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Fate of Parathion in Ground Water in Commercial Cranberry Culture in the New Jersey Pinelands

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The recent increase in public concern over contamination of ground water has led to a reconsideration of pesticide uses which might adversely affect water quality. In particular, cranberry culture practices in New Jersey raise an important question of possible contamination which, until recently had not been well investigated. Cranberry bogs require an abundance of pure water and are thus usually located close to streams or lakes. Maintainance of the water table in the cranberry bog at a level close to the soil surface (6 - 12 inches) i.e., a virtually saturated system, is required for the best and most productive growth of the cranberry plant. In addition, bogs are generally flooded with water from about early December to mid May. Flooding serves as a protection against frost damage, as a pest control measure, as a promoter of optimum growth and as a medium for aquatic harvesting. New Jersey's cranberry bogs are located in the Pine Barrens; a sensitive recharge area for the Cohansey Aquifer, a major sole-source aquifer in south-central New Jersey. The potential for contamination of sections of the aquifer by pesticides is very real as insecticide usage is necessary for the production of an economically viable commercial cranberry crop (Marucci 1972).

This paper describes a study which examined the possible contamination of ground water resulting from the recent use of parathion (O,O-diethyl O-4 nitrophenyl phosphorothioate) and its horizontal and vertical movement in the bog soil of the Cohansey aquifer.

MATERIALS AND METHODS

Two cranberry bogs (one experimental and one control) located at the Rutgers' Blueberry and Cranberry Research Center near Chatsworth N.J. were employed in this study. On the control bog (bog no 2), three clusters of three 2 in id wells (0.5, 1.0, 1.5 meter depths) were sunk and five clusters of 2-in id wells (same depths were sunk in the experimental bog (bog no 9) in the pattern shown in figure 1. After the wells were emplaced, they were augered out and stainless steel

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screens were placed at the bottom. Bog no 9 was surveyed in order to establish elevations relative to a fixed datum such that ground water flow vectors could be established. Weekly sampling of all well water commenced on July 10, 1986 with the inclusion of three reservoir sites and three outflow sites. Water sampling was performed on a two week cycle during the winter months.

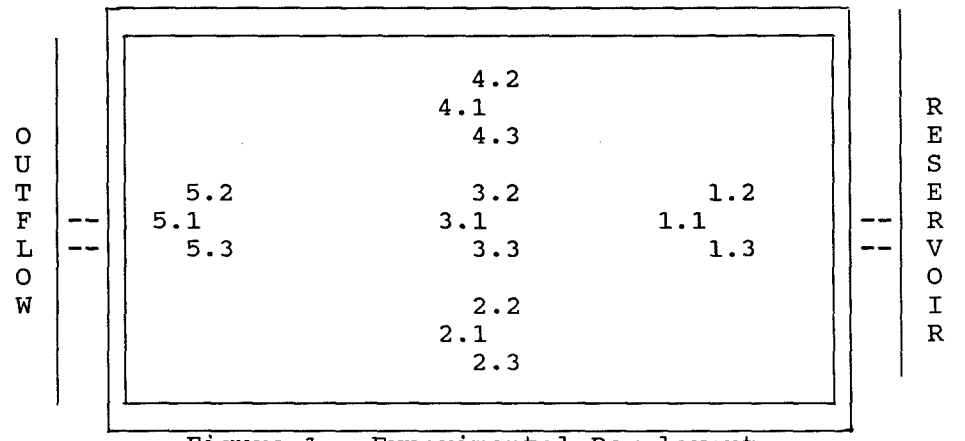

Figure 1. Experimental Bog layout
1,2,3,4,5 - sites of well clusters
0.1 - well depth - 1.5 meters
0.2 - well depth - 1.0 meters
0.3 - well depth - 0.5 meters

All sampling was stopped on June 17, 1987 representing the completion of one year of monitoring the ground and surface waters of the system.
Parathion was applied by spray boom to bog no 9 according to the following schedules:

Spray Schedule - 1986 Growing Season

Date	
June 7	1 pound per acre
July 2	1 pound per acre
July 12	1 pound per acre

Spray Schedule - 1987 Growing Season

The 1986 spray schedule was repeated for the 1987 Season

All water samples (approximately 1 liter) were extracted with 10 mL of Pesticide Grade Hexane and stored in a freezer until analyzed. The analysis of the parathion residues was performed on a Hewlett Packard Gas Chromatograph and a Tracor 570 Gas chromatograph using Electron Capture Detectors. Both instruments were fitted with glass columns 4 ft long and 4 mm id and packed with 1.5% SP 2250/1.95% SP 2401 on 100/120 mesh Supelcoport.

The column flow rates were 45 mL per min of Argon 95%/-Methane 5%, with a column temperature of 225° C, inlet temperature of 225° C and Detector temperature of 350° C. Very good separation was realized with complete resolution back to the baseline between peaks. Core samples from the top six inches of soil were taken from both bogs on October 16, 1988 after the cranberries had been harvested (water floatation method). The samples were sectioned in one inch segments and frozen. A portion of each segment was exhaustively extracted with acetone using the soxhlet extractors and analyzed along with the water sample extracts.

RESULTS AND DISCUSSION

In general, parathion, which was the New Jersey Agricultural Station's recommendation to New Jersey's cranberry growers, showed no discernible vertical movement in the experimental bog from the surface to the ground water (see results displayed in figure 2). In the few cases where ground water residue was found, it was so small and so inconsistent that it may very well have been the result of channeling along the well casing. Despite the fact that the control bog was untreated, an examination of table 1, indicates the presence of parathion residues in certain soil segments. There is an adjacent cranberry farm about one half a mile distant (within eyesight) and upstream where parathion was applied by airplane. Not only was there a visible drift of this spray in the air, but the parathion was also quite probably carried by the stream into the reservoirs which furnished water for all the bogs at the station (See Table 2). This parathion exposure might explain the presence of parathion in the control bog. It is therefore probable that the experimental bog was also affected by these aerial applications.

There appears to be no correlation between the residues found in the surface water (the reservoir and outflow) and soil with those found in the ground water. In addition, well depth also seems to have little correlation with the concentration of parathion found in the ground water. Where residues of parathion are found in the soil, the concentration is highest in the upper stratum. Parathion is relatively insoluble in water but none of the samples showed residues even approaching the maximum solubility. In addition, no paraoxon was found in any of the samples. A previous laboratory study (Winnett et al 1986) employing a one meter column of bog soil demonstrated little vertical transport of parathion. It thus appears that there is little danger of parathion pollution from applications made in normal cranberry culture at these sites. Furthermore, parathion residues in the surface waters show little potential to migrate to the ground water in the Pine Barrens (Cohansey Aquifer).

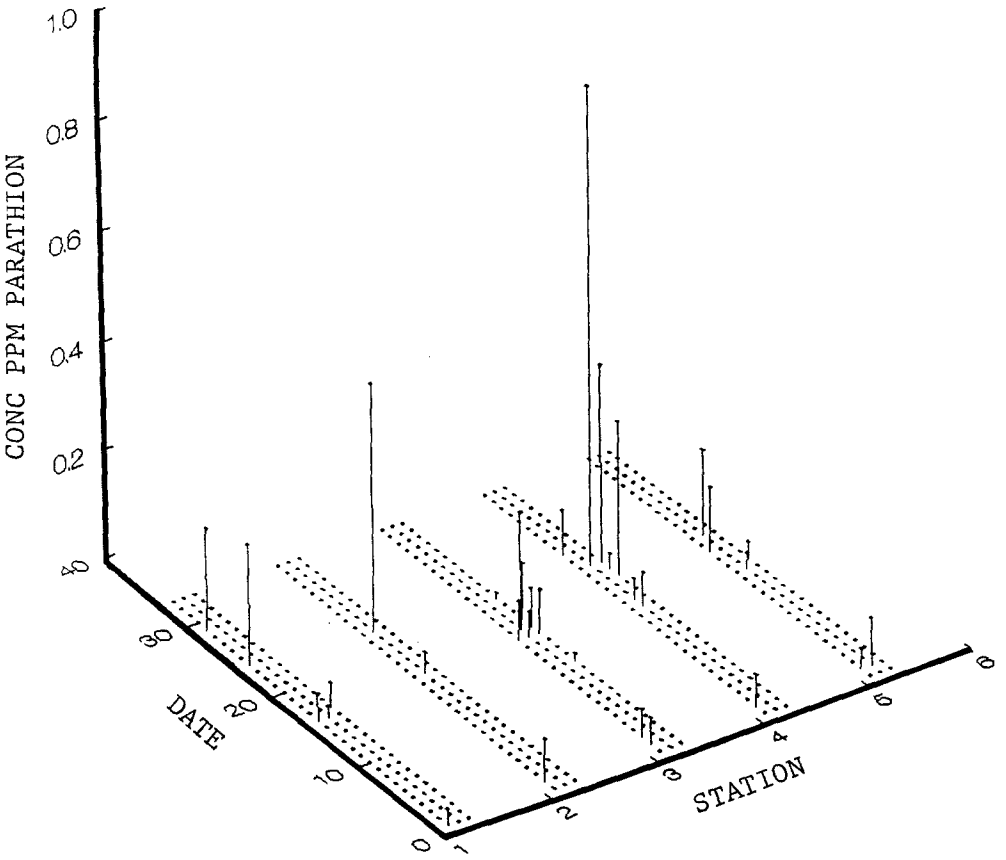

Figure 2 - Parathion Concentration in Bog 9 Groundwater
July 10, 1986 to June 24, 1987

Date Nos 1 - 19, 1 week sampling intervals starting June 10, 1986
Date Nos 20 - 31, 2 week sampling intervals starting December 4, 1986
Date Nos 31 - 33, 1 week sampling intervals starting June 3, 1987
Well 0.1 - 1.5 meter well depth; 0.2 - 1.0 meter well depth; 0.3 - 0.5 meter well depth

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Table 1 Bog Soil Profile Analysis of Parathion, October 16, 1986

Bog	Location	Soil Depth (inches)	Parathion Conc. in soil in ppm
2	Right	0 - 1	0.434
		1 - 2	0.100
		2 - 3	0.023
		3 - 4	trace
		4 - 5	0.003
		5 - 6	ND
2	Center	0 - 1	ND
		1 - 2	ND
		2 - 3	ND
		3 - 4	ND
		4 - 5	ND
		5 - 6	ND
2	Left	0 - 1	0.019
		1 - 2	0.044
		2 - 3	0.021
		3 - 4	0.035
		4 - 5	0.034
		5 - 6	no sample
9	Reservoir End	0 - 1	0.325
		1 - 2	0.072
		2 - 3	0.092
		3 - 4	0.088
		4 - 5	0.064
		5 - 6	no sample
9	Middle of Bog	0 - 1	0.092
		1 - 2	0.043
		2 - 3	0.040
		3 - 4	0.054
		4 - 5	0.071
		5 - 6	0.062
9	Outflow End	0 - 1	0.007
		1 - 2	ND
		2 - 3	0.052
		3 - 4	ND
		4 - 5	ND
		5 - 6	no sample

ND = none detected; Limit of sensitivity is 0.002 ng
trace = less than 0.002 ug/kg

Table 2 Parathion concentration (ug/kg) in reservoir and outflow sites for the period July 10, 1986 to June 24, 1987

Date	Res 1F	Res 2E	Res 2B2	Out 1/9	Out 10/20	Out B
1986						
7/10	0.1687	ND	ND	ND	ND	0.091
7/17	ND	ND	ND	0.0669	0.5162	0.0143
7/24	ND	ND	ND	0.0144	ND	ND
7/31	0.033	0.26	NS	NS	5.42	NS
8/7	ND	ND	ND	ND	ND	0.118
8/14	ND	ND	ND	ND	ND	ND
8/21	ND	ND	ND	0.123	0.165	0.12
8/28	ND	ND	ND	ND	ND	ND
9/4	ND	ND	ND	ND	ND	ND
9/11	ND	ND	ND	ND	ND	ND
9/18	ND	ND	ND	ND	ND	ND
9/25	ND	ND	ND	ND	ND	ND
10/9	ND	0.051	ND	ND	ND	ND
10/16	ND	0.034	0.037	0.945	1.141	0.222
10/23	ND	ND	ND	0.019	ND	0.033
10/30	ND	ND	ND	ND	ND	ND
11/6	ND	ND	ND	ND	0.008	0.041
11/13	trace	ND	ND	ND	ND	ND
11/20	ND	ND	ND	0.027	ND	0.025
12/4	ND	ND	ND	ND	ND	ND
12/18	ND	0.0265	NS	0.052	ND	0.039
1987						
1/14	0.018	0.020	0.025	0.067	0.134	0.090
2/4	ND	ND	ND	ND	0.0102	ND
2/18	ND	ND	ND	trace	ND	ND
3/4	ND	ND	ND	0.0032	0.033	trace
3/19	ND	ND	ND	0.0539	0.018	0.025
4/1	ND	0.0147	ND	ND	ND	ND
4/15	ND	ND	ND	0.0095	0.0319	ND
5/6	ND	ND	ND	0.012	0.0151	ND
5/20	ND	ND	ND	ND	ND	ND
6/3	0.2551	0.4324	0.5823	0.2686	0.2894	0.185
6/10	0.0787	0.1608	0.5823	0.2686	0.2894	0.185
6/17	0.0173	0.0298	0.0120	0.4740	0.0823	0.0795
6/24	ND	ND	ND	0.0129	0.0183	ND

ND = none detected; Sensitivity for Parathion was 0.002 ug/kg
NS = no sample

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