

Best Management Practices for Phosphorus in the Environment

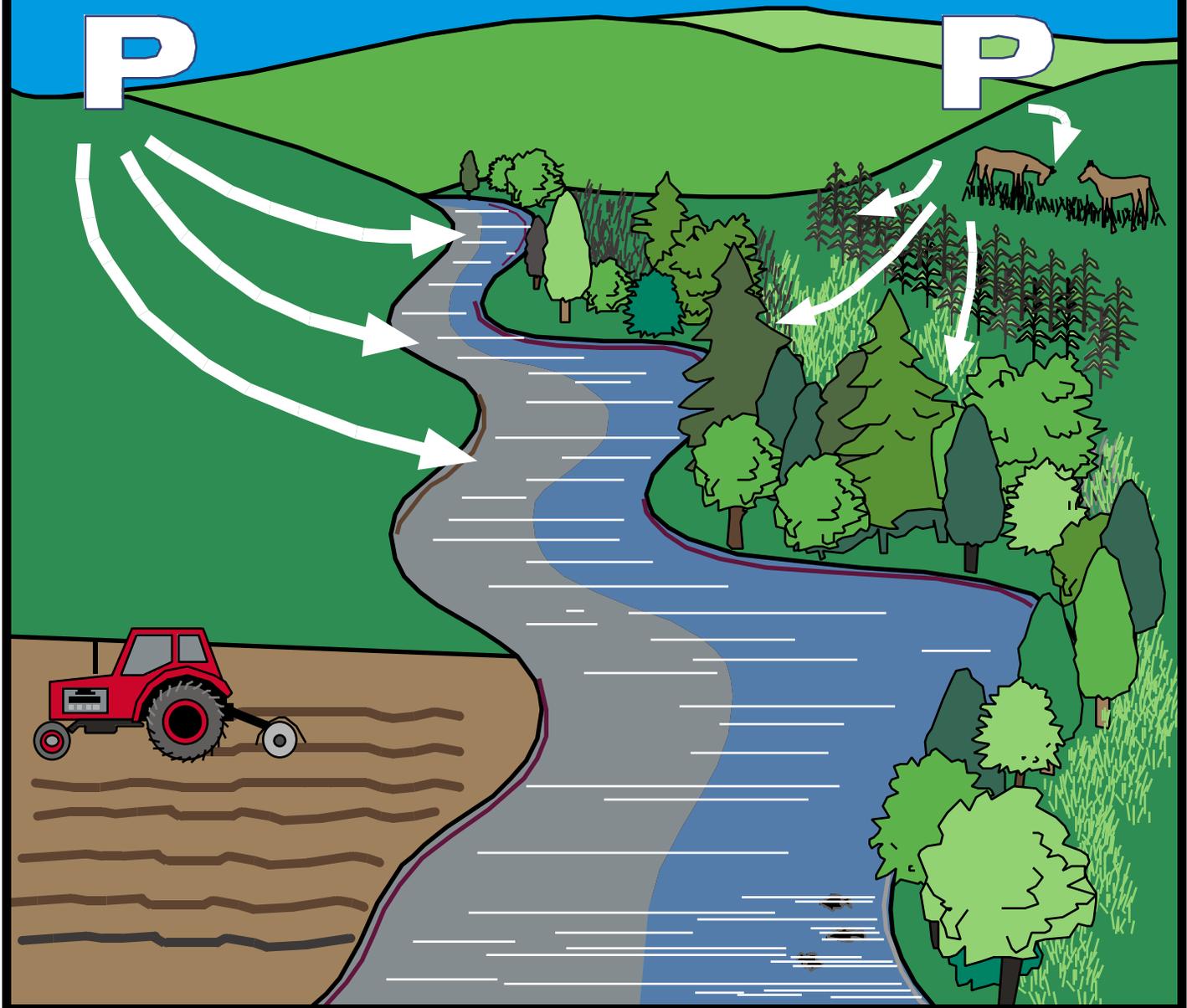


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Best Management Practices for Phosphorus in the Environment

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Phosphorus is a naturally occurring element, essential to life. It is a vital component of the genetic material found in all cells and is involved in energy transfer reactions. In many soils and aquatic systems, phosphorus is the element that limits growth. When phosphorus is supplied, plant growth is stimulated. In most agricultural situations, additional phosphorus will improve productivity. But in rivers, streams and lakes, phosphorus can cause problems by stimulating excess plant growth and reducing the quality of the water. Like many other things, too much of a good thing can be bad.

Since the Clean Water Act of 1972, the government has had the power to regulate the quantity of potential pollutants released from point-sources in our waters. In 1998, the United States Environmental Protection Agency (USEPA) and the United States Department of Agriculture (USDA) jointly released the Clean Water Action Plan. The Clean Water Action Plan recognized that there had been significant progress since the Clean Water Act, with significant reductions in pollution from point sources. However, today *“by far, the predominant source of remaining water pollution is runoff from urban and agricultural lands and facilities such as animal feeding operations and mines.”*

The report goes on to state that *“over-enrichment of waters by nutrients (**nitrogen** and **phosphorus**) is the biggest overall source of impairment of the nation’s rivers and streams, lakes and reservoirs and estuaries.”*

Phosphorus from agricultural sources is considered to be an important threat to water quality.

Before we can take steps to reduce the amount of phosphorus getting into the rivers and streams of Tennessee, we need to understand how it gets there. If we understand where and how phosphorus is getting into our waters, we can implement best management

practices (BMPs) to reduce and even eliminate phosphorus as a potential pollutant from our water supply.

Phosphorus in the Soil

The ultimate sources of phosphorus in the environment are primary minerals, such as apatite (calcium phosphate). Phosphate-bearing minerals are found in many different rocks and soils. Over time as these minerals weather, phosphorus is released into the soil. Phosphorus is very reactive in the environment. In solution it is found as one of several orthophosphate forms (PO_4^{3-} , HPO_4^{2-} or H_2PO_4^-) depending on the acidity of the solution. If orthophosphate is not quickly taken up by plants or soil micro-organisms, it will react with other compounds (such as calcium, iron, aluminum and manganese) associated with the soil, making it unavailable to many plants. For this reason, phosphorus has traditionally been considered the limiting nutrient in many agricultural soils.

Phosphorus in Agriculture

During the past 50 years, the limited availability of phosphorus in soils has been corrected through the use of commercial, inorganic, phosphate fertilizers. Phosphate fertilizers are produced by extracting phosphorus from rocks rich in phosphate minerals, converting it into more soluble chemical forms and making it more available to plants. The addition of relatively large quantities of these fertilizers on agricultural soils over many decades has resulted in a build-up of phosphorus in many soils. In those soils, crops no longer respond to additional phosphate fertilizer. This is now the case in at least half of the agricultural soils in Tennessee. Soils with high phosphorus reserves generally do not negatively affect crop yields, except to affect the availability of some micro-nutrients such as zinc.

The practice of applying phosphate fertilizers to build up the soil phosphorus reserves was encouraged

in the past, and was compared to “putting money in the bank.” The wisdom of the time was that, like having lots of money in the bank, high soil phosphorus levels could only be beneficial. In recent years this concept has been questioned, due to concerns about the relationship between high soil phosphorus levels and the threat to water quality from phosphorus-rich soil particles getting into water from runoff.

Phosphorus in Water

As with unfertilized soils, phosphorus is often the limiting nutrient in aquatic systems. Unlike soils, aquatic systems have a low buffering capacity or ability to store phosphorus when it increases above natural background levels. If phosphorus is applied to a source of water where it is limiting, the growth of algae and other aquatic micro-organisms will be

quickly stimulated. Increased growth requires more oxygen. Growth will continue until either the oxygen or phosphorus becomes limited. If oxygen becomes depleted, all the oxygen-requiring or aerobic organisms in the ecosystem will be affected. If the rate of death of these organisms increases, the oxygen demand in the system will increase even more. Increased rates of death will result in increased demand for oxygen needed for decomposition, until it eventually becomes limiting. When this happens, the system changes from being an oxygen-based to a non-oxygen-based or anaerobic system. Under anaerobic conditions, even more changes occur and unpleasant odors are produced. This whole process is known as eutrophication (Figure 1).

One of the early visual signs of eutrophication is the color of the water. The stimulation of algal

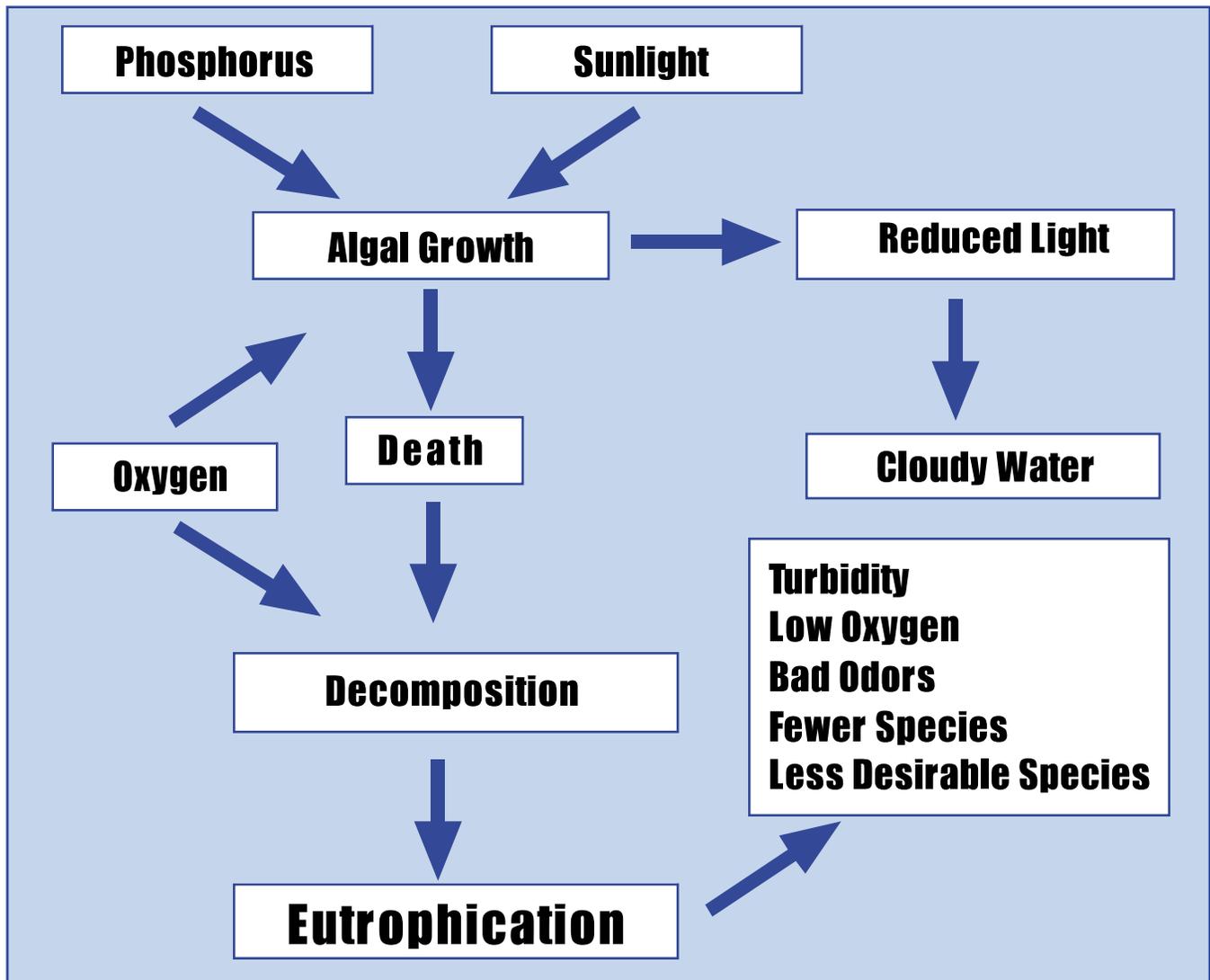


Figure 1. Effect of Phosphorus on Eutrophication

growth will give the water a greenish color and will restrict light penetration below the water surface. With time, oxygen levels will become too low and some fish species and other aquatic organisms will begin to die. Eventually, many of these organisms will be replaced with less desirable species. Depletion of dissolved oxygen in eutrophic waters causes many dissolved constituents to be in forms (e.g. ammonia, hydrogen sulfide, methane) that are potentially toxic to wildlife and livestock. Increased sedimentation with eutrophication impairs navigational and recreational use. Lake depths are reduced and enhanced vegetative growth blocks navigable waterways. Decaying algal biomass produces surface scum, undesirable odors occur and, with fewer fish populations, insect pests such as mosquitoes can increase.

Clearly, enrichment of surface waters with phosphorus is undesirable. Not only does it negatively impact the environment, it can increase the costs of water purification to remove odor, turbidity and color. To protect, preserve or even improve the quality of our waters it is important that we limit the amount of nutrients such as phosphorus entering the water.

Phosphorus in Surface Waters

Under natural conditions, the phosphorus content of surface waters is the result of a combination of factors. Phosphorus in water can come from three major sources:

1. Mineral phosphorus released from the weathering of phosphate minerals in river beds.
2. Organic and inorganic phosphorus in the runoff from lands adjacent to the surface waters.
3. Organic phosphorus from the direct deposition of animal feces and urine, or release from wastewater treatment plants.

Phosphorus reaching surface waters from runoff can be in a variety of organic and inorganic forms, depending on the soil surface and how much particulate matter is contained in the runoff. Water-dissolved orthophosphate and some small organic molecules will be almost immediately available to aquatic micro-organisms. These forms will quickly stimulate growth of aquatic micro-organisms. How much growth is stimulated will depend on the diluting effect of any stream or river flow, and the

supply of phosphorus from runoff over time. Phosphorus adsorbed onto the surface of soil clay and silt particles or associated with any soil organic matter will act as reserves of phosphorus and will become available over time. In slow-moving or static waters, these particles will maintain relatively high phosphorus levels in the water. In faster-moving rivers and streams, these particles will be carried downstream, slowly releasing phosphorus until they eventually settle.

In some areas other minor sources can be important. Leaching and atmospheric deposition can both contribute phosphorus to surface waters. In most areas, ground water concentrations of phosphorus are very low (less than 0.02 mg / L or 0.02 parts per million) and unlikely to impact the surface waters. Leaching of phosphorus from soils to ground water is very unusual, except from sandy soils after many years of heavy manure application. A much greater threat to ground water quality in Tennessee is the application of manures close to open sink holes. Sinkholes are common across much of Middle and East Tennessee. They are formed when the underlying limestone bedrock is dissolved to form direct channels to the ground water, creating a direct route for phosphorus.

Phosphorus concentrations in precipitation are generally low (less than 0.03mg / L) and result from dust being deposited with the rainfall. Relatively small concentrations in rainfall can result in a substantial load. For example, in one river basin in North Carolina, deposition of about half a pound of phosphorus per acre was estimated, and accounted for 22 percent of loading in the river.

The level at which phosphorus becomes important to water quality depends on the natural background level found in the water. In general, lakes are more sensitive to elevated phosphorus levels than streams or rivers, and slower-flowing, small volume streams and rivers will be more sensitive than faster-flowing, or larger volume streams and rivers.

The United States Environmental Protection Agency (USEPA) considers 0.05 mg / L (0.05 parts per million) to be the critical phosphorus level in lakes and 0.10 mg / L (0.10 parts per million) to be critical in streams. In some ecosystems, for example the Florida everglades, target concentrations are even lower than these figures, with 0.01 mg / L (0.01 parts per million) set as the target concentration allowed to enter the Everglades by 2000. Median phosphorus

concentrations in two United States Geological Survey surveys of pristine (unaffected by human activities) areas of 63 and 928 river basins found concentrations of 0.016 mg / L and 0.018 mg / L (0.016 and 0.018 parts per million). Runoff from agricultural fields is often much higher than these values, even if the phosphorus loss is only a fraction of the applied phosphorus.

Human Effects of Phosphorus in Surface Waters

Phosphorus inputs into the environment have increased since the 1950s. Some of them come from point sources, for example, from wastewater treatment plant discharges. Other phosphate sources come from non-point sources, such as run-off and erosion following rainfall from agricultural fields and fertilized lawns and gardens in urban areas.

From the 1950s, phosphate laundry detergents were a major source of the increase in phosphorus in the raw wastewater effluent released from water-treatment plants. For example, in the 1940s, effluent contained about 3 mg / L of phosphorus. By 1970, this had increased to 11 mg / L of phosphorus. In 1994, the detergent industry voluntarily ended the manufacture of phosphate detergents after many states established phosphate detergent bans. Today, effluent contains about 5 mg / L of phosphorus. Some states have also established limits on phosphorus that can be discharged from wastewater treatment facilities. About 7 percent of wastewater treatment plants have tertiary treatment for the removal of phosphorus. There are no such limits in Tennessee.

With reductions in phosphorus from point sources, attention is now shifting towards non-point sources. A primary source of agricultural non-point source of phosphorus is runoff from fields and from manure-disposal sites. Controlling or reducing runoff from these sites will greatly reduce the phosphorus impact from agricultural sources might have on water quality.

Controlling Run-off of Agricultural Phosphorus

As long as soil erosion is controlled and phosphate fertilizers, plant residues, manure and wastewater from farming operations are not directly applied to surface waters, there will be no point source phosphorus pollution. Control of non-point phosphorus pollu-

tion can be achieved by controlling the quantity and type of runoff from agricultural fields. Sites with steep slopes and highly erodible soils adjacent to surface waters will always be at greater potential risk to phosphorus pollution than sites with less steep slopes and less erodible soils. Management practices can greatly influence whether high- or low-risk sites become potential polluters. The use of cover crops and buffer strips can greatly reduce the amount of sediment leaving a field. Similarly, a lack of soil cover or barriers between the field and water can increase the risk of pollution.

Best Management Practices for Manure Phosphorus Management

Most of the phosphorus in agricultural runoff is associated with organic matter (plant residues or manure) or the soil particles. If the amount of sediment or organic matter reaching surface waters is reduced, the amount of phosphorus will also be reduced. Different agricultural practices can be used to reduce the amount of phosphorus that is being land-applied as manure so that the risk of water pollution is minimized (Figure 2). Some best management practices (BMPs) for phosphorus management include the:

1. **Manipulation of animal and poultry diets** to reduce the amount of phosphorus excreted in manure.
2. **Physical or chemical treatment of manure treatment** to separate some of the phosphorus from the manure or change the chemistry of the manure.
3. **Application of manure** based on crop nutrient requirements, using methods that reduce the risk of runoff to surface waters.
4. Effective **soil erosion control** practices on application sites including no-till agriculture, contour tillage, leaving crop residues on the soil surface after harvest and growing winter cover crops.
5. Use of **vegetative buffer strips** along stream and river banks to slow down run-off, capture sediments and increase infiltration and phosphorus uptake rates.

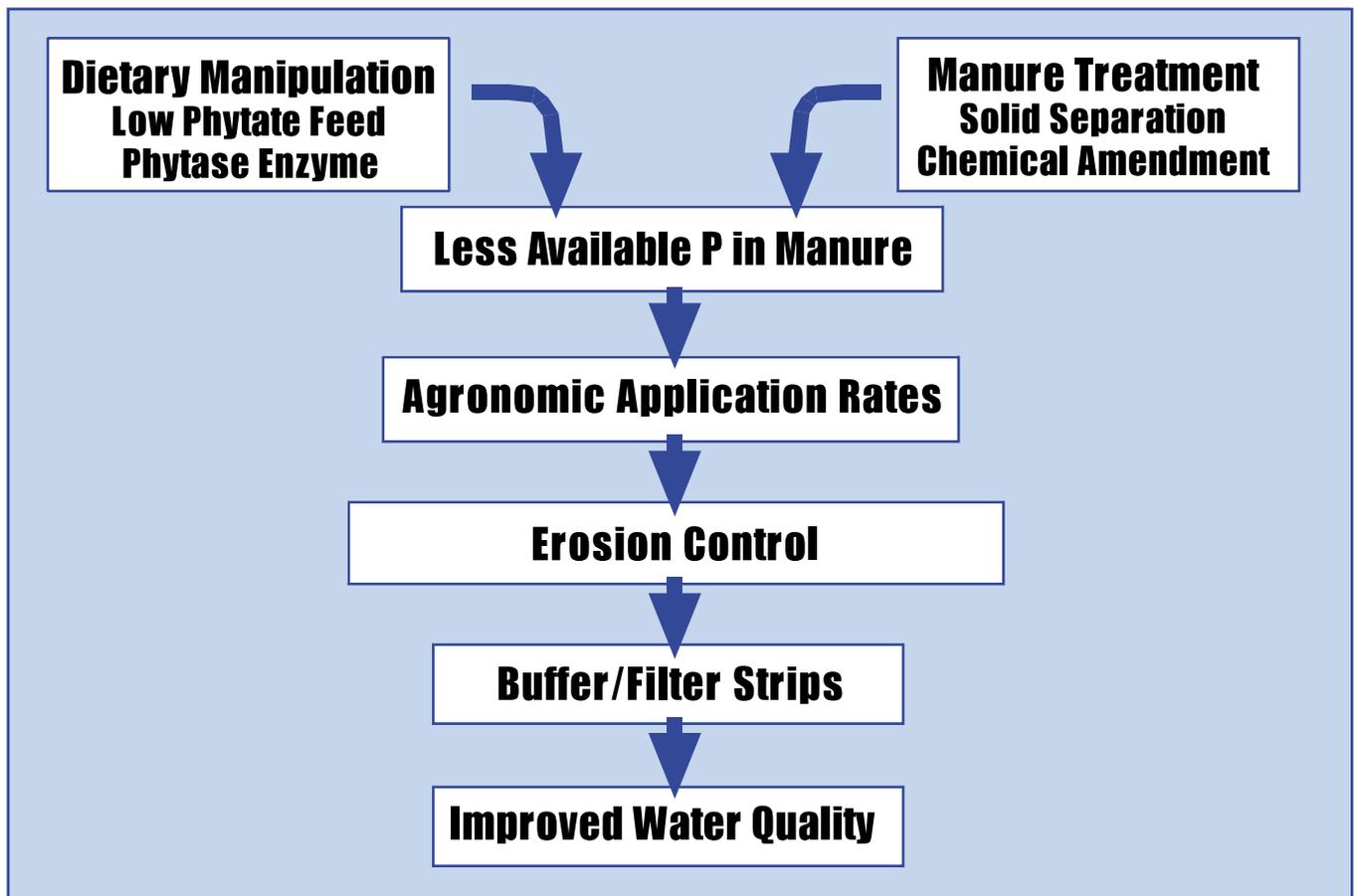


Figure 2. Best Management Practices for Manure Phosphorus Management

Dietary Manipulation

Phosphorus is supplied to animals and poultry in different forms. One form of phosphorus commonly found in plant seeds and grain is phytic acid (phytate). In a typical broiler diet, up to one third of the total phosphorus can be phytate-phosphorus. One problem associated with diets high in phytate is that it is largely unavailable to monogastric (single-stomach) species such as swine and poultry, and will be excreted in the manure.

Phytate can be broken down with an enzyme called phytase. This enzyme, produced by microorganisms or plant seeds, can be added to the feed to improve phosphorus absorption rates, reduce total dietary phosphorus requirements by more than 15 percent and reduce total excretion rates. Although phytase reduces total excretion rates, few studies have been conducted on the effect on phosphorus runoff after land application. Initial research has observed that the amount of soluble phosphorus in poultry litter from birds where phytase has been included in the diet

can increase if the litter is not immediately land-applied. In some cases, this may be higher than in litter from birds that have not been fed phytase. This highlights the importance of combining several different BMPs to effectively manage phosphorus and protect the environment.

An alternative technology being developed by plant breeders is the development of new low-phytate corn varieties that have the potential to improve phosphorus uptake rates from feed and thus reduce excretion rates. These are varieties where less of the phosphorus is in the phytate form, so more will be adsorbed by monogastric animal species. These corn varieties will be available commercially after 2002. Initial research suggests that up to 70 percent of the phosphorus will be bioavailable, compared to only 15 percent in conventional corn varieties. Other research has reported increases in phosphorus digestibility by 31 percent, with 13 to 43 percent reductions in phosphorus excretion rates in pigs. Similar breeding work is being conducted with soy varieties, but this work is less advanced than in the corn varieties.

Manure Treatment

Relatively simple technologies have been developed to modify the chemical or physical qualities of manure. The type of technology depends on whether it is handled or stored as a dry or liquid manure.

In dry manure handling systems, alum (aluminum sulfate) can be used to treat the litter inside poultry houses. Alum is typically mixed with the litter between “grow outs.” The aluminum in the alum reacts with the phosphorus in the litter to make it much less water-soluble. After land application, up to 90 percent less soluble phosphorus can be observed in the runoff from alum-treated compared to untreated litter at rates similar to sites where no litter has been applied. The use of alum also has an economic benefit to poultry producers. Less gaseous ammonia is released from the litter, resulting in improved bird health, increased weight gains and reduced mortality. These benefits more than offset the cost of the chemical.

In liquid manure systems, more phosphorus is found in the solid fraction of the manure, which typically makes up less than 10 percent of the total volume. By physically separating the solids using a mechanical separator, and by only land-applying the liquids, less phosphorus is applied. This reduces the potential for phosphorus runoff and makes it more economically feasible to transport the phosphorus-rich manure solids to other sites for land application that have a lower risk of phosphorus runoff.

Manure Application

Manure can be a major contaminant if applied directly to surface water. The organic matter, nutrients and pathogens contained in manure can all negatively impact water quality.

Application of manure should always be based on crop nutrient requirements. This is especially important close to surface waters. Prior to the application of manure, it is advisable to prepare a nutrient management plan (NMP) for your farm. A NMP is an inventory of nutrients across your farm. It identifies sources of nutrients (soil nutrients, commercial fertilizers, manure, leguminous cover crops) and matches them with where the nutrients are needed, based on the crop and expected crop yield in each field. It is important to soil test each field at least once every three years and to follow the recommendations from the soil test. In cases where manure is applied to a field, it is important to give full credit for the manure nutrients that are applied. Like a farm budget, NMPs are important

decision-making tools used in the day-to-day management of your farm. They make economic sense by identifying which fields need nutrients and which fields do not. They also make environmental sense by avoiding the over-application of nutrients at particularly sensitive sites.

Application equipment should be calibrated to ensure that manure can be applied efficiently and that only the required quantity is applied. Manure application should be based on either crop nitrogen or phosphorus needs. For almost all crops, manure applied based on nitrogen will over-apply phosphorus. Alternatively, manure applied on crop phosphorus needs will under-apply nitrogen. Estimates of manure phosphorus and other nutrients such as nitrogen and potassium should be made prior to application to reduce the risk of over-application, pollution or wasting your resources. In fields where there is a low risk of runoff to surface water, manure application rates can exceed crop phosphorus requirements, but should not exceed crop nitrogen requirements. In fields where there is a high risk of runoff, manure should be applied to meet crop phosphorus needs. This may require supplemental commercial nitrogen fertilizer to meet crop nitrogen needs.

Timing is important in manure application. Where practical, manure should be applied immediately prior to crop establishment to give the crop maximum benefit and to reduce the risk of runoff. If manure is to be applied when the main crops are not actively growing, it is advisable to apply manure over a cover crop or on soil with a good residue cover. This will reduce the risk of phosphorus runoff, and in the case of cover crops, supply them with nutrients. If manure has to be applied to a bare soil, the risk of runoff can be reduced by either injecting manure below the soil surface, or incorporating the manure within 48 hours of a surface application.

In addition, it is advisable not to apply manure close to other sensitive sites such as sink holes, wells and areas close to public access points. The non-application setbacks recommended by the Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture (USDA) are summarized in Table 1.

Where practical, manure should be applied on fields where the risk of runoff, and thus phosphorus pollution of surface water, is minimal. Extra caution is needed when applying manure on a field adjacent to surface water, wells and sinkholes. Manure application based on the phosphorus requirements of a crop can

Table 1. Recommended Non-Application Buffer Widths¹

Object / Site	Situation	Buffer Width (feet) from Object Site
Well	Located up-slope of application site	150
Well	Located down-slope of application site	300
Waterbody or stream ²	Predominant slope < 5% with good vegetation ³	30
Waterbody or stream ²	Predominant slope 5 - 8% with good vegetation ³	50
Waterbody or stream ²	Poor vegetative cover, or predominate slope > 8%	100
Waterbody or stream ²	Cultivated land, low erosion	30
Public road	Irrigated wastewater	50
Public road	Solids applied with spreader truck	50
Dwelling	Other than producer	300
Public use area	All	300
Property line	Located down-slope of application site	30

often make more economic and environmental sense, but will require application of commercial nitrogen fertilizers to meet the crop nitrogen requirements.

When manure or other organic by-products are land-applied, the NRCS recommends that one of three phosphorus application options be considered:

- **Phosphorus Index (PI) Rating:** Nitrogen-based manure application on low- or medium-risk sites. Phosphorus-based or no manure application on high- or very high-risk sites.
- **Soil Phosphorus Threshold values:** Nitrogen-based manure application on sites on which the soil

test phosphorus levels are below a threshold value. Phosphorus-based or no manure application on sites that equal or exceed threshold values.

- **Soil Test Recommendation:** Nitrogen-based manure application on sites where there is a soil test recommendation to apply phosphorus. Phosphorus-based or no manure application on sites where there is no soil test recommendation to apply phosphorus

In Tennessee, where many of the soils are naturally high in soil phosphorus, a Phosphorus Index rating is being developed by the NRCS and the University of Tennessee Agricultural Extension

¹/NRCS. 1998. Nutrient Management. Field Office Technical Guide 590 – 1. USDA Natural Conservation Service Conservation Practice Guide.

²/ Waterbody includes pond, lake, wetland or sinkhole. Stream includes both perennial and intermittent streams.

³/ Good vegetation refers to well-managed, dense stand, which is not over grazed.

Service to assist producers in assessing the risk of runoff from each field. This index serves as a planning tool to identify sites and practices that can impact phosphorus movement in a landscape. The index rates several field features (runoff potential; erosion rate; soil test phosphorus; vegetative buffer width and phosphate application type, rate, timing and methods), and assigns a field vulnerability for phosphorus loss value for each field. Fields that score low or medium using this index can safely handle more manure than those that score high or very high. In fields that rate high or very high using the phosphorus index, manure rates should be based on crop phosphorus requirements or uptake. In fields that rate low or medium using the phosphorus index, manure rates based on crop nitrogen requirements should not pose a significant threat to water quality.

At some sites, application of manure based on nitrogen rather than phosphorus would never be recommended unless strict conservation measures are implemented. This would be the case in sites with a high risk of runoff in Tennessee (Table 2). Conservation measures that would reduce the risk of runoff from a site would include the establishment of vegetative buffers, and manure application methods that would apply the manure with crop cover or over residue covered soil. If manure is applied on bare soil, it should either be injected or incorporated within 48 hours of application.

Soil Erosion Control Practices

Water erosion generally occurs only on slopes, and its severity increases with the degree of the slope. There are a number of different methods of reducing soil erosion, including no-till agriculture, contour tillage, leaving crop residues on the soil surface after harvest and growing winter cover crops.

No-till agriculture has been widely adopted across Tennessee since the development of equipment and herbicide technologies in the 1960s and 1970s, which made the technique more acceptable to farmers. No-till reduces soil erosion by keeping crop and plant residue on the surface longer. The major problem with no-till is that weed growth can only be stopped by heavier herbicide applications than with traditional tillage methods. In this case, farmers must make the hard choice between soil conservation and heavier applications of herbicides. No-till also does not work well in all soil types. No-till works best in the silty type soils found in West Tennessee and in

sandy soils. In heavier clay soils, fall plowing is required to break the soil up enough for adequate crop yields. No-till also does not work in compacted soils. The only way to break down soil compaction is through traditional moldboard plowing or the use of a subsoiler.

Contour tillage reduces water erosion. On hilly areas, plowing is done across the hill rather than straight up and down. One problem with this is that some fields' shape make this method impractical. Terraces can also be constructed so to reduce water erosion.

Leaving crop residues on the field after harvesting is another way to reduce soil erosion. For example, after corn is harvested, the stalks are left on the field all winter as a protective layer on the soil surface, reducing soil erosion. This protective layer remains on the surface until the soil is plowed, thus minimizing the time that the soil surface is exposed to the elements.

Cover crops are grasses, legumes or small grains planted to protect the soil from erosion during non-crop periods. They remain in the field until the main crop is planted. By reducing erosion and runoff, cover crops reduce the amount of phosphorus that could potentially reach streams or rivers. Cover crops, growing during periods when other crops are not in the field, can also take up phosphorus and other nutrients that can be lost from runoff. Cover crops can also provide food and shelter for wildlife.

Vegetative Buffer Strips

Vegetative buffer strips are vegetated areas along rivers, streams (Figure 3) and other sensitive sites, such as sink holes, where fertilizers and manure are not normally applied. The purpose of these strips is to form a physical barrier between the field and the surface water. Any runoff coming from the field will be slowed down and intercepted by the vegetation. This will not only reduce the speed of movement of the runoff, but capture some of the sediments and larger organic particles in the runoff, promote infiltration and increase nutrient uptake. In addition to nutrient removal, buffer strips can provide secondary benefits, such as stream stabilization, or a refuge area for wildlife species.

The optimum width of vegetative strip will depend on the characteristics of each site, such as the angle and length of the slope, vegetative cover and the erodibility of the soil. A buffer strip reduces the quantity and rate of runoff reaching the river or stream adjacent to the field rather than eliminating it. Strips at

Table 2. Site Assessment for Runoff Potential in Tennessee

Slope %	Cover	Texture of Top Soil	Length of Horizontal Slope (ft)		
			75	150	300
0 to 2	Bare soil or conventional tillage	All textures	Low	Medium	Medium
	No-till row-crops with light to medium residues		Low	Low	Low
	Pasture or no-till row-crops with heavy residues		Low	Low	Low
2 to 5	Bare soil or conventional tillage	Silt loam (West TN)	Medium	Medium	High
		Silt loam	Low	Medium	Medium
		Other	Low	Low	Medium
	No-till row-crops with light to medium residues	Silt loam (West TN)	Low	Medium	Medium
		Silt loam	Low	Low	Medium
		Other	Low	Low	Low
	Pasture or no-till row-crops with heavy residues	Silt loam (West TN)	Low	Low	Medium
		Silt loam	Low	Low	Low
		Other	Low	Low	Low
5 to 12	Bare soil or conventional tillage	All textures	High	High	High
	No-till row-crops with light to medium residues		High	High	High
	Pasture or no-till row-crops with heavy residues		Low	Medium	High
> 12	Bare soil or conventional tillage	All textures	High	High	High
	No-till row-crops with light to medium residues		High	High	High
	Pasture or no-till row-crops with heavy residues		Medium	High	High

Low = Manure application prior to normal rainfall poses a low or negligible threat to water quality if manure is applied at an appropriate agronomic rate.

Medium = Manure application prior to normal rainfall could pose a threat to water quality if suitable conservation practices and appropriate agronomic rates are not employed.

High = Manure application prior to normal rainfall can pose a serious threat to water quality. Under most circumstances, manure application would not be recommended without strict conservation measures employed.

least 35 feet wide have been shown to reduce phosphorus loading from 50 to 90 percent under research conditions. Strips wider than 35 feet will reduce runoff even more, but can be impractical in small fields. In fields where strips less than 35 feet are impractical, strips narrower than 35 feet are better than no strips.

Many different grass, shrub and tree species can be used for vegetative buffer strips. For nutrient removal, a mixture of different species with different rooting depths is preferred. Grass species forming a dense ground cover are the most efficient at trapping sediments from runoff, but may not be the most appropriate if the landowner also wishes to encourage ground-loving birds and small mammal species. In cases where a secondary objective of creating a buffer strip is to encourage wildlife, native grass and sedge species such as Switchgrass (*Panicum virgatum*), Broom sedge (*Carex scoparia*), Big Bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), Eastern Gamagrass (*Tripsacum dactyloides*) should be planted. Native grass species do not compete well with many of the more productive forage species used in Tennessee, so establishment may be slower. Native grass species do not produce a dense ground cover, so vegetative strips for both wildlife and nutrient removal purposes should be wider than those used for conventional forage species.

Tree and shrub species can be important components in a vegetative buffer strip. These deeper-rooting

species will be able to capture mobile nutrients such as nitrate, which can leach beyond the rooting zone of grass species. Deeper-rooting tree species have an important secondary role in stream bank stabilization, especially on the outer banks of a stream or river where erosion is greatest. A mix of different trees rather than a single species is preferred. A variety of different tree species with different shapes, sizes and rooting depth planted randomly along a stream bank will provide shade, food, perches, shelter and nesting sites for wildlife.

Establishment of a vegetative buffer strip will depend on the past management and cropping of the site to ensure optimum growth. It is important to check the soil pH before establishing the buffer strip. The use of commercial fertilizers is usually not necessary, except in cases where the soil fertility would limit establishment of a good vegetative stand. It is important to manage vegetative buffer strips for them to function well. Grass strips should be mowed or harvested for hay to encourage dense vegetative growth. Undesirable weed species should be controlled. After major storm events, the strips may need to be inspected and if necessary repaired, to prevent concentrated flow within the filter strip. Gullies should be filled in and sediment buildup that might disrupt flow should be removed. Tree species should be harvested when they reach maturity.

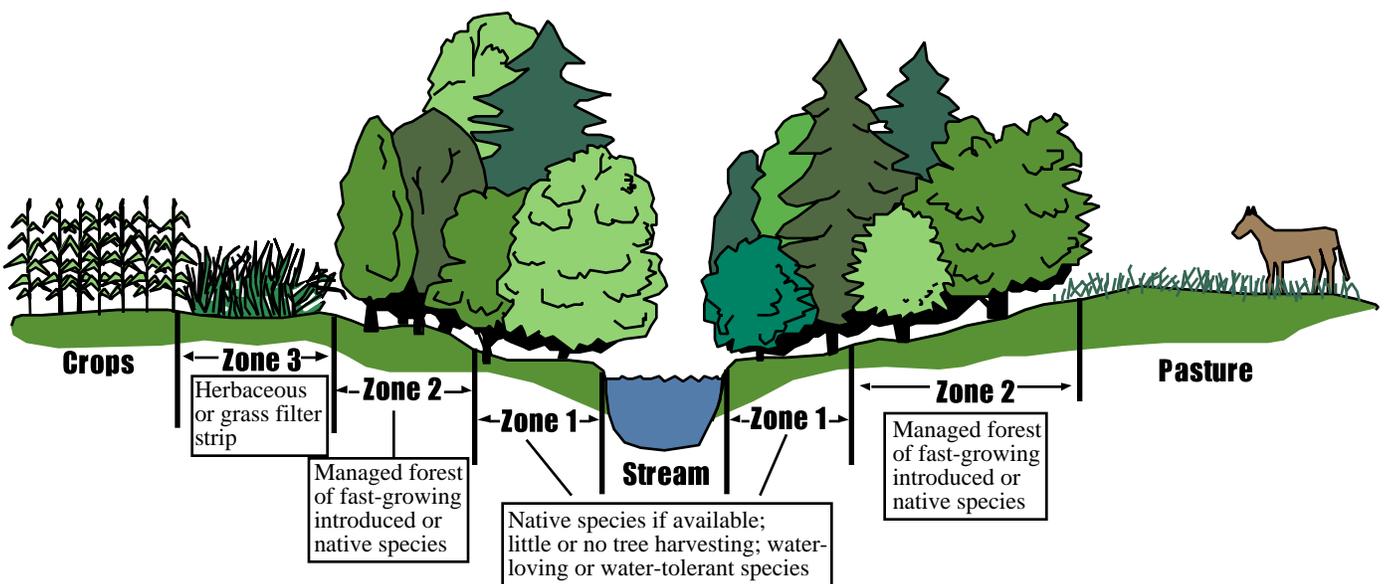


Figure 3. Buffer Strip Function

Points to Remember: Best Management Practices for Phosphorus in the Environment

- Phosphorus pollution from agricultural runoff can seriously impact water quality. Reducing phosphorus inputs to our surface waters will improve the quality of water for all Tennesseans.
- Reducing direct runoff reduces phosphorus runoff.
- Reduce soil erosion.
- Know your soil and manure phosphorus levels through testing and analysis. Match fertilizer and manure phosphorus to crop needs. It makes economic and environmental sense.
- Use care when applying manure, especially near water.
- Do not over-apply fertilizer or manure phosphorus on sites adjacent to rivers, streams reservoirs or lakes, or near sinkholes.
- Establish buffer strips along river and stream banks, reservoirs and lakes. If possible, the strips should be at least 35 feet wide; however, strips narrower than 35 feet are better than none!

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COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS

The University of Tennessee Institute of Agriculture, U.S. Department of Agriculture,
and county governments cooperating in furtherance of Acts of May 8 and June 30, 1914.

Agricultural Extension Service

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