Agriculture, Agricultural Chemicals, and Water Quality

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The American agricultural system is unparalleled in its ability to produce food and fiber, providing quality products for both domestic consumption and export. Total agricultural production today is over 2 times the level of 1930. Much of this productivity gain has been made possible by improvements in fertilizers and pesticides for crop protection, as well as crop varieties and cropping technologies.

This chapter discusses agricultural chemicals (fertilizers and pesticides), their potential for contributing to water quality problems, and some ways that USDA agencies are helping farmers to reduce agricultural contributions to nonpoint source water pollution. (Nonpoint source pollution is pollution that does not originate at any one source, but that develops over large areas through either natural or human systems and processes.)

Agricultural production involves the movement of soil and water and the growing of plant materials—all of which can affect water quality and quantity. Modern crop production chemicals (both fertilizers and pesticides) can move off-site through volatilization (evaporation), leaching (dissolving in water and seeping downward through the soil), and other pathways (such as runoff and erosion) to become significant contributors to pollution of surface and ground waters. Many farmers view themselves as stewards of the natural resources they manage. Today, these farmers need knowledge about environmental problems as well as crop production systems, and about farm practices that can preserve long-term soil productivity and water quality.

Water: Quantity and Quality

Earth—as seen from space—is a water planet: a serene, blue world swathed in white, moisture-laden clouds. Over 70 percent of the Earth’s surface is covered by water, but most of this is salt water. It is the small fraction (less than 3 percent) that is fresh water which sustains all land-based plants and animals (see fig.1). In fact, only about 1 percent of all the water on Earth is available for human consumption.
This water is endlessly renewed in a cycle fueled by the Sun's energy: falling as precipitation, aiding in plant growth, re-charging ground water, flowing to the ocean, and evaporating to form clouds again.

This fresh water supply is not distributed evenly across the Earth’s land area, or even across the same country. Despite the semi-arid character of much of the Western United States, our country is considered relatively “water-rich” within the global community of nations. As human populations continue to expand and develop more of the Earth’s land area, there is an increased need to protect and maintain this small fraction of life-supporting fresh water.

Figure 1. Distribution of the world's water

<table>
<thead>
<tr>
<th>Water Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceans</td>
<td>97.41%</td>
</tr>
<tr>
<td>Ice caps and glaciers</td>
<td>1.984%</td>
</tr>
<tr>
<td>Groundwater</td>
<td>0.592%</td>
</tr>
<tr>
<td>Lakes</td>
<td>0.007%</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>0.005%</td>
</tr>
<tr>
<td>Atmospheric water vapor</td>
<td>0.001%</td>
</tr>
</tbody>
</table>


Agriculture and Agricultural Chemicals

Soil is the main nutrient source for growing plants, but farmers have for thousands of years added growth-enhancing nutrient substances to the soil or rotated their crops in a certain order to replenish nutrients used by plants. Until this century, most of these fertilizers (and the few available pesticides) were naturally occurring compounds, and crop rotation was almost universally practiced to help maintain soil productivity.

However, the development and widespread use of industrially synthesized nitrogen fertilizers in the 1920’s, crop-protecting pesticides in the 1940’s, and genetically improved crop varieties in the 1950’s (which are usually grown in monoculture) have combined to make today’s conven-
tional agriculture much more chemical-intensive than ever before. Pesticide use in U.S. agriculture has more than doubled since 1962; fertilizer use in 1985 was almost 13 times higher than in 1930. There is also a trend for farmers to use more-concentrated fertilizer materials.

Four major crops—corn, cotton, soybeans, and wheat—account for about two-thirds of U.S. fertilizer use. Corn, which makes up about 21 percent of U.S. acreage, accounts for about 43 percent of the nitrogen use. Economic forces and national agricultural policies have often combined to promote the continuous production of high-value crops on the same land. Also, the uncertainties always present in crop production cycles in some regions of the United States have contributed to farmers' decisions to increase the use of agricultural chemicals in some years as a form of insurance to try to boost yields.

The agricultural chemicals used by farmers are generally mixtures, or formulations, of two or more chemicals. One or more active ingredients (which provide the product's desired effects) are combined with one or more inert ingredients (such as carriers, diluents, stabilizers, or preservatives) to make the finished product that is applied to soil or crops. Other chemicals (formed during the manufacture of the active ingredients or the formulation pro-

Soybeans flourish in no-till wheat straw. Sustainable agriculture ensures long-term soil productivity and enhances water quality.
*Gene Alexander/USDA KS-2053-32*
cess) may also be present in minute amounts. Therefore, today’s farm management planning includes an increasingly complex chemical management component.

Protecting Water Quality
In the United States, improvements in surface water quality have occurred in the past 20 years since the passage of the Clean Water Act (Federal Water Pollution Control Act) in 1972. Most of this improvement has come about through reductions of "conventional" pollutants (sediment, organic matter, nutrients, salts, bacteria) from point sources of pollution such as industries and municipal wastewater treatment plants, primarily by the installation of more and better treatment facilities to remove pollutants.

During this same period, however, it has also become clear that:
• Conventional pollutants are not the only point-source pollutants of concern, and
• Point-sources are not the only cause of water quality degradation in the United States.
Toxic pollutants can continue to cause water quality problems.

SCS technician Darren Lemmons takes a soil moisture reading to determine the soil’s capacity to supply moisture to plants.
Tim McCabe/USDA 91BW0455
after conventional pollutants are cleaned up. Furthermore, nonpoint sources of pollution, primarily from human activities such as agriculture, forestry, urban runoff, construction, abandoned mines, and atmospheric deposition, are being recognized as significant contributors of both conventional and toxic pollutants to our water resources (see fig. 2).

Naturally occurring nonpoint source pollution can also occur, from processes such as geologic erosion, saline seeps, and dissolution of nutrient-rich rocks and soils. These nonpoint sources are proving to be much more difficult to control than point sources.

While nutrients (nitrogen and phosphorus) and sediment are major nonpoint pollution problems for surface waters, the primary concerns for ground water supplies are pesticides and the nitrate form of nitrogen. This nitrate contamination raises additional specific concerns for the human health implications, since ground water is the source of drinking water for about 105 million people in the United States (see table 1). About 97 percent of all rural drinking water, 55 percent of water for livestock, and more than 40 percent of all irrigation water is from ground water sources. Whereas surface water is subject to naturally occurring environmental processes that help to chemically transform or degrade pollutants—processes such as heating and cooling cycles, exposure to sunlight, microbial transformation, and oxidation—ground water is not subject to these processes. Therefore, once contaminated, this important resource recovers very slowly, if ever.

The U.S. Environmental Protection Agency (EPA), in 1990, released results of a national survey of pesticides in community water systems and rural domestic wells. About 10 percent of the community water systems and 4 percent of the rural domestic wells contained detectable concentrations of pesticides, while over 50 percent of the wells surveyed contained detectable concentrations of nitrates.

For pesticides, less than 1 percent of all the wells surveyed had concentrations slightly above levels considered safe for human health, while about 1 percent of the community wells and about 2.4 percent of the private rural wells contained nitrate concentrations above the maximum contaminant level established to protect human health.

**The Task Ahead**

Effective reduction of nonpoint source water pollution in rural America requires the timely delivery of new conservation technologies through educational materials and training—with State or Federal financial assistance, if necessary. USDA continues to strongly encourage voluntary actions to
Figure 2. Sources and types of nonpoint pollution in affected U.S. rivers and lakes

Primary Sources of Pollution

Rivers
165,000 miles
- Construction 2%
- Land disposal 1%
- Agriculture 64%
- Other 9%

Lakes
3.3 Million Hectares
- Resource extraction 1%
- Silviculture 1%
- Urban runoff 12%
- Other 7%
- Agriculture 57%
- Hydromodification 13%

Primary Types of Pollution

Rivers
165,000 miles
- Pesticides 3%
- Salinity 2%
- Oxygen demand 4%
- Toxics 6%
- Acidity 7%
- Physical habitation alteration 9%
- Pathogens 9%
- Nutrients 13%
- Sediment 47%

Lakes
3.3 Million Hectares
- Pathogens 2%
- Pesticides Less Than 1%
- Salinity 3%
- Oxygen demand 3%
- Acidity 4%
- Physical habitation alteration 4%
- Nutrients 59%
- Sediment 22%

Agriculture and the Environment
improve water quality and quantity. USDA has an established network of technical specialists and educators to help land users through local soil and water conservation districts, and to help other groups eliminate or avoid soil and water resource problems.

USDA’s Agricultural Stabilization and Conservation Service (ASCS), Extension Service (ES), and Soil Conservation Service (SCS) have the personnel and systems to provide the necessary education, technical assistance, and financial assistance. These agencies are staffed with professionals experienced in sound management of water resources.

One of many new projects in-

### Table 1. Percentages of people relying on ground water for domestic use in the United States

<table>
<thead>
<tr>
<th>States</th>
<th>Percent of State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona, Florida, Hawaii, Mississippi, Nebraska, Nevada, New Mexico</td>
<td>Over 90</td>
</tr>
<tr>
<td>South Dakota</td>
<td>80 - 89</td>
</tr>
<tr>
<td>Delaware, Iowa, Maine</td>
<td>70 - 79</td>
</tr>
<tr>
<td>Alaska, Indiana, Kansas, South Carolina, Washington, Wisconsin, Utah</td>
<td>60 - 69</td>
</tr>
<tr>
<td>Georgia, Minnesota, New Jersey, New York, Ohio, Pennsylvania, Virginia</td>
<td>40 - 49</td>
</tr>
<tr>
<td>Alabama, Connecticut, Massachusetts, Missouri, North Carolina, Oklahoma, Oregon</td>
<td>30 - 39</td>
</tr>
<tr>
<td>Colorado, Kentucky, Rhode Island</td>
<td>20 - 29</td>
</tr>
<tr>
<td>Maryland, Puerto Rico, Virgin Islands</td>
<td>Under 20</td>
</tr>
</tbody>
</table>

Note: For this report, Puerto Rico and the Virgin Islands are treated as States.

Source: State Ground Water Program Summaries, Office of Ground Water Protection, USEPA, 03/85.
stituted by USDA as part of the President’s Water Quality Initiative (see Chapter 12) focuses on the protection of private rural wells, the drinking water source which has been shown to be most often contaminated by nitrates and pesticides. SCS and ES employees are cooperating to develop this program. Agency personnel will work with land users to identify which areas of a particular farm are affecting the water quality in private wells, and will help clients plan and implement procedures to protect their water supply from the intrusion of agricultural chemicals.

Ed May, SCS soil conservationist, taking a water sample to check for bacteria in a stream, as part of a national water quality monitoring program.
Tim McCabe/USDA 91BW0457

This abandoned mine is an example of a nonpoint source contributing to pollution of our water resources.
Tim McCabe/USDA PA-41077-34