

Degradation and Persistence of Carbosulfan 25 EC in black, red and alluvial soils

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Abstract: Persistence of carbosulfan was studied under laboratory conditions in black, red and alluvial soils following application @ 5 and 10 mg kg⁻¹. Carbosulfan residues progressively declined with time and reached below detectable level (<0.01 mg kg⁻¹) within 75 days in red and alluvial soil and 90 days in black soil. However, more than 95% of carbosulfan degraded within 60 days after incubation irrespective of the soil type and concentration.

Key words: black soil, red soil, alluvial soil, carbosulfan residues, persistence, degradation, half- life

I. Introduction

Soil is the ultimate sink for bulk of the pesticides and fertilizer applied in agriculture and public health. Once pesticides find its way into the environment, a major part of it comes in contact with soil, where they are either totally deactivated or their biocidal efficacy gets reduced in several ways such as adsorption, leaching, volatilization, decomposition, etc. Thus the reactions and behaviour of pesticides in soils help in its efficient and economic use and also help to develop methods by which deleterious side effect might be counteracted.

Degradation of insecticides varies largely according to the properties of insecticides and soil. An ideal insecticide should persist in the soil, up to the critical period and then should degrade fast to innocuous products without any environmental hazards. Quite often the applied insecticide remains in the soil for longer period posing environmental hazards. Soil type, soil moisture level, soil pH, Soil organic matter and soil microbial activity has a chief role in degradation of insecticides in soil. The carbamate insecticides are slightly to moderately persistent in soils. Almost all carbamate insecticides have half-life of short duration in soils, ranging from only few days to a few weeks. Keeping this in view, a comparative study was undertaken on the degradation and persistence of the insecticide, carbosulfan and their residues in three different types of soil.

II. Materials and Methods

Sampling: Three different soils were collected from different areas of Tamil Nadu Agricultural University. Samples were collected from each of the selected locations using a hand held auger driven to a plough depth of 15 cm. A minimum of 20 cores were taken across the field and bulked together from which a single representative sample of 500 g was taken by quartering technique. Quartering was done by dividing the thoroughly mixed samples into four equal parts. The two opposite quarters were discarded and the remaining two quarters were remixed and the process was repeated until the desired sample size of 500g was obtained. From this, a sub sample of 10g of soil was taken for persistence studies.

The samples collected from the field was shade dried by spreading in a clean sheet of paper after breaking the large clumps, if present with a wooden mallet. Then the soil material was sieved through a 2 mm sieve. The sieved soil materials were stored in a clean container with proper labelling for laboratory analysis.

Degradation and persistence

The representative soil samples were dried at room temperature and sieved through 1 mm mesh. These three different soils were added with 5 and 10 µg g⁻¹ of carbosulfan technical material and incubated under laboratory condition. The samples were analysed for residues on 1, 3, 7, 14, 30, 45, 60, 75, 90, and 105th days after treatment.

Extraction, clean up and estimation: Ten grams of treated soil samples were mixed with 0.3 g activated charcoal, 2g Florisil[®] and 10 g anhydrous sodium sulphate. Glass column of 22 mm x 60 cm was clamped vertically at two places. A cotton plug was inserted at the bottom of the column with the help of a glass rod and 2 cm layer of anhydrous sodium sulphate was packed over it, followed by the soil sample prepared above and again sodium sulphate at the top. After filling, the column was tapped gently to get a uniform packing. The sample was then eluted with 100 ml of hexane: ethyl acetate (7:3) ratio. The elutant was collected in a 250 ml beaker and it was condensed to near dryness.

Derivatisation: The condensed extract was dissolved in 1 ml of reactant solution¹ (1.0 g of 1-fluoro 2,4-dinitrobenzene in 100 ml of acetone) and transferred quantitatively to stoppered 25 x 190 mm test tubes. With this, 15 ml of phosphate buffer solution (phosphate buffer of pH 11 - 25.0 g of Na₂HPO₄ was dissolved in 2480 ml of distilled water and 20 ml of 1 M NaOH solution) was added, mixed well and kept in the water bath and the temperature was maintained at 50°C for 30 minutes. After 30 minutes the test tubes were removed from the water bath, cooled and transferred to a 60 ml separatory funnel. The content was extracted twice with exactly two 25 ml portions of n-hexane and the organic layer was collected and the hexane extracts was condensed and retained for final determination.

Operation parameters: The carbosulfan residues were dissolved in 10 ml of hexane for final injection (2 µl) in Chemito model 2685 Gas Chromatography (GC) equipped with ⁶³Ni electron capture detector (ECD) and fitted with a glass column (3% OV 17) of 1.8 m x 2.0 mm I.D. The operating conditions were as follows: injector port (255 °C), detector (280 °C), oven temperature (235 °C), column temperature (300 °C), carrier gas (nitrogen) 20 ml min⁻¹. Under these operating parameters, the residue of carbosulfan was detected at 8th minute (retention time).

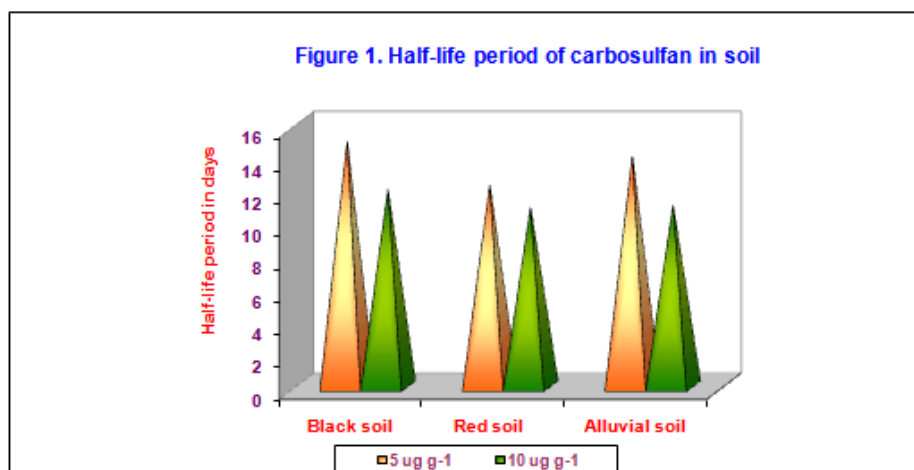
Recovery study: The analytical method of carbosulfan was standardized with the known purity standards in gas chromatography. Recovery studies were conducted to assess the validity of the present method. Ten gram of the three different soil samples were fortified at 0.5, 1.0 and 1.5 µg g⁻¹ of carbosulfan technical grade (92.5% purity) solution. The residues were extracted and estimated as per the method mentioned above and the mean per cent recovery ranged from 85.3, 89.7 and 86.6 per cent for black, red and alluvial soil respectively

III. Results and Discussion

Carbosulfan at 5 and 10 µg g⁻¹ levels degraded to BDL at 75 days after application in red and alluvial soils and 90 days after application in black soil indicating the higher persistence of carbosulfan in black soil (Table:1). The initial deposit after 1 day of application in black soil was 4.44 and 9.27 µg g⁻¹ for the levels of 5 and 10 µg g⁻¹, which was degraded to 0.09 and 0.12 µg g⁻¹ at 75 days after application. In red and alluvial soil, the initial deposits of 3.61, 4.17 and 8.90, 9.02 µg g⁻¹ at 5 and 10 µg g⁻¹ levels of carbosulfan after 1 day, degraded respectively to 0.09, 0.18 and 0.12, 0.13 µg g⁻¹ at 60 days after application. Hence it is evident from the results that carbosulfan at 5 and 10 µg g⁻¹ levels degraded below detectable levels at 90 days after application in the three different types of soils viz., red, black and alluvial soil.

Table: 1 Degradation and persistence of carbosulfan in soil

DAT	Black soil				Red soil				Alluvial soil			
	5 (µg g ⁻¹)		10 (µg g ⁻¹)		5 (µg g ⁻¹)		10 (µg g ⁻¹)		5 (µg g ⁻¹)		10 (µg g ⁻¹)	
	R	% D	R	% D	R	% D	R	% D	R	% D	R	% D
1	4.44	11.2	9.27	7.3	3.61	27.8	8.90	11.0	4.17	16.6	9.02	9.80
3	4.07	18.6	8.05	19.5	3.15	37.0	7.80	22.0	3.52	29.6	7.93	20.7
7	3.52	29.6	6.95	30.5	2.77	44.6	6.10	39.0	2.78	44.4	6.58	34.2
15	2.31	53.8	5.12	48.8	1.94	61.2	4.39	56.1	2.13	57.4	4.63	53.7
30	1.39	72.2	3.17	68.3	0.92	81.5	2.80	72.0	1.10	78.0	3.07	69.3
45	0.92	81.5	1.87	81.3	0.55	89.0	1.22	87.8	0.61	87.8	1.46	85.4
60	0.25	95.0	0.46	95.4	0.09	98.16	0.12	98.8	0.18	96.4	0.13	98.8
75	0.09	98.2	0.12	98.8	BDL	100	BDL	100	BDL	100	BDL	100
90	BDL	100	BDL	100	BDL	100	BDL	100	BDL	100	BDL	100



Longer persistence was noticed in black soil comparatively. Similar results were reported that the degradation reaction rate constant 'k' was highest in black soil and least in laterite soil². Longer persistence observed in black soils may also due to adsorption of carbosulfan to soil colloids. Similar findings were reported that soil organic matter was the most important factor influencing the adsorption of pesticides in soil^{3,4}.

The residue data pertaining to carbosulfan degradation in soil, when represented by different functions gave significant correlations between time and residues.

The semilog representation of carbosulfan in soil followed first order function with varied doses of carbosulfan irrespective of the soil types. The intercept (a), slope (b) and half-life ($T_{0.5}$) and their upper and lower limits are presented in Table 2. The half-life of carbosulfan ranged from 14.98 to 12.05 days for black soil, from 10.93 to 12.31 days for red soil and from 11.07 to 14.10 days for alluvial soil. Similar report stated that the half-life of carbosulfan varied from 8.8 to 17.5 days indicating the low persistence nature of carbosulfan⁵ (Fig 1).

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Table: 2 Intercept, slope and half -life of carbosulfan in soil

Soil	Dose ($\mu\text{g g}^{-1}$)	a	LL	UL	b	LL	UL	$T_{(0.5)}$	LL	UL	Prediction equation
Black soil	5	6.231	6.644	5.816	-0.460	-0.035	-0.005	14.98	18.38	11.58	$Y=6.231-0.046X$
	10	7.070	7.622	6.518	-0.057	-0.043	-0.715	12.05	17.98	9.12	$Y=7.070-0.057X$
Red soil	5	6.049	6.507	5.591	-0.056	-0.041	-0.071	12.31	15.53	9.105	$Y=6.049-0.056X$
	10	7.010	7.741	6.279	-0.063	-0.039	-0.086	10.93	14.98	6.893	$Y=7.740-0.063X$
Alluvial soil	5	6.071	6.313	5.820	-0.049	-0.041	-0.056	14.10	16.33	11.81	$Y=6.071-0.041X$
	10	7.054	7.871	6.238	-0.062	-0.036	-0.088	11.07	15.69	6.44	$Y=7.054-0.036X$
$T_{(0.5)}$ - Half-life		a - Intercept		b - Slope		LL - Lower limit		UL - Upper limit			

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