The Loss of Phosdrin and Phorate Insecticides from a Range of Soil Types*

by R. G. BURNS
Department of Soils and Plant Nutrition
University of California
Berkeley, Calif. 94720

Organo-phosphorus insecticides are frequently used for the control of soil insects. In consequence, a knowledge of the factors influencing their persistence in this environment is of prime importance.

Previous studies have indicated that many factors, including soil water (1,2), pH (3), microflora (4,5,6), inorganic matter and organic matter (7,8,9), influence the rate of insecticide loss. Generally larger amounts of pesticide need to be added to soils high in organic matter and clay to produce the same pest control as would result from the addition of low quantities of the chemical to other soils. Both clay and organic matter have high adsorption capacities and it is desirable to compare rates of insecticide disappearance in a wide range of soil types in an attempt to better understand the complex relationships between soil inorganic and organic matter and pesticide loss.

MATERIALS AND METHODS

The five Sacramento Delta soils used throughout the course of these investigations are described in Table 1.

TABLE 1. CHARACTERISTICS OF SACRAMENTO DELTA SOILS

Soil type	% Clay	% O.M.	pH	CEC Meq/100 g
Sand	1.4	0.39	5.4	3.25
Clay	27.4	2.11	5.9	37.50
Muck	13.2	24.36	4.9	56.75
Peat	7.8	38.36	4.1	50.00
Peat/Sand	8.6	13.41	3.4	42.00

*This work was supported in part by Public Health Service Grant ES 00054.

The insecticides phosdrin [0,0-dimethyl 0-(2-carbomethoxy-1-methylvinyl)] phosphate and phorate (0,0-diethyl S-ethylthiomethyl phosphorodithioate) were of analytical grade and purchased from Polyscience Corporation of Evanston, Illinois.

0.2 mg of insecticide in 0.5 ml of hexane was added to 2 g of air-dry soil in a 25 ml Erlynmeyer flask. The solvent was allowed to evaporate and the soil thoroughly mixed. The soils were held at 75% water holding capacity and aged at room temperature. Sterile controls were run concurrently by autoclaving like quantities of moist soil for 30 minutes at 15 psi. After a suitable cooling period insecticide was added aseptically using a disposable syringe.

To extract the insecticide, 10 ml of Nanograde acetone and 5 g of sodium sulfate was added to the 2 g of soil and shaken for 15 minutes. Ten ml of Nanograde hexane was then added, the flask stoppered, and the suspension agitated on a shaker for 24 hours. The extract was then centrifuged to remove the suspended soil and the solvent/pesticide fraction reduced to 10 ml and stored in a volumetric flask until measurement. It was found that further "clean-up" procedures were unnecessary. Using this method, recovery rates for phorate of 98% (±5%) and for phosdrin of 91% (±5%) were achieved and found to be independent of soil type.

The gas chromatograph used for quantitive determination of the insecticides was a Varian Aerograph 204B connected to a Varian 20 chart recorder. The hydrogen flame detector was adapted for phosphorus analysis by the addition of a cesium bromide pellet to the top of the quartz tip. A glass column 3 ft by 1/8" was packed with D.C. 200 5% b/w on 70-80 mesh Chromosorb G. Nitrogen was used as the carrier gas at a flow rate varying from 20-25 ml per minute. The hydrogen flow rate was 15 ml per minute and the air flow was 175 ml per minute. The injector column temperature was between 220° and 235°C. The detector was constant at 220°C. Operating parameters varied within the ranges described depending upon the insecticide being measured.

RESULTS

I. Phosdrin

Soils were incubated for 0, 3, 6, 12, 48, 72, 96 and 144 hours. The results are represented in Table 2 and indicate a rapid loss of insecticide from the muck, clay and peat soils and a somewhat slower rate of disappearance from the peat/sand and sand soils.

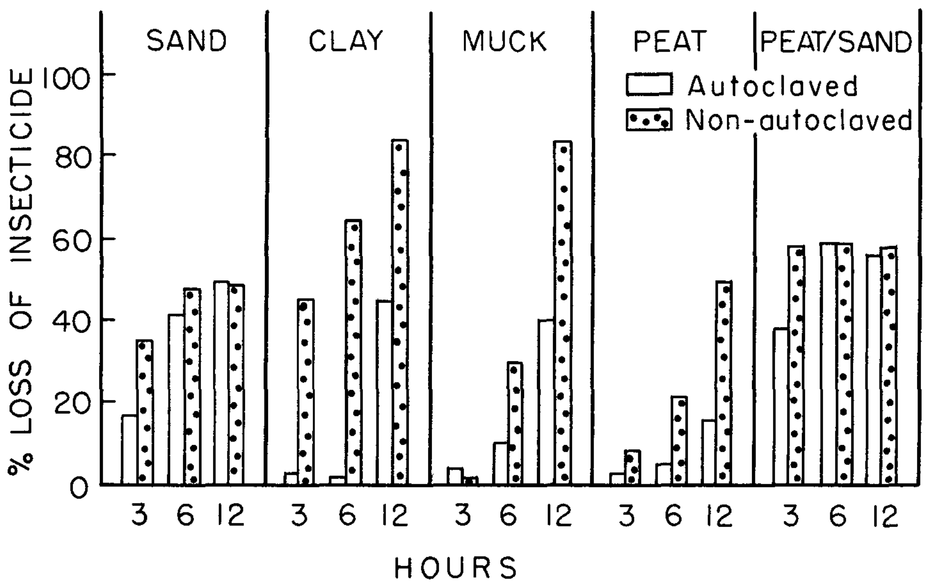
TABLE 2. THE LOSS OF PHOSDRIN FROM FIVE SOILS

Hours	Clay	Muck	Peat	Peat/Sand	Sand
0	100	100	100	100	100
3	54	100	91	43	66
6	36	70	79	41	52
12	16	18	50	42	51
24	7	7	38	41	39
48	0	0	10	35	31
72	0	0	0	37	26
96	0	0	0	27	21
144	0	0	0	16	12

Figures represent percentage of amount at time zero.

Much of the insecticide loss from the two sandy soils occurs within the first six hours. Figure 1 represents phosdrin losses from autoclaved and non-autoclaved soils during the first twelve hours of the experiment.

FIG. 1. THE LOSS OF PHOSDRIN FROM AUTOCLAVED AND NON-AUTOCLAVED SOILS



Where the difference in loss between autoclaved and non-autoclaved soils is small (peat/sand, sand) the indication is that non-biological pesticide loss is occurring independent of sterilization. It is reasonable to assume these losses are due to volatilization as both leaching (closed system) and adsorption (high and consistent extraction rates) can be disregarded. Where the difference is great (clay, muck, peat) it would appear that biological loss of insecticide has occurred. It can be seen that pesticide levels in the autoclaved soils are on the decrease at the 12-hour mark and it is probable that autoclave-induced sterility is somewhat ephemeral and biological degradation is beginning to occur. This conclusion is supported by the observation that losses from both autoclaved and non-autoclaved soils are essentially the same after approximately 36 hours.

II. Phorate

In using this comparatively persistent insecticide, soils were aged for 0, 1, 2, 3, 6, 12, 24, and 48 days. The results are shown in Table 3.

TABLE 3. THE LOSS OF PHORATE FROM FIVE SOILS

Days	Clay	Muck	Peat	Peat/Sand	Sand
0	100	100	100	100	100
1	94	98	98	83	81
2	83	95	97	75	72
3	72	99	86	74	59
6	65	92	89	75	57
12	56	93	98	74	61
24	44	85	89	71	61
48	24	82	77	66	53

Figures represent percentage of amount at time zero.

The results, as in the phosdrin experiment, show disappearance rates to be most rapid from the clay soil. The losses from muck and peat soil are somewhat slower, whilst both sand and peat/sand again show high volatilization losses during the early stages of the experiment.

CONCLUSIONS

Let us consider the two major effects of organic matter in studies of this nature. A certain minimum level of soil organic matter is necessary for microbial maintenance and to present the pesticide with an active population of degraders. However, the adsorption capacity of organic matter is considerable and may, in some instances, serve to retard pesticide loss in much the same way as the clays do.

Evidence presented herein, concerning the disappearance rates of phosdrin and phorate from the clay soil, suggests that the factors accelerating this loss (high microbial activity) outweigh those which may retard it (adsorption). The slower rate of phorate loss from muck and peat soils is probably caused by high adsorption rates due to high levels of organic matter. In contrast to this, phosdrin added to muck and peat soils disappeared at much the same rate as when added to the clay soil. It is suggested that adsorption onto organic matter may be less tenuous with some insecticides (phosdrin) than with others (phorate). Desorption from organic matter surfaces, in relation to microbial breakdown rates, has been recently proposed for the bipyridylium herbicides (10,11).

Loss of phosdrin is ultimately slowest from the peat/sand and sand soils. In the former retardation may be due to organic matter adsorption; in the latter because of a low microbial content brought about by the paucity of organic matter. In both soils and with both insecticides the high sand content is largely responsible for initial volatilization losses. It is of importance to note the pH of the soils used and to keep in mind how it may also affect both adsorption and microbial activity.

A large number of carefully planned studies of this nature will need to be carried out before any definite relationships can be proposed. However, generally speaking, pesticide disappearance from soils with high CEC will be slow, and it is clear that the two major components contributing to this CEC (organic matter and clay) have both an individual and a joint affect upon pesticide loss.

REFERENCES

1. Harris C. R. J. Econ. Entomol. 57 946-950 (1964).
2. Harris C. R. J. Econ. Entomol. 60 41-44 (1967).
3. Griffiths D. C. Rept. Rothamsted Expt. Station (1968).
4. Ahmed M. K. and Casida J. E. J. Econ. Entomol. 51 59-63 (1958).

5. Lichtenstein E. P. and Schulz K. R. J. Econ. Entomol. 57 618-627 (1964).
6. Matsumura F. and Boush G. M. Science 153 1278-1280 (1966).
7. Getzin L. W. and Chapman R. K. J. Econ. Entomol. 53 47-51 (1960)
8. Harris C. R. J. Econ. Entomol. 59 1221-1225 (1966).
9. Edwards C. A. Soils and Fert. 27 451-454 (1964).
10. Burns R. G. and Audus L. J. Weed Res. 10 49-58 (1970).
11. Damanakis M., Drennan D. S. H., Fryer J. D. and Holly K. Weed Res. 10 264-277 (1970).