Agricultural Sector Faces Challenges in Reducing Stream Phosphorus Loads

The U.S. Environmental Protection Agency (USEPA) has identified agriculture as the major nonpoint source of phosphorus (P) to surface waters and the greatest impediment to achieving water quality goals stated in the Clean Water Act. Rivers and streams draining intensively farmed regions of the upper Midwest (such as east-central Illinois) transport large quantities of P, degrading local water quality as well as contributing to the load exported to the Gulf of Mexico. The USEPA has mandated the adoption of nutrient criteria into state water quality standards, and the Illinois EPA is currently developing stream nutrient criteria for total phosphorus (TP).

Scientists at the University of Illinois at Urbana-Champaign have monitored P concentrations and determined loads in three extensively drained agricultural watersheds during the past decade in studies funded in part by the Illinois Council for Food and Agricultural Research. Specifically, they measured dissolved reactive P (DRP) and TP in streams and tiles (perforated subterranean pipes called tiles) to identify the primary transport pathway of P from agricultural fields to streams. Results from the study were published in the March–April 2007 issue of the *Journal of Environmental Quality* and were also presented in Seattle, WA at the 2004 ASA–CSSA–SSSA Annual Meetings.

Annual flow-weighted mean concentrations of DRP and TP in streams were determined from weekly grab samples (or daily during major stream flow events) to provide data for 16 watershed by water year combinations (Embarras River sampled for seven years, Lake Fork of the Kaskaskia River for six years, and Big Ditch of the Sangamon River for three years). Four drainage tiles in the Embarras River watershed were monitored during the 1995–1996 water years, and three tiles in the Big Ditch watershed were monitored during the 2001–2003 water years. Due to the lack of animal production or significant wastewater discharges, these watersheds were well suited for investigating the transport of P from fields to streams in a dominantly corn and soybean, artificially drained landscape.

Tile water flowing into a drainage ditch in the Embarras River watershed after a heavy spring rain.

Overland runoff following a rain-on-snow event in the Big Ditch watershed.

The study revealed stream P loads were greatly increased by overland runoff and extreme discharge in some years; however, tile drainage was an important contributor of P every year. Although there were several years during the study with less-than-average precipitation and minimal overland runoff, flow-weighted mean concentrations of TP in streams of central Illinois exceeded 0.1 mg L^{-1} in all 16 watershed by water year combinations examined. In addition, following a rain-on-snow event in January of 2001, there was a substantial P load (80% in the form of DRP) exported from the three watersheds during a seven-day period, representing approximately 40% of the annual TP load for each stream. Both DRP and ammonium concentrations in streams were greater than at any other time during the study, suggesting that unincorporated di-ammonium phosphate fertilizer was transported directly into streams.

"Overall, these data add to our understanding of P transport from fields to streams and underscore the difficult challenges facing the agricultural sector in reducing nonpoint source pollution in extensively tile-drained watersheds," says Lowell Gentry, one of the researchers. "Also, we observed conditions that created a worse-case scenario for widespread transport of P fertilizer during a rain-on-snow event that suggests that P fertilizer should be incorporated after application."

The research team, under the direction of Dr. Mark David at the University of Illinois, continues to monitor these streams for nutrients, adding to its long-term data sets. Currently, David's team is focusing on the relationship among nutrients, chlorophyll-a, and dissolved oxygen in streams and rivers throughout the state to assist the Illinois EPA in establishing appropriate nutrient standards.

Gentry, L.E., M.B. David, T.V. Royer, C.A. Mitchell, and K.M. Starks. 2007. Phosphorus transport pathways to streams in tile-drained agricultural watersheds. J. Environ Qual. 36:408–415. View the full article online at http://jeq.scijournals.org/content/vol36/issue2/