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Questions & Answers About Atrazine

Department of Agronomy MF-1023 Atrazine & Water

Why is there so much attention on atrazine and drinking water?

Atrazine is one of the most widely used herbicides in the United States. In Kansas, it is applied annually to approximately 1.2 and 2 million acres of corn and sorghum, respectively.

Once atrazine is applied, it begins to degrade through the action of soil microbes that use it as an energy source, and through chemical reaction with water, hydrolysis. The half-life — time span required for half of the herbicide to degrade — of atrazine in the topsoil is about 60 days under moist and warm conditions. This is a longer half-life than that of most pesticides. Atrazine in water generally degrades more slowly. The combination of widespread use and relative persistence help account for its frequent detection in surface waters.

The Environmental Protection Agency's (EPA) drinking water standard for atrazine concentration was 150 parts per billion (ppb). Because atrazine concentrations in water supplies were far below that, it was not considered a problem. Recently, the EPA reduced the drinking water standard for atrazine to 3 ppb. Some surface waters in Kansas, especially in the east, may exceed the new 3 ppb standard. Many eastern Kansas communities rely on surface water for public water supplies, and this has increased public concern about atrazine contamination.

What is atrazine?

Atrazine is a herbicide that helps to selectively control broadleaf (dicot) weeds, such as pigweed, cocklebur, and velvetleaf, and certain grass weeds in fields of corn and sorghum. Selective control means that the target weeds are controlled, with little or no injury to corn and sorghum crops. Atrazine is well tolerated by actively growing corn or sorghum, which absorb and metabolize the herbicide, deactivating it.

In 1959, atrazine was registered as an approved herbicide in Kansas. It is still widely used because it is economical and effectively controls many weeds, reducing the risk of crop losses due to weed interference. Its use can also reduce or eliminate the need for inter-row cultivation of corn and sorghum fields.

How toxic is atrazine to humans and other animals?

Toxicity is measured in different ways. **Acute oral toxicity** is a measure of how poisonous or toxic a substance is when swallowed as a single dose. The acute oral toxicity of atrazine in laboratory rats is 5,100 mg/kg. If we assume the acute oral toxicity is the same in humans as in laboratory rats, then a 150-pound person would have a 50 percent probability of death by poisoning by ingesting about 0.75 pound of atrazine in a single dose. In comparison, 0.5 pound table salt or 2.5 ounces aspirin would produce the same probability of death by acute poisoning.

The reason atrazine is effective for weed control, but relatively nontoxic to animals, is that it inhibits photosynthesis in susceptible species of plants. Photosynthesis is the process that occurs in green leaves and stems of plants, whereby light energy is converted to chemical energy, or carbohydrate. This process is not present in animals.

Chronic toxicity is an estimate of how a substance would affect an organism over a long period of time — a life span, for example — at very low levels of exposure. Actually measuring chronic effects on a population of laboratory animals is not feasible. Therefore, much higher levels of the substance are administered to laboratory animals for up to several generations, with the results extrapolated to trace level exposures to the human population. Whereas the methodology for determining acute toxicity is rather straightforward, the methodology to estimate chronic toxicity is much more subjective, and heavily influenced by public policy.

How does the EPA determine Health Advisory Levels?

Long-term — chronic — toxicology studies on animals are used to determine the "maximum tolerated level" and the "no observable effect level" for pesticides and other substances. Then additional safety factors are applied to the no observable effect level, to determine the EPA's drinking water standard, also called the "maximum contaminant level," or MCL.

The earlier 150 ppb atrazine MCL was based on chronic — one-year — dog feeding studies where a 100-fold safety factor was applied to the no observable effect level. Recently, a mammary tumor in a two-generation rat study triggered an additional safety factor, lowering the MCL to 3 ppb. This is the concentration of atrazine that the EPA considers safe to consume in drinking water over an average 70-year human life span.

Doesn't the tumor finding in the female rat suggest that atrazine causes cancer?

The tumor finding is limited to one study, in the high dose group, on a strain of rats with a high spontaneous background for mammary tumors. As a result of that study, atrazine is classified a Group C substance, defined as "possible human carcinogen; limited evidence of carcinogenicity in animals in the absence of human data" (see "Pesticides in Drinking Water," MF-961).

Don't municipal water treatment plants take atrazine out of the water?

No, most do not. Atrazine could be readily removed by treatment with activated charcoal, but adding that treatment process to municipal water treatment facilities would be expensive and could create additional disposal problems. Activated charcoal filters are available for household treatment of drinking water (see "Activated Charcoal Filters," MF-883, and "Questions To Ask Before Buying Water Treatment Equipment," MF-923).

What about atrazine in private water supply wells?

Atrazine is sometimes detected in groundwater. In most instances, the source of atrazine in well water is leaching near the wellhead due to atrazine loading and cleanup activities, or back siphoning accidents during sprayer loading (see "Groundwater and Well Contamination," MF-932, and "Testing to Help Ensure Safety of Drinking Water," MF-951). Atrazine is not recommended for use in areas with shallow water tables and coarse-textured soils, where mixing of surface and ground water could lead to atrazine contamination of shallow aquifers. The atrazine label also prohibits application within 50 feet of a wellhead.

If we have an atrazine problem, why not remove the risk by banning the herbicide?

Banning atrazine would immediately reduce the contamination problem, but would increase other health and environmental risks. Corn and sorghum producers would likely compensate for the loss of this weed control tool by increasing reliance on cultivation and/or alternative herbicides. Increased reliance on tillage for weed control increases soil erosion by wind and water. Alternative herbicides generally provide less weed control and are more prone to causing sorghum or corn injury. Furthermore, increased use of alternative herbicides may raise a different complex of environmental and health concerns. Atrazine, which has been in use over 30 years, is much better understood than certain new herbicides that show promise as atrazine alternatives.

Zero risk sounds appealing, but does not reflect reality. Every aspect of human activity entails various degrees of voluntary and involuntary risk. Society has not banned jogging, electric power, X-rays, or automobiles in spite of the risks they entail. Rather, we manage risk by making careful and informed choices, and consider benefits as well as risks. Perhaps the same should apply to pest management choices on farms and in households.

Is it true that weeds have become resistant to triazine herbicides due to our dependence on them?

Triazine resistant biotypes of kochia and other species have been confirmed, and this is largely attributed to long term dependence on these herbicides. Atrazine and other herbicides should be used only as part of an integrated weed management program. (See "Questions & Answers on Managing Herbicide-Resistant Weeds," MF-926.)

Are there environmentally safe ways to use atrazine?

Yes. Atrazine herbicide can be used in widely different ways to help manage weeds in corn and sorghum. Some uses pose very low risk of loss from fields, whereas other uses have much higher risk for groundwater or surface water pollution. The environmental risk of atrazine can be managed by altering the application rates, timing, and placement of the herbicide. Atrazine should always be used in the context of integrated weed management systems that include other weed control factors.

How does atrazine move from the point of application into streams and reservoirs which may be sources of drinking water?

Atrazine can move into streams or reservoirs either dissolved in runoff water — the solution phase — or by adhering to eroding soil sediments — the sediment phase. The likelihood of atrazine loss in surface runoff depends on many factors including atrazine placement, time of application, soil type and pH, soil surface residues, and the amount and intensity of the first rainfall after application.

When it is used as a soil applied herbicide, atrazine must be "activated" following application. This is the process whereby the herbicide is moved into the top few inches of soil, allowing a portion of the herbicide to be dissolved in the soil water so that it can be absorbed by weed seedlings. Mechanical incorporation can partially activate atrazine, but rainfall is required for optimum activation. Most often, however, atrazine is applied to the soil surface and is activated by the next rainfall. Once activated, atrazine has little tendency for loss through surface water runoff.

The main risk of atrazine runoff occurs when the first rainfall after application is an intense storm with heavy runoff. The action of raindrops, especially on bare soils, turns the surface 0.25 to 0.5 inch of soil — the mixing zone — into a muddy slurry. In this zone, water, soil and atrazine intermix to create runoff. If surface runoff begins before the atrazine has had time to soak into the soil, as much as 5 percent of the applied atrazine may leave the field dissolved in runoff water, or carried on eroding soil sediments.

Due to its rather high solubility in water and its rather low tendency to adsorb to soil colloids, over 90 percent of the atrazine leaving a field is in the dissolved, or solution, phase. The risk of runoff loss is greatest from sloping fields with fine-textured, poorly permeable soils that have little plant residue cover. In Kansas, the most intense rainstorms generally occur between May 15 and July 15, so atrazine applied during this period is at greatest risk of loss through runoff.

What are some approaches to environmentally safe atrazine use?

Risk to both groundwater and surface runoff can be reduced by applying less atrazine per acre. A recent survey (Kansas Agricultural Chemical Usage, 1990 Corn and Soybean Summary, MF-988) showed that eastern Kansas corn producers apply an average of 1.5 lb. atrazine per acre, which is well below the 3 lb. maximum permitted on the label. It is important to remember that "across the board" rate cutting is not necessarily needed. For example, certain fallow fields with high residue cover may require over 2 lb./acre atrazine for adequate weed control, yet pose only slight risk of atrazine loss from leaching or surface runoff. In other cases, 1 lb./acre could lead to excessive runoff loss.

A good way to minimize atrazine load on the environment, and still benefit from its weed control effectiveness, is to switch from higher soil applied rates to much lower foliar applied rates. Commercially formulated herbicide mixtures such as Buctril/Atrazine, Laddok, and Marksman are foliar applied at rates that contain from 0.38 to 0.75 lb. atrazine per acre.

When atrazine is foliar applied, good weed control can be achieved with relatively lower rates because the herbicide is absorbed directly by plant leaves. Rainfall is not required for activation, as with soil applied atrazine. These foliar applications can provide excellent control of many broadleaf weeds, and are especially effective on large-seeded broadleaf weeds such as velvetleaf and common cocklebur. Atrazine absorbed by corn or sorghum leaves is readily metabolized and is not detrimental to those crops.

Proper application timing for foliar applied atrazine is required for satisfactory weed control. Herbicide labels must be consulted for guidelines on weed height. A planned postemerge application early in the season when weeds are small is much more satisfactory than trying to control taller, escaped weeds later in the season.

Over-the-row banding of herbicides is another effective strategy to reduce application rates. The amount of herbicide can be reduced by over half, depending on the width of the band and the crop row spacing. Using herbicides this way necessitates cultivation of weeds growing between the crop rows. Improved cultivator designs, and the development of cultivator guidance systems, can help speed up cultivation and reduce the weather risks associated with cultivation.

These low-rate approaches are most important where corn or sorghum are grown on sloping fields of fine-textured soils with high water runoff potential, and on fields with coarse-textured soils where the most serious environmental threat comes from atrazine leaching down into lower soil horizons. Especially vulnerable are sandy soils with shallow groundwater aquifers, including irrigated fields with runoff collection basins in moderate to highly permeable soils, sands and gravels.

I'd like to switch to foliar applied atrazine with its lower application rates, but postemerge applications just don't fit my program. Isn't there some way to continue using soil-applied atrazine?

Shallow soil incorporation is one way to greatly reduce the risk of atrazine loss in surface runoff. Because much of the herbicide is mechanically placed below the mixing zone, risk of runoff loss is reduced about 70 percent compared with runoff from atrazine left on the soil surface.

In dry years especially, incorporation enhances weed control, compared with surface (pre-emerge) applications, by reducing the amount of precipitation needed for herbicide activation. However, too deep or uneven incorporation may result in poor weed control. Shallow incorporation can be achieved with field cultivators, finishing disks, or harrows. It requires care to avoid throwing atrazine treated soil out of the crop row with the planter. Herbicide incorporation may not be an option on highly erodible fields where the conservation plan requires maintaining large amounts of plant residue.

Incorporation will not alleviate the atrazine pollution risk on coarse-textured soils, because leaching is more important than surface runoff on those soils. Minimizing the rate of atrazine applied is the key to reducing leaching potential on those soils.

Atrazine has a vital role in ecofallow/ecofarming systems such as the wheat-sorghum-fallow and wheat-corn-fallow rotations in central and western Kansas, and various no-till and ridge-till planting systems throughout Kansas. What are the guidelines for atrazine use in these situations?

Most of these are dryland farming systems where soil moisture is replenished during a fallow period between crops. Because of its residual weed control properties, atrazine is often applied to wheat stubble in late summer to control broadleaf weeds and winter annual grass weeds in fields to be no-till planted to corn or sorghum the following spring. The following considerations should be taken into account before using atrazine in this manner.

- Consider the amount and type of plant residues present. For example, wheat, corn and sorghum produce greater quantities of residues than soybeans and sunflowers and resist weathering better than soybean and sunflower residues. Atrazine may be safely applied to wheat stubble in fall for control of volunteer wheat and in preparation for no-till planting of corn or sorghum the following spring. The probability of heavy rains is low during the autumn months, so there is reduced risk of runoff losses. To enhance water infiltration and reduce runoff potential, plant residue on the soil surface should exceed 50 percent at the time of atrazine application.
- Consider the average precipitation for the area, and the risk of intense storms at different times of year. Dryland fields are less vulnerable than irrigated fields where application of large amounts of water can leach atrazine down into deeper soil horizons. The probability of

intense rainfall and high runoff is greatest from May to August. Precipitation and the potential for high runoff decrease in a westward direction across Kansas.
- Other conservation and soil management practices such as contour farming, strip-cropping, terraces, waterways, and ridge tillage can reduce water runoff and atrazine loss potential.

What about the storage and handling of pesticides, and sprayer operator's responsibilities?

Improper storage, handling, and sprayer loading and cleanup present a much greater pollution risk than the use of pesticides in fields. This is due to much higher concentrations of the substances around storage and mixing and loading sites. Point source contamination from improper storage, handling, and disposal are usually responsible for atrazine concentrations in groundwater which approach or exceed the MCL.

So what's the bottom line? Can atrazine be used in ways that eliminate all pollution potential?

There is no way to remove all risk of pollution from atrazine. However, steps can be taken to manage and reduce risk.

- Take steps to reduce atrazine rates on both coarse- and fine-textured soils. Lower rates of foliar applied atrazine are often much more effective for broadleaf control than higher rates soil applied. Consider the crop rotation benefits of less atrazine carryover following application of lower rates.
- If weed pressure is too high to risk relying on foliar applied herbicides, consider tank mixtures and/or sequential applications with a reduced amount of atrazine applied at planting, followed by foliar applications. This spreads out atrazine use and reduces overall risk of runoff and leaching.
- Where fields are tilled prior to planting, consider shallow incorporation of atrazine. Springtooth, spiketooth, and flexible harrows can be used to mix atrazine into the top two inches of soil. Many modern field cultivators have adequate clearance to perform well in fields with considerable plant residues.
- Atrazine applied to soil has considerable longevity. Consider applying it when the probability of heavy rains is reduced. Under Kansas weather conditions, atrazine applied in early April has half the risk of surface runoff compared to that applied in late May. Thus, early preplant applications ahead of corn or well ahead of sorghum planting have relatively reduced risk of runoff. Similarly, fall applications — after August — to wheat stubble also have low risk of surface runoff loss. Conservation tillage systems may permit intensification of cropping through improved water efficiency and infiltration into soils. This can reduce risks of atrazine loss in surface runoff.
- Consider the possibility of banding preemergence herbicides over the row and following up with cultivation. This allows use of the full herbicide rate in the row, if needed, to counter heavy weed pressure, yet reduces herbicide costs, carryover, and the herbicide load on the environment. In addition, cultivation can enhance soil aeration and place additional pressure on perennial weeds.
- Producers should ask themselves whether it's really necessary to use atrazine in their weed management program. Can they adopt crop production systems that reduce the need for herbicides in general, and atrazine in particular? Atrazine is an unusual and valuable herbicide because of the wide variety of ways it can be effectively used to help manage weeds. Knowledge of environmental risks associated with different uses will enable corn and sorghum producers to modify their management practices to assure environmentally sound uses.

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