Trends in Nutrients and Pesticides in the Nation's Rivers and Streams – *Lessons for understanding and managing water quality*

Our Nation's rivers and streams are a valuable resource, providing drinking water for a growing population, irrigation for crops, habitat for aquatic life, and many recreational opportunities. But, pollution from urban and agricultural areas continues to pose a threat to water quality. Since passage of the Clean Water Act in 1972, Federal, State, and local governments have invested billions of dollars to reduce pollution entering streams and rivers. Yet, recently, the Environmental Protection Agency reported that more than half of the Nation's stream miles have ecosystems in poor condition. In order to understand the return on our investments, and to more effectively manage and protect our water resources in the future, we need to know how and why water quality is changing over time. Long-term monitoring of nutrients and pesticides in the Nation's rivers and streams by the U.S. Geological Survey has revealed important lessons for understanding and managing water quality.

Trend analyses show that nitrate loading to the Gulf of Mexico from the Mississippi River increased during 1980 to 2010, despite major clean-up efforts. Simultaneous changes in multiple sources and slow ground-water movement to streams likely counteracted or delayed the effects of some management efforts. In contrast, widespread decreases in concentrations of some pesticides corresponded to decreases in use, while concentrations of some replacement pesticides increased with increases in use.

Nutrient Trends

- Nutrient concentrations are now much higher in many rivers and streams than they were a century ago. Since 1945, the population of the United States increased by nearly 150 million people, driving an increase in point-source wastewater inputs to the Nation's stream and rivers. During the same period, the use of commercial fertilizers – the largest source of nutrients nationally – increased by 10-fold.
- Despite investments in urban stormwater controls, enhanced wastewater treatment, and agricultural conservation practices, nitrate loading to the Gulf of Mexico from the Mississippi River Basin increased by 14% between 1980 and 2010. Nitrate from the Mississippi River is a primary cause of the large, oxygen-depleted dead zone that forms each year in the northern Gulf of Mexico and threatens ecological and fisheries resources.
- Our ability to determine which actions are causing upward or downward trends in nutrient concentrations in rivers and streams is limited by the lack of adequate data on how multiple nutrient sources, water-management practices like tile drainage, and nutrient management practices have changed over time. For instance, although nitrate loading from the Illinois River declined by 14 percent between 1980 and 2010, we cannot adequately explain the decline and, thus, cannot effectively apply the findings to improved management.
- A source that is often overlooked when evaluating the causes of nitrate trends is the transport of nitrogen to rivers through groundwater. Since the mid 1990's, nitrate concentrations have increased during low streamflows at the outlet of the Mississippi River. One of the possible causes is an increasing contribution of nitrate from groundwater. Because of the slow movement of nitrogen through groundwater, recent changes in stream quality may partly be a reflection of land management practices from many years ago. For the same reason, the full effect of today's management practices may not be measurable in these rivers until many years in the future.

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Pesticide Trends

- Unlike nutrients, pesticides typically only have one source – their application to control pests in agricultural, urban, and other land uses. As a result, attributing changes in pesticide concentrations to specific changes in their use is usually more clear-cut than with nutrients.

- Concentrations of several major pesticides, including metolachlor, alachlor, cyanazine, and atrazine, mostly declined or stayed the same from 1997 to 2008. The declines closely followed declines in their annual applications, indicating that reducing pesticide use is an effective and reliable strategy for reducing pesticide contamination in streams.

- While pesticide use in agricultural areas can be reasonably estimated, pesticide use in urban areas is more difficult to track. Instead, information on changes in regulation and the introduction or discontinuation of pesticides has been useful to help explain trends in water quality. For example, during 2003-2006, the outdoor use of the insecticide diazinon was phased out in urban areas. As a result, there were widespread declines in diazinon concentrations in US urban streams during 2000 to 2008. However, use of alternative insecticides, like fipronil, increased during the same period, resulting in increases in their concentrations.

- Regular monitoring of streams is required to determine if alternative pesticides are reaching streams in less toxic amounts. Pesticides targeted for monitoring also need to be re-evaluated regularly as use changes over time and new pesticides are introduced.

Lessons Learned for Managing Water Quality

Lessons learned about how and why nutrients and pesticides are changing over time can help us more effectively manage water quality in the future.

- The most common and predictable cause of trends in stream and river concentrations of a pesticide is a change in the amount applied. Reducing use in a watershed reduces concentrations.

- For nutrients, however, simultaneous changes in multiple sources and ground-water movement to streams can counteract or delay the effects of some management efforts.

- Despite extensive implementation of agricultural and urban management practices, widespread reductions in nutrient and pesticide concentrations directly attributable to these practices are not detectable. Management practices may have had a positive effect—some of the increases in concentration might have been larger without the practices in place—but the lack of widespread reductions suggests that the effects of management efforts are being delayed or offset by other changes, or that more will need to be done.

- Without improved data on where and when specific management practices and source changes are occurring, we cannot determine their effectiveness. To reliably determine the most efficient and cost-effective approaches to managing water quality in the future we need to improve the national tracking of all major sources, conservation practices, and other management practices, such as tile drainage, and combine it with continued and enhanced long-term monitoring of streams and rivers.

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