SOME NEW FINDINGS ON NITRATE IN WISCONSIN GROUNDWATER

Jeffrey K. Postle[1]

Over the past decade The Department of Agriculture, Trade and Consumer Protection (DATCP) has conducted several groundwater sampling programs that have contributed to the understanding of nitrate occurrence in Wisconsin groundwater. These studies have sampled both private drinking water wells and monitoring wells installed near agricultural fields. Early studies focused on susceptible areas (coarse-textured soils, shallow depth to groundwater) and showed that nitrate contamination was a problem in these areas. Two recent monitoring-well studies have expanded our knowledge of nitrate behavior in areas with medium-textured soils such as silt loams. The purpose of this paper is to summarize the results of three DATCP monitoring well studies and make some conclusions about in nitrate occurrence in Wisconsin groundwater.

Health Concerns and Other Negative Impacts of Nitrates in Groundwater

The Wisconsin Enforcement Standard (ES) for nitrate-N is 10 parts per million (ppm) and the Preventive Action Limit is 2 ppm. The main human health related concern with nitrate is methemoglobinemia or "blue baby syndrome". This condition is a concern for children under six months of age. Health advisory statements issued for wells with nitrate-N exceeding 10 ppm also include a warning for pregnant women. High levels of nitrate in groundwater can also be an animal health concern when combined with high nitrate concentrations in feed (Jackson and Webendorfer, 1983).

Well owners whose water exceeds the 10 ppm Enforcement Standard may have to consider obtaining an alternative water supply. The options for an alternative water supply include installing a new well, treating the water, using bottled drinking water, or hauling water from a known safe source. The costs of installing a new well range from $1,000-10,000. The cost of installing a water treatment system to remove nitrates is approximately $1,000. It is estimated that approximately 75,000 private wells in Wisconsin exceed the 10 ppm ES.

Sources of Nitrate in Groundwater

Nitrate in groundwater can originate from a number of sources including private sewage systems, nitrogen fertilizer applications, manure applications, animal waste storage and feedlots, legume (nitrogen fixing) plants, and municipal and industrial wastewater and

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[1]Groundwater Specialist, Wisconsin Department of Agriculture, Trade and Consumer Protection

sludge disposal. The use of nitrogen in crop production is generally considered to be a major source of nitrate in groundwater (Shaw, 1994).

DATCP Monitoring Well Studies

DATCP Groundwater Monitoring Project for Pesticides in Susceptible Areas

In this study nests of three wells were installed on the down-gradient side of 50 agricultural fields. The characteristics of these fields are coarse-textured soils, shallow depth to groundwater, and irrigation. Most of the well sites are in the Central Sands and the Lower Wisconsin River Valley. The focus of this study was to monitor for pesticides and nitrate in worst-case settings.

This study has been in progress since 1985. The wells have been sampled from one to four times per year depending on the pattern of detects. As was expected, this study led to a high frequency of detections for nitrate-N and many of the pesticides used on these fields. Table 1 shows a summary of the nitrate-N results from the Central Sands well sites where irrigated potato and vegetable production is common.

Table 1. DATCP Monitoring Well Sampling Results for Nitrate-N in the Central Sands Region, 1987-1998.

Year	# of sites	# of sites>10 ppm	Average Nitrate-N (ppm)	Maximum Nitrate-N (ppm)
1987	12	12	22	65
1988	16	16	21	44
1989	15	14	21	54
1993	11	11	18	52
1994	10	9	19	73
1995	8	8	28	117
1996	7	6	20	38
1997	8	7	22	39
1998	8	8	22	62

This table shows two important findings: First, most sites exceed the ES of 10 ppm for nitrate-N every year. It appears that complying with the ES with this type of crop production and environmental setting is difficult. Second, the average nitrate-N results over time have remained relatively consistent, hovering around 20 ppm. This seems to suggest that the shallow groundwater under these fields has reached an equilibrium with the agricultural practices that have been used.

Nitrate Results from the DATCP Atrazine Reuse Study

In 1998 DATCP initiated a groundwater monitoring project to evaluate the effects of renewed atrazine use in atrazine prohibition areas (PAs). The purpose of this project is to determine if PAs that meet certain criteria can be repealed without causing additional unacceptable groundwater contamination by atrazine.

In order to generate this data, DATCP, in cooperation with Novartis Crop Protection, installed monitoring wells in 17 test fields in PAs. Eight fields have coarse-textured soil and nine have medium-textured soil. Three wells are installed in each field and are monitored quarterly for atrazine, other herbicides, and nitrate. Each study field is between 10 and 40 acres and the wells are installed in a line across the middle of the field. These fields are primarily devoted to corn and soybean production.

The nitrate results from this study show that the shallow groundwater beneath these fields is being heavily impacted by nitrogen. The average nitrate-N concentration at all 17 sites is 35 ppm. Interestingly, the average nitrate-N concentrations for the coarse and medium-textured sites are identical. All sites have average levels at or above the ES. Table 2 shows the average and maximum nitrate-N concentrations for the 17 sites.

Table 2. Average and Maximum Nitrate-N Concentrations in the DATCP Atrazine Resuse Study, by Site.

Site	County	Soil Texture	Average Nitrate-N (ppm)	Maximum Nitrate-N (ppm)
24H	Green Lake	coarse	20	27
45F	Outagamie	coarse	53	73
50M	Portage	coarse	43	67
50N	Portage	coarse	35	49
65D	Walworth	coarse	21	35
69P	Waupaca	coarse	29	33
70G	Waushara	coarse	39	61
70Q	Waushara	coarse	37	43
09A	Chippewa	medium	10	29
13C	Dane	medium	28	47
13E	Dane	medium	41	53
13J	Dane	medium	21	32
23I	Green	medium	88	174
27B	Jackson	medium	10	16
29L	Juneau	medium	64	100
39K	Marquette	medium	33	44
56R	Saint Croix	medium	24	26

Nitrate Results from the Acetochlor Monitoring Well Study

In 1994 the U.S. Environmental Protection Agency granted a conditional registration to the Acetochlor Registration Partnership (ARP) to market herbicide products containing acetochlor in the U.S. As part of this conditional registration, the ARP agreed to install monitoring wells in several states including Wisconsin to determine if acetochlor is a threat to groundwater. Twenty-five monitoring wells were installed in Wisconsin next to agricultural fields that represent the range of conditions were corn is produced and acetochlor is registered for use. The sites range from medium to coarse-textured soils, but very sandy soils with low organic matter are not included because they are not legal use sites on the acetochlor product labels.

The ARP samples these wells monthly, and twice a year DATCP obtains split samples for pesticide and nitrate analysis. The data presented here is from the DATCP split samples. Table 3 shows the average nitrate-N levels from the 24 monitoring wells sampled in 1998.

Table 3. Average 1998 Nitrate-N Levels for 24 Wells in the DATCP Acetochlor Monitoring Study.

Site	Soil Texture	Average 1998 Nitrate-N (ppm)	County
WI01	medium	11	St. Croix
WI03	medium	20	Portage
WI04	coarse	14	Portage
WI05	coarse	36	Portage
WI06	coarse	39	Portage
WI07	coarse	3.3	Waupaca
WI08	coarse	1.5	Portage
WI09	coarse	21	Waupaca
WI10	coarse	12	Waupaca
WI12	medium	18	Dodge
WI13	medium	14	Dodge
WI14	medium	8.0	Dodge
WI15	medium	35	Dane
WI17	medium	14	Walworth
WI18	medium	0	Jefferson
WI20	medium	12	Rock
WI21	medium	17	Rock
WI22	medium	16	Rock
WI23	coarse	3.2	Portage
WI24	medium	42	Rock
WI25	medium	6.9	Rock
WI26	medium	11	St. Croix
WI27	medium	18	St. Croix
WI28	medium	22	Dane

This table shows that 18 of the 25 sites exceeded the ES for nitrate-N in 1998. Of the seven sites below 10 ppm, three are sites with coarse-textured soil and four have medium-textured soil. The average nitrate-N value in this study in 1998 was 16 ppm with no difference between the coarse and medium-textured sites.

Discussion

These three monitoring-well studies show that nitrate is having a serious impact on shallow groundwater at agricultural fields with a range of soil textures. The results presented in this paper are from monitoring wells located in or next to agricultural fields and therefore probably reflect non-point, field use related impacts rather than point sources. These studies indicate that nitrate impacts on shallow groundwater are occurring on medium-textured soils (where until recently we have had less data) as well as on coarse-textured soils. Specifically, it appears that that both corn and soybean production on medium-textured soils and potato and vegetable production on coarse-textured soils often lead to nitrate-N concentrations in groundwater that exceed the ES. These findings have considerable implications for any strategy for reducing nitrate levels in groundwater in Wisconsin.

References

Jackson, G. and B. Webendorfer, 1983. Nitrate, Groundwater, and Livestock Health. University of Wisconsin Extension Publication G3217.

Shaw, Byron, 1994. Nitrogen Contamination Sources: A Look at Relative Contributions. In: Nitrate in Wisconsin's Groundwater: Strategies and Challenges. University of Wisconsin - Stevens Point.