Pesticide Residues in the Top Soil of Five West Alabama Counties

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Widespread use of pesticides since World War II has resulted in extensive environmental contamination. The persistence of pesticides in soil and the environment in general has been, since early 1960, of concern largely because of the tremendous rise in public interest with the wholesomeness of our environment. This concern revolved primarily around the apparent presence of increasing concentrations of assorted foreign chemical substances in the environment. Studies have shown that pesticide residues at levels too low to detect in the diet often are concentrated in adipose tissue and in milk in quantities which are detectable (HAGYARD et al. 1973, ZWEIG et al. 1963). LICHTENSTEIN (1959) reported that most food crops accumulate greater quantities of pesticides than does soil. Such evidence indicating that pesticide residues accumulate with progression up the food-web warrants investigation of pesticides persistence in the soil.

Although most of the pesticides applied to field crops disappear rapidly from the soil, low residue levels are retained by the soil for long periods (IWATA et al. 1973) with as much as 80% remaining in the top 4 in. of the soil (STEWART and FOX 1971). Many factors, including the formulation in which the chemical is applied, mode of application, soil type and temperature, moisture and microbial activity, influence the persistence of pesticide in the soil (LICHTENSTEIN and SCHULTA 1964, IWATA et al. 1973, HARRIS 1972, HARRIS and SANS 1972).

This paper summarizes studies on the distribution of pesticides in randomly selected soil samples taken from diverse environments in five west Alabama counties.

MATERIALS AND METHODS

Sampling procedure. Initially soil profiles were dug to a depth of 36 in. but preliminary analysis of horizon samples showed that almost 95% of the pesticide residues was confined to the surface 6 in. of the soil. Thereafter, soil sampling was standardized using a 4-in. diameter toothed auger to a depth of 6 in. The auger was stabbed into the soil and then rotated as it was pressed down to break up stones and roots. Sampling sites were randomly selected but a minimum of five sample sites was available for each county.

Soil (100 g) was collected and transferred to aluminum foil, wrapped and placed in appropriately labeled polyethylene storage bags. Samples were stored in an ice chest during transport.

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Analysis for Pesticides. Soils were stored at -15°C and extracted in moist "as sampled" state (YULE and SMITH 1971).

All extractions and analytical techniques were performed with nanagrade reagents using a modified procedure of the Perrine Primate Research Laboratories, Environmental Protection Agency, Perrine, FL. Pesticide extraction of 2-g soil samples was by continuous Soxhlet extraction with an acetone-hexane (1:1 v/v) system for 5 hr (Fig. 1). The extract was concentrated to approximately 3 ml, applied directly to a 22 X 200 mm chromatographic column loaded with 30-g activated alumina and eluted with 100 ml of hexane. The elute was collected, evaporated to 5 ml and then applied to 25 X 300 mm chromatographic column containing 18 g of pre-conditioned florisil for partitioning. Finally the sample was separated into two fractions by eluting with 200 ml of 6% diethyl ether in petroleum ether (Fraction I) followed by 200 ml of 15% diethyl ether in petroleum ether (Fraction II). The elution rate was 5 ml per min. The subsequent eluates were concentrated to 25 ml, dried over anhydrous Na_2SO_4 and 2-μl aliquots from each fraction were used for gas chromatographic determinations.

Gas Chromatography. Each soil sample was analyzed twice by gas-liquid chromatographic techniques, using a Micro-Tek MT-220 (Tracor Analytical Instruments, Austin, TX.) gas chromatography system equipped with four 6 ft. x 1/8 in. I.D. glass U-tube columns. The detection systems consisted of a ^{63}Ni electron capture detector.

The liquid phases employed were OV-17 (1.5%)/QF-1 (1.95%) and OV-1 (3%). The OV-17/QF-1 column contained acid washed, silane treated Chromosorb W 100/200 mesh and the OV-1 column contained Chromosorb-W HP 800/100 mesh.

The column oven was maintained at 180°C. The ^{63}Ni detector was operated at 320°C. The instrument injection ports were at 250°C and transfer lines were at 225°C. The nitrogen carrier gas flow was 70 ml/min.

Analytical grade standards of pesticides, obtained from the EPA, were used for identification and quantitation.

RESULTS AND DISCUSSION

Tables 1-4 summarize the findings of this study. The two most prevalent pesticides were the chlorinated hydrocarbons, benzene hexachloride (BHC) and aldrin. These compounds were detected in 75% of the soil samples analyzed. Malathion was detected in 43% of the samples and represents the most abundant organophosphate. Two commonly used herbicides, atrazine and 2,4,5-T, were found in 36% and 24%, respectively, of the samples analyzed. Several other pesticides were detected in the soil samples, but their distribution was not as widespread as BHC, aldrin or the two herbicides. It is of interest to note that DDT was not detected to any significant extent in the soil samples, possibly due to its restricted use over the past 10 years.

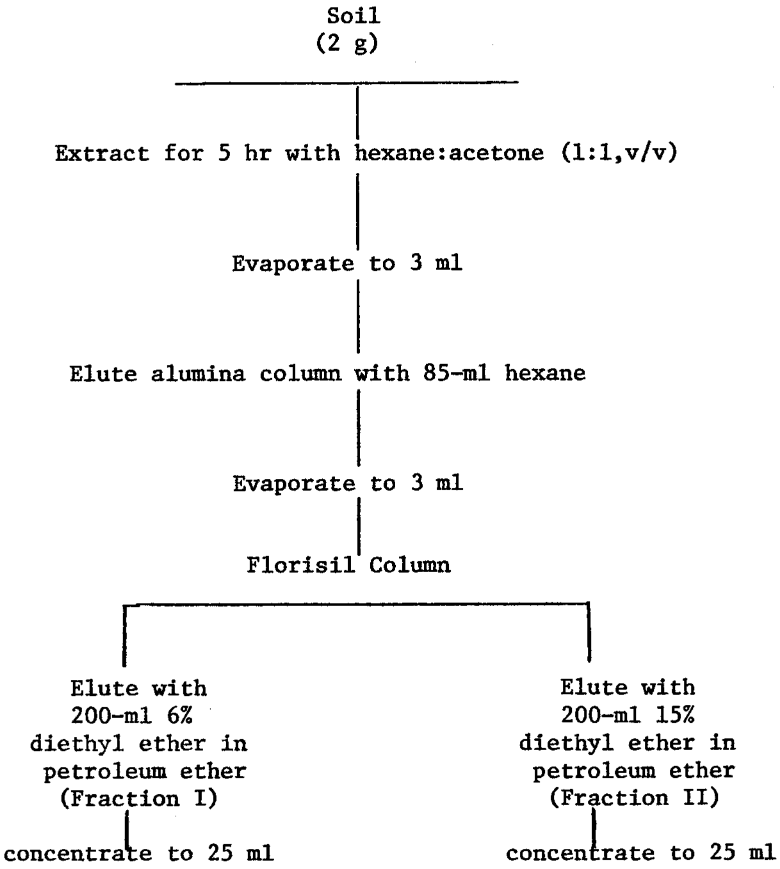

Fig. 1. Outline of procedure for extraction of pesticides from soil samples.

TABLE 1. Chlorinated-Hydrocarbon Residues in ppm of Surface Soil of a Five-County Area in West Alabama[a].

Pesticide	Tuscaloosa			Pickens			Greene			Marengo			Sumter		
	ND[b]	<0.1	>0.1	ND	<0.1	>0.1	ND	<0.1	>0.1	ND	<0.1	>0.1	ND	<0.1	>0.1
BHC	2[c]	8	0	4	3	0	2	11	0	1	5	0	0	5	0
Lindane	5	5	0	7	0	0	10	2	0	2	4	0	4	1	0
Aldrin	3	7	0	2	5	0	7	11	0	3	3	0	0	5	0
DDD	9	1	0	7	0	0	16	2	0	6	0	0	4	1	0
DDE	10	0	0	7	0	0	18	0	0	6	0	0	5	0	0
DDA	8	2	0	7	0	0	15	2	1	4	2	0	5	0	0
DDT	10	0	0	7	0	0	17	2	0	6	0	0	4	1	0
Hepatachlor Expoxide	10	0	0	6	1	0	17	1	0	6	0	0	5	0	0
Dieldrin	10	0	0	6	0	1	14	5	1	6	0	0	5	0	0
Methoxy-chlor	10	0	0	7	0	0	18	0	0	5	1	0	5	0	0
Perthane	10	0	0	6	0	1	17	1	0	6	0	0	5	0	0

[a] 6-18 samples per county

[b] Not detected

[c] Number of counties

TABLE 2. Non-chlorinated Pesticide Residues in ppm of Surface Soil of a Five-County Area in West Alabama[a].

	Tuscaloosa			Pickens			Greene			Marengo			Sumter		
Pesticide	ND[b]	<0.1	>0.1	ND	<0.1	>0.1	ND	<0.1	>0.1	ND	<0.1	>0.1	ND	<0.1	>0.1
Atrazine	7[c]	2	1	2	4	1	12	5	1	6	0	0	3	0	2
2,4,5,-T	6	4	0	7	0	0	14	3	1	5	1	0	5	0	0
Malathion	5	5	0	3	4	0	13	5	0	6	0	0	1	4	0
Diazinon	6	4	0	5	2	0	14	4	0	4	2	0	4	1	0
Methyl Parathion	9	1	0	7	0	0	17	1	0	6	0	0	4	1	0
Guthion	10	0	0	7	0	0	18	0	0	5	1	0	6	0	0
Mirex	10	0	0	7	0	0	17	1	0	6	0	0	6	0	0
Carbo-phenothion	9	0	1	6	1	0	15	2	1	6	0	0	6	0	0

[a] 5-18 samples per county

[b] Not detected

[c] Number of counties

TABLE 3. Percent Distribution of Chlorinated Hydrocarbons in Surface Soil of a Five-County Area in West Alabama.

County	Sample Areas (No.)	BHC	Lindane	Alrdin	DDD	DDE	DDA	DDT	Hepta-Chlor Epoxide	Dieldrin	Methoxy-Chlor	Perthane
Tuscaloosa	10	80	50	70	10	0	20	0	0	0	0	0
Pickens	7	43	0	71	0	0	0	0	14	0	0	14
Greene	18	61	11	61	0	0	0	6	6	17	0	6
Marengo	6	83	67	50	0	0	33	0	0	0	17	0
Sumter	5	100	20	100	20	0	0	0	0	0	0	0

TABLE 4. Percent Distribution of Non-chlorinated Pesticides in Surface Soil of a Five-County Area in West Alabama

County	Sample Areas (No.)	Atrazine	2,4,5-T	Malathion	Diazinon	Methyl Parathion	Guthion	Mirex	Carbo-phenothion
Tuscaloosa	10	30	40	50	40	10	0	0	10
Pickens	7	71	0	57	29	0	0	0	14
Greene	18	33	22	33	22	6	0	6	17
Marengo	6	0	17	0	33	0	17	0	0
Sumter	5	40	0	80	20	20	0	0	0

The presence of pesticides in every soil sample indicates the scope of environmental contamination by such chemicals. Reliable data on the actual amounts and types of pesticides applied to the areas under study were not available. Therefore, no correlation could be made between the amount of residues remaining after application and amount acutally applied. In general, residues were found in greater concentrations in and around farms and less in remote areas, except in the cases where samples were taken from drainage ditches in remote areas.

Chlorinated hydrocarbons such as BHC and aldrin were detected in drainage ditches and uncultivated forest where no pesticides had been applied directly. This observation confirms existing evidence that wind drift and rainwater wash-off contribute significantly to the spread of pesticides into non-target areas, thereby affecting a large variety of non-target flora and fauna (LICHTENSTEIN and SCHULTZ 1964).

Pesticide residues were found in heaviest concentration in new fields, old-farm fields, run-offs and drainage ditches. Since over 60% of the land area of the west Alabama counties of Greene, Sumter and Marengo is farmland while 27% of Tuscaloosa County and 42% of Pickens County are farmland, pesticide usage and environmental contamination are of major importance.

SUMMARY

The types and levels of pesticide residues in soil samples from five west Alabama counties were determined. Soil samples were taken randomly from preselected sites in each county and were analyzed by gas chromatography. Pesticide residues were found in all samples examined, even soil samples from areas where records indicated that no pesticides had been applied directly. The most prevalent chlorinated hydrocarbons were benzene hexachloride and aldrin while the most abundant organophosphate was malathion.

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