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Technical Reports from Symposium "Minimizing Agricultural Nonpoint-Source Impacts" held the week of 2 Nov. 1992 at the ASA annual meeting in Minneapolis MN.

Minimizing Agricultural Nonpoint-Source Impacts: A Symposium Overview

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ABSTRACT

Increased public awareness of the role of agriculture and associated chemical use in nonpoint-source pollution has prompted an urgency in obtaining information on the impact of current and proposed agricultural management practices on water quality. Because of easier identification and control of point sources of pollution, agricultural nonpoint sources now account for a larger share of all discharges than a decade ago. Consequently, there is a need to identify critical sources for control; target specific controls for different water quality objectives within different watersheds; and evaluate and implement cost-effective management practices that minimize the potential loss of agricultural chemicals to surface and groundwaters. This paper provides a brief overview of agricultural nonpoint-source issues and options presented at a special symposium, "Minimizing Agricultural Nonpoint-Source Impacts," held during the American Society of Agronomy meetings in November 1992 and cosponsored by the Metropolitan Waste Control Commission. Several papers that were given at this symposium and presented in this issue are introduced.

PASSAGE of the Clean Water Act in 1972 provided the mechanism for controlling point sources of pollution. In a compilation of state reports, the USEPA (1990) identified agricultural nonpoint runoff of sediment and agricultural chemicals to cause impairment of 55% of surveyed river length and 58% of surveyed lake area that still have water quality problems. Worldwide, 30 to 50% of the earth's land is currently affected by nonpoint-source degradation from erosion, fertilizers, pesticides, organic manures, and sewage sludge (Pimental, 1993). As a result, both soil productivity and environmental quality are threatened.

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Because of easier identification and control of point sources of pollution, agricultural nonpoint sources now account for a larger share of all discharges than a decade ago. Also, as further control of the remaining point-source problems become increasingly less cost-effective, and as water quality problems remain, more attention is being placed on controlling runoff from agriculture. Along with the increased attention comes the need to identify critical source areas requiring remediation; to target cost-effective best management practices (BMPs) for different water quality objectives within different watersheds and geographic locations; and to develop regional agro-ecosystem and water quality policies that will ensure the successful integration of farm water quality plans into current practices. Otherwise, the public's perception that agriculture cannot manage itself for the good of the environment, may increase and result in the possible adoption of more restrictive guidelines. Unfortunately, many benefits of remedial measures on water quality improvement may not be immediately visible. Consequently, research, extension, and policy should emphasize the long-term economic and environmental benefits of these measures.

RESEARCH OVERVIEW

Research on nonpoint-source impacts of agriculture has focussed on erosion, pesticide losses in surface and groundwater, NO_3-N movement to groundwater, and P loss in surface runoff. In Florida, for example, rapid urban growth and related water and land use demands have placed agriculture in direct competition and conflict with these resources (Bottcher, 1992). Increased agricultural nonpoint-source inputs of N and P to Lake Okee-

Abbreviations: AGNPS, agricultural nonpoint-source model; BAP, bioavailable phosphorus; BMP, best management practice; DDT, dichloro diphenyl trichloroethane; EPIC, erosion-productivity impact calculator; GIS, geographical information system.

chobee have raised concerns that the lake is becoming hypereutrophic (Federico et al., 1981). Nonpoint sources have also been identified as a significant source of nutrients to the Chesapeake Bay. The 1987 Chesapeake Bay Agreement established a nonpoint-source nutrient reduction goal of 40% for both N and P entering the mainstream of the bay. Currently, nonpoint-source programs in the bay monitor installation of BMPs and, with the use of watershed models, measure load reductions that have occurred and predict future reductions as a result of various nonpoint-source implementation strategies.

The public's perception of the threat from herbicide exposure stems from the use of DDT and other organochlorine compounds, which are no longer used or very restrictively used (Baker, 1993). Most herbicides now used on row crops in the Midwest, for example, have much shorter half-lives, are subject to minimal bioaccumulation, and have less impact on nontarget organisms.

Recent studies of herbicide concentrations in midwestern surface and groundwater-based supplies, have provided essential information on exposure patterns and for the development of measures to reduce human health risks posed by herbicides (Baker, 1992). A relatively small portion of the midwestern population is exposed to herbicides in excess of drinking water standards. Highest exposures occur through private wells affected by point sources of contamination. However, the majority of private and public groundwater-based supplies have herbicide concentrations below detectable levels, except supplies tapping vulnerable aquifers in agricultural regions. Baker (1992) found surface water supplies from rivers and reservoirs having watersheds dominated by row crop agriculture, accounted for the largest total quantities of herbicides entering human populations. From extensive monitoring of herbicide levels in agricultural runoff over the last decade, Baker (1992) concluded that where groundwater has become contaminated, control programs can generally be targeted to local recharge areas, while remediation of surface waters requires targeting at the watershed level.

Nitrate-N leaching may be reduced by fertilizer N placement in the zone of active root growth (Clay et al., 1994). In fact, ridge-applied chemicals are less susceptible to leaching in ridge tillage systems due to differences in water content and flow patterns between ridge and valley areas. If fertilizer slots on the ridge remain open during rainfall, while the valley slots are closed by soil sloughing, NO_3-N leaching from ridge applications may increase (Clay et al., 1994).

The transport of bioavailable P (BAP) in agricultural runoff can accelerate the eutrophication of P-sensitive water bodies, such as the Great Lakes, upper Chesapeake Bay, and Lake Okeechobee. As procedural and theoretical limitations of algal bioassays and chemical extractions have restricted widespread BAP measurement, Sharpley et al. (1994) developed a simple method using Fe oxide paper strips as a sink for BAP in runoff samples. The strips can be sent to a field location, BAP extracted, and the strip returned to a central laboratory for P removal and measurement. Thus, BAP measurement may be facilitated enabling estimation of nonpoint-source inputs of P forms more closely related to aquatic bioproductivity.

Due to the expense and labor intensivity of long-term field studies required to reliably quantify agricultural nonpoint sources, computer models have simulated relative management effects on pollutant transport. For example, erosion-productivity impact calculator (EPIC) and agricultural nonpoint-source (AGNPS) models were used by Sugiharto et al. (1994) to evaluate management alternatives to reduce dairy farm and watershed nonpoint-source pollution. Continual land application of manure from dairy and other confined animal operations has increased soil N and P to levels exceeding crop requirements in many areas of the USA with intensive cropping and livestock systems (Gilbertson et al., 1979; King et al., 1990; Sharpley et al., 1993; Sims, 1992). Sugiharto et al. (1994) predicted chisel plowing or no tillage of corn–oat–alfalfa (*Zea mays* L.–*Avena sativa* L.–*Medicago sativa* L.) rotations reduced erosion up to 41%, but increased P loss up to 113% compared with fall moldboard plowing. If manure remains on the soil surface with conservation tillage then the potential for nutrient loss in surface runoff is greater than when manure is incorporated.

A major limitation to model use is often the lack of detailed parameterization data on soil properties as well as climate, crop, and tillage information. Recent developments in geographical information systems (GIS) provide techniques for handling larger amounts of spatial data for modeling agricultural nonpoint-source impacts (Tim and Jolly, 1994). Also, GIS may facilitate linking soil productivity, chemical transport, and lake response models. Using an integration of AGNPS and GIS (ARC/INFO) showed vegetative filter strips reduced sediment discharge 41% and an adoption of several alternative management strategies 71%, from a 417-ha watershed in southern Iowa (Tim and Jolly, 1994). Linking water quality models with GIS can help identify critical nonpoint sources of sediment and agrichemicals in a watershed. Geleta et al. (1994) linked EPIC and GIS (Earthone) to evaluate crop yield and NO_3-N movement to surface and groundwater in the High Plains region of Oklahoma, where agriculture is the largest contributor of nonpoint-source pollution (Great Plains Agric. Council–Water Qual. Task Force, 1992). The modeling framework can be used to compare alternative water quality policies. Broad policies such as a restriction on the amount of N that can be applied can be compared to targeted policies, such as limiting N applications on irrigation water use on coarser soils or under furrow irrigation (Geleta et al., 1994).

CONCLUSIONS

The papers presented at the symposium and those that follow in this issue, emphasize the need to target cost-effective remedial measures on critical source areas in a watershed and to develop regional rather than local policies that guide agricultural management to minimize nonpoint-source impacts. Logan (1992) points out that in the last 5 yr, we have moved away from planning and research/demonstration of nonpoint-source pollution abatement, toward full-scale implementation of BMPs for control of sediment, nutrients, and pesticides in surface and groundwater. Implementation of BMPs into existing farm enterprises must be sustainable and problem targeted. Strategies for N, P, and pesticide control in-

clude integrated nutrient management, wetlands, riparian zones, permanent vegetation on critical areas, pollution credit trading at the watershed level, and exposure assessment for drinking water pollutants (Logan, 1992).

As an example, Wisconsin State Legislature established a nonpoint-source program in 1978, which receives $16 million annually. Projects are established on watershed boundaries, with local government and farmer participation voluntary (Wallace, 1992). The program involves a 2-yr planning period to assess water quality conditions, determine pollutant sources, and target dollars for a cost-effective clean-up. Best management practices are designed and installed during an 8-yr implementation period, with 70% cost-sharing available for land owners.

On a regional interstate level, Oberle and Burkart (1994) describe a program synthesizing information from USDA, USEPA, and USGS projects into evaluation of the regional effects of existing and innovative agroecosystems on nonpoint-source impacts. The program assembles and analyzes information characterizing Midwest agroecosystems and estimates water quality responses and effectively disseminates information to end users (Oberle and Burkart, 1994). The aim is to implement agricultural management systems, which integrate BMPs that minimize nonpoint-source impacts on regional water resources.

Cost-effective BMPs must be flexible, because many factors affect the source, fate, and management of agrichemicals in the environment. Thus, options available to landowners to minimize nonpoint-source impacts often require agronomic, economic, and environmental tradeoffs. For example, conservation tillage reduces erosion and total N and P losses in runoff, via increased vegetative and residue ground cover, but P bioavailability in runoff can be increased, NO_3-N leaching potential enhanced, and crop yields reduced (Sharpley and Smith, 1994). Additional conflicts within BMPs between SCS residue management and recommended subsurface fertilizer or manure applications may exist. In compliance with residue conservation programs, landowners may be required to maintain a 30% residue ground cover. Under this BMP, subsurface application or knifing of fertilizer or manure, which may be recommended to minimize N and P loss in runoff, could be unacceptable if it reduces residue cover below 30%. Thus, these tradeoffs and conflicts within and between BMPs must be weighed against the potential benefits of conservation measures in assessing their effectiveness.

As a critical part of BMP evaluation and the regulatory process, water quality standards for nonpoint sources of naturally occurring agrichemicals must consider background levels found under pristine conditions. For example, maximum tolerable levels of N and P in ground and surface waters must be greater than inputs from precipitation and native soil sources. Otherwise, landowners may be faced with trying to achieve unrealistic and unattainable water quality goals.

Minimizing agricultural nonpoint-source impacts on surface and groundwater quality is one of the major challenges facing both landowners and policy makers. It will require adoption of innovative management strategies on targeted source areas. The following papers were presented at the ASA Symposium in Minneapolis, MN (1992), on agricultural nonpoint-source impacts. They provide insights as to how we might meet and overcome these challenges.

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