ENVIRONMENTAL QUALITY

MU Guide

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Reduce Environmental Problems with Proper Land Application of Animal Manure

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Livestock or poultry production enterprises should have a comprehensive manure nutrient management plan to take advantage of the animal manure benefits. A plan is also important in reducing the risk of environmental problems when manure is used as a nutrient source for farm crops.

Benefits of good manure management

Reduced cost of commercial fertilizers. Manure contains the three major plant nutrients, nitrogen, phosphorus and potassium (N, P and K), as well as many essential micronutrients such as calcium, sulfur, zinc, boron, copper, magnesium and manganese. In addition to supplying plant nutrients, manure generally improves soil tilth, aeration, and water-holding capacity of the soil and promotes growth of beneficial soil organisms. Manure applied in the proper amounts at the appropriate time can supply some, if not all, of the nutrient requirements of many crops grown in Missouri.

Improved production efficiency. Sound manure management plans allow managers to direct their time and skills to other important facets of the operation without continued worry about manure accumulation and potential detrimental effects.

Improved animal health. Good animal manure management practices result in improved animal health. By getting the animal out of the manure and removing manure from buildings on a regular basis, the animal environment within the buildings is improved.

Protection of water resources and air quality. Ground and surface water are valuable and essential Missouri resources. Virtually all drinking water and recreational use of water resources comes from groundwater or surface water. Many other uses, such as food processing and irrigation, dependent on abundant supplies of high-quality water.

Effects of poor manure management

Loss of fertilizer nutrients. Applying too much manure, at the wrong time, or improperly handling it in other ways releases nutrients into the air or into ground or surface waters. Thus, instead of nourishing crops, nutrients become pollutants. Excess nitrogen can leach through soil into groundwater. Manure contamination can increase nitrate levels in ground water and cause bacterial contamination and fish kills in surface waters. Excess phosphorus can be contained in erosion or runoff from fields and accumulate in surface water impoundments such as ponds and lakes. This phosphorus can stimulate unwanted plant growth, such as algae, which causes turbidity and other undesirable conditions in the water. A common misuse of manure is to spread it on a field and then, in addition, apply commercial fertilizer to supply a crop's nutrient needs with no consideration for the manure's nutrient value. An efficient manure management and application system meets, but does not exceed, nutrient needs of the crop. This minimizes pollution.

Odors and animal or operator health problems. Odors and gases can be produced from large accumulations of manure. These odors and gases may have a harmful effect on the health of both workers and animals in the production enterprise if concentrations are great enough. Also, excessive odors can result in nuisance complaints and even legal actions in sensitive situations.

Negative social and regulatory climate for agriculture. The general public is continually becoming more environmentally conscious. Improper manure management can quickly harm the image of production agriculture. Irresponsible manure management will also, sooner or later, lead to stricter regulations if producers do not take the lead in implementing effective waste management systems.

The manure nutrient management plan

A good manure management plan covers all aspects of manure management on a farm, from feeding the animal to eventual field application. The USDA-EPA Unified National Strategy for Animal Feeding Operations, released in 1999, requires that Comprehensive Nutrient Management Plans (CNMP) be developed for all animal feeding operations by the year 2009. According to the Strategy, the CNMP should address feed management, manure handling and storage, land application of manure, land management, record keeping, and other options for making use of manure. The plan should address liquid and solid manure produced in the operation as well as runoff and erosion control from areas where manure is stored or applied. The scope of the plan should include manure collection and storage at the point of production and appropriate use of manure on cropland or pastureland.

In some cases, manure will be applied to land not owned by the animal production enterprise, and the plan should include the appropriate agreements or easements to ensure land availability. The overall purpose of the plan is to guide animal, manure management in a manner that prevents degradation of water, soil and air resources and protects public health and the environment.

A manure management plan is a specific combination of physical components, conservation practices and management measures for manure handling, storage, treatment and use on cropland or pastureland. These components, practices and measures generally fall into two distinct categories.

One category involves methods or structures that facilitate the collection, handling, storage and treatment of manure consistent with the purpose of the manure management plan.

The second category controls both the application of manure nutrients to the soil and the retention of nutrients in the soil profile where use by plants occurs.

Nutrient content of manure

The nutrient content of manure varies widely with animal species, age, ration and feed consumption, as well as with different methods of storage, treatment and land application. Extensive data is available on manure nutrients "as produced" by animals and poultry. However, this data is of limited use because of variations introduced by the different manure management methods.

Generally, the nutrient content of manure as contained in storage immediately before land application is the point of greatest interest in accomplishing the goals of the manure management plan. Table 1 gives a range of values for manure nutrients in storage for common livestock species and manure management systems in Missouri.

Manure should be applied to land to meet the nutrient requirements of the crop being grown. These requirements should be based on realistic yield goals. Yield goals may be estimated using previous yield data over a five- to 10-year period, provided management remains similar.

Other factors to consider in establishing yield goals include soil type and moisture availability. Local University Outreach and Extension centers, Natural Resources Conservation Service offices or qualified consultants can provide help in establishing yield goals.

Obtain soil tests to determine nitrogen, phosphorus and potassium levels in the soil so that you can apply manure at the proper rates to meet the needs of the crop.

A potential environmental problem associated with animal manure use is the application of manure nitrogen at rates far greater than crop requirements.

This can result in excessive levels of soil nitrogen and nitrate pollution of ground or surface waters. Hence, manure application rates should be based on nitrogen content. Application rates based on nitrogen content will often result in application of phosphorus and potassium and other micronutrients above crop needs. In these cases, efforts should be made to minimize this effect by applying to fields with lower soil tests for phosphorus and potassium. While phosphorus and potassium are not generally implicated as groundwater contaminants from a health standpoint, the loss of phosphorus in surface runoff can stimulate algae growth and thus have a negative affect on water quality of streams or lakes.

Under ideal conditions, nitrogen, phosphorus and potassium, as well as other micronutrients, move through cycles on a farm. These nutrients go from a field crop, to the animals, to the soil, and back again to another crop. When nutrients do not remain in this cycle and are lost there is the potential for environmental pollution.

Nitrogen

Of the three major nutrients, nitrogen is of most concern for pollution potential and has the most complex cycle.

In manure, as excreted by the animal, some nitrogen

Table 1. Average nutrient levels in livestock waste.

Waste type	Total N	Organic N	Ammonia N	P_2O_5	K_2O
Swine lagoon[1]	100–300	20–60	80–240	40–70	100–300
Swine pit[2]	30–45	10–15	20–30	20–30	20–30
Dairy lagoon[1]	80–150	35–70	45–80	50–100	100–200
Dairy pit[2]	25–35	15–20	10–15	15–20	20–30
Broiler litter[3]	50–80	40–65	10–15	40–60	30–40
Turkey litter[3]	50–80	40–65	10–15	40–60	30–40

Notes:
[1] lb/acre-inch
[2] lb/1,000 gal
[3] lb/ton

Actual values are highly dependent on dilution, bedding, litter material and other factors. Variations of 50 percent from average values are not uncommon. Table 1 values should only be used for planning purposes. It is strongly recommended that a laboratory analysis of the manure be obtained to determine its nitrogen, phosphorus and potassium content. Growers should adopt a program of routine manure analysis that includes total Kjeldahl nitrogen, ammonia nitrogen, phosphorus and potassium. Only then can accurate decisions be made in proper manure application to provide crop nutrients while protecting ground and surface water resources.

is contained in complex protein molecules of digested forage and feed. Nitrogen in this form is called organic nitrogen. The remaining fraction of the total nitrogen in manure is in the form of ammonia or ammonium nitrogen. After manure is voided by the animal, organic nitrogen is subject to conversion to ammonia nitrogen by bacteria; this process occurs to a significant degree in some types of manure storage.

Because ammonia nitrogen is the form most available to plants (after being quickly converted to nitrate by soil bacteria), it is important that the fraction of total nitrogen that is ammonia be known for good nitrogen management. Again a laboratory analysis is required for accuracy. Ammonia nitrogen can be lost to the atmosphere as a gas (volatilization) if the manure is surface applied without incorporation. The amount lost as a gas is difficult to predict because the process depends on many factors such as soil and atmospheric temperature, wind and humidity conditions at the time of spreading, application method (multiple light applications vs. a single heavy application), timing of application relative to optimum nitrogen uptake period (growing season) for the crop. Many of these factors cannot be controlled by the farmer. Published values for plant-available ammonia nitrogen from surface-applied manure range from 20 to 80 percent. Actual plant-available nitrogen in any given case depends on the factors noted above. If manure is a significant part of a crop fertility program, the farmer must consider the possible need for supplemental application of commercial fertilizer nitrogen in the event that plant-available nitrogen is in the lower end of the range noted above. The Missouri Department of Natural Resources requires that a value of 60 percent be used in estimating plant-available (surface applied, no incorporation) ammonia nitrogen unless supporting data or procedures suggest otherwise.

Organic nitrogen must be converted to the ammonium form by soil bacteria before plants can use it. This process is called mineralization. The rate at which this conversion takes place depends on several factors such as manure type, soil moisture, temperature and pH. Published values suggest that 20 to 90 percent of organic nitrogen in manure may be converted to plant-available forms during the year in which it is applied. The Missouri Department of Natural Resources requires that a value in the range of 45–62 percent (depending on manure type) be used in estimating cumulative availability of organic nitrogen unless supporting data or procedures suggest otherwise.

Soil bacteria convert ammonium nitrogen to nitrate, primarily at soil temperatures above 50 degrees Fahrenheit. Nitrates are the major form of nitrogen that plants take up and convert back into organic nitrogen as plant tissue, thus completing the cycle. Nitrates are readily dissolved in water and, because they are not retained by the soil, they can be lost. This process, called leaching, is most likely to occur in well-drained soils with resulting potential for groundwater pollution. Land application of nitrogen in concert with soil tests and crop requirements will minimize this potential.

Nitrates can also be lost from the soil through a process called denitrification. This process takes place in soil saturated with water under anaerobic conditions. Nitrate nitrogen is converted to nitrogen gases that are lost to the atmosphere. Unless soils remain saturated for extended periods of time, nitrogen losses by this process are minimal.

Phosphorus

Phosphorus in manure is present in both organic and inorganic forms. However, published values suggest that 75–80 percent of manure phosphorus is available to plants in the year that the manure is spread. Phosphorus is the least mobile of the three nutrients in soil and, under certain conditions of low soil pH, phosphorus buildup in the soil may be noted. Because of the tendency of phosphorus to remain attached to soil particles, leaching to groundwater is not usually considered a problem.

The primary environmental concern with phosphorus is the possibility of phosphorus-laden soil eroding into surface waters, or soluble phosphorus carried by runoff to surface waters. This can result in an undesirable condition called eutrophication, which is excessive plant growth in lakes, ponds or streams.

Potassium

Manure potassium is a soluble form and is considered to be immediately and completely available to plants when it is applied. Potassium is moderately mobile in the soil. It can accumulate to levels detrimental to plant growth, although this condition is unusual.

Small amounts of potassium may leach to the groundwater in sandy soils, but it is generally not considered to be a groundwater pollutant.

For further information

Agricultural Waste Management Field Handbook. Natural Resources Conservation Service, United States Department of Agriculture.

MWPS-18. *Livestock Waste Facilities Handbook,* 2nd edition, 1997. Midwest Plan Service, Iowa State University, Ames.

"Plant-Available Nitrogen Procedure" 4/17/98. Water Pollution Control Program, Missouri Department of Natural Resources, Jefferson City, Mo.

Soil Test Interpretations and Recommendations Handbook, rev. 12/92. Department of Agronomy, College of Agriculture, University of Missouri.

MU publications

G9181, *Agricultural Phosphorus and Water Quality*

G9182, *Managing Manure Phosphorus to Protect Water Quality*

Published with partial support from the Missouri Department of Natural Resources and the Environmental Protection Agency, Region VII. To learn more about water quality and other natural resource issues, contact the Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102. Toll free 1-800-334-6946.

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