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Wisconsin Groundwater Management Practice Monitoring Project
No. 52

GROUNDWATER
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Wisconsin Department of Natural Resources

GRADE A DAIRY FARM

WELL WATER QUALITY SURVEY

Wisconsin Department of Agriculture, Trade

and Consumer Protection

and

Wisconsin Agricultural Statistics Service

April 1989

Wisconsin Department of Agriculture, Trade and Consumer Protection

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GRADE A DAIRY FARM

WELL WATER QUALITY SURVEY

Wisconsin Department of Agriculture, Trade

and Consumer Protection (WDATCP)

and

Wisconsin Agricultural Statistics Service (WASS)

April 1989

Gary LeMasters, WDATCP
Douglas J. Doyle, WASS

Agricultural Statistics District	Grade A Farms (Ni)	Farms Sampled (ni)
Northwest	2755	64
North Central	2178	48
Northeast	1330	30
West Central	3899	87
Central	1640	38
East Central	3725	82
Southwest	3422	78
South Central	3464	80
Southeast	1130	27
	23543	534

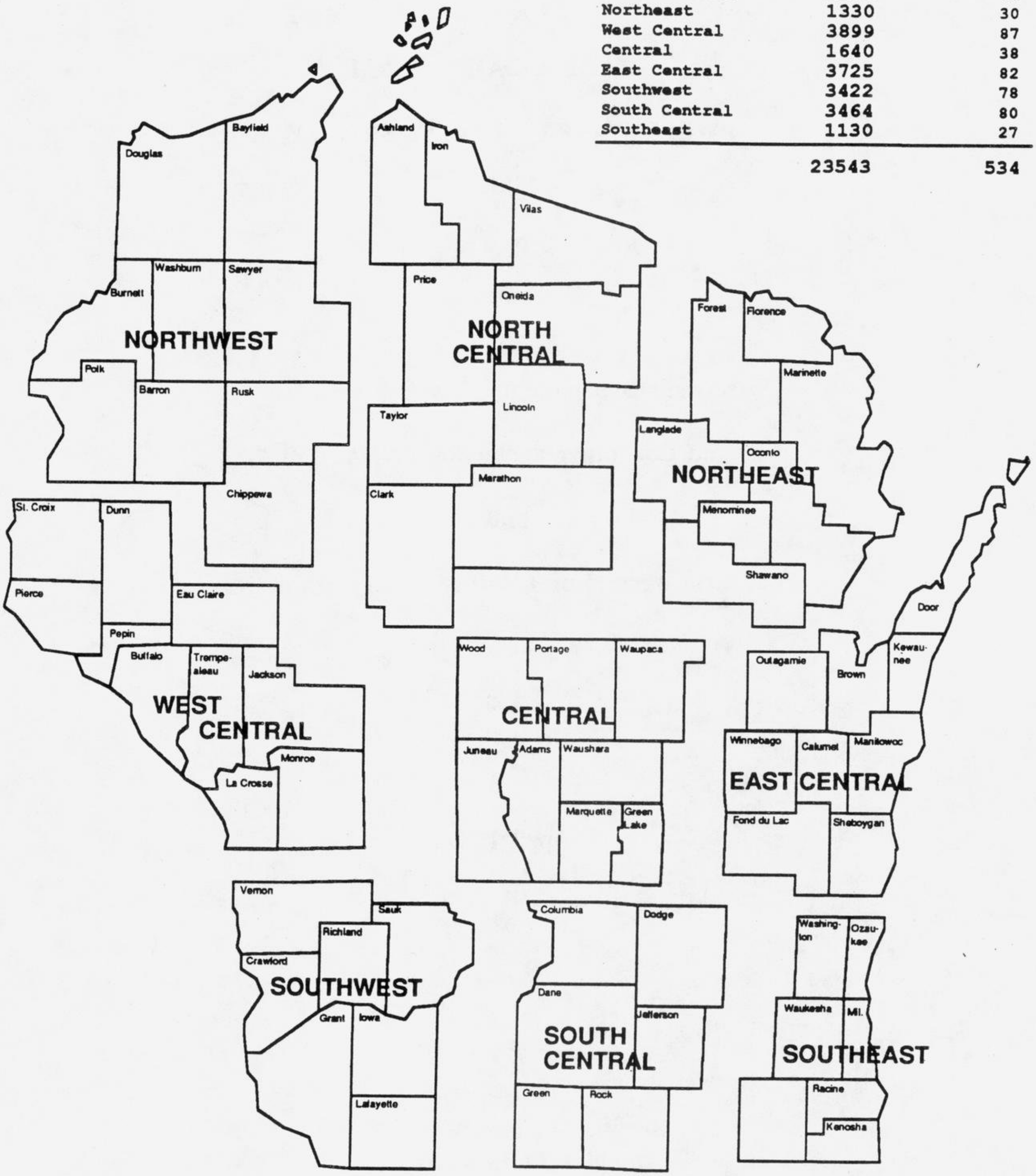

Figure 1. Wisconsin Agricultural Statistics Districts, the number of Grade A dairy farms in each district (Ni), and the number of farms sampled in each district (ni).

ABSTRACT

The Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) estimated the proportion of wells on Grade A dairy farms that contain detectable levels of pesticides and nitrate-nitrogen (NO_3-N). A random sample of 550 farms was drawn from the population of 23,543 Grade A dairy farms. These farms were chosen because WDATCP has authority to collect water samples as part of its inspection program and because sampling this population should provide a meaningful measure of the presence of pesticides in groundwater in rural Wisconsin.

Water samples were actually collected from 534 of the 550 farms and analyzed for 44 compounds including 10 of the herbicides and 4 of the insecticides most commonly used in Wisconsin. One or more herbicides were detected in 71 wells. Sixty-four (64) of these contained atrazine alone, 3 contained alachlor (Lasso®) alone, 1 contained metribuzin (Sencor®) alone, 1 contained atrazine and alachlor, 1 contained atrazine and metolachlor (Dual®), and 1 contained alachlor and metribuzin. The maximum concentration of atrazine was 19.4 micrograms per liter (ug/l) with a median of 0.45 ug/l. The Enforcement Standard for atrazine of 3.5 ug/l was exceeded in 3 wells. The maximum alachlor concentration was 5.9 ug/l with a median of 0.7 ug/l. The Enforcement Standard for alachlor of 0.5 ug/l was exceeded in all 5 wells where it was detected.

The proportion of wells on Grade A dairy farms that contain detectable levels of pesticides is estimated with 95 percent confidence to be between 10 and 16 percent. The proportion of wells containing detectable (at or above 0.15 ug/l) levels of atrazine is estimated to be between 9 and 15 percent. Between 5 and 9 percent of the wells contain atrazine above the Preventive Action Limit of 0.35 ug/l. There were insufficient data to estimate the proportion of wells containing any pesticide above an Enforcement Standard.

The proportion of wells containing NO_3-N is estimated to be between 61 and 69 percent. The proportion of wells containing NO_3-N above the Enforcement Standard of 10 mg/l is estimated to be between 7 and 13 percent.

The survey was not designed to determine whether the pesticide detections resulted from pesticide application according to label directions or from mishandling. However, many farm operators whose wells contained a pesticide above the Preventive Action Limit were interviewed about the way they handle and apply practices. From these interviews it seems that while most of the farm operators handle these compounds carefully, improper disposal of pesticide rinsate and empty containers may be a problem source. Farm operators also need better information about the construction of their well and the relationship between activities at the surface and groundwater quality. Finally, the regulatory community needs to assist the farm community in understanding the health implications of Wisconsin's groundwater standards.

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ACKNOWLEDGEMENTS

This report was a cooperative project between three divisions (Agricultural Resource Management, Food, and Operations) of the Wisconsin Department of Agriculture, Trade and Consumer Protection, the Wisconsin Agricultural Statistics Service (WASS) and the Wisconsin Department of Natural Resources (WDNR). The authors would like to express their thanks to the many people who contributed to its success.

Special thanks are due the 534 Grade A dairy farmers in the sample, without whose cooperation there would have been no survey. We also thank the farmers who agreed to be interviewed and who provided a valuable perspective on this subject.

Kevin Brey of the ARM Division kept track of all the sample results, wrote and mailed the notification letters, entered much of the data into the computer, collected the followup samples, and conducted many of the interviews. The survey would not have been possible without his productivity and attention to detail. Jeff Postle was always available to discuss the survey results and provide his perspective on their possible interpretation, and to review drafts of the final report.

The Food Division inspector staff deserve a round of applause for collecting the samples, week after week, during the hottest, driest summer in Wisconsin history and then in one of the iciest winters. The samples arrived at the lab on time each week from beginning to end, which made everything else that much easier.

Jack Daubert of the WDATCP General Laboratory coordinated the sample processing and analysis. His weekly progress reports were very useful by providing a common dataset for the various participants to work with, and he also made sure that each Food Division region had enough shipping boxes for that week's sampling. We would also like to acknowledge the efforts of Steve Sobek and the other chemists at the WDATCP General Lab.

Mike Barnett and Steve Steinhoff helped develop the sampling procedures used by their inspectors, coordinated the sampling with the three Food Division regional offices, and kept tabs on any problems the inspectors were having.

We would also like to thank Al Luloff, Bob Krill, Bill Rock, Dave Lindorff and Kevin Kessler of the Wisconsin Department of Natural Resources for their suggestions during the planning phase of the survey, for providing the pamphlets on pesticides and nitrate-nitrogen that were mailed to the participants, and for their suggestions during the preparation of the final report. WNDR also provided a grant to support needed personnel and for the costs of confirming pesticide samples at the State Laboratory of Hygiene.

Thanks are due to Dave Degenhardt and other staff of the State Laboratory of Hygiene for performing the confirmation samples and for processing the majority of the nitrate-nitrogen samples on such short notice.

Irene Lippelt of the Wisconsin Geological and Natural History Survey provided valuable assistance in searching for well construction records.

Many other people helped make this project a success, and we want to thank all those people who we have not mentioned specifically.

Copies of this report are available from:

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INTRODUCTION

In 1985 Wisconsin farmers were reported to have used about 5.2 million pounds of atrazine (a herbicide used primarily to control broadleaf weeds in corn) and 3.4 million pounds of alachlor (Lasso®, a herbicide used primarily for grass control in corn) on about 5 million acres of corn (WDATCP, 1986). At about this time the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) began a monitoring program to determine if agricultural chemicals were reaching groundwater in significant concentrations. Shallow wells were installed at the water table immediately downgradient from agricultural fields that featured sandy soils, shallow depth to groundwater, and irrigation. Among the most frequently found compounds in this program were atrazine and alachlor. At this time Wisconsin had not adopted any official groundwater standards for these compounds and the unofficial guideline concentrations were not being exceeded.

In 1988 the Wisconsin Department of Natural Resources (WDNR) adopted health-based groundwater standards for atrazine and alachlor which were significantly lower than the unofficial guidelines. While the monitoring program showed that these compounds could reach groundwater at levels above these new standards in susceptible areas, no reliable information was available about the statewide extent of groundwater contamination from these compounds. The Grade A Dairy Farm Well Water Quality Survey reported herein was designed to meet this need.

The survey was funded with pesticide research fund monies collected by the Agricultural Resource Management (ARM) Division of WDATCP, and by a grant from the WDNR. All samples were collected between August, 1988 and February, 1989. A total of 534 wells on Grade A dairy farms were sampled.

Throughout the report the concentration of a pesticide is expressed in units of micrograms of active ingredient per liter of water, abbreviated ug/l. This is the preferred unit for expressing a concentration of a pesticide in water, and is equivalent to the more familiar unit of parts per billion, abbreviated ppb. The concentration of nitrate + nitrite as nitrogen is expressed in units of milligrams of nitrate + nitrite as nitrogen per liter of water, abbreviated mg/l, which is the equivalent to parts per million. Nitrite concentrations in groundwater are usually insignificant so throughout the report the abbreviation NO_3-N will be used to denote both the nitrate and nitrite forms of nitrogen.

Regulatory Framework

The Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) regulates the bulk storage of fertilizers and the bulk storage and use of pesticides. Chapter 160 of the Wisconsin Statutes, "Groundwater Protection Standards", was adopted in 1984. It established an administrative process to produce numerical standards, comprised of enforcement standards and preventive action limits, for substances in groundwater. The standards are adopted by the Wisconsin Department of Natural Resources (WDNR) based upon recommendations by the Wisconsin Department of Health and Social Services (WDHSS). Standards that have been adopted for pesticides are in Table 1. The standards for alachlor, atrazine, metolachlor and butylate were adopted in 1988 while the remainder were adopted in 1985.

The Groundwater Law mandates that WDATCP consider the need for substance-specific rules each time the WDNR establishes groundwater standards for a pesticide. The Grade A Dairy Farm Well Water Quality Survey was designed to provide information to help WDATCP determine the need for rules for atrazine and alachlor. These two herbicides are used on the majority of the crop acres in the state.

Pesticide Use in Wisconsin

In 1985 the Wisconsin Agricultural Statistics Service (WASS) conducted a pesticide use survey, with data reported for each of the nine Agricultural Statistics Districts shown in Figure 1. The acres treated statewide with all herbicides in 1985 and the acres of all crops treated with atrazine for each of the Districts are shown in Figure 2. Atrazine was used on about 3.4 million acres of corn and sweet corn, while alachlor was used on about 1.9 million acres of corn, sweet corn and soybeans. The South Central Agricultural Statistics District had the largest acreage treated with atrazine, 730,000 acres, followed by the Southwest District with 506,000 acres.

OBJECTIVES

The primary study objective was to estimate with a known degree of confidence the proportion of wells on Wisconsin Grade A dairy farms that contain detectable levels of the most commonly used pesticides and nitrate-nitrogen (NO_3-N). If possible, we also hoped to make acceptably confident statements about proportions of wells at the WASS Agricultural Statistics District level. Finally, we desired knowledge about the relative contributions of pesticide application versus mishandling to any detections in groundwater.

METHODS

Survey Design

Sampling Frame

The Wisconsin Agricultural Statistics Service (WASS) was charged with ensuring that the well sampling project would generate unbiased estimates of the proportion of wells on Wisconsin Grade A dairy farms that contained detectable levels of pesticides and nitrate-nitrogen (NO_3-N). Potential contamination from pesticides is not limited to dairy farms. Corn was planted on over three million acres in Wisconsin during 1988 and only a portion of this was planted on dairy farms. Funding limitations necessitated sampling from a readily available list of farming operations. Further testing of wells on non-dairy farms is necessary to determine if they contain similar pesticide and NO_3-N concentrations.

The Brucellosis Ring Test list (WDATCP Animal Health Division, 24 May, 1988) served as the sampling frame for the project. Grade A milk producers are part of an ongoing inspection program and therefore can be visited for well water sampling in a cost-efficient manner. In addition, the list of Grade A producers is very complete and updated at regular intervals. The quality of the list was important and reduced the effect of non-response bias in the sampling procedure.

Some of the logistical challenges included the availability of staff for the water collection, laboratory analysis, and coordination of staff from several WDATCP divisions.

Further, there were only limited data from past water sampling on farms and some of the information useful in survey design was unavailable. Prior knowledge of historical estimates of means, proportions, and variances typically serves in determining sample size and sample allocation.

A stratified random sample of Grade A dairy farms was the most efficient methodology available. The geographical strata captured some of the variation in soil, climate and hydrogeology in Wisconsin. It also provided a means of allocating the sample to regions of the state having most of the Grade A dairy farms.

There are nine Agricultural Statistics Districts in Wisconsin, providing land area coverage of the state (Figure 1). The sample was allocated proportionally among these districts or strata based on the number of Grade A dairy farms in the district as a fraction of the total number of Grade A dairy farms in the state. At the time the stratified random sample was drawn, 23,543 Grade A dairy farms were in the sampling universe across all nine strata. It was estimated that no more than 10% of those dairy farms chosen for sampling would be out of business by the time water samples would be collected.

Sample Size

When estimating means, totals and proportions for a target population, the size of a stratified random sample is dependent on several factors including the population of each stratum, the degree of precision desired for each estimate (limited by the most important estimate to the research), the variance of the estimate for each stratum, and the cost of obtaining an observation in each stratum. In this instance, the primary objective was to estimate the proportion of wells on Grade A dairy farms with any pesticide and/or NO_3-N at detectable levels. In determining sample sizes for proportion estimators it is helpful to have some indicator of the proportion of the target population exhibiting the trait measured.

As a pilot study, this project enjoyed few indications of the factors discussed above, except for the population size in each stratum. The Agricultural Resource Management (ARM) Division provided some idea of the proportion of wells in which we might expect to find detectable levels of pesticides and NO_3-N. Staff from ARM suggested that 10% of the wells might contain pesticides. In addition, ARM felt that they needed to have a tolerance of plus or minus two percent of the proportion estimator. Based on this information and funding limitations we selected wells on 550 Grade A dairy farms, 534 of which were actually sampled. The number of Grade A dairy farms and sampled farms are in Table 2. Sixteen dairy farms were no longer operating when visited by the water collector.

Potential Non-sampling Errors

Time Dependency

A special challenge associated with the sampling design is the time dependency of groundwater recharge and leaching of pesticides and NO_3-N through soils. It was impossible to test all wells in a short time frame. The laboratory could process twenty-five samples per week and samples cannot be stored for more than seven days, so the samples had to be collected over a six month period. The effects of time dependency may have been confounded by the summer long drought of 1988 and are difficult to quantify without repeated sampling procedures. Retesting wells would improve the explanatory power of this pilot study.

Laboratory Detection

The analytical method used in this study has a detection level of approximately 0.15 ug/l for the pesticides and approximately 0.5 mg/l for NO_3-N. Therefore, if the concentration of the pesticide in question was less than 0.15 ug/l it was not detectable and was considered a zero reading. As a result, the actual mean concentration of a pesticide in wells on Wisconsin Grade A dairy farms and the proportion of wells with any pesticide or NO_3-N may be underestimated. However, the detection level is quite low and is probably less significant as a health standard than as a statistical concern.

Water Collection Site

In addition to selecting a random sample of Grade A dairy farms, it was necessary to specify which well the water collector would sample if a dairy farm had two or more wells. We specified that the water would be drawn from the well that supplies water to the two compartment wash sink in the milk house that is required of each Grade A milk producer. If there was more than one well the water would be sampled from a tap connected to the well most often used in the milk house.

There are two problems with this procedure. First, any filters attached to the supply line before the tap could affect the concentrations of pesticides and NO_3-N in the sample. However, no research is available on the effects of water treatment on these compounds. Secondly, in the case of multiple wells accessed through the milkhouse, the water collector had to judge which well was most often used in the milkhouse. These potential sources of bias could not be controlled without a more stringent experiment.

Sample Collection

The water samples were collected by the Food Division inspectors over the period August, 1988 to February, 1989. The samples for pesticide analysis were collected in washed and capped one-liter amber glass bottles with Teflon-lined caps. The NO_3-N samples were collected in 125-milliliter (ml) polypropylene bottles. All samples were collected from the cold water tap at the two compartment wash sink. The tap was allowed to run for at least five minutes before a sample was collected. No attempt was made to collect the sample before any water treatment device that may have been present. All samples were placed in an insulated shipping container, refigerated with prefrozen ice packs and shipped to the WDATCP General Laboratory via courier service. All samples were received by the laboratory within 48 hours of sampling. About 25 farms were sampled each week. The three Food Division Region offices scheduled sample collection with their inspectors, with sampling rotating between the three regions on a weekly basis.

Sample Analysis

Pesticide concentrations were determined using the Neutral Extractable Method of the State Lab of Hygiene Organics Section, Method 1200 (Wis. Lab. of Hygiene, 1988). The analytes that can be detected using this method are shown in Table 3. The WDATCP General Laboratory analyzed about 150 samples for NO_3-N and the State Laboratory of Hygiene analyzed the remaining samples. Both laboratories used the Cadmium Reduction Method 418C (USEPA, 1979) with a reporting level of 0.5 mg/l.

Notification

Each participant was notified of the sample results by letter. If an ES for a pesticide was exceeded and was confirmed by followup sampling the well owner was advised to seek an alternative source of drinking water. If the concentration of NO_3-N exceeded the ES of 10 mg/l the well owner was advised that the water should not be consumed by infants under six months of age. The pamphlet Pesticides in Drinking Water (WDNR, 1985) was sent to each participant where pesticides were detected at any concentration. The pamphlet Nitrate in Drinking Water (WDNR, 1986) was sent to each participant where NO_3-N was detected above the ES.

Followup to Detections

Each well containing a pesticide above an ES was resampled and a milk sample was collected also. The water sample was split between the WDATCP General

Laboratory and the State Laboratory of Hygiene and there was close agreement between the two laboratories. The WDATCP laboratory analyzed the milk for the pesticide(s) detected in the water; none of these pesticides were detected in any of the milk samples. Pursuant to Chapter Ag 161 of the Wisconsin Administrative Code, a preliminary investigation was conducted at each farm where an ES was exceeded to attempt to determine the source(s) of the contamination. The sample results were explained in person to the farm operator and information was collected concerning pesticide application history, pesticide handling practices and well construction.

Statistical Analysis

Proportion Estimates

An unbiased estimator of the proportion of elements in a finite population with a specified trait can be obtained from the following formula for a stratified random sample (Scheaffer et al., 1979):

$$\hat{p}_{st} \quad = \quad [1/N] \; \Sigma \; N_i \; \hat{p}_i$$

where

N = the number of elements in the target population.

N_i = the number of elements in the i^{th} stratum.

$\hat{p}_i$ = the proportion of elements in the i^{th} stratum exhibiting the specified trait.

The unbiased estimator of the variance for this proportion estimator is given by (ibid.):

$$\hat{V}(\hat{p}_{st}) \quad = \quad [1/N^2] \; \Sigma \; N_i^2 \left[\frac{N_i - n_i}{N_i}\right] \left[\frac{\hat{p}_i \; \hat{q}_i}{n_i - 1}\right]$$

where

n_i = the number of sampled elements in the i^{th} stratum.

$\hat{q}_i$ = $1 - \hat{p}_i$

The variance estimator can be used to derive confidence intervals as follows (Ott, 1984):

$$[\hat{p}_{st} - t_{0.05} \; (\hat{V}(\hat{p}_{st})^{1/2}) \leq P_{st} \leq \hat{p}_{st} + t_{0.05} \; (\hat{V}(\hat{p}_{st})^{1/2})]$$

where

$_{0.05}$ = the specified probability that the interval will not contain the true value with repeated samples.

$\hat{V}(\hat{p}_{st})^{1/2}$ = Standard Error of the proportion estimator.

For a 95% confidence interval this reduces to (ibid.):

$$[\hat{p}_{st} - 1.96\ (S.E.) \leq P_{st} \leq \hat{p}_{st} + 1.96\ (S.E.)]$$

Pesticide Concentrations

The mean concentration estimator for pesticides is given by the following (Scheaffer et al., 1979):

$$\hat{\bar{Y}}_{st} = [1/N]\ N_i\ \hat{\bar{y}}_i$$

where

N = the number of elements in the population.

N_i = the number of elements in the i^{th} stratum.

$\hat{\bar{y}}_i$ = the mean concentration for the i^{th} stratum.

The variance for this estimator is given by the following (ibid.):

$$\hat{V}(\hat{\bar{Y}}_{st}) = [1/N^2]\ \Sigma\ N_i^2 \left[\frac{N_i - n_i}{N_i}\right] \left[\frac{S_i^2}{n_i}\right]$$

where

n_i = the number of sampled elements in the i^{th} stratum.

S_i^2 = the variance estimator for the i^{th} stratum.

The strata level variance is given by (ibid.):

$$\hat{V}(\hat{\bar{y}}_j) = \Sigma \frac{(y_{ij} - \hat{\bar{y}}_j)^2}{n_j - 1} = S_i^2$$

where

y_{ij} = the concentration for the i^{th} sample in the j^{th} stratum.

$\hat{\bar{y}}_j$ = the mean concentration for the j^{th} stratum.

n_j = the number of sampled elements in the j^{th} stratum.

RESULTS

Sixteen producers went out of business before the well could be sampled; therefore samples from 534 wells were analyzed.

Pesticides

General Results

Of the 71 wells that contained detectable levels of one or more pesticides, 64 contained atrazine alone and 2 contained atrazine plus another pesticide. The table below shows the findings:

Pesticide	Number of Wells
Atrazine alone	64
Alachlor alone	3
Metribuzin alone	1
Atrazine + alachlor	1
Atrazine + metolachlor	1
Alachlor + metribuzin	1
Total wells with pesticides	71

The median atrazine concentration was 0.45 ug/l (The median is the number where half of the remaining numbers lie below and half lie above) and the ES was exceeded in only 3 wells. In contrast, the ES for alachlor was exceeded in all 5 wells where it was detected. Metolachlor (Dual®) and metribuzin (Sencor®) were the only other compounds detected. All four of these compounds are herbicides, with all but metribuzin associated with corn production (Figure 2). The complete pesticide results tabulated by county within each Agricultural Statistics District are in the Appendix.

State Proportion Estimates

The estimators presented earlier were used to yield the proportion estimates in Table 4. Thirteen percent of the wells on Grade A dairy farms in Wisconsin are estimated to contain detectable levels of any pesticide. The standard error of this proportion estimate is 1.4%. A 95% confidence interval can be constructed as follows:

$$[0.13 \pm (1.96)(0.014)] \text{ or } [0.13 \pm 0.027)]$$

We can say that in 100 repeated samples the estimated confidence intervals would contain the true population proportion 95 times.

The procedure estimates that atrazine could be found at detectable levels in 12% of the Grade A wells with a standard error of 1.4%. The confidence interval for this estimate is:

$$[0.12 \pm (1.96)(0.014)] \text{ or } [0.12 \pm (0.027)]$$

Comparison of District Proportions

Statistical Z tests (Zar, 1974) of District level proportions indicate that the South Central District had a higher proportion of wells with any pesticide detect than the West Central District. The test used is as follows:

$$Z = |\hat{p}_i - \hat{p}_j| \;/\; [(\hat{p}_i\hat{q}_i/n_i + \hat{p}_j\hat{q}_j/n_j)^{1/2}]$$

The actual district level proportion estimates for any detect, atrazine, atrazine above the PAL and atrazine above the ES are in Table 5. The confidence intervals for some of the estimates for some of the Districts are very wide. Therefore, the observed geographic pattern is suggestive of the need for more analysis.

State Estimates of Mean Concentrations

The mean concentration for atrazine in wells on Wisconsin Grade A dairy farms is estimated at 0.12 ug/l (Table 6). The standard error was estimated at 0.04 ug/l. The 95% confidence interval is:

$$[0.12 \pm (1.96)(0.04)] \text{ or } [0.12 \pm (0.08)]$$

Comparisons of District Mean Concentrations

It is useful to compare the district level estimates. When interpreting multiple comparisons, it is important to remember that failure to reject the hypothesis that two or more means are equal should not lead to the conclusion that the population means are in fact equal (SAS Institute, 1985). Multiple comparisons were done with a Student's t-test on all possible pairs of district level means. For the i^{th} and j^{th} district means you can reject the null hypothesis that the means are equal if:

$$|\bar{y}_i - \bar{y}_j| \;/s(1/n_i + 1/n_j) > t(\alpha;df)$$

where $\bar{y}_i$ and $\bar{y}_j$ are the means, n_i and n_j are the number of observations in the respective cells, s is the root mean square error based on the degrees of freedom (df), and the significance level of a two tailed test from a student's t distribution shown by α (ibid.).

Repeated t tests over several groups incur a large probability of type II error (chance of falsely rejecting the null hypothesis). Bonferroni t-tests provide simultaneous inferences in any statistical application requiring tests of more than one hypothesis. The SAS BON option in the SAS GLM procedure was used to conduct this test (ibid.). Both multiple comparison procedures indicate that sample sizes were too small at the district level to warrant comparisons of mean concentrations. Although the estimates for district level pesticide concentrations were not all significantly different from zero, they will provide an essential basis for future sampling designs and follow-up studies.

Enforcement Standards and Preventive Action Limits

Estimates were made on the proportion of wells that contain atrazine above the PAL. The survey data are shown in Table 7. From Table 4, 7% of the wells tested had atrazine above the PAL with a standard error of 1.1% Using the standard 95% confidence interval methodology we derive:

$$[0.07 \pm (1.96)(0.01)] \text{ or } [0.07 \pm (0.022)].$$

There were insufficient wells with either atrazine or alachlor over the ES to make an estimate.

Nitrate-Nitrogen

State Proportion of Wells with Detectable levels of NO_3-N

The proportion estimator and the corresponding variance estimator used for the pesticides are also appropriate in the analysis of NO_3-N detection. The procedure estimates that 65% of the wells on Grade A dairy farms contain detectable levels of NO_3-N, with a standard error is 0.019% (Table 4). The 95% confidence interval for this proportion is:

$$[0.65 \pm (1.96)(0.019)] \text{ or } [0.65 \pm (0.037)]$$

Comparison of District NO_3-N Proportions

Multiple comparison tests were conducted for NO_3-N proportions. The Z test (Zar, 1974) indicated that the Southwest Agricultural Statistics District of the state has a higher proportion of wells on Grade A dairy farms with $N0_3$-N above the PAL than the South Central Agricultural Statistics District (actual proportion estimates and standard errors for NO_3-N are in Table 5).

State NO_3-N Concentration Estimates

The mean concentration estimator and the corresponding variance estimator for the pesticides are also appropriate for the analysis of NO_3-N concentrations. The estimate of the mean NO_3-N concentration at the state level is 3.74 mg/l with a standard error of 0.23 mg/l (Table 6). The 95% confidence interval is given by:

[3.74 ± (1.96)(0.23)] or [3.74 ± (0.45)]

Comparison of District NO_3-N Mean Concentrations

The strata level estimates of mean NO_3-N concentration and standard errors may provide insight into the geographical variation of NO_3-N. However, several of these are not significantly different from zero and all had fairly wide confidence intervals. Therefore, they are not included in this report.

Enforcement Standards and Preventive Action Limits

The number of wells above the PAL and ES for NO_3-N are in Table 8. From Table 4, 48% of the wells are estimated to have NO_3-N above the PAL with a standard error of 1.2% percent. Further, 10% are estimated to have concentrations above the ES, with a corresponding standard error of 1.3%.

NO_3-N and Pesticide Association

Test of Association Between NO_3-N and Pesticide Detection

A recent pesticide survey in Minnesota (Klaseus et.al., 1988) cited a non-statistical association between the presence of NO_3-N and pesticides in a well. Pesticides occurred more frequently in wells with higher NO_3-N concentrations. No statistical test of association was conducted. To test this relationship with the Grade A survey data a Chi-square test (Ott, 1984) of independence between NO_3-N and pesticide at detectable levels was conducted as part of the overall analysis. The test statistic indicates that we should reject the null hypothesis of independence between having NO_3-N concentrations higher than the PAL and detectable levels of pesticides ($\alpha = 0.01$). A test of association between wells with NO_3-N above the ES and detectable levels of pesticides was significant ($\alpha = 0.05$). Wells with NO_3-N above the PAL (2 mg/l) and above the ES (10 mg/l) are significantly more likely to contain a detectable level of a pesticide than a well that contains NO_3-N below these concentrations. The chi-square test is not designed to indicate cause or effect, simply association.

The Minnesota authors did report a lack of a significant quantitative relationship between the concentrations of NO_3-N and pesticides as determined using linear regression. A similar lack of a quantitative relationship was found in this study.

DISCUSSION

Followup Investigations

About 36 farms with the highest concentrations of one or more pesticides were visited by staff from the ARM Division. Each farmer was interviewed about pesticide use and handling history and about construction of the sampled well. More detailed investigations were conducted at each farm where an ES was exceeded. Soil samples were collected from areas of historic pesticide mixing and loading and analyzed for the compound(s) found in the well. One warning letter was issued to a farmer where illegal pesticide container disposal practices were observed and significant concentrations of atrazine were detected in soil samples. Of the 36 farmers interviewed, about 50% mix and load pesticides on the farm, about 40% hire commercial applicators and about 10% mix and load pesticides at a farm other than the one sampled. About 70% of the farmers are themselves certified applicators.

Well Construction

The well on a Wisconsin Grade A dairy farm is required to meet the standards in Ch. NR 112 of the Wisconsin Administrative Code for such things as minimum setback distances from septic tanks and barnyards, minimum casing depth and well depth, and proper plumbing. When a well is drilled the driller submits the well log to the WDNR and leaves a copy with the well owner. The original well construction records are maintained by the Wisconsin Geological and Natural History Survey (WGNHS). For a variety of reasons it was very difficult to locate well construction records for the Grade A dairy farm wells. Of the 71 wells that contained pesticides a well construction record could be confidently associated with only 16 wells. The following statements apply only to this set of records.

These wells were generally high quality, properly constructed wells. The pesticide detections in these wells cannot be attributed to improper well construction or inadequate casing depth. The contaminated wells range in depth from 62 to 200 feet. The casing depth in these wells ranges from 37 to 117 feet. Eighty percent of these wells were finished in bedrock formations and 20% were finished in unconsolidated materials such as sand and gravel. None of the farmers who were interviewed were able to produce a well construction report for their well.

Pesticides in Groundwater in the United States

The Oregon State University Extension Service conducted a survey of state lead agencies to summarize pesticides in groundwater (Parsons and Witt, 1988). The authors stated that the principal criterion for whether pesticides had been detected in a state's groundwater seemed to be whether or not the state had looked. Thirty-three of the 35 states who reported having sampled groundwater for pesticides had some contaminated wells. Fifteen of the 50 states could not provide any data and in 10 of these no testing had been done by any agency.

Twenty-eight states, including Wisconsin, had tested for atrazine and 17 had found it. No pesticides were detected in 4798 of 5569 (86%) wells tested (detection limits vary between states and over time), while 11 (0.2%) were above the Health Advisory level of 3 ug/l used in the survey. In the Grade A survey 88% were "no detect" for atrazine and 0.6% exceeded the ES of 3.5 ug/l. Twenty-three states had tested for alachlor and 16 had detected it. Of the 5016 wells sampled, 4874 (97%) were "no detect" versus 99% for the Grade A survey.

The authors of the Oregon report note that their survey results do not accurately reflect the incidence of pesticides in either wells or aquifers as a whole due to the use of pre-selected, susceptible wells and aquifers, as well as the effect of "mining", or multiple sampling in areas where positives have already been detected. In this context the agreement between their results and those of the Grade A survey is surprising, as no such preselection was used in this survey.

Pesticides in Minnesota Groundwater

The Minnesota Departments of Health and Agriculture recently completed a survey of pesticides in two kinds of wells (Klaseus et.al., 1988). The Minnesota Department of Health (MDH) sampled 400 public supply wells and the Minnesota Department of Agriculture (MDA) sampled 100 observation, irrigation and private drinking water wells and five drain tiles. Both sets of wells were selected from agricultural regions of the state, and, within those regions, from areas believed to be susceptible to groundwater contamination by pesticides. For example, of the 400 MDH wells, 282 terminated in unconsolidated glacial, alluvial, or lacustrine deposits. In the MDH survey pesticides were detected in 114 (28.5%) of the 400 sampled wells.

Atrazine was found in 107 wells and was the only pesticide in 94 of the 400 wells. As in the Grade A survey, atrazine concentrations were quite low, exceeding 1.0 ug/l in only 7 wells. The authors reported an association between depth of the well casing and pesticide presence in those wells in unconsolidated aquifers, but none where wells were finished in bedrock. Forty-three percent of wells cased less than 50 feet deep into unconsolidated aquifers were contaminated at least once, while only 18% of the wells deeper than 50 feet were contaminated.

In the MDA survey one or more pesticides were detected at least once in 51 of the 100 wells. Atrazine accounted for 112 of the 144 (78%) pesticide detections. As in the MDH survey concentrations of atrazine were quite low, with a median concentration of 0.38 ug/l. This is close to the median of 0.45 ug/l in the Grade A survey.

From the Oregon and Minnesota projects it is clear that atrazine is commonly found in groundwater in susceptible areas in other states at similar frequencies to those found in this survey. The outstanding difference is that the Grade A survey sampled randomly selected wells, without regard to susceptibility.

Distribution of Pesticide Detects in Wisconsin

The number of wells sampled in each Agricultural Statistics District and the number containing atrazine are shown in Table 7. Twenty-three of the 80 wells (29%) in the South Central Agricultural Statistics District had detectable levels of atrazine, followed by 13 of 78 wells (17%) in the Southwest District. The South Central District leads the other districts in atrazine use, as shown in Figure 2. Atrazine was used on 730,000 acres in this district in 1985 compared to 506,000 acres in the Southwest District. When this use pattern is combined with the number of Grade A dairy farms in the district (3464, second only to the East Central District) one would expect to detect atrazine here if in any area of the state. This is a simplification, however. The East Central District was third in atrazine use at 443,000 acres and contains the most Grade A dairy farms, yet atrazine was detected in only 6 of the 82 wells sampled (7%).

Differences in the geological materials from which the soils formed may partially explain the different frequency of pesticide detections in the South Central and East Central districts. The soils of the East Central District are generally formed in medium and heavy textured glacial tills, while those in the South Central District, especially those in Dane County where most of the wells with detects are located (see the Appendix), include areas of soils that are shallow to bedrock or formed in a mantle of loessal material (wind blown silts) overlying stratified sand and gravel. Further work in these areas will in all likelihood identify other factors that may have contributed to the observed differences.

Historical Explanation for Pesticides in Groundwater

The Council for Agricultural Science and Technology (CAST) published a report in 1985 titled "Agriculture and Groundwater Quality" (CAST, 1985). The authors attributed the detection of pesticides in groundwater in recent years to the greater sensitivity of modern analytical instruments, and to the fact that the majority of the locations for analysis are areas of relatively heavy pesticide use and susceptible soils and geology. The authors state further that where pesticides have been detected in drinking water the wells were "...sited in or directly adjacent to repeatedly treated fields and drilled only to shallow water-table aquifers." (CAST, 1985, p.46).

Greater sensitivity in analytical procedures for pesticides in water does play a role in the results of the Grade A survey. In 1986 the State Laboratory Hygiene lowered its reporting limit for atrazine from 1 ug/l to 0.15 ug/l. Had 1 ug/l been used in this study the number of wells with atrazine would have decreased from 66 to 12. However, the greater laboratory sensitivity is a response to lower groundwater standards as more is learned about the chronic health effects of these compounds.

CAST (ibid.) also attributes many pesticide detections in groundwater to poor siting of wells. The Wisconsin Groundwater Law applies protection to the entire groundwater resource, rather than only certain aquifers. An exceedance of an Enforcement Standard in a monitoring well next to a farm field is given the same weight as an exceedance in a drinking water well. In addition, while most Grade A dairy farms are in areas where pesticides are routinely used, few of those visited during the survey are on landscapes with shallow water-table aquifers.

SUMMARY

WDATCP sampled 534 wells on Grade A dairy farms to yield a statistically based estimate of the proportion of wells in the population of Wisconsin Grade A dairy farms with detectable levels of the most commonly used pesticides. This proportion is estimated to be between 10 and 16%. The proportion of wells containing atrazine in concentrations above the Preventive Action Limit of 0.35 ug/l is estimated to be between 5 and 9%. There were too few detections of a pesticide above an Enforcement Standard to permit estimates of this proportion.

The Enforcement Standard for atrazine was exceeded in three of the 66 wells where it was detected, while the Enforcement Standard for alachlor was exceeded in all five wells where it was detected.

The proportion of wells on Grade A dairy farms in Wisconsin that contain NO_3-N above the Enforcement Standard of 10 mg/l is estimated to be between 7 and 13%.

Agricultural Statistics District	Grade A Farms (Ni)	Farms Sampled (ni)
Northwest	2755	64
North Central	2178	48
Northeast	1330	30
West Central	3899	87
Central	1640	38
East Central	3725	82
Southwest	3422	78
South Central	3464	80
Southeast	1130	27
	23543	534

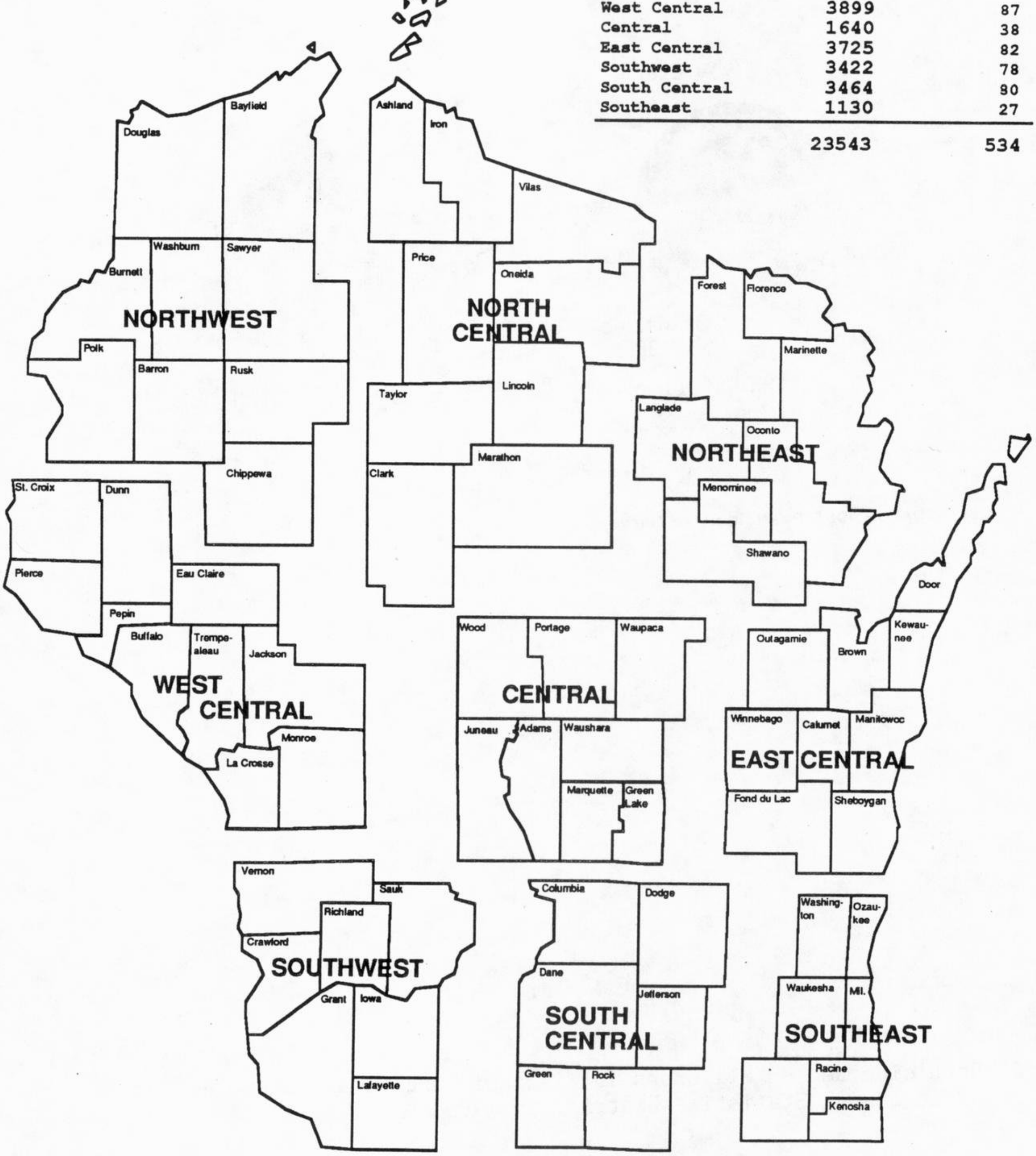

Figure 1. Wisconsin Agricultural Statistics Districts, the number of Grade A dairy farms in each district (Ni), and the number of farms sampled in each district (ni).

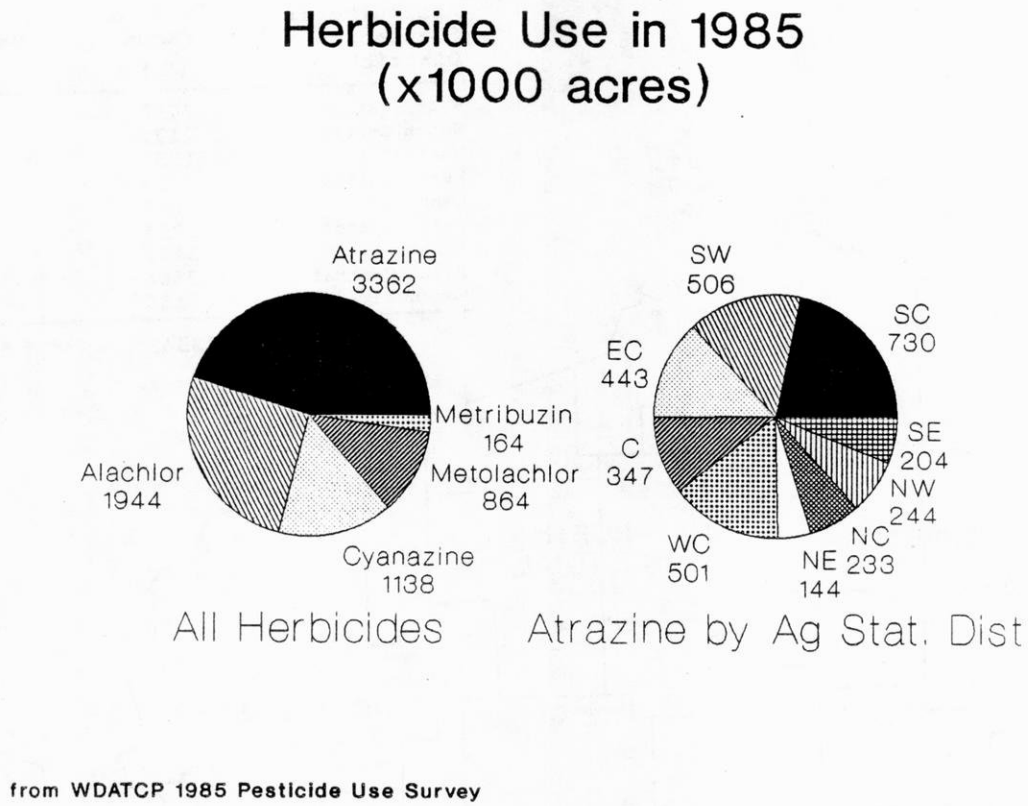

Figure 2. Herbicide use on all crops in Wisconsin and atrazine use by Agricultural Statistics District in 1985.

Table 1. Wisconsin groundwater standards for pesticides detected in or capable of entering groundwater [1/]

Compound	Brand Name	Category [2/]	ES [3/]	PAL [4/]
Alachlor	Lasso	H	0.5	0.05
Aldicarb	Temik	I	10	2
Arsenic		I	50	5
Atrazine	Aatrex	H	3.5	0.35
Butylate	Sutan	H	67	6.7
Carbofuran	Furadan	I	50	10
Cyanazine	Bladex	H	12.5	1.25
Dinoseb	Dinitro	H	13	2.6
Endrin		I	0.2	0.02
EPTC	Eptam	H	250	50
Lindane		I	0.02	0.002
Methoxychlor		I	100	20
Metolachlor	Dual	H	15	1.5
Simazine	Princep	H	2.15 [5/]	0.215 [5/]

[1/] These standards are published in Chapter NR 140 of the Wisconsin Administrative Code, updated in October 1988.

[2/] H = herbicide, I = insecticide

[3/] Enforcement Standard, concentration in micrograms per liter (ug/l), equivalent to parts per billion.

[4/] Preventive Action Limit,(ug/l).

[5/] Simazine concentration expressed as milligrams per liter (mg/l), equivalent to parts per million.

Table 2. **Grade A dairy farms and sampled farms by Agricultural Statistics District.**

Ag Stat District	Number of Grade A Dairy Farms	Number Sampled
Northwest	2755	64
North Central	2178	48
Northeast	1330	30
West Central	3899	87
Central	1640	38
East Central	3725	82
Southwest	3422	78
South Central	3464	80
Southeast	1130	27
Total	23543	534

Table 3. Analytes recovered through the neutral extractables method. State Hygiene Laboratory, Organics Section, Method 1200

ANALYTE	NITROGEN/PHOSPHORUS DETECTOR	ELECTRON CAPTURE DETECTOR
ALACHLOR	X	X
ALDRIN		X
ATRAZINE	X	
BENEFIN	X	X
BHC		X
BLADEX	X	
CASORON	X	X
CHLORDANE		X
CHLORDENE		X
CHLOROTHALONIL	X	
CHLORPYRIFOS	X	X
DACTHAL	X	X
DDT & ANALOGUES		X
DIAZINON	X	X
DIELDRIN		X
DIMETHOATE	X	X
DISULFOTON	X	X
ENDOSULFAN		X
ENDRIN		X
EPTAM	X	X
FONOFOS	X	X
HCB		X
HEPTACHLOR		X
HEPTACHLOR EPOXIDE		X
LINDANE		X
LINURON	X	X
MALATHION	X	X
METHAMIDAPHOS	X	X
METOLACHLOR	X	X
METHOXYCHLOR		X
METHYL PARATHION	X	X
PARATHION	X	X
PCB'S		X
PCNB		X
PENDAMETHALIN	X	X
PHORATE	X	
PHORATE-OXYGEN ANALOGUE	X	
PHTHALATES		X
PROMETONE	X	X
SENCOR	X	X
SIMAZINE	X	
SUTAN	X	X
TERBUFOS	X	X
TRIFLURALIN	X	X

NOTE: EVEN THOUGH MANY COMPOUNDS SHOW UP ON BOTH DETECTORS, THE NITROGEN/PHOSPHORUS DETECTOR IS SPECIFIC FOR THE ORGANONITROGEN AND THE ORGANOPHOSPHORUS ANALYTES.

Table 4. State level proportion estimates for any detected pesticide, atrazine, and nitrate-nitrogen (NO_3-N).

Category	Proportion	S.E.[1,2]
Any pesticide detect	0.13	0.014
Atrazine detect	0.12	0.014
Atrazine ≥ 0.35 ug/l	0.070	0.011
NO_3-N detect	0.65	0.019
NO_3-N ≥ 2 mg/l	0.48	0.012
NO_3-N ≥ 10 mg/l	0.10	0.013

[1] S.E. = standard error of the estimate.

[2] Proportion ± $t_{(0.05)}$(S.E.) = 95% Confidence Interval

ug/l = micrograms per liter.

mg/l = milligrams per liter.

Table 5. Agricultural Statistics District proportion estimates

Ag Dist.	Any Detect $\hat{p}_i$	Atrazine Detect $\hat{p}_i$	NO_3-N Detect $\hat{p}_i$	Atrazine ≥0.35 ug/l $\hat{p}_i$	NO_3-N ≥2 mg/l $\hat{p}_i$
North west	0.08 (0.034)	0.06 (0.029)	0.78 (0.052)	0.05 (0.027)	0.50 (0.062)
North Central	0.04 (0.028)	0.04 (0.028)	0.77 (0.060)	0.04 (0.028)	0.46 (0.071)
North East	0.07 (0.046)	0.07 (0.046)	0.47 (0.092)	0.03 (0.031)	0.27 (0.082)
West Central	0.13 (0.036)	0.11 (0.033)	0.77 (0.045)	0.07 (0.027)	0.57 (0.053)
Central	0.16 (0.059)	0.13 (0.054)	0.74 (0.071)	0.08 (0.044)	0.63 (0.078)
East Central	0.07 (0.028)	0.07 (0.028)	0.29 (0.050)	[3]	0.23 (0.047)
South West	0.19 (0.044)	0.17 (0.042)	0.87 (0.038)	0.09 (0.032)	0.69 (0.052)
South Central	0.29 (0.050)	0.29 (0.050)	0.61 (0.054)	0.20 (0.044)	0.50 (0.056)
South East	0.04 (0.038)	0.04 (0.038)	0.30 (0.089)	0.04 (0.038)	0.22 (0.080)

[1] Values in parentheses are standard errors of the proportions

[2] Proportion ± $t_{(0.05)}$(S.E.) = 95% Confidence Interval

[3] No estimate available for Atrazine ≥0.35 ug/l in District 6.

ug/l = micrograms per liter.

mg/l = milligrams per liter.

Table 6. State level concentration estimates for atrazine and nitrate-nitrogen (NO_3-N).

Category	Mean	S.E.[1/]
	---------------ug/l---------------	
Atrazine	0.12	0.04
	---------------mg/l---------------	
NO_3-N	3.74	0.23

[1/]Mean concentration ± $t_{(0.05)}$ (S.E.) = 95% Confidence Interval

ug/l = micrograms per liter.

mg/l = milligrams per liter.

Table 7. Atrazine data by Agricultural Statistics District

Ag Dist.	n	Detects	Max[1/]	Number ≥0.35 ug/l	Number ≥3.5 ug/l
Northwest	64	4	1.05	3	0
North Central	48	2	0.55	2	0
Northeast	30	2	1.22	1	0
West Central	87	10	2.53	6	0
Central	38	5	4.16	3	1
East Central	82	6	0.33	0	0
Southwest	78	13	19.40	7	1
South Central	80	23	4.43	16	1
Southeast	27	1	0.57	1	0
Total	534	66		39	3

ug/l = micrograms per liter.

[1/] Maximum concentration, ug/l.

Table 8. Nitrate-nitrogen (NO_3-N) data by Agricultural Statistics District

Ag Dist.	n	Detects	Max[1/]	Number ≥2 mg/l	Number ≥10 mg/l
Northwest	64	50	16.00	32	5
North Central	48	37	16.70	22	1
Northeast	30	14	11.90	8	1
West Central	87	67	24.00	50	6
Central	38	28	21.80	24	6
East Central	82	24	28.00	19	8
Southwest	78	68	13.50	54	9
South Central	80	49	44.00	40	19
Southeast	27	8	6.90	6	0
Total	534	345		255	55

mg/l = milligrams per liter.

1/ Maximum concentration, mg/l.

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Appendix. **Wells selected and sampled and pesticides detected by Agricultural Statistics District. Wells with atrazine or alachlor at or above the preventive action limits or enforcement standards are in bold type.**

County	Wells Selected	Wells Sampled	Wells Detect(s)	Well	Pesticide	Concentration (ug/l)
		Northwest Agricultural Statistics District				
Bayfield	2	2	0			
Barron	29	29	3	(1)	Atrazine	**0.39**
				(2)	Atrazine	**1.05**
				(3)	Atrazine	0.19
Burnett	0					
Chippewa	13	13	2	(1)	Atrazine	**0.46**
				(2)	Alachlor	**0.71**
					Metribuzin	0.17
Douglas	1	1	0			
Polk	9	9	0			
Rusk	7	7	0			
Sawyer	1	1	0			
Washburn	2	2	0			
Subtotal	64	64	5			
		North Central Agricultural Statistics District				
Ashland	1	1	0			
Clark	18	18	1	(1)	Atrazine	**0.53**
Iron	0					
Lincoln	1	1	0			
Marathon	23	21	1	(1)	Atrazine	**0.55**
Oneida	0					
Price	1	1	0			
Taylor	8	8	0			
Vilas	0					
Subtotal	50	48	2			
		Northeast Agricultural Statistics District				
Florence	0					
Forest	2	2	0			
Langlade	3	2	0			
Marinette	4	4	0			
Oconto	7	7	0			
Shawano	15	15	2	(1)	Atrazine	**1.22**
				(2)	Atrazine	0.23
Subtotal	31	30	2			

County	Wells Selected	Wells Sampled	Detect(s)	Well	Pesticide	Concentration (ug/l)
		West Central Agricultural Statistics District				
Buffalo	6	6	0			
Dunn	20	18	0			
Eau Claire	8	8	1	(1)	Atrazine	0.25
Jackson	5	5	2	(1)	Atrazine	**0.38**
				(2)	Atrazine	**0.53**
LaCrosse	6	6	0			
Monroe	8	8	1	(1)	Atrazine	0.31
Pepin	3	3	0			
Pierce	6	6	2	(1)	Atrazine	**0.37**
				(2)	Atrazine	**0.45**
St. Croix	18	16	4	(1)	Atrazine	**2.53**
				(2)	Atrazine	0.25
				(3)	Atrazine	0.15
				(4)	Atrazine	**0.48**
Trempeleau	11	11	1	(1)	Alachlor	**5.87**
Subtotal	91	87	11			
		Central Agricultural Statistics District				
Adams	1	1	0			
Green Lake	5	5	2	(1)	Atrazine	0.16
				(2)	Atrazine	**4.16**
Juneau	5	5	1	(1)	Atrazine	**0.64**
Marquette	2	2	0			
Portage	6	6	1	(1)	Metribuzin	0.44
Waupaca	9	9	2	(1)	Atrazine	**0.86**
				(2)	Atrazine	0.16
Waushara	4	4	0			
Wood	6	6	0			
Subtotal	38	38	6			
		East Central Agricultural Statistics District				
Brown	8	7	1	(1)	Atrazine	0.29
Calumet	12	11	0			
Door	2	2	1	(1)	Atrazine	0.16
Fond du Lac	17	17	3	(1)	Atrazine	0.33
				(2)	Atrazine	0.27
				(3)	Atrazine	0.27
Kewaunee	5	5	0			
Manitowoc	13	12	0			
Outagamie	16	16	1	(1)	Atrazine	0.18
Sheboygan	9	8	0			
Winnebago	5	4	0			
Subtotal	87	82	6			

County	Wells Selected	Wells Sampled	Wells Detect(s)	Well	Pesticide	Concentration (ug/l)
			Southwest Agricultural Statistics District			
Crawford	7	7	0			
Grant	19	19	3	(1)	Atrazine	**0.35**
				(2)	Atrazine	0.25
				(3)	Alachlor	**0.50**
Iowa	16	14	3	(1)	Atrazine	**0.35**
				(2)	Atrazine	0.30
				(3)	Atrazine	**0.62**
Lafayette	9	9	3	(1)	Atrazine	**0.62**
				(2)	Atrazine	0.20
				(3)	Alachlor	**1.95**
Richland	6	6	1	(1)	Atrazine	**1.05**
Sauk	14	14	5	(1)	Atrazine	0.27
				(2)	Atrazine	0.25
				(3)	Atrazine	0.33
				(4)	Atrazine	**1.91**
				(5)	Atrazine	**19.4**
					Metolachlor	0.56
Vernon	11	11	0			
Subtotal	80	78	15			
			South Central Agricultural Statistics District			
Columbia	8	8	3	(1)	Atrazine	**4.43**
				(2)	Atrazine	**0.58**
				(3)	Atrazine	**2.93**
					Alachlor	**0.53**
Dane	22	22	12	(1)	Atrazine	**0.49**
				(2)	Atrazine	**1.24**
				(3)	Atrazine	**0.52**
				(4)	Atrazine	**0.57**
				(5)	Atrazine	**0.47**
				(6)	Atrazine	0.20
				(7)	Atrazine	**2.80**
				(8)	Atrazine	**0.83**
				(9)	Atrazine	**0.45**
				(10)	Atrazine	0.18
				(11)	Atrazine	0.16
				(12)	Atrazine	0.27
Dodge	23	23	0			
Green	10	9	4	(1)	Atrazine	0.23
				(2)	Atrazine	**1.41**
				(3)	Atrazine	0.26
				(4)	Atrazine	**0.64**
Jefferson	8	8	0			
Rock	11	10	4	(1)	Atrazine	**0.45**
				(2)	Atrazine	**0.80**
				(3)	Atrazine	**0.68**
				(4)	Atrazine	0.19
Subtotal	82	80	23			

County	Wells Selected	Wells Sampled	Wells Detect(s)	Well	Pesticide	Concentration (ug/l)
		Southeast Agricultural Statistics District				
Kenosha	3	3	0			
Ozaukee	2	2	0			
Racine	2	2	0			
Walworth	5	5	0			
Washington	10	10	1	(1)	Atrazine	0.57
Waukesha	5	5	0			
Subtotal	27	27	1			
State Total	550	534	71			