WATER QUALITY MANAGEMENT PRACTICES OF SELECTED AGRICULTURAL PRODUCERS IN A SOUTHEASTERN OKLAHOMA WATERSHED

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"Talent is God's gift to man; the use of talent is man's gift to God." Unknown.

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"To live like a king, work like a slave." Unknown.

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CHAPTER I

Introduction

Water quality issues are playing a significant role throughout the world. Water is one of the most important natural resources in the daily life of a human being, but unfortunately it is also one of the resources which is least conserved and protected in many agriculturally related operations. We pay more attention than ever to good water as a resource, and yet many countries around the globe still lack realistic assessments of how water scarcity will affect the environment, food production, economic development, and the health of their populations (Moody, 1996).

The Cornell rural water clinic program in New York, undertaken by Lemley and Waganet (1993), purported to create educational programs so rural residents could increase their knowledge of water supply management. The authors concluded that the water quality data collected in their study provided an important tool for raising awareness of water quality issues. Yet, the public concern over water quality has grown significantly in recent years and has focused increasingly on agriculture as a potential source of surface and groundwater quality problems (Teague et al., 1995). There is a need for knowledge and understanding about water quality and agricultural best management practices which can be applied to improve water quality. This is a central point of concern for many farmers and the general public.

In the United States of America, the Safe Drinking Water Act (SDWA) Amendments of 1996 (P. L. 104-182) provided the Environmental Protection Agency (EPA) with new guidelines for developing regulations to insure the safety of public water supplies (Moody, 1996). The amendments also permitted the EPA to consider the possibility that treating water to remove one contaminant may produce byproducts that increase the health risks associated with another contaminant or interfere with other treatment processes. The modifications also allowed EPA to provide educational programming about water quality to the public.

The most exciting part of the new amendments is pollution prevention. While there is much that can and should be done immediately, it is critical to first expand the knowledge base about water supply systems and ecosystems through research and data collection (Harris, et al., 1995).

The Wister Lake Watershed covers approximately 260,000 ha (640,000 ac) in LeFlore and Latimer Counties in Southeast Oklahoma and Scott and Polk Counties in Southwest Arkansas (Hession et al., 1995) (see Figure I). The watershed drains into and includes Lake Wister in LeFlore County. The majority of the residents in LeFlore and three adjacent counties depend solely upon Lake Wister and the Poteau River for their water supply. Also, the annual report for FY 94 reported that water related recreational activities are important economic benefits, promoting development and improved quality of life in that region of the state. The Lake Wister Project was purported to improve or prevent further deterioration of water quality in the lake since Lake Wister has been considered eutrophic from the time it was surveyed in 1974 by the U.S. EPA as part of the National Eutrophication Survey (Hession et al., 1996). Furthermore, the Wister watershed area in LeFlore County is one of the largest and most rapidly growing poultry producing counties in the state. Poultry litter, spread as fertilizer on pastures, may result as a pollutant source if poorly managed and human activities such as inadequate waste disposal systems, failing septic systems, and runoff from urban areas are also potential nonpoint source contributors (Hession et al, 1992)

Problem Statement

Some of the factors that affect the ground and surface water quality are related to agricultural practices. Hence, determining the knowledge, attitudes, perceptions, and practices among poultry producers, farmers, and ranchers toward water quality could contribute to the development of educational programs to improve water quality. The problem is: that there is limited data about agricultural producers knowledge attitudes, perceptions, and practices concerning water quality and poultry litter management practices in the Lake Wister watershed in Southeast Oklahoma, specifically a part of that watershed, the Black Fork watershed.

Purpose of the Study

The ultimate purpose of this study was to identify water quality management practices of selected agricultural producers in the Black Fork watershed in Southeastern Oklahoma.

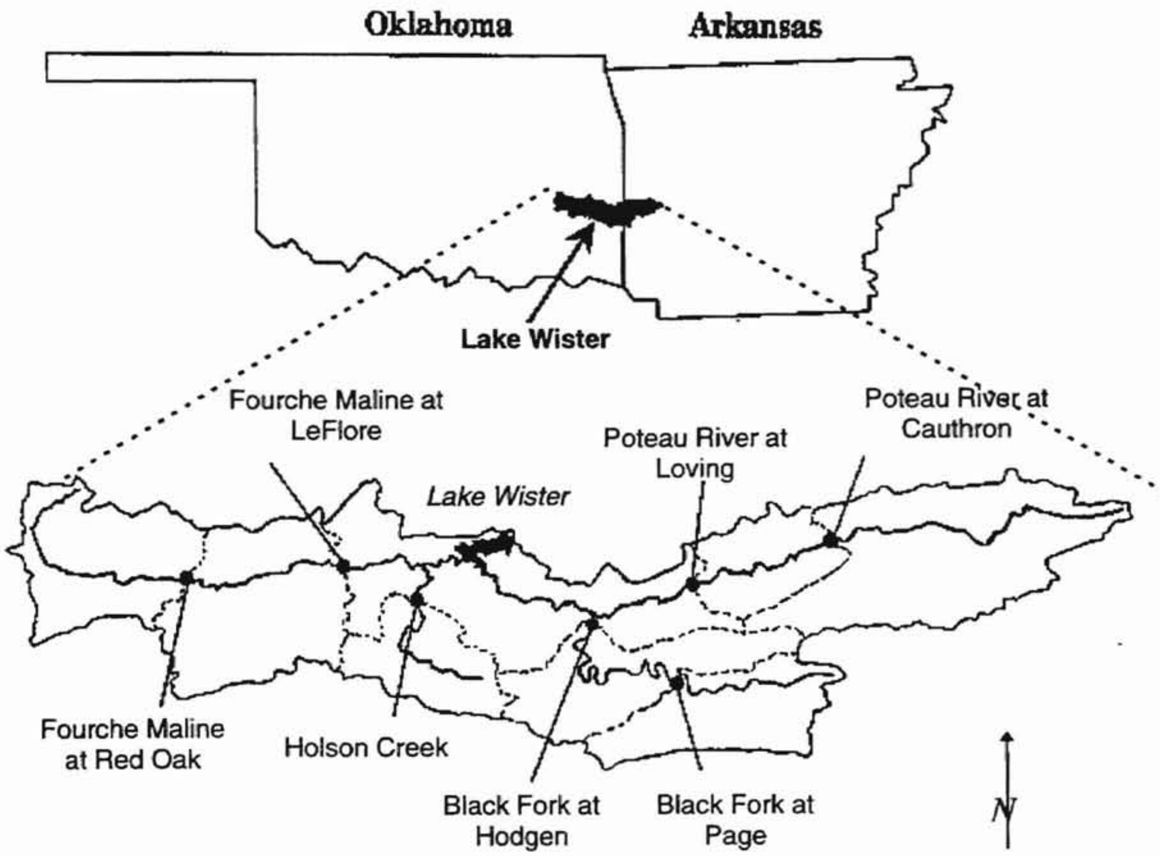


Figure I: Location of the Wister Lake Watershed with Major Subwatersheds Identified

Objectives of the Study

In order to accomplish the purpose of this study, the specific objectives were:

1) To determine, within the Black Fork watershed, the source and testing interval for household water among agriculture producers;

2) To determine, within the Black Fork watershed, agricultural producers' awareness of the Lake Wister Water Quality Project;

3) To determine within the Black Fork watershed, waste management practices involving poultry litter among agricultural producers.

4) To determine selected topics for Cooperative Extension Service and Natural Resources Conservation Services (NRCS) Educational programs.

Scope of the Study

The scope of this study included agricultural producers living adjacent to the Black Fork watershed system in LeFlore County in Southeastern Oklahoma watershed. Twenty five selected agricultural producers were interviewed for this study.

Assumptions of the Study

1) The researcher assumed that the agricultural producers answered the questionnaires diligently and honestly.

Definition of Terms

BMP: Best Management Practices - agronomically sound practices that protect or enhance water quality and are at least as profitable as existing practices. According to Logan (1990) agricultural BMPs are methods, measures, or practices designed to prevent or reduce agricultural nonpoint source pollution problems BMPs are site specific and he also suggests that BMPs are to be categorized according to environmental objective, target pollutant, environmental media affected and management approach of a specific practice.

NMP: Nutrient Management Programs- fertilizer and animal waste addition practices designed to provide adequate, but not excessive supply of nutrients for economical crop production. Usually including a soil testing program to identify nutrient input needs.

NPS: Nonpoint source pollution is caused by diffuse sources that are not regulated as point sources and is normally associated with agriculture, silviculture, urban runoff, runoff from construction activities, and activities or management of the land. Such pollution results in the human-made or human-induced alteration of the chemical, physical, biological, and radiological integrity of the water. In practical terms, NPS pollution does not result from a discharge at a specific, single location (such as a pipe) but generally results from land runoff, percolation, precipitation, or atmospheric deposition.

Point sources: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Agricultural stormwater discharges and return flows from irrigated agriculture are not included in this term.

Watershed: The whole region or areas contributing to the supply of a drainage area or basin. Stanford et al.(1992) defined watershed as the ridgeline or elevation contour that delimits drainage basins or catchments where the catchment is bounded by the watershed, and can be defined as a land area drained by a river/stream or system of connecting rivers/streams such that all water within the area flows through a single outlet. Droppelt et al. (1993) described watersheds as “ecosystems composed of a mosaic of different land or terrestrial patches that are connected by (drained by) a network of streams

Poultry Litter: Is a mixture of bedding material and manure and is generally a dry material with a consistency similar to commercial potting media (Hatzell, 1995).

Conservation Plan and Conservation District Waste Utilization Plan: Are really the same. It is a Conservation Plan which includes a Soils Map; a suggested rate of poultry litter application for the specific soil of the producer; and a set of poultry litter application guidelines. Asked two questions because some people will identify with NRCS and others with LeFlore County.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this chapter is to provide an overview of the theoretical background of water quality and watersheds. The review of literature is presented within the following sections: (1) Perceptions of farmers and ranchers toward water quality and water conservation; (2) Effect of nutrients from poultry production on water quality. (3) Farmers' and ranchers' knowledge about water quality and the agricultural BMPs affecting water quality; (4) Effects of agricultural practices on watershed, groundwater, and drinking water quality; (5) Best management practices related to poultry production toward water quality; (6) Adoption and implementation of BMPs affecting water quality; and (7) Summary.

Perceptions of Farmers and Ranchers Toward Water Quality and Water Conservation

The literature indicated that while farmers recognize the existence of water quality problems, their perception of problems decreased remarkably as questions focus on the local area or their own farm (Lichtenberg and Lessley, 1992). In the study on Maryland farmers' perceptions of water quality problems, Lichtenberg and Lessley (1992) found that the majority of farmers believed that there were water quality problems at the farm level, in the local area, and at the state level. Interestingly, while most farmers indicated the concern about water quality, they tended to think someone else caused the problem. Similarly, Pierce and Key (1996) concluded that producers in southwestern Oklahoma thought agriculture is a source of contamination to water quality, but do not think of themselves individually as the blame for the problem.

Pease and Borch (1994) stated that across most analysis variables, crop farmers are characterized by less expressed environmental concern and acknowledgment of water quality problems, while livestock farmers expressed greater awareness that their farms could contribute to water quality problems. U.S. EPA and its state counterparts regulate large Concentrated Animal Feeding Operations (CAFOs) as point sources, even though pollution caused by CAFOs is both point source and nonpoint source in nature (Frayey and Jones, 1995). The authors described that discharge from animal confinement and process areas represented a point source of pollution which is usually amenable to traditional site inspection and control. Whereas, manure solids and lagoon effluent applied to pasture or cropland, under current production practices, might cause NPS in the presence of precipitation.

Pease and Borch (1994) also reported that farmer attitudes toward the environment and the relationship between those attitudes and farming practices can give policy makers indications whether voluntary programs are likely to be effective. However, these voluntary programs would not succeed in promoting widespread changes in farming practices as long as farmers have no awareness of water quality problems stemming from their own farms and practices. Most farmers and many policy makers preferred water quality protection programs be voluntary because voluntary programs proved to be effective and less costly as a result of such incentive as state tax credits and cost-share payment. Furthermore, according to Logan (1990) many members of the agricultural community , including CAFO operators, argued that a voluntary NPS pollution abatement program would produce the same environmental benefits as command-and-control regulation at less cost to agricultural producers.

Pierce and Key (1996) discovered that producers for the most part used acceptable practices for disposal of unused/old pesticides. This indicated that producers did have knowledge of correct practices, but education is still needed to inform and/or reinforce acceptable disposal practices to the minority of producers who still use unacceptable practices which may deteriorate water quality. These findings supported Bruening and Martin (1992) conclusions on farmer perceptions of soil and water conservation issues that farmers believed improved communications and education were needed to ensure proper management of chemicals used in agriculture; and field demonstrations and county meetings were useful techniques to use when presenting information about soil and water conservation issues.

Potential contamination of groundwater by agricultural chemicals is an important socio-environmental issue because a majority of US citizens rely on subsurface water for household use (Napier and Brown, 1993). Kiuchi et al. (1996), in their study suggested that groundwater is an important natural resource that directly affects many people because in the USA, groundwater is the source of about 22% of the freshwater used. They also indicated that even though contamination of groundwater can occur naturally, agriculture is considered one of the most widespread nonpoint sources of groundwater contamination.

Napier and Brown, (1993) also found that farmers who believed pesticides and fertilizers in groundwater posed a threat to family health tended to perceive groundwater pollution as an important environmental issue. The study of Iowa and Virginia farmer opinions by Halstead, et al. (1990) concluded that farmers considered groundwater quality an important issue, and those farmers realized agricultural production contributed to the groundwater problem. Interestingly, farmers who applied nitrogen at rates exceeding recommendations were the least concerned about water quality issues.

In a review of 14 state and two national surveys on farmer attitudes toward groundwater quality, Padgitt (1989) made these general conclusions: groundwater quality was an issue of great concern to farmers, ranking slightly below profitability concerns; farmers perceived agricultural chemicals as being a major contributor to groundwater pollution; farmers were not convinced there were profitable alternatives to current fertilizer and pesticide practices and believed chemical use had already been reduced as much as economically feasible; and farmers preferred voluntary programs to protect water quality. The survey also discovered that few farmers were interested in alternatives to chemically intensive agriculture, however, a number of farmers were not taking full advantage of existing recommendations and technologies to alleviate groundwater problems, particularly those associated with nitrogen management.

Effect of Nutrients from Poultry Production on Water Quality

King (1996) reported that the broad topic of water quality and poultry production was of concern to poultry farmers, researchers, federal and state agencies, environmentalists, and consumers. Some researchers were interested in how water quality affects the overall performance of poultry and others were exploring ways to adequately process all by-products of poultry and egg production in order to prevent pollution.

In eastern Oklahoma, according to West (1992) poultry production had risen significantly in the last five years which resulted in increasing accumulation of poultry waste. Poultry manure is biologically active when mixed with the soil or when applied during periods of high humidity and warm temperatures. Application of poultry waste or litter on pasture and cropland was the primary method of disposal in this region. The author concluded that surface-applied poultry litter could contribute to increased amounts of N and P in percolates from soils which would eventually contribute to stream and lake quality in eastern Oklahoma.

Presently, Chapman (1996) poultry waste had the potential to be either a pollutant of surface or ground water or a resource used as a fertilizer, soil amendment, energy source, or feed source. However, without proper management, poultry waste could be adversely impact the use of water for such activities as drinking, processing, fishing, and swimming.

Barton (1996) suggested that the water supply in regions where poultry are grown should be analyzed for mineral and microbial content to determine suitability of consumption.

Waste-disposal areas such as chicken-house floors, septic tank filter fields, stockpiled animal manure or feedlots, and dead-chicken pits and abandoned poultry houses were potential sources of nitrates and other chemical constituents in downward-percolating recharge water (Hatzell, 1995). The author reported that in north-central Florida waste disposal practices on poultry farms were thought to be affecting the quality of ground water. Florida ranked twelfth in broiler-production in the nation in 1991.

In addition, Chapman (1996) reported that the major water quality concerns about poultry waste storage, handling, and land application had to do with nitrates and pathogens which might impact both surface and ground water, and phosphorus which under normal conditions only impacts surface water.

Hatzell (1995) explained that there are two types of wastes produced on the poultry (broiler) farms, litter and dead chickens. Litter was periodically removed from the chicken-house floors and was either spread directly from the houses onto the fields by broadcasting or stockpiled on the land surface which can be either sold or applied to the farm fields. Dead chickens were disposed on the farm by placing them in a covered pit dug into the soil. The decomposition of litter and dead chickens provided possible sources of nitrate and other constituents that might affect ground-water quality. The author illustrated that dissolved nitrate did not readily combine with other substances that might remove nitrate from the water and when water containing nitrate moved downward to recharge an aquifer, the water quality might be degraded.

He concluded that there was an indication that the increases in the concentrations of nitrate and other constituents occurred in ground water in the vicinity of broiler farms and also that the disposal of litter and dead chickens was the probability source of the increases in nitrate concentrations in ground water.

Farmers and Ranchers' Knowledge About Water Quality and Agricultural Best Management Practices Affecting Water Quality

According to Baker (1986) research has shown that ground water contamination in rural areas has been mainly due to improper agricultural management practices because excessive nitrogen (N) contributes to a large extent to groundwater and surface water quality pollution in Long Island. However, a study of percolate samples collected below corn crops, home lawns, pine forests, and conventional domestic septic systems, in Rhode Island by Gold et al. (1990), showed that all but the home lawns and forests, had annual flow-weighted mean nitrate-N concentrations greater than 10mg/l (ppm),-- the US. Environmental Protection Agency (EPA) Health Advisory level for nitrate in drinking water. The study found that septic system leachate based on three-person homes at a density of five homes/ha contributed as much nitrogen to groundwater as a urea-fertilized corn crop. Results suggested that an early-planted, well-established fall cover crop might significantly reduce nitrate-N leaching. In addition, Spooner et al. (1991) presented an excellent review of several aspects of degradation of ground and surface waters due to nonpoint source pollution.

Supalla, et al. (1995), discovered that producers who were well educated, technically knowledgeable, and environmentally concerned, were more likely to effectively manage the application of nitrogen. Producers who believed that following recommended fertilizer levels would reduce profits were less likely to do a good job of N management, and large farmers were found to be over fertilizing by slightly more than small farmers.

While discussing the effectiveness of various agricultural BMPs, Logan (1990) indicated that BMPs based on irrigation management, fertilizer management and tillage practices have medium to high impact on ground water quality. A study on three different sites in Pennsylvania about impacts of BMPs and Nutrient Management Programs (NMPs) on water quality by Hamlett and Epp (1994) discovered the followings: 1) BMPs alone decreased surface runoff, increased percolation, and increased nitrate leaching which effectively reduced sediment losses and also reduced losses of sediment-associated with (N) and phosphorus (P); 2) Improved NMPs alone were generally quite effective in reducing nutrient losses with the effectiveness directly related to reduction in excess nutrient application at each site. The authors then concluded there is not a single BMPs or NMPs that is adequate for controlling pollutant losses from agricultural lands. Therefore, even though adoption of improved NMPs appeared to be critical in reducing leaching losses, combinations of BMPs with improved NMPs were more effective in reducing total N and P losses than either alone.

Presently, Domagalski (1996) has stated it is of a critical importance to understand conditions, such as the transport and the concentration, of NPS pollution in ground and surface waters in order to implement effective control strategies and apply the appropriate BMPs.

In Washoe County, Nevada, the Small Ranch Water Quality Program was initiated in 1994 to inform suburban ranchers about BMPs for preventing NPS water pollution. The program was successful because many small ranch owners readily comprehend that by managing their land and their animals carefully, they were protecting the regional water quality and their private property values as well (Cobourn and Donaldson, 1996). The authors also emphasized that it was a necessity to educate farmers and ranchers about soil and water conservation and BMPs. A major dilemma the authors encountered while conducting workshops was a highly detailed instruction for BMPs manuals. Since most suburban small ranch owners are not experienced in agricultural land management, information from BMPs manuals was difficult for lay people to apply.

Effects of Agricultural Practices on Watershed, Groundwater, and Drinking Water Quality

Agricultural crop production has a significant impact on the environment and nonpoint source pollution is a major water quality problems associated with agricultural production (Lovejoy et al., 1997). These finding support the conclusions (Logan, 1990) that landfills, lagoons, underground storage tanks, chemical spills, well injection sites, septic tanks, pesticide and fertilizer use, concentrated livestock operations, and other more minor sources are known to be leaking chemicals into groundwater at concentrations that sometimes exceed the drinking water standards (10 mg N/L) or health advisory level. Lovejoy et al., (1997) indicated that the damage to surface water quality due to sediment and nutrients from agricultural cropland in the US has been estimated to range from 2.2 billion to 7 billion dollars per year. The authors also reported that agriculture accounts for 66% and 65% of total national P and N discharges, respectively. The authors discovered that watershed models that can be used to predict changes in runoff, erosion, and nutrient movement as a result of agricultural crop production are essential to analyze nonpoint source pollution in agricultural watersheds.

Domagalski (1996) in a study at Sacramento River basin in California reported that the concentration of pesticides, insecticides, and herbicides were detected from both the rice field and orchard crops field caused by rainfall or irrigation runoff. The presence of these chemicals in high concentration in surface water not only contributed significantly to the deterioration of water quality for human consumption, but might also result in acute toxicity to aquatic organisms.

From evaluating the climatic effects on nitrate-N concentration in runoff and subsurface drainage between 1987 and 1994 in three different watershed in Ohio, Logan et al. (1994) reported that leaching of residual nitrate-N from agricultural soils can be discharged from subsurface drainage. Nitrate-N concentrations are often higher in subsurface discharges than in surface runoff (Logan et al. 1994).

White (1996) reported that inorganic chemicals such as nitrates in drinking water have been linked to a multitude of illnesses, and are of special concern in the Midwestern United States, where the application of fertilizers for crops is thought to exacerbate the problems. Furthermore, the author observed that nitrates in water come from a multitude of sources, among them are wastewater treatment plants and direct nitrogen assimilation. However, the data from an Iowa State University nitrate study indicated that as high as 80% of the nitrate comes from field tiles which indicated a significant portion of the nitrate measured in the Raccoon River was from agricultural use. McMullen, L. D, the general manager of Des Moines Water Works, as quoted by White (1996), pointed out that most of the nonpoint source is natural coming from cover crop decay or trees, leaves, and cattail.

Groundwater supplies in Central Platte Valley of Nebraska were threatened with contamination from numerous sources, but nitrate pollution from agricultural fertilizers was perhaps the most serious and widespread threat (Supalla, et al., 1995).

Another threat that contributed to the water quality problem is the little understanding of the role for biotechnology in water quality improvement. Elliott and Wildung (1992) reported that improving plant root-microbial activities might improve soil physical properties and reduce nutrient losses. In other words, soil microbes, crop residue, and plant-management practices might be designed to improve nutrient availability at optimum times for plant uptake, which might reduce the nutrient losses to the groundwater. Additionally, increased crop rotations and decreased tillage may increase microbial diversity, which also could result in improved nutrient use efficiency.

Even though significant progress has bees made in developing and implementing agricultural BMPs, nonpoint source pollution of surface and groundwaters by agriculture is a major water quality concern (Stone, et al., 1995). He concluded that improvement practices on watersheds could produce measurable improvements in water quality on farms that had elevated nutrient concentrations.

Sun, et al (1996) supported the previous literature that groundwater and surface water quality degradation from agricultural sources have been regarded among the major environmental problems of the 1990s. But he suggested that producers are caught up in a dilemma. On one hand, their own source of drinking water was susceptible to nonpoint-source pollution, and on the other hand, policies which restrict the use of nitrates or pesticides could reduce their profits (Halstead, et al., 1990). Therefore, Roberts and Lighthall (1991) concluded that since contamination results from accepted farming techniques, improvements in ground water quality will depend on widespread adoption of production practices that reduced environmentally mobile chemical inputs.

Best Management Practices Related to Poultry Production Toward Water Quality

Approximately 13 million Megagrams (14 million tons) of litter and manure was produced on U.S. poultry farms in 1990, most of which (68%) was broiler litter (Moore, et al 1995). In Arkansas, the nation's top broiler-producing state since 1971 according to Edwards, et al (1992), approximately one million metric tons of poultry waste were generated as a result of 1991 broiler production. The authors reported that all involved parties, namely US EPA, the public, and the producers, were interested in identifying and implementing practices which might maximize the benefits of poultry waste while minimizing adverse impacts on surface and ground water resources.

Suggested BMPs included proper nutrient management using agronomic rates of N and/or P; use of buffer zones between treated areas and waterways; and irrigation scheduling of liquid manure to limit groundwater contamination (Moore, Jr., et al 1995). Another practice with the potential to reduce constituent losses was the placement of the waste at the correct time of year which generally resulted in least constituent losses from the receiving field. The most effective BMP was limiting land application rates to those needed for nutrient received relatively little attention in comparison to the use of buffer strips and nutrient management. According to Moore and Miller (1994) litter amendments, such as, alum treatment of litter, might be effective BMPs since they resulted in less N loss and a decrease in P runoff.

Moore Jr., et al (1995) reported that the BMPs could be classified into three categories, namely structure control, source control, and land management. Structure control and source control were practices that limited pollutant transport through water management and those included terraces, grass waterways, buffer strips, manure storage facilities, dead composters, and so forth. Those practices were very effective, easy to manage, and included practices that focus on controlling the problem at the source rather than after nutrients entered into the aquatic system. Land management manipulated the soil system to minimize pollutant loss to surface water or groundwater which included timing and placement of manure, application method, and nutrient management

Chapman (1996) reported that concerns about the impacts of nitrogen, phosphorus, and pathogens on surface and ground water quality had forced the poultry industry to implement voluntary waste management guidelines to be used by growers. The author stated that there were strategies which might be used to effectively dispose of poultry waste and if properly followed, should be sufficient to protect surface and ground water quality without adversely affecting the economics of poultry production. These strategies included local land application as a fertilizer; offsite marketing for use as a soil amendment; feed additive, or energy source; and chemical additives that will immobilize nitrogen and phosphorus in the manure or litter.

In addition, the author stated that knowledge of management techniques, composition, properties of individual components, and modes of application of litter were essential for N and P to be properly used as fertilizer. Land application of poultry litter and manure was a BMP easily accepted by most producers and the general public, if it was done properly (Chapman, 1996). The author also indicated that the poultry industry had taken steps in most states to promote voluntary nutrient management plans or guidelines for use by growers in disposing of solid poultry waste.

The following were guidelines developed for handling broiler litter where producers did not have a site-specific land management plan (Chapman,1996):

1. Poultry litter storage should be roofed to prevent rainwater from coming into contact with litter. Poultry litter should not be stored outside unless covered and piles of litter should not be stored where drainage is toward wells, streams, and other water supplies.
2. Poultry litter should be evenly distributed over application sites at a rate not to exceed 11.2 metric tons/ha.
3. Surface land application of poultry waste should not be undertaken when soil is saturated, frozen, or covered with snow or during rainy weather.

4. Poultry waste should not be applied on land with greater than 15% slope.
5. Surface and subsurface application of poultry waste should not be made within 8m of rock outcrops; 30m of streams, ponds, lakes, springs, sinkholes, wells, water supplies, and dwellings.
6. The farmer should keep records of the dates, quantity, and specific sites where litter was applied and if is sold, a record should be kept of who bought the litter.
7. Vehicles should be covered or tapped if used for transporting poultry litter on any public road for more than 1 mile (p863).

Adoption and Diffusion of Best Management Practices Affecting Water Quality

In general, changing and adoption are some of the most difficult tasks to perform for most living organisms. Hence, adopting new innovations or new farming practices is also a complex process to farmers. Even though concern about ground water quality was high, farmers were not strongly convinced about risks involved and economic incentives for change were questionable (Halstead, et al., 1990). Nowak (1992) reported that farmers did not adopt production technology for two basic reasons: 1) Being unable to adopt, which implied the presence of an obstacle where the decision not to adopt is rational and correct. That is, the farmer is making a sound decision in rejecting BMPs because of this situation. 2) Being unwilling to adopt a new practice. This implied that the farmer has not been persuaded that new technology will work or is appropriate for the farm operation.

Whereas, Cooper and Keim (1996) stated two reasons that may prevent some farmers to adopt. One reason might be that the farmer is risks averse. In other words, even if the alternative practices might appear profitable on paper, the farmer may be unwilling to adopt the practices unless he/she sees a neighboring farmier adopting it. The other reason might be that the farmer either has no information or lacks sufficient information on the alternative practices.

A lack of producer information regarding both the profitability and the environmental benefits of adopting improved practices may be a reason why widespread adoption of these practices has not occurred (Feather and Amacher, 1994). The authors also concluded that fostering adoption through education plays an important role in making decisions for adoption and it might be a reasonable, possibly more cost-effective, alternative to either direct regulation or financial incentives in encouraging BMP adoption by farmers.

Cooper and Keim (1996) reported that farmers can be encouraged to voluntarily adopt environmentally sound management practices through the use of incentive payments. The Food, Agriculture, Conservation and Trade Act (FACTA) of 1990 authorized the US Department of Agriculture (USDA) to initiate the Water Quality Incentives Program (WQIP) which is managed by the Natural Resources Conservation Service (NRCS) through the Agriculture Conservation Program (ACP) (Cooper and Keim, 1996). The WQIP purported to diminish the negative impacts of agricultural activities on water supply by encouraging farmers to implement and adopt the approved BMPs. Farmers who agreed to the terms of the WQIP, were supported through the use of stewardship payments-- a fixed-offer amount-- and technical assistance.

Water quality projects such as the one at the Gum Creek Watershed (GCW) in the Coastal Plain Province of Georgia could be used to encourage farmers to adopt BMPs (Sun, et al 1996). The project was devoted to planning and installing cost-effective BMPs which should be affordable by both farmers and the government. This pilot project demonstrated that a state-administered, cost-shared project could effectively protect and improve the quality of ground and surface water while maintaining the productivity and profitability of agriculture.

Research has shown that there is usually a time-gap between the introduction of an agricultural innovation and its adoption by most farm operators which could be a result of lack of informational incentives (Bultena and Hoiberg, 1983). The authors found that early adopters of innovations often differ in their characteristics and life situations from persons who adopt practices later or who never adopt new practices. Thus, the authors hypothesized that the speed with which farmers adopt conservation tillage, "early", "later", or "nonadopters", would be inversely associated with the age and positively associated with educational accomplishment.

While physical science research designed to create new farming technologies and techniques is an essential component of agricultural development in any society, one of the most difficult tasks in the development process is to motivate farmers to adopt and continue using recommended farming practices (Napier and Camboni, 1993). The authors outlined that because adoption of soil and water conservation practices usually could not be justified by the basic economic returns at the farm level, alternative strategies for motivating farmers to adopt conservation practices must be devised through research. This research must focus on how socioeconomic factors affect adoption of the soil and water conservation practices at the farm level.

On a different notion, Enshayan, et al. (1992) indicated that "farmer-to-farmer" mentoring is an effective means for sharing practical, local knowledge of farming with reduced dependence on costly inputs. The authors believed that since old, experienced farmers are innovators and there is a wealth of information and knowledge among them, these farmers could help to encourage change in agricultural practices toward soil and water conservation.

In another study, Napier and Brown (1993) reported that for a farmer to seriously consider adoption of best management practices in order to prevent agricultural-induced groundwater contamination, he must be aware that water quality problems exist; be cognizant of the source of pollution; and be willing to act to resolve the water quality problem. In other words, the condition needed to achieve adoption of best management practices at the farm level will be the development of farmers' and ranchers' attitudes to be ready to adopt those practices.

Napier and Camboni (1993) concluded that until good predictive models concerning adoption of soil and water conservation practices at the farm level are developed, Americans will continue to implement conservation programs that will be costly and consume many years of human effort with relatively little to show for their efforts.

McMullen, as quoted by White (1996) believes there should be a better working relationship between the agricultural community and the water utilities not only in Iowa, but everywhere. In other words, the agricultural community must be made aware of what is going on and should be involved in decision making that leads to the solutions to the water quality problem.

Summary

There appears to be options, such as NMP, to improve upon the current farm management practices concerning the excessive application of N and other chemicals which contribute to the contamination of water quality. The literature reviewed indicated that farmers and ranchers recognized the existence of water quality problems due to agriculture practices, but they tended to perceive these as distant problems. Financial barriers and lack of financial information also played a significant role in decision making related to the adoption of BMPs.

A lack of empirical information and convincing alternative practices tended to be the barriers in the progress of several water quality programs. Farmers' perspectives, knowledge, and attitudes toward the impacts of agricultural practices on water quality should be included in the decision making pertaining to BMPs and other water quality projects. Ward, (1996) concluded that one of the relative to public information. Consequently, projects and programs should be considerably planned and carefully implemented in order to educate the public about water quality, and to encourage farmers to adopt appropriate agricultural management practices which will prevent water

CHAPTER III

METHODOLOGY

Introduction

The purpose of this chapter is to explain the methods used and procedures followed in this study. The purpose of this study was to identify water quality management practices of selected agricultural producers in the Black Fork watershed in Southeastern Oklahoma. The specific objectives were: 1) To determine, within the Black Fork watershed, the source and testing interval for household water among agriculture producers; 2) To determine, within the Black Fork watershed, agricultural producers' awareness of the Lake Wister Water Quality Project; 3) To determine within the Black Fork watershed, waste management practices involving poultry litter among agricultural producers; 4) To determine selected topics for Cooperative Extension Service and Natural Resources Conservation Services (NRCS) Educational programs.

In order to collect data which would assist in fulfilling the purpose of this study, the population was determined and the instrument was developed for the collection of data. A procedure was established and methods of data analysis were selected.

Population of the Study

The population of this study included twenty-five selected agriculture producers within the Black Fork watershed in LeFlore County in Southeastern Oklahoma. These producers were identified and interviewed by a representative of the Natural Resources Conservation Service in LeFlore County

Institutional Review Board (IRB)

Federal regulations and Oklahoma State University policy require review and approval of all research studies that involve human subjects before investigators can begin their research. The Oklahoma State University Research Services and the IRB conduct this review to protect the rights and welfare of human subjects involved in biomedical and behavioral research. In compliance with the aforementioned policy, this study received the proper surveillance, was granted permission to continue, and was assigned the following number: AG-97-022.

Development of the Instrument

The interview instrument was designed by the Natural Resource Conservation Service representative in LeFlore County, Oklahoma in Cooperation with the Water Quality Extension Agent and received approval by the Lake Wister District Water Quality Board. The instrument addressed issues related to water quality waste management, health department criteria, conservation plans, grazing systems, soil sampling, and water testing. Poultry and beef cattle producers conducting agricultural operations along the Black Fork Creek Watershed in Southeastern Oklahoma were surveyed concerning litter management practices and selected water quality issues. The instrument was designed to collect primarily nominal data, for instance frequency of responses.

Procedures for Collecting Data

The respondents in the Black Fork watershed were contacted by a representative of the Natural Resources Conservation Service in LeFlore County, Oklahoma and personal interviews were conducted concerning water quality topics and litter management practices. The NRSC representative provided a soil sample free of charge when conducting the interview.

Analysis of Data

Since this was a descriptive study frequency distribution, percentages, ranges, and means were used to describe the nominal and ordinal data ascertained in this research effort. An Microsoft Excel spreadsheet was used for data entry and the Microsoft Excel statistical package was used for data analysis.

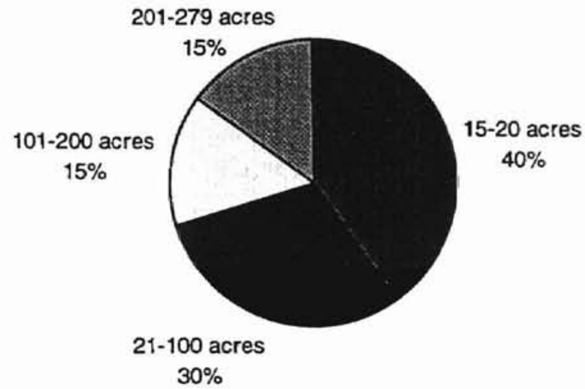
CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The purpose of this chapter was to report the results from the survey used to conduct the study. The purpose of this study was to identify water quality management practices of selected agricultural producers in the Black Fork watershed in Southeastern Oklahoma. These producers were interviewed by a representative of the Natural Resources Conservation Service in LeFlore County.

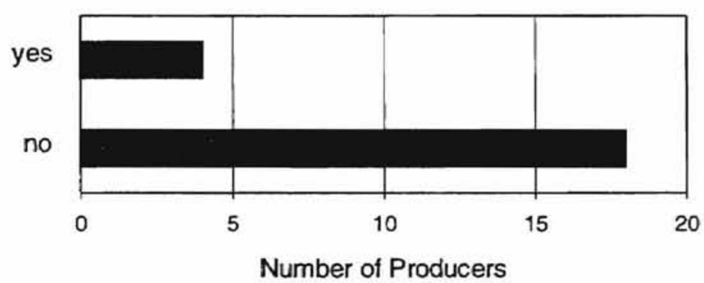
Of the 46 total subjects interviewed, 25 subjects reported operating a farm within the Black Ford Watershed. In this study, these 25 subjects were referred to as the population and were used in the analysis. The farms size ranged from a minimum of 15 acres to a maximum of 279 acres (Figure II).

FIGURE II: Percent in Each Acreage Range



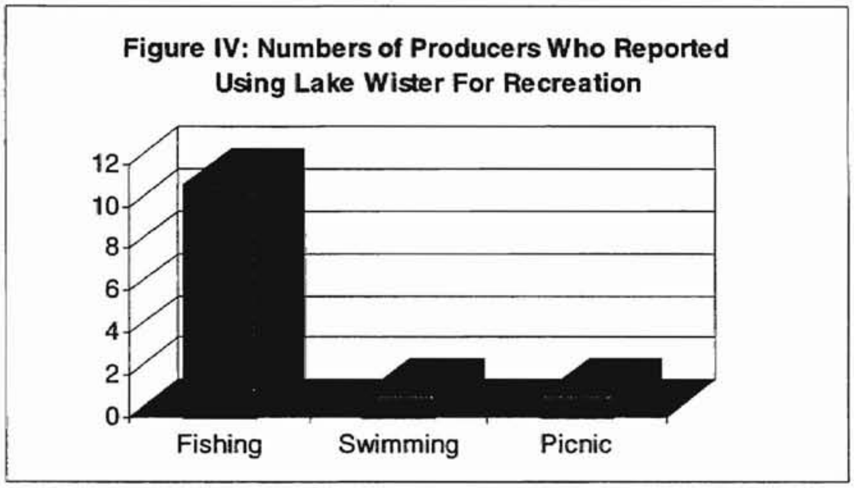
On the question about the source for agricultural producer household water, 24 (96%) reported private wells and one (4%) did not report. Of the 22 who responded when asked if their household water had been tested within the past two years, four (16%) answered yes and 18 (72%) answered no (Figure III).

Figure III. Household Water Tested in Last Two Years



All 25 respondents indicated awareness of the Lake Wister Water Quality Project. Eleven respondents reported that they used Lake Wister for fishing.

One of the eleven reported using the lake for swimming and another one of the eleven reported using the lake area for picnics (Figure IV).



Eight of the respondents indicated that they did not use the lake for recreation and six did not respond to the question. There were no responses recorded by producers when asked to rate the quality of Lake Wister.

Indicated in Table I is the number of producers who raised livestock and /or poultry. Of the 25 respondents, 19 (76%) raised beef cattle of whom seven indicated the amount of cattle raised. Eleven (58%) of the 19 raised only beef cattle. The other eight (42%) of the 19 raised both poultry and beef cattle. The seven cattle producers that reported the number of cattle raised had an average of 74.9 head with a range of four to 150 head. Four producers (16%) indicated that they did not raise cattle and two (8%) did not report. Also, two producers, who reported not raising beef cattle or poultry, said they raised horses.

TABLE I

NUMBER OF PRODUCERS REPORTED RAISING LIVESTOCK AND/OR POULTRY

Livestock	No.	%
Beef Cattle Only	11	44
Poultry Only	2	8
Beef Cattle/Poultry	8	32
Horses	2	8

Ten (40%) of the 25 respondents reported raising poultry and no one indicated the kind of poultry raised. Two (5%) of the ten poultry producers raised poultry only. Of the ten (40%) subjects who reported raising poultry, one had one house at 20,000 bird capacity; five had two houses at 20,000 bird capacity each; two had two houses at 25,000 bird capacities each; one had three houses at 20,000 bird capacities each; and one had four houses at 20,000 bird capacities each. Table II represents the total number of birds raised based on the producers. So, these 10 producers had 22 houses with a total capacity of 460,000 birds.

Five of the ten indicated cleaning their poultry houses themselves and another five indicated that a contractor cleaned the poultry houses for them. Three of the ten also reported cleaning cake after each batch of chickens, four reported that they did not clean cake after each batch of chickens and three did not respond when asked if they clean cake after each batch of chickens. One of the 25 respondents reported using rice hulls for bedding.

TABLE II

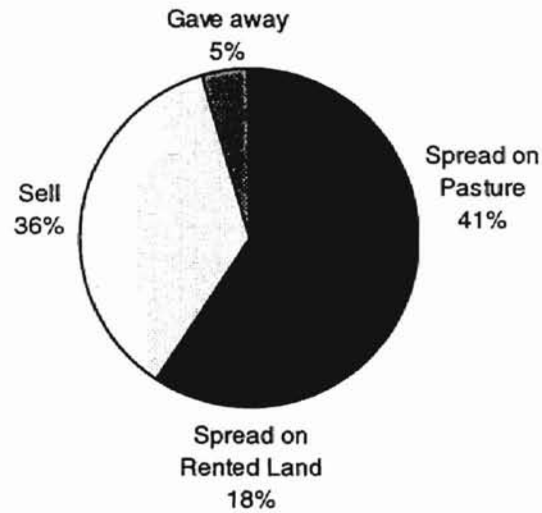
TOTAL BIRD CAPACITY BASED ON PRODUCERS

No. of Producers	No. of Houses	House Capacity	Total Capacity
1	1	20,000	20,000
1	3	20,000	60,000
1	4	20,000	80,000
2	2	25,000	100,000
5	2	20,000	200,000
OVERALL TOTAL			**460,000**

Of the ten respondents who produced poultry, nine reported spreading litter on their own pastures and the one producer whom did not spread litter on his own pasture sold all of his litter. Seven of the nine producers who spread litter on their own pastures also sold litter. One of the nine poultry producers gave litter to his neighbors.

As can be seen in Figure V, twelve of the 25 respondents reported spreading litter on their pastures, of whom, four also reported spreading it on rented land, eight reported selling it and one reported it to neighbors (Figure III).

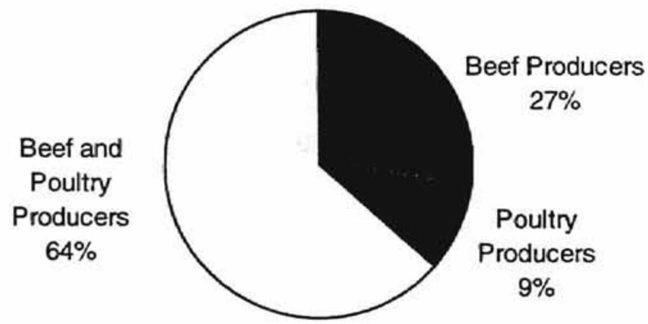
Figure V: Handling and Disposal of Litter by Agricultural Producers



Out of the 25 producers, 16 (64%)reported having a poultry litter application rate of 3 tons/acre of litter. The ten poultry producers reported that they did not have their litter tested for nutrient content. None of the producers who indicated on any question that they were producing and/or applying poultry litter had their litter tested for nutrient content. The ten poultry producers indicated that they did not have a place to store litter between cleanout and spreading, however, five of them indicated having an interest in a storage structure. Also, two livestock producers who spread litter but did not raise poultry, said they did not have a place to store litter.

Eleven respondents indicated having a NRCS, Conservation District waste utilization plan. Three of the eleven producers raised beef cattle only; one producer raised poultry only; and seven producers raised both poultry and beef cattle (Figure VI).

Figure VI: Number of Producers Who Have a NRCS, Conservation District Waste Utilization Plan



The ten poultry producers reported using "other" methods rather than composter or incinerator to dispose of dead chickens. One of these poultry producers indicated that the "other" method they used to dispose of dead chickens was having the dead birds picked up by a licensed cooker. Three of these poultry producers indicated having an interest in acquiring a composter.

Two of the respondents reported applying commercial fertilizer as well as poultry litter. One of the two indicated applying a rate of 200lbs/acre commercial fertilizer in addition to poultry litter. Eight (32%) of the 25 reported having a creek running through their pasture which flows throughout the year.

Seven respondents reported that they would be willing to establish a buffer strip along the creek on their property for demonstration purposes; one of those seven also reported that he was willing to establish a controlled riparian stream bank along the creek on their property for demonstration purposes.

Nineteen respondents said that their septic systems met Oklahoma Health Department criteria. One respondent said their septic system did not meet the Oklahoma Health Department criteria and five did not answer. Thirteen producers indicated having a conservation plan with the LeFlore County Conservation District; eleven said they did not have a conservation plan; and one did not respond.

One producer reported having active erosion occurring on his pasture; 21 producers indicated having no active erosion occurring on their pastures; and three producers did not indicate whether they had active erosion occurring or not.

Sixteen producers reported using a continuous grazing system. Four producers reported using a rotational grazing system. And, five producers did not indicate a grazing system.

Of the 24 who reported practicing weed control, all but one indicated that they mow as a form of weed control. Nine of the 24 producers that practice weed control reported that they spray to help control weeds. Eight of the nine who practice weed spraying as a control measure indicated using 2-4-D as the pesticide they use for this purpose.

One producer said that they had their soil tested within the last two years and 22 producers reported that they had not had their soil tested within the past two years. Two producers did not indicate whether or not they had their soil tested within the last two years. At the time of the survey, a representative of the NRCS performed soil tests for 15 of the 22 producers who reported not having their soil tested within the last two years. The NRCS representative also performed a soil test for one producer whom had soil tested within the last two years.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose of this chapter is to present the conclusions and recommendations from detailed observation of the findings.

Purpose of the Study

The ultimate purpose of this study was to identify water quality management practices of selected agricultural producers in the Black Fork watershed in Southeastern Oklahoma.

Objectives of the Study

In order to accomplish the purpose of this study, the specific objectives were:

1) To determine, within the Black Fork watershed, the source and testing interval for household water among agriculture producers;

2) To determine, within the Black Fork watershed, agricultural producers' awareness of the Lake Wister Water Quality Project;

3) To determine within the Black Fork watershed, waste management practices involving poultry litter among agricultural producers;

4) To determine selected topics for Cooperative Extension Service and Natural Resources Conservation Services (NRCS) Educational programs.

Major Findings of the Study

As shown in Table III, the selected agricultural producers in the Black Fork watershed indicated that private wells were the primary source of household water; few had their household water tested; all were aware of the Lake Wister Water Quality Project and about half used Lake Wister for recreation. The majority of the selected agricultural producers raised beef cattle and a little less than half raised poultry. Of the poultry producers, half cleaned their poultry houses themselves; half had a contractor clean the poultry houses; about a third cleaned cake after each batch; all spread litter on their own pastures; some spread litter on rented land; the majority sold litter and a few gave it away. The majority of the selected agricultural producers had NRCS, Conservation Waste Utilization and LeFlore County Conservation Plans and had acceptable septic systems. Few applied commercial fertilizer; few had soil tested within 2 years; and few had active erosion. About a third of the selected agricultural producers had creeks flowing year around; most used a continuous grazing system and few used a rotaional grazing system. The majority of these producers used a mechanical method for weed control, with a little over a third useing a spray method. Overall, the responses indicated the producers were interested in water quality practices and litter management techniques.

The results indicated that sixteen of the 25 producers aimed for 3 Tons/Acre poultry litter application rate. However, sixteen agricultural producers let the NRCS Agent perform a soil test on their property at the time of the survey.

TABLE III

SUMMARY OF MAJOR FINDINGS

Criteria	**Yes N=25**	**%**
Private Well as Source of water	24	96
Household Water Tested	4	16
Awareness of the Lake Wister Water Quality Project	25	100
Using Lake Wister for Recreation	11	44
Raising Beef Cattle	19	76
Raising Poultry	10	40
Producer Cleans Poultry Houses	5	20
Contractor Cleans Poultry Houses	5	20
Clean 'Cake' after Each Batch	3	12
Spread Litter on Own Pastures	12	48
Spread Litter on Rented Land	4	16
Sell It	8	32

TABLE III (Continues...)

SUMMARY OF MAJOR FINDINGS

Criteria	Yes N=25	%
Give It Away	1	4
NRCS, Conservation Waste Utilization Plan	11	44
Commercial Fertilizer Application	2	8
Creek Flow Year Around	8	32
Acceptable Septic System	19	76
LeFlore County Conservation Plan	13	52
Soil Tested Within 2 Years	1	4
Active Erosion	1	4
Continuous Grazing System	16	64
Rotational Grazing System	4	16
Mechanical Weed Control	23	92
Spray Weed Control	9	36

Conclusions

The analysis of data and subsequent findings were the basis for the following conclusions:

1. That Black Fork watershed farm operators were aware of the Lake Wister Water Quality Project.

2. That the respondents were conservation conscious as reflected by their NRCS and LeFlore County Conservation District Plans.

3. That the majority of the producers seemed to acknowledge the significance of soil testing by allowing the NRCS to perform soil tests at the time of the survey.

4. That poultry producers, even those who reported spreading litter on their own pastures, did not have a place to store litter between cleanup and spreading.

5. That the survey respondents mowed their farm for weed control instead of using chemicals which could have an impact on water quality.

6. That the majority of the producers spread the litter on their pasture at the application rate of 3T/A.

7. That producers do not test their poultry litter for nutrient content or their soil on their own.

8. That the survey respondents are interested in litter management techniques.

9. That some producers may not be disposing of their dead chickens in a practical manner.

10. That producers are willing to manage their riparian areas for demonstrations.

Recommendations

As a result of the conclusions drawn from the analysis and interpretation of data, the following recommendations are made.

1. Considering that most Southeastern Oklahoma watershed farm operators raise cattle and poultry, it is essential that further research and more extension programs focus on encouraging producers to practice nutrient and waste management practices.

2. It is recommended that NRCS and the county Extension agent work together to inform the poultry producers about the impact of poultry litter on water quality and to encourage them to construct places for litter storage between cleanout and spreading.

4. Since the study showed that most producers do not test their poultry litter for nutrient content, OSU should collaborate with the agencies concerned to organize Workshops to inform producers about the benefits of such tests.

5. Similar research should be conducted in other counties that are experiencing growth in poultry production.

6. Since LeFlore county poultry production is rapidly growing, it is recommended that the NRCS and the LeFlore county extension agents work together to educate producers about the importance of testing their household water, soil, and nutrient content on a regular basis.

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APPENDIXES

APPENDIX A

QUESTIONNAIRE

The Instrument

LANDUSER / PRODUCER SURVEY

POTEAU RIVER PROJECT

Black Fork Watershed

[ ] I live in the Blackfork Watershed and operate a farm.
Number of acres________________________

Do you: own / lease / rent (circle one)

[ ] I do not operate a farm, but, I live in the Blackfork Watershed.

1. Where does your household water come from?
   a) PVIA
   b) Private well
   c) Other (describe)

2. Has your household water been tested in the past 2 years? yes or no

3. Are you aware of the Lake Wister Water Quality Project? yes or no

4. Do you use Lake Wister for recreation? Please describe.

5. What do you think of the quality of Lake Wister (rate from good to bad 1-4). 1 - 2 - 3 -4

6. Do you raise beef cattle? yes or no
   If yes how many? _________

7. Do you raise poultry? yes or no
   If yes what kind? ____________

   a) How many houses do you have? _______, and what is the capacity of each house? ________.
   b) What kind of bedding do you use?
   c) Who cleans out your poultry houses?
      Self
      contractor
   d) Do you clean cake after each batch of chickens? yes or no

e) When do you clean our houses?
f) Where do you spread litter?
- on your own pastures
- on rented land
- sell it
- give it to neighbors
- contractors takes it away

8. What application rate do you shoot for?

9. Do you test your litter for nutrient content? yes or no

10 Do you have a place to store litter between clean out and spreading? Yes or no. Please describe ________________________.

11. Do you have an NRCS, Conservation District waste utilization plan?

12. How do you dispose of dead chickens? composter, incinerator, other.

13 If you don't apply poultry litter to your pastures do you apply commercial fertilizer? yes or no. If so, at what rate? ________________

14. Does your pasture have a creek running through it? yes or no
If yes, does it flow year round? yes or no

15 For demonstration purposes would you establish a controlled riparian streambank area along the creek on your property? yes or no
or a buffer strip? yes or no

16. Would your septic system meet OK Health Department criteria? yes or no

17. Do you have a Conservation plan with the LeFlore Count Conservation District? yes or no

18. Have you had a soil test on your pasture within the last 2 years? yes or no

19. Do you have active erosion occurring on your pastures? yes or no

20. What type grazing system do you use? continuous, rotational, or short duration grazing.

21. Do you practice weed control? yes or no
If yes, do you mow or spray
If you spray, what do you use? ________________.

APPENDIX B

IRB FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 06-08-97 **IRB#:** AG-97-022

Proposal Title: POULTRY LITTER MANAGEMENT PRACTICES OF AGRICULTURAL PRODUCERS IN A SOUTHEASTERN OKLAHOMA WATERSHED

Principal Investigator(s): James P. Key, Lucia Kafidi, Troy A. Pierce

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Disapproval are as follows:
This application is exempt. The study is analyzing apparently anonymous extant data.

Signature: [signature] Date: June 10, 1997
Chair of Institutional Review Board

cc: Lucia Kafidi
Troy A. Pierce

VITA

Lucia Tuyeni-Kelao Kafidi

Candidate for the Degree of

Master of Science

Thesis: WATER QUALITY MANAGEMENT PRACTICES OF SELECTED AGRICULTURAL PRODUCERS IN A SOUTHEASTERN OKLAHOMA WATERSHED

Major Field: Agricultural Education

Biographical:

Personal Data: Born in Ongenga, Namibia, On May 5, 1961, the daughter of Aaron Hangula and Ndesheetelwa Nathaniel.

Education: Graduated from Ponhofi Secondary School, Ohangwena, in December 1979; received Primary Teachers Certificate from Ongwediva Teachers Training College, Oshakati, in November 1983; received Bachelor of Science degree in Agricultural Education from University of Minnesota, St. Paul, Minnesota in July 1989. Completed the requirements for the Master of Science degree with a major in Agricultural Education at Oklahoma State University in July, 1997.

Experience: Raised on a farm near Ongenga, taught at Eengedjo Secondary School from January 1982 until August 1984; at Oshakati Secondary School from August 1989 until January 1993; and at PolyTech Namibia from February 1993 until July 1995; and granted a Fulbright Scholarship in 1995 to study at Oklahoma State University.

Professional Membership: Namibia National Teachers Union (NANTU).