Statement for the Record
U.S. Geological Survey
U.S. Department of the Interior
Before The
Committee on Transportation and Infrastructure
Subcommittee on Water Resources and Environment
and the
Committee on Agriculture
Subcommittee on Nutrition and Horticulture
U.S. House Of Representatives
On
Pesticides in Streams and Groundwater across the United States
February 16, 2011

Thank you for the opportunity to provide you with an overview of our current understanding of the occurrence of pesticides in streams and groundwater across the United States. I am Robert Gilliom, a hydrologist with the U.S. Geological Survey (USGS). I direct pesticide studies for the National Water Quality Assessment Program (NAWQA). Several peer-reviewed, previously published reports were drawn upon for today's overview. These reports are listed at the end of my written testimony.

Two USGS programs include a national focus on pesticides in water resources. These programs, NAWQA, and the Toxic Substances Hydrology Program, provide nonregulatory scientific information on the quality of our water resources and factors that influence it. This information used by a wide range of stakeholders, including Federal and State agencies, pesticide registrants, and interest groups. The NAWQA program provides a broad nationwide assessment of a wide range of pesticides. The Toxic Substances Hydrology Program complements the NAWQA program with a targeted research approach to evaluate new and emerging water-quality issues, often involving the development of new analytical methods and their application in specific pesticide-use settings. The NAWQA program's national findings, summarized in a 2006 report "Pesticides in the Nation's Streams and Ground Water," provide a nationwide view of pesticide occurrence, potential significance to humans and aquatic ecosystems, and relations between pesticide use patterns and levels found in water. Recent USGS studies have further evaluated trends in pesticide concentrations in streams and rivers. Among the major findings are that pesticides are frequently present in streams and groundwater, are not common at concentrations known to affect humans, but occur in many streams at concentrations that may have effects on aquatic life or fish-eating wildlife.

USGS Approach to Pesticide Assessment

USGS assessment of pesticides used a nationally consistent approach to study 51 of the Nation's major river basins and aquifer systems. Nationally, water samples for pesticide analysis were

ED_002432A_00000146-00001

collected from 186 stream sites, bed-sediment samples were collected from 1,052 stream sites, and fish samples were collected from 700 stream sites. Groundwater samples were collected from 5,047 wells. Most water samples were analyzed for 75 pesticides and 8 degradates [pesticide breakdown products], including 20 of the 25 most heavily used herbicides and 16 of the 25 most heavily used insecticides. Although many of the most heavily used pesticides were included, most of the more than 400 registered active ingredients were not analyzed.

In addition to water analyses, 32 organochlorine pesticide compounds were analyzed in bed sediment and (or) fish tissue, including 19 pesticides and 13 degradates or manufacturing by-products. Most of the organochlorine pesticides are no longer used in the United States, but organochlorine compounds still persist in the environment.

Pesticide Occurrence

At least one pesticide was detected in water from all streams studied, and pesticide compounds were detected throughout most of the year in water from streams with agricultural (97 percent of samples), urban (97 percent), or mixed-land-use watersheds (94 percent). In addition, organochlorine pesticides (such as DDT) and their degradates and by-products were found in fish and bed-sediment samples from most streams in agricultural, urban, and mixed-land-use watersheds. Most of the organochlorine pesticides have not been used in the United States since before the NAWQA studies began, but their continued presence demonstrates their persistence in the environment.

Pesticides were less common in groundwater than in streams. They occurred most frequently in shallow groundwater beneath agricultural and urban areas, where more than 50 percent of wells contained one or more pesticide compounds. About one-third of the deeper wells sampled, which tap major aquifers used for water supply, contained one or more pesticides or degradates.

The findings show that streams are most vulnerable to pesticide contamination. However, because groundwater contamination is difficult to reverse once it occurs, groundwater is also a potential concern in agricultural and urban areas where ground water is used for drinking water.

Potential for Effects on Human Health

Assessment of potential effects on human health is based on comparing measured concentrations to water-quality benchmarks established by US Environmental Protection Agency and others. Benchmarks are estimates of the concentrations above which pesticides may have adverse effects on humans, aquatic life, or fish-eating wildlife.

Most detections of pesticides were at low levels compared to human-health benchmarks. No streams draining undeveloped watersheds and only one stream with a mixed-land-use watershed had concentrations greater than a human-health benchmark. Annual mean concentrations of one or more pesticides exceeded a human-health benchmark in 8 of 83 agricultural streams and in 2

ED_002432A_00000146-00002

of 30 urban streams. Agricultural streams located in the Corn Belt (Illinois, Indiana, Iowa, Nebraska, Ohio, and parts of adjoining States) and the Mississippi River Valley accounted for most concentrations that exceeded benchmarks—all by atrazine, cyanazine (no longer in use by the end of the study), or dieldrin (no longer in use when the study began). The two urban streams where benchmarks were exceeded are in Texas (diazinon) and Hawaii (dieldrin).

None of the stream sites sampled for the 2006 report were located at drinking-water intakes. For perspective, 1,679 of the Nation's public water-supply intakes on streams were evaluated in the context of NAWQA land-use classifications and pesticide findings. Eighty-seven percent of these water-supply intakes are on streams draining undeveloped and mixed-land-use watersheds and are therefore unlikely to withdraw water with concentrations that are greater than a human-health benchmark. The likelihood of pesticide concentrations exceeding a human-health benchmark is greatest for those streams draining agricultural or urban watersheds, which account for about 12 and 1 percent, respectively, of public water-supply intakes on streams.

As an example of extrapolating these findings, the USGS model for atrazine in streams can be used to predict the likelihood that the annual average concentration of atrazine in untreated stream water exceeds the USEPA drinking-water standard of 3 micrograms per liter in any stream in the Nation. Atrazine concentrations were predicted to be highest in the Corn Belt and parts of the southern Mississippi River Valley, where use is high and natural features favor the transport of pesticides by runoff to streams. About 7 percent of the Nation's stream miles are predicted to have a 5 percent or greater chance of exceeding the drinking-water standard. Some of these streams may not be suitable as sources of drinking water without the use of strategies to lower concentrations. These types of analyses can be used to identify locations that have the greatest likelihood of water-quality problems and that are the highest priority for additional monitoring.

Human-health benchmarks were seldom exceeded in groundwater. One or more pesticides exceeded a benchmark in about 1 percent of the 2,356 domestic and 364 public-supply wells that were sampled. The greatest proportion of wells with a pesticide concentration greater than a benchmark was for those tapping shallow groundwater beneath urban areas (4.8 percent). The urban wells with benchmark exceedances included 1 public-supply, 3 domestic, and 37 observation wells, and most concentrations greater than a benchmark were accounted for by dieldrin, which is no longer used.

Potential for Effects on Aquatic Life and Wildlife

Concentrations of pesticides were greater than water-quality benchmarks for aquatic life and (or) fish-eating wildlife in more than half of the streams with substantial agricultural and urban areas in their watersheds. Of the 178 streams sampled nationwide that have watersheds dominated by agricultural, urban, or mixed land uses, 56 percent had one or more pesticides in water samples that exceeded at least one aquatic-life benchmark. Urban streams had concentrations that

exceeded one or more benchmarks at 83 percent of sites—mostly by the insecticides diazinon, chlorpyrifos, and malathion—although frequencies of exceedance declined during the study period. Concentrations exceeded benchmarks in 95 percent of urban streams sampled during 1993–1997 and in 64 percent of streams during 1998–2000. Agricultural streams had concentrations that exceeded one or more benchmarks at 57 percent of sites—most frequently by chlorpyrifos, azinphos-methyl, atrazine, p,p'-DDE, and alachlor. As the use of alachlor declined through the study period, benchmark exceedances for this compound also declined, with no exceedances during the last 3 years of study.

Aquatic-life benchmarks for organochlorine pesticide compounds in bed sediment also were frequently exceeded in urban areas (70 percent of urban stream sites). Most compounds that exceeded aquatic-life benchmarks for sediment were derived from organochlorine pesticides that have not been used since before the study began, such as DDT, chlordane, aldrin, and dieldrin. In agricultural streams, aquatic-life benchmarks were exceeded at 31 percent of sites—most often by DDT compounds and dieldrin. Comparisons of concentrations of organochlorine compounds in whole fish with wildlife benchmarks indicate a wide range of potential for effects on fish-eating wildlife. Similar to bed sediment, benchmarks for fish were exceeded most often by compounds related to DDT, dieldrin, and chlordane in urban streams, and by DDT compounds, dieldrin, and toxaphene in agricultural streams in areas where historical use on crops was most intense.

Assessment and management of the potential effects of pesticides on aquatic life and wildlife are complicated by the combined presence in streams of (1) currently used pesticides and degradates, and (2) organochlorine pesticide compounds derived from pesticides that were largely banned prior to 1990. The widespread potential for adverse effects shown by the screening-level assessment—combined with the uncertainty due to the preliminary nature of the assessment and the complexity of pesticide exposure—indicate a continuing need to study the effects of pesticides on aquatic life and wildlife under the conditions of pesticide exposure that occur in the environment.

Frequently Detected Pesticides and Relations to Land Use and Pesticide Use

Pesticides detected most frequently in streams and groundwater are among those used most heavily during the study or in the past. Their occurrence follows patterns in land use and use intensity, with additional influence—especially for groundwater—by natural factors and management practices. The most frequently detected herbicides used mainly for agriculture during the assessment period—atrazine, metolachlor, cyanazine, alachlor, and acetochlor—generally were detected most often and at the highest concentrations in water samples from streams in agricultural areas with their greatest use, particularly in the Corn Belt. Five herbicides commonly used in urban areas—simazine, prometon, tebuthiuron, 2,4-D, and diuron—and three commonly used insecticides—diazinon, chlorpyrifos, and carbaryl—were most frequently detected in urban streams throughout the Nation, often at higher concentrations than in

ED_002432A_00000146-00004

agricultural streams. Total DDT was measured at some of the highest concentrations in bed sediment and fish in parts of the Southeast and in parts of California, Oregon, and Washington, where DDT was historically used on cotton, tobacco, orchards or other crops.

Land use and pesticide use are not the only factors influencing the occurrence of pesticides. Natural features and land-management practices also affect their distribution, particularly in groundwater. Groundwater is most vulnerable to contamination in areas with highly permeable soil and aquifer materials and where drainage practices do not divert recharge to streams and other surface water.

Pesticide concentrations in stream water also vary by season, with lengthy periods of low concentrations punctuated by seasonal pulses of much higher concentrations. For example, in streams that drain farmland throughout most of the Corn Belt, concentrations of herbicides were generally highest during spring runoff following pesticide applications. Similarly, concentrations of diazinon were highest during the winter in parts of the San Joaquin Valley, California, when applications to dormant almond orchards were followed by rainfall. Seasonal patterns in pesticide concentrations are important to consider, both in managing the quality of drinking water withdrawn from streams in agricultural and urban settings, and in evaluating the potential for adverse effects on aquatic life.

Mixtures and Degradates

Pesticides most commonly occur as mixtures of multiple compounds, rather than individually, including degradates resulting from the transformation of pesticides in the environment. Streams in agricultural and urban areas almost always contained complex mixtures of pesticides and degradates. More than 90 percent of the time, water samples from streams with agricultural, urban, or mixed-land-use watersheds contained 2 or more pesticides or degradates, and about 20 percent of the time they had 10 or more. Mixtures were less common in groundwater. Nevertheless, about half of the shallow wells in agricultural areas and about a third of shallow wells in urban areas contained 2 or more pesticides and degradates—less than 1 percent had 10 or more. The herbicides atrazine (and its degradate, deethylatrazine), simazine, metolachlor, and prometon were common in mixtures found in streams and groundwater in agricultural areas. The insecticides diazinon, chlorpyrifos, carbaryl, and malathion were common in mixtures found in urban streams.

Degradates are often as common in streams and groundwater as their parent pesticides. For example, atrazine, the most heavily used herbicide in the Nation during the study period, was found together with one of its several degradates, deethylatrazine, in about 75 percent of stream samples and about 40 percent of groundwater samples collected in agricultural areas across the Nation. Degradates are particularly important in groundwater, which moves relatively slowly through soils and aquifers, providing the extended time and conditions favorable for

ED_002432A_00000146-00005

transformation of pesticides. Most degradates are less toxic than their parent pesticide, but some have similar or greater toxicities.

The widespread and common occurrence of pesticide mixtures, particularly in streams, means that the total combined toxicity of pesticides in water and other media often may be greater than that of any single pesticide compound that is present. This adds uncertainty to conclusions about potential effects of pesticides based on individual benchmark comparisons, and continued research is needed by human-health specialists and toxicologists on the potential toxicity of pesticide mixtures, including degradates, to humans, aquatic life, and wildlife. USGS data on the occurrence and characteristics of mixtures and degradates is helping to target and prioritize toxicity assessments.

Trends in Pesticides

Following the national assessment findings discussed above, the USGS has been assessing whether pesticide levels in the Nation's streams and groundwater are increasing or decreasing over time. USGS trend analyses indicate that several major pesticides mostly declined or stayed the same in "Corn Belt" rivers and streams from 1996 to 2006. The declines in pesticide concentrations closely followed declines in their annual applications, indicating that reducing pesticide use is an effective and reliable strategy for reducing pesticide contamination in streams.

Declines in concentrations of the agricultural herbicides cyanazine, alachlor and metolachlor reflect USEPA regulatory actions as well as the influence of new pesticide products. In addition, declines from 2000 to 2006 in concentrations of the insecticide diazinon correspond to the USEPA's national phase-out of nonagricultural uses. Studies in progress on urban streams confirm that the decline in diazinon is a strong national pattern. These USGS findings on pesticide trends have been used by EPA to track the effectiveness of changes in pesticide regulations and use.

The USGS studied 11 herbicides and insecticides frequently detected in the Corn Belt region, which generally includes Illinois, Indiana, Iowa, Nebraska and Ohio, as well as parts of adjoining states. This area has among the highest pesticide use in the Nation- mostly herbicides used for weed control in corn and soybeans. As a result, these pesticides are widespread in the region's streams and rivers, largely resulting from runoff from cropland and urban areas. Elevated concentrations can affect aquatic organisms in streams as well as the quality of drinking water in some high-use areas where surface water is used for municipal supply. Four of the 11 pesticides evaluated for trends were among those most often found in previous USGS studies to occur at levels of potential concern for aquatic life. Atrazine, the most frequently detected, is also regulated in drinking water.

Pesticide use is constantly changing in response to such factors as regulations, market forces, and advances in science. For example, acetochlor was registered by the USEPA in 1994 with a goal of reducing use of alachlor and other major corn herbicides- acetochlor use rapidly increased to a

ED_002432A_00000146-00006

constant level by about 1996, and alachlor use declined. Cyanazine use also decreased rapidly from 1992 to 2000, as it was phased out because of environmental concerns. Metolachlor use did not markedly decrease until about 1998, when S-metolachlor, a more effective version that requires lower application rates, was introduced. Each of these declines in use was accompanied by similar declines in concentrations. Overall, use is the most dominant factor driving changes in concentrations.

Only one pesticide -simazine, which is used for both agricultural and urban weed control - increased from 1996 to 2006. Concentrations of simazine in some streams increased more sharply than its trend in agricultural use, suggesting that non-agricultural uses of this herbicide, such as for controlling weeds in residential areas and along roadsides, increased during the study period.

Glyphosate, an herbicide which has had rapidly increasing use on new genetically modified varieties of soybeans and corn, and which now is the most heavily used herbicide in the Nation, was not measured until late in the study and thus had insufficient data for analysis of trends. USGS studies from 2001 through 2006 to investigate and document the occurrence, fate, and transport of glyphosate and its degradation product, aminomethylphosphonic acid (AMPA), included analyses of 2,135 groundwater and surface-water samples, 14 rainfall samples, and 193 soil samples. Results from USGS studies for 608 surface water samples show that glyphosate was detected in 32 percent, compared to AMPA detected in 51 percent. Results for 485 groundwater samples showed much lower occurrence, with 6 percent and 10 percent, respectively for glyphosate and AMPA.

This statement provides a brief overview of USGS research on pesticides in streams and groundwater. We welcome the opportunity to provide any further information or assistance.

Sources

All material provided is from the following peer-reviewed scientific publications :

Gilliom and others, 2006, The Quality of Our Nation's Waters—Pesticides in the Nation's Streams and Ground Water, 1992–2001: U.S. Geological Survey Circular 1291,172 p.

Gilliom, R. J., and Hamilton, P. A., 2006, Pesticides in the nation's streams and ground water, 1992-2001 - a summary: U.S. Geological Survey Fact Sheet 2006-3028, Available Online.

Vecchia, A. V., R.J. Gilliom, D.J. Sullivan, D.L. Lorenz, and J.D. Martin, 2009, Trends in concentrations and use of agricultural herbicides for Corn Belt rivers, 1996-2006: Environmental Science and Technology v. 43, pp. 9096-9102 ,Available Online.

Belden, J.B., R.J. Gilliom, and M.J. Lydy, 2007, How well can we predict the toxicity of pesticide mixtures to aquatic life? Integrated Environmental Assessment and Management, v.3, no. 3 ., pp 364-372. Available Online.

Scribner, E.A., W.A. Battaglin, R.J. Gilliom, and M.T. Meyer, 2007, Concentrations of glyphosate, its degradation product, aminomethylphosphonicacid, and glufosinate in ground- and surface-water, rainfall, and soil samples collected in the United States, 2001-06: U.S. Geological Survey Scientific Investigations Report 2007-5122, 111 p.