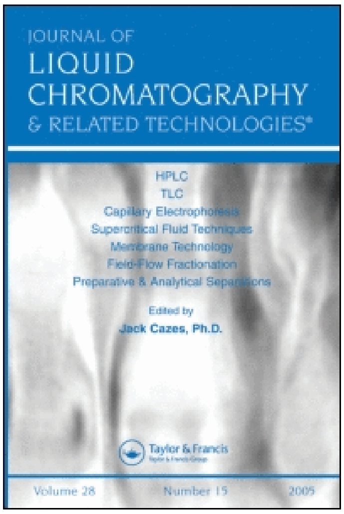

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Effect of Different Salt Leachates on the movement of some Carbamoyl Groups Containing Pesticides in Soils using Thin-Layer Chromatography

S. R. Sharma[a]; R. P. Singh[ab]; S. K. Saxena[ab]; S. R. Ahmed[a]
[a] Chemical Laboratory, Faculty of Engineering and Technology Aligarh Muslim University, Aligarh, India [b] Soil Chemist Department of Botany, Aligarh Muslim University, Aligarh, INDIA

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EFFECT OF DIFFERENT SALT LEACHATES ON THE MOVEMENT OF SOME CARBAMOYL GROUPS CONTAINING PESTICIDES IN SOILS USING THIN-LAYER CHROMATOGRAPHY

S. R. Sharma, R. P. Singh*, S. K. Saxena**, and S. R. Ahmed

Chemical Laboratory
Faculty of Engineering and Technology
Aligarh Muslim University
Aligarh 202001, India

ABSTRACT

The influence of pH, leachates of alkaline and saline salts, inorganic fertilizers and surfactants on the mobility of five carbamoyl group containing pesticides, viz. aldicarb, bavistin, carbofuran, dimecron and oxamyl has been studied using soil thin layer chromatographic technique. The variation in the movement of pesticides under different solvent amendments expressed in terms of R_f, R_B and R_M values and explained on the basis of adsorption and leachability.

* Soil Chemist; ** Professor, Department of Botany, Aligarh Muslim University, Aligarh - 202 001 (INDIA)

** Author for correspondence.

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INTRODUCTION

The importance of pesticides in controlling plant diseases for high agricultural production hardly need to be emphasized. When applied to soil their mobility plays a vital role in their efficacy against the target organisms in addition to polluting the environment. The subject of pesticide movement in soil has been nicely reviewed by Bailey and White (1) and Upchurch (2). McCarty and King (3) and Inch et al. (4) have studied the movement of some of the organophosphorus insecticides in soil columns. Helling and Turner (5), Helling (6,7,8) used TLC method involving the use of radioactive pesticides followed by measurement of mobility with radio-active scanning for evaluation of pesticide mobility in soils. Singh et al. (9,10,11), however, used this technique for determining the movement of certain nematicides in soils with simple chemical detectors. Despite this there are several pesticides specially carbamoyl group containing pesticides for which the movement has not been studied more particularly in Indian soils.

Hence, the present investigation has been designed to study the effect of different salt and fertilizer leachates (which are generally found in soil and used for crop improvement) on the movement of aldicarb, bavistin, carbofuran, dimecron and oxamyl.

MATERIALS AND METHODS

The soils used in these studies were surface samples of silt loam and sandy loam soils of Aligarh district. The physico-chemical properties of soils were determined by standard techniques and are summarized in Table I.

The soil used was ground in a hammer mill fitted with a 100 mesh seive to obtain samples with a small and nearly homogeneous particle size. The plates were coated with water slurry of the soil (0.5 mm thickness) by using a commercial TLC spreader. The plates were then air dried. Two lines at 3 and 13 cms above the base were scribed so that the standard development distance of 10 cm was used in all the plates. Aldicarb (2-methyl-2-(methylthio) propionaldehyde O-(methylcarbomoyl) oxime); bavistin (methyl 2-benzamidazole-carbamate); carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl carbamate); dimecron (O,O-dimethyl O-(2-chloro-2-diethyl-carbamoyl-1-methylvinyl) phosphate and oxamyl (methyl N'-N'-dimethyl-N (methyl carbamoyl) oxy-1- thio oxamimidate) were applied to the soil as a spot 3 cm from the bottom of the plates using lambda pipette. A strip of paper towel, about 2 cm wide moistened with distilled water was wrapped around the bottom of the plates. The loaded plates were then developed by ascending chromatography in a glass tank. The development was done for 3 hrs. for silt loam soil and 1 hr for sandy loam soil.

$CaSO_4$, $MgSO_4$, Na_2SO_4, Na_2CO_3, $NaHCO_3$, KCl, NH_4NO_3 and $NaNO_3$ of 0.01 M, 0.05 M concentration were used as

Table I. Composition and physico-chemical properties of soils

Soil type	Mechanical composition			pH	Organic matter	CEC in meq per 100 g
	Sand	Silt	Clay			
Silt loam	32.1	50.4	17.4	8.6	1.05	18.5
Sandy loam	70.2	7.0	22.8	8.8	0.35	9.0

developers to study the effect of different salts on mobility.

For studying the effect of pH on the developers the distilled water with original pH (pH 7) and pH adjusted to 4 and 10 with 0.1N HCl and 0.1N NaOH was used.

The effect of cationic, anionic and non-ionic surfactants was studied by using the solution of cetyl trimethyl ammonium bromide, sodium dodecyl sulphate and manoxol 'OT' of 0.5% and 1.0% concentration were used as leachates.

The developed plates were air dried at room temperature. Aldicarb, bavistin, carbofuran and oxamyl were detected by spraying the plates with 5% methanolic KOH followed by 0.1% p-nitrobenzenediazonium tetrafluoroborate while dimecron was detected with 0.5% brilliant green in acetone. Violet coloured spots developed for aldicarb, bavistin and carbofuran while oxamyl was detected as an orange spot. For the dimecron pale yellow spot was obtained on dark green background.

The movement of pesticides was expressed in terms of R_f (12), R_B (13) and R_M (14) values as

$R_f = \frac{1}{10}(\frac{R_T - R_L}{2})$ where R_T and R_L denote the tailing and lateral fronts respectively;

$$R_B = \frac{\text{Distance moved by bottom of spot}}{\text{Distance travelled by developer}}$$

and $R_M = \log(\frac{1}{R_f} - 1)$

RESULTS AND DISCUSSION

Results on the spots of various pesticides, indicating tailings and lateral movements developed on soil TLC plates with distilled water (adjusted to pH 4, 7 and 10) as developer and different saline and alkaline salts, fertilizers and surfactant solutions used as leachates and shown in Tables II-VI. By and large, the movement of all the pesticides was greater in sandy loam soil than silt loam soil when distilled water was used as developer, probably the later being rich in organic matter and clay content than the former. Based on R_f, R_B and R_M values the highest movement of dimecron was observed in silt loam soil while that of aldicarb in sandy loam soil. Highest R_M values of oxamyl is indicative of the fact that its movement was least in both the soils. On the basis of R_M values the movement of pesticides follows the order dimecron $>$ aldicarb $>$ bavistin $>$ carbofuran $>$ oxamyl in silt loam soil and aldicarb $\gg$ carbofuran $>$ dimecron $>$ bavistin $>$ oxamyl in sandy loam soil.

Results on the effect of pH of the developers on the movement of the pesticides are given in Table III. The R_f and R_B values for aldicarb increased while the R_M values decreased at extreme ranges of pH (pH 4 and pH 10) in silt loam soil. A reverse trend was observed in sandy loam soil. However, the movement of bavistin remained unaffected at pH 10 while at pH 4 the R_M values decreased in both the soils. On the other hand, the

Table II. Movement of different pesticides in soils using distilled water as developer (movement expressed as R_f, R_B and R_M)

Pesticides	Soils	R_f	R_B	R_M
Aldicarb	A	0.76	0.66	-0.50
	B	0.87	0.84	-0.83
Bavistin	A	0.70	0.57	-0.37
	B	0.75	0.64	-0.48
Carbofuran	A	0.70	0.55	-0.37
	B	0.87	0.78	-0.83
Dimecron	A	0.81	0.72	-0.63
	B	0.84	0.75	-0.72
Oxamyl	A	0.66	0.50	-0.29
	B	0.69	0.52	-0.35

A = Silt loam soil; B = Sandy loam soil.

Table III. Effect of pH on the movement of pesticides in soils using different pH leachates (movement expressed as R_f, R_B and R_M)

Pesticides	Soils	pH 4			pH 7			pH 10		
		R_f	R_B	R_M	R_f	R_B	R_M	R_f	R_B	R_M
Aldicarb	A	0.83	0.72	-0.69	0.76	0.66	-0.50	0.82	0.74	-0.66
	B	0.85	0.76	-0.75	0.87	0.64	-0.83	0.75	0.67	-0.48
Bavistin	A	0.65	0.45	-0.27	0.70	0.57	-0.37	0.66	0.50	-0.29
	B	0.76	0.63	-0.50	0.75	0.64	-0.48	0.62	0.36	-0.21
Carbofuran	A	0.60	0.40	-0.17	0.70	0.55	-0.37	0.59	0.47	-0.16
	B	0.77	0.65	-0.52	0.87	0.78	-0.83	0.39	0.00	0.19
Dimecron	A	0.78	0.65	-0.55	0.84	0.72	-0.72	0.74	0.60	-0.45
	B	0.68	0.45	-0.33	0.86	0.75	-0.79	0.70	0.54	-0.37
Oxamyl	A	0.56	0.28	-0.10	0.66	0.50	-0.29	0.33	0.15	0.31
	B	0.60	0.33	-0.18	0.69	0.52	-0.35	0.36	0.08	0.25

A = Silt loam soil; B = Sandy loam soil.

Table IV. Variation in R_f, R_B and R_M values with variation in the concentration of different salts in the mobile phase (movement expressed as R_f, R_B and R_M)

Pesticides	Soils	0.01M			0.05M		
		R_f	R_B	R_M	R_f	R_B	R_M
		(a) Calcium sulphate					
Aldicarb	A	0.82	0.73	-0.64	0.84	0.78	-0.72
	B	0.88	0.84	-0.87	0.94	0.88	-1.19
Bavistin	A	0.72	0.58	-0.41	0.79	0.69	-0.58
	B	0.80	0.71	-0.60	0.82	0.73	-0.66
Carbofuran	A	0.77	0.65	-0.52	0.74	0.68	-0.45
	B	0.81	0.72	-0.63	0.83	0.70	-0.69
Dimecron	A	0.83	0.70	-0.69	0.85	0.73	-0.75
	B	0.91	0.82	-1.00	0.92	0.84	-1.06
Oxamyl	A	0.71	0.69	-0.39	0.75	0.70	-0.48
	B	0.70	0.54	-0.37	0.61	0.42	-0.19
		(b) Magnesium sulphate					
Aldicarb	A	0.89	0.84	-0.91	0.87	0.75	-0.83
	B	0.83	0.74	-0.69	0.85	0.77	-0.75
Bavistin	A	0.80	0.70	-0.60	0.74	0.61	-0.45
	B	0.75	0.64	-0.48	0.76	0.65	-0.50
Carbofuran	A	0.85	0.74	-0.75	0.76	0.63	-0.50
	B	0.76	0.67	-0.50	0.78	0.68	-0.55
Dimecron	A	0.75	0.56	-0.48	0.86	0.76	-0.79
	B	0.67	0.48	-0.31	0.76	0.63	-0.50
Oxamyl	A	0.69	0.55	-0.34	0.73	0.62	-0.43
	B	0.72	0.60	-0.41	0.56	0.39	-0.10

continued ...

Table IV. continued ...

Pesticides	Soils	0.01M			0.05M		
		R_f	R_B	R_M	R_f	R_B	R_M
		(c) Sodium carbonate					
Aldicarb	A	0.87	0.78	-0.83	0.91	0.83	-1.00
	B	0.91	0.85	-1.00	0.82	0.72	-0.66
Bavistin	A	0.82	0.72	-0.66	0.86	0.80	-0.77
	B	0.82	0.72	-0.66	0.72	0.52	-0.41
Carbofuran	A	0.65	0.50	-0.27	0.81	0.70	-0.63
	B	0.85	0.74	-0.75	0.82	0.74	-0.66
Dimecron	A	0.92	0.83	-1.06	0.89	0.80	-0.91
	B	0.70	0.50	-0.37	0.86	0.76	-0.79
Oxamyl	A	0.70	0.60	-0.37	0.69	0.52	-0.34
	B	0.77	0.67	-0.52	0.82	0.75	-0.66
		(d) Sodium bicarbonate					
Aldicarb	A	0.84	0.77	-0.72	0.88	0.79	-0.87
	B	0.90	0.80	-0.95	0.83	0.75	-0.69
Bavistin	A	0.80	0.70	-0.60	0.80	0.68	-0.60
	B	0.80	0.70	-0.60	0.78	0.68	-0.55
Carbofuran	A	0.71	0.59	-0.39	0.79	0.67	-0.58
	B	0.87	0.73	-0.83	0.79	0.67	-0.58
Dimecron	A	0.91	0.82	-1.00	0.88	0.76	-0.87
	B	0.93	0.85	-1.12	0.88	0.76	-0.87
Oxamyl	A	0.70	0.57	-0.37	0.72	0.57	-0.41
	B	0.75	0.65	-0.48	0.72	0.57	-0.41

continued ...

Table IV. continued ...

Pesticides	Soils	0.01M			0.05M		
		R_f	R_B	R_M	R_f	R_B	R_M
(e) Sodium sulphate							
Aldicarb	A	0.80	0.71	-0.60	0.83	0.75	-0.69
	B	0.87	0.80	-0.83	0.92	0.84	-1.06
Bavistin	A	0.70	0.60	-0.37	0.78	0.68	-0.55
	B	0.77	0.64	-0.52	0.77	0.64	-0.52
Carbofuran	A	0.68	0.53	-0.33	0.72	0.59	-0.41
	B	0.80	0.69	-0.60	0.79	0.71	-0.58
Dimecron	A	0.90	0.79	-0.95	0.91	0.82	-0.66
	B	0.85	0.72	-0.75	0.88	0.75	-0.87
Oxamyl	A	0.61	0.43	-0.19	0.67	0.49	-0.31
	B	0.65	0.48	-0.27	0.59	0.35	-0.16

A = Silt loam soil; B = Sandy loam soil.

Table V. Variation in R_f, R_B and R_M values with variation in the concentration of fertilizers in the mobile phase (movement expressed as R_f, R_B and R_M)

Pesticides	Soils	0.01M			0.05M		
		R_f	R_B	R_M	R_f	R_B	R_M
		(a) Ammonium nitrate					
Aldicarb	A	0.84	0.77	-0.72	0.91	0.85	-1.00
	B	0.90	0.80	-0.95	0.85	0.75	-0.75
Bavistin	A	0.78	0.70	-0.55	0.78	0.70	-0.55
	B	0.79	0.70	-0.58	0.63	0.40	-0.23
Carbofuran	A	0.66	0.49	-0.29	0.70	0.53	-0.37
	B	0.81	0.66	-0.63	0.66	0.55	-0.29
Dimecron	A	0.74	0.63	-0.45	0.84	0.72	-0.72
	B	0.83	0.70	-0.69	0.71	0.56	-0.39
Oxamyl	A	0.70	0.57	-0.37	0.65	0.53	-0.27
	B	0.66	0.46	-0.29	0.46	0.40	0.07
		(b) Potassium chloride					
Aldicarb	A	0.82	0.75	-0.66	0.78	0.70	-0.55
	B	0.89	0.81	-0.91	0.73	0.63	-0.43
Bavistin	A	0.79	0.70	-0.58	0.79	0.65	-0.58
	B	0.82	0.68	-0.66	0.78	0.72	-0.55
Carbofuran	A	0.76	0.64	-0.50	0.71	0.58	-0.39
	B	0.81	0.66	-0.63	0.79	0.66	-0.58
Dimecron	A	0.66	0.49	-0.29	0.77	0.67	-0.52
	B	0.81	0.70	-0.63	0.68	0.51	-0.33
Oxamyl	A	0.70	0.60	-0.37	0.61	0.41	-0.19
	B	0.60	0.42	-0.18	0.42	0.19	0.14

continued ...

Table V. continued ...

Pesticides	Soils	0.01M			0.05M		
		R_f	R_B	R_M	R_f	R_B	R_M
		(c) Sodium nitrate					
Aldicarb	A	0.85	0.76	-0.75	0.91	0.87	-1.00
	B	0.92	0.83	-1.06	0.92	0.83	-1.06
Bavistin	A	0.79	0.67	0.58	0.82	0.72	-0.66
	B	0.90	0.82	-0.95	0.83	0.68	-0.69
Carbofuran	A	0.80	0.65	-0.60	0.80	0.72	-0.60
	B	0.87	0.77	-0.83	0.91	0.81	-1.00
Dimecron	A	0.94	0.87	-1.19	0.89	0.78	-0.91
	B	0.87	0.78	-0.83	0.89	0.79	-0.91
Oxamyl	A	0.71	0.57	-0.39	0.71	0.57	-0.39
	B	0.71	0.57	-0.39	0.70	0.53	-0.37

A = Silt loam soil; B = Sandy loam soil.

Table VI. Variation in R_f, R_B and R_M values with variation in the concentration of cationic, anionic and non-ionic surfactants in the mobile phase (movement expressed as R_f, R_B and R_M)

Pesticides	Soils	0.5 %			1.0 %		
		R_f	R_B	R_M	R_f	R_B	R_M
		(a) Cetyl trimethyl ammonium bromide					
Aldicarb	A	0.73	0.61	-0.43	0.83	0.74	-0.69
	B	0.86	0.78	-0.79	0.89	0.81	-0.91
Bavistin	A	0.68	0.55	-0.33	0.76	0.61	-0.50
	B	0.69	0.55	-0.35	0.70	0.58	-0.37
Carbofuran	A	0.54	0.33	-0.07	0.66	0.50	-0.29
	B	0.82	0.65	-0.66	0.84	0.72	-0.72
Dimecron	A	0.78	0.66	-0.55	0.87	0.75	-0.83
	B	0.74	0.63	-0.45	0.89	0.78	-0.91
Oxamyl	A	0.52	0.32	-0.03	0.56	0.40	-0.10
	B	0.60	0.39	-0.18	0.75	0.63	-0.48
		(b) Sodium dodecyl sulphate					
Aldicarb	A	0.68	0.55	-0.33	0.75	0.67	-0.48
	B	0.86	0.79	-0.79	0.74	0.65	-0.45
Bavistin	A	0.66	0.50	-0.29	0.79	0.65	-0.58
	B	0.73	0.55	-0.43	0.71	0.59	-0.39
Carbofuran	A	0.68	0.55	-0.33	0.85	0.73	-0.75
	B	0.76	0.65	-0.50	0.73	0.65	-0.43
Dimecron	A	0.83	0.68	-0.69	0.72	0.66	-0.41
	B	0.84	0.74	-0.72	0.73	0.59	-0.43
Oxamyl	A	0.64	0.50	-0.19	0.68	0.55	-0.33
	B	0.68	0.50	-0.33	0.69	0.50	-0.35

continued ...

Table VI. continued ...

Pesticides	Soils	0.5 %			1.0 %		
		R_f	R_B	R_M	R_f	R_B	R_M
		(c) Manoxol 'OT'					
Aldicarb	A	0.83	0.74	-0.69	0.72	0.63	-0.41
	B	0.87	0.78	-0.83	0.73	0.64	-0.43
Bavistin	A	0.73	0.60	-0.43	0.61	0.45	-0.19
	B	0.82	0.66	-0.66	0.73	0.60	-0.43
Carbofuran	A	0.72	0.55	-0.41	0.56	0.43	-0.10
	B	0.87	0.78	-0.83	0.86	0.78	-0.79
Dimecron	A	0.81	0.72	-0.63	0.77	0.71	-0.52
	B	0.77	0.58	-0.52	0.71	0.57	-0.39
Oxamyl	A	0.63	0.45	-0.23	0.57	0.44	-0.12
	B	0.67	0.50	-0.31	0.62	0.44	-0.21

A = Silt loam soil; B = Sandy loam soil.

movement of carbofuran, dimecron and oxamyl decreased both in acidic and alkaline ranges than neutral range (pH 7). Such a behaviour could be due to the differences in the adsorptive nature of the various pesticides studied at the three pH levels, under study. Non-ionic pesticides used in this study are adsorbed by soils to a greater extent in the acidic and alkaline ranges than the neutral range. Higher adsorption thus resulted in lower mobility of the pesticides with acidic and alkaline leachates than neutral.

The increase in concentration of alkaline and saline salt solutions resulted in the increase in R_f and R_B values and decrease in R_M values of all the pesticides except oxamyl in sodium carbonate in silt loam soil (Table IV). In sandy loam soil the movement of all the pesticides increased in sodium sulphate while decreased in sodium carbonate. With calcium sulphate the movement of carbofuran, dimecron and oxamyl decreased and those of aldicarb and bavistin increased. The movement of aldicarb, carbofuran and oxamyl decreased in magnesium sulphate while those of dimecron and bavistin increased. The movement of dimecron increased while aldicarb, bavistin, carbofuran and oxamyl decreased in sodium bicarbonate.

The average optimal R_M values of carbofuran and oxamyl were obtained in calcium sulphate while those of aldicarb, bavistin and dimecron in sodium carbonate.

The least movement of aldicarb, bavistin and carbofuran was obtained in sodium sulphate except dimecron in silt loam soil and oxamyl in sandy loam soil. These five salts so studied broadly fall into two categories: one with weak base anions, i.e. sulphates and other with strong anions, i.e. carbonates and bicarbonates. The average maximum movement of different pesticides thus can be put in the following order,

Aldicarb: $Na_2CO_3 > NaHCO_3 > MgSO_4 > CaSO_4 > Na_2SO_4$ in both the soils.

Bavistin: $Na_2CO_3 > NaHCO_3 > MgSO_4 > CaSO_4 > Na_2SO_4$ in both the soils.

Carbofuran: $CaSO_4 > MgSO_4 > NaHCO_3 > Na_2CO_3 > Na_2SO_4$ in both the soils.

Dimecron: $Na_2SO_4 \gg Na_2CO_3 > NaHCO_3 > CaSO_4 > MgSO_4$ in silt loam soil and $Na_2CO_3 > NaHCO_3 > CaSO_4 > MgSO_4 > Na_2SO_4$ in sandy loam soil.

Oxamyl: $CaSO_4 > MgSO_4 > NaHCO_3 > Na_2CO_3 > Na_2SO_4$ in silt loam soil and $CaSO_4 > MgSO_4 > Na_2SO_4$ $NaHCO_3 > Na_2CO_3$ in sandy loam soil.

A perusal of Table V shows that when ammonium nitrate, potassium chloride and sodium nitrate were used as leachates, the movement of all the pesticides increased except carbofuran in ammonium nitrate and dimecron and oxamyl in sodium nitrate in silt loam soil. In sandy loam soil there was decrease in the movement of dimecron and oxamyl in sodium nitrate and those of carbofuran, dimecron and oxamyl in potassium chloride. In sodium nitrate the movement of all the pesticides increased in both the soils. With ammonium nitrate the increasing concentration of the leachates correspondingly increased the movement of all the pesticides in silt loam soil while it decreased in sandy loam soil. The movement of all the pesticides decreased with increasing concentration of potassium chloride in leachates. The average of R_M values of different pesticides follows the order KCl > NH_4NO_3 > $NaNO_3$ for aldicarb, dimecron and oxamyl and NH_4NO_3 > KCl > $NaNO_3$ for bavistin and carbofuran.

The results on three surfactants, viz. cetyl trimethyl ammonium bromide (cationic), sodium dodecyl sulphate (anionic) and manaxol 'OT' (non-ionic) on the movement of pesticides in soils are summarized in Table VI. The effect of cationic and anionic surfactants on the R_f, R_B and R_M values indicated that at low concentration of the surfactant, the movement of all the pesticides decreased except dimecron in sodium dodecyl sulphate. With increasing concentration of cationic surfactants, the mobility of all the pesticides increased in both the soils but in case of anionic surfactants a reverse trend was observed in sandy loam soil. When non-ionic surfactant was used as leachates, the mobility of aldicarb, bavistin and carbofuran increased while that of dimecron remains unaffected and oxamyl decreased in silt loam soil while in case of sandy loam soil generally the mobility of all the pesticides decreased. On increasing the concentration of manoxol 'OT' in the mobile phase the movement of all the pesticides decreased. These results are in agreement with the work of Hower (15) and Huggenberger et al. (16) who studied the interaction of clay mineral with montmorillonite and the effect of surfactants on adsorption and mobility of selected pesticides in soils. Variations in the behaviour of pesticides under different conditions could be due to differences in the type of pesticides used in the present study.

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REFERENCES

1. Bailey, G. W. and White, J. L., Residue Reviews, 32, 29 (1970).
2. Upchurch, R. P., Residue Reviews, 16, 29 (1966).
3. McCarty, P. L. and King, H. P., Perdue Univ. Eng. Bull.; Ext. Ser. No. 121, 156 (1966) through Chemical Abstract, 67, 81422x (1967).
4. Inch, T. D., Ley, R. V. and Utley, D., Pestic Sci., 3, 243 (1972).
5. Helling, C. S. and Turner, B. C., Science, 162, 562 (1968).

6. Helling, C. S., Soil Sci. Soc. Amer. Proc., 35, 732 (1971).

7. Helling, C. S., Soil Sci. Soc. Amer. Proc., 35, 737 (1971).

8. Helling, C. S., Soil Sci. Soc. Amer. Proc., 35, 743 (1971).

9. Singh, R. P., Khan, A. M. and Saxena, S. K., Ind. J. Nematol., 7, 140 (1977).

10. Singh, R. P., Khan, A. M. and Saxena, S. K., Nematol. medit., 7, 209 (1979).

11. Singh, R. P., Saxena, S. K. and Khan, A. M., Nematol. medit., 9, 139 (1981).

12. Singhal, J. P. and Singh, R. P., Colloid & Polymer Sci., 255, 488 (1977).

13. Rhodes, D. C., Belasco, I. J. and Pease, H. L., J. Agric. Food Chem., 18, 524 (1970).

14. Bate-Smith, E. C. and Westall, R. G. C., Biochem. Biophys. Acta, 4, 427 (1950).

15. Hower, W. F., Clay and Clay Minerals, 18, 97 (1970).

16. Huggenberger, F., Letey, J. and Farmer, W. J., Soil Sci. Soc. Amer. Proc., 37, 218 (1973).