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RESEARCH PROJECT SUMMARY

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Occurrence of Agricultural Pesticides in Surface Drinking Water Sources in New Jersey

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ABSTRACT

In order to assess the potential impact of agricultural use of pesticides on surface drinking water sources in New Jersey, water samples were taken from surface drinking water watersheds during 1990, 1992 and 1994. Samples were collected during the growing season, when agricultural runoff of pesticides was most likely. Samples were taken both during base flow conditions (fair weather) and during storm events. Samples were analyzed for a variety of pesticides that are 1) known to be used in the state or 2) are presently regulated or anticipated to be regulated in drinking water. Several pesticides were detected in many of the watersheds, but they generally occurred at concentrations below any health-based criteria. As expected, pesticides were most frequently found in the agricultural watersheds. Only atrazine, simazine and metolachlor were commonly reported. Some non-agricultural watersheds were also found to contain pesticides, which were likely present due to nonagricultural use. Concentrations often were higher during storm events than during base flow conditions.

INTRODUCTION

An increasing number of pesticides are being regulated in drinking water due to U.S. Environmental Protection Agency regulations (McGeorge et al., 1992). While some of the pesticides are no longer used and are not likely to pose a threat to drinking water supplies, others, both regulated and unregulated, are known to be used in New Jersey in watersheds that are used as surface water sources of drinking water. In some parts of the country, pesticide concentrations in surface water due to agricultural runoff are known to be significant (Baker, 1988). Little information is available pertaining to concentrations of pesticides in New Jersey waters resulting from agricultural runoff or other mechanisms. Such information is necessary in order to ascertain if any remedial action or watershed management activities are necessary to enable continued use of these source waters as drinking water supplies in light of the additional regulations.

This project summary reports some of the results of three research projects that investigated the occurrence of both regulated and non-regulated agricultural pesticides in surface waters used as drinking water in New Jersey. More complete discussion of these projects are available in Buxton and Dunne (1993) and Ivahnenko and Buxton (1994).

Many of the watersheds used as sources of surface drinking water were sampled and analyzed for pesticides over the course of the three investigations (Figure 1). In 1990, each of the six watersheds sampled were agricultural in nature. For each watershed, one or two samples were taken during storm events, when pesticide concentrations are expected to be highest (Baker, 1988), and one or two samples were taken during base flow conditions, which are during dry spells when streamflows are low. In 1992, one agricultural and one nonagricultural watershed were sampled more intensively during both storm and base flow periods. One goal of the sampling conducted in 1992 was to investigate more thoroughly the variation in pesticide concentration over the time-course of a storm event (not discussed in this project summary). In 1994, several different watersheds were sampled with a variety of land-use types (residential, rural, urban, agricultural). One of the goals of the 1994 study was to investigate occurrences of pesticides in non-agricultural watersheds. In 1990 and 1992, samples were taken from the flowing river or stream near the point at which the drinking water provider removes its water. In 1994, the samples taken were actually raw water samples submitted by the provider.

Samples were analyzed for pesticides known to be used during agricultural operations in New Jersey, pesticides currently regulated in drinking water, and pesticides that are anticipated to be regulated in the future (Table 1). The analytical method used was in most cases gas chromatography with mass spectrometric confirmation (Rosen et al. 1993). Detection limits for these pesticides were typically in the parts-per-trillion range, well below the health advisories for these chemicals. Thus, the presence of these pesticides at concentrations below any regulated levels could frequently be determined.

RESULTS AND DISCUSSION

Over the course of the three sampling projects, various triazine, acetanilide, carbamate and organophosphorus pesticides were found in measurable quantities (Tables 2-4). However, only three pesticides were commonly reported in multiple locations each year: atrazine, simazine, and metolachlor. Carbaryl, diazinon, isofenphos, cyanazine, linuron and alachlor were each reported a few times. The remaining pesticides were only reported once, and only in the Rahway River watershed.

Generally, the highest measured concentrations were in the sub-parts-per-billion range, well below any health advisories for the chemicals. Upon comparison of the highest measured concentrations of the pesticides with their health advisory limits, it was found that in only one case did a measured concentration exceed the health level (1990, Matchaponix Brook watershed, diazinon). In one other case, the measured concentration was equal to the limit (1994, Oradell Reservoir, metolachlor). Prior and subsequent sampling at these locations yielded only very low or undetectable levels of these pesticides, indicating the transient nature of the elevated concentrations.

In 1990, when only agricultural watersheds were sampled, all samples except one contained measurable amounts of pesticides (Table 2). In agreement with observations by others (Baker, 1988), concentrations measured during storm flow conditions were slightly higher than those during base flow conditions.

In 1992, one agricultural and one non-agricultural watershed was sampled during several storm and base flow events. As might be expected, pesticides were found in the agricultural watershed (Millstone River) but not in the non-agricultural watershed (Shark River).

In 1994, a variety of watershed types were sampled. Surprisingly, one of the two agricultural watersheds sampled (Raritan River) did not show yield any measurable pesticides, as it did in 1990.

Many of the concentrations measured in 1990 were near the limit of detection. It is possible that lower application amounts in the watershed or less favorable runoff conditions in 1994 may have resulted in pesticide concentrations in the surface water to fall below the detection limit. The other agricultural watershed (Delaware and Raritan canal, which passes through the Millstone and Raritan watersheds), showed pesticides, as expected. The Wanaque Reservoir watershed is largely rural and showed no pesticides. The Passaic, Rahway and Oradell Reservoir watersheds do not contain significant agricultural land, but each yielded pesticides in at least one sample. The Passaic River watershed contained mostly organophosphorus pesticides. It is conceivable that the sources of these pesticides are from the numerous sewage treatment plant discharges upstream of the drinking water intake, which may receive waste pesticides from numerous miscellaneous uses by homeowners, industries, and other applicators. The Rahway and the Oradell Reservoir watersheds do not contain sewage treatment plant discharges. However, Oradell reservoir does have two golf courses in the immediate vicinity of the drinking water intakes. Pesticides used on golf courses include alachlor and metolachlor. Rahway river is more puzzling, but the highly urban nature of this watershed leads one to speculate that the pesticides observed result from numerous miscellaneous uses in the watershed. It should be pointed out that the pesticides present in this watershed were predominantly organophosphates, rather than the herbicides commonly used in New Jersey Agriculture..

The pesticide concentrations observed in the watersheds studied were generally in the sub-parts-per billion range and well below any health advisory levels. This is in contrast to other parts of the country, such as the midwest, where extended periods have been observed in which concentrations of certain pesticides remain above advisory levels. The midwest watersheds generally are much larger and much more uniform in their land use (large areas may be planted with corn, for example). In New Jersey, there are very few large areas of uniform agricultural land use, due the typical small size of the farms and the diversity of crops within a watershed. So large sources of a single pesticide are less likely.

RECOMMENDATIONS

It appears that no new substantial management practices are necessary to protect surface drinking water sources from agricultural pesticide contamination. As discussed, above, there were two isolated incidents in which a measured concentration was at or above advisory levels at a particular point in time. When these incidents are observed, it would be prudent to isolate the source of the contamination and make case-by-case adjustments in pesticide management practices where necessary. Measures more substantial than this are not likely to be necessary, due to the brief time spans at which elevated levels of pesticides were observed.

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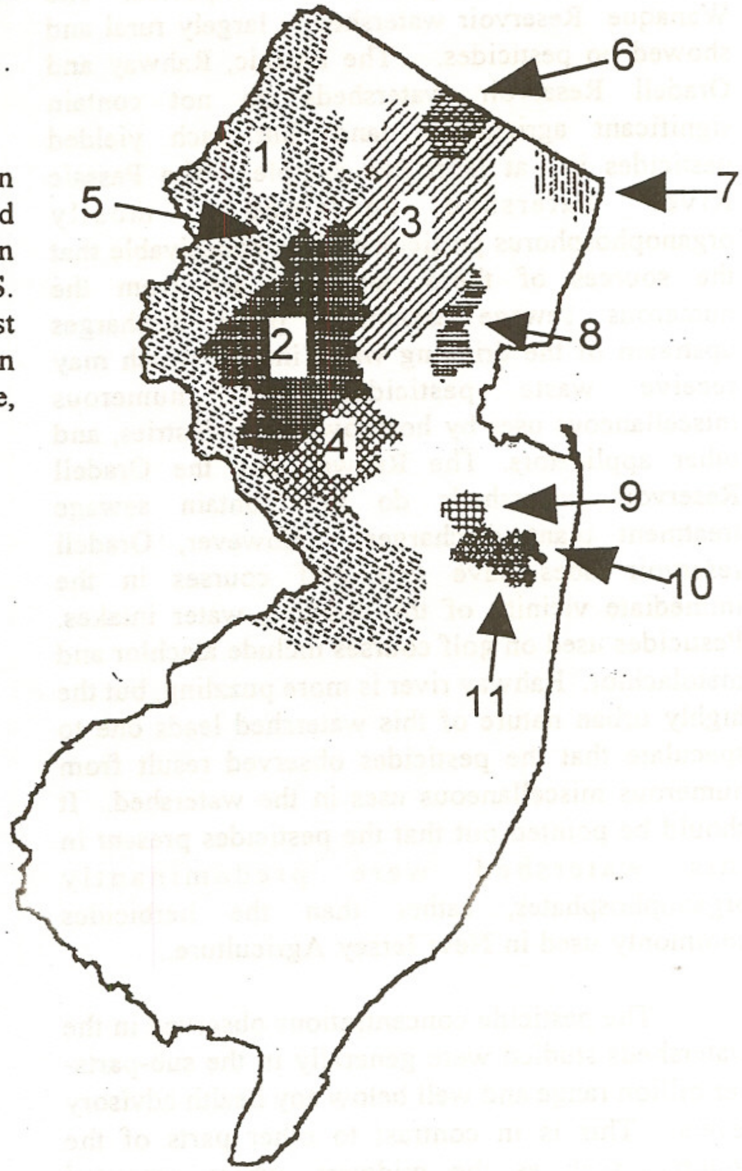

Figure 1. Watersheds sampled during 3-year sampling program. 1, Delaware River; 2, Raritan River; 3, Passaic River; 4, Millstone River; 5, Lower Mine Hill; 6, Wanaque Reservoir; 7, Oradell Reservoir; 8, Rahway River; 9, Matchaponix Brook; 10, Shark River; 11, Manasquan River. Watersheds sampled during 1990: 2,4,5,9,11. Watersheds sampled during 1992; 4,10. Watersheds sampled during 1994: 1, 2, 3, 6, 7, 8. Predominately agricultural watersheds: 2,4,5,9. Largely rural watersheds: 6,7. Largely surban/urban watersheds: 3, 8, 10, 11.

Table 1. Target List of Pesticides

	MCL/Health Advisory (ppb)
Triazines	
Atrazine	3
Cyanazine	9
Metribuzin	
Simazine	1
Acetanilides and related	
Alachlor	2
Linuron	44
Metolachlor	10
Propachlor (a)	
Butachlor (a)	
Metalaxyl (a)	
Carbamates	
Butylate	
Carbaryl	700
Carbofuran	
3-hydroxycarbofuran (a)	
Organophosphates	
Chlorpyrifos	20
Diazinon	0.6
Fenamiphos	
Fonophos	
Isofenphos	
Parathion	
Terbufos	

	MCL/Health Advisory (ppb)
Phenoxy acids	
2,4-D(b)	70
Chlorophenoxyacetic acid (a)	
2,4,5-TP (a)	
2,4,5-T (a)	
DCPA acid metabolites (a)	
Dinitroanilines	
Trifluralin (a)	
Pendimethalin	
Other	
Captan	
Chlorothalonil	
Chlordane (a)	
Heptachlor (a)	
Heptachlor epoxide (a)	
Lindane (a)	
Methoxychlor (a)	
Pentachlorophenol (a)	1
Dinoseb (a)	
Diquat (a)	
Endothall (a)	
Glyphosate (a)	
Picloram (a)	
Dicamba (a)	
Methomyl (a)	
Bentazone (a)	
Bromacil (a)	
4-nitrophenol (a)	
Prometon (a)	

(a) Targeted only in 1994
(b) Targeted in 1990 and 1994

Table 2. Pesticides Found in Agricultural Watersheds Sampled in 1990

Watershed	Number of base flow samples with measurable pesticides/ total samples	Number of storm flow samples with measurable pesticides/ total samples	Pesticides found	Base flow Highest conc. (ppb)	Storm flow Highest conc. (ppb)
Lower Mine Hill	4/4	2/2	Alachlor	0.03	
			Atrazine	0.15	0.61
			Metolachlor	0.04	0.08
Manasquan River	2/2	0/1	Diazinon	0.05	
			Metalochlor	0.03	
Matchaponix Brook	2/2	1/1	Carbaryl	0.33	5.48
			Diazinon	0.21	1.11
			Isofenphos		0.61
			Metalochlor	0.11	0.13
Millstone River	2/2	2/2	Alachlor	0.06	0.13
			Atrazine	0.14	0.18
			Carbaryl	0.23	0.26
			Cyanazine	0.06	0.04
			Linuron	0.25	
			Metolachlor	1.74	2.7
			Diazinon		0.11
			Isofenphos		0.1
Raritan River, main branch	2/2	1/1	Atrazine	0.06	0.06
			Cyanazine		0.07
			Linuron		0.07
			Metolachlor	0.1	0.8
			Simazine	0.05	0.05
Raritan River, south branch	2/2	1/1	Atrazine	0.06	0.26
			Metolachlor	0.05	0.45

Table 3. Pesticides Found in Two Watersheds Sampled in 1992

Watershed	Event	Number of samples wit measurable pesticides/ total samples	Pesticides found	Highest conc. (ppb)
Millstone River (Agricultural)	Base Flow - March 9	0/1	none	
	Base Flow - May 4	1/1	Simazine	0.13
	Base Flow - May 15	0/1	none	
	Base Flow - May 28	1/1	Atrazine Simazine	0.07 0.07
	Storm - May 31-June	7/10	Atrazine Simazine	0.07 0.07
	Base Flow - June 4	1/1	Atrazine	0.04
	Storm - June 6-June	8/8	Alachlor Atrazine Metolachlor Simazine	0.11 1.1 1.2 0.05
	Storm - July 9	1/1	Atrazine Metolachlor Simazine	0.17 0.2 0.02
	Base Flow - August 4	1/1	Atrazine Simazine	0.03 0.04
	Base Flow - Sept. 2	1/1	Atrazine Metolachlor Simazine	0.05 0.07 0.03
	Storm - Sept. 26-Sept	2/5	Atrazine Metolachlor Simazine	0.02 0.07 0.04
	Base Flow - Sept. 30	0/1	none	
Shark River (control)	Base Flow - March 9	0/1	none	
	Base Flow - May 4	0/1	none	
	Storm - May 8 &9	0/5	none	
	Base Flow - May 15	0/1	none	
	Base Flow - May 27	0/1	none	
	Storm - May 31	0/3	none	
	Base Flow - June 4	0/1	none	
	Base Flow - July 8	0/1	none	
	Base Flow - August 4	0/1	none	
	Base Flow - Sept. 2	0/1	none	
	Storm - Sept. 25-27	0/5	none	
	Base Flow - Sept. 29	0/1	none	

Table 4. Pesticides Found in Six Watersheds Sampled in 1994

Watershed	Number of base flow samples with measurable pesticides/ total samples	Number of storm flow samples with measurable pesticides/ total samples	Pesticides found	Base Flow Highest conc. (ppb)	Storm Flow Highest conc. (ppb)
Raritan River	0/2	0/2	none		
Wanaque Reservoir	0/2	0/2	none		
Oradell Reservoir	1/1	0/2	Metolachlor Alachlor	0.774 2.036	
Passaic River	0/2	1/2	Diazinon Isofenphos		0.364 0.326
Rahway River	1/2	2/2	Simazine Prometon Metolachlor Diazinon Malathion Isofenphos Metalaxyl Triaminefon Triadimenol TCPA	0.569	 0.604 0.332 0.382 0.08 0.213 0.893 0.21 0.391 0.553
D&R canal	1/2	0/2	Metolachlor Atrazine	1.126 1.175	
Delaware River	0/1	0/1	none		