WATER QUALITY MONITORING -- WHAT IS BEING DETECTED?

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Due to the concern over the impact of agricultural chemical use on water quality, the amount of water quality monitoring data has increased substantially during the last few years. Several groundwater surveys for nitrates and pesticides have been conducted in the Midwest. A partial list includes surveys conducted in Illinois, Kansas, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin.

As interest in water quality has increased, and similarly, the need for more and better water quality information, water quality surveys have become more sophisticated. There has been an increase in understanding of the complexity of factors influencing survey results, and as a result survey design and sampling techniques have improved. The amount of background information collected has also increased. Results of recent and on-going surveys have the potential for broad implications with respect to the status of water resources. However, due to a number of factors, each survey has limitations.

Iowa has a relatively large amount of water quality survey data available that helps assess the impact of agricultural chemical use on water quality. Both statewide and county-level surveys have been conducted, including private and public wells, surface water and groundwater sources. Included below are the results of some of the water quality monitoring surveys that have been conducted in Iowa. These results represent only a portion of the water quality data available, but are included because they highlight many of the factors that influence water quality. Also included are surveys conducted at the national and state levels. These offer additional perspectives of the impact of agricultural chemical use on water quality.

Interim Results of EPA National Pesticide Survey

The Environmental Protection Agency is currently conducting a national pesticide survey of community and domestic wells. The survey is important and unique because it is designed to provide nationwide estimates of nitrate and pesticide occurrence in drinking water wells.

The survey will eventually include 600 community wells representing approximately 51,000 community water systems nationally, and 750 domestic wells representing approximately 13,000,000 domestic wells. The survey includes 12 community water systems in Iowa. As of September 30, 1989, 936 wells have been sampled, including 482 community water wells and 454 domestic water wells.

EPA has released findings of the first 180 community wells (from 44 states) and 115 domestic wells (from 10 states) sampled in the national survey. EPA has cautioned that interpretation or extrapolation of the survey results to all wells nationally should only be conducted after all wells are sampled.

The preliminary findings show that 6 wells (3%) of the 180 community water wells sampled showed some level of pesticide residue. Five of the 6 wells with pesticide detects contained the metabolite of a herbicide commonly used for weed control in turf grasses and vegetables; and one well had a detect of a banned pesticide. Seventy -nine wells (44%) of the 180 community wells sampled showed some level of nitrate residues. None of the detections in community wells were above EPA health advisory levels or maximum contaminant levels.

Of the 115 domestic wells sampled, 9 wells (8%) showed some level of pesticide residues. Three of the 9 wells with pesticide detects contained the metabolite of a herbicide commonly used for weed control in turf grasses and vegetables; 4 of the 9 wells had detectable levels of banned pesticides. Two of the 9 wells had a detect of either a commonly used corn herbicide or a commonly used soybean herbicide.

Three pesticide detections in domestic wells exceeded EPA health advisory levels; these three detects were due to two pesticides now banned by EPA. Sixty - six domestic wells (57%), contained nitrate residues; 8 wells (7%) exceeded the MCL of 10 ppm for NO_3-N.

Well sampling is scheduled to conclude in February of 1990. A preliminary report on the results is scheduled for release in fall 1990, with a full analysis available during winter of 1990-91.

1987 Iowa Public Water Supply Pesticide and Synthetic Organic Compound Survey

From November 1986 to November 1987, the Iowa Department of Natural Resources sampled and analyzed 853 public water supplies in Iowa for 35 pesticides and 35 synthetic organic compounds. Detection limits were 0.2 ppb for pesticides and 1.0 ppb for synthetic organic compounds (SOCs). This survey was unique in that it was the first statewide assessment of water quality in Iowa.

The 853 public water supply systems consisted of 735 wells, 44 surface water systems, and 74 consecutive systems. Pesticides were detected in 62 wells (8%) out of the 735 public wells sampled (Table 1). Most of the pesticide detects in wells were herbicides; an insecticide was detected in only one well. The most commonly detected herbicide was atrazine, which was detected in 6% of the well systems; atrazine was the only pesticide detected in 33 of the 62 wells with detects. Alachlor, cyanazine, and 2,4 -D were detected in less than 2% of the wells. Metolachlor and metribuzin were detected in less than 1% of the wells. Fifty -nine percent of the well systems had detectable levels of synthetic organic compounds, primarily trihalomethanes, which are chlorination by -products.

In contrast to the well systems, pesticides were detected in 28 surface water systems (64%) of the 44 sampled (Table 1). Atrazine was the most commonly detected pesticide, being detected in 59% of the surface systems. Cyanazine, metolachlor, and alachlor were detected in 37, 17, and 12% of the surface systems,

respectively. Synthetic organic compounds, primarily trihalomethanes (chlorination by -products) were detected in 96% of the surface water systems.

Pesticides exceeded EPA lifetime health advisory levels in 8 wells (1%) out of 735 wells sampled (Table 1). Six surface water supplies (14%) had pesticide levels that exceeded health advisory levels. Synthetic organic compounds exceeded maximum contaminant levels in 4 wells (0.5%) out of all sampled wells and 16 surface supplies (36%).

Table 1. The number of Iowa public water supplies with pesticide and synthetic organic compound (SOC) detections and the number which exceeded EPA lifetime health advisory (HA) levels or maximum contaminant levels (MCLs). (Iowa DNR, 1988)

Water Supply	Total No. Sampled	Pesticide		SOC	
		Detected	HA Exceeded	Detected	MCL Exceeded
		----------No. of supplies----------			
Well	735	62	8	434	4
Surface	44	28	6	42	16

The specific compounds which exceeded EPA lifetime health advisory levels or maximum contaminant levels are listed in Table 2. EPA lifetime health advisory levels for alachlor, atrazine, and cyanazine are 0.4, 3, and 10 ppb, respectively. The lifetime health advisory level for total trihalomethanes is 100 ppb. In the six wells where only alachlor was detected, the average concentration was 1.3 ppb, with a maximum of 3.8 ppb. Four of these six wells have potential point sources within a few hundred feet, and as close as 50 feet, of the well.

Table 2. Pesticides and synthetic organic compounds that exceeded EPA lifetime health advisory levels or maximum contaminant levels in Iowa pulic water supplies.

	Wells	Surface
Pesticides:		
Alachlor only	6	3
Atrazine only	1	3
Alachlor + atrazine + cyanazine	1	-
Total	8	6
Synthetic organic compounds:		
Total trihalomethanes	1	16
Benzene + methyl -butylether	1	-
Tetrachloroethylene	1	-
Vinyl chloride	1	-
Total	4	16

Atrazine only was detected in one well at 3.5 ppb. One well had a multiple detection of alachlor (20 ppb), atrazine (14 ppb), and cyanzine (11 ppb). Both of these wells have potential point sources nearby.

In the three surface supplies that exceeded the alachlor lifetime health advisory level, the average concentration was 1.1 ppb with a maximum of 1.5 ppb. Where the atrazine health advisory level was exceeded, the average atrazine concentration was 3.7 ppb with a maximum of 4.3 ppb.

The results of this survey demonstrate the difference in vulnerability between surface water and groundwater systems to pesticide contamination. Analysis of the data shows that different aquifers vary in vulnerability to contamination; also, the vulnerability of a particular aquifer varies in different regions of the state. The survey indicates that the majority of pesticide detects are due to four to five herbicides, with the majority of detects caused by atrazine. The survey shows that a majority of wells and surface water systems have detectable levels of trihalomethanes. The survey also implicates potential point sources as significant contributing factors to the pesticides detected in groundwater.

The Iowa Statewide Rural Well-Water Survey

As indicated above, there has been a large increase in the amount of water quality monitoring data available during the last few years. However, there have been very few surveys that have systematically sampled farm wells. Two exceptions to this are the Iowa Statewide Rural Well -Water Survey and the Wisconsin Farm Well Survey (discussed below).

The Iowa Statewide Rural Well-Water Survey is one of the most ambitious and comprehensive surveys to be conducted in the midwest. Sampling was completed in June, 1989. Results have not been released, but are are expected by January 1, 1990. The survey was designed and conducted by the Iowa Department of Natural Resources Geological Survey Bureau and The University of Iowa Center for Health Effects of Environmental Contamination. Systematic sampling of 700 rural wells was included in the survey. Sample design was based on rural population density and total geographic coverage of all 99 counties in Iowa. Ten percent of the wells were sampled quarterly to determine temporal variation in water quality. Analysis of water samples included nitrate, coliform bacteria, 27 pesticides, and specific pesticide metabolites in addition to several other parameters. The survey also included a questionnaire and site evaluation in order to determine well characteristics, potential point sources of chemicals, agrichemical use and practices, and existing health symptoms or conditions.

Included below are the results of the Wisconsin Farm Well Survey and two county -level surveys that were conducted in Iowa.

Wisconsin Farm Well Survey

Between August, 1988 and February, 1989, the Wisconsin Department of Agriculture, Trade and Consumer Protection sampled well water from 534 randomly selected Wisconsin Grade A dairy farms. Samples were analyzed for nitrate - nitrogen (NO_3 -N) and 44 compounds including 10 herbicides and 4 insecticides

commonly used in Wisconsin. Detection limits were approximately 0.15 ppb for pesticides and 0.5 ppm for NO_3-N.

One or more herbicides were detected in 71 of 534 wells, or 13% of the sampled wells (Table 3). Atrazine was found alone or in combination in 66 of the 71 wells. The maximum concentration of atrazine was 19.4 ppb with a median concentration of 0.45 ppb. Three of these 66 wells exceeded the EPA lifetime health advisory level of 3 ppb for atrazine. Alachlor was detected in 5 of the 534 wells (< 1%). The maximum alachlor concentration was 5.9 ppb with a median of 0.7 ppb. All detections of alachlor exceeded the EPA lifetime health advisory level of 0.4 ppb for alachlor.

Table 3. Number of Wisconsin Grade A dairy farm wells with pesticide detects.

Pesticide(s) Detected	No. of Wells
Atrazine alone	64
Alachlor alone	3
Metribuzin alone	1
Atrazine + alachlor	1
Atrazine + metolachlor	1
Alachlor + metribuzin	1
Total	71

On a statewide basis, the proportion of wells on the 23,543 Grade A dairy farms containing detectable levels of atrazine was estimated to be between 9 and 15%. In comparison, the proportion of wells containing detectable levels of NO_3-N was estimated to be between 61 and 69%. The proportion of wells containing NO_3-N above the EPA drinking water standard of 10 ppm was estimated to be between 7 and 13%.

The survey was not designed to determine whether the pesticide detections resulted from pesticide application according to label directions (non-point source) or from point sources. However, many farm operators whose wells contained a pesticide that exceeded Wisconsin standards were interviewed about pesticide use and handling history and about construction of the sampled well. The report concluded that while most of the farm operators handle pesticides carefully, improper disposal of pesticide rinsate and empty containers may be a source of contamination. The interviews also indicated that farm operators need better information about 1) well construction, 2) the relationship between surface activities and groundwater quality, and 3) health implications of drinking water standards.

1989 Franklin, Hamilton, Humboldt, and Palo Alto Counties Farm Well Survey

In April, May, and June of 1989 the Iowa State University Cooperative Extension Service sampled 170 farm wells in Franklin (55 wells), Hamilton (31 wells), Humboldt (36 wells), and Palo Alto (48 wells) counties. Water samples were analyzed for bacteria, nitrates, five herbicides (alachlor, atrazine, cyanazine, metolachlor, and trifluralin), and one insecticide (terbufos).

Two to three wells per township were sampled. Both shallow and deep wells were selected for the survey. As a result, a wide variety of well types and depths were sampled. Drilled wells were the most common, but bored, dug, and sandpoint wells were included in the survey. Well depth ranged from 20 to over 500 feet.

Depth to bedrock is variable in these four counties, ranging from less than 10 feet to over 100 feet. Bedrock is especially shallow in western Humboldt county (<10 feet). There are limestone quarries and a few sinkholes in this area. In addition, Humboldt county contains 40% (138) of the registered agricultural drainage wells in Iowa (346 total). In contrast, Franklin, Hamilton, and Palo Alto counties have 2, 1, and 0, respectively, registered agricultural drainage wells.

Detection limits for pesticide analysis in this study were nitrate, 0.5 ppm; alachlor, 0.3 ppb; atrazine, 1.6 ppb; cyanazine, 0.2 ppb; metolachlor, 0.5 ppb; terbufos, 0.5 ppb; and trifluralin, 0.10 ppb.

The results of the four county survey showed that 8 wells (<5%) exceeded the nitrate drinking water standard of 45 ppm. Seven of these 8 wells were in Franklin county.

Herbicides were detected in one well out of the 170 wells sampled in the four counties. This well was located in Humboldt county. Both alachlor (2.0 ppb) and cyanazine (0.23 ppb) were detected. Current EPA lifetime health advisory levels for alachlor and cyanazine are 0.4 and 10 ppb, respectively. There were no other herbicide or insecticide detections.

The 1.6 ppb detection limit for atrazine is considerably higher than the more commonly reported 0.1 or 0.2 ppb. Other monitoring data indicates that atrazine detects in north central Iowa wells have generally been below 1.0 ppb. Therefore, detects of low -level atrazine concentrations may have been missed in this survey. The overall results of the survey demonstrate that a relatively small percent of farm wells in these four counties had nitrate and pesticide detects.

Floyd and Mitchell Counties Farm Well Survey

This survey offers a sharp contrast to the four-county farm well survey discussed above. In this survey, a relatively high percent of the wells had pesticide detects. The survey demonstrates the many factors that can potentially influence the movement of agricultural chemicals to groundwater.

From February 1986 until January 1987, the Iowa Department of Natural Resources and the University of Iowa Department of Preventive Medicine analyzed

water samples from 10% (184) of the farm wells in Floyd and Mitchell counties for nitrates, nine herbicides, and six insecticides. This survey is unique in three ways. First, it is one of the few surveys that has systematically sampled farm wells in Iowa.

Second, each farm well was sampled four times throughout the year so that seasonal variations in the presence and concentration of nitrates, herbicides, and insecticides could be determined. Wells were sampled in February 1986, May 1986, September 1986, and January 1987. As a result, over 700 water samples were analyzed for this survey.

Third, Floyd and Mitchell counties have four geologic regions that vary in till thickness and underlying limestone characteristics. As a result, the potential for nitrate, herbicide, and insecticide movement from the surface to groundwater varies among these four regions. These regions, listed in order of increasing vulnerability, are defined as 1) deep bedrock, greater than 50 ft., 2) shallow bedrock, less than 50 ft., 3) very shallow bedrock, less than 15 ft., and 4) karst (sinkholes). Farm wells in each of these four regions were sampled in this survey. A preliminary report on the survey has been published by the Geological Survey Bureau of the DNR. A summary of the results is included below.

Average nitrate concentrations were higher in areas of greater geologic vulnerability. Wells in the more protected deep bedrock aquifer averaged 5 ppm nitrate. Vulnerable areas with higher rates of infiltration recharge had higher nitrate concentrations. The average nitrate concentration from wells in shallow aquifer, very shallow aquifer, and karst regions was 25, 32, and 43 ppm, respectively. The drinking water standard for nitrate is 45 ppm. The report did not indicate the percent of wells with nitrate detects or discuss seasonal variations in nitrate detections or concentrations.

Atrazine was the most commonly detected herbicide (Table 4). Atrazine was detected in some samples during each of the four sampling periods, being detected in 19 to 31% of the samples. Over the entire year, atrazine was detected in 25% of all samples and was detected in 43% of the 184 wells. The mean atrazine concentration for the four sampling periods was 1.14 ppb. The EPA lifetime health advisory for atrazine is 3.0 ppb.

Alachlor, metolachlor, and metribuzine were detected less frequently than atrazine, but these herbicides were detected in each sampling period. Alachlor, metolachlor, and metribuzin were detected in 9, 6, and 6%, respectively, of all samples taken, representing 13 to 19% of all wells. Detections of these herbicides did not vary greatly among sampling periods. Mean concentrations for alachlor, metolachlor and metribuzin were 0.75, 0.68, and 0.33 ppb, respectively. EPA lifetime health advisories for alachlor, metolachlor, and metribuzin are 0.4, 100, and 200 ppb, respectively.

Butylate, cyanazine, propachlor, and trifluralin were detected in 2% or less of all samples. Mean concentrations of these herbicides were below EPA lifetime health advisory levels. DCPA was not detected in any samples.

Carbofuran or carbofuran metabolites and chlorpyrifos were detected in each of the four sampling periods. However, these two insecticides were detected in less than 2% of all samples. Ethoprop, fonofos, and phorate were detected in 0.5% or less of all samples. Terbufos was not detected in any samples. All insecticide detects were below EPA health advisories.

Table 4. Percent of well samples with pesticide detections taken during four sampling periods in Floyd and Mitchell counties.

Pesticide	Sampling period 2/86	5/86	9/86	1/87	All periodsconc	Mean
	(% of samples)				(ppb)	
Atrazine	28	31	20	19	25	1.14
Alachlor	6	11	10	8	9	0.75
Metribuzin	6	8	4	7	6	0.33
Metolachlor	5	8	6	5	6	0.68
0.68 Propachlor	3	2	2	<1	2	0.40
Cyanazine	2	1	<1	1	1	0.27
Trifluralin	<1	1	0	1	<1	0.05
Butylate	0	0	0	<1	<1	0.01
DCPA	0	0	0	0	0	--
Carbofuran	3	1	<1	1	2	0.02
Chlorpyrifos	1	2	1	<1	1	0.02
Phorate	0	0	2	0	<1	3.5
Ethoprop	0	0	1	0	<1	0.07
Fonofos	0	0	<1	0	<1	0.03
Terbufos	0	0	0	0	0	--

The percentage of wells with one or more pesticide detections during the year of sampling varied with geologic region (Table 5). The highest percentage of wells, 92% (11 wells), with pesticide detections was in karst or sinkhole regions. The lowest percentage of wells, 41% (16 wells), with pesticide detections was in the deep bedrock areas. Sixty percent of the wells had one or more pesticide detections at some time during the year of sampling. Overall, mean concentrations of pesticides were less than 1.0 ppb, except for atrazine (1.14 ppb) and Thimet (3.5 ppb).

Table 5. Number of wells and percentage ofwells in Floyd and Mitchell counties with one or more pesticide detects in each geologic region.

Geologic region	No. of wells	% of wells w/ detect(s)
Karst (sinkholes)	12	92
Very shallow bedrock	20	70
Shallow bedrock	113	62
Deep bedrock	39	41
Total	184	60

Most pesticide detections occurred in May, 1986, during the time of application, when 42% of all wells had one or more pesticide detects. The second highest number of detections occurred during snow-melt recharge in late February and early March. The highest concentrations of many pesticides also occurred at this time.

The percentage of wells with pesticide detects in this survey is considerably higher than other public and private well surveys conducted in Iowa, Illinois, Minnesota, and Wisconsin. There are some unique factors in Floyd and Mitchell counties that have the potential to influence water quality. One factor is the shallow bedrock and karst topography areas of these two counties. Animal and crop production practices in these areas have a greater potential to impact groundwater quality than in other geologic regions, both by infiltration to shallow bedrock aquifers and by surface water and sediment runoff entering sinkholes.

Surface water and sediment runoff entering sinkholes has the potential to impact groundwater quality throughout the year, especially early in the growing season, and in late winter snowmelt. Sediment with adsorbed pesticides that has entered and remained in the bedrock aquifer system, may serve as a year -round source of pesticides. Chemical and microbial degradation of pesticides within the bedrock aquifer system may be considerably reduced as compared to degradation rates in the soil profile. As a result, pesticides that normally degrade relatively rapidly may persist in the bedrock aquifer system for an extended period of time.

Another factor to be considered is the presence of agricultural drainage wells in these two counties. There are 72 registered agricultural drainage wells in Floyd county and five in Mitchell county. Over 70 percent of these agricultural drainage wells are in deep aquifer areas, and these may be affecting water quality in wells.

Also, some sites in this survey recorded problems with pesticide spills or other handling accidents. Six percent of the farmers interviewed indicated that

pesticide handling problems have occurred on their farms. A few point sources of pesticides may impact large portions of underlying aquifers.

The influence of many of these factors on overall groundwater quality in Floyd and Mitchell counties is not well understood. The analysis of data collected in this survey is continuing. Additional information will help define and provide possible solutions to the water quality problems observed in this region of Iowa.