MANAGING AGRICULTURAL NUTRIENTS IN MARYLAND'S CHESAPEAKE BAY BASIN

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Abstract: During the 1970's, water quality in the Chesapeake Bay declined due to increased soil sediments and plant nutrient inputs. One of the solutions proposed by government officials to improve water quality was to adopt a 40 percent nutrient reduction goal, which was to be attained by the year 2000. This goal was outlined in the 1987 Chesapeake Bay Agreement and was adopted by several states. As a result of the Bay Agreement, nitrogen and phosphorus loadings into the Bay from point and non-point sources have decreased by over 16 million kilograms per year. Despite these improvements, the 40 percent goal was not met by 2000 and the deadline was extended to the year 2010. To meet this new deadline, government officials in Maryland have developed several new programs and policies such as the 'Tributary Strategies' Program, the Maryland Nutrient Management Program and the Water Quality Improvement Act of 1998. The purpose of the 'Tributary Strategies' Program is to reduce the amount of nutrients that enter the Bay from each of its tributaries. One of the methods described in the 'Tributary Strategies' Program as playing a key role in reducing nutrients from agricultural non-point sources is nutrient management planning. Nutrient management planning is a series of best management practices aimed at reducing non-point source pollution by balancing nutrient inputs with crop nutrient requirements. The Water Quality Improvement Act provides guidance to the Maryland Nutrient Management Program for the development of nutrient management plans. These plans are developed by certified advisors working for the Maryland Cooperative Extension and certified consultants working for private industry, and are based on soil and manure test results, yield goals and residual nitrogen estimates to generate field-by-field nutrient recommendations. Since the Water Quality Improvement Act was passed, advisors have written plans for over 91,000 hectares of farmland.

INTRODUCTION

The Chesapeake Bay, with an area of approximately 5,960 square kilometers, is the United States of America's largest estuary. It receives about half of its water volume from the Atlantic Ocean and half from its 165,900 square kilometer watershed, which includes areas of six states and the District of Columbia. The Bay is very shallow, averaging approximately 6.5 meters in depth. Compared to other coastal and inland bodies of water, the Bay has a large drainage basin for the volume of water it contains. For the Baltic, this ratio is approximately 43.62 square kilometers of watershed per cubic kilometer of water volume, and the ratios for many other water bodies are only a fraction of the Baltic ratio. This large watershed-area to water-volume ratio coupled with increased spring and summer halocline formation makes the Bay particularly vulnerable to the effects of nutrient pollution. In 1976, concerns regarding declining water quality within the Bay and its tributaries led to a six-year water quality study of the Bay. About forty research projects coordinated by the Environmental Protection Agency (EPA) documented declining water quality and reductions in the numbers and diversity of fish, shellfish and submerged aquatic vegetation (SAV) in the Chesapeake Bay. Eutrophication and turbidity caused by soil sediments and increases in plant nutrient inputs were considered to be the main causes of these declines. Nutrient reduction was

therefore considered to be a major consideration for improving the habitat for benthic organisms and fish. Reductions in nutrients would result in reduced algal blooms and increased light penetration to SAV. Water quality models simulating ecosystem processes along with loading levels from 1985 were used to establish a 40 percent reduction goal for the amount of nutrients, particularly nitrogen and phosphorus entering the Bay from point and non-point sources. This 40 percent reduction goal was outlined in the 1987 Chesapeake Bay Agreement and was to be attained by the year 2000. The signatories of the 1987 Bay Agreement include Maryland, Virginia, Pennsylvania, the District of Columbia and the EPA. In 1997, it was realized that although much progress had been made towards reducing the amount of nutrients entering the Bay, the 40 percent reduction goal for nitrogen would not be met. Therefore, work began on the 2000 Chesapeake Bay Agreement. The 2000 Bay Agreement focused on achieving and maintaining the 40 percent reduction goal set in 1987 and also getting the Chesapeake Bay removed from the federal list of impaired waters by the year 2010. The improvements that have occurred thus far, as a result of the implementation of the 1987 Bay Agreement, include a decrease in the point source nitrogen loads by over 7 million kilograms per year and a decrease in the point source phosphorus loads by over 2 million kilograms per year. Nitrogen loading into the Bay from non-point sources has also decreased by over 7 million kilograms per year and phosphorus loading from non-point sources has decreased by more than 454,000 kilograms per year (1). Despite these improvements, nitrogen loads from both sources need to be reduced by another 18 million kilograms per year and phosphorus loads from both sources need to be reduced by an additional 454,000 kilograms per year (2). State legislators believe that one key way in which non-point source loading will be reduced is to rely on the tributary strategies that are already in place in some of the Chesapeake Basins.

TRIBUTARY STRATEGIES PROGRAM

In 1992, the 1987 Chesapeake Bay Agreement was amended and as a result, each state (Maryland, Virginia, Pennsylvania and the District of Columbia) agreed to develop their own 'Tributary Strategies' Programs by combining existing regulatory programs with voluntary programs. The purpose of a 'Tributary Strategies' Program is to ensure that the 40 percent reduction goal is met by reducing the amount of nutrients that enter the Bay from each of its tributaries. Tributary strategies are important because they provide the opportunity to integrate nutrient reduction efforts through a wide variety of initiatives and also provide a framework for a comprehensive approach to nutrient reduction.

Under Maryland's 'Tributary Strategies' Program, the state was divided into ten major watersheds and a tributary strategy was developed for each watershed. Each watershed's nutrient loads were determined on the basis of point source loads and land use loading rates and areas. Several program and practice options for reducing nutrients exist under the Maryland ‘Tributary Strategies' Program and each option has a specific goal. The options, which have the highest importance in the statewide strategy of reducing nutrients, are building animal waste management systems, using conservation tillage, planting cover crops, enhancing stormwater management and implementing erosion and sediment control plans. Another option, which is a high priority statewide strategy for reducing nutrients, is nutrient management planning. Nutrient management planning is a series of best management practices (BMPs) aimed at reducing nutrient non-point source pollution by balancing nutrient inputs with crop nutrient requirements. Nutrient management planning is considered to be one of the most cost-effective means of controlling excessive nutrient applications. Table 1 provides a list of the goals set by the 'Tributary Strategies' Program and the progress that the combined watersheds have made towards achieving those goals.

Table 1 'Tributary Strategies' Program goals and watershed progress (as of 1998)

Program Option	Program Goal	Watershed Progress
Animal Waste Management Systems	1028 systems	567 systems
Conservation Tillage	137,621 ha.	110,189 ha.
Cover Crops	67,715 ha.	39,532 ha.
Enhanced Stormwater Management	54,635 ha.	8146 ha.
Erosion and Sediment Control Plans	7805 ha.	3226 ha.
Nutrient Management Planning	351,095 ha.	335,364 ha.

Source: Maryland Department of Natural Resources Website (http://www.dnr.state.md.us/bay/tribstrat/index.html)

MARYLAND NUTRIENT MANAGEMENT PROGRAM

Prior to the 1987 Chesapeake Bay Agreement, programs existed to implement some aspects of water quality improvement, but no program was in place to specifically address nutrient management planning. However, it was known that implementation of nutrient management planning could play a key role in reducing the amount of nutrients from agricultural non-point sources. In 1989, the Maryland Department of Agriculture (MDA) and the University of Maryland/Maryland Cooperative Extension (MCE) established the Maryland Nutrient Management Program (MNMP). The primary focus of this program was to place 0.54 million hectares of Maryland's 0.91 million hectares of farmland under nutrient management plans by the year 2000.

WATER QUALITY IMPROVEMENT ACT OF 1998

Prior to 1998, it was the opinion that excess non-point source nitrogen from fertilizers and manures was the main threat to the Chesapeake Bay from agricultural enterprises within Maryland. Thus, nutrient management plans were based on nitrogen recommendations only, and the adoption of these plans by farmers was (with a few exceptions) voluntary. In 1998, the Maryland state legislature passed the Water Quality Improvement Act (WQIA), which according to MDA, "is designed to protect the health of Maryland's citizens and its waterways by establishing both short and long-term strategies for reducing nutrient levels in our rivers and streams". Under the WQIA, all agricultural enterprises with an annual gross income of $2500 or more and livestock operations with more than eight animal units (one animal unit equals 454 kilograms) are required to have nutrient management plans. These plans must now address both nitrogen and phosphorus.

Manure and other organic wastes generally contain high levels of both nitrogen and phosphorus. With the heavy applications of organic wastes to fields to supply the nitrogen requirements of crops, soils have built up excessive levels of phosphorus. This did not seem to be a problem since it had long been the convention that phosphorus was relatively immobile in the soil. Thus by controlling surface runoff and the resultant soil erosion, the phosphorus attached to soil particles would pose little threat to water quality. Therefore, nutrient management plans were based on nitrogen recommendations only. However, researchers have discovered that under certain conditions there could be a significant amount of soluble phosphorus near the soil surface, which can be carried to water bodies in surface runoff. Also, these researchers have found that some soils, primarily those that are shallow and coarse textured, could have significant leaching of phosphorus to groundwater resources.

To address the phosphorus problem, the WQIA mandates which type of nutrient management plan (nitrogen- based or phosphorus-based) an agricultural operation must have. For example, farmers who use commercial fertilizers are required to have nitrogen and phosphorus-based plans developed by December 31,2001 and implemented by December 31, 2002. Farmers who apply animal manure or bio-solids must have a nitrogen-based plan developed by December 31,2001 and implemented by December 31,2002. Farmers applying animal manure or bio-solids must also develop phosphorus-based plans by July 1, 2004, and these plans must be implemented by July 1, 2005. Those who fail to obtain a nutrient management plan are subject to a $250 administrative penalty, a $100 fine for each violation after the first violation, recovery of cost-share grants for projects in violation of the law and limits on future cost-share assistance.

The WQIA legislation applies not only to traditional agricultural operations but other agricultural operations as well. These operations include vegetable growers, organic producers, nurseries, greenhouses, turf grass producers and certain horse farms. In addition to agricultural operations, the WQIA affects nutrient applicators working for the commercial fertilizer industry, private fertilizer applicators and poultry feed distributors. According to the WQIA, applicators working for the commercial fertilizer industry must be certified to write nutrient management plans or work under a consultant who is certified. Those applicators servicing one or more hectares of non-agricultural land or state property are required to apply fertilizers in accordance with the recommendations of the University of Maryland/MCE. Private fertilizer applicators applying fertilizers to more than four hectares of agricultural land in which they own or manage are required to complete an MDA nutrient application

education program once every three years. If private applicators apply fertilizers to one or more hectares of non-agricultural land or state property, they are required to apply fertilizers in accordance with the recommendations of the University of Maryland/MCE. Poultry feed distributors were required by December 31, 2000 to add phytase or other enzymes to poultry feed in order to increase phosphorus use efficiency by the animal thus reducing the amount of phosphorus in poultry waste.

CERTIFIED ADVISORS AND CONSULTANTS

To facilitate nutrient management planning as mandated by the WQIA, the MDA in cooperation with a Nutrient Management Advisory Committee, administers a mandatory certification exam to those who want to write nutrient management plans. To renew a certification, individuals are required to attend 6 hours of continuing education training per year. The MNMP is responsible for implementing the ever-expanding continuing education and training program. After becoming certified and licensed, private consultants and firms are required to report their planning progress to the MNMP annually. In Maryland, there are 219 certified private consultants, however only 107 are currently writing plans. Since the WQIA was passed in 1998, private consultants have written 524 new nutrient management plans for approximately 43,081 hectares of farmland (R. Cuizon, Maryland Department of Agriculture, personal communication). There are also 199 certified consultants in Maryland's government agencies, and 30 of those are MCE nutrient management advisors based in county offices throughout the state. These publicly funded MCE advisors provide nutrient management planning services to clients and also emphasize how such planning enhances farm profitability and improves water quality. Nutrient management advisors develop plans for many clients, however top priority is given to producers with pollution problems, large livestock operations and those in priority watersheds or the 'Chesapeake Bay Critical Area'. After plans are developed for producers in these high priority situations, advisors then develop plans for producers in the following order of priorities: (1) Producers participating in the Manure and Poultry Litter Transport Programs (2) Producers referred by Soil Conservation Districts (SCD) for animal waste management systems or other cost-shared structures requiring nutrient management plans, or farmers with cost-shared structures requesting updated plans (3) Producers using manure from other producers' operations (4) Producers having limited resources in that they cannot afford nutrient management services provided by private industry (5) Producers requesting assistance in order to meet WQIA requirements (6) All other Maryland agricultural producers who can benefit from MNMP educational resources. When developing nutrient management plans, advisors use soil and manure test results, realistic expected yield goals and estimates of residual nitrogen to generate field-by-field nutrient recommendations. By 1998, there were approximately 445,500 hectares of agricultural land in Maryland under nutrient management plans. Over the last 3 years since the WQIA was passed, MCE advisors have written 3344 new plans for Maryland farmland (totaling 91,293 hectares) and 1235 new plans for animal producers (3). In addition to writing plans, advisors perform other free services such as yield checks, pre-sidedress nitrate tests (PSNT) for corn, collecting manure samples to be tested by the University of Maryland Soil Test Laboratory and manure spreader calibrations.

FREE SERVICES

Advisors conduct yield checks to establish realistic yield goals on a field-by-field basis. Yield goals are a critical factor in determining nitrogen recommendations for crops. Another free service provided by MCE advisors is the PSNT for corn, which is the major field-crop in Maryland. The PSNT is an in-season soil nitrate test taken when the corn is approximately 30 cm tall and provides an accurate measure of soil nitrate and the availability of nitrogen over the growing season. This allows farmers to tailor their fertilizer use to existing soil nutrient conditions and reduce their use of 'insurance N' fertilizer as a sidedress application. The PSNT can also predict the amount of N that will become available from previous legumes crops, manure or bio-solids applications, soil organic matter and residual nitrate. This test is best used on fields that have received manure or biosolids, but should not be used if commercial fertilizer is the only source of N for corn production or the total N fertilizer application prior to sidedress (including preplant and starter band N) is more than 56kg/ha. MCE advisors use inexpensive, readily available commercial meters to produce rapid and reliable field specific results. Since 1998, MCE advisors have conducted the PSNT on approximately 36,500 hectares of

farmland resulting in an average reduction of nitrogen application by 30kg/ha (4).

Manure testing procedures are also provided free of charge by the MNMP through a grant from the Maryland Department of Agriculture. These services are provided to all farmers regardless of whether or not they adopt a voluntary nutrient management plan. Advisors demonstrate the correct sampling techniques recommended by the University of Maryland Soil Test Laboratory, which is responsible for conducting the analyses on these manure samples. Advisors also perform manure spreader calibrations on-farm to ensure the tested manure is spread at the agronomically correct rate for the crop being grown.

BEST MANAGEMENT PRACTICES

A range of other initiatives complements the MNMP's free services. These initiatives (Table 2) are provided by the Maryland Agricultural Water Quality Cost-Share Program (MACS) to help farmers install BMPs.

Table 2 BMPs eligible under the MACS Program

Animal Waste Management Systems	Field Borders/Windbreaks	Roof Runoff Management
Conservation Cover	Filter Strips	Sediment Basins
Contour Farming/Orchards	Grade Stabilization Structures	Spring Developments
Cover Crops	Grassed Waterways	Stream Crossings
Critical Area Plantings	Lined Waterways/Outlets	Stream Fencing
Dead Bird Composting Facilities	Nutrient Management Services	Strip Cropping
Diversions	Riparian Buffers	Terrace Systems

Source: Maryland Department of Agriculture Website (http://www.mda.state.md.us/resource/mawqcs10.htm)

The purpose of the MACS Program is to provide cost-share assistance (up to 87.5 percent of cost) to farmers for the installation of eligible BMPs. Since BMPs help reduce soil erosion and protect water quality, their use in certain situations is mandated under the WQIA and the Chesapeake Bay Critical Area Law. For all BMPs, except animal waste treatment and containment projects, the MACS Program will pay up to $20,000 per project and a maximum of $50,000 (when combined with other BMPs). For animal waste treatment and containment projects, MACS will pay up to $75,000 per project and a maximum of $100,000 (when combined with other BMPs). To be eligible for the MACS Program, an individual, or business must be operating a farm in Maryland and must have excessive levels of soil, nutrients or pollution running off into Maryland's waters.

Two other cost-share programs not listed in Table 2 are the Manure Transport (5) and Poultry Litter Transport (6) Programs. These programs were established in 1999 as four year, $750,000 pilot projects, with the purpose of providing cost-share assistance (up to $20 per ton) to animal producers for transporting excess manure off of their farms. The programs were designed to help producers make the transition to phosphorus-based nutrient management plans (as mandated by the WQIA), and are open to those who have high soil phosphorus levels or inadequate land to fully use their manure. Farmers on the receiving end of the transport programs are eligible to accept manure and poultry litter only if these wastes can be safely land-applied according to an agronomic and environmentally sound nutrient management plan.

UNIVERSITY OF MARYLAND RESEARCH

In addition to the cost-share programs provided by MDA for the installation of BMPs, other nutrient reducing strategies are being researched by the University of Maryland. These strategies include reducing the amount of nutrients excreted in animal wastes, developing cost-effective, low-impact nutrient and irrigation solutions for the nursery and greenhouse industries, generating up to date nutrient recommendations for the turfgrass industry, reducing soil erosion and runoff from urban landscapes and reducing phosphorus runoff from agronomic fields.

The current focus of the Animal Nutrient Management Program is to develop ways to reduce the amount of nutrients excreted in animal wastes by increasing nutrient retention. Researchers study how all of the nutritional factors in the animals interact to affect nutrient availability and retention. The animals used in the studies include poultry, beef and dairy cattle and striped bass under commercial conditions. The specific projects in this program include determining the best combination of feed additives to increase phosphorus retention in broilers, turkeys and laying hens, determining the

phosphorus requirements of dairy cows in different stages of lactation and determining nitrogen and phosphorus requirements of striped bass. In addition to research, the Animal Nutrient Management Program faculty educates the public on improving animal diet formulation and nutrient utilization and animal management techniques.

Since the greenhouse industry is the second largest agricultural industry in Maryland, the issue of reducing nutrients is a priority. To address this issue, researchers in the Nutrient Management for Nursery and Greenhouse Industry Program, are studying the development of cost effective, low-impact nutrient and irrigation strategies. The 3 major research projects in this program include (1) a 2-year study determining the nitrogen and phosphorus uptake and leaching potential of container-grown woody perennial species (holly and azalea) using a sprinkler and drip irrigation system (2) a study involving monitoring substrate moisture status and cyclic irrigation control in a soilless substrate (3) a study in which the economics of various nutrient management strategies for container systems are determined. A cross-disciplinary team in this program also developed a World Wide Web based class entitled "Water and Nutrient Management Planning for the Nursery and Greenhouse Industry". Attendees of this class have included growers, consultants and MCE and MDA professionals. In 2000, the class won several national awards including the Outstanding Professional Skill Award and the Gold Medal Award from Agricultural Communicators in Education (7).

In the Turfgrass Nutrient Management Program, faculty members evaluate various kinds of turfgrass (as many as 800) every year in order to generate up to date nutrient recommendations, which are used by golf course operations, turf farms, lawn care companies, governmental properties and parklands. These nutrient recommendations are published biannually as a fact sheet entitled “Turfgrass Cultivar Recommendations for Certified Sod and Professional Seed Mixtures in Maryland”.

In the Urban Nutrient Management Program, the focus is on reducing soil erosion and runoff from urban landscapes and appropriately fertilizing lawns and gardens. MCE staff are responsible for training Master Gardener volunteers who in turn educate homeowners about ways they can reduce fertilizer and pesticide use on their lawns, thus helping to reduce runoff into the Chesapeake Bay. There are currently 556 Master Volunteers who donated over 30,000 hours in Maryland in 1999 (8).

Because phosphorus runoff from agricultural fields has become a high priority, the current research in the Agronomic Nutrient Management Program is focused on ways to reduce this phosphorus loss. Some of the research projects in this program include planting field buffer strips to reduce phosphorus runoff and determining the phosphorus leaching potential from manure. In order to determine what the potential of phosphorus runoff is from a particular agronomic field, soil scientists at the University of Maryland have worked with the Agronomic Nutrient Management Program to develop the Phosphorus Site Index (PSI). The PSI is a process which rates the potential of phosphorus to move off of a field and into a water body. This index is based on numerical values and indicates whether the potential risk for phosphorus movement is low, medium, high, or very high. To help advisors quickly calculate the PSI, the Nutrient Management Software Laboratory at the University of Maryland has developed the PSI software program. This software is a Windows-based program that includes soil mapping unit information for each county in Maryland, soil leaching potential and watershed information. The Software Lab is also in the process of developing a new program entitled “Nutrient Management for Maryland” (NuMan MD). This Windows-based program allows the advisors to make nutrient recommendations based on updated information, and will replace the existing FERTREC program. The updated features of NuMan MD include updated fertility recommendations for all crops to meet Maryland nutrient management requirements, fertility recommendations for an additional 30-40 crops, direct uploading and insertion of soil test file information, and the ability to insert information from existing FERTREC files.

CONCLUSION

Because the Chesapeake Bay is the United States' largest estuary, maintaining its water quality is a top priority. Government officials have designed policies such as the WQIA and the Chesapeake Bay Agreement to provide guidance to the people of Maryland on reducing nutrient pollution going into the Chesapeake Bay. From these policies, important programs have developed such as the Tributary Strategies Program, the MNMP, the MACS Program

and the Manure/Poultry Litter Transport Programs. In addition to these programs, the University of Maryland faculty is continuously conducting research to provide farmers, industries and private landowners with solutions to help reduce nutrients going into the Bay while at the same time maintaining the profitability of the farming enterprise. The combined efforts of everyone in the state is the key to achieving the 40 percent reduction goal and having the Chesapeake Bay removed from the federal list of impaired waters by the year 2010.

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