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Unusual Persistence of DDT in Some Western USA Soils

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Agricultural use of DDT (1,1,1-trichloro-2,2,2-bis [p-chlorophenyl] ethane) was canceled in 1972. By the late 1970's and early 1980's, the National Soils Monitoring Program of the U.S. Environmental Protection Agency (EPA) was consistently finding higher soil residues of the degradate DDE (1,1-dichloro 2,2-bis[p-chlorophenyl] ethylene) than of parent DDT. Similarly, the U.S. Fish and Wildlife Service (FWS) had been finding during the late 1970's that DDT and related compounds had been decreasing in birds throughout the United States.

However, during the early 1980's, the FWS determined that body burdens of DDE in some avian species were beginning to increase in the desert southwest (Clark and Krynitsky, 1983; White and Krynitsky, 1986). The FWS raised the concern that the increasing avian DDE levels might indicate recent DDT use.

During 1984 and 1985, the EPA and the agriculture departments of Texas and New Mexico, in response to the FWS, conducted soil sampling in 13 areas (see fig. 1) where contaminated birds had been collected. It was agreed that soil samples containing higher levels of DDT than DDE would serve as a possible indicator of illegal DDT use.

This was an intensive soil sampling program; over 236 fields were sampled. The sampling of one field involved taking 50 soil cores. Surprisingly, in a few fields from the region designated number nine, near Dell City, Texas, the concentration of DDT far exceeded that of DDE. In fact, of 96 fields sampled there in 1985, 17 had DDT levels greater than one part per million and each of these fields contained five times more DDT than DDE. None of the other 12 sampling areas contained DDT to DDE ratios greater than one.

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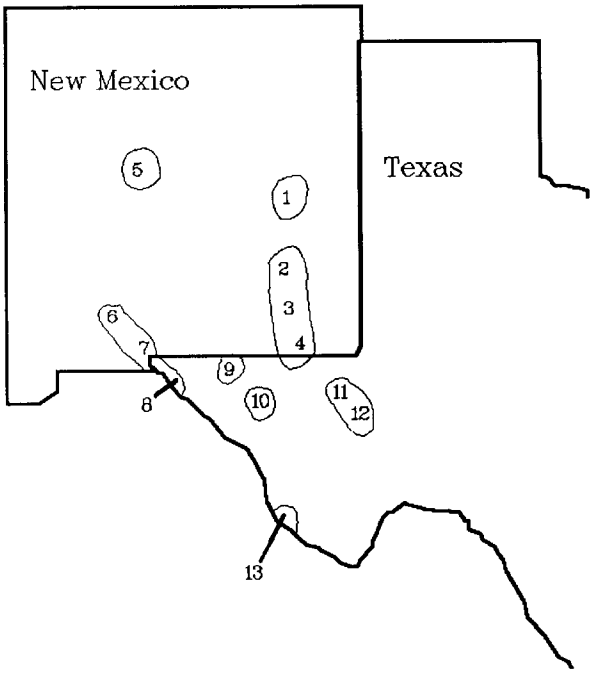

New Mexico
1. Fort Sumner
2. Roswell
3. Artesia
4. Carlsbad
5. Los Lunas
6. Hatch
7. Las Cruces

Texas
8. Fabens
9. Dell City
10. Van Horn
11. Pecos
12. Balmorhea
13. Presidio

Figure 1. Areas where soils were sampled by the agriculture departments of New Mexico and Texas.

A controversy developed as to whether such high ratios of DDT to DDE might corroborate the accusations of recent illegal use of DDT products. Dell City area soils containing higher levels of DDT than of DDE became classified as "suspicious" soils. Soils bearing the expected higher level of DDE were dubbed as "normal."

To resolve the controversy, the authors, in 1989, conducted a DDT soil metabolism study with representative samples of the suspicious and normal soils. It was felt that a soil metabolism study could, once and for all, determine if there was, indeed, something unusual about the rate at which the suspicious soils degrade DDT.

MATERIALS AND METHODS

Procedures for the soil metabolism study largely followed the methods described by Guenzi and Beard (1976) except that no gas traps were used. The procedure consists of fortifying aliquots of soil with known concentrations of the chemical of interest. These fortified aliquots are, then, incubated, and the increase in concentration of the metabolites is observed after an adequate time period has elapsed. Our experimental design was a comparison of mean increase in DDE levels in suspicious and normal soils which had been uniformly fortified with DDT.

The soils from five Dell City fields (Fields 1-5) were selected for the investigation. These soils were clay loams and visually indistinguishable from each other. In each of the five, the combined residue of DDT and DDE was above two ppm. Fields 4 and 5 had the "normal" ratio of about three times more DDE than DDT, and fields 1, 2, and 3 had levels of DDT that were far higher than the DDE levels.

The original levels of DDT and DDE (parts per million air dry weight) are shown in Table 1 below.

Table 1. Original concentration of DDT and DDE in the study soils

Field #	DDT (ppm)	DDE (ppm)
1	7.17	0.61
2	4.40	0.41
3	3.24	0.36
4	0.56	2.30
5	0.50	2.50

Enough analytical standard DDT was added to bring the five samples up to a nominal concentration of 20 ppm. One hundred and seventy-five ten gram aliquots of these fortified soils were weighed out into small glass vials. Water was added to bring the ten grams of soil in each vial to 1/3 bar moisture. Eighty (sixteen aliquots from each of the five study soils) of these vials containing fortified and moistened soil were capped and frozen. An equal number were placed in an incubator together with 19, ten-gram aliquots of uncontaminated "blank" soil. The incubation began on 11 May 1989. The incubated samples were maintained at 1/3 bar moisture and 40±2°C for 100 days (until 19 August 1989). At the end of 100 days, the frozen and incubated aliquots were analyzed for DDT and DDE. Detections were made using a Hewlett Packard Model 5830 gas chromatograph equipped with an

Table 3. Duncan multiple range test comparison of DDE increases in five west Texas soils (*denotes pairs of groups significantly different at the 0.05 level)

		Versus Field#
Mean	Field#	2 3 1 4 5
0.09	2	
0.10	3	
0.29	1	
1.35	4	* * *
1.84	5	* * * *

We, therefore, conclude that the high levels of DDT and the high ratio of DDT to DDE in some Trans-Pecos soils were, most probably, not caused by illegal use of DDT. According to the results of our study, the cause was, the extremely slow rate at which these soils convert DDT to DDE.

We are not suggesting that the extremely slow degradation of DDT to DDE was a large factor in causing the increase in avian DDE levels which had concerned the U.S. Fish and Wildlife Service. The increasing levels of DDE in birds during the early 1980's are much more easily explained by the overall increase in DDE, per se, in soils throughout the Southwest. DDE is somewhat more volatile than DDT and is, therefore, more easily mobilized from the soil and into the avian food chain (insects, seeds, etc.).

The cause of the slow conversion from DDT to DDE in the Dell City area soils still remains unknown. We can provide some incidental observations to those who wish to investigate the phenomenon further. A map of the Dell City sampling area showed that all the suspicious soils were clustered north and east of the city. We also note that the three "suspicious" soils had field capacities that were at least 30% higher than either of the two "normal" soils. Also, Dr. Kurt J. Irgolic of Texas A & M University *(personal communication)* provided results of inductively coupled plasma analyses of four Dell City soils representing two normal and two suspicious fields. His results show that the levels of several metals (Al, Ba, Cd, Co, Cr, Fe, K and others) were twice as high in the normal soils.

To summarize, there are some agricultural soils near Dell City, Texas, which contain a high DDT to DDE ratio. Our aerobic soil metabolism study clearly indicates that the high ratio is due to the low capacity of the soil to

electron capture detector. The nitrogen flow rate was 20 ml/minute and the OV-17 column was maintained at 215°C. Confirmation was by mass spectroscopy. Recoveries averaged 97.7%(±4.42) and 97.2%(±3.63) for DDT and DDE respectively. Every batch of samples analyzed included at least one fortification for evaluating recovery and one blank sample. All blanks and laboratory fortifications were prepared from Dell City agricultural soils which were free of DDT and DDE contamination.

The samples that had been fortified to 20 ppm DDT and frozen were the "day zero" samples. Those that had been spiked and incubated were the "day 100 samples." The most important statistic to be determined was the "increase in DDE concentration over 100 days." This statistic was derived by subtracting, the average DDE concentration in the "day zero" samples from the DDE concentrations in the "day 100" samples.

These increases were evaluated with a one-way analysis of variance and the mean increases were compared with a Duncan Multiple Range Test. Both statistical tests were conducted with the personal computer version of Statistical Package for the Social Sciences (SPSS Inc., 1988).

RESULTS AND DISCUSSION

The increases in DDE concentration and the comparisons among the five soils are shown in Tables 2 and 3 below. Table 2 shows that the mean increases in DDE levels ranged from approximately 0.09 ppm to 1.84 ppm. Both of the normal soils (Fields 4 and 5) generated several fold more DDE than did the "suspicious" soils. Table 3 presents the results of the Duncan Multiple Range Test with regard to increases in DDE levels. DDE increases for the two normal soils were significantly higher even when the effect of multiple comparisons is considered.

Table 2. Increases in DDE levels (ppm) for five west Texas soils spiked with 20 ppm of DDT and held at field capacity for 100 days

Field#	Number of Replicates	Increase in Mean DDE Levels
1	4	0.29 ±0.16
2	4	0.09 ±0.03
3	4	0.10 ±0.03
4	5	1.35 ±0.20
5	4	1.84 ±0.50

degrade DDT to DDE. We also note that there is some evidence that this slow rate of degradation might be linked to low metal content or high field capacity.

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