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DEGRADATION OF DDT UNDER TROPICAL CONDITIONS

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Abstract

Persistence of ^{14}C-DDT was monitored in field soils of tropical and subtropical climates in São Paulo State, Brazil, and persistence of ^{14}C-DDE - the main metabolite of DDT - was also studied in the subtropical region by nuclear and GLC techniques. In the extracts of soils treated with DDT the main recovered product was ever DDT; DDE represented only 16% of the extractable radioactivity after 16 weeks, and DDD was detected only after 48 weeks. Bound residues amounted to about 10% after 48 weeks. After the same period, extracts from ^{14}C-DDE-treated soils contained only DDE. Thus, the ^{14}C-DDT half life was over 200 weeks in both regions, and of ^{14}C-DDE was about 88 weeks. Parallel laboratory studies confirmed the persistence, as no volatilization or mineralization were detected within 6 weeks at 45 °C. Comparing with experiments equally conducted in other world tropical regions by a research programme coordinated by the International Atomic Energy Agency, this high persistence in Brazilian conditions could be caused by the high acidic nature of the soils.

Presentation

The dissipation and degradation rates of DDT under tropical field and laboratory conditions were studied in tropical environments of different countries, including Brazil, through Research Programmes coordinated by the International Atomic Energy Agency (Vienna, Austria).

In Brazil, experiments were set up in two areas of São Paulo State with no previous history of DDT applications: at latitude 24° 56' S and longitude 45° 20' W (Praia Grande, SP) which soil contained 3.3% organic matter, 61% sand, 14% silt, 25% clay and pH 4.5, and at 23° 30' S and 46° 37' W (São Paulo city, SP), which soil contained 4.3% organic matter, 23% sand, 5% silt, 72% clay
and pH 4.8.

Soil surface contained in hard PVC cylinders (15 cm lenght, 10 cm diameter) driven into field soils received 10 mg of p,p'-DDT and 8 μCi ^{14}C-DDT (equivalent to 13.3 kg/ha), or 2 mg DDE together with 8 μCi of ^{14}C-DDE (equivalent to 2.6 kg/ha). The behaviour of DDT was studied in both regions, but DDE was studied only in São Paulo. Three cylinders were taken out on sampling times up to 72 weeks and the soil columns were weighed, mixed thoroughly, subsamples removed for moisture contents (IAEA, 1986), and for analysis. A sample of the field soil from beneath each tube was also removed for analysis.

The ^{14}C-extractable residues were determined by soxhlet extraction of soil samples (3 x 50 g per tube) with 150 mL methanol and radioactivity determination of 1 mL aliquots. Other 20 mL aliquots of the methanol extracts were extracted with hexane (3 x 10 mL). Part of the hexane was concentrated and applied on thin-layer chromatography plates (TLC - silica gel 60 F_{254}) which were developed with hexane (Sherma & Zweig, 1973). The hexane extracts were also analyzed by gas liquid chromatography (GLC) with an electron capture detector (ECD) using glass column (1.2 m x 2.0 mm i.d.) packed with 2% OV-17 on Chromosorb W (Andréa *et al*, 1994a). Not

extracted or bound residues were determined by combustion of extracted soil samples (3 x 0.5 g per tube) in a Harvey Oxidizer OX-400.
To support field data on ^{14}C-DDT behaviour, laboratory studies were conducted on volatilization, mineralization and binding of ^{14}C-DDT in soil collected from Praia Grande (Andréa *et al,* 1994b). The soil sample (300 g) was rewetted to 65% of the maximum holding capacity one week before the pesticide application.

	^{14}C-residues (% of applied)					
Time	Praia Grande			São Paulo		
Weeks	Extractable	Bound	Extractable + Bound	Extractable	Bound	Extractable + Bound
0	100.0	0	100.0	100.0	0	100.0
1	99.4 ± 6.9	0	99.4	107.1 ± 7.0	0	107.1
2	105.1 ± 3.3	0	105.1	96.2 ± 7.1	2.1 ± 1.5	98.3
3	96.7 ± 7.4	0.5 ± 0	97.2	93.7 ± 3.7	2.2 ± 1.4	95.9
4	90.0 ±14.1	1.0 ± 0.6	91.0	94.5 ± 4.8	1.8 ± 1.6	96.3
6	90.5 ± 5.0	2.7 ± 0.5	93.2	100.5 ± 4.0	2.5 ± 1.8	103.0
8	92.7 ± 5.5	2.7 ± 1.8	95.5	100.5 ± 8.5	1.7 ± 1.2	102.2
10	88.8 ± 2.4	2.4 ± 0.6	91.2	100.1 ± 3.3	1.0 ± 0.5	101.1
16	82.0 ± 6.7	5.6 ± 3.5	87.6	105.2 ± 6.1	1.5	106.7
40	76.3 ± 6.3	5.9 ± 0.9	82.2	95.9 ± 11.2	1.5 ± 0.5	97.4
48	76.0 ± 4.4	6.1 ± 0.9	82.1	83.4 ± 2.7	9.8 ± 4.8	93.2
72	66.7 ± 5.5	9.0 ± 0.5	75.7	49.5 ± 1.2	16.0 ± 0.5	65.5

Table I *Dissipation of ^{14}C-DDT in Praia Grande and São Paulo soils (means of 3 replicates ± S.D.)*

A hexane solution containing 24 mg p,p'-DDT and 16 µCi of ^{14}C-DDT was applied to the soil sample, which was throughly mixed and (6 x) 0.5 g samples were combusted for determination of total ^{14}C. The remainder of soil was placed inside a closed system (Kloskowski *et al*, 1981) to trap $^{14}CO_2$ and ^{14}C-organic volatiles. The system was maintained at 45 °C for 6 hours per day, during 6 weeks. The traps were changed weekly and, after the 6 weeks period, soil samples (6 x 0.5 g) were combusted to determine total ^{14}C.

Time	^{14}C-residues (% of applied)		
weeks	Extractable	Bound	Extractable + Bound
0	100.0	0	100
1	98.5 ± 6.1	0.4 ± 0.4	98.9
2	98.5 ± 3.8	0.8	99.3
3	92.8 ± 3.3	0	92.8
4	101.8 ± 4.6	0.6	102.4
6	95.9 ± 15.2	1.3 ± 0.8	97.2
8	92.9 ± 4.6	1.1 ± 0.6	94.0
10	86.3 ± 3.8	1.4 ± 0.4	87.7
16	82.3 ± 7.5	1.6	83.9
24	80.2 ± 9.4	2.7 ± 2.1	82.9
32	67.8 ± 6.0	4.4 ± 1.4	72.2
40	69.7 ± 6.8	5.1 ± 2.1	74.8
48	62.7 ± 11.1	4.6 ± 0.9	67.3

Table II *Dissipation of ^{14}C-DDE in São Paulo soil (means of 3 replicates ± S.D.)*

Other samples (4 x 50 g) were soxhlet extracted and combusted, as described before, to determine ^{14}C-extactable and ^{14}C-bound residues. At Praia Grande ^{14}C-DDT declined slowly to 82% after 40 weeks, but in São Paulo less than 3% was lost in the same period (Table I).Most of the radioactivity was recovered as extractable (Table I) suggesting a very slow rate of volatilization, and nothing was detected below the tubes. The soil extracts contained 89% of DDT and 11% of DDE at Praia Grande after 48 weeks. DDD (18%) was detected only in the 72 weeks samples, which presented also only 3% of DDE, the rest being DDT. In São Paulo soil extracts, 92.6% were DDT, 4.8% DDE and 2.6% DDD, in the same period.

^{14}C-DDE also declined slowly to 67% after 48 weeks (Table II). Volatilization was faster than of DDT; major residues were only DDE in the extractable form, and bound residues amounted only 5% in the study period.

Calculated half lives of DDT were 206 and 262 weeks for Praia Grande and São Paulo, respectively, and of DDE was 87.8 weeks in São Paulo.

Laboratory experiments indicated absence of ^{14}C-volatiles and $^{14}CO_2$ formed up to 42 days. The ^{14}C-residues (mainly ^{14}C-DDT) were 95.5% ± 1.7% as extractable and 1.8% ± 0.3% as bound.

The long persistence of DDT was demonstrated under field Brazilian conditions, and laboratory experiments proved that there was no volatilization or mineralization. As most results from other tropical countries showed half lives of 2 - 10 months for DDT, Brazilian results were attributed to the high acidic nature of São Paulo soils (IAEA, 1994).

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