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# POTENTIAL FOR REDUCING NUTRIENT LOADS TO THE CHESAPEAKE BAY WITH IMPROVED LIVESTOCK WASTE MANAGEMENT

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## ABSTRACT

An extensive literature review was conducted to evaluate best management practices (BMPs) and for the agronomy, dairy, swine and poultry industries in the Chesapeake Bay watershed. This indepth evaluation will be applicable in developing new tributary strategies for further reducing nutrient loads from agriculture. Emphasis was placed on reviewing new technology for nitrogen and phosphorus agronomic BMPs and new manure management BMPs. Manure management BMPs included treatment and modifying poultry and animal diets to decrease manure nutrient excretion in the manure. Manure management practices that may effect the dairy industry in the Chesapeake Bay watershed include dietary manipulation to optimize amounts of rumen degradable protein and rumen nondegradable protein in cattle feed and use of low protein roughages such as corn silage or low protein concentrates. Dietary manipulation will reduce excretion of N in manure and reducing P levels in feed rations for high producing cows to about 0.40%. Feed modification in the swine industry has included adding phytase to the diet, formulating the crude protein according to requirements, incorporating non-starch polysaccharides in the diet to move N excreted in the feces and less in the urine and supplementing with synthetic amino acids. The manipulation of the pig's diet to reduce nutrient excretion is feasible and practical, but economics is still a major issue in using this technology. One of the major poultry industry issues in the watershed is the concentration of broiler production in some areas. The broiler diet can be modified to reduce the excretion of P. Two practices that are being used include adding phytase to the feed and using high available phosphorus corn in the diet. Alternative uses of manure is also an option.

Keywords: Nitrogen, phosphorus, manure, Chesapeake Bay, dairy, swine, poultry

## INTRODUCTION

The Chesapeake Bay watershed has a land area of approximately 180,000 $km^2$ , and a total water surface area of 9890 $km^2$ . Of this water surface area, 390 $km^2$ are tidal fresh water, 9,190 $km^2$ are a mixing zone of fresh and salt waters, and 300 $km^2$ are salt water. The Bay is rather shallow, with a mean depth of 10 m. There are six major basins within the Chesapeake Bay watershed. These are the Potomac, Susquehanna, Rapahannock, York, James, and Patuxent basins. These basins supply 90% of the flow to the Chesapeake Bay watershed. The Susquehanna River alone drains 43% of the watershed and contributes nearly 50% of the freshwater. Agriculture is the largest contributor of nonpoint source nutrients. With the 2000 Bay Agreement further nutrient load reductions are being developed than the original reductions in the 1987 agreement. Since livestock and poultry are large sources of N and P in the watershed, further reductions in nutrient loads from animal agriculture will have to be developed. This paper will discuss the potential for N and P reductions in manure if manure management technology is implemented.

## DAIRY BMPS

Typical manure handling methods in the watershed today are daily spread, solid manure handling with bedding and storage, scrape and storage in a tank or basin and a lagoon and flush system. Some new manure management systems may have potential for reducing nutrients. Solids separation can be used in the dairy industry with a flushing system or scrape system. Solids can be removed by sedimentation or by mechanical separation. Separation by mechanical means can be accomplished by a number of means including a screw press separator, drag chain separator, stationary inclined screen, roller presses or vibrating screens (Hartzell,2001). Solids separation probably the potential to remove from 20% to 50% of the N and P from liquid or slurry dairy manure. (Moore, 1989, Chastain et al., 1999). Addition of chemicals to aid in the sedimentation of solids will increase N and P removal rates, but the increased cost may not be justified. Separated solids can be composted and dried to be used for bedding or sold or applied to the dairy farm's land.

One manure management method that may have promise for large dairy farms in the future is anaerobic digestion. Zucker et al.(1997) completed a feasibility study on anaerobic digestion in Livingston County, New York, where a 100 farms surrounding York have more than 30000 dairy animals in a 20 mile radius. The economic analysis indicated on-farm facilities would be more feasible for large dairy operations of 850 cows or more within a regional facility with 4000 cows.

Composting is an established on-farm manure management practice. One composting constraint is the requirement for relatively dry manure or a bulking agent. There are a number of multi-farm operations that already exist in the Northeast. Shared mobile composting equipment would make composting more feasible on small farms. A centralized facility could be run by a private contractor. Biodrying is a special form of composting has the ability to reduce dairy manure from

12% solids to 40% solids. Recycled compost at 40% solids would be spread in the alleys of the dairy farm 7.5 cm inches thick to absorb one days production of manure. The mixture then would be scraped into the shed to compost. The recycle loop could continue indefinitely (Wright, 2000). This system would be suitable for small dairy farms that do not use liquid manure handling (Wright, 2000). Sequencing batch reactors and integrated manure systems also have potential for reducing nutrients and have been tested on a number of farms.

Manipulating N and P in feed has potential for reducing nutrient excretion. Sutton et al. (2001) concluded after an extensive literature review that using multiple strategies to improve nutrient utilization in dairy cattle, N and P feeding could be reduced by 30 to 40 % which would result in less of these nutrients being excreted in manure. Because of the gamble of feeding less N and P may result in less milk production, verification of research on-farm will be needed as an incentive for farmers to adopt new feeding technologies. Some of the feeding strategies include:

- Dietary manipulation to optimize amounts of rumen degradable protein and rumen nondegradable protein in cattle feed and use of low protein roughages such as corn silage or low protein concentrates will reduce excretion of N in manure. Nitrogen should not be based only on crude protein level (CP).
- Reduce P levels in feed rations for high producing cows to about 0.40% as recommended by the NRC (NRC,2001).
- Increased use of home grown feeds can provide a better nutrient balance on a dairy farm.

## SWINE BMPS

In the Chesapeake Bay watershed, swine are raised in enclosed buildings or on open lots with shelter. In most cases manure is handled as a liquid or semi-solid. For open lots either an earthen manure storage basin or anaerobic lagoon is used. The manure may be scraped or flushed into the storage basin or lagoon. In Pennsylvania nursery and grower-finish facilities generally have a deep pit under slotted floors (Kephart, 2000). Sow units almost always have shallow pits with outside storage. In Virginia hogs producers are more likely to use open lots than in Pennsylvania. Anaerobic lagoons and flushing systems are used more in Virginia and other southeastern states.

Some of the newer manure treatment options being tested in North Carolina may help with nutrient management (Humenik, 2001). Solids separation will help remove nutrients from the waste stream. Addition of polymers may increase the rate of solids removal. These solids could be sold and moved off the farm. Composting of anaerobic digestion solids may also help to alleviate the nutrient balance on some swine farms. Sequencing batch reactors and constructed wetlands may be two of the new treatment technologies that may have application on some swine operations to remove nutrients.

Researchers have attempted modification of the nutrient content of pig diets in order to enable more effective utilization of dietary nutrients and reduce losses through excretion. Various different strategies have been experimented with, among which increasing crude protein (CP) content of diet, adjusting dietary electrolyte balance (dEB), and supplementing with phytase are the most common. Pigs are unable to utilize organic phytate bound P in their diets because they lack the enzyme phytase. Hence swine diets are often supplemented with inorganic P in order to meet dietary requirements. Formulating diets based on optimal growth requirements rather than maximum growth requirements could reduce P input by about 8%. Incorporation of phytase in the diet and reduction of inorganic P in the diet can reduce P input by about 20% and incorporation of both practices can result in a 28% reduction in P input and about 30% reduction in P excretion (Prince et al., 1998). Incorporation of non-starch polysaccharides in the diet, reducing CP content in the diet and supplementing with synthetic amino acids are promising options for reducing N excretion in the manure. Reducing CP and supplementing with synthetic amino acids may decrease N excretion by up to 25%. Phased feeding can help reduce N excretion in the manure by 10% or more and P by 15% or more. Using phytase in the pig's diet has the potential to reduce P excretion in the manure by 10% or more. Ractopamine added to feed has the potential to reduce manure production and N and P excretion by 10% or more. However, farm decisions are often made based on cost considerations rather than environmental concerns. Therefore the financial aspects of these options will need to be evaluated before they can be commercially implemented.

## POULTRY BMPS

Delaware, Maryland, Pennsylvania and Virginia are large poultry producers. Broilers are produced on the Delmarva Peninsula and the Shenandoah Valley of north central Virginia. Laying hens and broilers and poultry are produced in southeastern Pennsylvania. Vertical integration of the broiler industry has led to the geographic concentration of poultry growers, resulting in a surplus of poultry litter within these areas of geographic concentrations, most notably the Delmarva Peninsula. Poultry operations produce more manure than any other livestock activity occurring within the Shenandoah and Potomac watersheds.

In recent years there has been an effort to improve the balance between N and P in broiler litter. Many soils where broiler litter has been applied test excessively high in P.

Phytase additions to feed is being used and is being promoted. Chickens lack the enzyme phytase making it difficult for them to digest phytate P. This is critical to broiler health and growth as nearly 70 percent of the total P found in many feed grains is phytate P. Due to the importance of P to poultry health and bone structure and uncertainties as to the exact amount of P in the feed ration that can be utilized by the bird, P is generally overfed to create a margin of safety (Sutton, et al., 2001). The intent of adding phytase to the broiler diet is to reduce the amount of excreted P by making more of the P contained in the feed grains bio-available to the birds. Thus limiting the need for inorganic P supplements to the feed ration. Besides phytase, some *lactobacillus*-based pro-biotics have shown to improve growth and feed conversion in broilers. Angel (2000) found that P retention was increased 22% and N retention was 10% higher in birds fed a low P, Ca and protein diet containing *lactobacillus-based pro-biotics* than birds fed the control diet. Citric acid has also shown to reduce P excreted in the manure along with 25-hydroxycholeciferol (25(OH)D3). In experiments to determine the level of non-phytate P required by broilers and the effect of the feed additives phytase, citric acid and (25(OH)D3), Angel and Applegate (2000) found that 24% less P would be excreted in the manure with reduced non-phyate P diets they found were sufficient for broiler performance to meet P requirements. When phytate is added to the diet with lower P levels, the P excreted in the manure was reduced by 36% The use of citric acid and (25(OH)D3) reduced P excretion in the manure by another 10 % with the low P diet.

High available phosphorus corn (HAP) is another approach. HAP corn is a plant genotype that contains lower levels of phytate P, however it contains the same level of total P as normal corn varieties. In HAP corn 35% of the total P is in the form of phytate P, while in normal corn 75 to 80% of the total P is composed of phytate P (Angel and Applegate, 2000).The use of HAP corn reduces the need to supplement broiler diets with inorganic P, and reduces the P concentrations of excreta as less of the P within the feed is non-available and excreted. The seed company, Pioneer, has conducted studies with both swine and poultry that suggest a 3 to 5 fold increase in the bioavailability of P from HAP corn. With appropriate feed formulation, HAP corn can provide up to a 40% reduction in excreted P (Iragavarapu and Doerge, 1999).

Finding alternative uses for broiler litter is another approach being used. Some of the alternative use practices include:

- Composting of poultry litter. Composting reduces the litter's volume and moisture content making it easier to handle. Composted poultry litter can be more readily transported to nutrient deficit farms easier than litter due to its increased density and reduced moisture content. It can also be sold in bulk or bag to nurseries and landscaping industry. The primary constraints to composting are transportation costs, consumer bias against litter as a compost feedstock, lack of consumer education regarding the attributes and benefits of compost, and entrance into a highly competitive market (Carr and Brodie,1997).
- Broiler litter can also be utilized as a cattle feed supplement is fed to beef cattle. Total Digestible Nutrients (TDN) is a measure of the CP and crude fiber values. Litter that has a TDN of 50 % is comparable to a quality hay. The CP content of litter, after five or six flocks have been grown, ranges between 20-25 %. Feed costs represent 60% of the total cost of raising a cattle herd; by using broiler litter as a feed supplement, feed costs can be reduced by as much as a third. Two methods exist for processing broiler litter to be used as a feed supplement. The litter can be deep stacked and ensiled or it can be heated and pelletized. Litter that is pelletized can be combined with molasses, soybean hulls, corn or

fat to improve the nutritional content of the pellet. Regardless of the method chosen, the litter must be heated to destroy pathogens

- Pelletized poultry litter. Pelletizing poultry litter offers several advantages over raw manure. There is little if any odor, it is pasteurized to destroy any pathogens or weed seeds, and the product is easily handled and much denser, thereby reducing transportation costs. The nutrient content of the pellets can also be manipulated by adding chemical or organic nutrients to the litter prior to drying it to achieve the desired N/P/K/ratio.
- Electric generation. Electricity can be generated from the combustion/gasification of poultry litter. However, manure has a relatively low energy content.

## AGRONOMIC BMPS

The USDA and USEPA have developed a joint strategy for sustainable nutrient management. As part of this strategy three management options for land application of P that are proposed include:

- Managing P based upon agronomic soil P thresholds, so that P applications are based upon crop needs.
- Managing P based upon environmental soil P thresholds, by identifying a critical environmental soil P concentration above which P enrichment is unacceptable.
- Using a P index to limit P application on fields at greatest risk for P loss.

Recent research has shown that new soil tests such as water soluble P, easily desorbable P (Fe-oxide coated filter paper) P flux and the degree of soil P saturation can better predict the loss of P to surface and groundwater than agronomic soil tests (Sims et al., 1998).

Accounting for all N sources is an important BMP. Nitrogen available from manure applications, legumes, soil organic matter, and other sources should be accounted for before supplementary applications of N are made. The importance of accounting for all sources of N varies greatly from farm to farm and region to region, depending on the relative contributions of various sources of N to the soil-crop system. Another important BMP is setting realistic yield goals. One of the important facets in determining N requirements for crops is yield. It is important to set realistic yield goals when deciding how much N to apply. Methods to set realistic yield goals include using farm averages, using a rolling 7- to 10-year field average or adjusting the past average and increase it by a chosen percentage (usually less than 5%) to take advantage of higher-yielding varieties

The most efficient method of using N fertilizer and minimizing it loss is to supply it as the crop needs it. Maximum N use occurs near the time of maximum vegetative growth. If irrigation is used, N may be applied through the irrigation system in four or five applications. For non-irrigated crops, split applications or side-dressings are two effective methods for controlling the timing of application. Manure should be applied as soon as possible after planting except when used as a N source to top-dress small grains.

Early-season soil (preside-dress soil $NO_3$ test)and plant $NO_3$ tests have been developed for estimating available N contributions from soil organic matter, previous legumes, and manure under the soil and climatic conditions that prevail at specific production locations. These tests are performed 4 to 6 weeks after the corn is planted. Early-season soil $NO_3$ tests involve taking soil samples in the top 30 cm of the soil profile. Early-season plant $NO_3$ testing involves determining the $NO_3$ concentration in the basal stem of young plants 30 days after emergence. One disadvantage of the early season soil and plant $NO_3$ testing is that there must be a rapid turnaround between sample submitted and fertilizer recommendations from the soil testing laboratory. If side-dress N fertilizer is being used in conjunction with manure, the early-season $NO_3$ test should help reduce the potential for over fertilization (Magdoff et al. 1987; Iversen et al. 1985).

The use of leaf chlorophyll meters is a relatively new method to measure N in corn. Girardin et al. (1985) demonstrated a strong relationship between N crop deficiency, photo-synthetic activity, and leaf chlorophyll content. They can be used to schedule fertigation later in the season.

With the large number of livestock and poultry in the Chesapeake Bay watershed manure testing is an important BMP. Since it is well known that N and P excretion are directly related to diet and with the increased emphasis placed on diet modification, standard book values for N and P concentrations in the manure should not be used. The manure should be tested as close as possible to the time it is land applied, since nutrients are lost with different methods of handling, storage and treatment.

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