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11.4 PESTICIDES IN GROUNDWATER, SURFACE WATER, AND DRINKING WATER

Pesticide contamination in water has become a pervasive problem in the US. Surface water runoff carries pesticides from agricultural fields into rivers, lakes, and reservoirs. Rain or snow carries pesticides through the soil into groundwater that is the source of drinking water.

Under the Safe Drinking Water Act, originally passed in 1974 to regulate the nation's drinking water, the USEPA sets standards for allowable pesticide levels in drinking water and requires water utility companies to monitor these levels. Setting these standards is a two-part process. First, the EPA sets a nonenforceable Maximum Contaminant Level Goal (MCLG), which is a goal based solely on health considerations. These MCLGs are set at levels 'at which no known or anticipated adverse effects on the health of persons occur, and which allows an adequate margin of safety.' Second, the EPA sets enforceable Maximum Contaminant Levels (MCLs), which are based on MCLGs but adjusted to ensure technical and financial feasibility. Due to this adjustment, federally enforceable MCLs are not as stringent as the MCLGs, allowing pesticides to legally remain in public drinking water. Therefore, federal regulations for pesticides commonly found in drinking water fail to adequately protect the public's health (EWG, 2010).

The EPA has set enforceable MCLs for three pesticides called atrazine, alachlor, and simazine. However, it has not set enforceable MCLs for cyanazine, metolachlor, and acetochlor, which are three major pesticides used in the US. Instead, the EPA has issued nonenforceable Lifetime Health Advisories (LHAs) for these contaminants. Consequently, water utility companies are not required to test for these contaminants or inform their customers if these contaminants are found at levels that exceed federal health advisories (EWG, 2010).

11.4.1 ATRAZINE

Atrazine is a widely used herbicide utilized for the control of broadleaf and grassy weeds in corn, sorghum, rangeland, sugarcane, macadamia orchards, pineapple, turf grass sod, asparagus, forestry grasslands, grass crops, and roses. It is used most extensively on corn crop in Illinois, Indiana, Iowa, Kansas, Missouri, Nebraska, Ohio, Texas, and Wisconsin. Total estimated agricultural use in the US is 76.4 million pounds annually, with 86% of that amount applied to corn alone (EPA, 2008a). Due to health concerns and persistent contamination of groundwater, atrazine was banned in the European Union in 2004.

Many factors contribute to atrazine runoff and drinking water contamination. First, atrazine does not bind well to soil particles, so it is easily carried off of fields with storm water. Second, many areas of heavy application (namely Northern Missouri and Southern Iowa) have high clay content in the soil. Clay soils have relatively low infiltration rates and thus promote runoff during storm or flood events. Third, many Midwest farms practice no-till farming, which increases runoff potential and loss of atrazine due to the restrictive layer of the claypan that limits infiltration. Finally, atrazine application periods typically occur during the months that receive the most rain. Heavy rainfall directly following application can greatly increase atrazine losses. Because of these factors and the sheer quantity and density of atrazine application, hundreds of water systems have atrazine detections in their finished drinking water, impacting millions of people across the country.

In 2004, Holiday Shores Sanitary District in Holiday Shores, Illinois, filed class action lawsuits against the manufacturers and primary distributors of atrazine. These lawsuits have expanded to include over 60 cities from across the Midwest looking to hold the corporations accountable for the contamination of their drinking water systems. A judgment in the case has not yet been issued.

Health Effects of Atrazine

The endocrine-disrupting properties of atrazine have been demonstrated in studies. Atrazine has been found to alter the brain's pituitary functions, resulting in the suppression of two hormones, luteinizing hormone and prolactin hormone. Changes in these hormones have concerning consequences. Research has shown that even brief atrazine exposure to a lactating mother alters the endocrine makeup of the mother's milk, raising concerns about the subsequent development of the child. Exposure to atrazine and atrazine metabolites have caused delayed puberty in both male and female rats (USEPA, 2009) Additional studies showed health effects such as increased risk of intrauterine growth retardation, reduced semen quality, and spontaneous abortions in humans, as well as demasculinization and hermaphroditism in frogs (Munger, 1997; Arbuckle, 2001; Hayes, 2002; Swan, 2003).

The effects of atrazine in frogs have received particular attention. Hayes et al. (2002) examined atrazine exposure on the development of the African clawed frog. During larval development, the larvae of the frogs were exposed via immersion to 0.01 to 200 ppb of atrazine. Study results demonstrated that greater than 0.01 ppb of atrazine exposure resulted in hermaphroditism and demasculinization in

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male frogs. Furthermore males had a ten-fold decrease in testosterone levels when exposed to 25 ppb atrazine. The study concluded that atrazine converts testosterone to estrogen.

A growing body of evidence also indicates that agrichemical exposures may contribute to birth defects. Winchester (2009) investigated whether babies conceived during the months when surface water agrichemicals are highest are at greater risk for birth defects. In the study, concentrations of nitrates, atrazine, and other pesticides were measured in water samples from 186 stream sites representing 51 hydrological systems, accounting for 50% of the US drinking water, from 1991 to 2002. The highest concentrations of pesticides were found in May and June, with annual peaks from April to July. Results from the study of approximately 30 million babies, showed that total birth defects, as well as 11 of the 22 birth defect subcategories, were more likely to occur in babies that were conceived between April and July.

Ochoa-Acuna (2009) investigated atrazine exposure from drinking water and the prevalence of small-for-gestational-age (SGA) and preterm delivery. The study found that atrazine, and perhaps other co-occurring herbicides in drinking water, was associated with an increased prevalence of SGA. Alarmingly, SGA resulted from exposure to atrazine in drinking water at levels just above 0.1 µg/L, well below the current MCL of 3.0 µg/L.

Cancer has also been associated with exposure to atrazine. MacLennan (2002) evaluated cancer incidence among approximately 2,000 workers at a Louisiana plant that manufactured atrazine and other triazine herbicides. Incidences of prostate cancer among active company employees were statistically increased.

Syngenta and the Atrazine Monitoring Program
After the use of atrazine was banned in Europe in 2004, the EPA expressed concern over the presence of atrazine in some water systems in the US. Subsequently, the Atrazine Monitoring Program (AMP) was created. With assistance from the EPA, Syngenta, the primary manufacturer of atrazine, tested 134 public water systems weekly or biweekly for atrazine and three chlorotriazine breakdown products: DIA, DEA, and DAC.

The AMP data revealed that levels of atrazine and its chlorotriazine breakdown products during some periods of the year were much higher than levels reported by water systems. Many water systems tested as part of the AMP showed levels exceeding the MCL at some point during the year. In other words, values reported by water systems and values shown by the AMP did not match up.

The AMP data showed that atrazine 'spikes' likely occurred during weeks of atrazine application or heavy rainfall. These spikes of atrazine levels in post treatment water exceeded the 3 ppb MCL for short periods of time, but averaging and infrequent testing allowed these levels to be overlooked by water systems. Figure 11.1 presents AMP data of several water systems with an atrazine 'spike.' State data from the same period do not indicate a spike.

Inconsistencies between data reported to the state by water systems and data from the AMP sparked much political and media interest. In August 2009, the *New York Times* published an article titled, 'Debating How Much Weed Killer is Safe in Your Water Glass,' detailing inconsistencies between the two data sets and the overall danger of atrazine contamination in the US. Increased media coverage placed more pressure on Congress to address these issues, which in turn placed pressure on the EPA. The EPA responded with a press release stating it would begin a re-evaluation of atrazine. EPA's re-evaluation plan includes the review of atrazine effects to inform safety measures and plans for incorporating new epidemiologic and experimental studies into the atrazine risk assessment.

11.4.6 REMOVAL TECHNOLOGIES

Investment in removal technologies has obvious benefits. Many pesticides can be removed from water using a technology called granular activated carbon (GAC). GAC has a random porous structure, containing a broad range of pore sizes ranging from visible cracks and crevices down to molecular dimensions. GAC uses this porous structure to remove dissolved contaminants from water in a process known as adsorption. This porous structure results in a large adsorption surface area (USBR, 2009).

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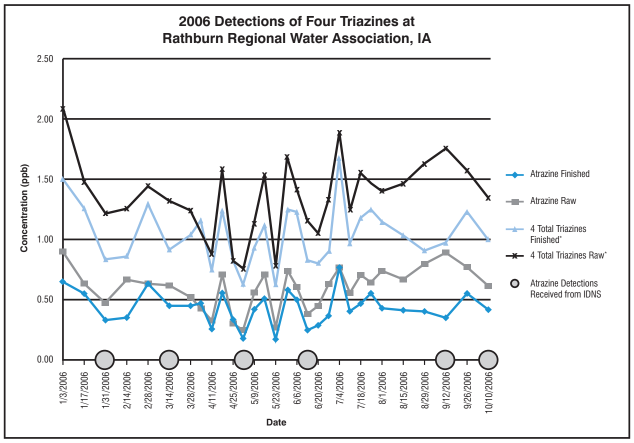
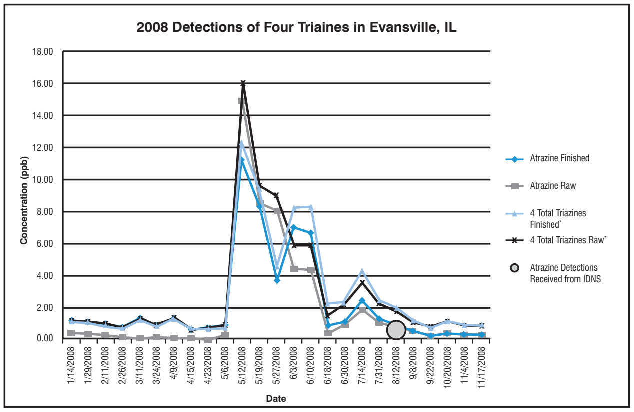
GAC is found in many applications ranging from personal in-home use to industrial, commercial, and municipal treatment systems. GAC treatment technologies include:

- Pour-through devices for treating small volumes, such as a hand-held… filter [pitcher].



*Total triazines includes atrazine and 3 daugher products, although many other breakdown products may be present.
Dates of IDNS Atrazine Detections are approximate.



*Total triazines includes atrazine and 3 daugher products, although many other breakdown products may be present.
Dates of IEPA Atrazine Detections are approximate.

Figure 11.1 Comparison of Syngenta AMP data and state data (source: Syngenta AMP, Illinois EPS (IEPA) Bureau of Water, Iowa Department of Natural Resources Water Supply Program (IDNSWP)). Lines represent concentrations of atrazine or atrazine plus three degradate triazines detected under the Atrazine Monitoring Program. Dots represent atrazine concentrations reported to the state by water systems.

- Faucet-mounted (with or without bypass) for treating water at a single faucet
- In-line filter (with or without bypass) for treating large volumes for several faucets
- High-volume commercial units for treating community water supply systems. Typically they are gravity-fed (larger volumes) or pressure-driven (smaller volumes) contactors. These high-volume units can be sequenced in parallel or in series. GAC filters can be used alone or can also be combined with media filters (USBR, 2009).

Installation and operation of granular activated carbon systems [for central treatment systems], however, are expensive. Capital costs to install GAC systems are in the order of millions of dollars. Purchase of land (if necessary), and operation and maintenance costs, including reactivation or the purchasing of new carbon columns, can add to the overall cost.

Many public water providers cannot afford to install this type of advanced treatment system. In order to recover costs for the installation of new treatment systems, water systems have filed lawsuits against the manufacturers of chemicals found in drinking water. For example, Holiday Shores Sanitary District (in Holiday Shores, Illinois) has filed class action lawsuits against the manufacturers and primary distributors of atrazine, to recover costs of treatment.

11.5 CONCLUSION

Pesticides will continue to be part of human life and the environment in order to increase crop production. It is imperative for public health authorities to educate the public, farmers, and farm workers on the use of and risks from pesticides. Improvement of human quality of life by means of more efficient and environmentally-friendly food production will clearly be a challenge for years to come. Reduction in the annoyance produced by pests is also part of the equation and poses major challenges to balance the well-being of the ecosystem. Rigorous testing and more stringent rules need to be adopted to address the harms posed by pesticides. Scientists, legislators, public health officials, and other stakeholders should familiarize themselves with the different pesticides that are used in their environment and invest in research and development for safer alternatives.

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QUIZ 1: "The Risks of Hazardous Wastes Excerpt" (0.25 CPD)

1. **What does the USEPA take into consideration when setting the MCLG for a contaminant?**
   a. Instrumentation detection limits and feasibility of enforcement
   b. The financial feasibility of reducing a contaminant to a specific limit
   c. The likelihood of seasonal contaminants
   d. The levels at which no adverse health effects can take place
2. **What does the USEPA take into consideration when setting the MCL for a contaminant?**
   a. Instrumentation detection limits and feasibility of enforcement
   b. Contribution from other contaminants
   c. The likelihood of seasonal contaminants
   d. The levels at which no adverse health effects can take place
3. **In the absence of enforceable MCLs for certain pesticides, the EPA has issued nonenforceable LHAs (Lifetime Health Advisories). What type of actions are water systems required to take for contaminants under LHAs?**
   a. No actions and no reporting is required
   b. Bi-annual testing and reporting is required
   c. Quarterly testing and reporting is required
   d. Annual testing and reporting is required
4. **What are the pathways by which pesticides can get into drinking water**
   a. Runoff
   b. Evaporation
   c. Taken up by vegetation
   d. Evapotranspiration
5. **What is the effect of the high clay content and the no-till farming practice in the US Midwest on the loss of atrazine from the area to which it was applied?**
   a. Reduces the need for reapplication
   b. Helps prevent runoff
   c. Improves soil infiltration rates
   d. Promotes runoff
6. **Atrazine is classified as what type of health hazard?**
   a. Endocrine disruptor
   b. Lysosome
   c. Mutagen
   d. Pathogen
7. **Why doesn't the AMP and reported data from the public systems match?**
   a. Poor sampling technique by public systems
   b. Bias in the AMP program
   c. Testing frequency insufficient
   d. Outdated analytical equipment
8. **Which treatment technology is recommended by the authors for atrazine?**
   a. Ion Exchange
   b. Reverse osmosis
   c. Granular activated carbon
   d. Ozonation
9. **What is the drawback to centralized water treatment for atrazine?**
   a. Expensive
   b. Inefficient
   c. Not regulated
   d. Ineffective