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Methods to determine phosphorus loss from farm fields

by John Sawyer, Department of Agronomy

Movement of phosphorus (P) from farm fields to surface waters can elevate P in water systems above critical levels for aquatic plant growth and thus enhance nutrient enrichment and seasonal deficient oxygen, a process called eutrophication. Phosphorus commonly controls vegetative production in freshwater bodies, and hence the potential for eutrophication. The sourcing of P from production fields (including P from manure and fertilizer) is now one focus area considered as being an important contributor of total P entering surface waters, and hence significantly contributing to water quality concerns.

Background. In April 1999, the Iowa Natural Resources Conservation Service (NRCS) issued an Interim Conservation Practice Standard, Nutrient Management Code (590). This standard is the guidance used by NRCS staff and the private sector when providing technical assistance to producers requesting assistance on nutrient management. Under some situations the technical guidance in this standard may be required if the producer is voluntarily participating in cost share programs that address water quality concerns. The NRCS in each state is required to revise their state Nutrient Management standard (590) in accordance with guidance provided by national policy and in the national 590 standard. For P, the national standard provided states with

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three options for guidance on application of P. In other words, there is a choice of three methods states can use to assess the risk of P loss from farm fields, and thus determine the potential management changes needed to modify P application. This is a field-specific assessment of the potential for P transport from the field. These options are 1) soil test, 2) soil P threshold level, and 3) P Index rating. The state NRCS has until April 2001 to implement one of these methods in the Iowa 590 standard.

Soil test. This assessment method is very similar to an agronomic interpretation of P need. The soil is tested using routine soil test P methods for crop production, and test results are interpreted using tables developed for crop response (Table 1). At soil tests less than optimal, P is applied based on crop need (or at a nitrogen [N] need for the crop). At some intermediate (optimal-to-high) level, P is applied based on the crop removal. Eventually, P application is withheld at even higher soil tests (Table 1, Excessive). The theory behind this risk assessment method comes from the knowledge that as soil test P increases, dissolved P in runoff increases.

This environmental P interpretation does parallel agronomic use interpretation, like that currently recommended in Iowa State University publication PM 1688, *General Guide for Crop Nutrient Recommendations* in Iowa (for an example, see Table 2 for corn P interpretation and recommendations).

There are significant advantages and problems in using the soil test approach to modifying P applications for water quality purposes. Advantages include 1) uses soil tests and sampling methods that are familiar to farmers and advisers; 2) follows agronomic guidelines for crop P need; and 3) applies simple decision process and easy regulatory control. From the standpoint of optimal agronomic and economic P resource use and protection of soil and water resources, the soil test P risk assessment method makes a lot of sense. Disadvantages include 1) research-based correlation between soil test level and P reaching surface waters is limited; 2) management practices (recent P application, rate, method, source, timing, and tillage) can override the effect of soil test level on P losses; 3) beyond edge of field

Table 1. Risk assessment option using soil test P method.

Soil Test P Level	P Application
Low	N based
Medium	N based
High	P based (e.g.,1.5 times crop removal)
Very high	P based (e.g., crop removal)
Excessive	P based (e.g., no application)

Source: NRCS National Conservation Practice Standard, Nutrient Management 590.

Table 2. P recommendations for corn grain production.

	P Soil Test (ppm)				
Soil Test Category	Very Low	Low	Optimum	High	Very High
Bray P_1 and Mehlich-3 P:					
Low subsoil P	0–8	9–15	16–20	21–30	+31
High subsoil P	0–5	6–10	11–15	16–20	+21
Olsen P:					
Low subsoil P	0–5	6–10	11–14	15–20	+21
High subsoil P	0–3	4–7	8–11	12–15	+16
	lb P_2O_5 to apply (lb/acre)*				
	100	75	50	0	0

*The recommended amounts of P_2O_5 for the optimum soil test category are based on nutrient removal for the reported yield. The amount shown in the table for the optimum soil test category is for 140 lb of corn grain per acre. Although P_2O_5 is not recommended at the high soil test category, a small amount equivalent to that contained in 100 pounds of a common complete NPK grade, applied as a starter fertilizer banded to the side and below the seed row, may be advantageous under conditions of limited soil drainage, cool soil conditions, or crop residues on the soil surface. None is recommended for the very high soil test category.

management can affect P losses (distance to surface water, connectivity between the field and water body, grassed waterways, and buffers); and 4) soil P tests do not predict soil erosion (P leaves fields in conjunction with soil particles). There is also the issue of where and how to collect soil samples for best prediction of P loss.

Phosphorus threshold. This assessment method is very similar to the soil test method. Instead of interpreting soil tests as given in Table 1, and relating to crop need, an environmental soil P threshold level is determined (Table 3). This environmental soil P threshold could be determined from a routine soil P test, an environmental soil P test, P saturation of the soil, or some other soil test. Advantages and disadvantages are similar to those described for the soil test method. The largest disadvantage is that no threshold value has been correlated to a critical P loss concentration from farm fields (mainly due to the linear increase found in dissolved P loss with increasing soil P level).

Phosphorus Index (PI). The PI is an integrated approach to estimating the risk of P loss from farm fields and movement to surface waters. Instead of looking at just one test, it integrates the many field-specific factors that influence P loss and potential movement to surface waters: erosion, sediment delivery, relative field location in the watershed, buffer strips, soil conservation practices, soil test P, precipitation, runoff, tile flow, and P application (fertilizer or manure) method, timing, and rate.

The PI has several advantages over other risk assessment methods: 1) estimates erosion and sediment losses because total P is an important aspect of P supply to surface waters; 2) accounts for beyond field edge effects on P reaching surface waters; 3) includes P applications; and 4) adjusts for P management strategies and soil conservation practices. The PI also could include some characteristics of the other methods, for example, an environmental P threshold. As for any of the P loss assessment methods, the predicted risk of P delivery to surface waters indicated by a PI should be field tested with representative situations (calibrated against measured P delivery) and interpreted for surface water quality impacts.

The PI is more complex and difficult to determine, but is a more reasonable and effective approach to assessing risk of P loss from fields and delivery to surface waters than soil test or threshold methods. Because of the integrated system, the PI is useful for understanding the important factor or factors causing a high P loss risk, and can help identify management practices to lower that risk. And that is the goal, to reduce risks of P loss, help water quality, and provide producers options for P management.

The Iowa approach. The Iowa NRCS, through work and discussion of the State Technical Committee, has decided from the three possible methods to develop a PI for use in the Iowa 590 nutrient management standard. Other midwestern states are also taking this approach. A PI is currently under development in Iowa by a team of NRCS employees, Iowa State University Extension specialists, and Iowa State University and United States Department of Agriculture (USDA) soil scientists. Once recommended by the USDA State Technical Committee and adopted by NRCS, an electronic version of the Iowa Phosphorus Index and user's guide will be available on the Web at http://www.ia.nrcs.usda.gov

Table 3. Risk assessment option using soil P threshold value (TH).

Soil Test P Level	P Application
<3/4 TH	N based
•3/4 TH and <1 1/2 TH	P based (e.g., crop removal
•1 1/2 TH and <2 TH	P based (e.g., crop removal)
•2 TH	P based (e.g., no application)

Source: NRCS National Conservation Practice Standard, Nutrient Management 590.

Compost is changing the attitude toward waste

by Tracy S. Petersen, freelance associate

When Stacie Johnson went into the composting business, she thought her days would be filled with converting manure to a rich organic compound and selling it to customers. She didn't anticipate that she'd fill much of her time with educational activities such as workshops, interviews, and answers to calls about making compost.

"I'm actually representing a fundamental change," said the Cedar Rapids woman, who calls her business Organic Matters. The change Stacie strives to make is helping people see manure as a nutrient and soil builder, and not strictly as fertilizer.

Among livestock producers, Stacie talks about manure as a resource. She equates it to a seed or a calf that must be nurtured to produce a valuable end product. To her customers, she speaks about the multiple benefits of compost and organic matter.

The compost Stacie creates is generated from a stable with 47 horses. Each year the stable provides 4,000 to 5,000 cubic yards of manure mixed with sawdust shavings. To reduce the woodiness of the compost, Stacie mixes the horse manure with manure from a nearby dairy. She has a ready supply—the dairy produces 3,000 pounds of manure each day.

Stacie uses three manure management methods. In the first, she composts the horse manure with a static pile for 12 to 18 months. It is then sold as a soil builder.

In the second method, Stacie mixes fresh horse manure with dairy manure and introduces it to an in-vessel digester The manure mixture remains in the digester for 4 days, where the microbial activity heats the material to 150˚F.

Stacie's third method, vermiculture, involves placing the compost in worm beds—700 pounds of worms (1,000 worms per pound). The result is a rich organic compound good for everything from boosting tomatoes and starting seeds to improving lawns and agricultural fields. The castings are too expensive to be applied to agricultural fields.

The compost particularly benefits agricultural producers by enriching the land. Manure that is being composted has less odor than that which is stored, and has an earthy odor when it is applied to the land. It decreases pollution, reduces weed seeds (they are killed in the composting process), and improves the soil's ability to hold water in drought or wet periods.

"This is a great option for agricultural producers," Stacie said. "If they don't take the compost to the field they can sell it." Finished compost has a current market value of $10 to $500 per yard, depending on the process and packaging.

Stacie sells her compost in increments from a bucket to semi-loads. The smallest increments of worm castings, which she calls Heavenly Humus, are sold as Buckets of Blessings for Plants and Plant Lovers. These are available at her small retail shop and in some garden centers in central and eastern Iowa.

Stacie also sells bulk compost from her facility at Four Oaks Farm and Stable in Robins. Many of her customers are homeowners, who purchase 2 to 6 cubic yards of compost at a time. Landscapers purchase 10 times that much and haul theirs away by the semi truck.

Stacie, who calls herself an "entre-manure," started her business in September 1999. With a solid product in place, she is now concentrating on market development. "I'm attempting to educate a whole industry, so more people will understand this," she said. And she's optimistic. "I really see the potential for transforming a rural surplus, manure, into a value-added product. I'm an environmentalist at heart, but I know it has to make economic sense. What I'm trying to do is find the balance."

Controlling open feedlot runoff

by Jeff Lorimor, Department of Ag and Biosystems Engineering

Controlling open feedlot runoff needs to be addressed by feedlot operators across the state. Feedlot runoff can kill fish and contribute nutrients to surface waters that degrade water quality. The water quality of freshwater streams and lakes has been of concern for many years; the Gulf of Mexico water quality is a more recent concern.

The law. The Clean Water Act is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. The Clean Water Act makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit (National Pollutant Discharge Elimination System, NPDES) is obtained. Agricultural operations are not eligible for NPDES permits, which means they must capture runoff and pump it back onto agricultural land so it doesn't run off.

The Clean Water Act requires controls to be installed below open feedlots. All lots, regardless of size, are required to install settling basins to remove solids from the runoff before they leave the lots. Large lots of more than 1,000 animal units (1 AU = a 1,000-lb beef animal) need settling basins to remove solids **plus** detention basins to catch and hold all liquid runoff. The captured runoff in the detention basin must then to be pumped or hauled for application to agricultural land. These large lots should have an operation permit, issued by the Iowa Department of Natural Resources (IDNR). The permit allows the lot to discharge whenever a large enough rain occurs, but not at any other time. Although the laws have been in place for nearly 30 years, they haven't been rigorously enforced. The Environmental Protection Agency (EPA) is currently stepping up enforcement of these old laws as well as considering some revisions to the laws.

Why does the law require capture of runoff? Runoff must be captured because the water quality coming off feedlots is significantly less than we want in our lakes and streams: we don't want them to be waste lagoons. The following are typical nutrient concentrations found in open-lot runoff after the solids are settled out: total nitrogen, 400 ppm; ammonia, 300 ppm; phosphorus, 80 ppm; and chemical oxygen demand (COD), 6,000 ppm. COD is the amount of oxygen required by microbes in the water.

Total ammonia is of concern because of hypoxia issues in the Gulf of Mexico. Ammonia more than 3–20 ppm kills fish. High COD deprives the water of oxygen, suffocating the fish. Phosphorus is of concern because of its effect on algal growth, even at very low levels (less than 1 ppm).

The size of settling basins and detention basins is defined by IDNR requirements. Typically, settling basins should be between 1/10 and 1/40 of the lot size. Detention basins should hold from 5 to 17 inches of runoff, depending on the frequency of pumpout. In both cases it's obvious that the smaller the lot, the smaller the control facilities. Iowa State University Extension, Natural Resources Conservation Service, and private consulting engineers can help with specific basin designs.

As a feedlot operator, what should you do? If you are a lot owner or operator, you should have settling basins installed below your lot, and should be removing solids from the basin periodically so they work properly. If your lot holds more than 1,000 AU you also should have, or apply for, an operations permit. Doing so may require you to construct the above-mentioned control facilities, but may save you from being fined if EPA stops by your lot. Keep good records of liquid depth in your basin, pumpout times, and weather conditions.

It's important to protect the state's surface waters. The law requiring controls has been in place for nearly 30 years, but it's now starting to be enforced more vigorously. To protect water quality and avoid legal and regulatory problems, you should move ahead with runoff control facilities on your open lots.

Public hearings to be held on manure management plans

by Karen Grimes, Department of Natural Resources

The Department of Natural Resources (DNR) will hold five public hearings in December to receive input from the public on a proposal that would require submittal and approval of manure management plans before construction or expansion of unpermitted confinement feeding operations and the accompanying manure storage structures. The proposed rule change also would require simultaneous submittal of the plan to the county board of supervisors. Under current rule, unpermitted operations must submit a plan to the DNR and have an approved manure management plan prior to manure application, but not prior to construction.

The review and approval of these plans can help producers that aren't large enough to need a construction permit in their planning and site evaluation process, said Wayne Gieselman, coordinator of the DNR animal feeding operations program. "The review process can also pick up potential environmental problems at sites, saving the producer money. High-risk areas might include some alluvial aquifers, those sandy areas near streams and rivers, or areas of shallow soil depth above bedrock," he added.

The proposed changes to Chapter 65 rules are in response to a confinement feeding operation in Pottawattamie County where a producer put up a number of buildings, including two sets that were close enough together that they pushed the operation above the construction permitting threshold. Gieselman said, "Both sets of these buildings sit empty today because, even if they are under separate ownership, they are still under common management and need a permit if their pig source is the same and they use a similar management contract."

The proposed rule change originated with a proposal that 16 state representatives sent to the Environmental Protection Commission requesting submission of manure management plans prior to construction of unpermitted confinement operations.

The public hearings will be held at these locations on the following dates:

- Sioux Center, December 12, 2000, at 7 p.m. in the lower conference room of the Sioux Center Public Library, 327 1st Avenue N.E.
- Hampton, December 13, 2000, at 7 p.m. in the large room of the First National Bank Building, 211 1st Avenue N.W.
- Atlantic, December 18, 2000, at 6:30 p.m. in Room 101 of Iowa Western Community College, 906 Sunnyside Lane
- Des Moines, December 19, 2000, at 1 p.m. in the second floor conference room of the Wallace State Office Building, 502 East 9th Street
- Cedar Rapids, December 20, 2000, at 1:30 p.m. in the Marland Room (second floor of Iowa Hall) of Kirkwood Community College, 6301Kirkwood Boulevard S.W.

Those who attend the hearing may submit comments orally or in writing, but they will be asked to give their names and addresses for the record and to confine their remarks to the subject of the rule. Anyone who plans to attend a public hearing and has special requirements should contact the DNR with their specific needs.

Written or e-mailed comments on the proposed amendments can be made on or before January 5, 2001. Written comments should be directed to Amy Rossow, Iowa Department of Natural Resources, Wallace State Office Building, 502 E. 9th St., Des Moines, Iowa 50319-0034; fax (515) 281-8895. Comments also can be e-mailed to Amy.Rossow@dnr.state.ia.us

Current rule allows the DNR 60 days to approve or disapprove a manure management plan. Owners of confinement feeding operations other than small animal feeding operations must submit the plans. For existing facilities, the plans should have been submitted by November 15, 1999. Producers cannot apply manure without an approved plan.

Under current rules and the proposed rule change, small animal feeding operations would not have to submit manure management plans. Small operations are those that have an animal weight capacity of 400,000 pounds or less of beef, dairy, and veal cattle; or 200,000 pounds or less for all other species.

The construction permit threshold starts at 200,000 pounds of animal weight capacity if earthen manure storage is used (400,000 pounds for cattle). If formed storage is used, the permit threshold is 625,000 pounds for most species and 1,600,000 pounds for cattle. If manure is stored only in the dry form, the threshold is an animal weight capacity of 1,250,000 pounds for most species, and 4,000,000 for cattle.

More information on manure management plans and the requirements for manure application can be found on the DNR Web site at www.state.ia.us/government/dnr/organiza/epd/wastewtr/feedlot/feedlt.htm

Biofilter project smells of success

by Sherry Hoyer, Iowa Pork Industry Center

A demonstration project at the Kirkwood Swine Facility at Kirkwood Community College in Cedar Rapids is pleasing to both smell and sight and that's just what project organizers had in mind. Iowa State University (ISU) Extension livestock field specialist Terry Steinhart and ISU Extension agricultural engineer Greg Brenneman designed a biofilter for the exhaust system at the college's 10-stall farrowing house to decrease odors and blend in visually with the surroundings. This Iowa Pork Industry Center-funded project has succeeded on both counts, Steinhart said.

"Because of its location on campus, this biofilter needs to be nice-looking and not have grass sprouting from it," he said. "The idea of using a biofilter is to cut down or eliminate the odor, and the smell coming from the biofilter is very similar to that of soil after a rain."

A biofilter is a device or structure containing biological material that serves as a filter by allowing air to pass through it. A true biofilter has active bacteria growing in the biological material that break down odorous compounds as they pass through the filter. A biofilter is not like a dust filter that fills up and must be cleaned; instead, it is a living ecosystem of microorganisms that continually feed on odorous gases.


The entire biofilter is roughly the size of a king-size bed.

Steinhart and Brenneman visited with Richard Nicolai of the University of Minnesota's Biosystems and Agricultural Engineering Department and used his recommendation when designing this biofilter. The recommendations are available in a document called Biofilter Design Information at http://www.bae.umn.edu/extens/aeu/baeu18.html

Building the biofilter wasn't a difficult process and the cost was relatively low, too. Steinhart and Brenneman said it took three people working 5 hours to complete the biofilter. This demonstration project is a bit more costly because they chose to build a "box" to contain the biofilter material for its visible on-campus location.

"On a farm design, there wouldn't necessarily be a need for sides on a producer's biofilter, so we would get used pallets and cover them with 1/4-inch mesh wire," Steinhart said. "A plenum would be constructed of plywood to distribute the air under the pallets and up through the compost material. Compost and wood chips should be available at little or no cost."

In addition to building the biofilter, Brenneman said producers need to remember two things when considering whether to add a biofilter to a facility's exhaust system. "A good rule of thumb is that you need about 1 square foot of biofilter material for every 10 cubic feet per minute of ventilation," he said. "And, remember that your exhaust fan will need to operate against a higher static pressure when you're using a biofilter. This means your fan should be able to provide adequate airflow at least 1/4 inch and preferably up to 1/2 inch of static pressure. Replacing your fan with a more powerful one is where the cost comes in for a producer." Fan replacement cost is estimated at $350–400.

The Kirkwood biofilter is made from a 2 foot by 8-foot piece of plywood and 2 ∞ 6 boards on end that are covered with 1/4-inch mesh wire on the bottom. The building pit air is forced into the

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space below the mesh and through the biofilter material between the 2 ∞ 6 boards. Steinhart said the wire mesh keeps the wood chip and compost material from falling into the area where the exhaust air enters the biofilter. The plenum acts like a chimney to push the conditioned air through the filter material. Current biofilter material includes wood chips, horse manure, sawdust, straw, and cornstalks, although the mixture may vary according to what is available and moisture content.

"One problem is that the material must be kept moist, otherwise the bacteria go dormant and aren't able to work on the odor coming into the material," Steinhart said. "However, you also can over water. If the material becomes anaerobic, the lack of oxygen essentially turns the compost back into manure."

Steinhart said he doesn't think there will be a problem with the material freezing in the winter, as long as the right moisture balance can be established. He also plans to add small worms (see Petersen article in this issue) to the compost material in the spring to help provide consistency in the aerobic decomposing process.

Both said they are willing to work with other ISU Extension livestock and ag engineering specialists on specific plans for producers, but advise producers to start the process by having the National Pork Producers Council conduct an odor and environmental assessment of their facilities.

"This is a free service and it will help you locate problem odor sources," Steinhart said. "Where is the odor coming from—pit fans, exhaust fans, lagoon? If it's from exhaust fans, this system might be a good 'odor eater' for your operation."

For more information on biofilters contact Terry Steinhart, Keokuk County Extension, (515) 622-2680, tsteinha@iastate.edu; Greg Brenneman, Johnson County Extension, (319) 337-2145, gregb@iastate.edu; or me at (515) 294-4496, shoyer@iastate.edu.

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