



January 14, 2010

MINNESOTA DEPARTMENT OF AGRICULTURE SPECIAL REGISTRATION REVIEW

SUBJECT: Summary of the Special Registration Review of the Herbicide Atrazine in Minnesota

The Minnesota Department of Agriculture (MDA) administers and enforces state and federal pesticide laws and regulations under the Pesticide Control Law, Chapter 18B. This includes the registration, sale, use, distribution, storage, and disposal of atrazine in Minnesota. In response to one of several recommendations in an evaluation report from the Office of the Legislative Auditor for the State of Minnesota, the MDA has initiated a process that includes criteria from the Auditor's report to select and review pesticide registrations. These reviews may consider appropriate additional state-specific restrictions, limitations on use as a condition of registration, or registration without state-specific restrictions. The MDA has selected atrazine as the first pesticide to go through this special registration review process. This process is not intended to be redundant of analyses and decisions reached by the U.S. Environmental Protection Agency (USEPA) during federal pesticide registration.

The MDA along with partners at the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Health (MDH) have completed a special registration review of atrazine. As part of this review, the MDA evaluated the need to prevent "unreasonable adverse effects on the environment" [Minn. Stat. § 18B.26 Subd. 5(b)] from atrazine. "Unreasonable adverse effects on the environment" means "any unreasonable risk to humans or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide [Minn. Stat. § 18B.01 Subd. 31]." Assessments from the MPCA and MDH describe the magnitude of observed atrazine concentrations relative to potential human health and environmental risks based on known toxicity endpoints and state standards. Assessments from the MDA describe known economic costs and benefits from the use of atrazine in Minnesota. These assessments are the foundation of this summary and are available in their entirety by contacting the Pesticide and Fertilizer Management Division of MDA at <http://www.mda.state.mn.us/chemicals/pesticides/atrazine/atrazinereview.aspx> or by calling 651-201-6141.

In fall of 2008, a scoping document was prepared to guide the review and determine the scope of work necessary to conduct a special registration review of atrazine. A "Notice of Intent" for the special registration review was published on page 488 of the Minnesota State Register on Monday, September 8, 2008 and comments were accepted through November 10, 2008. The MDA received comments from four (4) interested parties. Subsequent to completing the scoping document, the MDA, MPCA and MDH met periodically to discuss components of the atrazine technical review.

The following summary provides information to the Commissioner of Agriculture to assess, which if any, additional non-regulatory and/or regulatory actions are warranted for the registration of atrazine in Minnesota.

Background

Atrazine (EPA Reg. No. 100-497) is an herbicide used to control mostly broadleaf weeds and a few specific grasses in Minnesota corn fields. There are no non-agricultural uses of atrazine in Minnesota. Atrazine is in the triazine chemical family; other active ingredients in this family include simazine and terbuthylazine. Atrazine has four hydroxyl and three chlorinated breakdown products (environmental degradates or human metabolites). Atrazine and its chlorinated breakdown products, deethylatrazine (DEA), deisopropylatrazine (DIA) and diaminochlorotriazine (DACT) are the primary focus of this review.

Atrazine is classified by the EPA as a Restricted Use Pesticide (RUP). Anyone selling or using a pesticide product containing atrazine is required by law to be licensed (commercial or non-commercial applicators) or certified (private applicators).

Since initial federal registration in 1958, atrazine has been a component of weed control programs in Minnesota. Atrazine is applied both in prepackaged mixtures and as a component of tank mixes for pre- and post-emergent weed control. Atrazine is rarely applied alone; rather, it is a component in various pesticide mixtures. There are close to 100 different pesticide products registered in Minnesota that contain atrazine.

Typically atrazine is applied once per season at a rate of approximately 0.55 pounds of active ingredient per acre (lbs of a.i./A). The maximum label use rates are 2.0 lbs of a.i./A per application and 2.5 lbs of a.i./A per year. The MDA and the National Agricultural Statistics Service (NASS) collect pesticide use data from farmers throughout Minnesota. The most recent NASS data (2005), which estimates pesticide use based on a relatively small sample size, indicates that atrazine was applied on an estimated 41% of the 7.3 million field corn acres in Minnesota. By comparison, according to the most recent 2007 MDA use survey of corn growers, derived from a relatively larger sample size, approximately 22% of corn acres in Minnesota receive atrazine applications.¹

Atrazine use varies across counties in Minnesota depending on the number of corn acres, geography, weed species, soil type, and pesticide packages that individual pesticide dealers promote. As the vast majority of atrazine use is limited to field and sweet corn, corn acres within each county also affects county atrazine use statistics. Atrazine use in several southeast and south central Minnesota counties is higher than in other areas of the state because soils there are relatively lower in pH, allowing the use of atrazine in rotation with sensitive crops without long residual effects.

Human Health Assessment

Atrazine Toxicity

MDH evaluated the potential for atrazine to cause non-cancer and cancer effects based on animal toxicology studies. In mammalian studies, exposure to atrazine alters neuroendocrine function, specifically gonadal-pituitary function, resulting in reproductive and developmental effects. Altered function is expressed in a variety of ways in the rat studies, including suppressed release of leutinizing hormone (leading to changes in estrus cycles), suppressed prolactin secretion in milk (causing prostatitis), delayed preputial separation, delayed vaginal opening, and delays in male and female puberty. Liver, kidney, and heart damage are other non-cancer effects that have been observed in animal studies. For cancer effects, at this time MDH concurs with EPA's current analysis of rat cancer bioassays and the resulting classification of atrazine as "Not Likely to Be Carcinogenic to Humans." The MDH is continuing to assess acute, short-term, subchronic, chronic, and cancer endpoints for atrazine and its chlorinated metabolites, DEA, DIA, and DACT. In some of the toxicological information available for DACT, the primary metabolite in mammals, critical effects are observed at doses lower than the same effects seen for atrazine. Based on this information, the health-based assessment for DACT indicates a potentially higher level of toxicity than for atrazine for some health endpoints. MDH is continuing to research the potential magnitude of this difference in potency. Based on currently available information and the magnitude of uncertainty factors that may be applied, it is unlikely that a new MDH Health Risk Limit (HRL) value for atrazine (parent) will be lower than the current drinking water HRL of 3 parts per billion (ppb). However, new, potentially lower health-based guidance values may be derived for DACT. Because DEA and DIA are rapidly metabolized to DACT, guidance values derived for DACT may be applicable to DEA and DIA. The conclusions stated in this summary reflect MDH's current understanding of the available toxicity information for atrazine and its chlorinated metabolites. These chemicals remain a subject of active research as well as a pending US EPA re-evaluation.

¹ Both the MDA and NASS survey methods bring important results to the discussion about agricultural chemical use in Minnesota. However, there are differences in design and execution of these two surveys and results may not be comparable. These differences are further described in survey reports available online at <http://www.mda.state.mn.us/chemicals/pesticides/pesticideuse.aspx>

MDH has also reviewed information compiled by EPA for the degradate hydroxyatrazine (HA), described in the EPA Reregistration Eligibility Decision (RED) document for atrazine. In developmental studies, effects were observed only at the highest dose tested and were not considered by EPA to be an appropriate acute or short-term toxicity endpoint of concern. EPA does not expect the neuroendocrine effects associated with atrazine, such as attenuation of the leutinizing hormone surge, to occur following exposure to hydroxyatrazine. As a result, representatives from MDA, MDH, and MPCA have designated hydroxyatrazine as a low priority atrazine degradate.

Epidemiology

For epidemiological evaluation, MDH relied on peer reviewed studies and a 2003 review conducted by EPA. Epidemiology studies have reported that atrazine exposure may be positively associated with adverse health outcomes including prostate cancer, non-Hodgkin's lymphoma, reproductive effects, birth outcomes, and birth defects. Interpretation of these studies is often hindered by methodologic limitations which reduce the number and kinds of inferences that can be made. Limitations include the use of aggregate rather than individual measures of exposure, lack of high-quality exposure data, small sample size, limited statistical power for certain outcomes, and/or limited ability to control for confounding factors. Although the weight-of-evidence from reviewed studies can be currently summarized as insufficient to establish causal relationships, atrazine remains a subject of on-going, active research and review. In particular, EPA plans to solicit expert advice on how to more effectively incorporate epidemiology studies into the atrazine risk assessment in February 2010 and to seek peer review of its evaluation of atrazine epidemiology studies in September 2010.

Exposure via Public Water Systems (PWS)

For the general population, the oral route via drinking water is the dominant exposure pathway for atrazine based on its occurrence in Minnesota surface and groundwater. Detections of atrazine (parent²) in public water supply systems in Minnesota are rare. Currently there are 961 active community water supplies (CWS) serving approximately 4,187,000 Minnesotans, or 80% of the state's population based on 2008 U.S. Census figures. Between 2000 and 2008, 12 (2%) out of 544 CWS sampled had atrazine detections between the 0.1-0.3 ppb laboratory "limit of detection" and 1.2 ppb, representing approximately 13% of the population served by community water. Since the inception of the Safe Drinking Water Act (SDWA) compliance monitoring program for atrazine in the early 1990s, no single or running-average atrazine concentration in CWS has exceeded the federal MCL of 3 ppb.

As with CWS, no non-community public water system in Minnesota has ever violated the federal MCL of 3 ppb. Between 2000 and 2008, atrazine was detected in 11 out of 571 non-transient non-community (NTNC) public water systems tested (found in 1.7% of the samples), with a maximum detected concentration of 1.8 ppb. Between 2000 and 2008, atrazine was detected in 1 out of 71 sampled transient non-community (TNC) public water systems, with a maximum concentration of 0.6 ppb.

According to the MDH, without analysis of atrazine degradates, PWS data are of limited use to fully understand atrazine's presence in the state's public drinking water. Although degradates are often detected together with atrazine, combined concentrations are still expected to be low, relative to current drinking water standards, based on atrazine-only results. Infrequent sampling is another major limitation in PWS monitoring, as peak concentrations are unlikely to be captured. Data from CWS and MDA monitoring programs suggest that atrazine concentrations may be declining over time in certain areas of the state.

Exposure via Private Drinking Water Wells

An estimated 20% of Minnesotans receive drinking water at home from private wells. No federal or state regulations mandate the testing of atrazine in private wells; therefore, testing is currently the responsibility of the well owner. Testing can be done through various private laboratories. The MDA has a webpage to guide those interested in such testing:

<http://www.mda.state.mn.us/en/protecting/waterprotection/pesticides.aspx>.

While private wells are not routinely regulated for contamination by any state agency, the MDA and MDH, local units of government, and non-governmental organizations have conducted sampling of private wells through special projects. Detections in private water supplies typically occur in areas

² Only parent atrazine is analyzed for public water supply system compliance with the federal SDWA.

that have sandy soils and/or shallow water tables. Individuals participating in such surveys are always informed of their results.

A Rural Well Survey of seventy-four private wells, sampled in either the central sands or southeast karst regions of Minnesota, was conducted by a previous atrazine registrant, Ciba, in conjunction with MDA, from September 1992 to March 1995. Atrazine, or at least one of its three chlorinated degradates, was detected in approximately half of the wells sampled. Four wells sampled had total chlorotriazine concentrations greater than the current Minnesota HRL of 3 ppb, with a maximum concentration of 5.6 ppb (total chlorotriazine). Although this study provides valuable information on the relative contribution of atrazine's major degradation products in private wells located in vulnerable areas of Minnesota, use of this study is not appropriate to describe present-day atrazine concentrations since use restrictions were implemented in the early to mid 1990's, primarily to protect water supplies.

In 2004, MDA conducted a survey of drinking water in 71 private wells statewide. Ten wells had a positive detection of atrazine plus the chlorinated degradates DIA and DEA, with detections ranging from 0.06 to 2.52 ppb. The survey 90th percentile concentration was 0.09 ppb. No detections in this survey exceeded the Minnesota HRL of 3 ppb.

In 2009, MDA conducted a Potable Well Study in southeast Minnesota using an immunoassay method to screen for the presence of atrazine plus the chlorinated degradates DIA and DEA. Wells from 9 counties in the Volunteer Nitrate Monitoring Network were selected. Of the 100 kits that were sent out, 92 were returned for atrazine screening. Detected concentrations in 44 of the 92 wells (representing both atrazine parent plus chloro-degradates) ranged from 0.07 to 1.26 ppb, with a 90th percentile concentration of 0.22 ppb. Of the 44 water samples with positive detections, none of the concentrations of atrazine (plus chloro-degradates) exceeded the Minnesota HRL of 3 ppb.

Local units of government and water planners have also conducted surveys of private wells for atrazine. From 2004-2007, Dakota County conducted a survey of 68 private drinking water wells for multiple contaminants including atrazine and the chlorinated degradates DEA, DIA, and DACT, along with the hydroxy degradates, deethylhydroxyatrazine (DEHA), deisopropylhydroxyatrazine (DIHA), and hydroxyatrazine (HA). Thirty-seven of the 68 wells surveyed (or 54%) had detectible levels of atrazine and/or chlorinated degradates. Concentrations were low relative to the Minnesota HRL of 3 ppb and no samples had single or aggregated concentrations of 1 ppb or greater.

According to MDH, the small amount of data from private drinking water wells makes a complete assessment of exposure for private well users difficult. However, based on the entirety of available data from drinking water wells and groundwater monitoring wells (described below), atrazine (and atrazine plus chlorinated degradate) concentrations in private wells are expected to be absent or below established health benchmarks. Nevertheless, the potential remains for concentrations to occur above health benchmarks in high atrazine use areas and geologically vulnerable areas.

Although the MDA does not routinely monitor private drinking water wells (except as special projects, as noted above), the MDA routinely monitors for atrazine and its chlorinated degradates in ground and surface water resources and provides monitoring results in a publically available annual report. The MDA's state-wide network of groundwater monitoring wells may be representative of very shallow private drinking water wells finished in glacial outwash and other sand and gravel aquifers. The MDA has focused groundwater and spring monitoring on two Pesticide Monitoring Regions (PMRs) considered most vulnerable to contamination: central sand plains (PMR 4) and southeast karst region (PMR 9). The current trend shows a decrease of slightly greater than 0.01 ppb per year in PMR 4 monitoring wells and frequent but low (below 3 ppb) levels in PMR 9 springs.

In 2007 and 2008, the MDA began to screen for the chlorinated degradate, DACT, in groundwater monitoring samples. In 2007, the maximum concentration of DACT found at a groundwater monitoring site was 1.5 ppb and, when combined with other atrazine constituents at that site, resulted in a maximum of 2.42 ppb. In 2008, the maximum concentration of DACT found at a groundwater monitoring site was 1.85 ppb and, when combined with other atrazine constituents at that site, resulted in a maximum of 2.50 ppb. No detections exceeded the Minnesota HRL of 3 ppb for atrazine parent plus chlorinated degradates.

Other private well and groundwater surveys for atrazine have been conducted in Minnesota and are described in the MDA Atrazine Monitoring Assessment that supports this review. These include a 2007 MDH assessment of flooded public and private wells in southeast Minnesota; a 2008 private well survey conducted by the nongovernmental organization, The Land Stewardship Project (LSP); MDA/MPCA urban monitoring well surveys; and a 2000-2006 USGS groundwater monitoring survey. The majority of wells in these surveys had no atrazine detected, and when detected, concentrations were well below the Minnesota HRL of 3 ppb.

Other Human Exposure Topics

Based on a review conducted by MDH as well as EPA, food-related exposure to atrazine appears to be negligible. Atrazine residues are rarely found in food samples and when found, are at very low levels.

Exposure is expected for Minnesota agricultural workers mixing, loading, and applying atrazine. MDH evaluated EPA's occupational risk assessments (developed for the 2003 atrazine IRED) for this registration review. EPA has taken certain actions to mitigate unacceptable occupational risk through its reregistration process and subsequent label amendments. However, exposure from mixing and loading atrazine was not combined with exposure from applying atrazine in EPA's evaluation. Because workers may be involved in all three activities, it is important to consider total risk from these operations. This represents a gap in EPA's occupational risk assessment as a whole and may have implications for Minnesota's agricultural workers. It is also anticipated that the existing occupational risk assessment for atrazine will be revised during EPA's 2010 atrazine review to include more protective risk assessment approaches applicable to pregnant and adolescent workers. Currently acceptable risks may be found unacceptable at that time.

The MDH assessed urinary biomonitoring data for the atrazine metabolite atrazine mercapturate (AM). A recent study investigated whether measuring AM is sufficient to estimate human exposure to atrazine, as the low detection frequencies in CDC's biomonitoring program and individual studies are surprising given atrazine's widespread use, frequent detection in water, and detections from household samples. It was found that relying on AM underestimates exposure to atrazine and that multiple metabolites, particularly DACT and DEA, must also be measured to accurately assess atrazine exposure. As studies-to-date have likely been underestimating human exposure by only measuring AM, the MDH has concluded that urinary biomonitoring data are insufficient to characterize exposure to atrazine at this time.

Human Health Assessment Conclusions

For this registration review, the MDH concluded that toxicology studies and environmental samples are most useful to characterize hazard and exposure respectively, as epidemiologic data are currently insufficient to establish causal relationships, and biomonitoring data lack information on key metabolites. The oral route via drinking water is expected to be the dominant dietary exposure pathway. Although detections of parent atrazine in public water supplies are rare, there is concern for private wells users living in areas with high corn acreage and/or geologically sensitive areas. Unlike public water supply systems, private wells are not always properly constructed, located, maintained, and tested. Based on the entirety of available groundwater monitoring data, atrazine and atrazine plus chlorinated degradate concentrations in private wells are likely to be absent or below established health benchmarks. However, the potential exists for concentrations to occur above health benchmarks.

As previously stated, MDH has adopted the EPA MCL of 3 ppb as the HRL for atrazine as per the stipulations of the 2007 Water Level Standards legislation, and currently recommends this value for use in groundwater assessments. Atrazine plus chlorinated degradate concentrations are below this health benchmark in current, available Minnesota drinking water data. Comparing drinking water monitoring results to MCLs or HRLs serves as a way to evaluate data but is not equivalent to a comprehensive health risk assessment. While this initial evaluation indicates no risks of concern and a more refined risk assessment is not deemed necessary at this time, MDH anticipates the continued release of new data on human exposure and health effects for atrazine and plans to re-evaluate atrazine as these data become available. MDH is also conducting an on-going toxicological evaluation of available data which suggest that any new recommended guidance values for atrazine are not likely to be lower than the current HRL. However, new, lower health-based guidance values may be derived for DACT that would also be applicable for DEA and DIA. If the final values are ultimately lowered, MDH will be available to advise MDA on any public health implications.

EPA's current occupational assessment for atrazine does not evaluate risks to workers both mixing/loading and applying atrazine. This precludes MDH from making a final determination regarding worker risks.

Environmental Risk Assessment

Water Quality Standards

The presence of atrazine in environment is assessed and regulated using scientifically-based water quality standards in comparison to duration and magnitude of concentration. Minn. R. ch. 7050 sets protection of aquatic life with an atrazine chronic standard of 10 ppb for Class 2 surface waters. The basis of this standard is protection of the ecologically important aquatic plant, wild celery. For aquatic community protection (both plants and animals), the sensitive plant endpoint was considered more restrictive than endpoints based on animal toxicity. The one-day maximum or acute standard for aquatic life protection is 323 ppb. MPCA also has a surface water quality chronic standard for protection of human health of 3.4 ppb (based on drinking water and fish consumption (Class 2A, 2Bd waters)).

Aquatic Life Risks

The MPCA assessed recent aquatic toxicity studies of atrazine and its degradates as related to Minnesota surface waters based on current aquatic life acute and chronic water quality standards, 323 ppb and 10 ppb, respectively. The chronic standard is implemented based on a four-day average concentration. Exceedance of this four-day average more than once in three years is a violation of state water quality standards. The MPCA considers these current standards appropriate based on aquatic community assessment against atrazine monitoring data. There is no single response of aquatic animals exposed to atrazine that has been concluded by the EPA to have plausible ecological relevance at concentrations below the current Minnesota chronic aquatic life standard of 10 ppb.

Atrazine is detected often in streams around the state; however, exceedances of water quality standards have not lead to impairment listings. Since 2004, median concentrations during field season sampling from a variety of streams throughout Minnesota have ranged from 0.025 to 1.49 ppb. The highest point-in-time maximum concentration of 33.2 ppb was detected at the Twin Cities metro-area Chaska Creek (not used for drinking water) in 2002 from a storm-event sample. The second highest concentration of 32 ppb was detected in the Middle Branch of the Whitewater River in 2004. Of the intensive automated monitoring stations operated by the MDA, the Middle Branch of the Whitewater River has the longest record of atrazine results, extending from 1993 through 2008. Annual maximum concentration trends in the Middle Branch of the Whitewater River have greatly decreased since 2004. During 2008, the maximum concentration of any subsample was 3.52 ppb collected at the South Branch of the Whitewater River on June 12th.

The USEPA's October 2003 Atrazine Interim Reregistration Eligibility Decision (IRED) required the registrants of atrazine to conduct watershed monitoring to ensure protection of aquatic ecosystems. Under this *Ecological Watershed Monitoring Program*, 40 watersheds were monitored in ten Midwestern states between 2004 and 2006.³ The Program included one watershed in Minnesota, the North Fork of the Whitewater River, in southeast Minnesota. In June of 2005, auto sample concentrations from this river spiked to over 10 ppb for two consecutive days; recording concentrations of 15.03 ppb on June 7th and 11.17 ppb and 6.34 ppb on June 8th. All other auto sample concentrations from this location during both 2005 and 2006 were below 2 ppb.

The MPCA has reviewed all Minnesota monitoring results for atrazine since 1993 – including data collected under the *Ecological Watershed Monitoring Program* - and no concentrations have triggered any federal regulatory action or led to impairment listings in Minnesota.

Detections in lakes are frequent but well below MPCA's chronic aquatic life standard of 10 ppb (4-day average) or MPCA's surface water quality chronic standard, human health-based value of 3.4 ppb (based on drinking water and fish consumption (Class 2A, 2Bd waters)). In 2007, the MDA participated in the National Lakes Assessment Project (NLAP) in cooperation with the USEPA and

³ The MDA obtained this monitoring information immediately after the results were published but could not make the information public under federal law. In July of 2009, EPA posted this information in the Federal Docket.

MPCA. Of the 55 samples collected, atrazine parent was detected in approximately 87% of the samples (degradate detection frequency- DIA (2%), DEA (64%)). The maximum level of detection for atrazine parent was 0.68 ppb. In 2008, the MDA sampled 14 different lakes statewide (17 samples total) as part of an endocrine disruptor study in cooperation with the United States Geological Survey (USGS). Atrazine was detected in 65% of the lakes with only one sample having a quantifiable concentration of 0.06 ppb (Lake Harriet). DEA was the only other detected compound and was found in 59% of the samples with one sample having a quantifiable concentration of 0.05 ppb (Lake Harriet).

Atrazine toxicity and endocrine-mediated effects to amphibians and amphibian populations have been an issue of concern that has engaged a substantial amount of scientific inquiry. The MPCA has been closely following EPA scientific reviews along with other scientific literature about amphibian exposure to atrazine. However an extensive evaluation of the literature to assess toxicity endpoints was not completed for this registration review because this area is still under extensive review by the EPA. Uncertainties about aquatic animal responses to endocrine disruptors primarily stem from scientific debate and lack of standard methods to address non-conventional endpoints that have not been incorporated sufficiently in ecological risk methods historically and for many reasons based on effects to populations survival, growth and reproduction. The EPA's Endocrine Disruptor Screening Program is poised to provide data needed to more accurately assess a broader spectrum of endpoints relative to ecological species health.

Human Health-based Chronic Standard

Some of the surface water streams monitored and reviewed above are also protected for potable water use under Class 2A designation; in these streams such as the Middle Branch of the Whitewater River, MPCA has also evaluated atrazine and chlorinated degradate concentrations for violations of 3.4 ppb applied as a 30-day average. The inclusion of the chlorinated degradates DEA and DIA was based on EPA's RED that had concluded these degradates should be weighted equally in toxicity to the parent atrazine. No surface waters have violated the human health-based chronic standard.

It is anticipated that the human health water quality standard (HH-WQS), developed to protect fish consumption and drinking water sources in Class 2A and 2Bd waters (currently 3.4 ppb), will change in the future after MDH has promulgated new HRLs. Minnesota's HH-WQSs are founded on maintaining consistency with MDH's HRLs. The MPCA also plans to incorporate the toxicological profiles of chlorinated degradates into state water quality standards in future revisions after the MDH adopts new degradate HRLs.

Other Environmental Concerns

Additional environmental concerns were raised in MDA's atrazine scoping document. According to MPCA, a review of the effects of pesticide mixtures would require a comprehensive effort to examine scientific literature for many pesticides and determine appropriate endpoints, which is currently beyond the scope of this registration review. No aquatic life criteria exist for mixture exposures nor do EPA methods exist for developing such criteria. The MPCA is working on biological indicator models that may serve in evaluating effects of changes to riparian cover. These biological models (Tiered Aquatic Life Use) are anticipated to go into rule making in 2012. Finally, the MPCA reviewed labels from two atrazine formulations used in Minnesota and made recommendations that would not result in additional use restrictions. Rather, these recommendations focused on label content organization, formatting (e.g. bold type), and additional clarification of Minnesota Rules for pollution prevention.

Environmental Risk Assessment Conclusions

According to the MPCA, existing state standards for atrazine are protective of surface water aquatic life uses. Surface water monitoring since 1993 has not shown any waters with atrazine concentrations that violated the state's water quality standards resulting in any impaired waters determinations. The MPCA looks to efforts by the EPA and other ongoing scientific efforts to augment the understanding about the effects of atrazine on the aquatic environment. Conventional endpoints (survival, growth, reproduction) observed in acute and chronic toxicity tests may serve as surrogates to capture a combination of sub-lethal measurable effects. Efforts by EPA to revise existing national atrazine criteria and to provide additional research information will be important for making future assessments.

The MPCA has concluded that at this time, lack of guidance and sound scientific evidence for alternate endpoints precludes development of criteria based on atrazine's role as part of multiple stressors of aquatic systems. In their review, the MPCA also stated that MDA's ongoing efforts to reduce atrazine's

environmental presence may offer general benefits by reducing its potential role as a stressor to aquatic organisms.

For this registration review, the MPCA recommends that state efforts to continue monitoring surface waters using existing water quality benchmarks and standards are critical to providing assessment of condition and risk to surface waters in areas where atrazine is used. Given large uncertainties of atrazine effects on aquatic systems, continued vigilance and use of Best Management Practices (BMPs) for atrazine are important actions at this time. Of special concern and as a focus for management activities by MDA are protection of ambient waters that include static systems (i.e. small lakes), low dilution waters (i.e. small streams) and other surface waters that may be vulnerable to sustained levels of atrazine inputs from surface runoff and tile drainage. Considering on-going investigations of atrazine by EPA, their published benchmarks for protection of aquatic communities, and the protection afforded by current Minnesota Rule 7050, revisions to the Minnesota aquatic life atrazine WQs are not warranted at this time.

Economic and Benefit Assessment

Agronomic Benefits

There are many agronomic reasons why Minnesota corn growers choose to use atrazine. Atrazine is a flexible, broad-spectrum herbicide that can be applied for both pre-emergent and post-emergent weed control. It is most commonly applied pre-emergent in Minnesota and is often combined with acetochlor (e.g., Harness[®] or Surpass[®]) or metolachlor (e.g., Dual[®]) in prepackage mixtures. Adding atrazine to a prepackage mixture improves weed control consistency and in some cases offers beneficial synergy interaction. There are no direct chemical replacements for atrazine that offer residual weed control to control early season grass and broadleaf weeds.⁴ For post-emergent control, there are more alternatives to atrazine, however they usually cost more.

Additional agronomic benefits claimed in part by atrazine registrants include: it is not subject to volatile drift from application sites; it complements soil conservation programs by providing residual control in no-till corn systems and it may lower overall herbicide use due to synergies with herbicides that have different mechanisms of action.

Atrazine, in combination with other herbicides, also plays a role in resistance management, offering good control over aggressive weeds that are known to have developed resistance to glyphosate in other corn-belt states. According to weed scientists from the University of Minnesota, glyphosate-resistant biotypes of giant and common ragweed and common waterhemp have been confirmed in Minnesota and are listed on the International Survey of Resistant Weeds web site.⁵ There are reports of other glyphosate-resistant biotypes from Minnesota farmers and agricultural chemical dealers.

Various studies have attempted to document the role of atrazine in relation to corn yields. Most of these studies estimate that growers in Minnesota would incur, on average, close to a 5 bushels/A yield loss if atrazine were not available. However, yield differences cited in both state specific and national studies vary significantly.

Atrazine applied as a single active ingredient in a product such as Aatrex[®] is the least expensive corn herbicide available; applied at an average rate of 0.50 lbs a.i./A it costs approximately \$1.71 /A. In addition, atrazine sold in packaged product mixes often costs less than when purchased alone. Studies indicate that, at current prices, herbicide control costs in some corn fields would increase without atrazine; however, estimates vary significantly depending on the data source and type of comparison, ranging from \$3.00 to \$28.00 /A.

Potential Weed Management Alternatives

Papers and reports published outside of Minnesota have attempted to identify atrazine alternatives for preemergent weed control; however, many of these recommended alternatives are not compatible with Minnesota's environmental conditions (soil type, climate, etc.) or have not been registered in Minnesota. The herbicide isoxaflutole (Balance[®]) is not registered for use in Minnesota, and simazine

⁴ Pre-plant or pre-emergence

⁵ <http://www.weedscience.org/in.asp>

and metribuzin are rarely used in Minnesota because of crop injury risks. The MDA has been advised by weed scientists from the University of Minnesota that there are no direct replacements for atrazine in preemergent weed control that are currently registered for use in Minnesota; however, a combination of preplant or preemergent herbicides may offer a suitable alternative. For example, the new active ingredient saflufenacil (Kixor[®]), may offer an atrazine alternative for preplant burndown and preemergent weed control. Saflufenacil received federal registration in fall of 2009 and is registered for use on corn and soybeans in Minnesota. Applicators choosing to use saflufenacil will most likely apply it with the herbicide dimethenamid-p, in a new product called Integrity[®].

Other postemergent weed control tactics may be employed to maintain corn yields without the use of atrazine. Published literature on atrazine alternatives has stated that the HPPD inhibitor mesotrione (Callisto[®]), offers a 1:1 replacement for atrazine. However, in Minnesota this is not an effective single replacement because mesotrione does not offer adequate grass weed control. Several HPPD inhibitors, including tembotrione (Laudis[®]) and topramezone (Impact[®]), can be applied as postemergent atrazine alternatives (controlling both grass and broadleaf weeds). However, there are caveats: Herbicides with an HPPD site of action provide better weed control in combination with atrazine due to certain synergies; as a result, they are often applied in combination with atrazine.⁶ Additionally, the use of HPPD inhibitors requires a variety of crop rotation restrictions that can reduce the flexibility of using these herbicides.

In Minnesota, a combination of herbicides for both preemergent and postemergent weed control will offer the best alternative to atrazine. However, applying various combinations of herbicides may result in unintended risk to human health or the environment compared to risks associated with applications of atrazine alone. Each of these herbicides alone or in combination would have to be evaluated to determine their human health, environmental and economic profile relative to atrazine. As with many potential atrazine alternatives, cost and weed control efficacy are likely to be factors in the adoption of atrazine alternatives in the herbicide marketplace.

Corn can be grown in Minnesota without atrazine and other conventional herbicides by using nonchemical methods or by using chemical herbicides approved for certified organic corn production. A detailed discussion of the agronomic issues associated with organic vs. conventional corn production in Minnesota is beyond the scope of this pesticide-specific technical review, but analyses are available through MDA publications.

Mitigation Costs

In general, it is difficult to place estimates on the absolute or relative costs of the health and environmental effects of using atrazine in Minnesota. However, general consideration can be made to future costs or redirection of resources that would stem from multiple exceedances of a regulatory drinking water or surface water standard for atrazine. Concentrations of atrazine in Minnesota water resources have not triggered a regulatory process to either shut down a public drinking water supply or to establish for surface waters a total maximum daily load (TMDL) study. However, future monitoring results could identify water resources that do not meet drinking water or surface water quality standards. For public or private drinking water supplies, mitigation costs would be linked to the drilling of new wells, closure (temporary or permanent) of existing wells or to purification and treatment of the water supply. For surface waters not meeting standards, TMDL studies would require state funds and staff resources. Costs would increase if mitigation measures were required at atrazine concentrations below current water quality standards. Costs could also be incurred by producers required to restrict their use of atrazine or employ alternatives described earlier.

If specific aquifers or surface waters are identified as having atrazine concentrations leading to unreasonable adverse effects on human health or the environment, it is unlikely that all corn production areas in Minnesota would be affected by required mitigation measures. Costs of mitigation measures to corn producers would likely be limited to the modified or prohibited production of corn on crop land in critical areas of sensitive aquifers or near sensitive surface waters. Current efforts to control of atrazine leaching and runoff losses from cultivated fields are focused on implementation of existing mitigation measures: federal label restrictions, state label enforcement and a variety of practices recommended as part of MDA's atrazine-specific voluntary BMPs. A review of the federal label and MDA guidance suggests that mitigation measures can be reasonably understood and implemented. A review of MDA label enforcement shows that a majority of Minnesota farmers

⁶ <http://appliedweeds.cfans.umn.edu/pubs/Sweet%20Corn%20Herbicide%20Advancements%202008-2009.pdf> (PAGE 15).

inspected for their atrazine use appear to understand and adhere to label requirements for mixing and loading, application setbacks for wells, sinkholes, streams and rivers. To date, mitigation measures and enforcement have contributed to reducing historic concentrations of atrazine in water resources and to preventing unreasonable adverse effects on human health and the environment relative to standards. And, it can be noted, considerable programmatic costs are expended by the MPCA, MDH and MDA on the development, promotion and enforcement of current mitigation measures and standards.

Economic Benefit Assessment Conclusions

Within the context of conventional corn production, the MDA concluded that herbicide alternatives to atrazine are available in Minnesota but typically cost more. Various combinations of other herbicide active ingredients may offer similar weed control benefits; however, available cost estimates for these alternatives vary significantly, making direct comparisons between these atrazine alternatives and the current use of atrazine difficult. Furthermore, differences in scope, design, and execution of various economic and yield studies on atrazine make comparisons difficult and may not reflect "real world" scenarios for Minnesota corn farmers. The range in yield-benefit or loss from use of atrazine or its alternatives can vary greatly between years on the same farm or from one farm to the next, and national or even regional yield-benefit averages tend to mischaracterize potential impacts to individual farmers. Most atrazine economic studies include states with high atrazine use. Minnesota is unique because it is the only major corn growing state that consistently shows (through use surveys) atrazine use on less than 50% of all corn acres, and use at a lower rate (lbs. per acre) than other, major corn-producing states. In addition, the corn herbicide market is a vertically integrated, sophisticated market, offering new product mixes each year. Pesticide dealers may promote new brand name pesticide packages that include atrazine as provided by pesticide manufacturers. Each of these scenarios complicates any point-in-time economic analysis of atrazine and any potential responses.

Conclusions of Review and Opportunities for Action

Groundwater monitoring data from monitoring wells, examined by MDH and MDA for this review, indicate a historic decline in atrazine and its chloro-degradates to concentrations below health-based guidance. Detections in public drinking water supply data (for atrazine parent only) are rare and below applicable standards. Recent private drinking water well survey results are also below health-based guidance.

Surface water monitoring data examined by MPCA and MDA indicate that current atrazine concentrations are below MPCA's chronic standard, which protect all designated beneficial uses: aquatic plant and animal life (including fish, amphibians and reptiles) and human use of waters for drinking and fishing.

Nevertheless, there remain several reasons for concern. Although observed concentrations are currently below applicable standards, atrazine is still frequently detected in vulnerable groundwater and surface waters of the state. Also, while groundwater data show a decline in atrazine, there remains the potential for short periods of high concentrations in streams immediately after atrazine applications followed by spring rain storms.

The agencies recognize that there is considerable scientific debate about the human health and environmental impacts of atrazine, and are committed to tracking emerging science to ensure that Minnesota's health-based guidelines and environmental standards are scientifically defensible. This Minnesota-specific atrazine review was conducted using available EPA science documents, open literature, and other relevant sources cited in MDA, MDH and MPCA assessments; however, current decisions are subject to limitations based on the diverse nature and constant evolution of research related to atrazine. EPA has launched a new evaluation of atrazine based on emerging scientific and regulatory concerns, after which it will consider revisions to current atrazine risk assessments and whether new restrictions are necessary to better protect health and the environment.

Current and historical prevention, evaluation and mitigation measures (e.g., label revisions and enforcement, monitoring and promotion and adoption of BMPs) have played an important role in protecting human health and the environment. Additionally, atrazine continues to be an important weed-control tool in Minnesota corn production. While herbicide alternatives to atrazine are available

in Minnesota, they typically cost more and can be less effective at controlling specific weeds. These benefits were considered as part of this review.

The conclusions of this Minnesota-specific atrazine review may need to be revisited – along with a reevaluation of current state standards – if emerging science or EPA evaluations reach new conclusions about human health and environmental impacts of atrazine and its benefits to farmers.

The MDA concludes that: Existing mitigation measures have contributed to reductions in concentrations of atrazine in Minnesota's water resources and to the prevention of occurrences of atrazine exposures above current state and federal health and environmental guidance. State agencies recognize the ongoing debate about the impacts of atrazine, and are tracking the emerging science.

The agencies remain concerned about the potential for atrazine exposure and violations of health and environmental guidance. Therefore, the agencies can take action on the following opportunities for prevention, evaluation and mitigation of atrazine impacts:

- The MDH and MPCA recommend continued water monitoring by MDA for atrazine and its chlorinated degradates in both geologically sensitive areas and high-use areas.
- The MDH recommends that future monitoring programs include analysis of DACT concentrations and combined total chloro-triazine concentrations. Continued monitoring will allow tracking of long-term trends. It will also ensure that atrazine label restrictions and best management practices remain effective at minimizing off-site movement of atrazine and that drinking water concentrations remain below levels of concern if changes in use practices or greater than normal flooding/storm events occur.
- The MDH recommends that MDA and MDH collaborate to increase education and outreach efforts to private well owners on risk factors for pesticide contamination and guidance on when a well should be tested.
- To refine occupational risk estimates and clarify uncertainties, the MDH recommends seeking additional information to address exposure to workers both mixing/loading and applying atrazine. The MDH anticipates that the occupational risk assessment for atrazine will be modified, as part of EPA's 2010 review, to include greater protections for adolescent and/or pregnant workers. MDH also recommends that any unacceptable risks identified in the revised assessment be revisited in Minnesota as they pertain to current labeling and worker protection.
- The MDA has played an active role in procuring atrazine toxicity data from EPA considered necessary by MDH to conduct its assessments. The MDH encourages the MDA to continue to facilitate discussion between MDH and EPA OPP on key toxicology data and assessment for atrazine; particularly the appropriateness of a separate assessment for DACT.
- Given large uncertainties of atrazine effects on aquatic systems, the MPCA emphasizes that continued vigilance and use of Best Management Practices (BMPs) for atrazine are important actions at this time (several of the MPCA suggested label changes lend themselves to promotion through BMPs or other educational outreach activities).
- The MPCA recommends that MDA's pesticide management activities encompass protection of ambient waters that include static systems (i.e. small lakes), low dilution waters (i.e. small streams) and other surface waters that may be vulnerable to sustained levels of atrazine inputs from surface runoff and tile drainage.
- The MDA recommends that current MDA atrazine BMPs be evaluated for revisions to address any identified concerns raised in this review.

- The MPCA recommends several non-regulatory changes in atrazine label form and content. The MDA has limited authority or opportunities to affect such changes. Several of the suggested changes (e.g., revisions to environmental hazards sections) are longstanding issues or concerns of FIFRA State Lead Agencies throughout the nation, not just for atrazine, but for all pesticide labels. The MDA, through the State-FIFRA Issues Research and Evaluation Group (and other organizations) has been working with EPA to address such concerns, primarily through EPA's pesticide Label Review Manual. Other suggested changes (e.g., clarification or emphasis of state rules related to "sensitive area") can be incorporated into education and outreach materials associated with BMP promotion, pesticide applicator licensing and certification training programs, state basin and local water planning, etc.
- The MDA recommends continued enforcement of the atrazine label regarding personal protective equipment (PPE), environmental hazard statements, setbacks for mixing and loading, setbacks for wells and sinkholes, setbacks during application designed to protect surface water, and restrictions related to tile-outletted fields. Continued efforts to educate applicators about pre-packaged and tank-mixed herbicide products containing atrazine are critical to compliance issues and water resource protection. MDA BMPs currently recommend application setbacks or other mitigation measures around surface tile inlets in any field with a surface tile inlet, and such BMPs should continue to be promoted and evaluated. If proven to be effective but not widely adopted, and unreasonable adverse effects on the environment are evident (e.g., through surface water impairment declarations, chronic standard exceedances or other concerns), surface tile inlet mitigation measures could form the basis of additional BMP review and revision, or lead to a regulatory requirement supported by a Minnesota supplemental label.

Review Collaborators:

Minnesota Department of Agriculture

Nila Hines, MS, Registration Review Coordinator
Pesticide Management Unit
651.201.6208
Nila.Hines@state.mn.us

Joseph E. Zachmann, PhD, Research Scientist
Pesticide Management Unit
651.201.6588
Joseph.Zachmann@state.mn.us

Minnesota Department of Health

Deanna Scher, PhD, Research Scientist
Health Risk Assessment Unit
Division of Environmental Health
651.201.4922
Deanna.Scher@state.mn.us

Paul Moyer, MS, Research Scientist
Health Risk Assessment Unit
Division of Environmental Health
651.201.4912
Paul.Moyer@state.mn.us

Minnesota Pollution Control Agency

Phil Monson, MS, Research Scientist
Water Quality Standards Unit
218.302.6623
Phil.Monson@state.mn.us

Angela Preimesberger, MS, Research Scientist
Water Quality Standards Unit
651.757.2656
Angela.Preimesberger@state.mn.us