Pesticides in Agricultural Streams

Pesticides are chemicals or biological agents that control plant or animal pests and may include herbicides, insecticides, fungicides, and rodenticides. More than a billion pounds of pesticides (measured as pounds of active ingredient) are used in the United States each year to control weeds, insects, and other organisms that threaten or undermine human activities. About 80 percent of this total is used for agricultural purposes (U.S. EPA, 2011). Although pesticide use has resulted in increased crop production and other benefits, pesticide contamination of streams, rivers, lakes, reservoirs, coastal areas, and ground water can cause unintended adverse effects on aquatic life, recreation, drinking water, irrigation, and other uses. Water also is one of the primary pathways by which pesticides are transported from their application areas to other parts of the environment (USGS, 2000).

This indicator is based on stream water samples collected between 1992 and 2001 as part of the U.S. Geological Survey's (USGS's) National Water Quality Assessment (NAWQA) program, which surveys the condition of streams and aquifers in study units throughout the contiguous United States. Of the streams sampled for pesticides, this indicator focuses on 83 streams in watersheds where agriculture represents the predominant land use, according to criteria outlined in Gilliom et al. (2007). These 83 streams are located in 36 of the 51 NAWQA study units (i.e., major river basins). From each site, NAWQA collected 10 to 49 water samples per year over a 1-to-3-year period to analyze for 75 different pesticides and eight pesticide degradation products, which together account for approximately 78 percent of the total agricultural pesticide application in the United States by weight during the study period (Gilliom et al., 2007). This indicator reports on two variables: (1) the number of stream sites in which pesticides or degradation products were detected and (2) the number of stream sites where the concentration of one or more of these compounds exceeds standards for aquatic life. A related indicator discusses pesticide concentrations in ground water in agricultural watersheds.

Several types of water quality benchmarks for aquatic life were used. Where available, data were compared with EPA's acute and chronic ambient water-quality criteria for the protection of aquatic life (AWQC-ALs). The acute AWQC-AL is the highest concentration of a chemical to which an aquatic community can be exposed briefly without resulting in a potential adverse effect. The chronic AWQC-AL is the highest concentration to which an aquatic community can be exposed indefinitely without resulting in a potential adverse effect. An exceedance was identified if a single sample exceeded the acute AWQC-AL or if a 4-day moving average exceeded the chronic AWQC-AL (per EPA's definition of the chronic AWQC-AL). Results were also compared with EPA's Pesticide Aquatic Life Benchmarks, which were derived from toxicity values presented in registration and risk-assessment documents developed by EPA's Office of Pesticide Programs. These benchmarks included acute and chronic values for fish and invertebrates, acute values for vascular and nonvascular plants, and a value for aquatic community effects. An exceedance was identified if a single sample exceeded any acute benchmark or if the relevant moving average exceeded a chronic benchmark. Altogether, aquatic life benchmarks were available for 62 of the pesticides and degradation products analyzed. More information about the derivation and application of aquatic life guidelines for this indicator can be found in Gilliom et al. (2007).

What the Data Show

Of the streams sampled, all had at least one pesticide detection and 86 percent had five or more compounds present, which suggests that pesticides frequently occur as mixtures (Exhibit 1). In 57 percent of the streams sampled, at least one pesticide was detected at a concentration that exceeded one or more aquatic life benchmarks (Exhibit 1). Approximately 7 percent of the streams (six of the 83 streams sampled) had five or more pesticides at concentrations above aquatic life benchmarks.

Limitations

- These data represent streams draining agricultural watersheds in 36 of the study units (major river basins) sampled by the NAWQA program in the contiguous United States. While they were chosen to be representative of agricultural watersheds across the nation, they are the result of a targeted sampling design, and may not be an accurate reflection of the distribution of concentrations in all streams in the nation's agricultural watersheds.
- This indicator does not provide information about trends over time, as the data in Gilliom et al. (2007) only represent the first cycle of the NAWQA program. NAWQA has completed its second cycle of sampling (2001–2012) and has initiated a third cycle. In addition, NAWQA has analyzed trends using Cycle 1 and Cycle 2 data, which show decreasing concentrations of several pesticides over time (Ryberg et al., 2010; Sullivan et al., 2009).
- This indicator relies on aquatic life benchmarks that were available as of 2006. At that time, aquatic life benchmarks did not exist for 21 of the 83 pesticides and pesticide degradation products analyzed. Current standards and guidelines do not account for mixtures of pesticide chemicals and seasonal pulses of high concentrations.
- The analyses in Gilliom et al. (2007) rely on both AWQC-ALs and Pesticide Aquatic Life Benchmarks. These benchmarks are developed under two different statutory requirements using different methodologies. AWQC-ALs are designed to be protective of aquatic communities, while EPA's Aquatic Life Benchmarks are taxa-based thresholds. Both are designed to be protective of aquatic health.
- This indicator does not provide information on the magnitude of pesticide concentrations, only whether they exceed or fall below benchmarks.

Data Sources

Summary data for this indicator were provided by USGS's NAWQA program, based on supporting technical data published in conjunction with Gilliom et al. (2007). Overall pesticide occurrence was determined from individual site results in Appendix 6 of Gilliom et al. (2007) (http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/), while exceedances were calculated from a separate supporting data file (http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/figures/descriptions/6_05_exceeddata.txt).

References

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U.S. EPA (United States Environmental Protection Agency). 2011. Pesticides industry sales and usage: 2006 and 2007 market estimates. February 2011.

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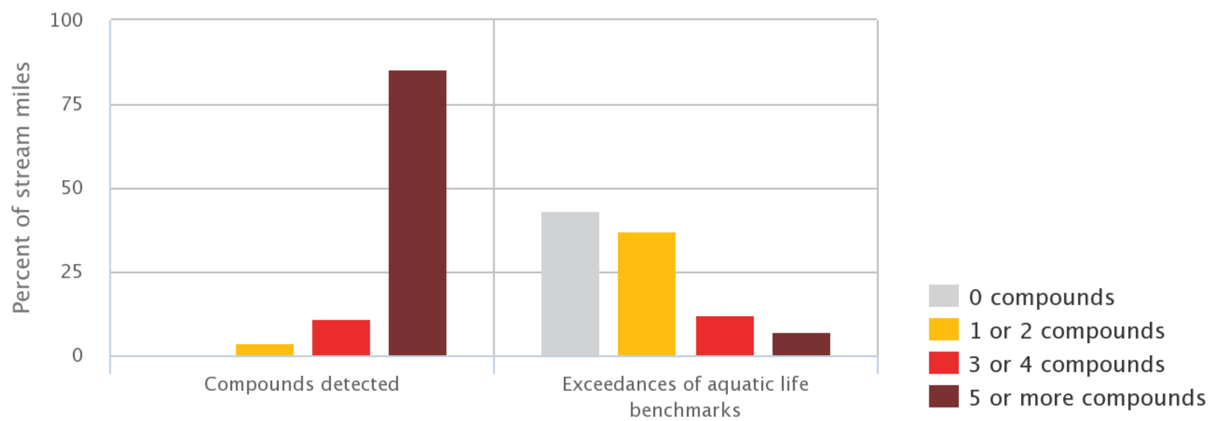
Exhibit 1. Pesticides in streams in agricultural watersheds of the contiguous U.S., 1992–2001



Coverage: 83 stream sites in watersheds where agriculture is the predominant land use. These watersheds are within 36 major river basins studied by the USGS NAWQA program.

All streams had at least one compound detected.

Trend analysis has not been conducted because these data represent one cycle of sampling. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: Gilliom et al., 2007