Remedial Measures

To reduce P losses from agriculture to water, we should attempt to (1) balance P inputs in the form of feed and fertilizer with outputs in the form of crop and animal produce and (2) manage the soil P level on a watershed scale. Reducing P loss in agricultural runoff may be brought about by source and transport control strategies (Table 34-7). We have generally been able to reduce P transport from agricultural land in erosion. However, much less attention has been directed toward source management and the control of dissolved P losses in surface runoff.

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Source management

Source management attempts to minimize P buildup in the soil above levels sufficient for optimum crop growth by controlling the quantity of P in manure and the amount of P that is applied in a localized area. See the dietary strategies lessons, that is, Lessons 10-13, for more information. Techniques for doing this include

- Manipulating animal intake of dietary P.
- Using enzyme additives for livestock feed.
- Using corn hybrids with less phytate P.
- Before the land application of manure, determining the P content of both manure and soil.
- Using commercially available manure amendments.
- Facilitating the movement of manure from surplus to deficit areas.
- Using innovative methods to transport manure.
- Considering composting.
- Using some manures as “bioenergy” sources.

Manipulation of animal intake of dietary P helps balance farm P inputs and outputs in livestock operations since feed inputs are often the major cause of P surpluses (Table 34-3). Phosphorus intakes above minimum dietary requirements do not seem to confer any growth advantage and are excreted. Thus, carefully matching dietary P inputs to animal requirements can reduce the amount of P that they excrete.

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A significant amount of the P in grain is in phytate form, which hogs and chickens cannot digest. As a result, it is common to supplement feed with mineral forms of P. This supplementation contributes to P enrichment of manures and litters. Thus, enzyme additives for livestock feed that increase the efficiency of P uptake from grain during digestion are being used. One example is phytase, an enzyme that enables the digestive systems of hogs and chickens to absorb P in grains. Keeping in mind the need for cost effectiveness in terms of livestock weight gain, such enzymes could reduce the need for P supplements in feed and potentially reduce the P content of manure.

Another approach to better balance farm P inputs and outputs is to increase the quantity of P in corn that is available to hogs and chickens. Corn hybrids with less phytate P are available. Without the phytase enzyme, hogs and chickens cannot digest this phytate P, which is excreted. Subsequently, P concentrations in the litter of poultry fed the “low phytic acid” corn were 23% less than those in the litter of poultry fed the “wild-type” corn. Thus, the use of low-phytate corn in poultry feed can increase the availability of P and other phytate-bound minerals and proteins and reduce the amount of P excreted.

Table 34-7. Best management practices for control of nonpoint sources of agricultural P and N.

Practice	Description	Impact on Loss[1] P	Impact on Loss[1] N
Source Measures			
Feed additives	Enzymes increase nutrient utilization by animals.	+ve	+ve
Crop hybrids	Low phytic acid corn reduces P in manure.	+ve	neutral
Manure management	Compost, lagoons, pond storage; barnyard runoff control; transport excess out of watershed	+ve	+ve
Rate added	Match crop needs.	+ve	+ve
Timing of application	Avoid autumn and winter application.	+ve	+ve
Method of application	Incorporated, banded, or injected in soil	+ve	neutral
Crop rotation	Sequence different rooting depths.	neutral	+ve
Manure amendment	Alum reduces NH_3 loss and P solubility.	+ve	+ve
Soil amendment	Fly ash, Fe oxides, and gypsum reduce P solubility.	+ve	neutral
Cover crops/residues	If harvested, can reduce residual soil nutrients	+ve TP -ve DP	+ve
Plowing stratified soils	Redistribution of surface P through profile	+ve	neutral
Transport Measures			
Cultivation timing	Not having soil bare during winter	+ve	+ve
Conservation tillage	Reduced and no-till increases infiltration and reduces soil erosion	+ve TP -ve DP	+TN -ve NO_3
Grazing management	Stream exclusion, avoid overstocking	+ve	+ve
Buffer, riparian, wetland areas, grassed waterways	Removes sediment-bound nutrients, enhances denitrification	+ve TP neutral DP	+ve
Soil drainage	Tiles and ditches enhance water removal and reduce erosion	+ve TP -ve DP	+ve TN -ve NO_3
Strip cropping, contour plowing, terraces	Reduces transport of sediment-bound nutrients	+ve neutral DP	+ve neutral NO_3
Sediment delivery structures	Stream bank protection and stabilization, sedimentation pond	+ve	+ve
Critical source area treatment	Target sources of nutrients in a watershed for remediation	+ve	+ve

[1]TN is total N, NO_3 is nitrate, TP is total P, DP is dissolved P, +ve is positive impact on P and N loss, and –ve is negative impact on P and N loss.

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Farm advisors and resource planners are now recommending that the P content of both manure and soil be determined by soil test laboratories before the land application of manure. Without these determinations, farmers and their advisors tend to underestimate the fertilizer value of manure.

Commercially available manure amendments, such as slaked lime or alum, can reduce ammonia (NH_3) volatilization, leading to improved animal health and weight gains; they can also reduce P solubility in poultry litter by several orders of magnitude and decrease dissolved P, metal, and hormone concentrations in surface runoff (Moore et al. 2000). Perhaps the most important benefit of manure amendments for both air and water quality is an increase in the N:P ratio of manure, via reduced N loss because of NH_3 volatilization. An increased N:P ratio of manure would more closely match crop and P requirements.

At the moment, manures are rarely transported more than 10 miles from where they are produced. A program should be established to encourage manure movement from surplus to deficit areas. However, mandatory transport of manure from farms with surplus nutrients to neighboring farms where nutrients are needed faces several significant obstacles. First it must be shown that manure-rich farms are unsuitable for manure application and that the recipient farms are more suitable for manure application. The greatest success with re-distribution of manure nutrients is likely to occur when the general goals of nutrient management are supported by consumers, local governments, the farm community, and the livestock industry involved.

Some farmers are already using innovative methods to transport manure. In some states, extension and local trade organizations have established "manure bank" networks that put manure-deficit farmers in contact with manure-surplus growers. However, the biosecurity of any manure transportation network that is developed must be ensured to prevent the spread of diseases.

Composting, another potential tool, may also be considered as a

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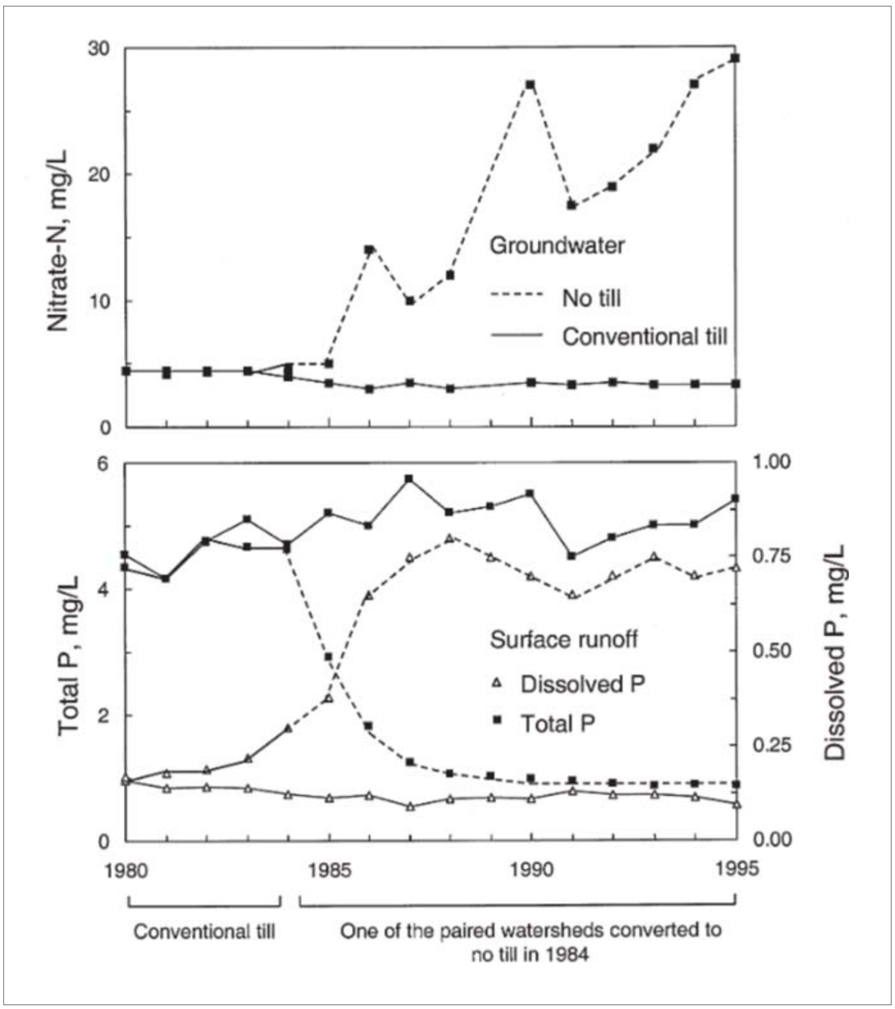

Figure 34-17. Mean annual nitrate-N concentration of groundwater and dissolved and total P concentration of runoff as a function of tillage management of watersheds in Oklahoma.
Adapted from Sharpley and Smith 1994.

management tool to improve manure distribution. Although composting tends to increase the P concentration of manures, the volume is reduced and thus transportation costs are reduced.

There is interest in using some manures as sources of "bioenergy." For example, dried poultry litter can be burned directly, or by pyrolytic methods, converted into oils suitable for the generation of electric power. Liquid manures can be digested anaerobically to produce methane, which can be used for heat and energy.

Separating manure solids from liquids may increase the management options for some types of manure, such as dairy and swine. This process results in some nutrient separation as well, leaving a large proportion of the available N in the liquid fraction and a large proportion of the P in the solid fraction. While this does not change the total amount of nutrients that must be handled, it may enable better targeting of the individual nutrients to locations where they will do the most good and/or will be less likely to cause environmental problems. Also, because the solid fraction is more concentrated, it may be feasible to transport it to more remote fields.

Transport management

Transport management refers to efforts to control P movement from soils to sensitive locations such as bodies of fresh water. Phosphorus transport via surface runoff and erosion may be reduced by conservation tillage and crop residue management, buffer strips, riparian zones, terracing, contour tillage, cover crops, and impoundments (e.g., settling basins). Basically, these practices reduce rainfall impact on the soil surface, reduce runoff volume and velocity, and increase soil resistance to erosion. However, none of these practices should be relied upon as the only or primary means of reducing P losses in agricultural runoff. Conversion from furrow irrigation to sprinkler irrigation to drip irrigation significantly reduces irrigation erosion and runoff. Furrow treatments, such as straw mulching and use of polyacrylamides, will also reduce in-furrow soil movement. These treatments, however, are generally more efficient at reducing sediment P than dissolved P. Also, P stored in stream and lake sediments can provide a long-term source of P in waters even after inputs from agriculture have been reduced. Thus, the result of remedial measures applied within the contributing watershed will not be noticeable for some time in many cases of poor water quality. Therefore, immediate action may be needed to reduce future problems.

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