NATIONAL CENTER FOR WATER QUALITY RESEARCH

Water Quality News and Notes

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Dissolved Phosphorus From Cropland Runoff: Why is it a Big Problem?

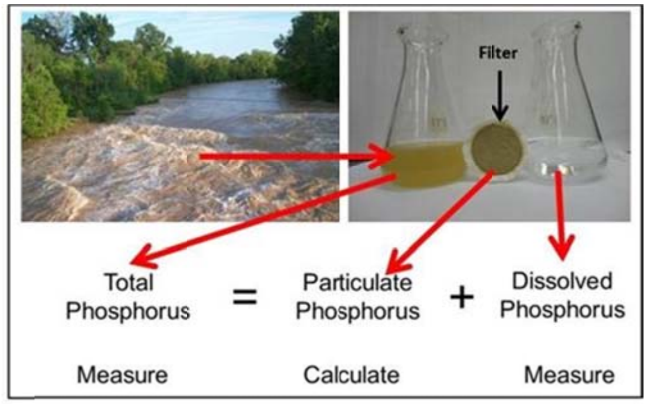

Figure 1. Illustration of the splitting of river samples into total, particulate and dissolved phosphorus.

What is dissolved phosphorus? Dissolved phosphorus is the phosphorus that remains in water after that water has been filtered to remove particulate matter (Figure 1). Phosphorus that remains on the filter with the particulate matter is called particulate phosphorus. Together these two forms of phosphorus make up the total phosphorus concentration in a water sample. In laboratories, water samples are typically analyzed for total phosphorus and dissolved phosphorus. Particulate phosphorus is calculated by subtracting dissolved phosphorus from total phosphorus, using the relationship shown in Figure 1.

Why is dissolved phosphorus a problem? Phosphorus, or P for short, is a common pollutant in surface waters because, when its concentrations are too high, it causes excessive growth of algae. Dissolved P is a special problem because (1) it is highly "bioavailable" to algae, i.e. it supports rapid algal growth and reproduction, (2) the amounts or loads of dissolved P entering Lake Erie have been increasing dramatically in recent years, and (3) dissolved P remains in the water while particulate P settles to stream and lake bottoms where it may no longer be available to algae.

Table 1. Annual average total and bioavailable phosphorus loads exported from the Maumee River at Waterville, 2006-2010.

Phosphorus Form	Total Phosphorus	Particulate Phosphorus	Dissolved Phosphorus
Total, metric tons	2,508	1,864	644
		74%	26%
Bioavailable, metric tons	1171	559	612
		48%	52%

About 95% of dissolved P is bioavailable to algae while only about 30% of the particulate P attached to eroded sediment is bioavailable. Even though particulate P dominates total P loading to Lake Erie from the Maumee and other Northwest Ohio rivers, dissolved P contributes more bioavailable P (See Table 1). Over the past 5 years, dissolved P represented 26% of the total P and 52% of the bioavailable P entering Lake Erie from the Maumee River.

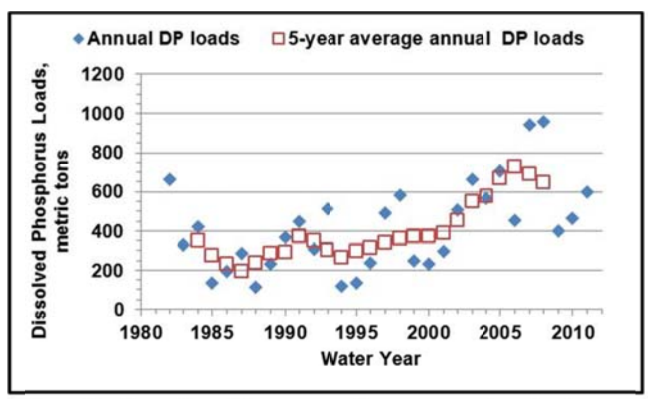

Figure 2. Annual and 5–year running average dissolved phosphorus (DP) export from the Maumee River at Waterville.

Trends in dissolved P loads from the Maumee River are shown in Figure 2. Annual loads are highly variable from year to year, due to annual differences in weather conditions and river discharge. Figure 2 shows 5-year running average annual loads of dissolved P. The increasing dissolved P loads are very evident from the 5-year running averages. Low points in 5-year averages occurred in 1987 (192 metric tons) and 1994 (263 metric tons), while the high 5-year average was in 2006 (726 metric tons). Over this same time interval, the overall trend in particulate P and suspended solids loading has been downward, thanks to efforts by farmers to reduce erosion.

The upward trends in dissolved P have been linked to the return of serious algal "blooms" or rapid increases in algal populations, in Lake Erie. These blooms cloud the water and reduce oxygen levels, threatening fish and other aquatic life. Some types of algae can produce toxins that can cause illness

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and death in animals and occasionally in humans. Beaches are often closed due to severe algal blooms. Algal blooms threaten income from tourism, which is very important to the economies of many cities and towns in Northern Ohio.

During storm runoff events from the Maumee River, large volumes of river water move into the western basin of Lake Erie in a short amount of time, carrying eroded soil and nutrients with it. Sediment and particulate P settle to the bottom rather quickly as runoff waters enter the lower river and Maumee Bay. Dissolved P remains in the water column and supports the development of algal blooms such as that shown in Figure 3.

Figure 3. This satellite image of the western basin shows algal blooms forming in storm water runoff from the Maumee River. (August 19, 2003)

What has caused the increasing dissolved P problem?
Only about 7% of the total P "exported" from the Maumee River to Lake Erie can be accounted for by municipal and industrial "point sources", or pipe outlets, entering the river upstream from the sampling station. Thus the increases in dissolved P loading have to be coming from "nonpoint" sources, including farm fields. Since cropland is the dominant source of nonpoint pollution in the watershed, cropland is now recognized as the source of the increases. The following changes in agriculture (and weather) have been identified as contributing to the upward trends in dissolved P export:

- Increased broadcasting of fertilizer onto the soil surface especially in the fall and winter, without incorporation;
- Build-up of P concentrations at the soil surface due to (1) broadcast fertilizer applications, (2) crop residue breakdown on the soil surface, and (3) the decline of mold board plowing that inverts the soil. (Moldboard plowing has largely been replaced with no-till and minimum-till to reduce erosion and particulate P movement from fields to streams.)
- Fertilizer applications even when excessive P is already available in the soil;
- Soil "compaction", or packing, caused by equipment traffic and other factors, that increases surface runoff;
- Excessive P concentrations, as measured by soil tests, on some fields receiving animal manures;
- Increased tile drainage intensity coupled with the development of channels through the soil (macropores) that convey surface water directly to drainage tile, which empty into streams thereby bypassing stream-side filter strips.
- More frequent storm events with large amounts of rain over a short time period, giving rise to more surface runoff.

What can farmers do to reduce dissolved phosphorus loss from cropland? This question is currently at the forefront of many discussions involving groups such as: farmers; extension agents; fertilizer dealers and producers; local, state and federal agricultural and environmental agencies; implement manufacturers; nonprofit organizations; and university researchers. A partial list of the general categories of BMPs under discussion is shown below:

- Nutrient management (right amounts, timing, application methods, and forms);
- Tillage management aimed at reducing erosion, increasing water infiltration and improving soil tilth;
- Water management to allow timely field operations while maintaining appropriate soil moisture and minimizing nutrient loss. (Examples are controlled drainage and sub-irrigation.)
- Conservation crop rotations and winter cover to reduce erosion and improve soil structure;
- Edge-of-field buffers and/or end-of-tile treatment systems to remove nutrients.

As part of a grant from the Great Lakes Protection Fund, our laboratory has assembled a "Toolbox" of BMPs for reducing dissolved phosphorus export from cropland. The toolbox is now available for use by the various groups who are addressing the dissolved phosphorus problem. Copies of the "Toolbox," which was compiled by Mr. John Crumrine, a retired NRCS District Conservationist, are available from David Baker (dbaker@heidelberg.edu).

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