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A Review of the Federal Clean Water Act and the Maryland Water Quality Improvement Act: The Rationale For Developing a Water And Nutrient Management Planning Process For Container Nursery And Greenhouse Operations[1]

John D. Lea-Cox[2] and David S. Ross[3]
Department of Natural Resource Sciences and Landscape Architecture
University of Maryland, College Park MD 20742

Abstract

Newly enforced provisions of the Federal Clean Water Act of 1972 and new state laws like the Maryland Water Quality Improvement Act of 1998 are forcing agriculture to develop effective procedures to show that they are not polluting our nation's water resources. Formulating a water and nutrient management process for nursery and greenhouse operations that takes both water and nutrient applications into account is very important. Many operations already have implemented improved management practices to conserve water and nutrients. For those operations that do not have these procedures in place, it will be necessary to find cost-effective ways to ensure that these operations can comply with laws, and document that they can effectively reduce the risk of nutrient movement from their operations to a minimum.

Index words: best management practices, clean water, EPA, Maryland, non-point source, nitrogen, phosphorus, point-source, nutrients, total maximum daily load, TMDL.

Significance to the Nursery Industry

The United States Environmental Protection Agency (EPA) is now strictly enforcing provisions of the 1972 Federal Clean Water Act by ensuring that all states implement a Total Maximum Daily Load (TMDL) program for all watersheds. Many state governments are also considering laws and regulations to ensure that non-point sources of pollutants are assessed and regulated. One such law, Maryland's Water Quality Improvement Act, was passed in 1998. This legislation mandates the writing and implementation of nitrogen (N) and phosphorus (P) management plans by December 31, 2002. All N and P applications, from both organic and inorganic sources, will be regulated for all sectors of agriculture, in addition to urban applications of nutrients by commercial nutrient applicators. Nursery and greenhouse operations are therefore faced with the task of finding cost-effective ways to ensure that they comply with these laws and can document that they do not release large quantities of nutrient pollutants into the environment.

Introduction

Non-point (or diffuse) sources of pollutants are having a negative impact on the quality of water in watersheds and aquifers throughout the United States (11). Clean water is a critical requirement of streams and lakes that help sustain natural and managed terrestrial ecosystems, and rivers that maintain viable bay and estuarine ecosystems. The economic, environmental and social importance of improving and protecting water sources is substantial. Human communities place an intrinsic value on having access to and utilizing clean water. It is a part of the quality of life of a community and directly affects the future growth and economic vitality of an area. Given these facts, there is a definite need to address the primary sources of nutrients and other water pollutants that have adverse effects on natural ecosystems and human populations.

The 'Green' industry, which includes the floricultural, ornamental, turf and landscape maintenance industries, is among the fastest growing segments of agriculture in the United States. In 1997, nursery and floriculture industry receipts totaled $10.6B and accounted for 70% of all horticultural farm gate receipts (24). In 1998, greenhouse and nursery products were the third largest wholesale agricultural commodity in Maryland (24), with plant sales totaling $523M and associated landscape services bringing the total 'Green' industry value to $800M (25). Many greenhouse and container-nursery production operations can be classified as intensive agriculture because they use a combination of fertilizers, growth regulators, insecticides, and fungicides to mass-produce landscape and ornamental plants in high volumes on small acreages. Retail greenhouse and nursery operations also tend to be concentrated in and around urban population centers, are very visible to the public, and have the potential to disproportionately impact both urban environments and the public perception of agricultural chemical use (3).

Greenhouse fertility programs commonly utilize high levels of soluble applied nutrients, and total applications of N can reach several thousand kilograms per hectare (≅ lb/A) per year (20). Over half of the irrigation water used by both open and protected horticulture is applied by sprinkler sys-

[1]Received for publication May 1, 2001; in revised form August 6, 2001.
[2]Assistant Professor, Department of Natural Resource Sciences and Landscape Architecture.
[3]Associate Professor, Department of Biological Resources Engineering.

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tems (24). Based on irrigation system design recommendations (1), water applications using overhead sprinkler irrigation can exceed 180,000 liters per hectare (≅ 20,000 gal/A) per day. This can generate from 18 to 90 kiloliters of wastewater per hectare (2,000–10,000 gal/A) per day (3). Nearly half of the plants grown in Maryland are now grown in containers (25), utilizing some kind of soilless substrate. Many growers have ignored the negative effects of overapplications of water and nutrients because the cost of these inputs is only a small fraction of the total cost of production. However, the increasing scrutiny on declining water quality and the increased use of surface and groundwater resources, particularly in urban areas, is dictating that we reevaluate many common nursery and greenhouse production practices.

Given the suspected impacts of agriculture on surface and groundwater resources, nursery and greenhouse operations in Maryland are now required to account for nutrient use as well as their impact on local water resources. Developing nutrient management plans for individual greenhouse and nursery operations will be a challenge, since each operation has a unique combination of site, operational and management variables, even before one considers the wide range of annual and perennial species that are grown by these businesses. The intent of this review is to examine recent federal clean water policy, summarize water quality initiatives in Maryland, and provide the rationale for the development of a water and nutrient management planning process for the nursery and greenhouse industries (15).

Federal Non-Point Source Pollution Policy

The EPA first announced in August 1999 that it was preparing to enforce a largely ignored part of the federal Clean Water Act of 1972, requiring states to take aggressive steps to lessen pollution in 20,000 of the nation's rivers, lakes and bays. This action was precipitated by lawsuits against the EPA lodged in 31 states by various environmental groups. Many of these lawsuits have sought to force the agency to impose the non-point source pollution controls originally specified in the Clean Water Act of 1972 (14). Before 1999, the EPA had mainly required states to grant permits for 'point-sources' of pollution (e.g., steel mills, wastewater plants) to ensure that nutrient and other pollutant discharges did not exceed federal health standards. The EPA now has to ensure that all states implement a TMDL program for all watersheds and bodies of water (9). The final TMDL program rule (see below) was published in the Federal Register on July 13, 2000. The U.S. Congress authorized a National Research Council committee to examine the science behind the TMDL approach, and in 2001, the committee issued a report, which in principle supported this process (19). The full TMDL program requirements are specified in section 303 of the Clean Water Act (14) and in the original TMDL regulations (8).

Thus it appears that states will soon be obliged to reduce 'non-source' pollution from more diffuse sources, including agricultural and urban runoff, under provisions of the Clean Water Act (14). This kind of pollution is very difficult to measure and control, but it is the major threat to the nation's rivers, streams and lakes, accounting for an estimated 60 percent of current water pollution (11). Under current schedules, individual states will have to submit their final TMDL plans by 2005, which in some cases could involve tightening restrictions already in place for identified point-source polluters. States will have several additional years to ensure the plans are implemented. If a state shirks its responsibility, the EPA has the authority to intervene and assess penalties for non-compliance.

Final Total Maximum Daily Load Rule

The final TMDL rule broadens the focus of the Clean Water Act from monitoring specific discharges of pollutants from point-sources, to focusing on the *overall quality* of a body of water. This new approach takes into account the ability of the body of water to handle contaminants from all (point and non-point) sources of pollution that impact it. The focus on overall water quality requires each state to set a TMDL for each pollutant or stressor in each body of water, and is based on the relationship between pollution sources and *in-situ* water quality conditions (10). A TMDL is therefore a written, quantitative assessment of water quality impacts from all potential point and non-point pollutant sources. TMDL's seek to:

- identify water quality concerns and specify the necessary reductions in each pollutant;
- calculate the maximum allowable pollutant loadings for a body of water according to water quality standards and,
- attain clean water quality standards by outlining the action required to restore a body of water to these standards.

In Maryland, various combinations of water bodies and pollutants have resulted in over 300 potential TMDL goals in various watersheds (17, 12).

The Maryland Situation—An Example of a State TMDL Strategy

The state of Maryland has been proactive in cleaning up its rivers and streams over the past two decades for one major reason—the state surrounds the Chesapeake Bay; in many respects the state's economy is dependent on the vitality of this bay. In 1987, representatives of the states of Maryland, Pennsylvania, the District of Columbia, Virginia, the Chesapeake Bay Commission, and the EPA agreed to a goal of a 40% reduction in N and P entering the Chesapeake Bay. As a result of this agreement, Maryland initiated a watershed strategy approach that included a voluntary agricultural nutrient management planning program, targeted primarily at reducing N inputs from animal wastes and fertilizer.

Many state governments are considering laws and regulations to ensure that non-point sources of pollutants are assessed and regulated. One such law, Maryland's Water Quality Improvement Act, was passed in 1998 (16). This legislation mandates the writing and implementation of N and P management plans for almost all sectors of agriculture by December 31, 2002. The Maryland Department of Agriculture (MDA) finalized the regulations that put this law into effect in May 2000 (16). Target nutrients for nutrient management plans are now N *and* P, which means that nutrient sources cannot be applied based merely on the N content, since this may result in P applications in excess of crop requirements.

Agricultural producers in Maryland are now responsible for finding effective ways to ensure that they comply with these laws and can document that they do not release large quantities of nutrient pollutants or sediments into the environment. Economic and crop requirements remain central to

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good nutrient management on the farm. However, in addition to this, the potential impact of these nutrients on environmental quality must now be assessed (4). By taking a watershed strategy approach to reducing non-point N and P in the rivers and streams that flow into the Chesapeake Bay, Maryland and other states in this large watershed are now trying to formulate comprehensive agricultural clean water programs.

Nutrient Management Planning in Context

The 'traditional' soil-based nutrient management process takes a mathematical approach to developing nutrient management plans. First, the presence and availability of nutrients in the soil is analyzed. The total nutrient removal over the season by the crop is then estimated, based on knowledge of the cultivar, the growth rate of the crop, and the nutrient concentrations in the biomass removed. Certain efficiency factors, based on nutrient removal by other mechanisms (e.g., microbial use, soil fixation, etc.) can be estimated. Consequently, fertilizer application rates for each crop/soil type can be calculated, based on the above information. Complexity may be added to this nutrient management process, i.e., when soil-P values are found to be excessive. A risk-assessment approach is taken in Maryland for P movement where the soil fertility index value (FIV) is greater than 150 and further P fertilization is required to maintain adequate crop yields. A P-site index analysis accounts for the movement of P in sediment-laden runoff, and takes into account the presence of buffer areas that hinder the movement of P to surface waters (5).

For nursery and greenhouse operations, the nutrient management planning process becomes more complicated for a number of reasons. Most importantly, the nutrient use of many ornamental species, especially woody perennial species, has not been adequately studied and plant nutrient uptake rates over time are not known. In addition, a great many species are grown and production times can range from a few weeks for annual crops to many years for perennial or tree species. Growth rates and production methods also vary greatly between field, container and greenhouse operations, and growers use a variety of fertilization methods, including conventional, slow-release and soluble fertilizers, where appropriate. Container-production and greenhouse sites can also be compacted, which usually means surface-water control measures are necessary to regulate and contain water and nutrient runoff. Water management is, therefore, an integral component of the nutrient management process in nursery and greenhouse operations, especially where irrigation or rainfall has the ability to leach soluble nutrients.

The Rationale for Environmental Risk Assessment

Formulating a strategy to encompass this information therefore required the consideration of various alternatives to the 'mathematical approach' of the traditional nutrient management planning process. A key program that offered a model for the development of a horticultural risk assessment and risk management approach, was the Farm*A*Syst program developed by the University of Wisconsin (13). This program provides an interesting approach to environmental risk assessment that is cooperatively supported by the USDA Cooperative State Research, Education and Extension Service, the USDA Natural Resources Conservation Service and the EPA. The program has allowed each state to develop customized worksheets to protect the drinking water of people who live on farms and in rural residences. The Farm*A*Syst program worksheets help farmers pinpoint environmental risks involving livestock facilities and animal waste, pesticide management, fertilizer use, and other farm and ranch activities (13).

The application of risk assessment to human decision-making can be traced back thousands of years (22, 6). Recent formalized risk assessment processes developed out of the occupational and user chemical assessments of the 1930s, the nuclear hazard health assessments starting in the 1960s, and the cancer health assessments of the 1970s and 1980s. The National Research Council published an influential study (18) providing a four-stage risk assessment concept that was first applied by the EPA to the estimation of human health risks from chemicals in water (21). Andrews (2) points out that environmental impact assessment (EIA) and environmental risk assessment (ERA) are intrinsically similar concepts, while perhaps differing in scope. Eduljee (7) provides a comprehensive review of the risk assessment process and illustrates differences between the EIA and ERA concepts in practice.

The Environmental Risk Assessment Process in Maryland

In considering all the factors outlined above, a water and nutrient management process for nursery and greenhouse nutrient management planning was developed that utilizes a systems-based risk assessment approach (15). The process was designed not only to look at nutrient movement from a physical point of view, but also to capture data (e.g., irrigation duration) from management factors that may influence nutrient leaching and runoff from nursery or greenhouse production sites. The process allows the nutrient management planner to objectively evaluate the efficiency of the operation and then formulate specific best management practice recommendations that will implement the nutrient management plan—without placing an undue economic burden on the business. The challenge was to formulate a strategy that would allow a grower to capture this information and write a nutrient management plan to accurately assess the efficiency of these cultural practices. It was also important to develop a process that incorporated a relatively simple set of metrics that would give similar reporting data for very different growing operations, so that plans could be objectively evaluated by the regulatory agency.

In brief, the process evaluates the physical factors that can contribute to nutrient runoff, and measures key variables from substrate, irrigation and fertilization practices that have the potential to contribute to N and P runoff from the site (15). In consultation with the grower, the planner develops a set of 'management units' which groups plant production into the least possible number of units. Favored management units are 'container size' categories, since container size is a variable that all operations use. More importantly, container size integrates plant density, irrigation efficiency and fertilizer loading rates per unit area. A relatively simple risk assessment is then conducted for each management unit, which translates information about management practices into quantitative data. This risk assessment ranks and sums the variables for irrigation and fertilizer use, together with site factors and substrate characteristics. This process estimates the

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risk of N and P moving from the nursery and identifies high-risk factors to the planner/grower.

The final part of the process is defining risk management options and best management practices that will ensure effective implementation of the plan. The planner should be able to provide the grower with a range of alternatives to reduce any high-risk practices (23). However, the decision as to what best management practices are adopted is left to the grower, as the various options are likely to have different economic impacts on the operation. For example, a high-risk situation where high concentrations of soluble fertilizers are applied through overhead sprinklers could be mitigated a number of ways. Alternatives include reducing the concentration of fertilizer applied or reducing the frequency and duration of fertigation events. Irrigation duration should be scheduled to minimize leaching of nutrients, and monitoring the electrical conductivity (EC) of the leachate should guide the scheduling of fertilizer applications (23). Alternatively, the grower could lower the risk of nutrient runoff by substituting a slow-release fertilizer formulation and/or by containing the leaching and runoff in lined containment ponds. In this last scenario, containment may completely circumvent the need for any change in practice. However, in order for this to be truly effective, containment ponds would need to be of an adequate size to intercept all surface water runoff, and recycling of nutrient-laden water would be necessary in order to 'close the loop'. In most cases, the implementation of this recycling strategy would probably reduce the nutrient runoff risk to near zero. Under Maryland law, this approach would not discharge the responsibility for filing a nutrient management plan, but it would greatly simplify the planning process.

In summary, provisions under the Federal Clean Water Act and new state laws are placing the burden on agriculture to develop effective procedures to show that they are not polluting our nation's water resources. Formulating a process for nursery and greenhouse operations that takes both water and nutrient applications into account is important, because site conditions may be conducive to runoff. Many operations have already moved to slow-release formulations, drip irrigation on larger containers, monitoring EC's, and careful scheduling of irrigation events in an effort to follow best management practices to conserve water and nutrients. All operations will benefit from cost-effective ways to make improvements to ensure they can comply with the new laws and to document that they can effectively reduce the risk of nutrient movement from their operations to a minimum.

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