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Survey for Pesticides in Wells Associated with Apple and Peach Orchards in West Virginia

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Commercial apple and peach orchards in the eastern panhandle of West Virginia typically receive 10–13 pesticide applications per year for the control of arthropod pests and diseases. Water used for spray application is obtained primarily from wells located at or near pesticide mixing sites within or adjacent to the orchards.

In a five-year study of rural wells in Ontario, Canada, pesticide contamination resulted from: 1) back-siphoning of spray solution, 2) spills at the mixing site, and/or 3) spray drift or surface runoff from field application (Frank et al. 1987). Out of 40 wells with suspected contamination from pesticides used in orchards, on tobacco or on vegetables, one shallow well contained phosmet residues resulting from surface runoff following application in an orchard (Frank et al. 1987). A spill of 1,2-dibromo-3-chloropropane (DBCP) from a rusty can caused the contamination of a well associated with a South Carolina peach orchard (Carter et al. 1984).

Chemical contamination of wells also may occur through leaching; nitrogen fertilizer is a commonly leached agrichemical (Valiulis 1986). Years of fertilizer application in cherry orchards have resulted in nitrate-N contamination of wells in northern Michigan (Rajagopal 1978).

Depletion of groundwater in limestone caverns can result in the formation of sinkholes which provide a direct route ("run-in") for the transport of pollutants to groundwater (Valiulis 1986). The presence of karst terrain (cavernous limestone) and residential development of orchard land has resulted in increased concern about water quality in the eastern panhandle of West Virginia.

Because of heavy pesticide usage in orchards and the nature of the soil structure in the eastern panhandle, this study

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was conducted during 1985 and 1986 to evaluate wells associated with orchards for pesticide contamination.

MATERIALS AND METHODS

Twenty wells associated with orchards were sampled in the eastern panhandle counties of Berkeley (8), Jefferson (8) and Hampshire (4) of West Virginia. Wells were selected to represent various conditions (Table 1): 1) wells located within and adjacent to orchards; 2) wells located at pesticide mixing sites and various distances from mixing sites; and 3) wells with various use patterns (household only, pesticide mixing only, or both).

Table 1. Well historical data, descriptions, uses, and locations

			Use		Distance (m) from:	
Well no*	Depth (m)	Years in existence	Household	Pesticide mixing	Sprayed orchard	Pesticide mixing site
1	49	70	X	X	In orchard	137
2	25	40+	X	X	15	23
3	95	20+	X	X	15	8
4	69	20+		X	15	8
5	101	1	X		8	>400
6	92	4	X		In orchard	30
7	49	30	X	X	27	12
8	43	20	X		In orchard	at site
9	43	2		X	6	6
10	15	56		X	In orchard	at site
11	90	11		X	In orchard	15
12	76	78	X		61	>400
13	92	25 - 30		X	15	at site
14	55	30		X	In orchard	at site
15	67	37	X	X	15	5
16	15	25+	X	X	In orchard	8
17	73	12	X		32	61
18	67	14	X		30	>400
19**	42**	60**	X		37	92
20	152	20+	X		34	46

*Well locations: 1 to 8, Berkeley County; 9 to 16, Jefferson County; 17 to 20, Hampshire County.

**This well was 18 m deep for the first 37 years of use and deepened to 42 m for use during the last 23 years.

All 20 wells were sampled monthly from May to October during 1985. Three of five wells in which pesticide residues were detected were sampled again in December; the other two were winterized prior to sampling. In 1986, the five wells with detectable pesticide residues were sampled monthly from April to November (except for September). One well, used for drinking, was further sampled during December 1986, and January and February 1987 to confirm pesticide residues.

Samples were collected in either 474 mL or 946 mL mason jars which had been cleaned and rinsed with distilled water and methanol. All samples were obtained from faucets after the pump was allowed to run for one min. Samples were stored in a refrigerator prior to processing.

All water samples collected on or before November 21, 1986, were extracted and concentrated at West Virginia University. Pesticides in water samples of 100-200 mL in 1985 or 800-900 mL in 1986 were adsorbed on 6 mL octadecyl (C_{18}) columns (J. T. Baker Chemical Co., Phillipsburg, NJ), and were eluted with 1.5 to 2.0 mL of methanol. The recovery of terbacil and endrin were 97-101 and 58-67 percent, respectively based on extraction and analysis of fortified water samples of known concentration. This technique was devised for relatively polar pesticides, and the low recovery of endrin was found to be due, in part, to inefficient elution with methanol. Analysis of the extracts for pesticides was performed with gas chromatography at the Quality Control Division of the West Virginia Department of Agriculture (WVDA). Pesticide identity was confirmed by mass spectrometry.

After November 21, 1986, water samples were sent directly to three laboratories for endrin analysis: 1) WVDA; 2) USDA; and 3) WV Environmental Health Services. At the USDA-ARS Analytical Chemistry Laboratory in Beltsville, MD, endrin was adsorbed on octyl (C_8) columns and was eluted with hexane:ethyl ether. At the West Virginia Environmental Health Services Laboratory in Charleston, endrin was extracted with methylene chloride:hexane according to the standard EPA procedure. Quantitation was by gas chromatography. Data presented are uncorrected for percent recovery.

RESULTS AND DISCUSSION

No pesticides were found in 15 of the 20 wells sampled. Five wells contained terbacil residues in 1985, however, no terbacil was detected in samples collected from these wells in 1986 (Table 2). Terbacil is a commonly used herbicide in orchards that was applied through 1984 in orchards 7 and 8, through 1986 in orchards 2 and 9, but never in orchard 10.

Four of the five wells with terbacil residues also had residues of endrin (Table 2). Only one positive sample was obtained from wells 8 and 9 during 1985-86, however, with recently acquired capabilities to analyze for endrin at the WVU College of Agriculture and Forestry, it was detected in three monthly samples during 1987 in well no. 9 (average of 0.1 ppb), whereas samples from well no. 8 were negative. Endrin was consistently detected in samples from well no. 7 (9 positive samples) and no. 10 (6 positive samples) during 1985 and 1986.

Table 2. Terbacil and endrin residues detected in water samples collected from wells associated with orchards in the eastern panhandle area of West Virginia - 1985 and 1986.

Date sampled	Amount of residue (ppb)								
	Terbacil Well no.					Endrin Well no.			
	2	7	8	9	10	7	8	9	10
7-8-85		0.4	1.2	0.7		0.6	0.1	0.1	1.3
8-5-85			1.2			0.4			2.7
9-17-85	0.6	0.4			0.5	0.2			0.7
10-21-85		0.3				0.7			
12-3-85*			NS		NS	1.6**	NS		NS
7-14-86						0.5			2.1
8-14-86						0.2			3.5
10-14-86						0.1			0.8
11-21-86***			NS		NS	1.4	NS		NS

*An attempt was made on 12-3-85 to sample all wells in which pesticide residues were detected on earlier dates to confirm previous findings. Only wells 2, 7, and 9 could be sampled; wells 8 and 10 had been shut down and winterized.

**Mean of two samples (1.2 and 1.9 ppb).

***Wells 8 and 10 were winterized by this date.

NS = No sample. Where no entry occurs, no residues were detected.

Since well no. 7 also supplies a household, it was sampled one additional time in 1986 and twice in 1987 to verify previous findings. The 1986 sample was reported positive for endrin by the WV Environmental Health Services Laboratory (Table 3). All samples collected in two consecutive months in 1987 were also reported positive by this lab, as well as by WVDA and USDA laboratories (Table 3). Residue levels reported, at least once by each lab, were above the maximum allowable contaminate level of 2 ppb established for endrin.

Table 3. Detection of endrin residues in water from well no. 7 by three laboratories - 1986 and 1987.

Date sampled	Amount of residue (ppb)		
	WV Environmental Health Services	WVDA Quality Control Division	USDA Analytical Chemistry Lab (Beltsville)
12-15-86	>2.0	NS	NS
1-21-87	4.0	2.2	1.2**
2-19-87	4.0	1.7*	2.5***

*Mean of two samples (1.6 and 1.8 ppb).

**Mean of two samples (0.7 and 1.7 ppb).

***Mean of two samples (1.3 and 3.7 ppb).

NS = No sample.

A West Virginia Department of Health (DOH) official has determined that well no. 7 does not meet acceptable standards for construction; the well head is below grade in an undrained pit. It is the opinion of the DOH official that endrin contamination most likely occurred as the result of a spill near the well during spray preparation. Although endrin was last used at the site in 1979, well contamination most likely occurred prior to paving the area around the well head in 1975. Subsequent sampling in the vicinity of well no. 7 by the DOH official has revealed endrin in two of six wells sampled, but only in trace amounts (within drinking water standards). The DOH official believes that the contamination of well no. 7 is localized to the immediate well vicinity and has advised the owner on corrective measures.

Endrin residues in well no. 10, as determined by WVDA, exceeded the maximum allowable contaminant level of 2 ppb in three of the six positive samples (Table 2). Since this well was used only for pesticide mixing, follow-up sampling and analysis by the three laboratories was not conducted as with well no. 7. Subsequent sampling of well no. 10 and analysis by the WVU laboratory detected endrin at 1.0, 1.2 and 2.1 ppb in three consecutive monthly samples in 1987. Well no. 10 is located at a pesticide mixing site where pesticide containers were frequently piled as they were emptied during spraying operations. Although properly constructed, this well is quite shallow (Table 1) and could have been contaminated with endrin, which was last used in the early 1970's, as the result of a spill or leaching from empty pesticide containers.

Two of 20 wells sampled (10%) were found to be contaminated with endrin at levels deemed unsatisfactory for drinking purposes. One other well apparently was contaminated but endrin was below the maximum allowable contaminant level. All three wells were used for pesticide mixing and were located at or close to the mixing site. It is likely that contamination of these wells occurred as the result of pesticide mixing operations rather than field use. Improper well construction and disposal of empty pesticide containers are believed to be important contributing factors.

Endrin was commonly used from 1955 to the early 1970's as a single ground application per year for orchard vole control. Although endrin is no longer used, its detection in this study reveals the persistence and potential of this chlorinated hydrocarbon to contaminate groundwater years after use has ceased.

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