Research Triangle Park, NC; and hexane, 9262-3, was obtained from J.T. Baker Inc., Phillipsburg, NJ. All samples were prepared using bulk hexane extraction followed by gas chromatography to determine pesticide concentrations, with some modifications to standard procedures as described below (Environmental Protection Agency 1986).

From the sub-samples, a 10 g sample of either grass clippings or compost was tested. The extraction volume of hexane was 100 mLs. Samples were extracted in a 250 mL Erlenmeyer flask, unstirred, at room temperature for 24 hours. After extraction, 2 mLs of the extract were removed from the flask and analyzed without further cleanup. Four microliters of the extract were injected into two Hewlett Packard 5890 gas chromatographs, one equipped with a nitrogen-phosphorus flame ionization detector (NP-FID), and the other a flame photometric detector (FPD) operated in the phosphorus mode. The operating conditions were identical: Capillary column, 0.53 m x 15 m, SPB-1 (Supelco Inc, Bellefonte, PA); Temperature program, 150°C, isothermal 2.5 min, rate 4°C/min to 240°C, final hold 15 min, total run time 40 minutes; Splitless injection, purge time 0.5 min, 250°C; Detector temperatures 265°C; Carrier gas, helium. Detector makeup gas and flame gases were set to the instrument manufacturers specifications for optimal performance. The detection limit for pendimethalin using the NP-FID was 0.05 ppm, and for diazinon, chlorpyrifos and isofenphos using the FPD was 0.02 ppm. Peak areas were calculated using a Hewlett Packard 3396 integrator using external standard calculation.

Method blanks together with spiked control grass and compost were tested on a weekly basis. The method blank showed no interfering peaks at the retention times of the compounds of interest. Samples were spiked at 0.05, 0.2, 0.5, and 2.0 ppm for all four pesticide compounds. Recoveries were between 94%-106% for diazinon, chlorpyrifos, and isofenphos on the FPD. Recovery of pendimethalin ranged between 75%-114%. Standards were included in the analysis before and after each set of samples using the FPD. A pendimethalin standard was included in the analysis before and after each sample using the NP-FID due to the variable response of the NP-FID.

RESULTS AND DISCUSSION

During 1989, grass clippings and compost were analyzed for residues of diazinon, chlorpyrifos, and isofenphos. The insecticides degraded rapidly in the grass clippings, in all cases less than 1 ppm was found fourteen days postapplication. These results parallel other findings on the analysis of grass thatch (Sears and Chapman 1979). No detectable residues were found in grass clippings or compost after three weeks. Based on these data, further experiments were conducted in 1990 using larger plot areas.

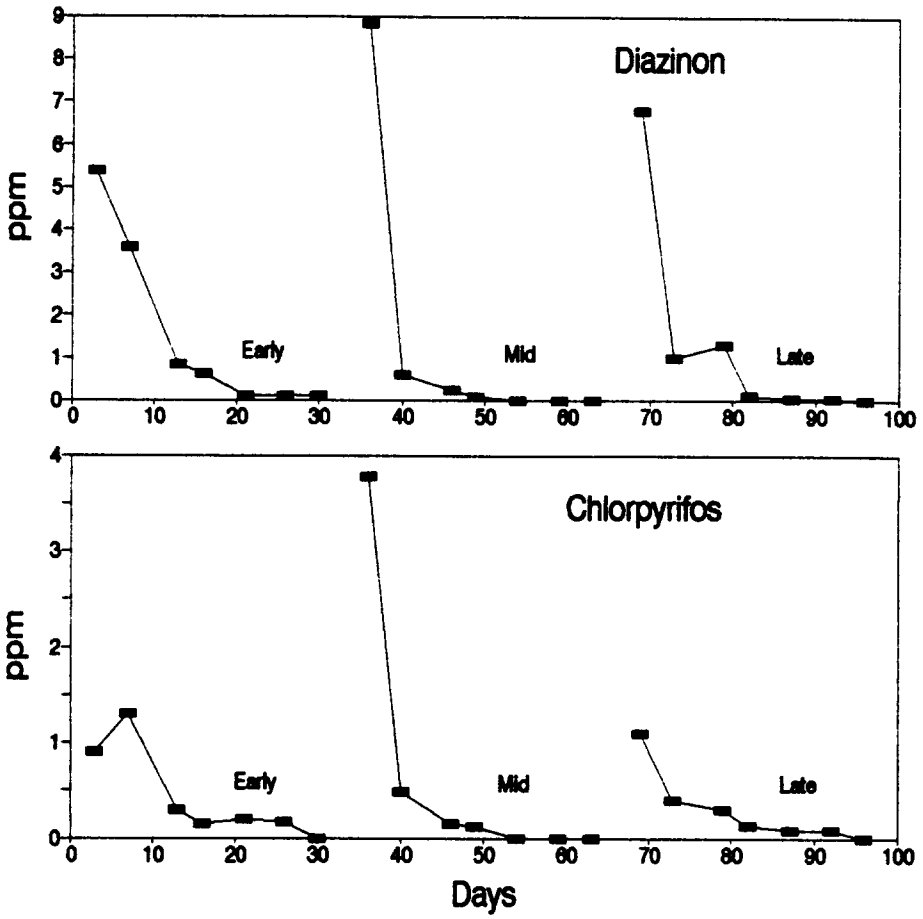

Figure 1. Degradation of diazinon and chlorpyrifos in grass clippings from early, mid, and late summer pesticide applications, applied on days 1, 38, and 68.

In 1990, pesticides were applied at three separate application intervals, early, mid, and late summer. Figures 1 and 2, show the degradation of the pesticide compounds in the grass clippings. The pesticides were applied on days 1, 38, and 68, for early, mid, and late intervals, respectively.

Degradation of the pesticides in the grass clippings was rapid during the first two weeks after treatment for all three test periods. Within seven to fourteen days, most residues of pesticides had almost disappeared. After twenty eight days, trace amounts (0.30 ppm) of pendimethalin were still found in the grass samples, but no detectable residues of the insecticides were found. Degradation of all compounds was nearly complete by the fourth week after treatment. Variability between treatments was high during the first week possibly due to uneven dispersal of the pesticides at application or differences in weather conditions.

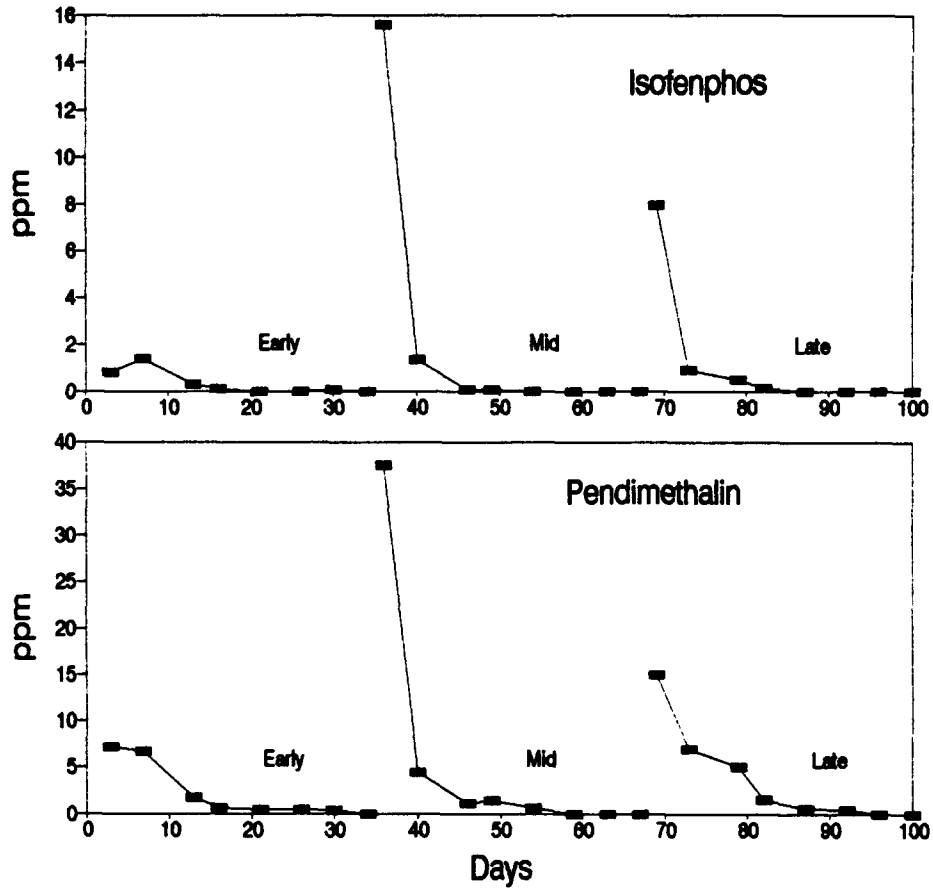

Figure 2. Degradation of isofenphos and pendimethalin in grass clippings from early, mid, and late summer pesticide applications, applied on days 1, 38, and 68.

The pesticides in compost made from early and midsummer grass clippings degraded rapidly. These compost piles contained residue levels averaging less than 0.5 ppm for all compounds during the first five weeks. After six weeks, there were no detectable residues in these piles. The late summer application, however, continued to show residues of all the compounds for a period of sixteen weeks. Table 1 lists the data of the degradation of the pesticides in the late summer compost.

Pesticide residues in the late summer compost were high during the first three to four weeks. Of note, the sample taken after three weeks contained 40 ppm pendimethalin, but relatively low concentrations of the other pesticides. This was possibly due to an uneven distribution of the herbicide in the grass clippings. Subsequent samples of compost never contained such high concentrations of pendimethalin, but elevated residue

Table 1. Degradation of four pesticides in compost made from late summer grass clippings.

Weeks after Application	Pesticides			
	Diazinon	Chlorpyrifos	Isofenphos	Pendimethalin
	ppm			
1	0.55	0.30	3.50	3.20
3	0.02	0.60	0.35	(40)*
4	<0.01	0.10	0.10	0.60
5	<0.01	<0.01	0.04	1.00
6	<0.01	<0.01	0.10	0.20
7	<0.01	<0.01	0.10	0.90
10	<0.01	<0.01	0.09	0.89
12	<0.01	<0.01	0.08	0.10
13	<0.01	<0.01	0.10	0.07
14	0.09	0.08	0.07	0.09
16	0.03	0.02	0.09	0.09
17	<0.01	<0.01	<0.01	<0.01
18	<0.01	<0.01	<0.01	<0.01
20	<0.01	<0.01	<0.01	<0.01

* Outlier.

levels (0.20-1.00 ppm) of this herbicide persisted for approximately ten weeks. The pile was turned at fourteen weeks, and trace amounts of all pesticides (<0.10 ppm), were found for the next two weeks. There were no detectable residues in the compost after seventeen weeks.

Temperature of compost is an important factor governing dissipation of pesticides through volatilization (Spencer 1987). Compost temperatures were monitored every three weeks. The early and midsummer compost temperatures reached a maximum of 51°C and 52°C, respectively. Temperatures of the late summer compost, never exceeded 27°C, and usually reflected the ambient air temperatures.

Based on our findings, composted grass clippings containing these four pesticides during the summer, under natural degradation processes, should be free of pesticide residues by the time compost is used in the following growing season.

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