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Animal Waste and the Land-Water Interface

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Extended Abstracts of Posters Presented at an Interdisciplinary Conference held July 16-19, 1995 Fayetteville, Arkansas

Don Scott and
Kenneth Steele, editors

INTRODUCTION

This book presents abstracts of research studies conducted on animal wastes and the interface between application of animal waste to land. The abstracts were divided into sections which tend to organize summaries of research studies conducted on similar topics. These topics range from characteristics of animal waste to the effects of animal wastes on streams, lakes, wetlands, and watersheds, development of best management practices, nutrient management, edge of field losses and alternative uses. The posters will be available for viewing from 10:00 a.m. Monday, July 17, until 12:00 noon on Wednesday, July 19, 1995.

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Poster Number	*CHARACTERISTICS OF ANIMAL WASTES AND WASTE-AMENDED SOILS*	

STREAM EFFECTS

IMPACT ON LAKES AND WETLANDS

WATERSHED MANAGEMENT

BEST MANAGEMENT PRACTICES

NUTRIENT MANAGEMENT

REGULATORY VS. VOLUNTARY

EDGE OF FIELD LOSSES

ALTERNATIVE USES

MISCELLANEOUS

Characteristics of Animal Wastes and Waste-Amended Soils

NITROGEN TRANSFORMATIONS AND LOSS IN PASTURES RECEIVING SWINE LAGOON EFFLUENT

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One of the most common treatments for swine waste in the South eastern U.S. is with the use of anaerobic lagoons. Proper utilization and/or disposal of anaerobic swine lagoon effluent is a major concern for the rapidly growing pork industry. The effluent is commonly irrigated onto bermudagrass pastures that may be cut for hay or grazed for beef production. Application of effluent often exceeds 500 kg N/ha/yr on these sites. Little data exists regarding the fate of effluent N on these receiving sites, prompting concern about the potential environmental impacts of these practices. This work reports on the mineralization and nitrification of swine lagoon effluent and gaseous-N losses following application to grazed and ungrazed fields at two sites in the Coastal Plain of North Carolina.

One site at the James Vernon Research and Education Center near Plymouth, NC has a fine-loamy over sandy or sandy-skeletal, mixed, thermic Typic Umbraquult (Portsmouth series). The other site in Sampson Co., NC has a loamy, siliceous, thermic Arenic Paleudult (Wagram series). Table 1 contains a summary of soil properties.

Table 1. Soils used in field experiments

Soil	Texture	Bulk density	Particle density	Porosity	Organic matter*	Irrigation event
		$g\ cm^{-3}$	$g\ cm^{-3}$		%	$kg\ N\ ha^{-1}$
Portsmouth	fine sandy loam	1.14	2.52	0.55	4 - 12	84
Wagram	loamy sand	1.50	2.63	0.43	0.5 - 2	106

* from soil surveys

Over 80% of the effluent N is initially present as NH_4^+, which is conducive to NH_3 volatilization and rapid nitrification. It was estimated that 70% of the applied N is plant available, due to losses occurring with irrigation (Safley *et al.*, 1992). Nitrification of applied N was complete by the next irrigation (approximately 2 weeks).

The volatilization flux of N_2O from the soil surface was monitored before and after irrigation events, using methods adapted from King and Ball (1992). Nitrous oxide flux increased dramatically upon irrigation, with rates as much as 78 mg N_2O-N ha^{-1} hr^{-1} at the Plymouth site. Within 2 days N_2O flux declined by 75% to 2 mg N_2O-N ha^{-1} hr^{-1}. Over
the 2-wk irrigation interval, it was estimated that 1.3 to 5.0 kg N ha^{-1} was lost as N_2O + N_2. This amount represents 1.6 to 6.0% of the 84 kg N ha^{-1} applied to the field during a

single irrigation event. Assuming C_2H_2 completely inhibited the reduction of N_2O to N_2, it was calculated that an average of 78% of the total emissions were as N_2. Laboratory studies revealed denitrifying microbial enzyme activity varied across the Plymouth site, and was correlated with water-extractable dissolved organic carbon (r^2=0.60, p<0.01).

Background emissions of $N_2O + N_2$ at the Sampson Co. site were only 0.5 mg N_2O-N ha^{-1} hr^{-1}, and less than 3 mg N_2O-N ha^{-1} hr^{-1} after irrigation. Total emissions at the Sampson Co. Site were calculated to be < 0.1% of applied N.

The denitrification rate was a function of the soluble C, and the duration of emission limited by the NO_3- pool formed following the previous irrigation. A N balance predicted total gaseous-N losses greater for grazed than for hay fields, chiefly due to NH_3 volatilization. The primary environmental concern with the Plymouth site is lateral movement of NO_3- into drainage ditches, while at the Sampson Co. site the chief concern is leaching of NO_3- into ground water.

References:

King, L.D. and P.R. Ball, 1992. Denitrification in a white clover sward killed by ploughing, rotary hoeing, shallow tillage, or with herbicide. New Zealand Journal of Agricultural Research 35:441-450.

Safley, L.M., Jr., J.C. Barker, and P.W. Westerman, 1992. Loss of nitrogen during sprinkler irrigation of swine lagoon liquid. Bioresource Technology 40:7-15.

ANIMAL WASTE PRODUCT (CHEESE WHEY) REDUCES SOIL EROSION

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Animal waste products come in various forms and disposal can be a problem. One such product is whey which is the watery part of milk separated from the coagulable part (curd) in the cheese making process. Approximately nine metric tons of whey results from the production of each metric ton of cottage cheese. Whey from cottage cheese and creamed cheese made by the phosphoric acid method is referred to as acid whey, and is an excellent animal feed, but the supply of whey exceeds the demand for animal feed in some areas, thereby creating a disposal problem. Acid whey cannot be economically dehydrated and disposal through sewage plants is expensive so land application is the best alternative.

Excess cottage cheese whey which was being disposed into a landfill in Southern Idaho is being used as a *best management practice* in sodic soil reclamation. It was found to improve soil chemical and physical conditions and increase soil aggregate stability (1,2,3). The acid whey dissolved lime and released Ca into the soil solution. This Ca replaced Na on the soil exchange complex and helped flocculate clay particles. The Ca and PO_4 ions from the phosphoric acid used to process the cottage cheese also precipitated helping to cement the newly formed aggregates resulting from the flocculation process. Milk proteins in the whey are sticky and may also help aggregates form. Whey contains milk sugars and proteins that stimulate soil biological activity which produces polysaccharides, that can act as cementing agents. These processes along with high Ca and K concentrations in the acid whey, promote soil aggregate stability. These findings indicated that acid whey might decrease soil erodibility, and be useful as a *best management practice* for controlling furrow irrigation induced erosion. As a result, a field study was conducted on a Portneuf silt loam (coarse-silty, mixed, mesic *Durixerollic Calciorthids*) to determine the effectiveness in using acid whey for reducing furrow irrigated induced erosion and increasing water infiltration.

Plots were plowed, roller-harrowed, chemically treated for weeds, furrowed, pre-plant irrigated, and planted to sweet corn (*Zea mays L.*). All furrows in all treatments were 76 cm (30 inches) apart, center to center.

The treatments, replicated four times, were: (1) untreated (control); (2) whey only; (3) straw only, and (4) straw + whey. Straw was applied to treatments 3 and 4 at 1.8 kg/30 m (4 lb/100 ft), equivalent to 780 kg/ha (700 lb/acre). Cottage cheese whey was applied at the rate of 45 l/30 m (12 gal/100 ft).

Compared to the untreated furrows, straw alone significantly reduced season-long sediment outputs by 84%. The straw became partially covered and held in place by sediment. Straw created mini-dams that slowed the water which increased the wetted perimeter causing higher infiltration. Whey alone likely reacted with the soil at application time to increase the stability. Several soil reactions take place with the acid whey to produce cementing agents that increase the soil stability. As a result, whey alone was effective in significantly reducing sediment loss by 86%. Persistent cracks in the soil developed in the whey treated furrows that increased infiltration. Whey + straw had the greatest effect on reducing erosion and increasing infiltration compared to the other treatments. The straw + whey treatment reduced erosion by 98%

This study showed that a one-time application of two low-cost agricultural by products, cottage cheese whey and straw, to irrigation furrows can significantly reduce soil loss and increase infiltration. These treatments can conserve soil, water and plant nutrients.

References:

1. Jones, S.B., C.W. Robbins, and C.L. Hansen. 1993. Sodic soil reclamation using cottage cheese (acid) whey. Arid Soil Res. Rehab. 7:51-61.

2. Lehrsch, G.A., C.W. Robbins, and C.L. Hansen. 1994. Cottage cheese (acid) whey effects on sodic soil aggregate stability. Arid Soil Res. Rehab. 8:19-31.

3. Robbins, C.W., and G.A. Lehrsch. 1992. Effects of acid cottage cheese whey on chemical and physical properties of a sodic soil. Arid Soil Res. Rehab. 6:127-134.

COMPOSTED AND NON-COMPOSTED BEEF FEEDLOT MANURE EFFECTS ON CORN PRODUCTION AND SOIL PROPERTIES

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Composted and non-composted manure can be utilized as nutrient sources for crop production. The effectiveness of different loading rates of these organic nutrient sources and their effects on soil properties and environment need further studying. The objective of this study was to determine the effects of composted and non-composted beef feedlot manure at different loading rates and application times on corn production and soil properties.

Composted and non-composted beef cattle feedlot manure were applied to supply N or P requirements of corn either for one or two-year period. Plots with adequate manure or compost for corn P requirements also received additional N as fertilizer. Fertilizer and no fertilizer checks were also included in the experiment. Nitrogen and P requirements of corn was determined based on the removal of N (151 kg ha^{-1}) and P (25.8 kg ha^{-1}) by corn crop with an expected yield level of 9.4 Mg ha^{-1} (150 bu $acre^{-1}$). The manure and compost N and P availability were assumed to be 40, 20, 10, 5% of total N and P in the first, second, third, and fourth year after application, respectively. These numbers were modified to 20, 20, 10, 5 for compost N and 40, 20, 10, 5 for manure N, while the values 60, 20, 10, 10% were used for manure or compost P in 1994. Manure and composted manure were applied in the autumn of each year or every other year since 1992 and the materials were disked in soon after application. The area was planted to corn every spring. After corn harvest in the autumn of 1993 and 1994, soil samples were taken to 120 cm depth from all plots. The samples were used to determine several soil properties.

In 1993, corn grain yield increased with manure or compost application as compared with the no-fertilizer check (Table 1). Corn receiving manure produced similar or slightly higher grain than the fertilizer check. Composted manure was not as effective as manure or fertilizer check. Applying non-composted or composted manure to satisfy corn P requirements with additional N added as fertilizer resulted in the same grain yield as manure or compost application for N requirement or fertilizer check. Compost or manure applied for corn N or P requirements for two years, resulted in grain yield similar to that for the fertilizer check in the first year. Composted manure was not as effective as non-composted manure or fertilizer in the first year of application probably because of the lower N availability from composted manure. First year N availability from composted manure was about 20%.

Grain yields were similar for all manure, compost and fertilizer treatments in 1994 (Table 1). It seems that when adjusted for N availability, manure and compost can provide corn

Table 1. Manure, compost and fertilizer effects on grain yield (1993 and 1994) and soil properties (0-15 cm) in 1993 at Mead, NE.

Variables	Grain 1993	Grain 1994	Soil C	Bray & Kurtz P 1	NO_3-N	EC
	----- Mg ha^{-1}----		%	------ mg kg^{-1}------		d S m^{-1}
Fertilizer	8.2	9.9	1.85	77	3.5	0.20
Check	6.0	6.2	1.87	60	2.4	0.20
Manure for N	8.6	9.3	2.06	110	7.3	0.27
Manure for P	8.8	9.9	1.87	74	4.1	0.25
Manure for N / 2 y	8.6	9.9	1.98	125	9.5	0.30
Manure for P / 2 y	8.7	10.0	2.08	125	9.1	0.30
Compost for N	6.9	9.1	1.86	104	3.6	0.26
Compost for P	7.8	9.5	1.86	80	3.7	0.23
Compost for N / 2 y	7.9	8.8	2.18	224	6.3	0.34
Compost for P / 2 y	7.7	9.6	1.89	89	3.7	0.23
$LSD_{0.10}$†	-	-	0.16	28	2.0	0.03
Analysis of variance	------------------------------		PR > F		----------------------------	
Replication	0.01	0.01	0.01	0.01	0.68	0.01
Treatment	0.01	0.01	0.01	0.01	0.01	0.01
Comp. N vs. Man. N	0.01	0.79	0.04	0.69	0.01	0.38
Comp. N vs. Fert.	0.02	0.31	0.89	0.11	0.96	0.01
Man. N vs. Fert.	0.83	0.49	0.03	0.05	0.01	0.01
All Comp. vs. Fert.	0.12	0.29	0.19	0.01	0.40	0.01
All Man. vs. Fert.	0.32	0.83	0.05	0.02	0.01	0.01
Man. N vs. Man. P	0.82	0.48	0.04	0.03	0.01	0.11
Comp. N vs. Comp. P	0.12	0.57	0.94	0.16	0.93	0.15
Man. N/2y vs. Man. N	0.88	0.44	0.37	0.37	0.06	0.08
Comp. N/2y vs. Comp. N	0.07	0.68	0.01	0.01	0.03	0.01

†LSD values can not be calculated for grain yield since they are least squares means adjusted for plant population differences.

grain yield that is equivalent to or greater than fertilizer application. However, surface soil levels of plant available P, organic C, NO_3-N, and EC were significantly greater with higher rates of manure and compost application than for fertilizer, check or manure or compost for P requirement. These high levels of salt, nitrate, and P can be carried by runoff and contaminate surface waters. Nitrate also has the potential to reach ground water. In 1993, the Bray and Kurtz #1 P test extracted 70% of manure P and 64% of compost P that were applied in 1992. This indicates high plant availability of manure or compost P. It seems that manure or compost application to provide plant P requirement, with additional N as fertilizer, is a viable option of producing high grain yield with no or very little adverse effects on the soil and the environment. High rates of manure or compost application can contaminate the surface and ground waters.

MINERALIZATION OF N AND P FROM A VARIETY OF POULTRY WASTE OF THE SOUTHEAST UNITED STATES

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Land application is a routine method for producers in the Southeastern United States to disperse concentrated amounts of poultry waste products and enhance plant growth due to nutrient release from the wastes. Application of poultry waste at rates which provide more available nutrients than the plant population is able to utilize can lead to excessive quantities of readily available nutrients (Kingery et al., 1994). Two plant essential elements that are of environmental concern in excessive amounts are nitrogen (N) and phosphorus (P). Poultry wastes need to be applied at levels that are agronomically beneficial yet minimize concerns of environmental contamination due to leaching or runoff of soil water. Predicting potentially available N and P from poultry waste prior to application would be an excellent management tool for producers to maintain plant yields yet alleviate environmental concerns (Sims and Wolf, 1994). To develop these laboratory methods, field measurements of mineralization are needed for correlation of the proposed laboratory methods. Therefore, the objectives of this study were to measure N and P mineralized in the field from a variety of poultry wastes.

Thirty-two wastes representing a cross section of poultry operations were collected from the southeastern U.S. Included were four types of bedding materials (hardwood shavings, peanut hulls, pine shavings, and rice hulls), broiler, breeder, and turkey operations as well as dead-bird compost. Nutrient ranges of these wastes were 244-334, 23.9-44.7, and 11.4-21.3 g kg^{-1}, for organic C, total N, and P, respectively. The wastes were collected and kept in cold storage prior to use. For field mineralization the waste were applied to fallow micro-plots (1x1-m) at a rate of 9 Mg ha^{-1} at two locations in Alabama and one in Mississippi. In each micro-plot, soil cores (6.4-cm diameter) were installed to a depth of 18-cm with mixed resin exchange bag fitted at the bottom. The mixed resin bags were composed of equal volumes of anion and cation exchange resins, whose purpose was to capture any mineralizable nutrients that were sufficiently mobile to leach from the upper soil horizons. Soil and resin samples were collected six times from April to October 1994. The N mineralized from the waste was measured as the amount of NH_4- plus NO_3-N, extracted with 2 M KCl from the soil and resin. Phosphorus mineralization was determined as the amount of plant available PO_4 extracted from the soil.

Nitrogen mineralization of the litter materials ranged from 27 to 44 % of the applied total N or 80 to 140 kg N ha^{-1}. For the dead-bird compost N mineralization ranged from 18 to 42 % of the applied total N or 70 to 120 kg N ha^{-1}. For both types of waste sources the majority of the N was recovered as NO_3-N from the mixed resin bags. This N represents the fraction of the applied N that was available for plant uptake or had the potential to be lost from the system by leaching. Phosphorus mineralization of the litters increased available P levels from 20 to 65 kg N ha^{-1} above the initial P levels. For the dead-bird compost P mineralization increased P levels from 60 to 90 kg N ha^{-1} above the initial P levels. Mineralization of P from the dead-bird compost was less variable among the waste than for the litter sources indicating that the composted material was more uniform in the P released.

The results from the initial portion of this project indicate that there is considerable variation in the poultry waste sources in the Southeastern US. The field mineralization methods were adequate to supply the needed values to correlate with developed laboratory methods. Finally the mineralization of N and P varied with litter source which underscores the need to develop the laboratory methods for predicting mineralization in the field.

References:

Kingery, W.L., C.W. Wood, D.P. Delaney, J.C. Williams, and G.L. Mullins. 994. Impact of long-term land application of broiler litter on environmentally related soil properties. J. Environ. Qual. 23:139-147.

Sims, J.T., and D.C. Wolf. 1994. Poultry waste management: agricultural and environmental issues. Adv. Agron. 52:1-83.

AGRONOMIC AND ENVIRONMENTAL IMPLICATIONS OF BROILER LITTER AMENDMENTS TO SOYBEANS

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Agriculture on the Delmarva Peninsula is dominated by a highly concentrated poultry industry (~2600 poultry houses per 2450 km^2) that is vital to the economic stability of the region. The poultry industry is mainly concentrated in the southern portion of the peninsula, an area characterized by sandy, well-drained soils that overly shallow water tables frequently used as a source of drinking water. The close proximity of the industry to agricultural fields economically facilitates the transport and application of broiler litter (BL), a mix of manure and sawdust, to grain crops. Unfortunately, previous research has shown that agricultural use of poultry litter on the Delmarva Peninsula may contribute to nitrate pollution of groundwater.

Although not recommended by university personnel, much of the BL is applied to land cropped to soybeans, the dominant crop in the region. The impact of this practice on crop productivity and groundwater quality has not been determined. Therefore, two field experiments were conducted to determine the effect of BL amendments to soybean ground on crop yields and N_2 fixation, and the contribution of BL to plant N, soil N, and groundwater nitrate.

Experiment 1 (BL Rate Study) was conducted over a two-year period. Treatments were four rates of BL (0, 4.5, 9.0, and 13.4 Mg Ha^{-1}, field moist) applied in May. Experiment 2 (BL Timing Study) was conducted for one year. Treatments consisted of four times (Nov., Jan., Mar., and May) of application of 9.0 Mg BL ha^{-1}. In both experiments, the BL was broadcast and immediately incorporated by disking. Soybean, cv. Avery, was planted soon after manure application. Microplots containing non-nodulating isoline of Clark (non-nod) were set up in each plot to facilitate estimates of BL-N uptake and N_2 fixation by the difference method. Shoot samples of Avery and Clark were collected at flowering (R2) and physiological maturity (R7) and analyzed for dry weight and N content. Soil samples were collected from each plot to a depth of 30 cm just prior to BL application and every two weeks until mid-September. At post-harvest, soil samples were taken to a depth of 1.2 m. and were analyzed for ammonium, nitrate, pH, and soluble salts (EC). In Experiment 2 only, groundwater samples were collected monthly from sampling wells in each plot and analyzed for nitrate.

Nitrification of NH_4-N added by the BL occurred within the first eight weeks of the field study. Concentrations of NH_4-N dropped from as high as 12 mg kg^{-1} for 13.4 Mg BL ha^{-1} to background levels of less than 2 mg kg^{-1}. After week 12, all amended soils and the control displayed slight increases (~1 mg kg^{-1}) in NH_4-N levels. These increases suggest that mineralization of more resistant forms of soil organic N and BL N into NH_4-N may have been occurring.

Results for the rate study indicate that nitrate levels in the soil alone remained stable (~5 to 8 mg kg^{-1}) during the 18 week sampling period. Where BL was applied, NO_3-N increased from background levels to ~25 mg kg^{-1} up until six weeks then decreased. Nitrate-N levels began to stabilize at week 10 and remained at ~10 mg kg^{-1} for the rest of the season.

Broiler litter had no effect on Avery shoot weight and little effect on seed yields. Broiler litter decreased nodule numbers, nodule fresh weight, and N_2 fixation. Dinitrogen fixed in the rate study was 127, 81, 44, and 54 kg ha^{-1} for the 0, 4.5, 9.0, and 13.4 rates, respectively. Plant N derived from BL was 37, 60, and 52 kg ha^{-1} for the low, medium, and high rates, respectively. These values equate to nitrogen use efficiencies (% recovery of BL-N) of 25% or less for total BL-N and 40% or less for estimated plant available N.

Data for the timing study are still being processed. The accepted NO_3-N limit for drinking water (10 mg N per kg) was exceeded only when the BL was applied in January (July groundwater sampling) or November (July sampling). By this July the results of one full year of groundwater sampling will be available.

USE OF WASTE AMENDMENTS TO REDUCE PHOSPHORUS BIOAVAILABILITY FROM AGRICULTURAL LAND TREATED WITH ANIMAL MANURES

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Increased land application of poultry and swine manures in eastern Oklahoma has led to concern of the environmental impact of nutrients on surface waters (Sharpley et al., 1991). Excessive land application of animal waste increases available phosphorus in soil and increases potential environmental impact to surface waters. Recent Soil Conservation Service guidelines (SCS, 1994) limit land application of animal waste based on soil available Mehlich III P content. Many soils that have received excessive manure application have available P levels that exceed SCS guidelines. The objective of this research was to evaluate the ability of municipal and industrial waste amendments to reduce bioavailable P in soils that have received excessive manure application.

Four soil amendments, which reduced dissolved P more than 90% in test solutions, were used in this study. Amendments included two drinking water treatment alum sludges (A1, A2), bauxite residue or red mud (RM), and cement kiln dust (CKD). These amendments were incubated with three soils that contained large amounts of Mehlich III available P. Mehlich III available P were 553, 510 and 296 mg P kg^{-1} and soil pH were 5.3, 5.8 and 8.2 for two Dickson silt loams and a Keokuk very fine sandy loam, respectively. The experimental design was a completely randomized block design with two application rates (3 % and 10 % w/w) and three replications. Soils (250 g) were mixed with amendments and maintained at field capacity and constant temperature ($25^{\circ}C$) with a 16 day light simulation. Soil samples were taken from the pots at intervals of 3, 5 and 9 weeks. Both soluble and bioavailable forms of P were determined for all amended soils. Soluble P was determined by 1:2 soil:0.01 *M* $CaCl_2$ extraction and bioavailable P was determined by Mehlich III soil extraction and 0.1 *M* NaOH extraction (Dorich et al., 1985). Extracted P was measured by a modified Murphy-Riley method (Olson and Sommers, 1982). Results showed all amendments reduced bioavailable P. The ability of the 10 % amendment rate to reduce bioavailable P (in mg P kg^{-1}) from 553 in the slightly acidic Dickson soils were A2 (246) > RM (344) = CKD (357) > A1 (365) (Fig. 1). However, for the calcareous Keokuk soil, a different trend was observed: bioavailable P was reduced from 296 mg P kg^{-1} to A2 (119) > A1 (180) > RM (209) > CKD (233). All reductions in bioavailable P were significant at $P < 0.05$. Reduction of bioavailable P was greater at the 10 % amendment rate than at the 3 % rate. Amendments, except A1, slightly increased the soil pH for the slightly acidic Dickson soils. Amendments had no effect on soil pH of the calcareous Keokuk soil. The CKD and RM amendments increased soil EC, but the other amendments had little effect on soil EC.

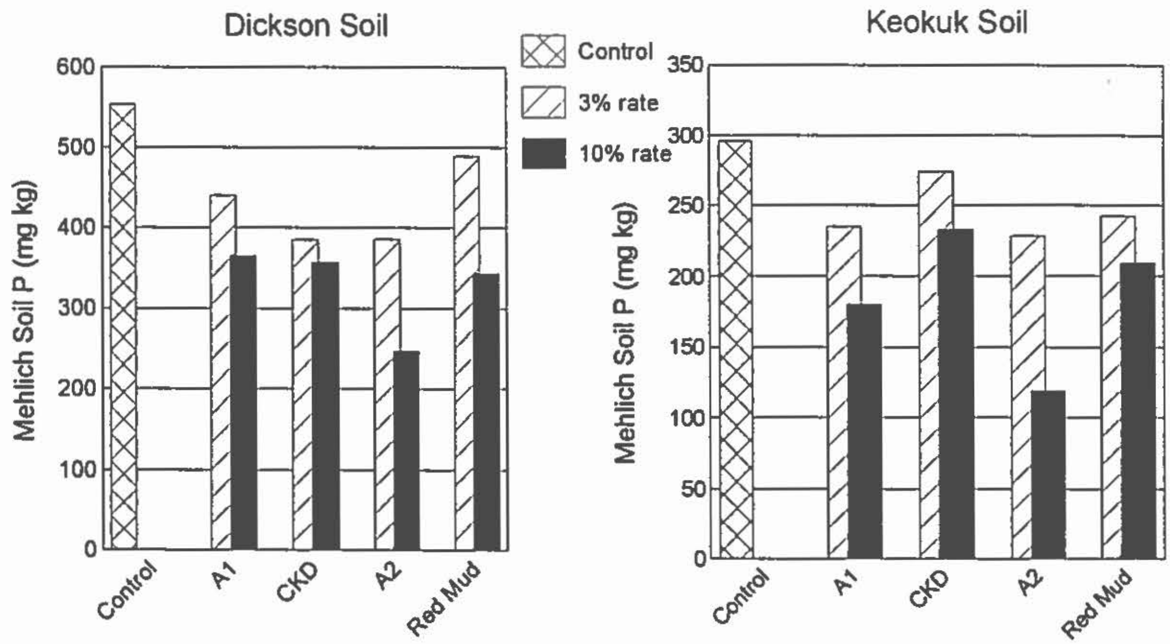

Figure 1. Effect of waste amendments on Mehlich III-extractable P in soil.

References:

Dorich, R.A., D.W. Nelson, and L.E. Sommers, 1985, Estimating algal available phosphorus in suspended sediments by chemical extraction. *J. Environ. Qual.*, 14(3):400-405.

Olsen, S.R. and L.E. Sommers, 1982, Phosphorus, p. 413-414, *In* A.L. Page et al. (ed.) Methods of Soil Analysis, Part 2, 2nd edition, Soil Science Society of America, Society of Agronomy, Madison, WI.

Sharpley, A.N., B.J. Carter, B.J. Wagner, S.J. Smith, E.L. Cole, and G.A. Sample, 1991, Impact of long-term swine and poultry manure application on soil and water resources in eastern Oklahoma. USDA-ARS Technical Bulletin, T-169.

Soil Conservation Service, 1994, Soil Conservation Service Conservation Practice Standard: Waste Utilization, Code 633, USDA-SCS, Stillwater, Oklahoma.

IRRIGATION OF CATTLE FEEDLOT RUNOFF ON WINTER WHEAT

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Unpaved cattle feedlots in the Southern High Plains produce rainfall runoff containing high concentrations of nutrients, salts, oxygen-demanding organic matter, and volatile solids (Sweeten, 1990). The design rainfall event for a 25 year, 24 hour design storm as utilized by EPA and several cattle feeding states ranges from 130 mm (5.1 in.) in the vicinity of Lubbock and Amarillo, Texas to only 76 mm (3.0 in.) at Greeley, Colorado. The volume of open lot runoff can be approximated by the USDA soil cover complex curve number (SCN) 90. A water balance approach to sizing of holding ponds is generally used also. The two primary methods of effluent disposal are (a) evaporation and (b) irrigation onto crop or pasture land. Either method requires periodic solid residue removal and requires adequate land area for spreading of solids or liquids. To have a sustainable system, adequate land area should be provided to utilize available nutrients and to assimilate salts contained in feedlot runoff.

A four-year study involving irrigation of winter wheat with collected runoff from a 45,000-head cattle feedlot was conducted on the Southern High Plains of Texas. Soil salinity and nutrient levels of soils were controlled through proper effluent application rates in level borders and through soil management that included chiseling to prepare for leaching during wet weather. Twelve level borders adjacent to the feedyard were established, and ten of them were irrigated each year with effluent from two runoff holding ponds. Applications averaged 0, 101, 169 and 234 mm (0, 4.0, 6.7 or 9.2 in.) of effluent annually. No other irrigation water was available. Soil samples were taken at least annually at 305 mm intervals between 0-1,200 mm depth. Cattle feedlot runoff was high in nutrients and salinity (Table 1). However, effluent quality improved for land application as the runoff control system was converted from a total-evaporation system to an irrigation disposal/utilization system.

The effluent contained an average of 3.0, 0.8 and 4.6 kg/ha-mm (67, 18, and 460 lbs/ac-in) of total N, P and K applied based on concentrations of 295, 78 and 2,029 mg/L. Soil salinity and nutrient content reached a peak after the 1991 crop year and a very dry spring. However, deep chiseling the soil after the 1991 wheat crop, followed by abnormally high rainfall of 933 mm (36.75 in.) in the subsequent 12 months, reduced the soil salinity (Table 2). Final soil salinity values were 1.8 mmhos/cm or below for either 1, 2, or 3 effluent irrigations per year, with total effluent application averaging 0, 101, 169, or 234 mm/yr (0.0, 4.0, 6.7, or 9.3 in/yr), respectively. By comparison, the control (non-irrigated) treatment had a final soil conductivity value of 0.4 mmho/cm. At the end of the study (June 1992), soil samples showed higher nitrate in the soil profile for the treated plots (14-17 ppm) than in the control plots (3.4 ppm). Phosphorus ranged from 12 ppm in control plots to 23-26 ppm in treated plots, which is not excessive.

Wheat forage yields were not impressive and no clear yield trend was established with respect to effluent treatment. Effluent-treated plots produced higher forage protein levels and protein yields than non-irrigated control plots.

Table 1. Mean Concentrations of Solids, Nutrients, and Salinity in Runoff Holding Pond Contents and Effluent Used for Irrigation, June 1987 - June 1992

	Mean	Standard Deviation	Minimum	Maximum
Total Solids TSS ppm	10,931	3,489	5,955**	17,150*
Volatile Solids VS ppm	3,734	1,566	1,800**	7,015*
Chemical Oxygen Demand COD ppm	5,394	1,856	3,120**	7,685*
Total Nitrogen N ppm	295	103	123	403**
NH_3 -N ppm	225	83	100	345
Total Phosphorous P ppm	78	22	52	103
Potassium K ppm	2,029	812	757	3,179*
Conductance EC (mmhos/cm)	12.1	2.5	8.5	15.0*
SAR	11.5	7.1	5.0	28.1
SSP	31.8	15.2	19.3	69.3

* Mean of Initial 4 samples in June, 1987.
** Mean of final 2 samples in June, 1992.

Table 2. Summary of Soils Analysis on Feedyard Wheat Plots, June, 1992

Parameter (Salts)	Control (2 plots) A-1,9	One Annual Irrigation per year (2 plots) A-2,4,8,11	Two Annual Irrigations per year (3 plots) A-5,7,12	Three Annual Irrigations per year (2 plots) A-3,10
pH	8.18	8.26	8.37	8.50
EC, mmhos/cm	0.4	1.4	1.8	1.3
NH_4-N, ppm	3.4	2.6	3.2	2.5
NO_3-N, ppm	3.4	16.7	15.0	14.4
P, ppm	11.8	23.2	36.4	34.1
K, ppm	15	57	104	79
Na, ppm	14	155	142	206
Ca, ppm	79	211	241	162
Mg, ppm	10	35	31	22
Cl, ppm	316	577	784	352
SAR	0.4	8.5	3.3	4.6

[1] Data are means after four years of effluent treatment.

References:

Sweeten, J.M., 1990, Feedlot Runoff Characteristics for Land Application, In: *Agricultural and Food Processing Wastes*. (Proceedings of the 6th International Symposium on Agricultural and Food Processing Wastes), American Society of Agricultural Engineers, St. Joseph, Michigan, pp. 168-184.

MINERAL COMPOSITION OF SHEEP FECES BEING DEPOSITED IN GRAZED APPALACHIAN HILL-LAND PASTURES

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Sustainable agricultural systems currently being developed rely upon more extensive use of soil and water conservation methods and attention to water quality factors. Conservation and management practices to reduce potential nonpoint sources of pollution in agricultural systems become strategically important in hilly and mountainous regions more suited to grassland agriculture where grazing ruminants harvest the crop.

Grazing management and animal manure can be beneficial to soils by improving tilth, water holding capacity and aeration, and reducing wind and water erosion. However, little information is available for determining the amount and composition of fecal nutrient and impact of grazing livestock agriculture on environmental quality in hill-land pastures.

In a preliminary trial, ten merino wethers (avg. wt. 68 kg) were fitted with fecal collection bags and allowed to graze orchardgrass-tall fescue-clover pasture (16.9% CP; 36.4% ADF and 66.0% NDF). Total fecal collection was done for 5 d and mean fecal output per d was determined based on metabolic body size (BWkg.75) of the sheep. Feces collected was composited and subsequently analyzed for N, P, K, Ca, Mg, S, Mn, and Cu.

Total amount of fecal mineral nutrients being deposited in fifteen 0.2-ha paddocks grazed by six groups of 21 wethers was calculated using information determined from the fecal collection study. Amount of feces and nutrients being deposited by each group averaged (kg/d/ha) 46.2 feces, 1.1 N, .59 P, .56 K, .57 Ca, .45 Mg, .20 S, .01 Mn, and .0015 Cu.

Herbage composition was 2.71% N, 0.36% P, 2.96% K, 0.28% Ca, 0.46% Mg, 0.37% S, 123 ppm Mn, and 8.25 ppm Cu during this 5-d period.

Fecal nutrients recycled to pastures can contribute significant amounts of macrominerals and need to be credited to the overall nutrient management plan. Plant canopies kept vegetative during the growing season can maximize uptake of fecal nutrients thereby reducing runoff and leaching loss potential of excess nutrients, especially N, P, and K deposited in pastures by grazing livestock.

Grazing management strategies need to be refined for hill-land agriculture to not only maintain high quality forage and a uniform supply of forages for production livestock, but also control placement and timing of livestock manures in grazed pastures. Consideration must also be given to plant communities that provide rapid and efficient uptake of nutrients in order to reduce pollution potential from livestock waste.

Future research at the Appalachian Soil and Water Conservation Research Laboratory will focus on diversified forage plant communities and grazing management strategies in hill-land agriculture to evaluate nutrient movement and resultant impact on water quality.

The authors wish to thank the USDA, Natural Resources Conservation Service at Morgantown, West Virginia for their assistance in nutrient analyses of feces and herbage.

PATHOGEN INDICATOR ORGANISM SURVIVAL IN SOIL

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Pathogen indicator bacteria (fecal coliform) are above levels acceptable for swimming in many Northwest Arkansas streams. Fecal organisms contaminating streams could be reduced by enhancing bacterial and viral death before transport from soils into streams. Therefore, temperature studies both in the laboratory and field were undertaken to evaluate the die-off of fecal coliform, Escherichia coli, and coliphage in soil amended with poultry litter, septic effluent, and E. coli culture.

In the laboratory study, die-off rates were determined for fecal coliform and coliphage in soils amended with poultry litter or E. coli. Captina silt loam was amended with E. coli culture at 1.32 x 107 CFU/g dry soil. Poultry litter was applied at a rate of 0.1g/g dry soil. Waste treatments were incubated at 5 and 350C following amendment and initial moisture adjustment to -0.03 MPa. Fecal coliform and coliphage numbers were determined at intervals and first order kinetics were used to determine die-off rates.

Die-off rates indicated that increased temperature enhanced the death of bacteria in the laboratory study soil. When incubated at 35 °C, fecal coliform populations were reduced by 99.9% within 10 days after soil amendment with E. coli culture. However, at 5 °C it took 30 days for the same reduction. Litter amendments at 5 °C took 70 days for 99.9% reduction in fecal coliform levels. Coliphage from broiler litter persisted ten times longer than fecal coliform under cool conditions. As an indicator organism, fecal coliform is less persistent in soil at 5 °C than coliphage. Using results from this laboratory experiment a survival study is being conducted under field conditions.

A field study was conducted to evaluate indicator organism survival. In the same soil used for the laboratory study, waste treatments were incubated under field conditions during the summer. Waste amendments consisted of broiler litter applied to the soil surface, soil incorporated broiler litter, and septic effluent applied to the soil surface. Amendment rates were equivalent to those used in the laboratory study. Amended soils were packed into PVC tubes with 0.45um membranes covering the ends contacting the soil. Average soil temperature and percent soil moisture during the summer incubation was 19.2 °C and 17.8%, respectively. Fecal coliform, E. coli, and coliphage were determined at intervals and first order kinetics were used to generate die-off rates.

The bacterial indicator organism, fecal coliform produced die-off rates that were not significantly different from rates for E. coli. By extrapolating the die-off rate constants to a 99.9% reduction, from 40 to 230 days would be required for reduction of bacterial indicators in soil ammended with broiler litter. Coliphage could persist in surface-amended litter for at least 770 days under the conditions of this study. It could take from 80 to 130 days for the bacterial indicators to die-off in soil amended with septic effluent.

In summary, increased soil temperature promoted bacterial die-off. The die-off rates for the bacterial indicators (fecal coliform and E. coli) were no significantly different from each other. At cool temperatures in the laboratory study and in the surface-amended litter of the summer field study, coliphage persisted longer than fecal coliform. High temperature can increase die-off rates of pathogen indicators and reduce the organisms available for transport into water systems. Temperature should be considered and integrated into best management practices designed to reduce pathogen levels in surface and groundwater.

Stream Effects

SUCCESS OF BEST MANAGEMENT PRACTICES (BMP'S) IN REDUCING STORMFLOW TOTAL SUSPENDED SOLIDS (TSS) IN A SOUTHERN APPALACHIAN STREAM

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Total suspended solids (TSS) have been monitored in Tellico Creek (Macon Co., NC) since November, 1990, during baseflow and stormflow conditions, to ensure that construction of a transmission line did not adversely affect water quality or a major trout farming operation downstream. A vertical series of single-stage suspended sediment samplers (US U-59) was employed to automatically collect representative TSS samples on the rising stage of storm hydrographs, when erosion and worst-case sediment impacts are most likely to occur. Depth-integrated samples were also collected, in duplicate, at approximately twice-monthly intervals. Stream stage and the stages at which each of the single-stage samplers filled were measured against a fixed stake to which the samplers were attached, and stream discharge was measured at various stages, to provide a stage:discharge regression equation from which to estimate flood discharge levels, and instantaneous TSS loads corresponding to each single-stage sample.

The mean TSS of 24 stormflow samples, collected over nine months before transmission line construction started, was 411 mg/L, and the mean of 27 stormflow samples collected at the same site (the lower end of the work area) in 16 months during and after construction was 138 mg/L - a reduction of 66%. Similarly, the maximum stormflow TSS sample during and after construction (844 mg/L) was 58% less than the maximum stormflow sample (2019 mg/L) collected in the preconstruction period. Baseflow TSS at this site also fell, from an average of 13 mg/L (N=40) before construction, to an average of 9.3 mg/L (N=70) after construction. Improving and stabilizing roads, installing culverts and broad-based dips, maintaining silt fences to reduce sediment transport, promptly seeding disturbed areas, and observing vegetated buffer zones along the creek all contributed to successful completion of the transmission line project in 1992.

Lower areas of the creek, however, remained subject to sedimentation impacts exceeding 10,000 mg/L TSS. Volume-weighted TSS transport at seven sites throughout the watershed allowed us to identify a small family farm as the source of 90% of TSS loading above the trout farm. With the landowner's cooperation, BMP's were applied in 1994 and 1995, to improve water quality. Approximately 5000 feet of fencing was installed in 1994 to exclude cattle from the streambank and allow a vegetated buffer zone to develop naturally. A new bridge enabled cattle to harmlessly graze on both sides of the creek, and watering tanks were substituted for direct stream access.

Had nature cooperated, we might have had results from two successful projects to report. As it turned out, catastrophic rainfall and flooding in 1994 obliterated several sampling stations and caused landslides, road slumping, and extreme channel erosion, and resulted in record high TSS concentrations throughout both the experimental watershed and the paired control watershed, with TSS in Tellico Creek exceeding 100,000 mg/L. In the control stream, Sugar Cove Creek, TSS reached nearly 45,000 mg/L, compared to a prior maximum of 870 mg/L and mean of 126 mg/L, among 92 storm samples over a 42-month period. Although much less frequent than anthropogenic impacts, natural disasters can clearly dwarf man's usual impact on the environment. While the exclusion of cattle from the stream immediately eliminated some direct damage to the stream bank, it is also apparent that the natural revegetation of the new buffer zone, and further reduction in sediment transport in the stream, will proceed over a period of years, barring additional extreme events.

THE EFFECT OF URBAN CONTAMINATION ON AN OZARK STREAM USED FOR AGRICULTURE

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Contamination of streams, water tables, and other aquatic resources is becoming a major environmental problem. However, concomitant urban pollution that also impacts water sources may be overlooked as an additive problem, especially when the urban area involved is not large. Crooked Creek (Boone and Marion Counties), in Northcentral Arkansas, supports a modest agricultural industry in the form of livestock and poultry husbandry. It is also a major smallmouth fishery and is used for other recreational activity. This stream has the largest urban center (Harrison AR) that is situated directly on the upper reaches of a major Arkansas Ozark stream.

To determine the effect of urban point and nonpoint contamination on the water quality of Crooked Creek, water samples were collected from 27 sequential sites, in one day, from above Harrison to the stream's juncture with the White River. This was repeated for all seasons from 1992-1994. Samples were analyzed for standard physical, chemical, and microbiological parameters. Water samples for bacterial counts were collected in sterile 100 ml specimen containers. Total coliforms were determined by using a spread-plate technique on MacConkey's medium and total heterotrophic bacteria determined by a dilution and pour plate technique in minimal plating medium. Water samples for chemical analysis were collected in pre-cleaned plastic containers. Chemical analyses were done as follows: NO_3, NO_2, Cl, PO_4, and SO_4 by flow injection analysis using a spectrophotometer; Al, Ba, Ca, Fe, Mg, Mn, Na, K, Zn, and Cu by an inductively coupled Argon plasma atomic emission spectrophotometer; Ag, Cr, Pb, Cd, As, and Se (trace metals) by a graphite furnace atomic absorption spectrophotometer. The trace metals, as well as Cu, Zn, and NO_2 contents, were all below the standard detection levels for analysis and were not considered to be of major concern. Hydrogen ion concentration was measured by standard procedures using an Orion pH meter.

Water quality was found to increase proportionally to the distance from Harrison. All chemical values except magnesium were highest at Harrison and decreased downstream. Increasing magnesium may be explained by the change in stream stratum from a calcium limestone in Boone County to a magnesium-rich dolomite formation in Marion County. Some values exceeded acceptable standards for Arkansas Ozark streams. All metallic ions showed a significant relationship with stream distance from Harrison by regression analysis. Unusual for an Ozark stream was the near neutral pH found at Harrison changing to the more expected alkaline pH downstream. Total coliform counts at Harrison were consistently above accepted values for swimming and continued to be so for 10-15 miles downstream. Nitrate, chloride, and phosphate values exceeded, or were close to, maximum accepted values.

It is not clear from this study exactly what contributions agriculture is adding upstream or downstream from Harrison. However, the data strongly suggests that a major portion of contamination of Crooked Creek is a result of urban rather than agricultural activity. Preliminary data obtained by our group has shown that the Caddo River in Western Arkansas, which passes through an agricultural area similar to Crooked Creek but without the much larger urban population, does not have as high values for pollution indicators. In contrast to the Caddo, tributaries of the Illinois River in Northwest Arkansas, which drain urban areas, appear to provide a large portion of the pollution of that stream. Increased urbanization of the Ozarks will add to the pollution burden of water resources in this area. It will be important to differentiate urban from agricultural contamination if effective remedial or preventive measures are to be applied. Continued studies of Crooked Creek could serve as a model for the combined effects of both urban and agricultural contaminants on the water quality of midamerican mountain streams.

SPATIAL AND LANDSCAPE CHARACTERISTICS OF SMALL LIVESTOCK CONFINEMENTS AFFECTING STREAM WATER QUALITY

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Livestock wastes are often a constituent of rural nonpoint source pollution (NPSP), and methods of identifying and assessing source areas in landscapes (i.e. watersheds) are essential to comprehensive NPSP control. A new, derived variable was developed in an attempt to provide a mathematical expression (value) of a number of spatial and physical variables associated with nearstream livestock confinement areas shown to affect local stream water quality. The "point" source variable (PSVAR) initially arose from a 1989 study of four small agricultural watersheds in northeast Kansas. This variable incorporates remotely sensed data on confinement size, activity level, distance from stream and stream distance to sampling point for water quality parameters into a single "index" value that was then related to water quality conditions. In an examination of confinements within 300 meters of a stream channel, the PSVAR was found to be highly correlated with several water quality parameters indicative of animal waste pollution, including elevated levels of ammonia and chemical oxygen demand (COD). However, the initial associations were identified during a drought period, which may have increased relative contributions of confinements to local degradation of stream water quality. In the initial evaluation of PSVAR, it was shown graphically and through interpretation of correlation coefficients that relatively small, unregulated livestock confinements contributed to instream concentrations of nitrogen, turbidity, total suspended solids (TSS) and COD.

To further investigate the potential utility of the PSVAR, data from a nonpoint source pollution project in agricultural areas of the great plains were analyzed. This NPSP project, sponsored by US EPA (Region VII) allowed for analysis of data at a much larger scale (both spatially and temporally) in an attempt to calibrate/validate PSVAR as a potential tool for identification and assessment of sites with the potential to act as point sources. The study watersheds were located in northeast Kansas, eastern Nebraska, and throughout Iowa. This project was over two years in duration, allowing for analysis of water quality and PSVAR on a seasonal and an annual basis. In addition, non-drought flow conditions were experienced during this project, reducing the likelihood that extreme low flow conditions might exaggerate the influence of livestock confinements on stream water quality. The results of both of these studies indicate that small, typically unregulated livestock confinements do have the potential to affect stream water quality and must be addressed in evaluations of NPSP in agricultural landscapes. Further refinements to the PSVAR are needed to make it a viable tool for evaluation and management of rural stream water quality. We are currently evaluating the influence of site-specific soil factors, interceding land use/land cover and drainage features on PSVAR predictions. These ongoing investigations attempt to utilize remotely sensed or existing data (e.g. aerial photography, county-level soil survey data) to improve PSVAR performance in order to reduce the need for field collection of data.

Impact on Lakes and Wetlands

TROPHIC STATUS OF BEAVER LAKE, ARKANSAS: PAST AND PRESENT

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Accelerated eutrophication is a major environmental concern in surface water bodies of the United States. The degree of eutrophication is believed to be largely related to phosphorus loading. Phosphorus loading can usually be correlated to land use. This study was conducted to assess the current trophic status of Beaver Lake, Arkansas, and to compare the results to a similar study conducted on Beaver Lake in 1973-1974 (Meyer, 1974).

Water samples were taken 18 times annually at ten sites within Beaver Lake beginning at one meter below the surface and continuing with every other meter to the lake bottom, corresponding to the previous study. In situ determinations of pH, electrical conductivity, temperature, dissolved oxygen, light extinction and Secchi depth were made. Samples were filtered for determination of soluble reactive phosphorus, soluble metals, ammonium, nitrate, and anions. Samples were also taken for alkalinity, total phosphorus, total nitrogen, total metals and chlorophyll *a*, *b* and *c*. Water samples were also collected from the major tributaries of Beaver Lake (White River, Richland Creek, Brush Creek and War Eagle Creek) to evaluate the relationship between water quality and land use.

Based on overall chlorophyll concentrations, Beaver Lake is more eutrophic than 20 years ago. A significant increase from the 1974 study to the present study was shown in the concentrations of chlorophyll *a*, *b* and *c*.

Table 1 - Overall average chlorophyll concentrations

Year	Chlorophyll-*a*	Chlorophyll-*b*	Chlorophyll-*c*
1973	3.94 b	0.71 b	1.68 b
1993	5.80 a	2.79 a	4.44 a

Means within a column with different letters are significantly different ($P > 0.0001$).

Significant increases were also observed when comparing chlorophyll concentrations by site, date, site*date, season and site*season. The preceding comparisons also indicated chlorophyll concentrations increased when using only the surface samples and when using only the samples within the photic zone (depth $\leq$ 5m). The combination of shallow Secchi depths and increased chlorophyll-*a* concentrations also suggests increased eutrophication of Beaver Lake. The increased eutrophication is probably related to increased phosphorus loading. Accelerated eutrophication in Beaver Lake is cause for concern, since it is the first lake in a chain of lakes on the White River. Other studies have indicated increased eutrophication in Table Rock Lake, Missouri, and Bull Shoals Lake, Arkansas, in recent years. Further observations and analysis will also be discussed.

References:

Meyer, R.L. 1974. Biochrome analysis as a method for assessing phytoplankton dynamics. Arkansas Water Resources Center, University of Arkansas. Fayetteville, Arkansas.

RESULTS OF THE FIRST YEAR OF AN EXPERIMENTAL CONSTRUCTED WETLAND TO TREAT WASTEWATER FROM A SWINE LAGOON IN INDIANA

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Options for use and disposal of wastewater from animal operations, such as dairies and swine operations, are becoming more limited in Indiana. Discharge of wastewater is prohibited, land application is restricted, and reuse systems are not without problems. Small producers may be hit particularly hard by this. Reductions in nutrient loads can enhance wastewater use in recycle systems and make utilization through land application easier. The scope of this project is to determine if constructed wetlands are a viable wastewater treatment option for small producers in the climate of northern Indiana and establish optimal operating conditions for such systems.

Planting of a 16-cell experimental constructed wetland at the Purdue University Animal Science Farm Swine Facility was completed in early May, 1994. After two months of vegetation establishment, wastewater from the final lagoon in a three-lagoon system was loaded into the system. Three hydraulic loading rates (450 Ld^{-1}, 900 Ld^{-1}, and 1800 Ld^{-1}) and two water depths (15 cm and 30 cm) were tested. Three replicates of each combination tested were conducted. Three cells were used for a wetland plant seed germination study, and one cell was maintained free of vegetation. Water quality of cell influent and effluent was monitored throughout the growing season. Vegetation response to different hydrologic regimes was monitored.

Water quality tests indicate shallow wetlands with dense vegetation and low hydraulic loading rates perform best in treating swine wastewater. However, greatest reductions in ammonia-nitrogen were achieved in the unvegetated cell. This may have resulted from three factors (singly or in combination): 1) pH fluctuation induced by algal photosynthesis could have resulted in precipitation of ammonia compounds; 2) greater exposure to oxygen from algal photosynthesis and exposed water surface might have allowed greater nitrification rates; and 3) volatilization of ammonia into the atmosphere would have been enhanced by open water.

Quality of wastewater in the lagoon was highly variable during the year. Biochemical oxygen demand (BOD) levels fluctuated during summer but stabilized in fall. Lagoon water also was used for irrigation water during late summer. Lagoon volume was greatly reduced during irrigation and this may have affected BOD levels. Following cessation of irrigation, BOD levels stabilized. Lagoon ammonia-nitrogen and conductivity levels began to increase in late summer and continued to increase throughout the fall. This also may have been linked to changes in the lagoon resulting from irrigation. It appears a chemocline may have developed in the lagoon, separating relatively cleaner surface water from a more concentrated layer at depth. Both wetland water and irrigation water were pumped from the surface of the lagoon, possibly removing the upper layer. A more detailed study during the second year will attempt to determine if this chemocline does exist in summer.

Vegetation performed better at shallower system operating depths. This was true for all plants tested. Broad-leaf cat-tail (*Typha latifolia*) displayed the greatest vigor, both in individual plant health and plant colony density. Softstem bulrush (*Scirpus validus*) had the next best performance. These two species continued to grow when subjected to extended loading with ammonia-nitrogen levels in excess of 250 ppm in late summer and fall. Mature plants continued to grow, but clonal expansion from rhizomes was reduced. Narrow-leaf cat-tail (*Typha angustifolia*), three-square bulrush (*Scirpus acutus*), and common reed (*Phragmites australis*) performed poorly or died out within cells. Both three-square bulrush and common reed were eliminated from cells under continued loading at high ammonia-nitrogen levels. The second year will determine if the plants were killed or just senesced.

Direct establishment of vegetation from seeds may not be a viable option for constructed wetlands in northern Indiana. Emergent wetland plants germinate best when soil temperatures are 25°C or higher. They also need exposure to air for germination. The late frost-free date (May 5) for this area prevents soils from reaching those temperatures until summer. Both native and exotic non-wetland plants will become established before then if the wetland is kept dry. If the wetland is kept flooded until mid-summer, plant establishment from seeds will be enhanced, but the wetland will not be operational until fall or the next season. Water levels must be kept low enough not to overtop young plants or the plants will die. Transplants of nursery stock (more expensive) or natural wetland plants (more labor intensive) appear to work better in this climate.

There has been much debate among constructed wetland researchers about the merits of multi-species vegetation assemblages versus monocultures. Because farm wastewater is highly variable, hardy plants that tolerate system stresses appear to be the best choice. This may result in decreased plant diversity, but it makes little sense to establish plants that could easily be killed by an episodic change in wastewater quality. The active treatment season lasts into December. Winter ice-up and declines in microbial transformation rates make system operation through the winter impractical. Systems with established vegetation should be able to be flooded by mid-May. This gives an active treatment period of six months. For constructed wetlands to be viable in northern Indiana, operators need a means of storing wastewater for the other six months.

Watershed Management

HOW TO EVALUATE (AND REDUCE) WATER POLLUTION (N, P) FROM ANIMAL WASTE AT VARIOUS GEOGRAPHICAL LEVELS - A DECISION SUPPORT SYSTEM IN BRITANNY

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The nitrate levels in Britanny's waters have been increasing for several years (a five-fold increase in fifteen years). Aside from the consensus of opinion regarding this growing problem, real difficulties are surfacing when it comes to establishing a precise diagnostic of the situation (source, development, consequences). Analysis of environmental problems is complex and requires a large quantity of data. We have developed a decision support system for evaluating and reducing agricultural pollution (Nitrogen and Phosphorus). This was possible thanks to computer technology such as geographical information systems. The **A.I.S.O.E. (Agricultural Information System Oriented Environment)** has been designed to integrate the various levels requiring consideration **(region, farm, plot)**.

The reasoning method, dubbed **"Overall Balance"**, makes it possible to get a general view of the surplus (or defecit) of nutrients at the regional, farm or plot level. This model is a calculation of the inputs (supply) and outputs (yield) of nitrogen, phosphorus and potassium. The difference is expressed as a positive or a negative balance. However, the different methods of calculating each value can lead to different results and contradictory interpretations. Since 1980, Cemagref has been developing a new methodology in an attempt to reduce the number of errors occuring in the initial data. As a result of this work, standards have been established so that comparable data are obtained, regardless of the area under consideration. This methodology can be put to very different uses as developing a diagnostic of non- point source pollution on a livestock farm by evaluating :

. the *potential nutrient production* on a livestock farm, the avaibility of nutrients and their management;
. the actual recycling these nutrients and the *structural risk* of surpluses or deficits;
. the commercial fertilizer savings achievable if waste management was optimized;

but, also another use as assessing the potential risk to non-point source pollution by providing an overall estimation of the nutrients discharged or which can be accomodated on land used for agricultural production in different geographical environments (watershed, district).

The results in Britanny have shown different situations: the nitrogen inputs are 395,000 tons, half of which is due to chemical fertilizers, the other half comes from manure. The contributions from animal origins are on an average 110 kg N/ha (75 kg P_2O_5/ha): 57% are due to bovines, 25% to porcines and 13% to poultry. These averages disguise great area to area variability: around 10% of the districts exceed 170 kg N from animal origin per ha (achieve 220, more over if we consider the regulation of effluent sewage, these figures are likely to double or triple). Regarding these assesments, situations are also changeable by using a "potential crop yield under good conditions of cultivations practices," we obtain in Britanny, a structural pollution risk of 96,000 tons of nitrogen and more than half of the districts have a global balance superior to 50 kg N/ha. We have verified this tool as a good method to target and identify critical non-point source pollutant contributing areas in Britanny. So, we have compared our results with real data which come from analysis of nitrogen in water (*40 watersheds are studied since 1987*). This was possible with a GIS Raster developed by ENSA-INRA in Rennes called Mntsurf. From a digital elevation model, we have the drainage network and limits of watersheds. The data from the model were compared with the real data and the correlation was good (>0.7) and a typology of these watersheds can be determinated with different variables (producted by digital elevation model or coming from raster map like geology, land cover).

Coupled with computer aids (GIS, ...), these methodological balance studies allow rapid evaluation of current or future (simulation) mineral content. Valuable decision support systems for relevant groups (farmers, local and regional decision makers) were developed. This initial study opens the door for specific studies on various typical geographical environments (susceptible zones, polluted watersheds). This research coupled with other work on hydrology and remote sensing within a geographical information system, should make it possible to further improve the decision support system and thus, to develop ever more reliable advice systems for farmers so that they can make optimum use of cultivated land using environmentally friendly practices.

References:

Abrassart, J., Bertrand, M., 1994. A decision support system for evaluating and reducing pollution (N,P). XII World Congress on Agricultural Engineering, Milano, August 29-September 1 1994 Proceedings, Vol. 1, p214-221.

Abrassart, J., Bertrand, M., Herve, A.M., 1993. Bilan global de l'azote, phosphore et potassium. Méthode pour une évaluation à différentes échelles. Informations Techniques du CEMAGREF, N°91, note 1.

Abrassart, J., Bertrand, M., Garon, F., 1993. Gestion de la fertilisation (GESUFER). Informations Techniques du CEMAGREF, N°91, note 3.

Bouldin, D., Klausner, S. 1983. Managing Animal Manure. Part II. SOILS. New-York. USA.

Hamilton, J.R. 1991 Economic Impact, value added, and benefits in regional project analysis. American Agricultural Economics Association.

De Mol, R.M., Koning, J.E.T., 1992. A simulation model for manure logistics on a farm level. 1-4 June 1992 Ageng Uppsala-Sweden.

THE USE OF ELECTROMAGNETIC CONDUCTIVITY SURVEY IN QUANTIFYING THE IMPACT OF ANIMAL WASTE LAGOONS AND ANIMAL LOAFING AREAS UPON GROUND WATER QUALITY

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For the past seven years, Clemson University in cooperation with the South Carolina Soil Conservation Service, the USDA-CSRS, North Carolina State University, the University of Georgia and Texas A&M University has been coordinating a number of projects dealing with the use of Electromagnetic Terrain Conductivity Survey (EM) as a tool to delineate the effects of water seepage from animal waste lagoons and loafing areas upon ground water quality. Field EM surveys have been conducted at over 45 lagoons in North and South Carolina, Georgia, and Texas. Soil and water samples have been collected and analyzed from over 120 boreholes installed at these sites. Correlations have been developed between subsurface ground water quality, local soil and hydrogeologic conditions, and surface EM measurements. A detailed expert system has been developed to permit rapid interpretation of EM survey and prediction of an "index of subsurface contamination". Survey results to date suggest that the greatest risk to the quality of rural ground water supply is posed by long-term, wide spread manure deposition on loafing areas, as opposed to the relatively localized effects of seepage from animal waste lagoons.

FIELD TESTING OF A SHALLOW GROUND WATER VULNERABILITY ASSESSMENT PROCEDURE

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Field testing of a shallow ground water vulnerability assessment procedure (Bruner, 1990) was conducted to evaluate the effectiveness of the procedure at identifying areas where nitrate contamination associated with animal waste might occur. The vulnerability assessment procedure was based on the spatial distribution of ten key physical and chemical properties of soils, and was implemented using a Geographic Information System (GIS).

Field testing was conducted in the Big Creek watershed, a rural, 214 square kilometers sub-basin of the Tangipahoa River in Southeastern Louisiana. The watershed is an area of high ground water recharge that receives an average annual rainfall of 63.9 inches. Concentrated dairy activities (66 dairies) are present in the watershed, where a voluntary program of no-discharge lagoon installation and land application of lagoon wastewater has been underway since 1989.

Shallow water wells located on sixteen dairies and ten residential (non-dairy) sites were tested for nitrates and phosphates. Wells, selected by soil type, were sampled bi-weekly during the summer, 1993 and winter, 1994. Well depths ranged from 38 feet to 150 feet. A total of 265 samples were collected.

Sample results indicated that dairy sites had ground water nitrate concentrations below 2.9 mg-NO_3/l at the beginning of the sampling period. Nitrate concentrations at thirteen sites remained below 3.12 mg-NO_3/l all during the field testing. Concentrations above the initial base level were observed at three sites following a significant rainfall event. Elevated levels persisted at two sites for the remainder of the field testing. The highest concentration, 57 mg-NO_3/l, was observed on June 28, 1993 at a site determined to be more vulnerable than most other sites. Following contamination, the mean concentration at this site was 28.07 mg-NO_3/l with a standard deviation of 9 mg-NO_3/l. The second site experiencing persistent elevated concentrations had a peak of 10.16 mg-NO_3/l, and a mean concentration of 9.72 mg-NO_3/l (standard deviation of 0.65 mg-NO_3/l) following contamination. Phosphates were not detected at any sampling site.

Sample results for residential sites indicated that concentrations at six sites remained below 2.54 mg-NO_3/l throughout the field testing. A peak concentration of 37.69 mg-NO_3/l was observed for March 22, 1994, a date for which maximum dairy concentrations was 25.36 mg-NO_3/l. (Residential sites were sampled only in March and April, 1994.) Other elevated-concentration sites showed concentrations of 12.67, 10.23, and 9.54 mg-NO_3/l. Comparisons of dairy and residential data indicated that more residential sites (40 percent) experienced elevated nitrate levels than did the dairy locations (19 percent).

Statistical evaluation of the well sampling data continues at this time, with analyses to be performed to assess the relationships of nitrate concentrations to 1) spatial distribution of vulnerability, 2) distribution of individual soil parameters, and 3) type of site, i.e. dairy or residential.

References:

Bruner, B. G., G. W. Wilkerson, and J. Nye. 1990. Using Geographic Information Systems Technology to Assess Shallow Aquifer Vulnerability to Ground Water Contamination. Proceedings: Application of Geographic Information Systems,

Simulation Models, and Knowledge-based Systems for Landuse Management, Virginia Polytechnic Institute and State University, Department of Agricultural Engineering, Blacksburg, Virginia, 451-460.

AN ASSESSMENT OF POTENTIAL PHOSPHORUS CONTAMINATION IN THE UPPER ILLINOIS RIVER WATERSHED

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Evaluation of phosphorus loadings and sediment delivery in a representative basin of the Illinois River Watershed in Northwestern Arkansas was conducted with the integration of a Geographic Information System and a phosphorus transport model. The model known as SIMPLE (Spatially Integrated Model for Phosphorus Loading and Erosion) predicts dissolved and sediment-bound phosphorus yield, runoff volume, and sediment yield.

SIMPLE required the development of four primary data layers: soils, landuse, elevation, and hydrography. Compilation of the various data layers was accomplished with the GIS software Geographical Resources Analysis Support System (GRASS). The four primary data layers served as building blocks to derive parameters required to run the model such as curve number (CN), slope, distance to stream, and the factors necessary to calculate the Universal Soil Loss Equation (USLE).

The Fish basin was chosen as the representative hydrologic unit for several reasons. First, the Illinois River flows through this basin. This gives the opportunity to evaluate direct loading of P to the river. Second, the data needed to generate the necessary parameters to run the model are available. Third, the Fish basin drains approximately 2,248 hectares which is computationally an ideal size for the model. The dominance of agricultural activity in this basin manifests the importance of identifying and characterizing areas vulnerable to non-point source pollution.

Several simulations were run to determine the influence of litter application rate on P loadings to the Illinois River. Six application rates of litter at 0, 3500, 4500, 7000, 9000, and 13,000 kg/ha were specified. Simulation periods of 30 years (1960- 1989) were conducted for each litter application rate. Climate data were read into the model from an external rainfall file.

The simulation conducted with the litter application rate of 9000 kg/ha identified only 20% of the basin contributing significant P to the river and streams. Less than 11% of the sensitive areas in the basin contributed loadings greater than 2 kg P/ha. The sensitive areas were mostly pasture and situated near the river. Once these areas were identified, further analysis was conducted to determine the attributes that strongly influenced the transport of P in the Fish basin.

The SIMPLE input parameters associated with runoff conditions such as CN and soil hydrologic group influenced P loadings greatly. Landuse also played a key role in determining the fate of P. The model simulations at all applications rates indicate that most of the P loading to the Illinois River is contributed by the pasture whereas the forested areas contributed very little.

Watershed studies focusing on P transport could greatly benefit from the integrated modeling framework provided by GRASS and SIMPLE. Determination of regions in a watershed sensitive to high P loading diminishes the area of concern so that best management programs can be implemented more efficiently.

METHODOLOGY OF ANALYSIS
OF NON-POINT POLLUTION RISKS FOR A WATERSHED UNIT

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The reduction of water pollution is a priority of many environmental research programs in Brittany. The "Contrat de baie" program, sustained by The Brest Urban Community, aims to find the reasons why the Brest roadstead water quality decreased. The part from agricultural activities has been analyzed through the study of an experimental watershed (named : Le Kerouallon, 600 ha). The presence of nitrogen pollution has been measured in the water drained by this watershed (71 mg/l in Dec 92; 45 mg/l August 93; 69 mg/l Nov 93) (CANN, 1994). It is an intensive livestock farming zone. Agricultural practices have been analyzed with farmer surveys and practices follow up, since April 1994. Best management practices will be applied on the places where pollution has been found.

The use of GIS has been tested to identify areas where nitrogen pollution sensibility and pollutant pressure are high, so that the pollution risk is maximum. The first analysis has been realized at field scale in order to classify the parcels according to a nitrogen pollution risk index. The land sensibility has been defined from physical parameters such as pedology, topography, system of rivers. They have been combined in the GIS (ARCINFO, PC), to define homogeneous areas for nitrogen pollution risk. The distinction between surface and sub-surface runoff risk, and leaching risk has been made. The parameters involved in those two processes (soil texture, soil depth, soil hydromorphy, slope, presence of hedges and ramps) have been accounted in a decision tree. The two maps of runoff risk and leaching risk realized at the watershed scale, have been crossed with parcels: a parcel's typology has been made, named "land sensibility typology."

Temporal aspects have to be introduced in the step to explain the respective influence of runoff and leaching in nitrogen transport. The maps realized have to be modified according to the season and the soil saturation.

Soil analysis on the parcels allowed to determine nitrogenous plot profiles at the start of winter (Oct 1994). The mineral nitrogen residue, in 0-90 cm depth, varies from 20 kg/ha to more than 400 kg/ha on a few parcels; the mean is 110 kg/ha for 247 parcels analyzed. The hypothesis is to consider this nitrogen residue as the risk index of nitrate leaching. The comparison of this index map to the land sensibility typology has shown prior parcels for best management practices application. A data analysis has been applied to find the relations between the risk index and the practical parameters (crops, fertilizer and animal manure applied, crop rotations, parcel balance) which explain it. Then, a parcel's typology will be realized according to those explaining parameters, which will be named "pollutant pressure typology." Its comparison with the risk index should give the causes of the higher nitrogen pollution risk and consequently, the parameters on which modifications have to be applied.

Future analysis will be made at farm and watershed units to integrate other parameters and determine their importance in the risk index explanation. The methodology is developped to obtain a tool for pollution risk analysis applicable to a larger scale. This first analysis should give indices which may be obtained from sources like remote sensing, statistical data, and cartographical numeric data.

References:

Cann C., and Turpin N., 1994. Contrat de baie Rade de Brest. Flux de nutriments d'origine agricole vers la rade. Cemagref, 74p.

Champagne L., and Chapuis, R.P., 1993. Evaluation et cartographie de la vulnérabilité à la pollution des formations aquifères de la MRC de Montcalm selon la méthode DRASTIC. In *Sciences et Techniques de l'eau*, vol 26, n°3, pp. 169-176.

Gaury F., 1992. Systèmes de culture et teneurs en nitrate des eaux souterraines. Dynamique passée et actuelle en région de polyculture élevage sur les périmètres d'un gite hydrominéral. Thèse de Sciences Agronomiques, ENSA Rennes, INRA Mirecourt. 229 p.

Halliday S.L., and Wolfe M.L., 1991. Assessing Groundwater Pollution Potential from Nitrogen Fertilizer using a GIS. In *Water Resources Bulletin*, vol 27, n°2, pp. 237-245.

Hamlett J.M., Miller D.A., Day R.L., Peterson G.W., Baumer G.M., and Russo J., 1992. Statewide GIS-based ranking of Watersheds for agricultural Pollution Prevention. In *Journal of Soil and Water Conservation*, vol 47, n°5, pp. 399-404.

Philips D.L., Hardin P.D., Benson V.W., and Baglio J.V., 1993. Nonpoint Source pollution Impacts of Alternative Agricultural Management Practices in Illinois : A Simulation Study. In *Jounal of Soil and Water Conservation*, vol 48, n°5, pp. 449-457.

Sivertun A., Reinelt L.E., and Castensson R., 1988. A GIS Method to aid in Nonpoint Source Critical Area Analysis. In *International Journal of Geographic Information System*, vol 2, n°4, pp. 365-37.

Vedel S., 1992. Spatialisation du transfert de nitrates sous irrigation, cas de la plaine alluviale de Mauguio-Lunel. Couplage Système d'Information Géographique - Modèle de tranfert de polluants : réalisation d'une maquette. ENGREF - L3E 42p.

Best Management Practices

CURRENT MANURE MANAGEMENT STRATEGIES ACROSS A DIVERSITY OF MINNESOTA AGRICULTURE[1]

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Two geographic regions, the karst in the southeast (SE) and the outwash sands in the central interior (therein called Central Sands), are the most groundwater sensitive areas found in Minnesota. Ironically, the state's highest animal densities overlie both regions. Additionally, animal densities, particularly hogs, are increasing on the glacial till soils in south central MN (SC) where surface waters are threatened by nutrient loading. Successful efforts aimed at improving water quality through voluntary changes in farming practices will require a clear understanding of current nutrient management practices.

A series of agricultural assessments through personal farmer interviews were conducted on 300 farms since 1988. This information will be valuable in targeting educational efforts and determining adoption rates of Best Management Practices (BMPs). Nutrient inputs (fertilizers, previous legumes, and manure), yield and yield goals, and nitrogen management strategies (timing of applications, manure incorporation methods, etc.) were collected on a field-by-field basis covering approximately 195,000 acres.

Based on the analysis from approximately half of the existing data sets, it appears that Minnesota farmers are applying proper rates of commercial N fertilizers to corn in cropping systems without manure additions; rates were within $\pm$ 5 lb/A of University of MN recommendations (Figure 1). However the crediting process was seriously confounded by the addition of manure. Farmers in the SE[2] and SC[3] studies successfully accounted for 58 and 39%, respectively, of the potential first year manure-N credits. It is speculated that the apparent success is related to the degree of past educational activities. Virtually no credits were accounted for in manure applications on the Central Sands (Figure 2). However, despite the large crediting differences across the state, the overall net over-application rates were similar. This is due to the higher manure application rates in the SC and SE areas. Over-applications ranged from 50 to 68 lb/A (Figure 1).

These findings suggest that educational efforts should continue to be highly focused on proper manure crediting. The inventory type approach used in these studies is an extremely valuable tool capable of pin-pointing specific problems in complex, real world

[1]Partial funding for this research was provided by the Legislative Commission on Minnesota Resources through the Environmental Trust Fund.
[2]Legg, Thomas Devney, 1991. Farm level effects of environmental policies aimed at nitrogen management. Doctorate thesis. Department of Agricultural Economics, University of MN, St. Paul.
[3]Gunderson, L. M. and C. M. Hanson, 1995. County-level educational programs in resolving manure related water problems in south-central Minnesota. In Proceedings of the Animal Waste and Land-Interface Conference. Fayetteville, AR.

nutrient management situations. Furthermore, this study illustrates some of the hazards in gauging success of manure management programs based solely on differences inferred by decreases in commercial fertilizer usage (Figure 2).

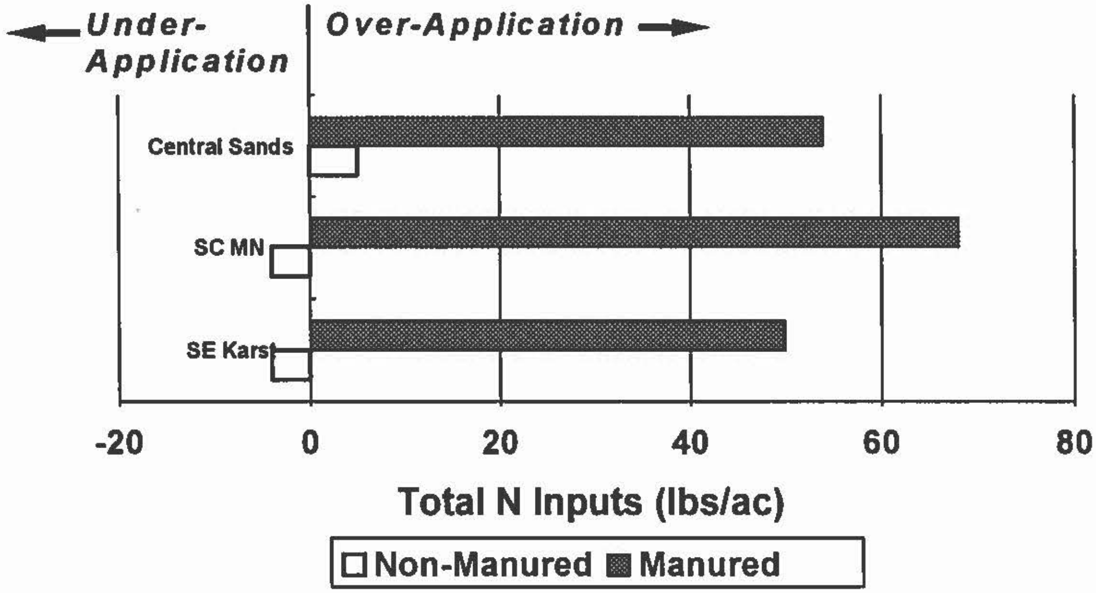

Figure 1. Nitrogen balances on manured and non-manured corn from three different geographic regions of Minnesota. Balances are calculated in comparison to University of MN fertilizer recommendations. Manure credits are based on first year availability.

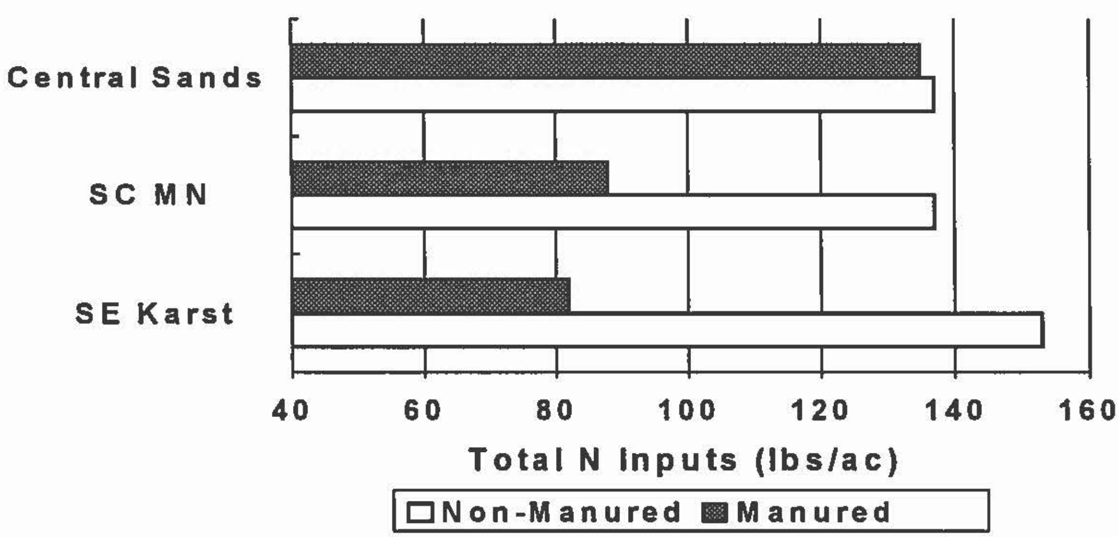

Figure 2. Commercial nitrogen fertilizer inputs on manured and non-manured corn.

EVALUATION OF ALUM APPLICATION TO POULTRY LITTER IN COMMERCIAL BROILER HOUSES

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Ammonia volatilization from poultry litter results in high levels of atmospheric ammonia in poultry houses, which is detrimental to both farm workers and birds. Ammonia losses also result in a nutrient imbalance in the litter (i.e. - high nitrogen to phosphorus ratio), which causes phosphorus buildup in soils and high levels of phosphorus in runoff waters from lands receiving litter. Recent studies have shown that alum ($Al_2(SO_4)_3 \cdot 16H_2O$) addition to poultry litter both inhibits ammonia volatilization and decreases phosphorus runoff from field-applied litter (Moore et al., 1995, Shreve et al., 1995). In order to determine if this best management practice is viable both from a production and an environmental view, evaluation on a commercial scale was warranted.

The objective of this study was to evaluate the effects of treating poultry litter in commercial houses on: (1) atmospheric ammonia levels in the houses, (2) weight gains, feed conversion and mortality in broilers, (3) energy (propane and electric) usage, (4) litter chemistry, and (5) litter microbiology.

The study was conducted for one year (five flocks) at two commercial broiler farms in NW Arkansas. One of the farms had six houses; the other had four houses. In half of the houses at each farm the litter was treated with dry alum at a rate of 1362 kg/house after the first growout and 1816 kg/house after the second, third, and fourth growouts; the remaining houses were untreated. The alum was broadcast onto the litter surface using a litter de-caker and thoroughly incorporated into the litter. Litter samples were taken weekly for pH, moisture content, fecal coliforms, E. coli, and yeasts and molds. Atmospheric ammonia measurements were also made and energy readings were taken at this time. Litter samples were also taken at the beginning and end of each growout for pH, alkalinity, total nitrogen, total phosphorus, total metals, soluble nitrogen (ammonium and nitrate), soluble phosphorus, soluble metals, and soluble organic carbon.

Results of this study indicated that the alum significantly reduced litter pH. Litter pHs of 5.0 to 5.5 were observed the day following alum application and increased with time to approximately 7.5 by the end of each growout (six to seven weeks). Ammonia volatilization was significantly lower in houses with alum-treated litter, resulting in significantly higher total inorganic nitrogen in the litter.

Weight gains in broilers were significantly higher ($\alpha = 0.05$) in houses with alum-treated litter, compared to controls (Fig. 1). The average weight of the alum-treated and control birds was 1.78 and 1.72 kg, respectively. At six weeks of age, the normal weight gain for a broiler in one day is 0.054 kg.

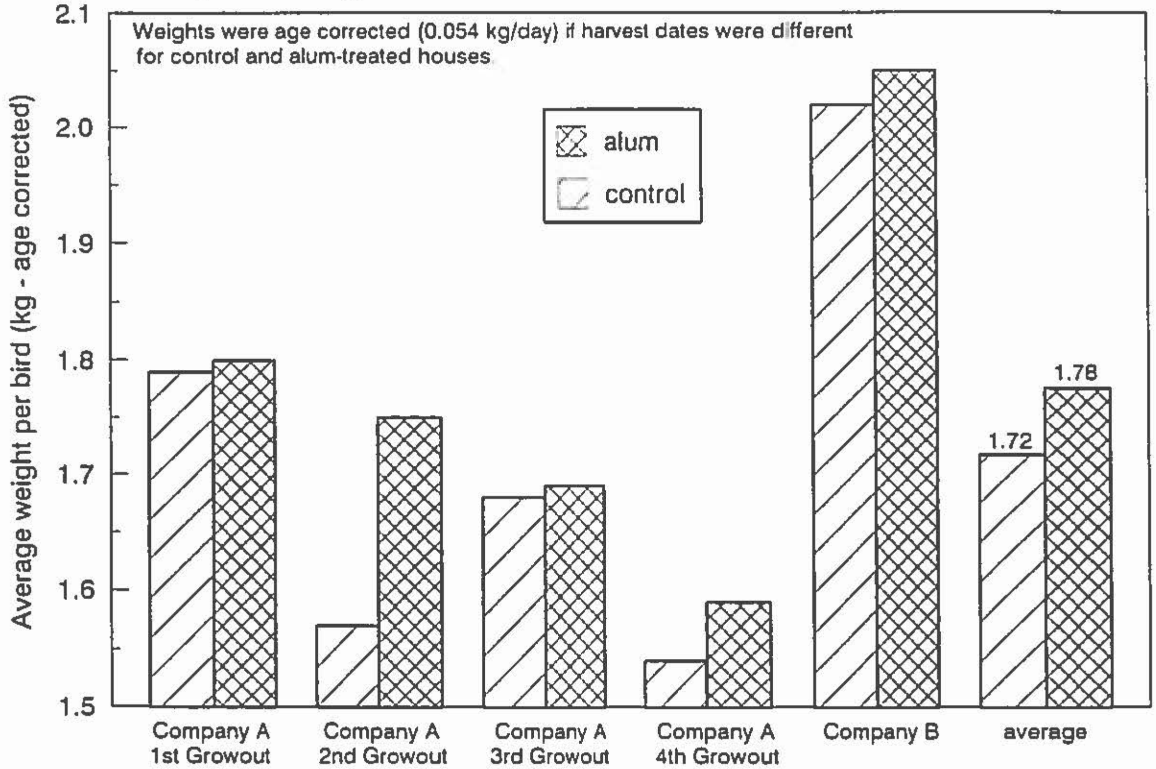

Figure 1 - Average bird weights in control and alum-treated poultry houses.

Increases in growth have allowed the integrator at Company A to harvest the birds from the alum-treated houses one day earlier than the controls, which lowers feed bills by as much as $700/house (20,000 birds eat 7,000 lbs feed/day, which costs $0.10/lb). Two tons of alum (1816 kg) only cost $400, indicating this practice may be cost-effective.

Results from this study indicate that improved environmental conditions in the poultry houses (i.e. - lower ammonia) from alum applications will result in faster growing broilers, which will pay for this BMP. Therefore, we are recommending alum be applied to poultry litter in broiler houses after each flock of broilers. It is important to mix the alum into the litter to insure proper contact and avoid excess consumption by the birds.

References:

Moore, P.A., Jr., T.C. Daniel, D.R. Edwards, and D.M. Miller. 1995. Effect of chemical amendments on ammonia volatilization from poultry litter. J. Environ. Qual. 24:(in press).

Shreve, B.R., P.A. Moore, Jr., T.C. Daniel, D.R. Edwards and D.M. Miller. 1995. Reduction of phosphorus in runoff from field-applied poultry litter using chemical amendments. J. Environ. Qual. 24:106-111.

INHIBITING AMMONIA VOLATILIZATION FROM POULTRY LITTER WITH CHEMICAL AMENDMENTS

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A substantial amount of nitrogen (N) in poultry litter is lost when the litter is still in the houses, via ammonia volatilization. This results in elevated levels of atmospheric ammonia (NH_3) in poultry houses, which is detrimental to the health of both farm workers and poultry. Research on the effects of ammonia on poultry has shown that it causes decreased growth rates, reduced feed efficiency, decreased egg production, damage to the respiratory tract, increased susceptibility to Newcastle disease, increased incidence of airsaculitis, increased levels of Mycoplasma gallisepticum, and increased incidence of keratoconjunctivitis (Carlile, 1984).

There are several litter amendments currently on the market which claim to reduce ammonia volatilization; however, there are no published reports from scientific studies in which these products were tested. The objective of this research was to determine the effects of various chemical amendments on: (1) ammonia volatilization from litter, and (2) nitrogen and phosphorus contents of litter. Two laboratory studies were conducted utilizing a wide range of chemical compounds. Poultry litter amended with various chemicals was weighed into air-tight containers and incubated at room temperature for six weeks. Ammonia-free air was passed through the containers and the volatilized ammonia was trapped in two boric acid traps connected in series. Total nitrogen in the litter was determined at the end of each study.

The controls lost an average of 14.8 and 14.4 g N/kg litter during the 42 day incubation period in the first and second study, respectively. The least effective chemical amendment tested was MLT (a product composed of calcium silicate and ethylene glycol), which actually increased volatilization over the controls by as much as 30%. Ammonia volatilization from other commercial products, such as Ammonia-Hold and PLT were not significantly different from the control litter, indicating these products perform poorly at the recommended rate of application.

Ammonia losses from the ferric chloride treatments were 8.64 and 6.32 g N/kg litter for the 50 and 100 g $FeCl_3$ treatments, respectively. These losses were somewhat higher than that observed for the ferrous sulfate treatments (6.83 and 3.31 g N/kg litter for the 65 and 130 g ferrous sulfate, respectively).

The best two treatments tested were alum ($Al_2(SO_4)_3 \cdot 16H_2O$), and phosphoric acid. Ammonia losses from the alum-treated litter were 3.24 and 0.7 g N/kg litter, for the 65 and 130 g alum treatments, respectively, whereas losses from the phosphoric acid treated litter were 6.32 and 1.05 g N/kg litter for the 20 g and 40 g H_3PO_4 treatments, respectively.

Treatments which had high rates of volatilization, such as the controls, Ammonia Hold and PLT, had the lowest amount of total N and water soluble ammonium, as would be expected. On the contrary, the treatments which inhibited volatilization, such as the high rates of alum, ferrous sulfate and phosphoric acid, resulted in significantly higher concentrations of inorganic nitrogen in the litter at 42 days. These treatments also had the lowest litter pH. The rate of ammonia volatilization is dependent on pH, moisture content, wind speed, ammonium concentration and temperature. Volatilization increases with increases in any of these variables. The pH of litter is very important because it determines the ratio of NH_3/NH_4. As pH increases, this ratio increases, causing volatilization to increase and vice versa.

Results from this study indicated that alum, ferrous sulfate and phosphoric acid greatly reduced NH_3 volatilization from poultry litter, whereas ammonia losses from litter treated with PLT and Ammonia-Hold were not significantly different from untreated litter. Alum has also been shown to decrease P runoff from fields receiving poultry litter and increase crop yields, by conserving N (Shreve et al., 1995). Since high NH_3 levels in poultry houses cause major economic losses to producers, the use of alum as a litter amendment should result in increased profitability to producers, while decreasing the negative environmental impact caused by P runoff from land application of poultry litter. Moore et al. (1995) found that broilers grown in commercial houses treated with alum at a rate of 10% by weight grew faster than broilers in untreated houses. Faster growth rates allow poultry producers to harvest chickens one to two days early, which results in enough savings in feed to pay for the alum.

References:

Carlile, F.S. 1984. Ammonia in poultry houses: A literature review. World's Poultry Science Journal 40:99-113.

Moore, P.A., Jr., T.C. Daniel, D.R. Edwards, and D.M. Miller. 1995. Effect of chemical amendments on ammonia volatilization from poultry litter. J. Environ. Qual. 24:(in press).

Moore, P.A., Jr., T.C. Daniel, D.R. Edwards and A. Waldroup. Evaluation of alum application to poultry litter in commercial broiler houses. Animal Waste and the Land-Water Interface Proceedings (this conference).

Shreve, B.R., P.A. Moore, Jr., T.C. Daniel, D.R. Edwards and D.M. Miller. 1995. Reduction of phosphorus in runoff from field-applied poultry litter using chemical amendments. J. Environ. Qual. 24:106-111.

FORAGE SYSTEMS FOR DAIRY WASTE MANAGEMENT

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The dairy industry in central Texas has undergone significant change during the last 15 years. Numbers of milking cows increased from 20,000 in 1980 to over 80,000 in 1995 in Erath county alone. Dairy size has also increased substantially with several dairies of 800 milking cows or more. The intensification of the industry, combined with confined feeding and importation of large amounts of feedstuffs, has resulted in real and perceived problems of animal waste management. During the last five years we have conducted several research and demonstration projects to design and evaluate best management practices (BMPs) for utilization of dairy waste on forage systems.

We established field plots on two cooperating dairies and on the Texas A&M University Agricultural Research and Extension Center at Stephenville to measure the yield and nutrient uptake response of a 'Coastal' bermudagrass (Cynodon dactylon L. Pers.)-only system compared with bermudagrass interseeded with winter wheat (Triticum aestivum L. cv Wintex) or ryegrass (Lolium multiflorum L. cv TAM-90). Four rates of anaerobic lagoon effluent were applied to plots on a Blanket clay loam at one cooperating dairy and four rates of solid manure were applied to plots on a Windthorst fine sandy loam at another cooperating dairy. The plots were maintained from 1990 to 1993. At the Research Center, four rates of solid dairy manure were applied to plots on a Windthorst fine sandy loam during 1992 to 1995. The rates of waste applied in each experiment were equivalent to 0, 100, 200, or 400 lb of N/acre and were applied in four equal increments during each season. Bermudagrass forage was harvested at approximately monthly intervals from May to October and winter forage was harvested once in April of each year. Soil was sampled to a 3-ft depth in each plot in each trial in spring after the winter forage was removed and in fall before the winter forage was interseeded. Soil cores were analyzed in 6-inch segments for macro and micronutrients. At the Research Center, soil moisture was monitored weekly with a neutron meter and soil water samples were collected at 18- and 36-inch depths via porous cup samplers. During each manure application at the Research Center, samples of manure were placed on a grass sod and exposed to the atmosphere for 96 hours to determine nitrogen losses presumably due to ammonia volatilization.

Forage yield response to dairy effluent was greater than that from solid waste on the dairy sites, probably because of the more available form of N (NH_4) in effluent. Average N removal by forage systems on the cooperating dairies ranged from 15 to 30%. Total N uptake by the forage systems ranged from 300 to 500 lb N/acre. At the Research Center site, forage yield increased linearly with increasing manure rate for each forage system but annual yields of the systems did not differ. On the dairy farm sites, yield increased quadratically with increased manure rates and Coastal-ryegrass outyielded Coastal-wheat or Coastal-only systems. Soil water was sampled during 1992 to 1995 (54 rainfall events for a total of 788 samples) at the Stephenville Research Center and analysis showed no significant concentrations of NO_3 (< 1 ppm) in samples collected at 18 or 36 inches below the soil surface of plots treated with up to 40 tons of solid dairy manure. Soil water samples were obtained most frequently during the wet winter months; during spring, summer, and fall, the growing forage crops and evapotranspiration limited the downward movement of water. This indicates that management to prevent loss of nutrients through the soil profile should focus on seasons when evapotranspiration and crop growth rates are low. The primary adverse effect of manure application to forage crops has been an accumulation of P in the surface six inches of soil. Phosphorus levels increased two to three fold after three years of manure application. Nitrogen losses to the atmosphere from surface-applied dairy waste in eight separate periods have ranged from 12 to 35% of the N initially present. Most of the N loss occurred within six hours of waste application and after 96 hours N losses were nil. An effective way to reduce these volatilization losses would be to incorporate the wastes immediately into the soil. However, incorporation may be impractical on perennial grass sods.

We have used our results to demonstrate and emphasize the need for producers to properly manage wastes year-round, but especially during the wet winter and early spring months (December to April). One management practice that has been widely adopted is the interseeding of small grains (wheat, oats, rye) or ryegrass into dormant grass sods in the fall to provide a nutrient "sink" during this critical period. We have also demonstrated to producers how large, uncontrolled applications of manure can quickly elevate soil phosphorus to unacceptable levels.

THE USE OF ALTERNATIVE WATER SOURCES FOR GRAZING CATTLE AS A STREAM STABILIZATION AND WATER QUALITY BMP

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This is a progress report of research being conducted by the Department of Biological Systems Engineering at Virginia Polytechnic Institute and State University. The goal of this project is to determine the impact of providing cattle with an alternative source of drinking water on streambank stabilization and water quality.

The study is being conducted on two different cow-calf operations which use rotational stocking in Southwest Virginia Bender Farms in Floyd, Virginia and River Ridge Farms in Independence, Virginia. The study is being performed on selected pasture(s) as a portion of the farms' whole rotational stocking systems. During the first part of the study (6 months), cattle had access to one stream for water. In the second part of the study, water troughs were made available, through spring developments according to NRCS specifications, for additional drinking water.

Differences in cattle behavior, streambank integrity, stream nutrients and solids as well as fecal bacteria (total coliform, fecal coliform, fecal streptococci) were observed and analyzed prior to and throughout the study period. Water samples from troughs were compared with those taken from streams in terms of suspended solids, nutrients and fecal bacteria. Comparisons of the economic and environmental sustainability of water troughs as a best management practice and alternative proposed management strategies, including fencing, were also performed.

Results of this project will identify whether providing cattle with an alternative to drinking from streams results in a significant decrease in a herd's impact on stream water quality. If the availability of a water trough is shown to be successful in attracting cattle away from streams, then streambank damage should be less than with those which rely on stream access as the sole water source. If water quality improves during the periods when the water trough is provided, this will indicate that the reduction in feces being directly deposited into the stream is related to the cattle preferring to drink from the trough and not from the stream. Thus, providing cattle with an alternative water source will bring about an environmental benefit, as well as providing adequate water for cattle.

REDUCING PHOSPHORUS RUNOFF FROM FIELD-APPLIED POULTRY LITTER USING ALUM AND FERROUS SULFATE

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Over one billion broilers were produced in Arkansas in 1992. In turn, these birds produced vast quantities of manure, which typically is utilized as fertilizer on western Arkansas pastures. Land application rates of litter, composed of manure and bedding materials, are based on meeting the nitrogen (N) requirement of crops. These recommendations do not consider phosphorus (P) content of litter, and litter application rates typically supply P in excess of crop demands. Although excess P does not have detrimental effects on land to which it is applied, it can adversely affect surface waters if it moves off-site via runoff or erosion. Edwards and Daniel (1993) reported that with surface-applied litter, 2.2 to 7.3% of total P applied was lost in runoff, with 80% or more of P in runoff in the dissolved form. The importance of manure as a source of P to surface waters was demonstrated by Duda and Finan (1983), who report up to 50-fold increases in TP runoff from watersheds with high livestock populations compared to mostly forested watersheds. To minimize runoff losses of manure P while still supplying crops with adequate N, the available nutrient content of litter should more closely match plant requirements. Increasing N availability or decreasing P availability could accomplish this. Moore and Miller (1994) report that several chemical amendments showed potential for converting P to less-soluble forms, but recognized that further research was required to determine detrimental and/or beneficial aspects of chemical amendments to poultry litter. Based on that preliminary work, a study was established to evaluate the effects of alum ($Al_2(SO_4)_3 \bullet 16H_2O$) and ferrous sulfate ($FeSO_4 \bullet 7H_2O$) on P runoff from field-applied poultry litter and on total fescue forage yield and quality from fields receiving amended litter.

Litter along or in combination with alum or ferrous sulfate (1:5 amendment:litter) was broadcast applied at 11.2 Mg ha^{-1} to small plots. An untreated control was included. Treatments were arranged in a randomized complete block design with three replications. Rainfall simulators (Edwards and Daniel, 1993) produced three runoff events at 2, 9, and 16 d after litter application. Runoff was collected and analyzed for soluble reactive phosphorus (SRP), total phosphorus (TP), ammonium (NH_4-N), nitrate (NO_3-N), and total nitrogen (TN). Plants were harvested, yields were determined, and tissue was analyzed for TN, TP, and metals. All analyses were made using standard methods. Flow-weighted average concentrations of runoff constituents were used in statistical analyses of the data. Where significant treatment effects were indicated ($p<0.05$), means were separated using Fisher's LSD.

Alum amendment of poultry litter resulted in an 87% reduction in SRP concentrations compared to litter alone for the first runoff event and a 63% reduction for the second runoff event. Ferrous sulfate amendment of poultry litter decreased SRP concentrations by 77% and

48% for the first and second runoff events, respectively, compared to litter alone. In all three runoff events, both alum and ferrous sulfate produced significant decreases in runoff SRP and TP in comparison to litter alone. Litter alone resulted in runoff SRP concentrations of 83, 17, and 8 mg L^{-1} for the three runoff events, whereas control plots had SRP concentrations in runoff of 1, 1, and 2 mg L^{-1}. Runoff concentrations of SRP from amended litter were not different from the control (α=0.05), and TP levels followed a similar trend. In the second and third runoff events, NO_3-N concentrations were increased by application of litter over than of the control (1.2 vs. 0.3 mg L^{-1}), and were increased by ferrous sulfate over alum for both events (1.5 vs. 0.6 mg L^{-1}). Litter application increased NH_4-N concentrations for all three runoff events over the control. Total N was also increased by litter application during all three runoff events from 1 mg N L^{-1} in the control up to a maximum of 107 mg L^{-1}.

Forage yield and quality were increased by all litter treatments. Alum amended litter produced significantly greater forage yields (2358 kg ha^{-1}) and significantly greater forage N concentrations than all other treatments. This yield response is most likely due to increased available N with this treatment resulting from decreased ammonia volatilization (Moore et al., 1995).

Runoff concentrations of both N and P were influenced by chemical amendments to litter, indicating that both alum and ferrous sulfate affected the chemistry of these litter constituents. Increased available N and decreased soluble P make treated litter more valuable as a fertilizer, which may make transportation of litter over long distances more economically feasible. In areas where limited land is available for application of litter, this can become an important consideration.

References:

Duda, A.M. and D.S. Finan. 1983. Influence of livestock on nonpoint source nutrient levels of streams. Trans. ASAE 26:1710-1716.

Edwards, D.R. and T.C. Daniel. 1993. Effects of poultry litter application rate and rainfall intensity on quality of runoff from fescuegrass plots. J. Environ. Qual. 22:361-365.

Moore, P.A., Jr., and D.M. Miller. 1994. Decreasing phosphorus solubility in poultry litter with aluminum, calcium, and iron amendments. J. Environ. Qual. 23:325-330.

Moore, P.A., Jr., T.C. Daniel, D.R. Edwards, and D.M. Miller. 1995. Effect of chemical amendments on ammonia volatilization from poultry litter. J. Environ. Qual. 24:In press.

VALIDATING A BUFFER ZONE NUTRIENT TRANSPORT MODEL

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Land application of manure associated with concentrated animal production increases the fertility of the receiving soil. However, manure application can cause problems with respect to water quality because of the transport of manure constituents such as carbon (C), nitrogen (N), and phosphorus (P) in storm runoff as found by many researchers. Water quality problems related to manure and fertilizer application have been identified as a major factor preventing the attainment of National water quality goals. The Environmental Protection Agency proposed the use of Best Management Practices (BMP) which reduce nonpoint source pollution while being consistent and sound in performance and compatible with the current agricultural practices.

Vegetative filter strips (VFS) have been widely investigated as a management option for retaining potential pollutants at or near the origin and thus minimizing their entry into downstream waters. Vegetative filter strips consist of grassed (or other vegetation) areas installed beneath pollutant source areas. Studies indicate that depending on parameters such as the condition of vegetation, nature of pollutant source and VFS area, VFS can be over 90% effective in removing inputs of some pollutants. Even though VFS appears to be an effective BMP, the lack of exact design criteria has resulted in uncertainty in its application.

In the present study, efforts have been made to develop an event-based model to simulate nutrient transport in VFS by linking together three submodels: modified Green-Ampt infiltration, nonlinear kinematic wave overland flow routing, and nutrient transport model. Since a large portion of pollutants in the runoff from pasture/range land are in soluble form, infiltration is considered as the primary mechanism of pollutant removal. The modified Green-Ampt infiltration model describes the infiltration in surface ponded stage as well as a stage without surface ponding. This model gives the excess rainfall as its output, which is the primary input to the nonlinear kinematic overland flow submodel. Nonlinear kinematic overland flow routing submodel gives the runoff at different points along the length of the plot as its output, which is the input to the nutrient transport model. Overland flow model has been known to reproduce many overland flow hydrographs successfully. The major outputs of the nutrient transport model are concentrations, and mass transport of nutrients flowing past successive VFS lengths.

Model validation was attempted using data from experimental field plots on VFS performance described by Srivastava et al. (1994). In that experiment, nine fescue plots having dimensions 1.5 m by 24.4 m were used. Fertilized lengths of 6.1, 12.2 and 18.3 m with corresponding VFS lengths of up to 18.3, 12.2, and 6.1 m, respectively, were examined, and runoff was produced from simulated rainfall applied at 50 mm/h for 1 h of runoff. The method of analyses and detailed results of this study were summarized by Srivastava et al. (1994). The effects of both litter treated lengths and VFS lengths on the concentration and mass transport of litter constituents were simulated. Comparisons between predicted and observed concentration and mass transport of constituents will help in verifying the validity of the assumptions made in the nutrient transport model, i.e. infiltration is the major process for nutrient removal. This study will also lead to better understanding of the transport mechanisms and thus will be useful in predicting VFS effectiveness in reducing various nutrients and in subsequent design of BMP's.

Reference:

Srivastava, P., D.R. Edwards, T.C. Daniel, P.A. Moore, Jr., and T.A. Costello. 1994. Influence of source area to buffer strip area ratio on vegetative filter strip performance. Paper No. 94-2554. ASAE, St. Joseph, MI.

MANAGEMENT EFFECTS ON OFF-SITE WATER QUALITY FROM LAND APPLICATION OF POULTRY LITTER

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Introduction

Laboratory and field scale rainfall simulator studies are being conducted at Oklahoma State University to evaluate the effects of management on surface runoff quality from land application of poultry litter to permanent pastures. Information obtained from these studies will be used to develop recommendations for poultry litter application to minimize off-site water quality impacts. Research over the next two years will be divided into two phases.

Phase 1: Laboratory Study

A laboratory study is currently being conducted to determine the effects of rainfall intensity and duration, vegetation height, slope, time between rainfall events, number of rainfall events, and litter application rate on nutrient losses in surface runoff. Small-scale plots are used to approximate field conditions using fescue grown in boxes 3.3 feet by 3.3 feet with six inches of soil. The soil is a silt loam from Eastern Oklahoma that is used for litter application and forage production.

The experimental design consists of 1) three slopes (5, 10, and 15 percent), 2) two vegetation heights (3 and 6 inches), 3) two litter application rates (3 and 6 tons/acre), 4) three rainfall intensities (1.0, 1.5, and 2.0 inches/hour), 5) five rainfall durations (26, 58, 84, 120, and 204 minutes), and 6) a series of rainfall events with time periods between storms varying from one to 30 days.

Phase 2: Field Study

Two field sites will be selected for rainfall simulator studies in high priority watersheds in northeastern and southeastern Oklahoma. During the first year, field studies will be conducted in the Poteau River Basin in LeFlore County located in southeast Oklahoma. During the second year of the project, field studies will be conducted in the Grand Lake Basin in Delaware County located in northeast Oklahoma.

Using a portable rainfall simulator, this study will evaluate the effectiveness of BMP recommendations and technologies in reducing nitrogen and phosphorus losses in surface runoff from land application of animal waste (poultry, dairy, and swine) to permanent pastures. BMP factors evaluated will include: 1) waste application rate, 2) soil incorporation vs surface application, 3) waste pre-treatment with amendments, 4) vegetation type and height, and 5) filter/buffer strips. Each demonstration site will consist of eight rainfall simulator setups. A setup consists of four plots, each 6 feet wide and 32 feet long. Within each setup, the rainfall simulator applies water uniformly to a 50-foot diameter area at an intensity up to 2.5 inches per hour. At each location, rainfall simulator experiments will be conducted in the early summer and late summer of the same year using the same plots. The purpose of this second demonstration is to determine nutrient losses in surface runoff from selected plots without applying additional waste. Information gained from the second demonstration will aid in evaluating the effectiveness of the various management practices on nutrient retention and utilization.

Nutrient Management

EFFECT OF TIME AND RATE ON NITRATE-N AND PHOSPHORUS LOSSES FROM SURFACE-APPLIED BROILER LITTER

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An ongoing study is being conducted to determine the fate of nitrogen and phosphorus from surface-applied broiler litter to Coastal bermudagrass for hay production. Increased concerns over non-point source pollutants, primarily NO_3-N and P_2O_5, entering surface and ground waters from the surface application of broiler litter to haylands prompted this study to quantify NO_3-N and P_2O_5 contents of runoff and ground waters as compared to that from haylands with applied commercial fertilizer.

Six plots of uniform slope (1.1%) were established on a Wolfpen loamy siliceous thermic (Arenic Paleudalf) soil, with an established stand of Coastal bermudagrass. Plot borders were delineated by using aluminum edging to isolate runoff water within each plot and converge it through parshall flumes equipped with Stephens Type F runoff recorders. Passive samples of runoff water were collected after each runoff event. Each plot had three replicates, each containing a ceramic cup piezometer placed at a 137 cm depth to collect groundwater.

Treatments were as follows:

Treat-ment	Appli. Date	Fert. Type	Mg ha^{-1}	kg ha^{-1} N	kg ha^{-1} P_2O_5	kg ha^{-1} K_2O	Appli. Date	Fert. Source	Mg ha^{-1}	kg ha^{-1} N	kg ha^{-1} P_2O_5	kg ha^{-1} K_2O
1	6/4/93	BL	17.7	342	464	468	5/4/94	BL	19.5	487	780	458
2	6/4/93	BL	5.9	113	155	156	5/4/94	CF		101	0	0
	7/6/93	BL	5.9	113	155	156	6/4/94	CF		101	0	67
	8/20/93	BL	5.9	113	155	156	7/6/94	CF		101	0	155
							8/11/94	CF		101	0	0
3	6/4/93	CF		113	67	101	5/4/94	CF		114	0	56
	7/6/93	CF		113	44	92	6/4/94	CF		112	0	67
	8/20/93	CF		112	0	101	7/6/94	CF		112	0	155
							8/11/94	CF		101	0	0
4	6/4/93	BL	8.7	169	229	231	5/4/94	CF		101	0	0
	7/6/93	BL	8.7	169	229	231	6/4/94	CF		101	0	67
	8/20/93	BL	8.7	169	229	231	7/6/94	CF		101	0	155
							8/11/94	CF		101	0	0
5	6/4/93	BL	26.5	510	692	699	5/4/94	BL	29.1	728	1165	684
6			0	0	0					0	0	0

No significant trends were detected in runoff samples in either year with regard to rate of applied broiler litter or commercial fertilizer. Nitrate-N concentrations ranged from 0.4 mg kg^{-1} on the 0 and 26.5 Mg ha^{-1} plots on August 10, 1993, to 17.0 mg kg^{-1} on the 0 Mg ha^{-1} plot, on November 29, 1993. Phosphorus levels ranged from 0.0 mg kg^{-1} on the 0 Mg ha^{-1} plot, to 33.0 mg kg^{-1} on the 17.7 Mg ha^{-1} plot. Nitrate-N concentrations from the 1994 runoff samples ranged from 0.0 mg kg^{-1} to 40.0 mg kg^{-1}, with only the plots receiving commercial fertilizer having concentrations over 5.0 mg kg^{-1}. In 1994, the highest phosphorus concentration was 14.8 mg kg^{-1} collected from the 29.1 Mg ha^{-1} plot on July 15, 1994.

During both years, plots receiving commercial nitrogen had ground water with excessively high concentrations of NO_3-N (as high as 81.4 mg kg^{-1}), which occurred after the bermudagrass reached dormancy. Phosphorus did not infiltrate the soil profile in either year.

While these data have not been statistically analyzed, trends indicate that significant leaching and runoff of NO_3-N only occurred following commercial fertilizer application; applying broiler litter did not significantly contribute to NO_3-N loading in ground or surface waters. As expected broiler litter application did not enhance the level of phosphorus in the ground water.

INTEGRATED DAIRY WASTE MANAGEMENT, WATER QUALITY AND CROP UTILIZATION SYSTEM

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Many dairy farmers handle large quantities of animal waste. Land applications of animal waste have come under scrutiny from local and national environmental groups due to the occurrence of nitrates and phosphates in surface and ground water. A system which focuses on the ability of reed canarygrass (Phalaris Arundinacea L.) to effectively capture the waste nutrients, convert them into forage and minimize water contamination would be an environmental and economic advantage to dairy producers in the upper midwest.

The objective of this study is to develop agronomic practices utilizing dairy waste which produces a high-yielding, high-quality reed canarygrass forage and prevents excessive off-site movement of nitrates and phosphates. Various rates and application methods and timings of dairy waste and inorganic fertilizer will be applied to reed canarygrass plots at three locations for three years. Forage yield and quality will be measured in a three cutting system. Nitrate percolation through the soil profile will be measured in water samples collected with porous-cup lysimeters placed at the 5-foot depth at five time intervals; mid April, after frost goes out; after 1st cut; after 2nd cut; after 3rd cut and early November, just before freeze-up. Off-site movement of nitrates and phosphates into surface run-off will be measured for each rainfall event with wiers. Results to date indicate that first cutting yields are maximized at 150 lbs.N/A. Maximum dry matter yield for the season occurred at 600 lbs. N/A, 300 lbs. applied in the spring followed with 150 lbs. applied after the second cutting. Forage yields have shown a close correlation between lbs. of N/A as manure and as inorganic fertilizer. One time application of 20,000 gal/A of dairy waste is causing significant stand reduction when it is band applied.

THE NUTRIENT MANAGEMENT PROGRAM OF THE MARYLAND COOPERATIVE EXTENSION SERVICE

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Nutrient pollution, especially NO_3-N pollution, is a problem in the Mid-Atlantic Region. A recent U.S. Geological Survey report on groundwater quality on the Atlantic Coastal Plain found greater than 10 ppm NO_3-N in 33% of the water samples examined. Excess nutrients have also been identified as a primary cause of reduced productivity in the Chesapeake Bay. In order to improve the quality of Chesapeake Bay, the governors of states within the Chesapeake Bay watershed have set the goal of a 40% reduction in nutrient loadings by the year 2000. Agriculture was identified as a major contributor of nutrients to the Bay. The Maryland Department of Agriculture (MDA) provided funding to the Maryland Cooperative Extension Service (MCES) in 1989 to establish the Maryland Nutrient Management Program with the goal of optimizing nutrient inputs on cropland through individually tailored nutrient management plans which should insure farm profitability and reduce nutrient loadings to the Bay.

MCES provides nutrient management plans to farmers through Extension consultants located in each county. The general approach for developing nutrient management plans is to: assess the nutrient status of each field through soil testing for pH, P, and K; assess the nutrient resources available to the farmer through manure analysis and accurate cropping and manure histories for each field; forecast crop nutrient needs through use of realistic yield goals; formulate field-specific nutrient recommendations based on consideration of soil tests, expected yields, manure tests, and crop/manure history; assure delivery of recommended rates by manure spreader calibration; and conduct field-specific evaluation of N recommendations through use of the pre-sidedress soil nitrate test (PSNT).

The nutrient content of manure is highly variable (CV 122% for primary nutrients) and the use of average values can lead to both under and over application of nutrients. MCES provides an accurate nutrient analysis program for manure which is integrated with manure mineralization rates and crop requirements to develop field-specific manure application rates. Uncalibrated manure application equipment can be responsible for either inadequate or excessive application of nutrients. MCES consultants are providing valuable calibration training to farmers. The pre-sidedress nitrate nitrogen test (PSNT), which was calibrated through cooperative research with the United States Department of Agriculture Agricultural Research Service (USDA/ARS), is also an important part of manure management.

The PSNT is particularly well suited for manured fields where uncertainties in manure loading rates and N losses due to ammonia volatilization and denitrification are highly variable. The underlying principles of the PSNT involve allowing native organic matter decomposition to proceed "in place" throughout the spring and then to measure the accumulated NO_3-N in the top 12" of soil when the corn is 6" to 12" tall, just before the corn crop begins its period of rapid N uptake (Meisinger et al., 1993). N-sufficient sites have soil NO_3-N concentrations greater than 22 ppm. By identifying N-sufficient sites which need little or no additional sidedress fertilizer N, the use of the PSNT in nutrient management plans should reduce the practice of applying "insurance N". This should improve fertilizer N use efficiency and reduce NO_3-N contamination of ground water in the Mid-Atlantic region and NO_3-N losses to the Chesapeake Bay.

The PSNT is now used in every county in Maryland; however, it is not used as a "stand alone" nitrogen test. The following case study illustrates its use. A dairy farmer (140 head of milking cows and 600 acres of cropland) applied 10,000 gallons per acre of dairy manure (7 lbs. PAN per 1000 gal.) to 200 acres of corn closest to the barn and 200 lbs. of N, P_2O_5 and K_2O to all of his crops (corn, soybeans and alfalfa), in addition to 30 pounds of starter nitrogen on the corn. After the intervention of the MCES nutrient management consultant, he now spreads manure across the entire farm, credits the nitrogen from dairy manure, rotates legumes with corn, has acknowledged a more realistic yield goal for corn (110 bu per acre rather than 180) and applies phosphate and potash only if soil tests indicate the need. A moderate manure application rate (5,000 gal. per acre) to all cropland meets the phosphorus and potassium requirements. Credits for past and current year manure applications and legume credits indicate that nitrogen should be adequate for corn production. PSNT is used to verify N sufficiency on all corn acreage. Last year PSNT indicated that nitrogen was adequate on 75% of his corn acres. His saving averaged 170 pounds of N per acre.

Reference:

Meisinger, J.J., F.R. Magdoff, and J.S. Schepers. 1993. Predicting N fertilizer needs for corn in humid regions: underlying principles. pp. 7-27. In. B.R. Bock and K.R. Kelley (eds.) Predicting N fertilizer needs for corn in humid regions. Tenn. Valley Auth. Bull. Y-226. TVA, Muscle Shoals, AL.

DEVELOPING A PLAN FOR ASSIGNING MANURE SPREADING PRIORITIES

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The initial step of nutrient management planning for animal agricultural operations is the selection of the fields that will receive the manure produced on the farm. This must be done before decisions regarding purchased nutrients can be made. Farmers determine the distribution of manure to farm fields. Some, recognizing its nutrient value and the potential environmental consequences of misuse, apply it to fields where nutrient benefits can be gained and losses will be low. Others regard it as a waste and dispose of it in the easiest manner possible, often at high rates on fields near the barn.

Poor manure management has resulted in many of the water quality concerns that are currently being addressed in legislation. There are many reasons why manure is so poorly managed. These include the failure to believe credits, ignorance of application rates, poor spreading uniformity, losses, compatibility with cropping systems, and the management skills of the farmer.

We have created a simple three-step procedure that develops a manure management plan for a farm based upon the nitrogen need of the crops to be grown and the environmental considerations within individual fields. The first step estimates the amount of manure produced for the "manure year" or that period in which manure is applied to satisfy the nutrient need of a particular crop. This value can be adjusted for manure that is not collected, if for example animals are on pasture. The second step ranks individual fields with respect to crop N need, soil test P and K, proximity to surface water, slope and soil conservation practices, soil texture, and depth to bedrock (see attached form). The best field to manure in a given year receives the highest relative rank. The third step uses a "checkbook" approach and assigns manure to the highest ranked field first and continues in descending order of rank until all the manure is allocated. This procedure selects the group of fields to manure for the year. Practical limitations, such as the unavailability of access due to weather or cropping, will determine the actual order in which fields are manured.

Supporting information which will be needed to complete a manure spreading plan include: nutrient recommendations from a current soil test, specific site and soil information for each field, a cropping plan, the nitrogen content of the manure, an animal inventory, and the knowledge of the rate of manure application. Using a plan developed by this procedure will allow the farmer the opportunity to gain the most economic benefit from manure, while reducing the potential for surface and groundwater contamination.

Individual Field Manure Allocation Assessment (Field ______)

Category	Value	Points
1. Planned crop (choose one)		
a. Continuous corn or corn not following a legume	10	
b. 2nd year corn following legume forage	8	
c. 1st year corn following legume forage	1	
d. 1st year corn following non-forage legume	8	
e. Non-forage legumes	2	
f. Small grains (for grain)	6	
g. Small grain with seeding (removed as grain)	2	
h. Small grain with seeding (removed as silage)	4	
i. Prior to direct seeding legume forage	8	
j. Topdress good legume stand	1	
k. Topdress fair legume stand	2	
l. Topdress poor legume stand	3	
m. Grass pasture or other non-legumes	6	______
2. Soil test P and K		
a. Phosphorus		
1. > 150 ppm	1	
2. 75-150 ppm	3	
3. 30-75 ppm	5	
4. < 30 ppm	10	+______
b. Potassium		
1. > 200 ppm	6	
2. 100-200 ppm	8	
3. < 100 ppm	10	+______
3. Site/soil limitations (choose one from each category)		
a. Surface and groundwater proximity		
1. Applied and incorporated within 10-year floodplain or within 200 feet of surface water or groundwater access	1	
2. Application outside these restrictions	5	+______
b. Slope		
1. Slope > 12%	1	
2. Slope 6-12%; > 12% (incorp., contoured or terraced)	3	
3. Slope 2-6%; 6-12% (incorp., contoured or terraced)	5	
4. Slope < 2%; 2-6% (incorp., contoured or terraced)	10	+______
c. Soil texture		
1. Sands, loamy sands	1	
2. Sandy loams, loams/sands, loamy sands; spring applied	3	
3. Other soils/sandy loams, loams; spring applied	5	+______
d. Depth to bedrock		
1. 0-10 inches	0	
2. 10-20 inches	1	
3. > 20 inches	5	+______
4. **Total Points (rank)**		

* Base manure rate on soil test P or K and yield goal. Apply for the nutrient that is most limiting according to soil test.

** Runoff Reduction Practices (RRP) include any one of the following: manure incorporation or injection, contour strip cropping, or terracing.

Regulatory vs. Voluntary

COUNTY-LEVEL EDUCATIONAL PROGRAMS IN RESOLVING MANURE RELATED WATER PROBLEMS IN SOUTH-CENTRAL MINNESOTA

Larry M. Gunderson, Brown-Nicollet-Cottonwood Clean Water Partnership, St. Peter, Minnesota and C. Michael Hanson Brown-Nicollet-Cottonwood Clean Water Partnership, Windom, Minnesota

The Brown, Nicollet, Cottonwood Clean Water Partnership is a cooperative water quality project with over 30 co-sponsors in Brown, Nicollet and Cottonwood Counties located in Southcentral Minnesota. The overall mission of the project is to develop a strategy to minimize high nitrate concentrations in surface and ground water. During the first phase of the project, water test results from rural wells in the three counties showed nitrate-nitrogen levels in excess of the federal drinking water standard of 10 parts per million (20 percent of the wells were above the standard).

One of the first initiatives was to conduct a survey of farmers in the three counties to determine their agricultural practices. Forty-one farmers were interviewed using a series of questions on the management of commercial, manure and legume sources of nitrogen. The purpose of the survey was to:

-determine nitrogen rates and practices being used in the area
-identify opportunities to improve both farm profits and water quality
-identify education needs for our Clean Water Partnership efforts
-develop a base against which to measure the effectiveness of our educational programs

Analysis of the survey showed two key results:

1. Application rates of commercial nitrogen to <u>unmanured</u> corn are, on the average, approximately equal to the University of Minnesota recommendations.
2. Application rates of nitrogen to <u>manured</u> corn substantially exceed University of Minnesota recommendations.

To educate farmers on the importance of manure testing the project offered a collection and analysis service. Several farmers were employed under the Southcentral Emergency Employment Program, a federally funded post-flood project, to collect manure samples for free analysis. These farmers were organized to assist other farmers in manure sampling and management. Employees collected over 200 manure samples and distributed information on fertilization, manure sampling, safety, nutrient crediting and manure handling. The concept of using producers to collect the samples worked out very well because of their extensive experience in agriculture. Analysis results were sent to farmers along with an invitation to call project staff with questions.

Manure analysis indicated considerable variability in the nutrient contents of various manures. Liquid hog manure had the greatest range in nutrient content. The nitrogen content of the 90 samples of liquid hog manure tested ranged from 10 to 114 lbs N/1000 gallons manure with an average of 54 lbs N/1000 gallons manure. This variability is an important concept for producers as they plan their fertilizer usage.

Educational programs were conducted to relay information to producers about manure management. One educational program included an on-farm demonstration. Replicated plots were established on a cooperator's farm and treated with manure and commercial fertilizer. The plots were harvested and yields and economic returns were compared. Workshops were conducted for producers and agricultural professionals. Workshop topics included how to use manure testing results, spreader calibration, nutrient variability in manure and computer software to assist in making nutrient recommendations. Other methods of education included newsletters, booths at public events and speaking to interested groups.

Surveys of producers indicate nutrients in manure are often not managed efficiently. Because of the variability in nutrients, manure analysis is important when developing a manure nutrient plan. Educational efforts by extension personnel, farmers, fertilizer suppliers, crop consultants and others are needed to help producers manage manure to protect water quality and improve efficiency.

DESSERT: DAIRY DESIGN ECONOMICS IN SATISFYING STATE ENVIRONMENTAL REGULATIONS IN TEXAS - A LOTUS PROGRAM

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Dairymen face significant expenditures in retrofitting existing operations to achieve compliance with increasingly strict state and federal regulations dealing with NPS pollution. In addition to adhering to EPA guidelines, Texas dairymen must comply with a "zero discharge" requirement enforced by the Texas Natural Resource Conservation Commission (TNRCC).

High stocking densities on limited land resources can lead to significant denuded areas on dairy pastures thereby increasing potential for NPS pollution. Under such conditions, a dairy operated as a "pasture system" in Texas may be defined by the TNRCC as a concentrated animal feeding operation (CAFO). Without implementing considerable changes to the management or type of dairy operation, many producers do not have the physical or monetary resources to both achieve regulatory compliance and remain viable.

Preparation time to plan and design a dairy waste management system (DWMS) is usually extensive. Inordinate amounts of time are spent on repetitious planning. This is often due to producer uncertainty, operation resources-based determinations of treatment alternative applicability, and inadequate (or non-existent) quantification of farm-specific economic costs/benefits relative to the installation, operation and management of various DWMS alternatives. Increased public demand for services and diminishing public funding for staffing and cost-sharing have exacerbated this problem. A significant reduction in the quantity or level of services available to the producer from Federal, state and private professionals in the field may occur unless means to maximize DWMS planning efficiency are developed.

DESSERT is a menu driven LOTUS spreadsheet program created as a planning and decision making tool with design and economic components to address the aforementioned conditions.

DESSERT requires that the operator initialize the program one time to input climatological data for up to four counties. More counties can be input on different files. Once initialized, input is required to inventory field and herd parameters. Input time is estimated to take one to two hours. Once accomplished, the user may chose to input dairy system type with herd divisions per system type or allow DESSERT to calculate the applicability and parameters associated with the following types of dairy operations:

I. Grazing Systems
  A) Continuous Grazing System (CGS)
    1. Without confinement components
    2. In conjunction with livestock housing
    3. In conjunction with open lots
  B) Planned Grazing Systems
    1. Intensive Grazing Management (IGM)
      a) Without confinement components
      b) In conjunction with grassed loafing lots
        i) Without sacrifice area
        ii) With sacrifice area
      c) In conjunction with livestock housing
      d) In conjunction with open lots
    2. Grassed Loafing Lots (GLL)
      a) Without sacrifice area
      b) With sacrifice area

II. Confinement Systems
  A) Open Lots
  B) Confinement Barns
    1. Stand alone
    2. With partial herd in CGS
    3. With partial herd in IGM
    4. With partial herd in GLL

DESSERT will calculate the parameters for each option with fixed or variable land resources. Sizing of waste management system components is farm operation and input dependent. Water budgets are used to determine waste retention facility volumes. Nutrient loadings are calculated by field size, crop type/production level and season.

The program is supplied with an on-screen list of default values and assumptions (with technical references) which can be edited by the user, if desired.

The program will output up to 15 different options with their associated waste management system components, sizes, and a comparative economic analysis of costs and benefits.

GUIDELINES FOR LAND APPLICATION OF MANURE - TASK FORCE RECOMMENDATIONS FOR MINNESOTA

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A Minnesota Feedlot Advisory Group (FLAG) was organized by the Minnesota Pollution Control Agency in 1989 to facilitate greater discussion and coordination of concerns surrounding animal production and water quality. In 1993, FLAG established a multi-disciplinary Land Application of Manure Task Force (LAMTF) to develop recommendations for revising previously existing manure application guidelines. The LAMTF members included people representing livestock producer groups, farm organizations, environmental groups and federal, state and local agencies. LAMTF recognized that while guidelines would be designed to be voluntary, except where otherwise required by statute, some local officials may choose to incorporate the guidelines into feedlot ordinances. Therefore, LAMTF considered the economic and labor requirements of producers so that the guidelines did not place heavy burdens on farmers as a whole. The guidelines were developed to be practical, justifiable and sufficient to greatly reduce risks associated with phosphorus, nitrogen, oxygen demand and pathogen transport from manure application sites. LAMTF stressed that in situations where the water pollution potential from manure application poses no greater threat than proper use of commercial fertilizer, restrictions placed on the application of manure should be no greater than those placed on the use of commercial inorganic fertilizer.

Research results appropriate for Minnesota conditions, along with the collective experiences of the 26 task force members, formed the basis for the recommended guidelines. While the guidelines are supported by research results, the collective literature does not point to one precise set of numbers that is appropriate for all sites in Minnesota. A technical document was written which describes the basis and justification for the selected guidelines.

It was the intention of LAMTF that the guidelines be easily interpreted and understood by livestock producers and government officials, yet incorporate the primary variables affecting pollutant transport. Manure management practices to minimize nitrate movement to ground water are recommended statewide. Maximum application rates should be limited so that the plant available nitrogen expected during the growing season from all nitrogen sources does not exceed crop nitrogen requirements. The guidelines recommend that manure application rates be based on: realistic yield goals, laboratory manure nutrient analyses, soil tests, nutrient credits from current and previous manure applications, proper credits from other nutrient sources, and calibrated application equipment. Reduced application rates or setbacks are recommended on sloping lands in close proximity to lakes, streams, wetlands, intermittent streams and drainage ditches so that nutrient, pathogen and oxygen demand transport to surface waters is minimized. Setback recommendations were also made for application to frozen and unfrozen soil near wells, sinkholes, mines and quarries.

Edge of Field Losses

WATER QUALITY AND YIELD EFFECTS OF SIDEDRESSED LIQUID DAIRY MANURE ON CORN: FIRST YEAR RESULTS

William Jokela and Sidney Bosworth, Department of Plant and Soil Science, and Donald Meals, School of Natural Resources, University of Vermont, Burlington, Vermont

Field application of livestock manure can add significant amounts of phosphorus and other nutrients to surface runoff, contributing to eutrophication of freshwater bodies. Injection or other methods for direct incorporation of liquid manure provide an option to reduce adverse impacts on water quality and increase efficiency of manure nutrient use. The objective of this study was to evaluate the effects of sidedressed liquid dairy manure, either directly incorporated or surface applied, in comparison with pre-plant incorporated manure or sidedressed fertilizer N, on: a) corn silage yields and nutrient uptake, b) potential for nitrate leaching, and c) loss of P and N in surface runoff.

A field study was established in spring of 1994 in NW Vermont on a Whately soil (Mollic Haplaquept), a poorly drained silt loam over clay with a slope of 2 to 3%. The following treatments were applied to 6.4 by 30 m plots arranged in a randomized complete block design with four replicates: 1) PP-Bdcst, pre-plant broadcast manure, incorporated by disking within one hour (73,000 L/ha; 210 kg N and 40 kg P/ha), 2) SD-Incorp, sidedressed manure applied in the growing crop with immediate incorporation by s-tine cultivator shanks mounted on rear of tank spreader (49,000 L/ha; 150 kg N and 30 kg P/ha), 3) SD-Surf, sidedressed manure, surface applied (same rates as SD-Incorp), 4) SD-FertN, sidedressed fertilizer N, surface applied as NH_4NO_3 (65 kg N/ha), and 5) Control, no manure or additional fertilizer N. Starter fertilizer (20 kg N and 34 kg P/ha) was applied at planting to all treatments.

The SD-Incorp treatment yielded similar to the PP-Bdcst and SD-FertN, while the SD-Surf treatment gave lower yields, similar to the Control, suggesting substantial loss of NH_4-N via volatilization (Table 1). Plant uptake results, along with those of the late-season stalk NO_3 test, indicated that incorporated manure, both PP and SD, and SD-FertN provided adequate N to the crop, while SD-Surf and Control did not. Soil profile NO_3-N concentrations in November suggested that no leaching occurred below 0.9 m, although the PP-Bdcst and SD-FertN showed greater movement of NO_3 to the 0.9 m depth. Soil solution NO_3-N concentrations measured with ceramic suction samplers at approximately 50-cm depth were in the 8 to 10 mg/L range in most cases.

Surface runoff was collected from 10 post-sidedress events, using 1.5 x 2.3 m mini-plots surrounded by sheet metal barriers. Total P (1.1-1.4 mg/L) and total N (6-8 mg/L) concentrations from all events combined were not significantly affected by treatment. However, concentrations of soluble reactive P were 6 to 10 times higher from SD-Surf (0.55 mg/L) than from all other treatments, while NO_3- and NH_4-N were highest from SD-FertN. The most marked effect was a reduction in runoff volume of 90% or greater from the SD-Incorp treatment, presumably because of increased infiltration due to the soil loosening effect of the cultivation. This resulted in a cumulative total P runoff loss of 55 g/ha, compared to an average of 333 g/ha from the other treatments (Fig. 1).

Direct incorporation of sidedressed manure greatly reduced runoff losses of P and N, lowered NO_3 leaching potential, and increased efficiency of manure N use, while maintaining corn silage yields.

Table 1. Whole plant (silage) yield and N and P concentration and uptake.

	Treatment	Yield	Concentration		Uptake	
			N	P	N	P
1	PP-Bdcst	11.4 a	1.21 bc	0.24 ab	138 a	28 a
2	SD-Incorp	9.9 ab	1.36 a	0.27 a	135 a	27 ab
3	SD-Surf	8.6 b	1.24 abc	0.26 ab	108 bc	23 bc
4	SD-FertN	9.4 ab	1.29 ab	0.25 ab	121 ab	24 bc
5	Control	8.3 b	1.12 c	0.24 b	94 c	20 c

Means followed by the same letter are not significantly different at P=0.10

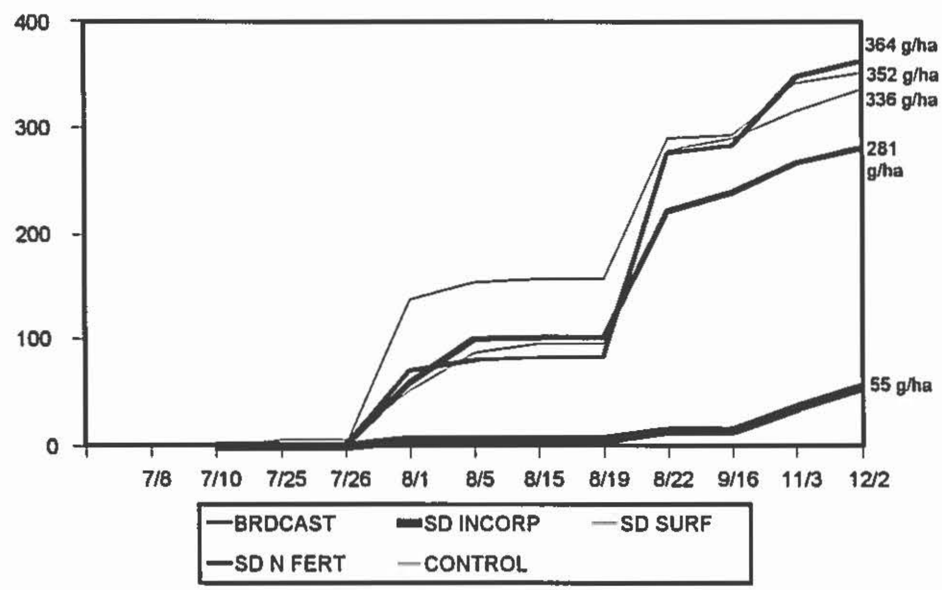

Fig. 1. Cumulative total P export from 10 monitored runoff events.

EVALUATION OF BROILER LITTER AS A SOURCE OF FERTILIZER NUTRIENTS AND A POTENTIAL HAZARD TO EAST TEXAS WATER QUALITY

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Surface water resources and the $1 billion integrated poultry industry are very important to east Texas. Compared to other animal manures and wastes, broiler litter is rich in fertilizer nutrients . Application of broiler litter on agricultural lands at high rates may be a non-point source of surface water pollution. The objective of this project is to evaluate the use of broiler litter as a fertilizer material on agricultural lands and its subsequent effects on the quality of surface waters in east Texas. This is a cooperative project of Stephen F. Austin State University, the Angelina Neches River Authority, and the poultry industry, with major funding also provided by the Texas Natural Resources Conservation Commission (formerly Texas Water Commission). The focus of the project is the Attoyac Bayou watershed in eastern Nacogdoches County where the concentration of contract broiler growers and litter application is quite high.

Field plot experiments on Coastal bermudagrass, the principal crop grown in the region, have been used to estimate the availability of N and P in broiler litter. A split plot fertilizer source study using ammonium nitrate (34-0-0) and broiler litter at equal rates of N from 0 to 560 kg ha^{-1} in increments of 112 kg ha^{-1} has shown that the N in broiler litter is about 78% as available as the N in ammonium nitrate. A study using concentrated superphosphate (0-46-0) and broiler litter at equal rates of P (0, 11, 22, 45, 90 and 179 kg ha^{-1}) has shown that the P in broiler litter is as available as the P in fertilizer materials. It is assumed that the K in broiler litter is as available to plants as the K in murate of potash (0-0-60). Based on the range and average nutrient concentrations of broiler litter produced in the region, current fertilizer prices, and these nutrient availabilities, broiler litter has a value of about $30.00 per ton. Typical spreader truck loads of litter in the region range from 3 to 5 tons, and thus, a value of $90 to $150 per truck load. Current litter spreading practices in the region give litter a cost of $25 to $30 per truck load plus $2 per loaded mile. This price differential between fertilizer value ($90 to $150 per truck load) and current spreading practices ($25 to $40 per truck load) suggest that proper valuation of the litter by farmers could result in longer hauls of litter and spreading litter at lower rates on more acres. This should decrease the hazard of litter as a non-point source of N and P in surface waters.

Additional field plot studies have been initiated using runoff plots to access the movement of nutrients from litter application into the runoff water of rain fall events. This study is conducted on a site with uniform slope of 5%, a stand of improved bermudagrass, and a Nacogdoches clay loam soil. One hundredth acre plots were established with total surface runoff collection devices installed. Varying rates of litter application with and without use of grass buffer strips will be used as treatments. Runoff water will be analyzed for total N, total P, NO_3-N, and PO_4-P and results reported. The literature indicates that small buffer strips can greatly reduce the load of nutrients in surface water.

Water quality in the Attoyac Bayou watershed is being accessed. Water samples are being collected weekly from the Attoyac Bayou at four locations ranging from areas where there is little broiler production through major production areas and finally where the Attoyac Bayou empties into Sam Rayburn Reservoir. Analysis of these samples should document changes in water quality between varying sites. Effects of broiler production and litter application can only be inferred from these data. In addition, detailed flow measurements and water sampling are being conducted on two small tributary streams, Waffelow and Terrapin Creeks, which flow to the Attoyac Bayou. Sampling sites have been established at locations on these creeks which will separate the watersheds into primarily forested or primarily improved pasture land. As a result, water will be sampled as it leaves three forested and three pasture land watersheds. Two of the pasture land watersheds have a history of receiving broiler litter applications at various times and rates, though there is no control over litter application during the course of this study. Automatic sampling devices make it possible to collect water samples during runoff events as well as at weekly intervals. Analyses of the water samples collected during this study will make it possible to infer possible effects of litter application.

Results from these studies should indicate how broiler litter applications are affecting surface water quality. The results will also be used to develop Best Management Practices that will reduce the impact of broiler litter application on surface water quality. Project outcomes will be useful in the development of responsible regulations which will protect the surface waters of the state and enable the poultry industry to remain an important economic force in the region while taking a proactive role in the preservation of surface water resources.

Alternative Uses

LABORATORY AND BENCH SCALE COMPOSTING AT THE TVA ENVIRONMENTAL RESEARCH CENTER

Larry Softley, Debbie Tuten, Cindy Kirsch, Sheri Grosso, and Shawn Doughty, Biotechnology & Remediation; and Pat Jansen, Herb Norris, Jerry Clayton, and Richard Strickland, Agricultural Research & Practices,
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The Tennessee Valley Authority (TVA) with university and private sector cooperators has been involved in the management and utilization of animal and other solid wastes for several years. Of primary interest is poultry litter utilization, particularly for value-added horticultural and agronomic uses for compost products. Composting is the aerobic microbial stabilization of organic materials. TVA's Environmental Research Center has established incubator and mini-composter tests to simulate large-scale composting. These tests are necessary to fully evaluate the parameters of composting under controlled conditions. Two large environmental chambers and twenty minicomposters (insulated 55-gallon plastic drums) are used for these tests. The objectives of these tests are: (1) to evaluate different composting mixtures before large-scale composting, (2) to perform composting studies under controlled conditions of aeration, temperature, and moisture content, and (3) to characterize the maturity, stabilizing, and physical properties of composted materials. This poster describes results obtained from compost trials using poultry litter and other organic feedstocks.

A major research activity over the last year has been the characterization of microbial populations during composting. Microbiological tests are used to identify major groups of microorganisms associated with composting, compare microbial species diversity, determine effect of different chemical/physical conditions of microbial populations, and determine the survival of potentially pathogenic organisms.

Present work includes (1) bioavailable carbon studies, and (2) bioremediating organic waste soils. The purpose of the bioavailable carbon study is to determine the best analytical procedure to estimate bioavailable carbon. The purpose of the bioremediation of organic waste soils is to determine the rate and extent of biodegradation of contaminants, determine optimum levels of contaminant to substrate, and study microbial succession and isolate effective degradative microorganisms.

Future work will include (1) evaluation of alternative composting methods to improve nitrogen retention, (2) evaluation of compostibility of different feedstocks prior to large scale tests, (3) composting of explosives/contaminants, (4) composting of bark residue from tannin extraction, (5) continued evaluation of microbial populations including potential pathogens during composting, and (6) evaluation of composting for the remediation of other waste contaminated soils.

All past, present, and future work will be used to correlate laboratory/bench scale testing with large scale composting trials and physical/chemical characteristics. This information will aid in characterizing the maturity and physical properties of the composted materials and determining proper uses for the finished compost.

THE TENNESSEE VALLEY AUTHORITY'S POULTRY LITTER UTILIZATION, COMPOSTING, AND PELLETING FACILITY

Richard Strickland, George Jones, Larry Softley, Pat Jansen, Debbie Tuten, Pat White, Sheri Grosso, Willie McDaniel, and Cindy Kirsch, Tennessee Valley Authority, Environmental Research Center, Muscle Shoals, Alabama

In 1990, TVA's Environmental Research Center (ERC) started a project to develop and introduce technologies to more fully exploit utilization opportunities and help alleviate the environmental problems associated with broiler litter. A large, fertilizer bulk storage building was converted into an indoor compost facility. The facility has a capacity of producing 600 tons of stable, odorless compost per year while conducting large-scale composting trials. This facility provides a supply of quality compost for the development and commercialization of soil amendments, potting soils, and enhanced organic fertilizers for large-scale testing. Laboratory scale equipment is available to produce up to 60 pounds per hour of pelleted compost, enhanced organic fertilizers and cattle feed for testing by university and industry cooperators. Future plans call for the completion of a large-scale pelleting facility (3-4 tons per hour) with the necessary screening, mixing, drying, and bagging equipment. After this facility is completed, ERC will supply private sector cooperators with between 100-300 tons of product for market testing and development as components of TVA's overall technology transfer efforts.

MANURE PRODUCTION/CROP NUTRIENT USE IMBALANCE-NEW TECHNOLOGY REQUIRED TO ENHANCE THE FEASIBILITY OF ALTERNATIVE SOLUTIONS

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This study evaluated a system design concept to separate swine manure liquids and solids immediately following excretion and passage through slotted flooring of a grow-finish facility. A pen was built on raised concrete slats above a sloping varnished plywood sub-floor. Manure was produced by four crossbred barrows (33 to 70 kg or 73 to 183 lb) fed a standard corn-soybean meal grower diet. Treatments were various sub-floor slopes (31.5%, 16.7%, 11.8%, 8%, and 2%) and orientations to slats (parallel and perpendicular). Solids (feces and wasted feed) accumulated on the plywood surface and were collected by manual scraping. Liquids (urine and waste water) drained off the sloped plywood and were collected in a polyvinyl chloride pipe. Solid and liquid production, moisture content, total phosphate and total Kjeldahl nitrogen were determined for the liquids and solids taken daily over a 4 day collection period. Solids accounted for 27% to 39% of the total manure wet mass with an average moisture content of 65%, and contained 87% to 98% and 37% to 76% of the total P_2O_5 and nitrogen, respectively and a carbon:nitrogen ratio of 14:1. The concentration of nutrients in solids did not differ (P>.01) among the various slope treatments. This phosphate partitioning compares to current liquid-solid separation technology that is capable of separation 20-40% of the total solids and total P_2O_5 for stored swine manure slurry. This 93% retention of the P_2O_5 in the solids collected creates a variety of transportation and use options for better management of manure nutrients.

Miscellaneous

A NEW, LOW-COST METHOD TO PROTECT STOCK WATERING PONDS

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Cattle require abundant, good quality water. Most cattle in eastern Oklahoma are given free access to wade in the ponds from which they drink. As a result, numerous problems can occur. Cattle suffering from Brucellosis, Mastitis and numerous other diseases can easily spread pathogens to the entire herd via drinking water. During summer, urine and manure is concentrated in the ponds, leading to potentially harmful levels of nitrates and other substances. Pond banks and dams can suffer severe erosion due to lack of vegetative cover and mechanical damage from hooves.

A long standing recommendation has been for cattle producers to consider the installation of below-dam, freeze-proof watering tanks along with fencing to exclude cattle from the pond and dam. One reason that few producers have adopted this practice is the expense of the tank and the labor required to install it. A new, low-cost, easy to install means of limiting cattle access to ponds has been developed by Charles Griffith of the Noble Foundation in Ardmore, Oklahoma. His technology is the basis for two on-farm demonstrations established during 1995.

An electric fence completely excludes cattle from all parts of the dam and pond except one small section of the pond delineated by a floating electric fence. This structure is constructed of two-inch diameter PVC piping and staked to the shore. The width of pond shoreline left open to drinking is equal to one foot for every 25 to 30 cows or 50 yearlings. This provides an area adequate for drinking but too small for prolonged wading. Herds larger than 300 animals are best serviced by multiple floating fence access points. Cost to modify a typical small to medium size pond is several hundred dollars, exclusive of fence charger. It may be necessary to construct a hard surface in the watering area using rock or gravel. Since the area where the floating fence is located is selected for its shallow depth, an added bonus of the system is the elimination of wintertime loss of cattle through ice.

ON-FARM STORAGE OF POULTRY CARCASSES PRIOR TO RENDERING

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Rendering is one of the best means for the conversion of poultry carcasses into a valued, biologically safe protein by-product meal. Removing poultry carcasses from the farm is most acceptable for the environment; however, spread of pathogenic microorganisms during routine pickup and transportation of poultry carcasses to a rendering facility may present a substantial threat to farm biosecurity.

In addition to biosecurity concerns, farm to farm pickup of carcasses also proves to be expensive. Thus, there is a need for means of storing carcasses on the farm for short periods of time in order to make transport of carcasses cost effective. Freezing carcasses for short-term storage prior to transportation has proven to be effective, but is costly. High capacity refrigeration units are required to accommodate high heat loads when heavy weight birds are encountered during the later stages of the growing cycle[5]. Moreover, pathogenic microorganisms can survive freezing.

Lactic acid fermentation of poultry carcasses prior to transport may be a method of stabilizing carcasses and preventing the spread of disease during transport to a rendering facility[1,3]. The goal of our ongoing work is to develop a fermentation system that is economically, microbiologically and environmentally sound for stabilizing carcasses, allowing them to be stored on-farm and subsequently transported to a rendering facility at the end of a growing cycle. Successful fermentation is enabled by the combination of prescribed amounts of ground carcasses with a fermentable carbohydrate source such as sugar, whey, molasses, or ground corn. For effective fermentation to occur, carcasses must be ground. Grinding aids the dispersion of intestinal anaerobic lactic acid-forming bacteria. During fermentation, sugars are converted into organic acids, i.e. lactic acid, by the indigenous bacteria which lowers pH to below 5.0 and preserves the organic material. Levels of lactic acid bacteria dramatically increase to suitable levels within 7-10 days that results in the preservation of carcass nutrients.

Pathogenic microorganisms associated with the carcasses are effectively inactivated or inhibited during the fermentation process via the decrease in pH[2]. In controlled laboratory studies, populations of indigenous coliform bacteria and added Salmonella typhimurium were reduced from moderately high (ca. 10^6 colony forming units, CFU/g) levels to undetectable levels (<10 CFU/g)[2]. In larger batch sizes, initial coliform levels were greater than 10^6 CFU/g and declined to undetectable levels (<10 CFU/g) by the 18th day of fermentation[4]. Since fermented material can be stored and will remain in a stable state for several months, carcasses can be accumulated until there is a sufficient amount to warrant the cost of transportation for rendering.

Initial investigations into the fermentation of poultry carcasses began at Auburn University in 1990. Subsequently two on-farm fermentation facilities have been installed on commercial broiler farms to demonstrate the feasibility of on-farm fermentation of poultry carcasses[4]. A grinding unit was specifically designed and fabricated, which allows for the simultaneous addition of a carbohydrate source during the grinding of carcasses. Daily, broiler mortality is ground and ground corn is added at 20% weight to weight. The mixture (mortality and carbohydrate) is directly fed into a 300 gallon capacity enclosed tank. Typically, the pH values of the fermented product decline below 5.0 within a seven-day period. All resulting ferment obtained from both farms is transported for rendering at the end of a typical grow-out cycle.

Fermentation can be adapted for the stabilized, pathogen-free storage of broiler carcasses during a typical growout period. Unlike routine pickup of "fresh" mortalities, fermentation and storage of dead poultry reduces transportation costs by 90% and eliminates the potential for transmission of pathogenic microorganisms through poultry via rendered products.

References:

1. Blake, J.P., J.O. Donald and D.E. Conner, 1992. On-farm fermentation of broiler carcasses. In: Proceedings 1992 National Poultry Waste Management Symposium, pp. 328-334. National Poultry Waste Management Symposium Committee, Auburn University, AL.

2. Conner, D.E., J.P. Blake and J.O. Donald, 1991. Fermentative stabilization of Poultry farm mortalities. Poultry Sci. 70(1):28.

3. Dobbins, C.N., 1988. Lactobacillus fermentation: A method of disposal/utilization of carcasses contaminated by pathogenic organisms or toxic chemicals. In: Proceedings of the National Poultry Waste Management Symposium, pp. 76-80. Ohio State University, Columbus, OH.

4. Kotrola, J.S., D.E. Conner and J.P. Blake, 1992. Development of a practical fermentative process for stabilization of poultry carcasses prior to rendering: Scale-up of laboratory studies. Poultry Sci. 71:(1)52.

5. Poss, P.E., 1990. Central pick-up of farm dead poultry. In: Proceedings 1990 National Poultry Waste Management Symposium, pp. 75-76. National Poultry Waste Management Symposium Committee, Auburn University, AL.

POULTRY LITTER EFFECTS ON ERGOVALINE PRODUCTION IN ENDOPHYTE-INFESTED TALL FESCUE

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Tall fescue (*Festuca arundinacea* Schreb.) is the predominant pasture grass on hilly land and marginal agricultural soils in the mid- to upper South of the U.S. This area is experiencing an increasing density of poultry production. Tall fescue pastures serve as the major land use onto which poultry manure (litter) is applied for the dual purpose of disposing of the waste and to provide fertilizer nutrients to support pasture production. An endophytic fungus (*Acremonium coenophialum* Morgan-Jones and Gams) in tall fescue produces ergot alkaloids, which are deleterious to health, growth, and reproduction of livestock grazing tall fescue. Nitrogen fertilization has been shown to increase the concentration of ergot alkaloids in endophyte-infected tall fescue (Belesky et al., 1988). The primary ergot alkaloid produced by this endophyte is ergovaline. Casual observations have indicated that poultry litter application to endophyte-infested tall fescue stands exacerbates livestock disorders; however, little information exists about litter effects on ergovaline levels. The objectives were 1) to determine the effects of poultry litter application on ergovaline concentrations, and 2) to characterize the season changes in ergovaline concentration in tall fescue.

Broiler litter was applied on March 1 of three consecutive years to 100% endophyte-infested tall fescue field plots at 0, 2.2, 6.7, and 11.2 Mg/ha. Commercial fertilizer was also applied to deliver 134 kg/ha N (equiv. to 4.5 Mg/ha of litter). Ergovaline concentrations increased with increasing rates of broiler litter up to 6.7 Mg/ha, then leveled off. Ergovaline concentration in the fertilizer treatment was intermediate to those of the 2.2 and 6.7 Mg/ha litter rates, supporting the role of nitrogen fertility as a determinant of fescue toxicosis potential in endophyte-infested tall fescue. Ergovaline was most concentrated in forage harvested in June and Sept-Oct. Annual applications of broiler litter at rates above 2.2 Mg/ha may significantly increase the incidence or severity of fescue toxicosis, especially in late spring and in fall. These considerations are important in deciding on optimal rates of poultry litter to apply to tall fescue pastures in addition to considering the potential for surface runoff of nutrients at high poultry litter application rates.

References:

Belesky, D.P., J.A. Stuedemann, R.D. Planttner, and S.R. Wilkinson. 1988. Ergopeptine alkaloids in grazed tall fescue. Agron. J. 80:209-212.

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