LIVESTOCK MANURE NUTRIENT ASSESSMENT IN NORTH CAROLINA

Prepared by:
J. C. Barker,
Professor,Department of Biological and Agricultural Engineering
and
J. P. Zublena,
Professor, Soil Science Department
North Carolina State University, NC

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Abstract

North Carolina is one of the leading US states in livestock and poultry production. In 1993, the on-farm inventory was approximately 4.4 million animal units, as defined by the U.S. Environmental Protection Agency. Current trends toward farm consolidation, specialization and intensification are sound from an economic and management perspective, but may fail to adequately address important environmental impacts.

A nutrient assessment was initiated to determine where clusters of livestock and poultry are located, to assess manure generation by county, to determine the recoverable manure nutrients which can be made available for plant growth, to determine the quantity of nutrients required for agronomic crops and forages in each county and to determine the balance in each county between plant available manure nutrients and agronomic crop needs.

Approximatelv 27 million tons of fresh manure containing 205,000 tons of nitrogen, 138,000 tons of phosphorus (P205), and 133,000 tons of potassium (K2O) were generated in 1993. About 57% of the total manure was considered collectable. After storage, treatment and field losses, about 19% of the fresh manure nitrogen, 37% of the phosphorus, and 29% of the potassium were considered plant available as fertilizer nutrients. Statewide, about 20% of the nitrogen and 66% of the phosphorus could be met with animal manure. Three counties had enough manure to exceed their nitrogen requirements while 18 counties had more than enough phosphorus.

Kevwords: Livestock, Manure, Nutrient, Distribution, Balance

Introduction and Objectives

North Carolina is one of the leading US states in livestock and poultry production. In 1993, approximately 4.4 million animal units, as defined by the U.S. Environmental Protection Agency, were counted as on-farm inventories. Current trends are toward production farm consolidation, specialization and intensification. These efforts, while being sound from an economic and management perspective, must also consider the full environmental impact which can ensue from the increased generation of unevenly distributed animal manure. Processing by-products and animal mortalities also cont.ibute to the nutrient load to be managed, however, this project only deals with production farm generated manure nutrients.

All animal by-products contain organics and nutrients. Manure organics can provide a fuel source, while the nutrients, if managed properly, can be used as a feed supplement or as a plant fertilizer. "Best Management Practices" (BMPs) for manure used as a feed or fertilizer include manure collection, treatment, storage, and nutrient/feed analysis. Additional BMPs are required when manure is used as a fertilizer. These practices include proper timing, rate, and application uniformity in relation to the nutrient needs of the growing plants. In addition, soil conservation practices to reduce the soil, manure, and nutrient movement off site are needed.

The nutrient assessment project was initiated to: 1) geographically depict where the livestock are located and identify "clustering effects", i.e., high densities of livestock production around support facilities such as feed mills, hatcheries, processing plants, etc.; 2) assess current generation of manure by county; 3) determine the amount of nutrients from manure which can be recovered and made available to agronomic crops; 4) determine the quantity of nutrients required for non-legume agronomic crops and forages in each county; and 5) calculate the percent of agronomic crop and forage nutrients which can be supplied by animal manure.

ObViously, to proceed with a nutrient assessment, many assumptions must be made regarding production methods, manure handling systems, application techniques, crops, and nutrient needs. Most assumptions have been made on a statewide basis, although it is recognized that they will change somewhat county by county. The information is presented to provide a methodology for an animal manure nutrient assessment and to get a first glance as to the carrying capacities of localized areas within the state.

Methods and Assumptions

Manure Characterization

Data on manure, litter, wastewater, and sludge quantities and characteristics are necessary, to assist in the planning, design, and operation of manure collection, storage, pretreatment, and utilization systems for livestock and poultry enterprises. Databases have been developed over the past 12 years containing summaries from a wide base of published and unpublished information on livestock manure production and characterization (Barker et al., 1995). These summaries represent typical domestic food animal and poultry species as well as different farm manure management systems within species. Fresh manure values represent "as voided" feces and urine. Farm manure management systems include the following:

1. paved lot manure scraped within two days either directly into a manure spreader for field spreading or into a short-term storage;
2. annual accumulations of poultry manure with wood shavings or peanut hulls as a litter base;
3. liquid slurry accumulating for 6-12 months from manure, excess water usage, and storage surface rainfall surplus;
4. surface liquid from an anaerob~c treatment lagoon; and
5. bottom sludge from an anaerobic treatment lagoon.

Actual values vary due to differences in animal diet, age, usage, productivity, management and location. Whenever site-specific data are available or actual sample analyses can be performed, such information should be considered in lieu of the mean summarized values.

Collectable Manure

All animals are not raised in confinement where their manure can be easily collected for reuse. Cattle and sheep spend most of their time on pasture. Some hog enterprises consist of dirt or pasture lots. A small percentage of turkeys are still finished on open range. While these unconfined animals still contribute manure nutrients to the pasture system, these nutrients are not addressed in this assessment.

Nutrients Remaining After Storage and Treatment Losses

During the time between manure voiding by the animal and transport to the field for spreading, much of the nutrients can be lost through drying or dilution, surface runoff, volatilization, or microbial digestion. Since different manure management systems either conserve or sacrifice varying amounts of nutrients, an estimate must be made of the percentage of farms using specific systems. Applying these percentages to the manure characteristics appropriate to the specific method gives the remaining nutrients after storage and treatment losses.

Plant Available Nutrients

Estimates of nutrient availability coefficients for various manure management systems and application methods are summarized in Table 1. The plant-available portion of the manure nitrogen was determined by combining a percentage of the ammonia (ammonium) -nitrogen using the appropriate ammonia volatilization value based on the application method with one-half of the organic nitrozen assumed to be plant available during the same year of application. Availability of all other nutrients were based on the application method.

Table 1. Manure Nutrient Plant Availability Coefficients

Crop Nutrient Requirements

Crop nutrient requirements were determined for all agronomic crops (barley, oats, wheat, corn (grain), corn silage, sorghum (grain), cotton, soybeans and burley tobacco; and forages (hay and pasture). Horticultural and silvicultural crops, most legumes and flue- cured tobacco were not included. Nitrogen recommendations for all crops were calculated by using suggested nitrogen fertilizer rates based on realistic yield expectations (Zublena et al., 1994). Crop and hay yields were based on averaging the highest 2 years of the last 5 years according to the 1993 North Carolina Agricultural Statistics (NCDA, 1989-94a) Grass pasture data was obtained from the 1992 Census of Agnculture (USDC, 1994). No nitrogen credit was given to soybeans since they are legumes. No nitrogen credit was given to flue-cured tobacco since its N needs are relatively low and it is very sensitive to N. Burley tobacco has a high nitrogen requirement and was included.

When calculating application rates for phosphorus, specific Soil Test Index values of 10, 40, 70 and 110 from "Crop Fertilization Bases on N.C. Soil Tests" (NCDA, 1987), were used in the computations. These values coincide with the Soil Test Index ranges of 0-25, 26-50, 51-100, and 100+, respectively.

Copper and zinc nutrient recommendations are based on a mineral soil classification. When representative soil samples fall within the range of 0-25 on the Soil Test Index, copper and zinc application rates of 2.2 kg/ha and 6.7 kg/ha were suggested, respectively (NCDA, 1987).

County Nutrient Balances

All county crop acreages were based on "Acres Harvested" from the North Carolina Agricultural Statistics (NCDA, 1994a). County soil test data was obtained from the North Carolina Soil Test Summary (NCDA, 1994b). Organic and inorganic sources of nutrients other than animal manure were not included in this assessment because individual county sources of information for those nutrients were not considered reliable. It would be important in doina a complete nutrient balance to consider all sources of nutrients as well as all crop needs (agronomic, horticultural, silvicultural) in a given watershed.

RESULTS AND DISCUSSION

Manure Characterization

Table 2 gives the mean values of livestock and poultry manure, litter, wastewater and sludge amounts and nutrient concentrations for several animal species and manure management methods. Fresh manure values are mostly taken from published literature sources and with few exceptions tend to be from the 1960s and 70s. Very little new research has been done recently on quantifying and characterizing fresh livestock manures. The remaining databases are more recent and represent measured parameter concentrations. Values were obtained primarily from state analytical laboratories, university research labs, and published literature sources. Primary nutrients have substantial numbers of samples averaged ranging to 1400 for some parameters. Secondary and micronutrients have smaller numbers of values. The databases for manure volumes are rather sparse and are highly dependent on production systems, manure storage and treatment, and climatic factors. Extreme values outside the range of three standard deviations from the mean of the raw data set were not included in the averages in Table 2. The complete databases provide the numbers of samples for each parameter plus the range of values, mean, and standard deviation.

Livestock and poultry on-farm inventories as of December 1993 were obtained from the *North Carolina Agricultural Statistics* (NCDA, 1994). Animal production in North Carolina produced approximately 27 million tons of fresh manure in 1993 (Table 3). These manures contained 205,000 tons of nitrogen, 138,000 tons of phosphorus (P205), 133,000 tons of potassium (K20), 1,700 tons of zinc, and 290 tons of copper.

Collectable Manure

In North Carolina most ruminants are on pasture, while most of the hogs and poultry are fed in confinement where the manure is collected. Table 4 lists the estimated percent of time that animals of various ages and usages are in confinement. From Table 3 approximately 57% of the total fresh livestock and poultry manure is considered collectable.

Nutrients Remaining After Storage and Treatment Losses

Table 4 gives estimates on the percent of farms using either a lot scrape manure collection method, a liquid manure slurry handling and storage method, or an anaerobic treatment lagoon. Using the appropriate manure characterization databases, approximately 35% of the nitrogen, 50% of the phosphorus, 40% of the potassium, 47% of the zinc, and 71% of the copper were available for land application after handling, storage and treatment losses (Table 3).

Plant Available Nutrients

All lot scraped manure, liquid manure slurry, and lagoon sludge were assumed to be soil incorporated within 48 hours of application. Dry poultry litter was assumed to be equally divided between surface broadcast and soil incorporation. All lagoon liquid was assumed to be irrigated without soil incorporation. From Table 4, a 50% mineralization rate for organic nitrogen was used for all manures. The appropriate plant nutrient availability coefficient corresponding to the application method was chosen from Table 1. Approximately 19% of the fresh manure nitrogen, 37% of the phosphorus, 29% of the potassium, 34% of the zinc, and 60% of the copper were determined to be plant available. This illustrates the transient nature of manure nutrients and how they can be affected by collection, handling, storage, treatment and application method.

Crop Nutrient Requirements

When considering on a state-wide basis the nutrient requirements of all non-legume agronomic crops and forages and the plant available nutrients from livestock and poultry manure, about 20% of the nitrogen, 66% of the phosphorus, 85% of the zinc, and 42% of the copper needs can be met with animal manures.

County Nutrient Balances

Figures 1 and 2 present geographically the nutrient distribution and balances by county for nitrogen and phosphorus, respectively. From Table 5, at the county level in 1993, 3 counties (3% of state) had enough animal manure to exceed the nitrogen requirements of all non-legume agronomic crops and forages, while 55 counties (55% of state) could only supply less than 10% of their nitrogen needs with animal manure. However, 18 counties (18% of state) could exceed their phosphorus needs with animal and poultry manure, while 29 counties could supply less than 10% of their needs.

Figure 1. Percent of non-legume agronomic crop and forage nitrogen needs supplied by recoverable plant available manure nutrients.

Figure 2. Percent of non-legume agronomic crop and forage phosphorus needs supplied by recoverable plant available manure nutrients.

Table 5. Summary of North Carolina County Livestock Manure Plant Available Nutrient Balances with Agronomic and Forage Crop Needs.

SUMMARY

Information derived from this livestock manure nutrient assessment project can be geographically depicted to serve as a tool for:

1. determining where the livestock are located and identifying "clustering effects";
2. evaluating the quantities of manure nutrients available for plant gro~vth and how they may supplement the inorganic nutrient sources in a given area;
3. assessing the potential for nutrient impairment of water resources; and

4. providing a decision-making guide for future county or area-wide growth and development.

Nutrient assessments can be used for layers in a geographic information system (GIS). Obviously, large volumes of data must be manipulated and computerization is a must.

This assessment is being used by the North Carolina Cooperative Extension Service to focus and network educational efforts on animal manure management where there is the greatest need. Discussions have been initiated with livestock and poultry integrators on the need to consider dispersing livestock operations to prevent nutrient "saturation" in localized areas. This excess nutrient load might be sources of water impairments if they exceed the crop nutrient needs of the area. The information is shared with county commissioners, planners, and commodity advisory boards.

Meetings have also been conducted with representatives of the inorganic fertilizer industry to explore opportunities for incorporating organic sources into existing fertilizer operations.

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LIVESTOCK MANURE NUTRIENT ASSESSMENT IN NORTH CAROLINA

INCLUDED

- Beef
- Dairy
- Swine
- Horse
- Layer
- Broiler
- Turkey
- Animal time in confinement
- Scraped lot semi-solid manure
- Urine
- Litter
- Liquid manure slurry
- Wastewater
- Anaerobic lagoon liquid
- Anaerobic lagoon sludge
- Plant available nutrients
- Barley, grain
- Oats, grain
- Wheat, grain
- Corn, grain
- Corn, silage
- Sorghum, grain
- Soybeans
- Tobacco, burley
- Hay
- Pasture

NOT INCLUDED

- Aquaculture
- Exotics
- Sheep
- Goat
- Veal
- Animal time on pasture/drylot
- Animal mortalities
- Feedlot runoff
- Processing by-products
- Nutrients biodegraded, scavenged, immobilized, volatilized, lost
- Horticultural crops
- Legumes
- Peanuts
- Soybeans, (N)
- Silvicultural crops
- Tobacco, flue-cured