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Minimizing the Risk of Herbicide Transport into Public Water Supplies—A Nebraska Case Study

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Herbicides and their by-products commonly are present in Nebraska's major rivers in small concentrations, but these concentrations increase in the planting season during runoff in spring and early summer. Although water from the Elkhorn and Platte Rivers mixes after their confluence, mixing is incomplete near the city of Lincoln well field, which includes horizontal collector wells located on an island in the Platte River.

This condition results in variable concentrations of herbicides across the width of the Platte River and offers opportunities and challenges to water-resources managers to prevent or reduce contamination in water that reaches the wells. Trace concentrations of herbicides—about 20 to 50 percent of the amount in the river—are transported from the river through the riverbed into the collector wells in about 5 to 7 days.

Acceptable levels of herbicides in treated drinking water for customers may be maintained by a combination of several techniques, including:

- *(1) Best management practices by farmers and homeowners applying herbicides,*
- *(2) natural filtration in valley sediments,*
- *(3) management of the well field, including mixing collector-well and vertical-well water, selecting laterals of the collector wells to be used, or avoiding use of the collector wells during spring and early summer runoff, and*
- *(4) treatment of the water using filtration and ozonation.*

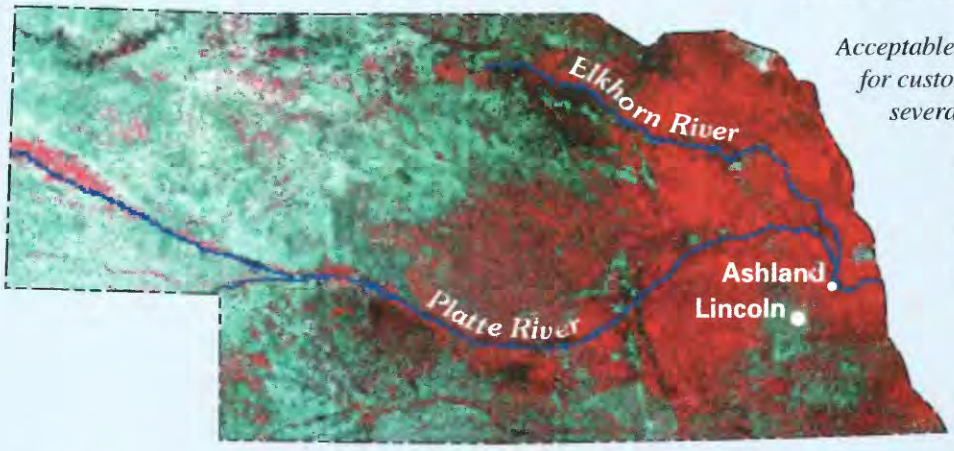


Figure 1. Location of Lincoln, Ashland, selected rivers, and cultivated land (shown in red) in Nebraska (Conservation and Survey Division, University of Nebraska-Lincoln, written commun., 2000).

Introduction

The well field that provides water to two treatment plants operated by the city of Lincoln near Ashland, Nebraska (figs. 1 and 2), consists of 40 active production wells. Two wells are horizontal large-capacity collector wells on an island in the Platte River. Thirty-eight wells are vertical wells on the west bank of the Platte River. These wells obtain water from river-valley sediments that are about 90 feet thick and are underlain by bedrock. Most of this water is derived indirectly from the Platte and Elkhorn Rivers.

During rainfall, herbicides are moved from land into rivers by runoff. The occurrence of herbicides in the rivers depends on the intensity and timing of the rainfall and location and timing of herbicide applications. Because the Platte River indirectly contributes water to the well field, herbicides also have been detected in trace amounts since the early 1980's in the raw and treated water from the well field. Since 1993, when the city of Lincoln started to use the collector wells, Lincoln's water supply also has become more vulnerable to spills and nonpoint-source contamination because of increased movement of surface water through the two collector wells into the treatment plants.

To evaluate the vulnerability of the city's drinking-water supply to contaminants from the Elkhorn and Platte Rivers, the U.S. Geological Survey conducted several studies in cooperation with the city of Lincoln from 1991 to 2000. This fact sheet summarizes selected results from those studies; details are presented in reports that are included in the "Selected References" section.

Surface Water.....

How well does surface water mix and how fast does it travel?

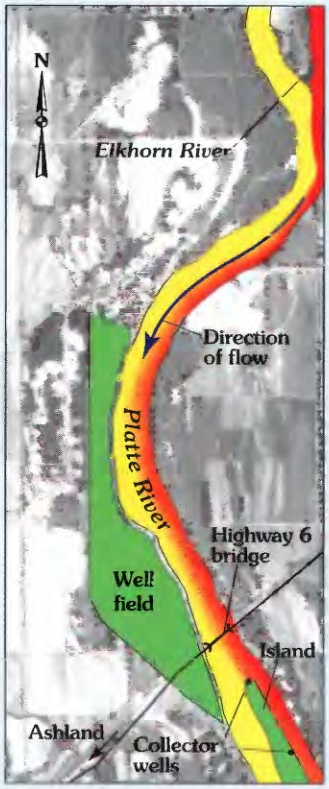


Figure 2. City of Lincoln well field and conceptual model of mixing of rivers near Ashland, Nebraska.

Mixing of water in the Elkhorn and Platte Rivers increases with distance downstream from the confluence of the rivers and depends on the relative amounts of water in these rivers. Water in the Elkhorn and Platte Rivers is incompletely mixed (50 to 80 percent) near the city of Lincoln well field (Verstraeten, Soenksen, and others, 1999) (fig. 2). This creates the opportunity to manage the well field to prevent or reduce herbicides in the water supply. Water-resources managers may estimate the time it takes for contaminants to travel in the rivers on the basis of the velocity of the rivers. The concentration of contaminants in the river can be estimated if known amounts of a chemical were spilled in the river.

Managers may estimate traveltime and contaminant concentrations before they reach the well field.

Sample collection from the Platte River.

Occurrence of Herbicides.....

Which herbicides are present in the Platte River and when?

Herbicides commonly are present in the rivers at very small concentrations during most of the year (fig. 3). These herbicides include acetochlor, alachlor, atrazine, cyanazine, and metolachlor. By-products (metabolites) of these herbicides, such as deethylatrazine and deisopropylatrazine, also are found in surface water. Herbicides are present at larger concentrations in the spring and early summer during and after intense rainfall than in the fall and winter.

Following intense rainfall, the concentrations of atrazine in the Platte River may be as much as 20 ppb (parts per billion or micrograms per liter), and the concentrations of alachlor may be as much as 2 ppb. Concentrations of more than 20 ppb have been measured at times in the Elkhorn River, and in the Platte River, generally on the east side of the island. One part per billion is equivalent to about one-eighth of a teaspoon of herbicides in a swimming pool that is 36 feet wide, 100 feet long, and 10 feet deep.

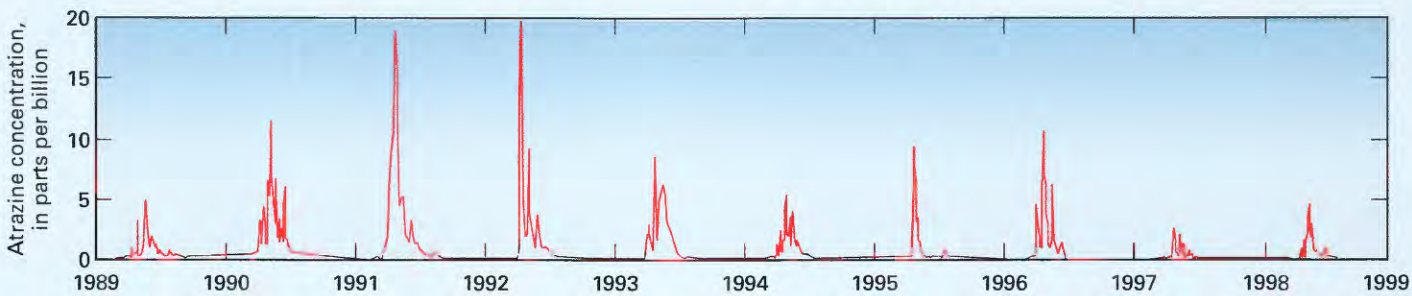


Figure 3. Atrazine concentrations in the Platte River on the east side of the island, 1989–98 (Carr, 1993; Verstraeten, Carr, and others, 1999; J.D. Carr, University of Nebraska-Lincoln, Chemistry Department, written commun., 2000).

Transport of Herbicides.....

How are herbicides in the Platte River affecting Lincoln's drinking water from river to tap?

Concentrations of herbicides in the river are reduced 50 to 80 percent as they filter through the riverbed and valley sediments to a collector well, which takes 5 to 7 days (fig. 4) (Verstraeten, Carr, and others, 1999). As the peak concentration entered the collector wells in 1997, herbicide concentrations in water from the north collector well increased 70 times, from background concentrations of 0.1 to 7 ppb (fig. 4).

On the basis of this information, gross estimates can be made in the future of herbicide concentrations in water from the wells when herbicide concentrations in the rivers are known. The quality of the water from the collector wells varies with (1) the selection of the collector well used, (2) the number and selection of horizontal laterals used, (3) the chemical characteristics of the contaminant, and (4) the relative mixing of water in the Elkhorn and Platte Rivers.

Sample for herbicide analysis.

The quality of water delivered by the city of Lincoln is affected by seasonal concentrations of herbicides in water from the Platte River, especially during spring and early summer. Filtration through valley sediments reduces herbicide concentrations to less than half of the original amount in the river.

In the treatment plant, the pretreated water consists of about 50 percent vertical-well water from the city of Lincoln well field, which has very small to undetectable levels of herbicides throughout the year, and 50 percent horizontal collector-well water. This mixing decreases the concentrations of herbicides in drinking water about another 50 percent. In 1997, during runoff after more than 80 percent of cropland was planted, atrazine levels from river to tap decreased eight times from 8 to less than 1 ppb (fig. 5).

> **"...atrazine levels from river to tap decreased eight times..."**

The quality of the drinking water also is affected by water demand. Water demand increases during the growing season, especially during hot and dry weather, more than 1 month after the largest concentrations tend to occur in the river.

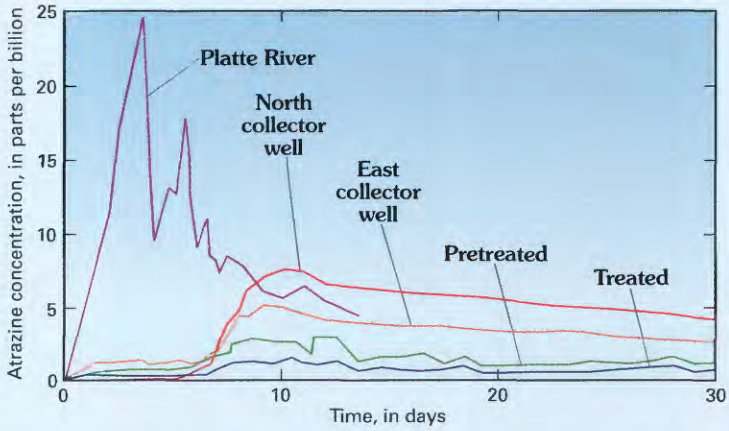


Figure 4. Herbicide concentrations in late May and early June 1997 (day 0 was May 27, 1997).

Greater demand requires a larger percentage of collector-well water. This potentially reduces the quality of the drinking water because the water from the collector wells is more affected by the surface water than the vertical wells, and the surface water tends to be more contaminated than the ground water. The U.S. Environmental Protection Agency Maximum Contaminant Levels (MCL's) for drinking water (U.S. Environmental Protection Agency, accessed January 18, 2000, at URL *http://www.epa.gov/OGWDW/wot/appa.html)* for alachlor (2 ppb) and atrazine (3 ppb) have not been exceeded for many years in treated water from the city of Lincoln.

Degradation of herbicides during transport in soil, river, and aquifer and during the ozonation process in treatment plants results in the formation of by-products. The health risk of the by-products of herbicides naturally created in the environment and during the ozonation process have not been studied fully.

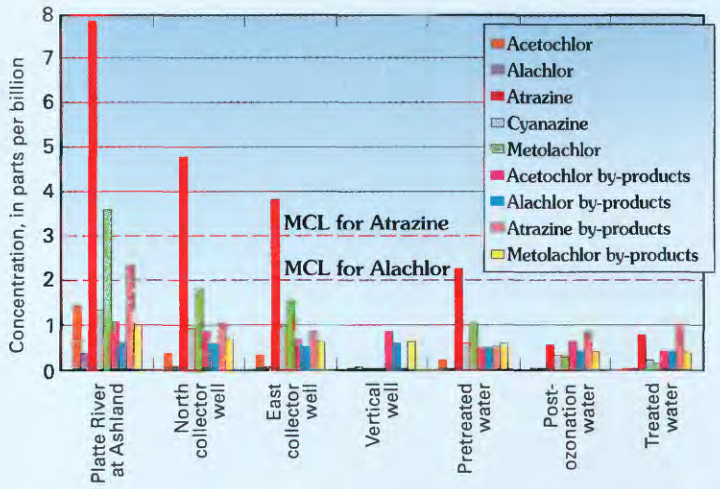
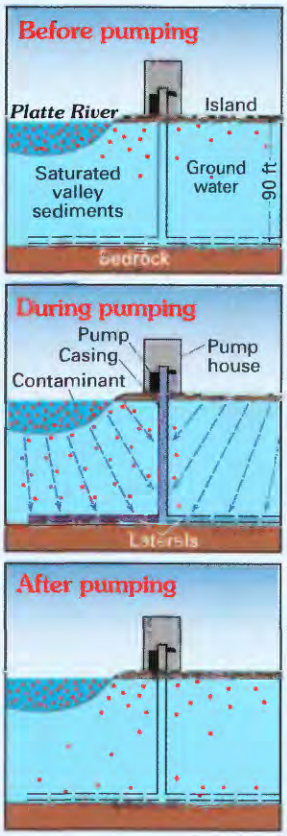


Figure 5. Herbicide concentrations during the runoff in early June 1997.

Solutions.....

What can be done to prevent herbicides from exceeding acceptable levels in drinking water?



"Using best management practices ... is the most effective way to reduce the load of herbicides in the river, ultimately protecting our environment and our drinking water," said Jerry Obrist of the city of Lincoln Water Systems.

Figure 6. Conceptual model of effects of pumping on quality of water from the north collector well.

Small herbicide concentrations in water from the collector wells can be limited through well-field management. The fraction of pumped water that consists of surface water varies from about 50 to 97 percent, depending on which laterals of the collector wells are used (Steele and Verstraeten, 1999). The rest of the water pumped by the collector wells is ground water containing small herbicide concentrations. Accordingly, water managers can affect the mixture of surface water and ground water by planning and adjusting which laterals are open and probably also by adjusting pumping rates.

The best quality of municipal water can be obtained by using those laterals most distant from that part of the river that is most contaminated or by not operating the collector wells until contaminant concentrations in the river have decreased to acceptable levels (fig. 6). A combination of best management practices in herbicide application, natural filtration, well-field management, and water treatment using ozonation and filtration helps control levels of herbicides in drinking water. Thus, by working together, agricultural and urban communities, and public water-supply managers can help maintain safe drinking water with respect to herbicides.

Acknowledgments

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