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IN THE FIELD

Developing institutions to encourage the use of animal wastes as production inputs

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Abstract. Animal feeding operations have come under increased scrutiny as sources of water pollution. Due to the concentration of animals at individual locations and in certain regions, the local environment may not be able to use all of the nutrients contained in the manure. Particularly, problematic are waters being impaired by nitrogen and phosphorus from animal manure. Since federal and state regulations have not been totally successful in precluding water contamination from manure nutrients, scientists and policymakers might seek ways to encourage the use of manure as a resource for crop production. By analyzing diverse state regulations, this paper identifies several strategies that would treat animal waste as a recyclable production input rather than a production byproduct. Citizens and regulators can encourage more sustainable livestock production by proffering regulations that mandate selected production requirements or practices. Agronomic rate regulations, limitations on manure application and timing, lagoon safety requirements, closure mandates, and alternative uses of manure constitute possibilities to remedy some pollution problems.

Key words: Animal feeding operations, Environmental quality, Manure, Nutrient pollution, Production input, Regulations, Water impairment

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Introduction

As animal feeding operations (AFOs) have expanded into larger concentrated animal feeding operations (CAFOs), animal production in the US has come under increased scrutiny. CAFOs, defined by federal law, are AFOs that exceed a defined number of confined animals and meet other criteria (*US Code Annotated*, 2001; *US Code of Federal Regulations*, 2001; Environmental Protection Agency, 2003). Most notable are the adverse effects of CAFOs on the environment (Meyer and Mullinax, 1999; Centner, 2000; Innes, 2000; Metcalfe, 2000; Centner, 2003). Excessive amounts of animal waste from thousands of animals at a single location, or multiple operations in close proximity, can impair water supplies (Bosch and Napit, 1992; Taylor, 1997; Letson et al., 1998; Sharpley, 1999; Parker, 2000; Gollehon et al., 2001). Another issue is their negative impact on sustainability. CAFOs have separated animal production from row crop production, thereby lessening opportunities to use animal wastes as an input for sustainable production (Drohan and Abdalla, 1999).

Water pollution from animal waste is one part of a larger problem for all of agriculture. About 60% of the impaired river miles in the US are being defiled by agricultural production (Environmental Protection Agency, 2000b). Research from around the world has identified agriculture as a major contributor to the impairment of ground and surface waters (Ribaudo, 1989; Matthiessen et al., 1992; Kronvang et al., 1995; Lee and Howitt, 1996; Skinner et al., 1997; Dinar and Xepapadeas, 1998; Rejesus and Hornbaker, 1999; Schou et al., 2000). Nutrient contamination entailing nitrogen and phosphorus from animal production is particularly troublesome in North America and Europe (Koelsch and Lesoing, 1999; De Boer et al., 2000).

In the US, nutrient problems have been exacerbated by the tremendous concentration of the livestock industry. Rather than diversified family farms with crops and livestock, animal production has moved to specialized operations often consisting of one animal species. In the past 40 years, the country has experienced a 92% decrease in the number of hog farms, a 93% reduction of farms with dairy cows, a 71% reduction in the number of poultry operations, and a 55% decrease in

cattle facilities (US Department of Agriculture, 1963; US Department of Agriculture, 1998).

Economies of scale have led to large production facilities (Fleming and Long, 2002). For example, hog production has become industrialized during the past 25 years (Rhodes, 1995). Lawrence and Grimes (2001) report that 156 firms (including some with multiple producers) produce more than one-half of our country's marketed hogs. With large numbers of animals at individual locations, animal manure sometimes becomes a production byproduct rather than a fertilizer input (Jackson et al., 2000). Many of our largest production facilities produce animals under contracts with contractors whereby the producer does not have much control over the operations (McBride and Key, 2003). Due to environmental problems caused by large amounts of animal wastes generated at AFOs, further regulations are being advanced to deal with discharges of pollutants from manure, including discharges occurring from the application of manure on fields.

Considerable research has addressed excessive amounts of nitrogen from animal wastes (Kuipers et al., 1999; Zebarth et al., 1999; Beegle et al., 2000; De Boer et al., 2000; Dzikiewicz, 2000; Smith and Frost, 2000; Smith et al., 2000). Since problems have been recognized in the US and Europe, the challenge is to develop innovative governmental responses. Since 1986, regulations in The Netherlands have sought to limit the amounts of nitrogen losses from agricultural land (Oenema et al., 1998). More recently, The Netherlands has banned animal manure spreading in winter months and requires covers over manure storage facilities (Neeteson, 2000).

The second major nutrient issue involves reducing excessive amounts of phosphorus from animal feeding operations (Edwards et al., 1996; Sharpley, 1996; Oenema et al., 1998; Parry, 1998; Withers and Jarvis, 1998; Koelsch and Lesoing, 1999; Gburek et al., 2000; Heathwaite et al., 2000; Moore et al., 2000; Neeteson, 2000; Sharpley et al., 2000; Sims et al., 2000; Valk et al., 2000). Researchers in the US and Europe have made progress in assuaging environmental harm from phosphorus. For example, Jongbloed et al. (1997) asserts that the excretion of phosphorus per pig has been reduced 50% in the Netherlands as a result of intensive nutritional research on phosphorus digestibility.

Yet, many in the US feel that the status of their water quality is unacceptable. The inability of the federal government to meet the water quality objectives set forth in the Clean Water Act of 1972 (*US Code Annotated*, 2001) has induced citizens to request that local, state, and federal governments take further action. One idea is for governments to adopt regulations that encourage practices whereby animal wastes would be employed as a production input rather than being disposed of in a manner that contaminates water and air resources. This paper analyzes regulatory responses that have been initiated in the US to foster more desirable uses for animal wastes.

Regulatory responses

The US Environmental Protection Agency (EPA) estimates that 9% of the nation's impaired river and stream miles have pollutants from animal feedlots (US General Accounting Office, 1995). Governments and regulators in the US have responded to these concerns with a variety of new laws and regulations. To address water pollution concerns, the federal EPA and the US Department of Agriculture (USDA) have been involved in ongoing efforts to reduce pollution from CAFOs (US Department of Agriculture, 1990; Environmental Protection Agency, 1998; US Department of Agriculture, 2000; Environmental Protection Agency, 2000b; Environmental Protection Agency, 2001b). In 1999, the USDA and EPA issued a joint "Unified National Strategy for Animal Feeding Operations" to set the stage for further action to reduce pollutants (US Department of Agriculture and Environmental Protection Agency, 1999). The EPA followed with a "Draft Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations" (Environmental Protection Agency, 2000a).

In 2001, the EPA advanced new federal regulations for CAFOs (Environmental Protection Agency, 2001a), provided information on data availability (Environmental Protection Agency, 2001c), and offered guidance for handling animal manure (Environmental Protection Agency, 2001d). The EPA's efforts culminated with a new final rule for CAFOs effective April 14, 2003 (Environmental Protection Agency, 2003). While the EPA retreated from some of its proposed regulations, the changes to federal regulations are significant and should assist in reducing pollutants entering waterbodies. An estimated additional 11,000 facilities need to apply for permits under federal law (Environmental Protection Agency, 2003).

Individual state governments have also sought to regulate CAFOs (Centner 2000; Metcalfe, 2000; Environmental Protection Agency, 2001b). Under the authority of the federal Clean Water Act, most state governments have designated a lead state agency to respond to pollutants from CAFOs. In conjunction with federally mandated National Pollutant Discharge Elimination System (NPDES) permit provisions, 25 states have incorporated additional state permit, license, or approval process requirements (Environmental Protection Agency, 2001b). Other states rely on their own individualized non-NPDES programs. Many states will

be modifying their regulations to conform with the dictates of the revised federal regulations. Additional laws and regulations govern nonwater problems, such as odors and health issues. Furthermore, some county and local governments have adopted laws and ordinances to remedy community CAFO problems.

Treating manure as a production input

A component that is not prominent among the legislative provisions governing CAFOs is how governments might offer more encouragement for the use of manure as a production input rather than treating it as a production byproduct. Animal manure is an excellent resource for crop production. It supplies nutrients and organic matter, augments the water-holding capacity, and increases a soil's fertility (Araji et al., 2001). Progressive legislation may recognize that the application of manure to land is an established and recommended practice (*Illinois Compiled Statutes Annotated*, 2001) and proceed to delineate criteria to advance sustainability. By incorporating sustainable ideas in regulations governing animal wastes, further encouragement might be given to help producers recycle nutrients from manure as a production input (Fleming et al., 1998; Sheffield, 2000).

Nutrient and manure management programs have three major objectives: to help protect water quality, reduce conflicts with others, and enhance crop performance. In the aggregate, most governmental regulations address the first two objectives and provide operators discretion in developing practices and implementing technology to reduce nutrient contamination (*Oklahoma Administrative Code*, 2000). While agriculture traditionally has used manure to enhance crop performance, excessive quantities of animal wastes from CAFOs may require governments to take further action to advance the more provident use of this byproduct.

Five major regulatory strategies can be identified that address mechanisms for treating manure and animal waste as a production input rather than a production byproduct for disposal. The first involves agronomic rate applications for nitrogen and phosphorus. State regulations may impose mandatory guidelines limiting the amounts of animal manure that may be applied to lands. The second strategy involves directives that enhance the absorption of manure into the ground for use by crops. Directives on the timing and method of application of manure to fields can affect the usability of nutrients. Lagoon design offers a third strategy to enhance production by addressing nutrient losses through seepage or lagoon failure. Closure of facilities and alternative uses for poultry litter offer two additional strategies to avoid excess nutrients being placed on lands near poultry CAFOs.

Agronomic rate applications

Thirty-four states have enacted regulations requiring CAFO wastes be applied to land at agronomic rates (Environmental Protection Agency, 2001b). These regulations offer a relevant response to the overuse of one or more nutrients. To comply with the agronomic requirements, producers employ a nutrient and manure management program. Producers calculate the nutrients in the manure and the soil to ascertain a crop's need for additional nutrients. The regulations prohibit the application of manure to fields where amounts of the listed nutrient are already present in sufficient quantities for the crop being grown. Nitrogen may be the only listed nutrient, or a state regulation may regulate phosphorus. In a few cases, provisions address applications of both.

While agronomic rate regulations sound good, more widespread application is possible. One need is to use new technology to more accurately calculate and measure the amount of nitrogen being applied in manure that will be available to plants. While soil and manure testing can provide a rough calculation regarding amounts of nitrogen, they do not reflect the mineralization of nitrogen nor atmospheric losses. Another problem is that many of the regulations only address nitrogen (Environmental Protection Agency, 2001b; *Indiana Administrative Code*, 2002). Given that overapplication of phosphorus remains possible, and often occurs with the use of manure, regulations limited to nitrogen fail to address a major contamination problem. A few states have confronted this issue with limitations on the application of manure based on both nitrogen and phosphorus (*Illinois Compiled Statutes Annotated*, tit. 510, section 77/20, 2001; *Minnesota Rules*, r. 7020.2225, 2000). These state regulations provide a model that might be employed in regions with surplus nutrients.

The new federal regulations for large CAFOs offer further support for regulating nitrogen and phosphorus applications. The best management practices to be used in the land application of manure by large cattle, dairy, swine, and poultry CAFOs require a nutrient management plan "based on a field-specific assessment of the potential for nitrogen and phosphorus transport from the field. . ." (Environmental Protection Agency, 2003 (*to be codified at* 40 C.F.R. section 412.4)). States with waters impaired by nutrients from animal manure may want to consider whether medium and small CAFOs should also be subject to these best management provisions.

Due to agronomic rate regulations, producers are required to forego applying excessive amounts of listed nutrients that can contribute to unnecessary water contamination. What this usually means for the application of manure is that a producer can only apply a quantity required to reach the recommended amount of phosphorus. For nitrogen requirements, an appropriate commercial fertilizer should be used to alleviate the deficiencies and provide for optimal crop production.

Directives on manure application

Although manure management is bothersome and costly, it is indispensable to the oversight of surplus nutrients from animal waste. States have helped producers by making information available to them on nutrient management plans and in providing testing services. Yet, these efforts do not seem to be sufficient. The excessive amounts of nutrients on some fields receiving manure acknowledge a breakdown in environmental stewardship practices. Rather than engaging in sustainable practices, producers are disposing of manure as a production byproduct. Short-term profitability objectives are interfering with long-term productivity and environmental quality. It is cheaper to over-apply manure to nearby fields than to transport it to other sites (McBride and Key, 2003). More is needed to achieve broader use of practices that foster sustainable agriculture.

Perhaps, the most important development has been recognition that training is required for persons in charge of disposing of manure. State legislatures have adopted provisions requiring training for animal waste management system operators (*Iowa Administrative Code*, 1999; *North Carolina General Statutes*, 2000). Maryland requires persons who apply nutrients to land to complete an educational program every three years (*Maryland Agriculture Code*, 2001). Georgia provisions list topics that should be taught to operators of CAFOs (*Georgia Compiled Rules and Regulations*, 2001). Yet, such training efforts may need to be augmented to address the coordination of reliable sampling and testing results with nutrient applications. Too often the sampling is part of a service accompanying fertilizer sales so that the overriding consideration is the use of additional commercial fertilizer. Many producers need more training on how to understand and evaluate nutrient testing results.

Some state nutrient and manure management provisions delineate practises that foster the use of nutrients for crop production. Several ideas may be highlighted. Minnesota enunciates a general prohibition against application of manure that would cause contaminated runoff (*Minnesota Rules*, 2000). On lands prone to flooding, manure application through injection or incorporation into the soil may be required (*Iowa Administrative Code*, 1999). Similar provisions may apply to steeply sloping cropland (*Iowa Administrative Code*, 1999). To minimize runoff of manure, some northern states limit the application of manure on snow-covered ground (*Iowa Administrative Code*, 1999; *Illinois Compiled Statutes Annotated*, 2001). Another provision may prohibit manure application in road ditches (*Minnesota Rules*, 2000).

For producers practicing stewardship practices, nutrient and manure management directives simply prescribe sensible husbandry practices known for decades. Yet, some CAFOs are being managed in the pursuit of short-term profits by persons without knowledge of conservation practices. Governmental directives may be required to augment long-term productivity objectives and achieve desired reductions of contaminants.

Lagoon regulations

While animal waste lagoons are not new, the recent contamination of waters by lagoon collapses has spurred greater regulations (Schmidt, 2000). Particularly important are the design provisions being added by many states through legislation and agency regulations. Advances in science have meant that the design and scale of lagoons have changed considerably. Lagoons have gotten larger, corresponding to larger animal production operations, and have incorporated new design specifications that make them less likely to fail. They also may be precluded from environmentally sensitive locations, such as a 100-year flood plain (*Georgia Compiled Rules and Regulations*, 2001). Governments are incorporating scientific information into lagoon regulations to help safeguard water quality.

The most common safeguards embody professional requirements for persons involved in designing manure storage structures and lagoons. For example, producers in Illinois must construct lagoons according to "Design of Anaerobic Lagoons for Animal Waste Management," as set forth by the American Society of Agricultural Engineers (*Illinois Compiled Statutes Annotated*, 2001). Generally, the regulatory provisions establish a requirement of design preparation by a professional engineer (*Minnesota Rules*, 2000).

A common design specification concerns lagoon liners. States are writing or have written detailed rules prescribing liner requirements (*Oklahoma Administrative Code*, 2000; *Illinois Administrative Code*, 2001). Other requirements may require a lagoon capacity determined by analyzing the volume expected to be generated over a designated number of days (*Illinois Administrative Code*, 2001). For large lagoons and those with land application of liquid manure, governments may mandate the installation of groundwater

monitoring wells. In Georgia, the rules on monitoring wells apply to swine CAFOs with 1001–3000 animal units (*Georgia Compiled Rules and Regulations*, 2001). The Illinois regulations require at least three monitoring wells for some lagoons (*Illinois Administrative Code*, 2001).

Some of the state lagoon regulations might be more proactive in addressing the problems of old lagoons. Furthermore, the adoption of regulations does not guarantee that lagoons will function properly. Concern also exists that states may lack resources for the enforcement of their regulations.

Closure of facilities

Governments are also concerned about the proper disposal of manure and accompanying nutrients when lagoons or other manure storage facilities are closed. A state's closure rules may delineate a requirement for notifying officials when a facility is closed (*Oklahoma Administrative Code*, 2000). In this manner, the state would be aware of the need for carrying out the closure plan. The state can then monitor closure procedures to ensure that animal wastes are disposed properly.

The new federal regulations effective in April 2003 address closure requirements through permitting requirements. CAFO permittees need to maintain permit coverage until the facility is no longer a CAFO and there is no remaining potential for an unpermitted discharge (Environmental Protection Agency, 2003 (*to be codified at* 40 C.F.R. section 122.23(h))). Thereby, permittees who do fail to close lagoons or manure storage structures properly will not be complying with federal law.

State legislatures may decide that regulatory provisions delineating financial responsibility provisions for producers who go out of business are needed (*Oklahoma Administrative Code*, 2000; *Oklahoma Statutes*, 2000; *Illinois Administrative Code*, 2001; *Illinois Compiled Statutes Annotated*, 2001). The provisions may involve special funds with moneys that can be used to clean up qualifying sites (*Iowa Code,* 1999). State closure regulations adopt financial responsibility provisions involving commercial or private insurance, guarantees, surety bonds, letters of credit, certificates of deposit, and designated savings accounts (*Illinois Compiled Statutes Annotated*, 2001). By having operators place moneys in one or more of these instruments, the state has assurance that funds will be available to remedy problems that may occur if a lagoon is closed or an operation experiences financial difficulty.

Regulations may also specify a timeframe for closure of a lagoon, such as 12 or 18 months. These provisions seem constructive, but may be counterproductive and lead to unnecessary expenses. Given the nature of a closure, situations will exist where quantities of nutrients and wastes must be disposed of in a proper manner. The most feasible disposal involves spreading the materials on nearby cropland. To assure that the cropland does not receive excess nutrients and to minimize nutrient contamination of groundwater, spreading disposal over a number of growing seasons may be necessary.

Uses for poultry litter

The EPA concluded that a majority of the on-farm excess nitrogen and phosphorus is produced by poultry operations (Environmental Protection Agency, 2003). Given the excess nutrients at many large poultry facilities, alternative uses for poultry waste are receiving attention. Poultry manure is often mixed with sawdust in a production facility creating animal wastes quite different from bovine and porcine wastes. This means that there may exist opportunities for the disposal of dry poultry litter quite distinct from the disposal of other types of manure. Possibilities include using poultry litter for compost, burning litter as a fuel, or moving litter to locations away from where it was produced.

In Georgia, a former poultry producer has gone into the composting business (Faucette, 2001). Poultry litter from farms within a 30-mile radius is brought to a facility and enters a composting process. The finished product is marketed as a certified organic product. Alternatively, a facility in Delaware processes poultry litter for export to grain farms in the Midwest (Guy, 2001).

Poultry litter may be developed as a clean burning source of electric power (Forster, 2000). A plant is scheduled to open in Minnesota (Forster, 2000), while a pioneering power station burning poultry litter was opened in Scotland in 2001 (Houlder, 2001). Questions may remain whether this is a good use of the nutrients contained in the litter.

Maryland has supplemented its nutrient management provisions with a poultry litter matching service and transportation project (*Maryland Agriculture Code Annotated*, 2001). This attempts to reduce excessive amounts of phosphorus in four counties through the public subsidization of transportation costs. On an experimental basis, the state and commercial poultry producers are facilitating the transportation of poultry litter from farms that experience phosphorus overenrichment to areas where the phosphorus can be used for crop production.

In other poultry-producing areas, an industry matching service is being used to find persons willing to

receive poultry litter. The Georgia Poultry Federation has found that there is a demand for poultry litter, and has been able to match all excess litter with suitable outlets (Office of Food Industry Programs, 2000). Through these voluntary programs, excess phosphorus can be moved to fields where it will not create a nutrient pollution problem.

Conclusion

Competitive forces and financial pressures have led to the concentration of animal production in the US at individual locations and in regions. Manure accompanying animal production has all too often been treated as a production byproduct rather than a recyclable input. Federal water pollution regulations governing CAFOs, in place for nearly 30 years, have attempted to control environmental problems but some evidence suggests that animal waste is impairing our water quality. Through the revision of regulatory proscriptions, we might be able to offer more encouragement for the beneficial use of animal byproducts.

The federal regulations make little distinction between individual operations producing contamination and those that are not contributing to the impairment of waters. Instead, they employ the size of operation and possibility of a discharge to regulate potential sources of water pollutants. Water pollution from nitrogen and phosphorus is not necessarily connected to the size of an individual CAFO. Rather, the problem involves the location of excess nutrients and the impairment of water resources. More exacting regulations are needed only in areas where there are problems.

This suggests a response that would match CAFO proscriptions with impaired waters and watersheds. Drawing upon the European Union's nitrate directive (1991), the US might format more stringent regulations for areas where animal production is a contamination problem. Precision farming technology and geographical information systems enable regulators to pinpoint contamination problems and develop more individualized responses for eliminating contaminants. Arkansas has sought to institute this idea with special rules for nutrient surplus areas (Arkansas Acts, 2003).

Moreover, existing governmental responses directed at potential pollution rather than actual pollution problems may impose expenses on businesses that are not contributing to an environmental problem. Thereby, the governmental regulations impose more costs than necessary. In its discussion of the final regulations effective in 2003, the EPA acknowledged costs accompanying regulations as being potentially burdensome to producers. For example, due to the burdens of recordkeeping, the EPA decided not to require small and medium CAFOs to maintain records of manure transferred offsite nor to provide recipients of manure an analysis of its nutrient content (Environmental Protection Agency, 2003).

State governments are beginning to realize that, to achieve desired water quality, further efforts directed at AFOs are needed. Although most of the regulations have been directed at contamination problems, several strategies exist to encourage producers to use manure as a production input. Regulations can require agronomic rates of application, limit the timing of the application of nutrients to land, direct safer construction of lagoons, regulate closure of CAFOs, and provide incentives for alternative uses of animal wastes. Further efforts might involve new educational programs and management recommendations to help producers voluntarily adapt practices that reduce pollutants moving into water resources. Thus, several ideas exist for serving as a foundation for further efforts by scientists, regulators, and citizens to formulate innovative production practices that would encourage sustainability.

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