Using the Dutch Nutrient Management Yardstick Model to Assess On-Farm Nutrient Balance in a System’s Farm

Introduction:

The council for Agricultural Science and Technology in 1996 recommended changes in animal diets in order to decrease nutrient outputs (CAST, 1996). Since then, the concentration of animal production units has continued, public concern about the environmental effects of animal manure has increased, and the Environmental Protection Agency (EPA) has proposed more restrictive requirements for concentrated animal feeding operations (CAFO regulations). Three nutrients that are mostly regulated by the EPA are nitrogen (N), phosphorus (P) and potassium (K). The two nutrients of great importance in animal nutrition and that are greatly regulated in animal production by the EPA are nitrogen (N) and phosphorus (P) (Allee et al., 2001; Chase, 1999). Nitrogen is a part of amino acids (AA) that form proteins required by all animals to meet their daily nutrient requirements (NRC). Animals consume proteins and AA and then excrete various forms of N. Phosphorus is a mineral nutrient required for bone growth and many important bodily functions (NRC 1994, 1996, 1998 & 2001). If these nutrients are directly discharged into surface water through runoff or deposited in water from other emissions, this will cause water pollution significantly. Volatilized N in the form of ammonia (NH₃) as a pollutant returns to the soil or surface water through rainfall. Volatilized NH₃ also contributes to odor problems (Hobbs et al., 1996). Nutrients excreted in livestock and poultry feces have always been seen as excellent sources of manure nutrients. However, as livestock and poultry units have increased in size, it has become more expensive to return manure to cropland that is sometimes saturated with such nutrients (CAST, 1996). Because there has been little pressure to decrease nutrient excretion, livestock and poultry producers have typically overfed protein (N) and phosphorus (P). Decreasing the amount of N and P excreted by poultry, swine, or cattle can minimize environmental pollution concerns for Wisconsin residents, reduce animal production costs (through reduced feed costs), and consequently increase revenue and profits for Wisconsin livestock producers.

Increasing livestock densities per unit area and the ever changing inter-relationship between animal production and the environmental impact of nutrient losses from livestock units are increasing the necessity for increased nutrient management on farms. The flow of nutrients and the management of these nutrients are directly associated to inputs and outputs within managed farm systems. In the comprehensive nutrient management plan, sampling, data collection and analysis play essential roles in allowing farming systems to use the most accurate data obtained from the accurate analysis of randomly collected representative samples to achieve a mass nutrient balance in a farm system. Although sampling and sample analysis methods or procedures have been published, there is very little knowledge in the area of models for accurately calculating comprehensive nutrient management plan in farming systems.

An on-farm pollution tool developed by the Centre for Agriculture and Environment in the Netherlands has been adapted for use in the United States by the Institute for Agriculture and Trade Policy in cooperation with the Blue Earth River Basin Initiative. Pioneer Farm has collected and analyzed samples obtaining valuable data that can be used to promote improved nutrient accountability for the benefit of livestock producers and the environment. The objective of this project is to organize these data into manageable data sets and use the nutrient
management tool yardstick to assess Pioneer Farm system’s nutrient balance. The goals of this objective are to assess on-farm nutrient balance in a farm system, use information gained from the baseline data to design livestock feeding programs that allow for reductions in nutrient feeding and excretion as well as reducing production costs associated with excess nutrient feeding, thus increasing producer profits.

**Procedures:**

Pioneer Farm collected samples, analyzed them and obtained research data on livestock feeds & other feedstuffs as nutrient input sources, manure & fertilizer as a nutrient input source on cropland application, and livestock or livestock product sale as nutrient output sources on the farm. Random sampling of feedstuffs, feed and manure in each of the three livestock enterprises (swine, beef & dairy cattle) were key to obtaining information on nutrient input and output on the Pioneer Farm. Data sets increased exponentially since the start of data collection some three and a half years ago at the Pioneer Farm. Data sets also existed from the analysis of milk samples collected from the bulk tank, feed samples randomly collected from each of the different swine, beef and dairy cattle diets. Liquid manure nutrient data available included data from hog slurry and dairy lagoon manure, and solid manure nutrient data available included data from analysis of randomly collected samples from several locations within each enterprise manure pile. Initially herd livestock inventories were taken for each of the enterprises with initial weight data recorded for each of the animals within each calendar year. Birth weight data were recorded for newborn livestock. Replacement stock purchased and brought onto the farm were weighed at the “farm gate” as they were introduced onto the farm. Dead animal weight data were recorded for animals that died within each calendar year nutrient input/output cycle. The total number of animals sold per period (year) and the average market weight data for animals sold off the farm for slaughter, as feeders or replacement breeding stock were recorded too. Dairy milk weight data for milk produced and sold in the dairy herd were also recorded. Weights for crop product yields for raised feedstuffs (corn, oats, forages, & hay) were recorded. Data from the analysis of N, P and K nutrient content for samples of raised feedstuffs, forages, hay as well as crop residue used for animal bedding were also recorded.

The Dutch Nutrient Management Yardstick is a mass balance tool designed to aid farmers identify the sources of nutrients entering and leaving the farm. This tool allows farmers to make more informed decisions with regards to ways to deal with nutrient loading on the farm. Nutrient inputs included all purchased feeds or feedstuffs, fertilizers, and replacement animals entering the farm premises. Nutrient outputs included meat animals, milk, crops, and manure sold off the farm. The program has built in default values for nutrient inputs from legume plants (e.g N fixation) and rain (e.g N deposition), and nutrient losses from leaching into the soil. The goal of mass balance on the farm to the farmer is to be near zero nutrients after mass balance taking into account both nutrient inputs and outputs on the farm. The Dutch Nutrient Management Yardstick Excel Spreadsheet version was used for data analysis for nutrient mass balance at the Pioneer Farm. The key to using The Dutch Nutrient Management Yardstick is the fact that the farm has kept a good set of records.
Figure 1: Dutch Yardstick Mass Balance Nutrient Flow Diagram

The data sets obtained from all the analysis of samples available in a data bank at the Pioneer Farm were organized into several data set formats (see fig.1: nutrient flow diagram above), quality controlled, entered the data into the Dutch Nutrient Management Yardstick Excel Spreadsheet Program. Nutrient balances were calculated and assessment results were obtained. Other computer models have been proposed to calculate a nutrient balance on the farm; but most have been too complicated or too costly to calculate farm nutrient balance. The Dutch Nutrient Management Yardstick has proven its worth in calculating a nutrient balance in the Netherlands as well as some other countries in Europe where environmental pollution is a priority in the farming systems.

Results:

The Dutch Nutrient Management Yardstick Program took these data presented in these specialized formats and allowed for all the variables to be read properly, analysis carried out and printed outputs or reports made available for conclusions to be drawn from the Pioneer System’s Farm. The total nutrient input and output were computed by multiplying the total
number and/or weight of the input or output factor at the farm gate by the nutrient content value obtained from the chemical analysis. The values for N deposition was as well as fixation were obtained by multiplying the total acres of cropland by the N deposition rate of 6 lbs/acre/year and the acres of legume by the N credit, respectively. After the Dutch Nutrient Management Yardstick Excel Spreadsheet computed the N, P & K totals, subtracted the nutrient outputs from the inputs to obtain the farm nutrient balance. Computations for the whole farm nutrient balance for the 2003 calendar year resulted in positive balances for N (96 lb/acre), P (8 lb/acre), and K (24 lb/acre). A positive nutrient balance indicates a nutrient surplus, or nutrients that are not utilized on the farm.

Many factors are associated with a farm system resulting in a nutrient surplus per calendar year. Overfeeding nutrients in livestock diets is one primary factor. Some progress has been made to decrease the nutrient output (excretion) of these nutrients by animals through diet modification and nutrition (Call, 1986; Cromwell, 1992). The amount of nitrogen excreted by livestock (dairy & beef cattle, swine, etc.) is influenced by three factors: the amount of N consumed, the efficiency with which the dietary N is used by the animal for growth and other functions, and the amount of endogenous N. Little can be done to influence the amount of endogenous N excretion. Thus, in order to decrease the amount of N excreted by livestock, either the amount of N consumed must be decreased (Prince et al, 2000) or the efficiency of utilization of dietary N must be increased (Hobbs et al, 1996), or both.

Dairy cattle (NRC, 2001), swine (NRC, 1998), beef cattle (NRC, 1996) and poultry (NRC, 1994) should be fed diets that meet each animal’s requirement for available phosphorous (P). One main reason producers feed excess P to livestock is because it is believed that P improves reproductive efficiency and fertility. Although feeding less P has been reported to negatively affect fertility and milk production, there is no evidence that overfeeding this nutrient will significantly improve reproductive efficiency (Satter and Wu, 1999; Knowlton, 2002). Overfeeding phosphorus occurs sometimes because producers are uninformed about livestock nutrient requirements, are unaware of the nutrient content of phosphorus in feeds, or are easily convinced by feed sales agents and consultants that their livestock requirements must be increased in order to increase productivity or fertility. Nearly all the excess phosphorus fed to livestock above their daily requirements is excreted in animal waste (Knowlton, 2002). Livestock producers also add excess phosphorus to their land by adding extra phosphorus from other inorganic sources, such as chemical fertilizers, which continue to add to the pollution problems faced by farmers (Yungblut, 2002). The other factors are the increase in nutrient input on the farm as well as the inability to export excess nutrients off the farm.

Some comparisons were done for data set analysis from the 2002 and the 2003 calendar years. Computations for the whole farm nutrient balance for the 2002 calendar year resulted in positive balances for N (93 lb/acre), P (21 lb/acre), and K (42 lb/acre). The reason for the decrease in nutrient surpluses in 2003 was the depopulation of the Swine Center and consequently the reduction of inputs (purchased feeds & feedstuff supplements and animal bedding for the swine unit).

Conclusions:

The goal of using The Dutch Nutrient Management Yardstick Mass Balance Excel Spreadsheet is to make farmers aware of nutrient loading on the farm, thus allowing them to make changes
where ever possible to reduce nutrient load on their farms. The main impact on livestock farms is in how livestock are fed in order to arrive at a near zero nutrient balance. At the Pioneer Farm results indicated positive or surplus balances in all the three main nutrients being measured. In subsequent data analysis and results presented here, several factors were observed to have contributed to the nutrient surpluses on the farm. Analysis of animal diets as a whole indicated that we were overfeeding these nutrients in diets and consequently increasing nutrient excretion in these livestock units. Therefore decreasing the amount of crude protein and phosphorous fed in diets will decrease the amount of N and P excreted by swine and cattle as such will minimize environmental pollution concerns, reduce animal production costs (through reduced feed costs), and consequently increase revenue and profits for Pioneer Farm. Other solutions to the surplus nutrient balances at the Pioneer Farm would include either increasing crop acreage to increase manure utilization on the farm for crop production or exporting excess manure away from the farm. Incidentally, Pioneer Farm has adopted a new concept of composting manure with future plans to export it off the farm thus decreasing nutrient saturation on the farm.

Results obtained in the project will foster knowledge sought by today’s Wisconsin livestock, forage and grain producers to practice environmentally sound agriculture by reducing excessive nutrient input on the farm, nutrient excretion by livestock, as well as nutrient application to crop land. These results will compliment research knowledge that is being sought by Pioneer Farm in particular, Wisconsin Agricultural Stewardship Initiative, and the Wisconsin farmers in general.

**Literature Cited**


