AEN-113

Cooperative Extension Service

# Nutrient Management Concepts for Livestock Producers

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Nutrients are constantly cycling through farms. Nutrients come onto a farm in the form of feed, commercial fertilizers, manure, or compost, and they leave the farm with harvested crops, sold livestock, and off-site disposal of manure and other waste. Sometimes nutrients are even lost to the air, soil, or water. Nutrient management allows farmers to use nutrients (specifically nitrogen, phosphorus, and potassium) wisely for optimal economic benefit with minimal impact on the environment.

Approximately 80 percent of nutrients fed to an animal pass through the gut and into its manure. If managed correctly, the nutrients and organic matter in this manure can be recycled to produce crops and save producers money. If managed incorrectly, manure can contribute to nonpoint source pollution that threatens water quality. One practice that reduces the impact of agriculture on natural resources is nutrient management planning, which involves monitoring and recording all aspects of soil fertility, manure sampling, and crop production so that air, soil, and water resources are not compromised.

There are two types of documents used for nutrient management planning: a nutrient management plan (NMP) and a comprehensive nutrient management plan (CNMP). Generally, a comprehensive nutrient management plan is written by a professional other than the producer, is more thorough and detailed, and accounts for all aspects of nutrients on the farm. A nutrient management plan often is written by the producer and is a more basic, hands-on document. At this time, the difference between an NMP and a CNMP is a technical difference between the federal and state agencies requesting and developing the documents; however, the concept behind each document is the same.

**Figure 1.** A poorly managed winter feeding area for cattle located along a stream is polluting valuable natural resources.

Regardless of the specific plan required or implemented, it is important for livestock producers and anyone using animal manures as fertilizer to understand the concepts of nutrient management. The scenarios described in this publication serve as examples of what producers may see on their operation, although every operation is different regarding crops, nutrient concentrations, manure handling, and land-application equipment.

## Regulation History

In 1994, Kentucky passed the Agriculture Water Quality Act (AWQA) to address nonpoint source pollution from forestry and agricultural operations greater than 10 acres in size. This act relies on voluntary compliance by forestry and agricultural operations to implement best management practices (BMPs) that control, trap, and prevent pollution from reaching surface and groundwater resources. The Agriculture Water Quality Act required full implementation of BMPs, including nutrient management planning, by 2001; but even today, many producers are unaware they need a nutrient management plan. In 1999, the United States Department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA) initiated a unified strategy to encourage all animal feeding operations (AFOs) to develop and implement a NMP within 10 years, meaning that all AFOs should have had a NMP by 2009; however, NMPs are still not widely developed or implemented. In 2011, the USDA modified their policy to require all producers requesting funding or technical assistance for any practice pertaining to manure management to have a comprehensive nutrient management plan (CNMP). This policy provides a financial incentive for a practice that has been required by the Kentucky Agriculture Water Quality Act since 1994. In addition, the Kentucky Division of Water and the EPA can levy fines against producers who do not have a nutrient management plan that is comprehensive in nature or a CNMP. The current fine for non-compliance is up to $25,000 per day.

## Manure Management Basics

If managed incorrectly, manure can create significant pollution problems and put environmental quality and human health at risk. Animal manure contains nutrients that are essential for plant growth, but manure also may contain pathogens, heavy metals, hormones, and pharmaceuticals that can find their way into ground and surface water resources and degrade water quality. Without implementing BMPs to control the generated nutrients, solids, and other pollutants from moving offsite, nearby natural resources can be severely impaired (Figure 1). If managed properly, manure can be beneficially used by land applying to crops, which allows producers to obtain significant crop yields without using inorganic fertilizers.

Producers should consider utilizing these nutrients as a soil amendment and/or an alternative to inorganic fertilizer. For example, 100 cattle weighing 650 pounds confined for 120 days (backgrounding calves) produce approximately 236 tons of solids containing 2,652 pounds of nitrogen, 1,638 pounds of phosphorus, and 1,950 pounds of potassium. Using current inorganic fertilizer pricing, the nutrients produced by these cattle represent approximately $3,000 worth of nutrients.

## Manure Production and Storage

Manure nutrient concentrations are affected by animal type, storage facilities, and land application methods. First, the nutrient concentrations of excreted manures vary among animals, diets, and growth stages (Table 1). These nutrient concentrations then decrease during storage, depending on animal type and storage method (Table 2).

For example, beef cattle excrete manure with a N:P ratio of 3.7, and that manure is deposited on a concrete feeding area exposed to the weather. Table 2 shows that manure held in an unroofed storage area loses leachate and that 75 percent of nitrogen and 85 percent of phosphorus is retained. This causes the N:P ratio to increase because a higher percentage of the original phosphorus was retained during storage. The new reduced nutrient concentrations must be considered when land applying manures.

**Table 1.** Nutrients as excreted per 1000 lbs. live weight per day.

| Animal Type | Total N (lbs.) | P (lbs.) | N:P Ratio |
|---|---|---|---|
| **Beef** (all cattle and calves) | 0.34 | 0.09 | 3.7 |
| **Dairy** | | | |
| Cows | 0.45 | 0.09 | 4.9 |
| Heifers | 0.45 | 0.09 | 4.9 |
| **Swine** | | | |
| Lactating sows with litters | 0.52 | 0.18 | 2.9 |
| Gestating sows, boars, gilts | 0.26 | 0.09 | 3.0 |
| Nursery and finishing pigs | 0.52 | 0.18 | 2.9 |
| **Poultry Litter** | | | |
| Layer | 0.84 | 0.30 | 2.8 |
| Breeder layer | 0.84 | 0.30 | 2.8 |
| Pullet | 0.62 | 0.24 | 2.6 |
| Breeder pullet | 0.62 | 0.24 | 2.6 |
| Broiler | 1.1 | 0.30 | 3.6 |

## Land Application of Manure

How and when manure is applied also affects the nutrient concentration, and therefore, the amount that needs to be applied. The application method affects how much of the nutrient applied will actually be available for plant use (Table 3). This effect varies between nutrients, with nitrogen availability being the most dependent on the application method.

In the case of the previous example, the beef cattle manure is scraped and hauled away in a manure spreader in the spring. The manure is then applied to a pasture without being incorporated. Table 4 shows that manure that is not incorporated within 7 days or more will provide approximately 35 percent of the nitrogen and 80 percent of the phosphorus available for use by plants during the current planting season. This means that the N:P ratio is now approximately 2.1. If the manure was incorporated immediately, approximately 75 percent of the nitrogen would have been retained. Although there are benefits to no-till cropping practices, injecting liquids or incorporating manure provides soil-manure contact, which allows nitrogen to be retained and undulates the soil surface, making it more difficult for nutrients and other pollutants to run off. Injecting and incorporating manures also cuts down on the generation of odors. Applying manure to an actively growing crop, like a forage, would also provide a means for controlling runoff and utilizing the nutrients in manures.

When applying manure in the fall, it is important to consider the retention of nitrogen with and without a cover crop (Table 3). Without a cover crop, only 20 percent of the nitrogen in beef cattle manure or 15 percent of the nitrogen in poultry or liquids originally available will remain, as opposed to 40 percent and 50

**Table 2.** Nutrients retained during storage (% of original amount).

| Manure Storage System | Beef | | Dairy | | Poultry | | Swine | |
|---|---|---|---|---|---|---|---|---|
| | N | P | N | P | N | P | N | P |
| Open lot (cool humid region) | 70 | 80 | 85 | 95 | -- | -- | 70 | 80 |
| Covered liquids and solids (essentially watertight) | 85 | 95 | 85 | 95 | -- | -- | 85 | 95 |
| Uncovered liquids and solids (essentially watertight) | 75 | 90 | 75 | 90 | -- | -- | 75 | 90 |
| Liquids & solids waste storage pond (diluted less than 50%) | 80 | 95 | 80 | 95 | -- | -- | 80 | 95 |
| With bedding in roofed storage | 80 | 95 | 80 | 95 | 70 | 95 | -- | -- |
| With bedding in unroofed storage (leachate lost) | 75 | 85 | 75 | 85 | -- | -- | -- | -- |
| In pits beneath slatted floor | 85 | 95 | 85 | 95 | 90 | 95 | 85 | 95 |
| Anaerobic lagoon or waste storage (diluted more than 50%) | 35 | 50 | 35 | 50 | 30 | 50 | 30 | 50 |

percent, respectively, with the planting of a cover crop. This means that nitrogen has leached, denitrified, or volatilized from the application site, which causes pollution of nearby natural resources. This loss of nitrogen is a serious problem that could be rectified by planting a cover crop, such as wheat or rye.

The application rate also affects nutrient concentration. When a producer applies manure to a field without taking into account the needs of the crop, the manure usually provides more nutrients than the field can use, letting nutrients go to waste. When managing nutrient application, a producer has the choice to base manure application on the nitrogen removed by the field, the phosphorus threshold, the phosphorus index, or something in between. If the manure was applied based on nitrogen removed by the field, then the producer needs to consider what N:P ratio the crop requires (Table 4).

The last calculation in this example showed that the producer would be applying a N:P ratio of approximately 2.1; however, the lowest ratio that a crop requires is 4.1 for corn for grain (Table 4). So if the producer was to calculate the application rate based on nitrogen removal, he would be applying twice as much phosphorus than the crop could remove. This means, under simple assumptions, there would be a build-up of phosphorus in the soil, which can lead to excess phosphorus contaminating ground and surface water resources.

**Figure 2.** Significant increases in soil test phosphorus have occurred on this livestock operation immediately surrounding the production area (white circles) and accompanying dry lots (white rectangle).

## Soil Test Phosphorus

Phosphorus build-up in the soil is a complicated issue that depends partly on the local soil type. Each soil differs from the next in its capacity to adsorb phosphorus, but producers throughout Kentucky need to be aware of phosphorus build-up issues specific to their operation, how to minimize this buildup, and the negative effects it can have on the environment.

High soil test phosphorus levels can impact natural resources, especially water quality. A soil particle has a limited capacity to adsorb phosphorus. Unadsorbed soluble forms of phosphorus may run off from the soil surface and reach surface waters or percolate through the soil profile and reach ground water

**Table 3.** Amount of nutrients available based on application method (% of original).

| Nutrient/Application Method | Availability Coefficient: Poultry or Liquid | Availability Coefficient: Other Manures |
|---|---|---|
| **Nitrogen** (spring applied) | | |
| Incorporation: 2 days or less | 65 | 50 |
| Incorporation: 3-4 days | 55 | 45 |
| Incorporation: 5-6 days | 50 | 40 |
| Incorporation: 7 days or more | 45 | 35 |
| **Nitrogen** (fall applied) | | |
| Without cover crop | 15 | 20 |
| With cover crop | 50 | 40 |
| Small grains (pre-plant) | 50 | 40 |
| Pasture (fall or early spring) | 80 | 60 |
| **Phosphate** | 80 | 80 |
| **Potash** | 100 | 100 |

**Table 4.** Nutrients removed by crop varieties (lbs./yield unit).

| Crop | Lbs./ Yield Unit | Total N | P | N:P |
|---|---|---|---|---|
| Alfalfa hay | 2000/ton | 50.00 | 6.11 | 8.2 |
| Corn for grain | 56/bushel | 0.70 | 0.17 | 4.1 |
| Corn for silage | 2000/ton | 7.50 | 1.57 | 4.8 |
| Winter wheat for grain | 60/bushel | 1.20 | 0.22 | 5.5 |
| Sorghum for grain | 56/bushel | 0.95 | 0.18 | 5.3 |
| Soybean for beans | 60/bushel | 3.00 | 0.31 | 9.7 |
| Tobacco, burley | 1/pound | 0.07 | 0.00 | 17.5 |
| Forage from pastureland | 2000/acre | 10.50 | 1.57 | 6.7 |

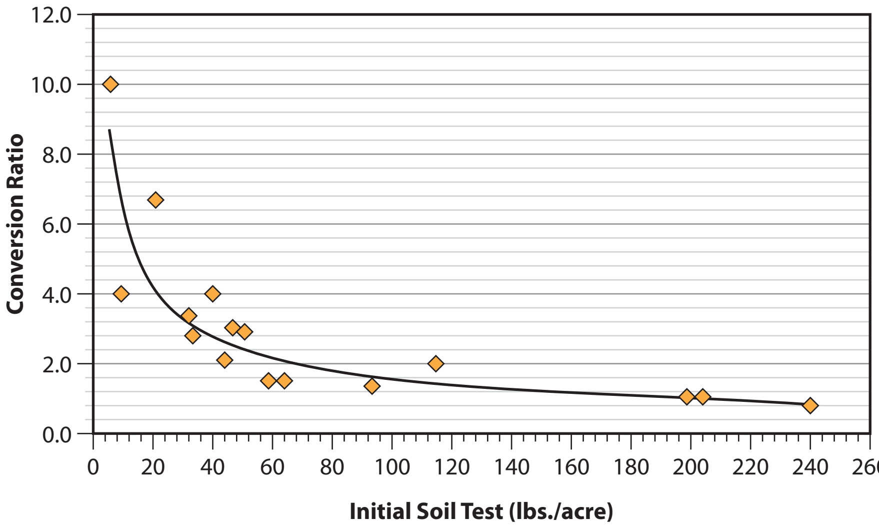


**Figure 3.** Relationship between initial soil test phosphorus and the amount (conversion ratio) of phosphorus (manure or inorganic fertilizer) needed to increase the initial soil test phosphorus by one pound.

resources. In addition, phosphorus that is attached to soil particles may move off-site with sediment when erosion occurs. Nutrient management can prevent the release of phosphorus into water resources.

Soil test phosphorus data have shown that manure application areas closest to the production area are often saturated with phosphorus (Figure 2). This is because producers minimize hauling distance and therefore repeatedly apply manure on the same convenient fields season after season, year after year. Pastures, dry lots, and winter feeding areas often have extremely high phosphorus levels when compared to crop fields that receive manure applications. Nutrients are removed from crop fields, while no removal takes place in pastures, dry lots, or winter feeding areas. It might seem like nutrients are removed when livestock graze these areas, but animals defecate in the fields, supplemental feeds may be deposited, and occasional mowing only controls weeds. Vegetation and nutrients may not actually be removed from these areas, causing the soil test phosphorus to build up exponentially.

Figure 3 shows how the addition of phosphorus (in the form of manure or inorganic fertilizer) increases soil test phosphorus. The data show that if the initial soil test phosphorus is 20 pounds to the acre, it takes approximately 4 pounds of phosphorus, in the form of fertilizer (manure or inorganic), to increase the soil test phosphorus by one pound. If the initial soil test phosphorus is 200 pounds to the acre, it takes approximately one pound of phosphorus to increase the soil test phosphorus by one pound.

There are several interesting points to make about this figure. First, the data show 240 pounds per acre soil test phosphorus as the maximum starting point. If the soil had 400 or 800 pounds of phosphorus per acre initially, which is not uncommon in Kentucky, it would presumably take the addition of even less phosphorus to greatly increase the soil test phosphorus level. The data also show an exponential increase in soil test phosphorus as more phosphorus is added. Soil-test data collected near farmsteads, production areas, animal confinement facilities, manure storage areas, and manure application areas have shown six to ten fold increases in soil test phosphorus in a six year period.

## Summary

This document was created to explain nutrient management concepts to livestock producers so they can comply with federal and state laws and keep the waters of the Commonwealth clean for future generations. Once they understand the basic concepts of nutrient management, producers should begin to take action by implementing nutrient management planning and other related BMPs. A list of basic BMPs and smart nutrient management practices is included on Page 5. Contact the local NRCS, Division of Conservation, and Extension offices to get more information about creating a nutrient management plan and an agriculture water quality plan as well as implementing BMPs.

## Basic Concepts of Nutrient Management

Livestock producers are required by the Kentucky Agriculture Water Quality Act to implement best management practices (BMPs) on a site-specific basis and consider adaptive management practices that could reduce pollution potential related to nutrient management. In some cases, multiple BMPs are needed to trap, filter, and control pollution from moving off-site. The following are some basic nutrient management practices that livestock producers should consider implementing:

- ❑ **Collect soil samples from your entire farm.** Based on the soil data, consider changing fields around to avoid the buildup of phosphorus beyond agronomic levels. Adaptive management, including switching pastures with crop fields and exporting nutrients from the farm, may be necessary.
- ❑ **Collect and analyze manure to determine nutrient concentrations.** Use this data to build a nutrient management plan.
- ❑ **Scrape and remove manure from paved feeding areas, winter feeding areas, and wherever animals congregate.** This prevents clean rainwater from becoming contaminated with manure.
- ❑ **Apply manure to actively growing vegetation to take advantage of the high nutrient concentrations.** Calibrate manure spreaders, and calculate an application rate based on nutrient removal. It is best to apply manure based on a crop's phosphorus removal using a realistic yield goal, and even then, soil test phosphorus may buildup over time.
- ❑ **Harvest vegetation to remove nutrients from the soil.** This prevents pollution of natural resources by preventing the leaching of nitrogen and the buildup of phosphorus in soil.
- ❑ **Buffer dry lots, winter feeding areas, confinement facilities, and other areas where animals are held and fed.** Allow vegetation to grow around these areas to filter pollutants before they can reach a water source or other environmentally sensitive area.
- ❑ **Exclude or limit animal traffic from filter strips** when they are used as a BMP for filtering runoff from paved feeding areas.
- ❑ **Exclude animals from streams and farm ponds.** Create alternative water sources for livestock. Install stream crossings to move cattle from one side of the stream to the other without damaging the entire stream. Build portable shade structures and move mineral blocks to lure livestock away from riparian/streamside areas.
- ❑ **Avoid and buffer environmentally sensitive areas such as streams, sinkholes, karst depressions, and areas around wells when applying manure to prevent contamination.** Vegetation around these sensitive areas traps contaminants and prevents pollution from moving off-site.
- ❑ **Design pastures for a rotational grazing system.** Include adjoining dry lots and winter feeding areas.
- ❑ **Keep records.** Keeping soil sample analyses, manure analyses, cropping history, and manure application history together will help with making nutrient management decisions as well as developing a Nutrient Management Plan and a Kentucky Agriculture Water Quality Plan.

## Resources

- The Agronomics of Manure Use for Crop Production (AGR-165)
- Alternative Water Source: Developing Springs for Livestock (AEN-98)
- Managing Liquid Dairy Manure (AEN-91)
- Nutrient Management in Kentucky (IP-71)
- Paved Feeding Areas and the Kentucky Agriculture Water Quality Plan (AEN-107)
- Planned Fencing Systems for Intensive Grazing Management (ID-74)
- Potential for Livestock and Poultry Manure to Provide the Nutrients Removed by Crops and Forages in Kentucky (IP-57)
- Riparian Buffers: A Livestock Best Management Practice for Protecting Water Quality
- Rotational Grazing (ID-143)
- Sampling Animal Manure (ID-148)
- Shade Options for Grazing Cattle (AEN-99)
- Stormwater BMPs for Confined Livestock Facilities (AEN-103)
- Strategic Winter Feeding of Cattle using a Rotational Grazing Structure (ID-188)
- Stream Crossings for Cattle (AEN-101)
- Taking Soil Test Samples (AGR-16)
- Using Animal Manures as Nutrient Sources (AGR-146)
- Vegetated Filter Strips for Livestock Facilities (ID-189)
- Woodland Winter Feeding of Cattle: Water Quality Best Management Practices (ID-187)

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Lexington, KY 40506 Revised 04-2024