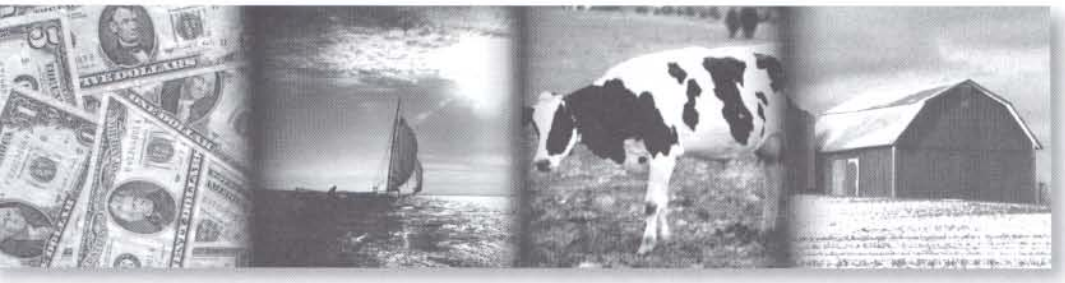

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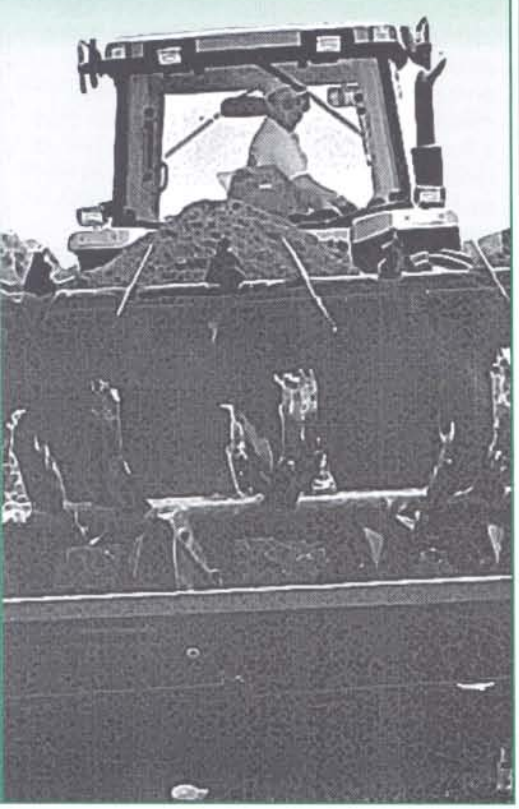
NUTRIENT MANAGER

Newsletter of the Maryland Cooperative Extension Agricultural Nutrient Management Program

FOCUS ON PHOSPHORUS



Phosphorus is essential for plant growth. With nitrogen and potassium, phosphorus is one of the three plant nutrients most commonly added to soils. Lack of adequate plant-available phosphorus in soils can limit crop production. Phosphorus from soils can get into surface and ground water. Too much phosphorus in streams, rivers, lakes, and the Chesapeake Bay can alter these habitats because aquatic plants become overfertilized.

PHOSPHORUS: A CHANGING STORY

A browse through agricultural journals and magazines from the 1950s through the 1970s reveals numerous articles about how to use phosphorus to optimize production. Many of these articles would suggest increasing phosphorus fertilization rates and provide advice on fertilizer placement and timing. At the time these articles were written many phosphorus soil test levels in most farming regions were less than adequate and phosphorus was limiting crop production. Inadequate levels of plant-available phosphorus are encountered less frequently today because producers heeded this advice. For example, soil analyses conducted by the University of Maryland Soil Testing Laboratory during 1996 showed that only 31 percent of the samples contained phosphorus levels low enough to potentially limit crop productivity. A closer look at these test results (Figure 1) reveals an increase in the percentage of samples that contain optimum and excessive levels of phosphorus since 1958.

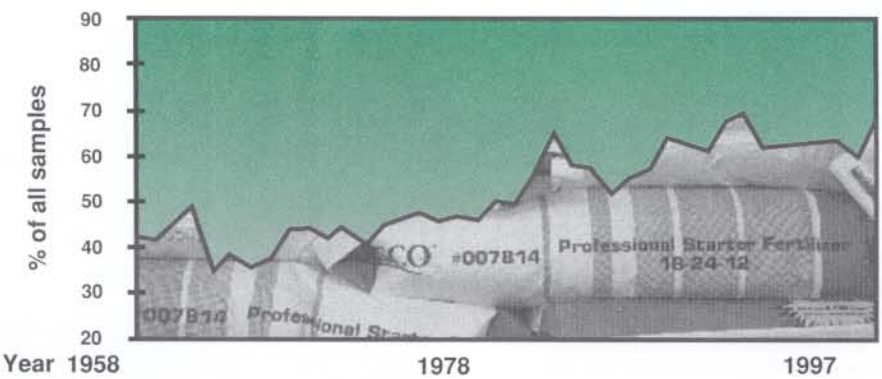


Figure 1. Percentage of Maryland soil samples testing optimum and excessive for phosphorus, 1958-1997.

(Data obtained from the University of Maryland Soil Testing Laboratory.)

WHAT HAPPENS TO PHOSPHORUS IN THE SOIL?

Figure 2 illustrates what happens to phosphorus in the soil.

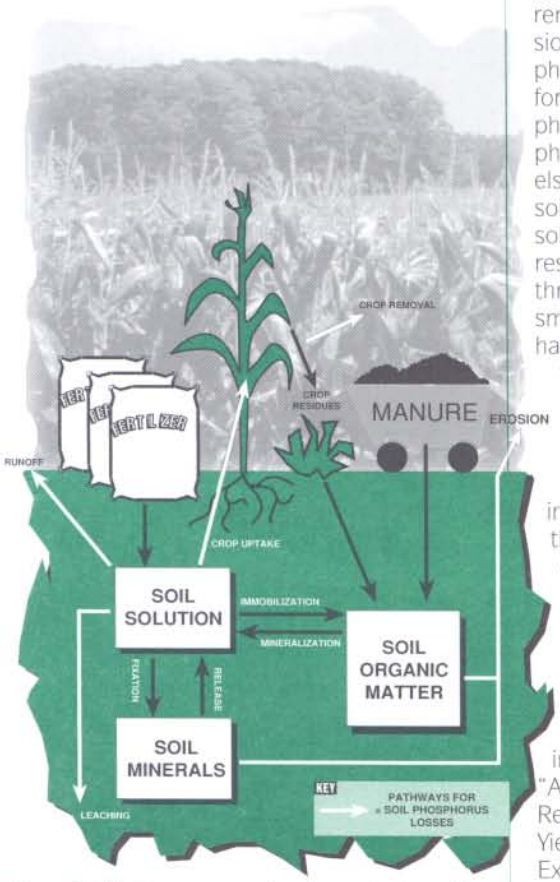


Figure 2. What happens to phosphorus in the soil?

Crops take up phosphorus in a soluble form. However, soluble phosphorus reacts quickly with the soil and most soil phosphorus is "fixed" or bound tightly to some soil minerals. Typically, it is the very small clay-size particles that "fix" phosphorus. Soils with a high proportion of clay-size particles (like silt loams and clay loams) therefore fix more phosphorus than soils with lower clay content (sandy loams and loamy sands). These clay particles release phosphorus very slowly. This capacity of soils to fix phosphorus is one reason why levels of phosphorus in soil solution are usually low.

Some phosphorus is held in soil organic matter. This becomes available during decomposition when organic matter is broken down by soil microbes. In agricultural soils this process is accelerated if the soil is disturbed during cultivation. Cultivation also increases the likelihood of phosphorus losses through soil erosion. Studies conducted by scientists from the Smithsonian Environmental Research Center on soils near Annapolis, Maryland, found that losses from corn fields were approximately seven times that of less disturbed forested areas on a per unit area basis.

Regardless of the form in which it is added, phosphorus levels may build up in soils when applied in quantities that exceed removal by crop uptake and losses via erosion and runoff. Eventually the level of phosphorus in the soil will become sufficient for crop needs. Addition of further phosphorus at this point increases the chance of phosphorus loss. When soil phosphorus levels become excessive the capacity of the soil to fix it may be exceeded and levels of soluble phosphorus in the soil may rise and result in increased phosphorus losses through surface runoff and, to a much smaller degree, leaching. This commonly happens when animal production is concentrated and the manure that is generated is repeatedly applied to the same area. Table 1 summarizes some common misconceptions about phosphorus.

Soil tests can provide producers with information on levels of phosphorus in their soils. Results obtained should be compared with the soil test categories used by the University of Maryland (see Table 2). Soils with phosphorus levels in the "Excessive" category do not require the addition of phosphorus. More information on these categories and plant nutrient recommendations are provided in Soil Fertility Management, SFM-1, "Agronomic Crop Nutrient Recommendations Based on Soil Tests and Yield Goals," available from your county Extension office.

HOW IS PHOSPHORUS LOST FROM THE SOIL?

Most of the phosphorus that is lost from soils is lost through either erosion or runoff. Erosion carries soil particles enriched with fixed phosphorus into lakes and rivers. As water flows over the soil surface it can dissolve phosphorus in a very thin layer at the soil surface and run off into surface waters where the phosphorus can cause eutrophication (see Figure 3). Some soluble phosphorus may be leached out of the surface layers of the soil. Although most of this phosphorus becomes fixed to soil particles, some may be transported below the root zone where it is no longer available to plants. This is a particular concern with coarse-textured soils, which have a low clay content and therefore saturate with phosphorus more quickly than finer-textured soils. Research in Delaware's Inland Bays area, in fields where chicken litter has been repeatedly applied, has demonstrated greater downward movement of phosphorus than in comparable, uncultivated soils on the field borders.

Table 2. University of Maryland's soil test categories fo lbs/acre and the fertility index values.

	LOW	MEDIU
lbs/A P_2O_5	0-61	62-10
Index value	0-25	26-50

PHOSPHORUS IN MANURE

One reason why phosphorus builds up in soils receiving manure is that there is an imbalance between manure nutrient composition and plant nutrient requirements. If, for example, Maryland nutrient recommendations are followed for the production of 150 bushels of corn per acre on soil with a medium phosphorus soil test, then 150 pounds of plant-available nitrogen (PAN) and 38 pounds of phosphate are required. Using average manure composition, Figure 4 shows that a farmer would have to apply 4.4 tons of broiler manure providing 253 pounds of total nitrogen per acre to meet the 150 pounds nitrogen recommendation.

However, this would result in an over-application of phosphate, 166 pounds per

Table 1. Myths about phosphorus.

MYTH	REALITY
Soils have an unlimited capacity to tie up phosphorus.	Soils can become "saturated" with phosphorus.
Phosphorus doesn't leach, it stays where it is applied.	Once a soil is "saturated" additional phosphorus is more readily soluble and may leach down the soil profile. Soluble phosphorus may reach the water table.
Phosphorus losses from runoff can be eliminated if erosion is controlled.	Although erosion control will limit most phosphorus loss, soluble phosphorus may be carried in runoff. If residues, fertilizers and manures are unincorporated, loss of soluble phosphorus in runoff is more likely.

phosphorus expressed as phosphate (P_2O_5) in

M	OPTIMUM	EXCESSIVE
	103-205	>205
	51-100	>100

acre as opposed to the 38 pounds, approximately 4 times more than required. This overapplication of phosphorus takes place, usually to a lesser extent, with other manure sources. If dairy manure is used to replace broiler manure in the same scenario, phosphorus application is applied at approximately 2.5 times the recommended rate (see Figure 4). Basing manure application rates on the phosphorus recommendation (as in phosphorus-based nutrient management plans) can eliminate this problem. In many cases, however, nitrogen supplementation with commercial fertilizer will be required.

Reducing Soil Phosphorus Levels

If phosphorus soil test levels are in the "Excessive" range, how long will it take for the levels to be reduced? Soil scientists in North Carolina investigated the Portsmouth soil in the Coastal Plain region of the state in which soil test phosphorus levels had been raised to an excessive level (400 pounds/acre) by high rates of commercial phosphorus fertilizer. Even with annual crop harvest, 14 years elapsed before soil test levels dropped to the point where phosphorus application would again be recommended.

Do some crops remove more phosphorus from soils than others? If so, can these crops be used as means of reducing soil phosphorus test levels? The concentration of phosphorus in adequately nourished plants is similar across species. Crops that produce more plant material (biomass) per acre will therefore remove more phosphorus from a soil. However, the amount actually removed from the field will depend upon how much of this biomass is harvested. For example, alfalfa removes more phosphorus per acre than corn and corn removes more than soybeans, primarily because of the amount of harvested crop removed from the field.

The Impact of Phosphorus on Aquatic Life: Eutrophication

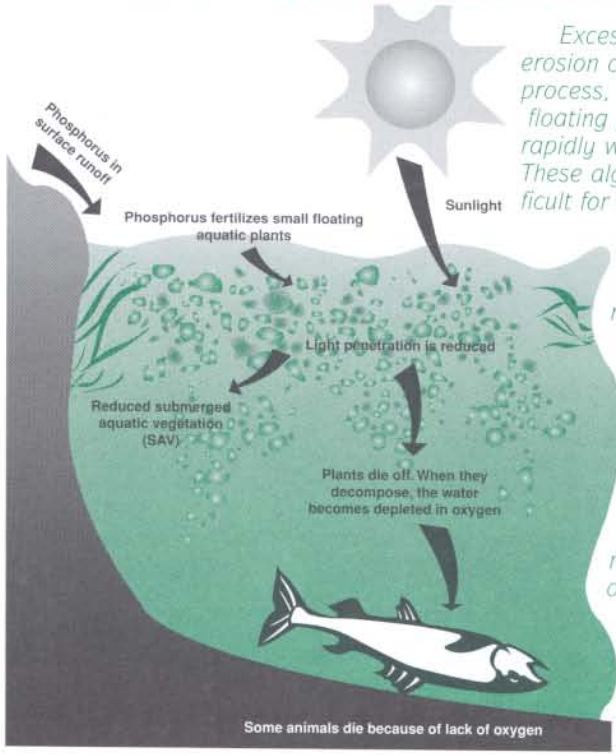


Figure 3. What happens when phosphorus gets into surface waters?

Excessive phosphorus from runoff and erosion can fertilize surface waters. In this process, called eutrophication, microscopic floating plants, known as algae, multiply rapidly when fertilized by phosphorus. These algae cloud the water making it difficult for larger submerged aquatic vegetation (SAV) to get enough light. The SAV may dieback, reducing available habitat of aquatic animals. When the algae themselves eventually die they decompose. During decomposition dissolved oxygen is removed from the water. Lowered oxygen levels make it difficult for other aquatic organisms to survive.

Phosphorus, attached to sediments derived from soil erosion, may accumulate in the sediments of lakes and streams. This phosphorus may be recycled slowly or released more rapidly when these sediments are disturbed, for example during a storm or flood. Pollution from phosphorus is therefore a long-term problem.

Phosphorus Placement

If phosphorus is not incorporated into the soil it is more likely to be lost to surface water through runoff and erosion. Where possible, broadcast application of phosphorus should be avoided or followed by rapid incorporation. Injection or rapid incorporation of manure will likewise reduce phosphorus loss in runoff. If required, fertilizer application for row crops should be banded as starter fertilizer at planting.

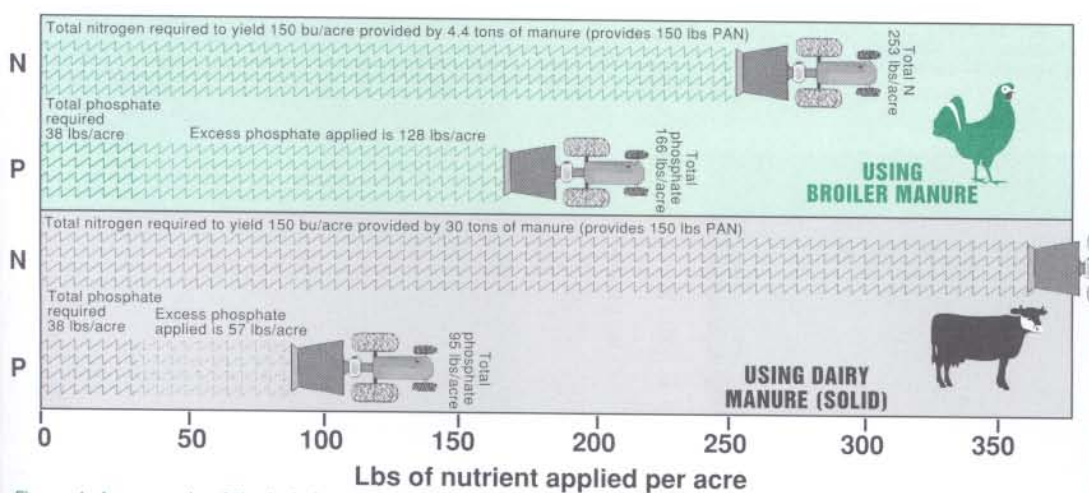


Figure 4. An example of the imbalance between recommended and actual application rates for phosphate when broiler or dairy manure is applied to supply the entire N recommendation.

(Figures are based on a corn yielding 150 bushels per acre grown on a soil with a "Medium" phosphorus soil test.)

Corn, grown on a soil with a medium phosphorus soil test, yielding 150 bushels per acre, requires approximately 150 lbs/acre of plant-available N and 38 lbs/acre of phosphate to meet its growth requirements. The application of 4.4 tons/acre of poultry manure or 30 tons/acre of dairy manure will, assuming same-day incorporation, meet these N recommendations, but will result in an overapplication of P. Broiler manure contains nearly four times the amount of phosphorus recommended when applied at rates that satisfy the N recommendations, dairy manure is 2.5 times.

BMPs TO REDUCE PHOSPHORUS LOSSES

- Use soil erosion control practices.
- Test soils regularly and avoid applications of fertilizers or manure that will raise levels above the "Optimum" soil test category.
- Avoid spreading manure on frozen ground.
- Obtain nutrient analyses of each manure source and apply manure in accordance with soil test recommendations and yield goals.
- Adopt phosphorus-based nutrient management plans for areas and soils that are particularly vulnerable to phosphorus runoff or leaching.
- Whenever possible inject or incorporate fertilizer and manures.

For nutrient management planning services, call your Cooperative Extension educator at the county Extension office.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, University of Maryland, College Park, and local governments. Thomas A. Fretz, Director of Maryland Cooperative Extension, University of Maryland.

ALLEGANY COUNTY
112 Baltimore Street
Suite 204
Cumberland, MD 21502
(301) 724-3320

ANNE ARUNDEL COUNTY
Anne Arundel County Government
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metro (301) 970-8250 x675

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HOME AND GARDEN INFORMATION CENTER
12005 Homewood Road
Ellicott City, MD 21042
1-800-342-2507

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Patricia Steinhilber
Program Coordinator

Jean Leslie
Communications Coordinator

Address comments about this newsletter to
Nutrient Manager, ANMP
NRSL, Plant Sciences Building
College Park, MD 20742-4452

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