Studies by the U.S. Geological Survey on Sources, Transport, and Fate of Agricultural Chemicals (ACT Study)

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Almond orchards in the Mustang Creek watershed in California

INTRODUCTION

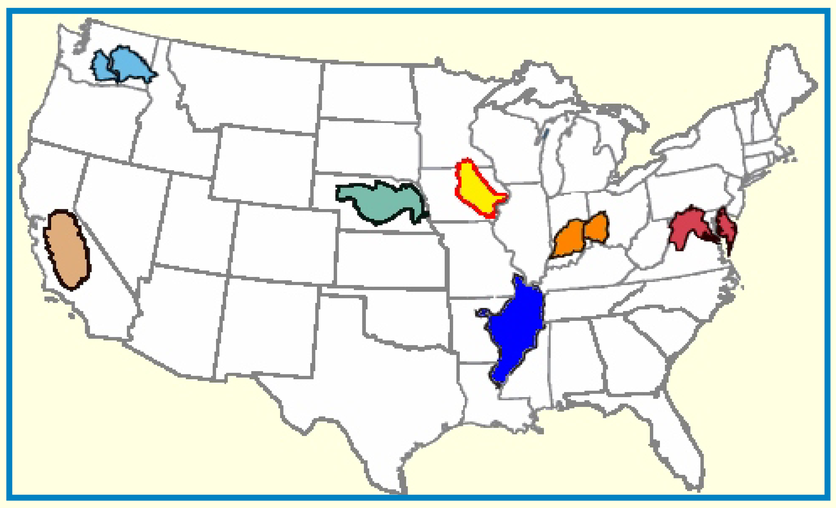
he U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program is assessing the sources, transport, and fate of chemicals applied to crops in agricultural basins across the Nation. Chemicals selected for study include nutrients (nitrogen and phosphorus) and about 50 commonly used pesticides and their transformation products, including triazine and acetanilide herbicides such as atrazine and metolachlor, and organophos-phorus insecticides such as chlorpyrifos and diazinon.

The basins in the studies represent a range of agricultural settingswith varying crop types and agricultural practices related to tillage, irrigation, artificial drainage, and chemical use as well as a range of landscapes with different geology, soils, topography, climate, and hydrology. Consistent methodology and analysis allow comparisons among the different basins. This study design leads to an improved understanding of the many factors that can affect the movement of water and chemicals in different agricultural settings. (See map and table below.)

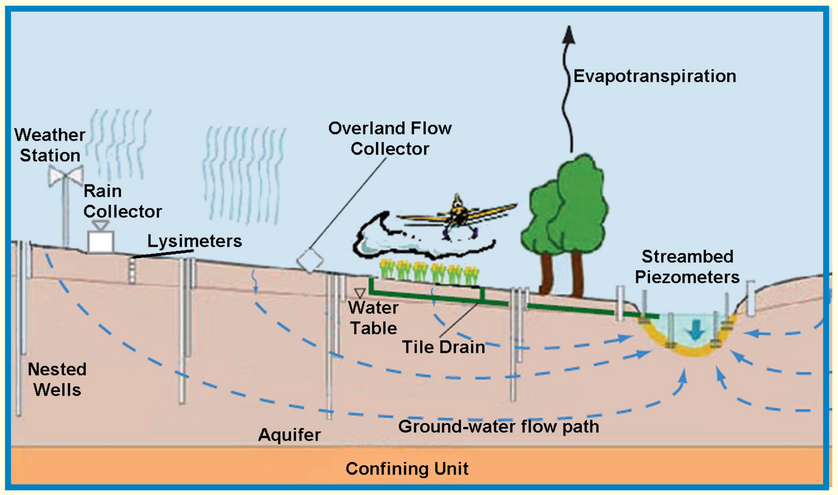
Information from these studies will help with decision-making related to chemical use, conservation, and other farming practices that are used to reduce runoff of agricultural chemicals and sedime nt from fields. This information also will benefit the U.S. Environmental Protection Agency, the Department of Agriculture, local and regional water managers, and agricultural chemical manufacturers who are involved in managing chemical use and pesticide registration.

OBJECTIVES OF THE AGRICULTURAL CHEMICAL STUDY

1. Quantify the amount of water and selected agricultural chemicals entering, leaving, and accumulating within the watershed (referred to as an annual "mass budget").
2. Determine rates of transport and residence times of water and chemicals in ground water, the soil zone, and in streams.
3. Assess transport and transformation of selected chemicals in different parts of the hydrologic system, as affected by natural processes, chemical properties, and agricultural management practices.
4. Develop tools and quantitative methods, such as models, to characterize the transport and fate of chemicals within the watershed, and extrapolate the findings to similar, unmonitored agricultural and environmental settings.
5. Interpret study results as to the implications for managing the water and water-quality impacts of agricultural systems.



Locations (above) and Characteristics (below) of the ACT Study Areas



At a typical study site, several methods are used to collect water and chemical samples from the air, soil, surface water, and ground water.

After being applied to the landsurface, agricultural chemicals can move upward into the atmosphere,downward through the soil to shallow ground water and underlying aquifers, eventually discharging to streams, or run off across the land into streams, eventually moving downstream to reservoirs and coastal waters. This process can take days, weeks, or even decades if water moves underground through the ground-water system.

What kind of data	Why the data are collected	How often
Meteorological data, including rainfall, wind speed, solar radiation, and air temperature. Soil temperature and moisture.	To determine amount of precipitation and estimate amount that reaches the water table and how much is lost to evapotranspiration	Continuously for 2 or more years
Streamflow at gaging stations	To interpret water-quality data correctly (the amount of water in streams affects chemical concentrations)	Continuously for 2 or more years
Quality of stream water, runoff water, rain water, tile drain water	To quantify the transport and behavior of natural and agricultural chemicals	>14 times a year for 2 years
Ground-water levels in wells	To determine direction of ground-water flow, which affects transport of chemicals	Continuously or at least quarterly
Quality of ground water, soil water, and shallow water in and around streambed/riparian zone	To quantify the transport and behavior of natural and agricultural chemicals	At least quarterly for 1 year
Quality of sediment in stream-bed and soils in agricultural field	To quantify the storage, behavior, and transport of water and chemicals in the soils and sediment	At least once during the study

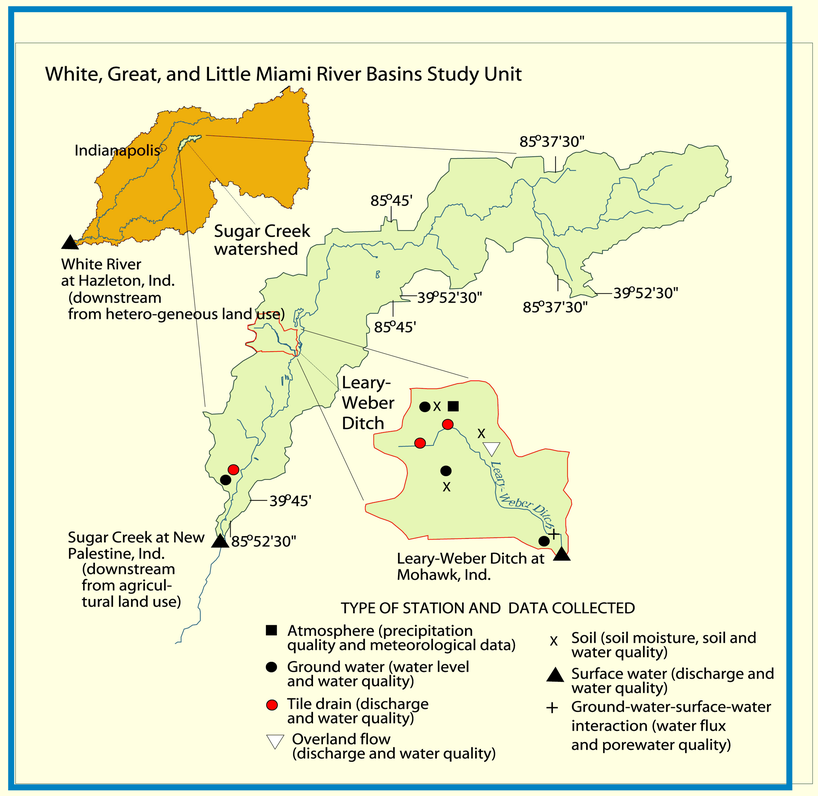
Leary Weber Ditch in Indiana (left) with an instrumented field (center) and a close-up of soil macropores (right).

Dairy cattle and vineyards in the Granger Drain in Washington

HOW ACT STUDY RESULTS CAN BE USED

The findings of these studies will provide a better understanding of the transport and fate of selected agricultural chemicals in various agricultural and environmental settings. This understanding will enable the development of models to extrapolate information from direct water-quality measurements to similar, yet unmonitored, agricultural areas. Farmers will gain a better understanding of how their operations affect water quality. The findings also will guide future scientific research on processes affecting transport and fate of agricultural chemicals and help water policy makers:

- Optimize selection and timing of monitoring on the basis of understanding geographic areas and water resources most likely to be affected;
- Evaluate conservation strategies such as the protection of riparian areas and buffer strips, crop management, and chemical-use management. Stakeholders associated with the U.S. Department of Agriculture and local and regional water managers will better anticipate the effectiveness and timing of these strategies for controlling transport of chemicals and sediment from fields, in streams, and within the ground-water system; and
- Improve registration and regulation of pesticides on the basis of a better understanding of their transport (including transport of breakdown products), as affected by chemical properties and natural processes.



At a typical study site, several methods are used to collect water and chemical samples from the air, soil, surface water, and ground water over a range of scales.

After being applied to the land surface, agricultural chemicals can move upward into the atmosphere, downward through the soil to shallow ground water and underlying aquifers, eventually discharging to streams, or run off across the land into streams, eventually moving downstream to reservoirs and coastal waters. This process can take days, weeks, or even decades if water moves underground through the ground-water system.

NAWQA study unit and agricultural chemicals study area	Major crops and animal Production	Primary agricultural management practices	Hydrogeologic setting
Central Columbia Plateau-Yakima River Basin Study Unit (Granger Drain sub-basin in WA)	Orchards, vineyards, corn, hay, mixed row crops; intensive dairy	Spray, furrow, and drip irrigation; water delivery and drainage channels; tile drains, ditches	Arid; deep loess soils underlain by basalt
San Joaquin-Tulare Basins Study Unit (Lower Merced River and Mustang Creek watershed in CA)	Orchards, vineyards, mixed row crops; intensive dairy and poultry	Spray, furrow, flood, and drip irrigation; conventional tillage and no-till	Arid; permeable sands with relatively shallow water tables and poorly drained soils with deeper water tables
Central Nebraska Basins Study Unit (Maple Creek watershed in NE)	Corn, soybeans, alfalfa, hay, and wheat; beef cattle, some dairy and hogs	Mostly dryland; central pivot irrigation; conventional and conservation tillage, no-till increasing	Semiarid; permeable surface and subsurface
White, Great, and Little Miami River Basins Study Unit (Sugar Creek watershed in IN)	Corn and soybeans; few to no animals	No irrigation; conventional and reduced tillage; tile drains and ditches	Humid; poorly drained soils; relatively impermeable glacial till and sediment
Potomac River Basin & Delmarva Peninsula Study Unit (Morgan Creek watershed in MD)	Corn and soybeans; some dairy	Some central pivot irrigation; conventional tillage and no-till	Humid; moderately to well drained soils; permeable sand and gravel suficial aquifer
Eastern Iowa Basins Study Unit (South Fork of the Iowa River watershed in IA)	Corn and soybeans; extensive hog confined feeding operations	No irrigation; conventional and conservation tillage; tile drains and ditches	Humid; poorly to moderately drained soils from glacial till
Mississippi Embayment Study Unit (Bogue Phalia watershed in MS)	Cotton, rice, soybeans, corn; catfish, few other animals	Flood, pivot, spray, and furrow irrigation	Subtropical; poorly drained alluvial soils

ADDITIONAL INFORMATION CONTACT:

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Web Site: http://in.water.usgs.gov/NAWQA_ACT/index.shtml

THE NAWQA PROGRAM

The study of agricultural chemicals is one of five national priority topics being addressed by the National Water-Quality Assessment (NAWQA) Program in its second decade of studies, which began in 2001. Other topics include (1) effects of urbanization on stream ecosystems; (2) ecological effects of nutrient enrichment; (3) mercury in stream ecosystems; and (4) transport of contaminants to public-supply wells.

During the Program's first decade (1991-2001), NAWQA scientists assessed water chemistry, stream hydrology, habitat, and biological communities in 51 major river basins (referred to as "Study Units"; a map is available at http://water.usgs.gov/nawqa). The assessments characterize the ambient water resourcethe source of about 60 percent of the Nation's drinking water and water for industrial, irrigation, and recreational uses. During its first decade, NAWQA made baseline assessments of pesticides, nutrients, volatile organic compounds, trace elements, dissolved solids, and radon, as well as the condition of aquatic habitats and fish, insect, and algal communities. These findings are described in hundreds of reports, which can be accessed at the NAWQA Web site above.

In the second decade of studies, 42 of the 51 study units are planned to be reassessed to determine trends at many of the streams and ground-water monitoring sites; to fill critical gaps in the characterization of water-quality conditions; and to build upon earlier NAWQA findings that show how natural features and human activities affect water quality and aquatic ecosystems.