Pesticides

What are they?

Pesticides are a broad class of substances designed to kill, repel, or otherwise disrupt living things that are considered pests. They include insecticides, herbicides, fungicides, and anti-microbials, among other types of biocides. Normal field applications, spills, misuse, or improper storage and disposal can all lead to pesticide contamination in groundwater. As pesticides breakdown in soil and groundwater or are absorbed and metabolized by the target pest, some are converted into related compounds called **metabolites**, which may also be harmful to the pest or other living things.

Pesticide application sign. *Photo*: DATCP.

The health effects of exposure to pesticides or pesticide metabolites vary by substance. About 30 pesticides (and some additional pesticide metabolites) currently have a health-based enforcement standard (ES) in groundwater (WI NR 140.10). A smaller number have a maximum contaminant level (MCL) in drinking water (WI NR 809.20). However, at least 90 different pesticides are used on major crops in Wisconsin (WASS, 2006). Occasionally, pesticides and pesticide metabolites that do not have a groundwater ES or drinking water MCL are detected in drinking water, in which case information on health effects may be very limited or difficult to evaluate. It is also difficult to predict the health effects of multiple pesticides in drinking water; several studies indicate that pesticide mixtures can have different health effects than exposure to individual pesticides at the same concentrations (Porter, 1999; Hayes et al., 2006). A few commonly detected pesticides which do have groundwater or drinking water standards in Wisconsin include atrazine, alachlor, and their metabolites.

Atrazine is an herbicide popularly used on corn. The groundwater ES for atrazine and its three chlorinated metabolites is 3 parts per billion (ppb). The drinking water MCL for atrazine (does not include metabolites) is also 3 ppb. Some people who drink water containing atrazine well in excess of the MCL over many years could experience problems with their cardiovascular system or reproductive difficulties. A number of epidemiological and animal studies support this (Hayes et al., 2002; ATSDR, 2003; Hayes et al., 2003; Hayes et al., 2006; Hayes et al., 2011; Craigin et al., 2011; Agopian et al., 2012; Agopian et al., 2013).

Alachlor is another herbicide used on corn and soybeans. While use of alachlor in Wisconsin is being replaced by other herbicides in the same family (e.g., *metolachlor, acetochlor*) (NASS, 2015 and 2016), its metabolites still linger in groundwater. Both the groundwater ES and drinking water MCL for alachlor are 2 ppb and one of its metabolites, *alachlor ESA*, has a groundwater ES of 20 ppb. Some people who

drink water containing alachlor in excess of the MCL over many years could have problems with their eyes, liver, kidneys, or spleen, or experience anemia, and may have an increased risk of getting cancer.

Occurrence in Wisconsin

In Wisconsin, the main source of pesticides in groundwater is agricultural herbicide and insecticide application. For this reason, detection is more common in highly cultivated areas where agriculture is well established, notably in the southcentral, central, and west-central parts of the state.

As of 2007, the last time DATCP conducted a statewide statistical survey of agricultural chemicals in groundwater, an estimated 33% of private wells in Wisconsin contain a pesticide or pesticide metabolite (DATCP, 2008). For wells where at least one agricultural chemical was detected, on average there are 2 to 3 pesticide compounds found in the water. The primary metabolites from alachlor and metolachlor, alachlor ESA and metolachlor ESA, respectively, are the two most common compounds. Each is found in about 22% of wells. Atrazine and its family of metabolites (total chlorinated residues, TCR) are also prevalent and occur in about 12% of wells. About 4% of well samples with atrazine TCR detections have atrazine TCR levels that exceed the groundwater ES.

GCC Agency Actions

Serious concerns about pesticide contamination in Wisconsin were first raised in 1980 when aldicarb, a pesticide used on potatoes, was detected in groundwater near Stevens Point. The DNR, DATCP, and other agencies responded to concerns by implementing monitoring programs and conducting groundwater surveys, initially testing exclusively for aldicarb (Rothschild et al., 1982; Kraft 1990) but soon expanding to other pesticides and eventually pesticide metabolites as well (Postle and Brey, 1988). DATCP also developed rules to restrict aldicarb use in areas vulnerable to groundwater contamination.

When findings from these sampling surveys in the late 1980s and early 1990s showed that atrazine, a popular corn herbicide, was particularly prevalent in groundwater across the state (LeMasters and Doyle, 1989; Cowell and LeMasters, 1992), special projects were conducted to investigate how and why it reaches the groundwater. Notably, researchers funded by the Wisconsin Groundwater Research and Monitoring Program discovered that normal field application of atrazine – not just point spills and misuse – was an important source of atrazine in groundwater (Chesters et al., 1990; Chesters et al. 1991). This knowledge, combined with other findings regarding the roles of soil, geology, and agricultural management (Daniel and Wietersen, 1989; Lowery and McSweeney, 1992; Levy and Chesters 1995; Levy et al. 1998), allowed the DNR and DATCP to effectively and fairly design both groundwater standards and the atrazine rule, as detailed in [this profile]

A plane sprays pesticides on a field. *Photo*: *DATCP*.

on the experience. Where atrazine use has been prohibited by the atrazine rule, follow-up studies demonstrate there is a clear reduction in atrazine levels, which generally drop below the groundwater standard in 2 to 7 years (DATCP, 2010). Many farmers would like the option to use atrazine in these areas, but they have adapted well to growing corn without it. A 2010 DATCP survey found that the vast majority of farmers in atrazine prohibition areas have not observed a decrease in yield, most believe it is not more difficult to control weeds with other alternatives, and there is an even split in those who think weed control is more vs. less costly without atrazine (DATCP, 2011a). By far, the most popular alternatives to atrazine are glyphosate-containing products such as Roundup. From a groundwater perspective, this is fortunate since glyphosate binds very tightly to soil and thus is generally not a groundwater threat. There are concerns, however, that overuse of glyphosate may lead to glyphosate-resistant weeds.

Many sampling surveys initiated by DATCP, the DNR, and other agencies in the mid-1980s to early 1990s are still ongoing today. The longest running survey on pesticides in Wisconsin began in 1985 and is designed to evaluate the potential impact of agriculture on groundwater quality by sampling monitoring wells near selected agricultural fields in areas with high groundwater contamination potential. Current results confirm that alachlor and metolachlor are the two most common pesticides in Wisconsin, followed by atrazine. Another study that has been repeated annually since 1995 focuses on re-sampling wells that have previously exceeded a pesticide standard. Over 160 wells have been sampled a second time in this survey, and over time, atrazine levels have declined in about 80% of the wells (DATCP, 2010). Many of these wells are located in what are now atrazine prohibition areas. DATCP has also conducted a statewide, statistically designed survey of agricultural chemicals in Wisconsin groundwater four times since the early 1990s (1994, 1996, 2001, and 2007). In the latest survey, nearly four hundred samples from private drinking water wells were analyzed for 17 pesticides and 14 pesticide metabolites (DATCP, 2008). Health standards have been established for 11 of the parent compounds and four of the metabolites. In addition to capturing the current picture of agricultural chemicals in groundwater, this series of studies relates these findings to land use and compares results over time to detect trends.

Monitoring well near an agricultural field. *Photo*: *DATCP*.

Future Work

In addition to continuing existing annual surveys, the statewide statistical survey of agricultural chemicals in groundwater will be repeated by DATCP in 2016 for the first time in 9 years. The new survey will analyze for close to 80 pesticide compounds, a dramatic increase over the 31 compounds tested during the last survey in 2007 and the 17 compounds tested in 2001. This reflects both changes in agricultural practices and improvements in laboratory methods capable of detecting these compounds.

One of the benefits of organic farming is the significantly decreased potential for pesticides in groundwater where organic practices are followed. As the organic market continues to expand due to increased consumer interest in organic food and reports of increased profits by organic producers (DATCP, 2011b), this may help manage the amount of pesticides reaching groundwater.

Further development of health standards and laboratory methods is of paramount importance for keeping pace with the evolving use of agricultural chemicals in order to ensure that the agricultural success that is so crucial for our state is fairly balanced with the protection of groundwater and human health.

Further Reading

DHS resources for contaminants in drinking water [link]

DNR overview of pesticides in drinking water wells [link]

DATCP water quality reports [link]

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