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Phosphorus losses to surface water

Jame Baker
Iowa State University

Michael J. Tidman
Iowa State University

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Abstract
Increased concentration of livestock and concerns for manure and fertilizer phosphorus (P) management present producers with the challenge of understanding P losses to surface waters. This article continues a series that aids producers with improving land and P management to reduce environmental concerns related to P transport and losses to surface waters. Phosphorus is a major nutrient for aquatic plant growth and is often a limiting nutrient in freshwater systems. P abundance in Iowa's surface waters produces aquatic plant overgrowth, primarily of algae. Plants and algae use much of the oxygen in water as they die and decompose, resulting in oxygen shortages that are detrimental to many aquatic organisms.

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Phosphorus is a major nutrient for aquatic plant growth and is often a limiting nutrient in freshwater systems. P abundance in Iowa's surface waters produces aquatic plant overgrowth, primarily of algae. Plants and algae use much of the oxygen in water as they die and decompose, resulting in oxygen shortages that are detrimental to many aquatic organisms.

Nutrient criteria for both P and nitrogen (N) are being developed. Because P is more of a problem for standing surface water, the Environmental Protection Agency is drafting separate standards for flowing (rivers) and standing waters (lakes). However, setting standards that protect receiving waters downstream is alsoa consideration.

Transport of P

There are three ways P moves off the landscape into surface waters: 1) dissolved in surface runoff, 2) attached to sediment in surface runoff, and 3) dissolved in leaching water (that returns to surface through base flow or tile drainage; see figure).

Each transport mechanism is affected by rainfall and each is difficult to manage consistently. P movement is also heavily influenced by soil properties and land management practices such as cropping and tillage.

Surface runoff carries dissolved P (DP) in organic and inorganic P forms. Particulate P (PP) is carried in sediment. Soil erosion is selective, with finer and less dense particles preferentially moved. P concentrations in sediment are higher than those found just below the soil surface because fine particles have more surface area per unit of mass, and particles with higher organic matter have a lower density.

Subsurface flow (tile and base flow) usually does not carry much sediment and therefore has lower PP levels (with the exception of tile systems fed by surface intakes). Also, if subsoils are low in P, water moving through them adsorbs DP, resulting in low levels of DP relative to surface runoff water. However, if subsoils are high in P or become saturated with P, levels of DP in subsurface drainage are greater than normal.

The thin layer of soil at the surface, called the **mixing zone**, interacts with rainfall and runoff and is the layer from which DP is extracted and PP is eroded. The concentrations of DP in water and PP in sediment are directly related to the levels of P present in the mixing zone.

After applications of P (manure or fertilizer), the amount lost as DP in surface runoff initially peaks but decreases over time as the amount and degree of interaction (of added P) with the soil increases.

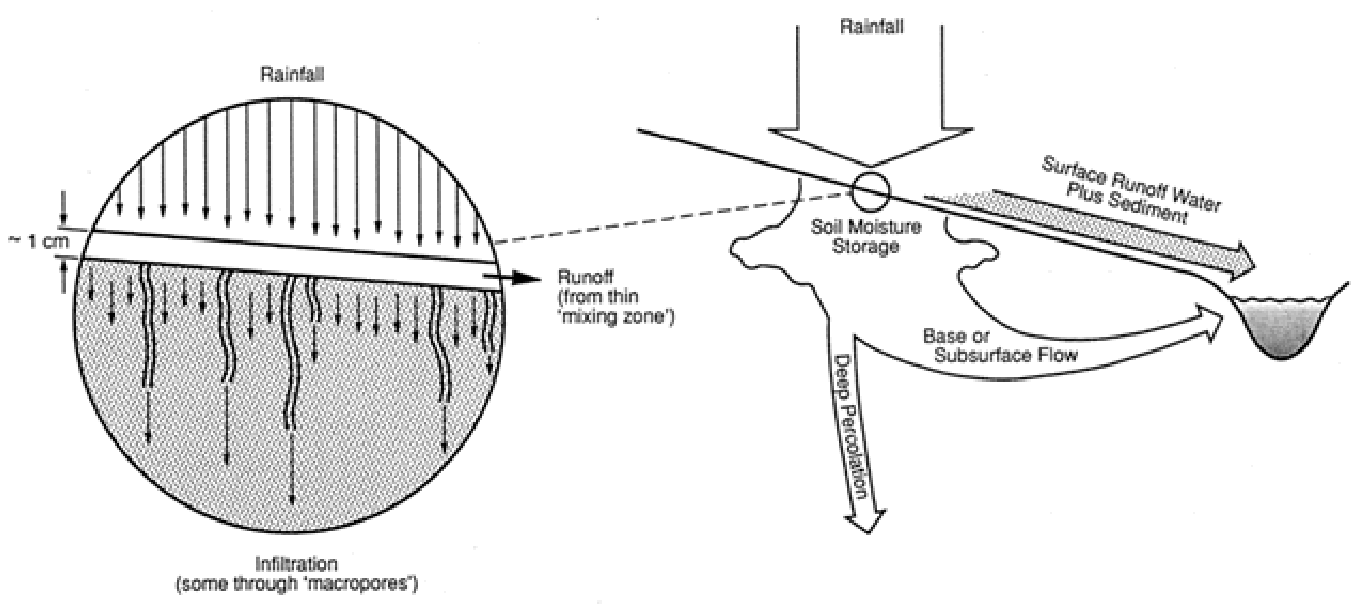
DP leaves the mixing zone as water moves over the surface and downward into the soil. Thus, the amount of DP in the mixing zone and concentration of DP in subsequent rainfalls decreases. In Iowa soils, there is considerable capacity to adsorb or fix P where excessive P rates have not been applied and subsoils are low in P.

Management

Incorporation limits P concentrations in the mixing zone and losses in surface runoff. One study of incorporated P demonstrated that soluble P concentrations in runoff were one-seventh of surface-applied P, and equal to where P was not applied. The more time between P application and runoff, the lower the P concentrations become (particularly soluble P). Given time, P diffuses in soil and becomes fixed. Also, small rainstorms without runoff can move P from the surface into the soil where it's less vulnerable to runoff loss.

Conservation tillage and no-till reduce P losses by limiting erosion and the mass of the sediment carrier. However, soluble P losses are generally not reduced because P is not incorporated--concentrations usually increase as much or more than runoff volume is reduced.

Vegetated filter strips (VFS) trap sediment, significantly reducing transported P. However, unless the VFS also decreases the volume of runoff water, it cannot decrease soluble P loss. Thus, soluble P concentrations are often greater after runoff passes through a VFS because of dissolved P from plant residues. Wetlands can trap P, although the amount (from bottom sediment and plant residue) released over time can equal that deposited or taken up by plants, resulting in no net removal of P.



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