FIELD SCALE EVALUATION AND TECHNOLOGY TRANSFER OF ECONOMICALLY, ECOLOGY SOUND LIQUID MANURE TREATMENT AND APPLICATION SYSTEMS

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TABLE OF CONTENTS

APPENDIX

Attachment 1	News Release Promoting SWEETA Website
Attachment 2	Slurry Separation A systems Approach to Manure Management
Attachment 3	Land Application of Separated Effluent from Swine Slurry
Attachment 4	Slurry Separation – Getting Started
Attachment 5	Slurry Separation – Cost Considerations
Attachment 6	Evaluation of a PAM Assisted Solid/Liquid Separation System
Attachment 7	Compost Facility Permits
Attachment 8	Seminar Presented at CLM Training Workshops
Attachment 9	Seminar Presented at the 2007 Annual C-FAR Meeting, Springfield, Illinois
Attachment 10	Abstract of Poster Presented at SWCS Conference
Attachment 11	Poster Presented at SWCS Conference
Attachment 12	Communication Brief Published in the Journal of Soil and Water Conservation, March/April 2008, Volume 63, Number 2
Attachment 13	Invitation Letter to Liquid Swine Manure Separation Workshop
Attachment 14	Picture of Waste Handling Facilities at ISU Farm-Lexington
Attachment 15	Pictures of Separation Equipment
Attachment 16	Advanced Water and Effluent Management Systems Booklet
Attachment 17	University of Illinois Extension Livestock Manure Management Conference Series
Attachment 18	Manure Management Workshop/Field Day Schedule (2009) ISU Farm - Lexington
Attachment 19	Popular Press Articles Related to Technology Transfer
Attachment 20	Illinois Pork Producers Association Email Newsletters Related to Manure Management/Technology Transfer
Attachment 21	Refereed Publications in Scientific Journals Related to Solid/Liquid Manure Separation and Land Application

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

OBJECTIVES:

1) Demonstrate and evaluate under production scale conditions new or improved AMP's for slurry application that singularly or in combination result in reduced NPS pollution and improved water quality.

2) Develop educational materials, offer workshops/field days and provide outreach activities to inform farmers, educators (extension specialists, government agency staff, etc.), and the general citizenry of BMP's to reduce NPS pollution originating from the land application of manure.

LIST OF EXPECTED DELIVERABLES/PRODUCTS OF PROJECT ACTIVITIES:

1. Field installation of modified, controlled drainage system designed to utilize separated effluent from swine slurry as a soil amendment for corn/soybean production (40 acres). **Completed.**

2. Development of adaptive management practices (AMP) to reduce NPS pollution when land applying composted swine slurry and separated effluent from swine slurry via surface irrigation (center pivot) and subsurface irrigation (modified controlled drainage). **Completed.**

3. Development of a website containing AMP's, operation guidelines and cost of operation analyses for: solid/liquid separation, SBR nitrification, land application of separated effluent via surface and subsurface irrigation, and compost application. **Completed.**

4. Development and distribution of brochures and e-mail newsletters containing AMP's for solid/liquid separation, SBR nitrification and land application of separated effluent via surface and subsurface irrigation, and compost application. **Completed.**

5. Presentation of three workshops/field days targeting livestock producers and grain farmers, and educators (extension specialists, government agency staff – EPA, NRCS, etc.). **Completed.**

COMPLETED DELIVERABLES:

1. Constructed a 170 feet long by 60 feet wide building to house manure processing equipment (deliverable 1).

2. Developed two liquid manure separation systems – one low technology system and one higher technology system (deliverable 1).

3. Successfully tested one production scale nitrification system (deliverable 2).
4. Established a 17 acre modified underground drainage system (MUGDS) to subsurface irrigate separated effluent (deliverable 1).
5. Operated the MUGDS for two years applying 900,000 gallons of separated effluent during year two (2009). Currently (2010) the MUGDS is in its third year of operation, second year for applying separated effluent, (deliverable 2).
6. Developed capacity to separate all of the swine slurry produced at the ISU Farm-Lexington on a year around basis (deliverable 2).
7. Reduced the phosphorus content of swine slurry at the ISU Farm-Lexington by 90.0+%, reducing the number of acres required to land apply separated effluent from 200 acres to 40 acres (deliverable 2).
8. Eliminated land application of raw slurry as a production method of application. The only raw slurry that is land applied is in plots for research trials (deliverable 2).
9. Achieved full composting of all of the separated biosolids generated from separating the swine slurry, all of the sheep manure and all of the cattle manure generated at the ISU Farm-Lexington. Approximately one half of compost produced is sold off farm (deliverable 2).
10. Held one field day/workshop at the ISU Farm – Lexington (June 28, 2007) targeting agency staff, extension specialists and commodity association staff (deliverable 5).
11. Presented two seminars as part of the University of Illinois Extension "Livestock Manure Management Conference Series" held March 24 and March 26, 2009 in Effingham and Princeton, Illinois. Seminar one was titled "Liquid Swine Manure Separation and Land Application". Seminar two was titled "Composting Livestock Manure". Brochure and handouts were distributed at these meetings (deliverable 5).
12. Held one field day at the ISU Farm – Lexington (September 22, 2009) targeting livestock producers and news media (deliverable 4).
13. Developed, produced and distributed six brochures to end-users, media, extension specialists and agency staff (deliverable 4). Brochure titles are:
    - *"Evaluation of a polyacrylamide (PAM) assisted solid/liquid separation system, consisting of a gravity screen and gravity belt thickner, coupled with separated solids composting for the treatment of swine waste".*
    - *"Slurry separation – a systems approach to manure management".*

- *"Slurry separation – cost considerations".*
- *"Slurry separation – getting started".*
- *"Land application of separated effluent from swine slurry".*
- *"Compost facility permits".*

14. Developed in cooperation with Agrem LLC, a booklet describing the MUGDS for distribution at field days and workshops titled "Advanced Water and Effluent management systems". Agrem LLC paid for development of this booklet. NRCS, CIG funds were <u>not</u> used to develop or to print copies of this booklet (deliverable 4).

15. Worked with Illinois Extension to develop a web site that includes compost, separation, land application information. The site address is: <u>www.sweeta.illinois.edu</u>. SWEETA is an acronym for Swine Waste-Ecological and Environmental Treatment Alternatives (deliverable 3). Since its development this website has had 29,746 total page views averaging over 1,500 page views:month.

16. Developed an email newsletter for Illinois swine producers that is has been distributed four times per year through the Illinois Pork Producers Association (deliverable 4) The title of the newsletters were:
    - *"Value of liquid swine manure as a fertilizer for corn production".*
    - *"More regarding the fertilizer value of liquid swine manure".*
    - *"Survey of Illinois commercial manure haulers and applicators".*
    - *"Slurry separation – a systems approach to manure management".*
    - *"Fall 2009 manure application".*
    - *"Handling manure will be especially stressful this year".*

17. Established a 40 acre, center pivot irrigation system to land apply separated effluent (deliverable 1).

18. Successfully separated and irrigated separated effluent for 3 years and are currently in year 4 – 2010 (deliverable 2). This system has applied over 1 million gallons of separated effluent in each of its three years of operation (07, 08, 09).

19. Separated over one million gallons of raw swine slurry in year one and over 2 million gallons in each of years two and three with the following results: reduced separable solids 98.4%, reduced total suspended solids 98.2%, reduced chemical oxygen demand 89.6%, reduced nitrogen content 60.6%, reduced phosphorus content 91.7% and increased N:P from 3.8:1 to 20.0:1 in year one; reduced separable solids 98.7%, reduced total suspended solids 93.7%, reduced chemical

oxygen demand 72.4%, reduced nitrogen content 45.5%, reduced phosphorus content 70.0% and increased N:P ration from 5.5:1 to 12:1 in year two (deliverable 2)

20. Presented seminar regarding solid/liquid separation of liquid swine manure at each of the Illinois Livestock Management Facilities Act Certified Livestock Manager training sessions (eight sessions) held in December 2007 and the spring of 2008 These seminars were either presented in person or as a pre-recorded video (deliverable 5).

21. Two graduate students assigned to this project will receive their Master of Science degree during 2010. Thus far two manuscripts have been published in peer-reviewed scientific journals (deliverable 4). The title of the two Master Theses are:
    - "*Effectiveness and economic costs of polyacrylamide assisted solid/liquid separation systems for the treatment of liquid swine manure*". Caroline Wade, author.
    - "*Development of a spreadsheet for estimating costs of solid/liquid separation of swine manure*". Jennifer Donley, author.

The two published manuscripts are:

- Walker, P.M., C.A. Wade and T.R. Kelley. 2009. Evaluation of a polyacrylamide assisted solid/liquid separation system for the treatment of liquid pig manure. Biosystems Engineering. 1 – 6
- Walker, P.M. and C.A. Wade. 2010. Comparison of the effectiveness and economic costs of two production scale polyacrylamide assisted solid/liquid separation systems for the treatment of liquid swine manure. Applied Engineering Agriculture. 26:No. 2. 299 – 305.

INTRODUCTION:

This project is located at the ISU Farm-Lexington in northeast McLean County. The farm lies within the Turkey Creek/Mackinaw River watershed. Co-mingled raw slurry from the Illinois State University (ISU) Farm, farrow to finish swine operation was/is being utilized for this project. Unprocessed raw slurry, separated effluent and composted separated biosolids are land applied on land owned/operated by the ISU-Farm, and two farmers i.e. Schuler Farms and Pope Farms. The IEPA permitted compost facility in which the separated biosolids are composted is located within the ISU Farm-Lexington.

Funding through an IEPA 319 Grant paid for the purchase and construction of a 60 feet wide by 170 feet long building to house the manure processing equipment. Erection of this building eliminated runoff of the separated effluent and/or unprocessed slurry during processing. One half of this building was insulated to house the separation equipment and to allow year around slurry processing in freezing weather and in raining/storming weather as well as under-optimal weather conditions. Housed within this building are two separation systems; six in-ground 20,000 gallon capacity, concrete holding tanks that are inter-connected; two electrical pumps and electronic control systems [one pump serves the center pivot irrigation (surface irrigation system) and one pump serves the modified under-ground controlled drainage system (MUGDS) (Underground irrigation system)]; and other slurry/effluent processing equipment such as sequential batch reactors, etc.

Originally one separation system was utilized for this project. During year two a second lower technology-lower cost system was developed. Currently both systems are utilized and the efficacy of the two systems is being evaluated and compared.

The original system was developed in previous research studies modifying technology widely employed by municipal sanitation utilities for treating waste water. With this continuous flow system raw (unprocessed) slurry from the liquid manure holding pile located beneath the slatted floors of the swine buildings is drained through a pull-plug sewer line into a holding tank located within the processing facility. Raw slurry is continually stirred within this tank to keep solids fraction in suspension. The raw slurry is pumped to an over-head gravity – screen – roll press mechanical separator to remove separable solids producing what we refer to as separated slurry. The separated slurry flows by gravity to an above ground 2000 gallon tank. From this tank separated slurry is pumped through a hose and venturi system to mix polymer (polyacylamide) with separated slurry to floc the remaining biosolids. The separated slurry-polymer mixture is pumped across a continuous gravity belt thickener that allows the liquid portion referred to as separated effluent to separate from the solids portion referred to as biosolids. The biosolids are collected into a settling basin that allows the biosolids to decante excess effluent and concentrate to the 15 – 18% solids concentration. The separated effluent flows to an in-ground holding tank for eventual pumping to and storing in an above ground Slurry Store® that has a holding capacity of one million gallons. When appropriate the stored separated effluent is pumped underground to a center pivot irrigation for surface land application.

The second separation system utilizes the same process as the gravity belt separation system until separated slurry is produced. With the second system the separated effluent continually flows by gravity to a 200 gallon holding tank from where it is pumped through a six inch line (into which polymer is added) to a second gravity screen separator As separated slurry flows across the second gravity screen separator the liquid fraction (separated effluent) is separated from the biosolids fraction. The biosolids are deposited into the settling basin to decante and the separated effluent flows to an in-ground holding tank for eventual storage within the Slurry Store® for later land application.

Subsequent to the separation and prior to the storage within the Slurry Store® separated effluent can be further processed through sequential batch reactors utilizing the remaining four in-ground holding tanks located within the processing facility. Separated effluent can be land applied via one of two systems: surface application through the center pivot irrigator or underground application through the MUGDS. Both the center pivot irrigation system and the MUGDS have been demonstrated and are operating under production scale conditions.

The MUGDS was developed and constructed/installed with funding from the CIG program. This system was partially installed during the late spring of 2007 The main tile lines and the lateral tile lines were installed during May of 2007. The controlled drainage reservoir was constructed during the fall of 2007. The system was tested during the fall of 2007 i.e. separated effluent was pumped through the underground tiles, the system was checked for leaks and the electronic control valves were checked for operating efficiency. One tile line leak was found at a connecting joint and it was repaired. Some adjustments to the computer program controlling the system was necessary and some of the electronic control valves required adjustment. The system was deemed operational and ready for the 2008 growing season.

During the late fall of 2007, the winter of 2007 and the spring of 2008 the MUGDS seemed to be functioning correctly and drain tile water collected from the 17 acre tile was collected within the controlled drainage reservoir without any overflow. Monitoring wells and lysimeters were installed by the Illinois State Water Survey/Illinois State Geological Survey (ISWS/ISGS) during the spring of 2008. Soil samples were collected during 2007 and analyzed for selected characteristics to determine background soil parameters. During 2008 the MUGDS was utilized as a means of controlling soil water from normal rainfall to access the systems effectiveness for controlling soil water. Corn was the planted crop during year one (2008). During 2009 separated effluent (900,000 gallons) was land applied through the MUGDS. Soybeans were the crop planted for the 2009 growing season. Corn is the crop planted for the 2010 growing season and one million gallons of separated effluent is expected to be land applied through the MUGDS.

Solid-liquids separation of swine slurry as an alternative manure management strategy

OBJECTIVES:

This project is designed to complete and fully operationalize a production-scale integrated livestock waste management demonstration site that will:

1) demonstrate new or improved BMPs that singularly or in combination result in reduced NPS pollution and improved water quality.
2) result in the development of educational materials designed to inform farmers, educators (extension specialists, government agency staff, etc) and the general citizenry about the impacts of NPS pollution originating from the land.
3) provide a facility for conducting continued research to reduce livestock manure's negative impact on NPS pollution.
4) directly reduce the NPS pollution potential of the Illinois State University Farm-Lexington livestock operation of (1,000 A.U. approx.) to the Mackinaw River-Turkey Creek sub-watershed.

METHODS:

The separated effluent (SE) is stored in a Slurrystore® for later use as a soil amendment and the separated biosolids (BS) are transported to the ISU Farm Compost Facility. Upon arrival at the compost site, the BS are mixed with landscape waste (woodchips or leaves) and composted for ultimate use as a soil amendment.

Four-forty acre fields (Fields One-Four) and one 15 acre field (Field Five) were selected for use in this study. Compost (BS and landscape waste) applied by broadcast is used as a soil amendment on Field One. Raw slurry applied via soil injection is used as a soil amendment on Field Two. Separated effluent applied via center pivot irrigation is used as a soil amendment on Field Three. Commercial fertilizer (anhydrous ammonia, di-ammonium phosphate and potash) applied by soil injection and broadcast is used as a soil amendment on Field Four. Separated effluent applied via a modified underground controlled drainage system will be applied to Field Five. Because funding from the DOA, SAG Program and the USDA, NRCS, CIG Program were not available until spring 2006 the modified underground controlled drainage system (MUGDS) was not installed in time for the 2006 or 2007 growing seasons. The MUGDS will be utilized for the 2008 and subsequent growing seasons.

Ground water wells and lysimeters were installed up-gradient and down-gradient of each field. Water and soil samples were collected prior to and subsequent to application of soil amendments, and analyzed for selected parameters. Samples of RS, SE, BS and compost were collected and analyzed prior to application, and pre-and post-separation.

During year one (calendar year 2006) the same variety(ies) of corn (Pioneer 34A16 and 34A19) was (were) planted in each field. The same variety of soybean (Pioneer) was planted in each field during year two (calendar year 2007) The same variety(ies) of corn (Pioneer) were planted in each field during year three (calendar year 2008). The varieties were a Round-up™ ready corn and a refuge corn. Upon harvest yields were determined by whole-field collection and adjusted to No. 2 yellow corn at 12.9% moisture.

RESULTS:

Between May 18 and October 10, 2006 1,067,237 gallons (g) of RS were separated producing 971,160 g of SE and 96,077 g of BS. This represents a collection rate for SE of 91.0%. Separation occurred approximately once every 7-10 days for 16 separation periods during the 145 day time span. An average of 52,702 g:d of RS were separated at each time producing an average of 47,959 g:d of SE over an 8-12 hour period of time. Table 1 provides the abbreviations used in each of the tables. Table 2 shows the concentration of selected constituents found in the RS, SE and BS. The separation process worked remarkably well resulting in the removal of 69.2% of DM, 98.4% of SS, 98.2% of TSS, 89.6% of COD, 60.6% of N and 97.1% of the P concentrations. The N:P ratio was improved from 3.8:1 in RS to 20.0:1 in SE.

During year two (2007) 1,234.966 g of RS were separated producing 1,118,967g SE and 115,999g BS giving collection rate of 91.0% for SE. Separation was conducted twice weekly from May 1 until November 1. An average of 51,457g of RS was separated weekly producing an average of 46,826g of SE over a 12 hour period:week. The separation process removed 52.4% of DM, 95.0% of SS, 92.1% of TSS, 63.1% of COD, and 36.4% of N and 70.0% of P concentrations. The N:P ratio was improved from 5.5:1 in RS to 12.1 in SE (Table 3).

During year two, two separation systems were compared (the continuous gravity belt system and the gravity screen system (Table 3) Both systems performed similarly with similar results.

Table 4 shows the selected nutrient values for compost produced using BS. Tables 5 and 6 show the costs for purchasing and land applying the inorganic fertilizer to Field 4 and the amounts of soil amendment added to each of the four treatment fields. The amount of soil amendment added was based on a target application rate of 180 lbs. N: acre. Table 7 shows the amount of actual N added and the predicted N required based on the actual yield (bu:ac) obtained. Of particular interest in Table 7 is the excess/deficit of P actually applied when subtracting actual P utilized by the corn from the actual P applied. Inorganic fertilizer and SE applications resulted in deficit P utilization rates. Compost and RS resulted in over application of P. However, based on predicted future application rates for compost, by year 3 of application compost will result in a negative P application balance. This is a good thing if the goal is to reduce P accumulation in the soil. Less compost is required as a soil amendment in year 2, year 3 and beyond due to increased N availability from compost applied in year 1 and the carryover of N from year 1, year 2 and year 3, respectively. Forty two tons of compost:acre were required in year one assuming a N availability of 35%. Only 15 tons:acre of compost were required in year 2 (applied in the fall of 2006 after harvest). Approximately 18 tons:acre of compost was applied in the fall of 2006 after harvest to provide sufficient N for an estimated bushel per acre yield, instead of the previous 180 bushel per acre yield.

Table 8 shows the cost to produce and apply compost. These costs are based on previous studies partly supported by the Illinois Department of Agriculture Sustainable Agriculture Grants Program (IDOA, SAGP). Table 9 shows the charges used to calculate the cost (Table 10) of separating RS to produce SE. The calculated cost to separate one gallon of raw slurry into its solid and liquid phases is 0.90¢:g RS or 0.99¢:g SE. Irrigation of water or SE costs 0.1¢:g based on industry average values (personal communication; R.J. Alton). Separation plus application results in a total cost of 1.0¢ - 1.09¢:g which is similar in cost when compared to the commercial cost of direct injection of RS via a dragline system (0.70¢:g) or to hauling and injecting with a slurry tank (as high as 1.70¢:g). The cost for commercial injection of RS at the ISU Farm the last two years has been 1.0¢:g.

Table 11 compares the value of each of the four soil amendment types from a purely agronomic perspective. Accordingly, RS followed by IF are the most economical fertilizer choices. Compost is too expensive in year one if the compost is applied at a sufficient rate to provide all of the corn plants N requirement. However, by year three, compost is more competitive in value due to lower required application rates. The agronomic value in this comparison does not account for any other benefits received from compost, RS or SE. The agronomic value of RS compared to SE is more than 300 times as beneficial but not included in the economical analysis is the intangible value of less odor during application for SE and the fact that SE results in deficit P application compared to RS which results in over applying P

Soil samples were collected for analysis during the fall of 2005 prior to application of soil amendments (fertilizer treatments) and during the fall of 2006 and 2007 subsequent to harvest and prior to soil amendment application for the succeeding year's (2007 and 2008) growing season (Table 12). The data for subsurface irrigation (SI) collected during the fall of 2006 represent background soil characteristics prior to initiation of treatment application, as 2008 will be the first growing season for this treatment. No trend lines in soil characteristic changes can be determined following one year of data collection. Multiple years of sample analyses will be required to determine effects of treatments on soil characteristics.

DISCUSSION:

Polymer assisted separation of liquid swine manure is both effective and economical. The two systems compared had similar separation efficiencies. Once the separation process began each year the raw slurry was cleaner compared to the raw slurry concentrations of solids and nutrients prior to the initiation of separation in year one. Therefore, the act of keeping manure pits drained and recharged with SE compared to storing large quantities of raw slurry decreases the potential for contamination when land applying raw slurry. Removing BS from RS decreases (almost eliminates) the potential for contaminating runoff or leachate occurring when applying SE. The improved N:P ratio occurring in SE (from 12:1 in RS to 20:1 in SE) is similar to the desired N:P ratio for corn (15:1). Separation removes so much of the P in manure, that the SE when land applied for its N value to meet the corn plants requirement results in a net P deficiency.

Specific to the ISU Farm-Lexington, prior to separation 200 acres of land was required to apply the raw slurry according to P rates and plant (corn) requirements. Over the past two years, 40 acres has been more than enough acres to land apply all of the SE produced when the rate of SE application was based on the SE nitrogen concentration. When SE is applied to supply the corn plants N requirement, the P requirement for the corn plant is not met.

The solids fraction and P of raw slurry are concentrated in the separated BS. Composting the BS reduces the odor associated with land applying raw slurry and puts the solids into a form (compost) that can be managed to reduce surface runoff and leachate contamination.

Similar yields of corn were observed during year one for C, RS and SE. Inorganic fertilizer resulted in higher corn yields than C, RS or SE During year two C resulted in the highest yield of soybean followed by IF. Raw slurry and SE produced similar soybean yields. The yield data from these two years provide supporting evidence that several years of study must be conducted to correctly assess the effects differing soil amendments.

As a result of the adaptive management practices developed through this project the potential for runoff and leachate contamination from livestock manure generated on the ISU Farm-Lexington has been reduced. None of the liquid swine manure generated is directly land applied as unprocessed, raw slurry (except for limited amounts, a few thousand gallons, applied to research plots as a soil amendment). Ninety-six plus percent of the unprocessed slurry is separated into its solid and liquid fractions. The separated effluent is land applied at agronomic rates for its N content. The separated BS are composted and either sold off-farm (approximately 50% of the compost) or land applied on-farm at agronomic rates as a soil amendment in support of research studies. Unprocessed slurry is no longer land applied as a production practice Therefore, the potential for phosphorus buildup in the soil and in either surface or ground water has been reduced/eliminated. All of the manure generated by the sheep flock and beef cattle herds is composted within the compost facility. No unprocessed or beef manure is directly land applied. The construction of the manure processing facility allows year around separation of liquid swine manure. Prior to the buildings construction the ISU Farm-Lexington could only separate slurry from April through November as the manure processing equipment was set up outside and freezing weather prevented its separation from December through March. The inability to separate raw slurry meant several hundred thousand gallons of raw slurry was directly land applied each year with greater potential for NPS pollution. In addition, construction of the manure processing facility has eliminated runoff and leachate generated from the separation process when the processing equipment was outdoors and subject to the "elements". Any (all) spillage of slurry, effluent or biosolids as a result of the separation process is now captured and processed.

Numerous outreach and dissemination activities have been conducted thus far and several more outreach activities are planned.

Outreach and Dissemination Activities:

- A one day, field day/workshop designed to inform agency staff (NRCS, IEPA, IDOA, etc.), extension specialists and commodity association staff (Illinois Pork Producers Association, Illinois Beef Association, Illinois Livestock Development Group, etc.) about the project featuring separation and surface application was held in June 2007. Thirty-five persons attended. A follow-up questionnaire was provided to all attendees to assess the quality/impact of the field day. The survey indicated that the field day was beneficial.

- The LUW Team is planning to hold a second field day in early September, 2008 and a third field day in July 2009 targeting livestock producers and news media The purpose of this field day will be to inform producers of the beneficial effects and cost effectiveness separation has on NPS pollution.

- The LUW Team worked with Illinois Extension to develop a website that includes information regarding composting, separation and land application of raw slurry and separated effluent. The SWEETA website includes economic comparisons of using inorganic fertilizer, raw slurry and compost as a soil amendment for corn production, based on actual costs and nutrient analyses. Information regarding Illinois EPA permitting, local siting approval and on-farm exemptions is also included. The website also includes information on composting horse bedding and manure. The site address is: http//web.extension.uiuc.edu/sweeta/index.cfm. A shorter address is being promoted that will link users to the website: www.sweeta.illinois.edu. SWEETA is an acronym Swine Waste-Ecological and Environmental Treatment Alternatives.

- Two brochures have been developed for distribution to end-users to enhance technology transfer of slurry separation. The titles are "*Slurry Separation – A Systems Approach to Manure Management*" and "*Land Application of Separated Effluent from Swine Slurry.*" These brochures promote AMP's to reduce NPS using separation.

- The LUW Team has developed an email newsletter for Illinois swine producers that is planned for distribution four times per year through the Illinois Pork Producers Association (IPPA). The newsletter is emailed to all pork producers who are members of the IPPA. The title of the first newsletter was "Value of Liquid Swine Manure as a Fertilizer for Corn Production "and it was published in May, 2008.

- Paul Walker (coordinator of the LUW Team) was invited to develop/present a seminar for the Illinois Livestock Management Facilities Act, Certified Livestock Manager training sessions. This seminar featured solid-liquid separation of solid-liquid separation of liquid swine manure and how the process can decrease NPS pollution. The training sessions were held across Illinois beginning in December 2007 and continuing through the spring of 2008. This seminar was presented in person or as a pre-recorded video/CD.

- A featured communications brief highlighting a portion of the project was published in the Journal of Soil and Water Conservation. March/April, 2008 issue.

- A poster emphasizing a portion of the project was presented at the Soil and Water Conservation Society Annual Conference held in Tampa, Florida in July 2007. This poster/abstract presentation received the third place competitive poster presentation award. The title was "*Field Scale Evaluation and Technology*

Transfer of Economically, Ecologically Sound Liquid Manure Treatment and Application Systems."

Table 1. Abbreviations

IF = Inorganic Fertilizer

- Anhydrous Ammonia
- Potash
- Diammonium Phosphate (DAP)

C = Compost

RS = Raw Slurry

RS1= Raw Slurry before Processing Started

BS = Biosolids/Separated Solids

BS-B = Biosolids/Separated Solids discharged from the gravity belt

BS-MS = Biosolids/Separated Solids discharged from the gravity screen

SE = Separated Effluent

SI= Subsurface Irrigation (Modified underground controlled drainage system)

DM = Dry Matter

SS = Settleable Solids

TSS = Total Suspended Solids

DO = Dissolved Oxygen

COD = Chemical Oxygen Demand

Table 2. Characteristics of Slurry, Effluent and Solids (Year 1)

Item	DM (%)	SS ml:L	TSS mg:L	pH	DO mg:L	COD mg:L	N (%)	P (%)	N:P
RS1	3.65	788	1782	7.6	0.0	127,000	1.0	0.53	1.9:1
RS	1.3	95.4	878.5	7.5	0.0	57,127	0.19	0.05	3.8:1
SE	0 4	1.5	15.9	7.8	44.9	5,922	0.08[b]	0.004	20.0:1
BS	10.4						0.9	0.64	1.4:1
Change[a]	-69.2	-98.4	-98.2	+4.0		-89.6	-60.6	-91.7	

[a]Percent change from RS to SE

[b]0.09% in irrigant.

Table 3. Characteristics Of Slurry, Effluent And Solids (Year 2)

Item	DM (%)	SS ml:L	TSS mg:L	pH	DO mg:L	COD mg:L	N (%)	P (%)	N:P
RS	0.82	103.5	4125	7.3	0	5115	0.11	0.02	5.5:1
SE-B	0.39	5.2	326	7.7	0.5	1885	0.07	0.006	12:01
SE-MS	0.37	1.3	258	7.6	1.7	1414	0.06	0.006	10:01
BS-B	9.33						0.55	0.35	1.6:1
BS-MS	10.77						0.65	0.43	1.5:1
Change:									
BS-B	-52.4	-95	-92.1	5.2		-63.1	-36.4	-70	
BS-MS	-54.9	-98.7	-93.7	3.9		-72.4	-45.5	-70	

Table 4. Compost Characteristics

N (%)	P (%)	K (%)	Ca (%)	DM (%)	pH	C:N
1.5	0.3	0.6	2.4	50.0	7.3	21:1

Table 5. Inorganic Fertilizer

Potash (0-0-60): $250/ton, $2.50/acre application

Anhydrous Ammonia (82-0-0): $449/ton, $6.00/acre application

Diammonium Phosphate or DAP (18-46-0): $332.32/ton, $2.50/acre application

Table 6. Soil Amendment Applied (40 ac)

Amendment	
IF	140 # N as A.A., 200 # DAP, 200 # Potash
C	1,708 tons – 42.7 t:ac wet/21.4 t:ac dry
RS	306,000 g – 7,650 g:ac
SE	971,160 g – 24,279 g:ac

Table 7. Nitrogen and Phosphorous Supplied (lb:ac)

Amendment	Yield[a]	N Req.[b]	N appl.	N diff.	Preq[c]	P appl	P diff.
IF	204	271	176	-95	44.9	40.9	-4.9
C	180	239	180	-59	39.6	136.7[d]	+97.1[e]
RS	179	238	214	-24	39.4	134.6	+95.2
SE	180	239	175	-64	39.6	7.8	-31.8
Target			180				

[a]bu:ac

[b]1.33 lb. N:bu-corn req.

[c].22 lb. P:bu – corn req.

[d]58.8 lb. in year 2, 38.4 lb. in year 3

[e] = 19.2 lb. excess in Year 2, = 1.2 lb. deficit in Year 3

Table 8. Compost Costs

Production	$10:ton	to	$35:ton
Application	$2:00:ac	to	$4.00:ac

Table 9. Separation Costs

Equipment	$100,000		
Labor	$15:h	.35/.31¢/g	SE/RS
Polymer[a]	$1.60:lb.	.14/.13¢/g	SE/RS
Fuel	$2.10:g	.15/.14¢/g	SE/RS
Main	2%:y	.08[a]/.07¢/g	SE/RS
Depr. (15 yr.)	6.7%:y	.27/.25¢/g	SE/RS

[a]560 mg:gal SE, 510 mg:gal RS

Table 10. Separation/Application Cost (¢:G)

Item	Separation	Application	Total
RS	0.90	0 10	1.0
SE	0.99	0 10	1.09
RS	Direct Injection = 0.70 – 1.70		

Table 11. Cost Of Soil Amendment

Amendment	Yield (bu:ac)	Cost ($:ac)	Cost ($:bu)	Year 2 (actual)	Year 3 (projected)
IF	204	107.62	0.53		
C	180	512.4	2.85	1.03	0.8
RS	179	76.5	0.43		
SE	180	264.64	1.47		

Table 12. Yield Data (bu:ac)

	Corn	Soybean
IF	204	67
C	180	73.7
RS	179	57.8[a]
SE	180	55.9[a]

([a])= Late Planting Date

Reducing ammonia volatilization and odor formation from treated swine manure

This portion of the report represents the sequencing batch reactor (SBR) part of the project. Prior to conducting the laboratory scale SBR study, a commercial pilot-scale SBR was tested at all the ISU-Farm in the Manure Processing Facility but the unit proved ineffective. The SBR evaluated could not keep up (treat) the volume of SE produced per minute of operation. Based on the observations of the laboratory SBR study, another commercial scale SBR unit will be evaluated during the summer of 2008.

OBJECTIVES:

The overall goal of the project was to develop process technologies that provide farmers with greater flexibility and security in their animal residual treatment. In the proposed project, a biological treatment technology to reduce odor and ammonia volatilization and selectively remove nitrogen was evaluated. This technology was integrated with the existing technology of polymer assisted separation (PAS) of swine manure. Our specific objectives for the proposed research were:

Objective #1: To determine critical design and operating parameters for the sequencing batch reactor (SBR).

Objective #2: To develop robust operating strategies that allow for efficient nitrification or for complete nitrogen removal (nitrification/denitrification) depending on nutrient demand.

SWINE MANURE MANAGEMENT APPROACHES:

The general practice for disposing of swine manure is by land application (Walker and Kelly, 2005). This disposal practice becomes difficult as animal feeding operations (AFO) grow in size and density increasing the costs of transporting swine manure. In addition, the swine manure is generally stored in lagoons that become anaerobic, generating odors that can be the source of complaints and volatilizing ammonia and methane. Deposition of atmospheric ammonia can cause eutrophication of surface waters and ultimately contributing to nitrogen loading of the Gulf of Mexico. Methane is of concern as a greenhouse gas.

A new management approach is being evaluated at the Illinois State University Farm to reduce odor and ammonia emissions and to allow for the reuse of nitrogen. While ammonia volatilizes during manure storage, the oxidation of ammonium will produce nitrate and nitrite that are not volatile and that is suitable for long term storage and land applied as fertilizer.

The management approach at ISU consists of two parts: (1) removal of solids from the swine manure and (2) nitrification of the ammonia to nitrate. Solid liquid separation is achieved utilizing a gravity belt separator where particle removal is enhanced by adding polyacrylamide as a coagulant. Walker and Kelly (2005) have shown that 99% of the solids and 63% of the chemical oxygen demand were removed from the swine manure to form separated effluent. Separated effluent can then be treated using a sequencing batch reactor (SBR) to nitrify ammonia and oxidize the remaining biodegradable organic substrate preventing the generation of products such as methane and hydrogen sulfide. Previous work by Zhang et al. (2006) has shown that it is possible to treat wastewater with high ammonia concentrations. Separated influent is a unique influent because the removal of the solids and the presence of residual polyacrylamide. Therefore, lab-scale nitrification testing was necessary to ensure that biological treatment can be used for stable nitrification.

BACKGROUND FOR BIOLOGICAL NITRIFICATION:

Nitrification is the two step process where ammonia is converted to nitrite with the production of hydrogen ions (Eq. 1). Nitrite is subsequently oxidized to nitrate (Eq 2).

Ammonia Oxidization

$$NH_4^+ + 1.5\ O_2 \longrightarrow NO_2^- + 2H^+ + H_2O$$

(1)

Nitrite Oxidization

$$NO_2^- + 0.5\ O_2 \longrightarrow NO_3^-$$

Ammonia and nitrite oxidation are carried out by two distinct groups of autotrophic bacteria. During ammonia oxidation (Eq. 1) acid is being produced that can significantly reduce the pH as the result of biological nitrification.

REACTOR CONFIGURATION:

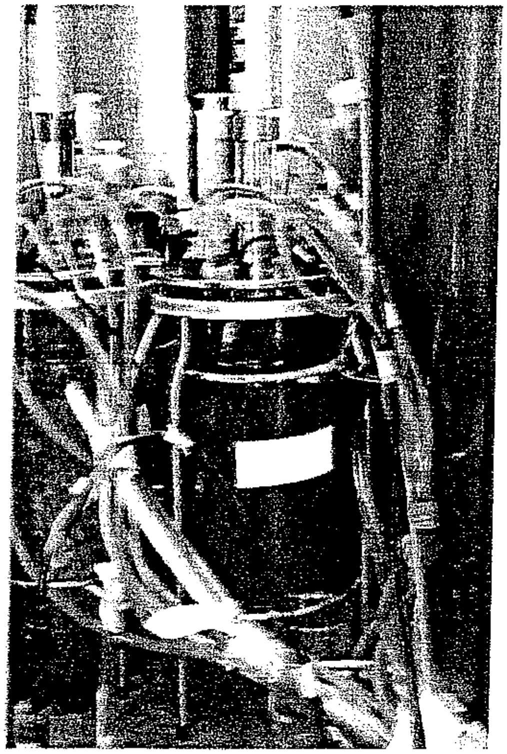
Two SBRs were operated in parallel for 1.5 years using different types of influent and different reactor configurations (Table 14). During phase 1 and 2, both SBRs were operated as conventional activated sludge SBRs. During phase 4 and 5, one of the SBRs was operated as a moving bed biofilm reactor. The SBRs were implemented using two identical glass reactors that have a water jacket to maintain a constant temperature of 25°C (Applikon). The working volume of each reactor was 5 L.

Overhead mixing and 4 vertical baffles generated mixing and prevented vortexing inside the reactor. Aeration was provided using aquarium pumps. that were automatically controlled . Dissolved oxygen concentrations were continuously measured (WTW Oxi 340, Wissenschaftlich-Technische Werkstätten, Weilheim, Germany), and dissolved oxygen concentrations were automatically controlled between 6 and 8 mg O_2/L by on/off aeration. The pH was automatically controlled by the addition of 2 M NaOH and 4 M HCl to maintain a pH between 7.2 and 7.8 during phases 1-3 and until day 40 in phase 4 and between pH 6.9 and 8.3 after day 40 in phase 4 and during phase 5.

The influent to the reactors was separated swine manure from the ISU farm. The reactors were seeded using nitrifying activated sludge from the Danville Sanitary District. Influent, effluent, base additions, and acid additions were fed to the reactor via peristaltic pumps (Masterflex, Cole-Parmer, Vernon Hills, IL, USA). The reactors were controlled and online measurements were recorded using LabView (National Instruments, Austin, TX, USA).

The reactors were operated as sequencing batch reactors with a 6 hour total cycle time. The activated sludge SBR was operated as follows: The influent was added during the first 10 minutes of the cycle. Aeration, pH control, and mixing were on from 0.3 to 5.5 hours. Sludge was wasted between 5.25 and 5.50 hours. The reactor's biomass was allowed to settle from 5.5 to 6 hours. The effluent was withdrawn between 5.8 hours and 6.0 hours. The activated Sludge reactor was operated with a solids retention time (SRT) of 15 days to retain the nitrifying bacteria. The composition of the separated swine manure sampled from ISU varied over time. During phase 3, the reactors were operated with a constant loading of 320 mg N/L d. A constant loading was achieved by adjusting the hydraulic retention time (HRT) in the reactor, depending on the ammonia concentration, in the separated effluent. HRT ranged from 1 to 3 d during the phase 4. During phase 5, the SBRs were operated with a constant HRT of 2.5 d.

The biofilm SBR was 50% filled with Kaldnes support media K1 (AnoxKaldnes, Providence, RI). The biofilm reactor was continuously aerated and pH controlled. The influent was added from time 0 hours to 10 minutes, and the effluent was withdrawn between 5.8 and 6 hours. The biofilm SBR was operated with a constant HRT of 12 h. With a short HRT and no settle phase to retain nitrifying bacteria, the nitrifying bacteria in the biofilm SBR were mainly attached to the biofilm support media. Suspended nitrifying bacteria were washed out of the system.



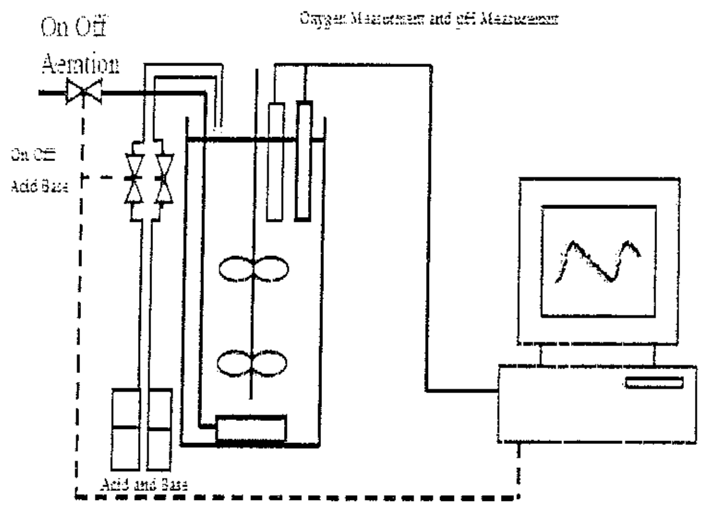


Figure 1 Biofilm Reactor(Left) Activated Sludge Reactor (Right)

Figure 2 Reactor Diagram for Both Reactor Types

Table 13: Summary of operating parameters of activated sludge and biofilm SBR during phase 4

Parameter	**Activated sludge SBR**	**Biofilm SBR**
HRT	1 to 3 d	12 h
Volumetric exchange ratio	25% to 8%	50%
Ammonia loading rate	320 mg N/L.d	320 mg N/L.d *
SRT	15 d	12 h
MLSS	2,000 mg VSS/L	N.A
pH	6.9 to 8.3	6.9 to 8.3

* The biofilm SBR was operated with a constant HRT of 12 h. To achieve the same target ammonia loading rate as the activated sludge SBR, the influent to the biofilm SBR was diluted with tap water.

Table 14: General reactor operations during this study

Phase	Time	SBR configuration	Reactor operations
Phase 1	July 2006 to November 2006	Two activated sludge SBR	Start-up using synthetic influent.
Phase 2	January 2007	Two activated sludge SBR	New start-up with separated effluent from ISU with an ammonia loading of 30 mg N/L.d
Phase 3	February 2007 to April 2007	Two activated sludge SBR	Operated with centrifuged raw swine manure from the University of Illinois farm at an ammonia loading of 30 mg N/L. d during winter shut-down of polymer assisted separation at ISU during the winter
Phase 4	May 2007 to July 2007	One activated sludge SBR and one biofilm SBR (after day 37)	Changed to separated effluent from ISU and operated at target ammonia loading of 320 mg N/Ld and with variable hydraulic retention time. Start of phase 4 was defined as day 0.
Phase 5	July 2007 to January 2008	One activated sludge SBR and one biofilm SBR	Operated with constant hydraulic retention time of 2.5 days.

ANALYTICAL METHODS:

Ammonia levels were determined using Hach's Nessler method or a microplate ammonia method Rhine (1998). Nitrite and Nitrate levels were determined using a Dionex ICS-2000 chromatography system with an AS50 autosampler. The column was a Dionex's AS18 IonPac anion exchange column. Oxygen uptake rates, OUR, for the reactors were calculated, by determining the slope of the change in oxygen concentration, when the DO levels were falling. MLSS and MLVSS were calculated using standard methods (APHA et al., 1998).

NITRIFICATION IN ACTIVATED SLUDGE SBR:

Figure 3 shows the complete effluent data for the activated sludge SBR for the overall project period Phases 2 and 3 are considered as start-up periods but were operated with lower ammonia loadings The main focus of our process evaluation will be on phases 4 and 5. Time zero in Figure 3 is when separated effluent from ISU was used as the influent at the target ammonia loading of 320 mg N/L.d It can be seen that effluent ammonia concentrations were below 5 mg N/L during the period of stable ammonia loading in phase 4. During phase 5 the effluent quality was more variable with effluent peaks up to 140 mg N/L. This variable performance can be explained by very large variations of influent ammonia concentrations in different batches ranging from 200 to 900 mg N/L. Ammonia oxidizing bacteria are slow growing bacteria and response times for a sudden increase of ammonia loading rates can be on the order of days to weeks.

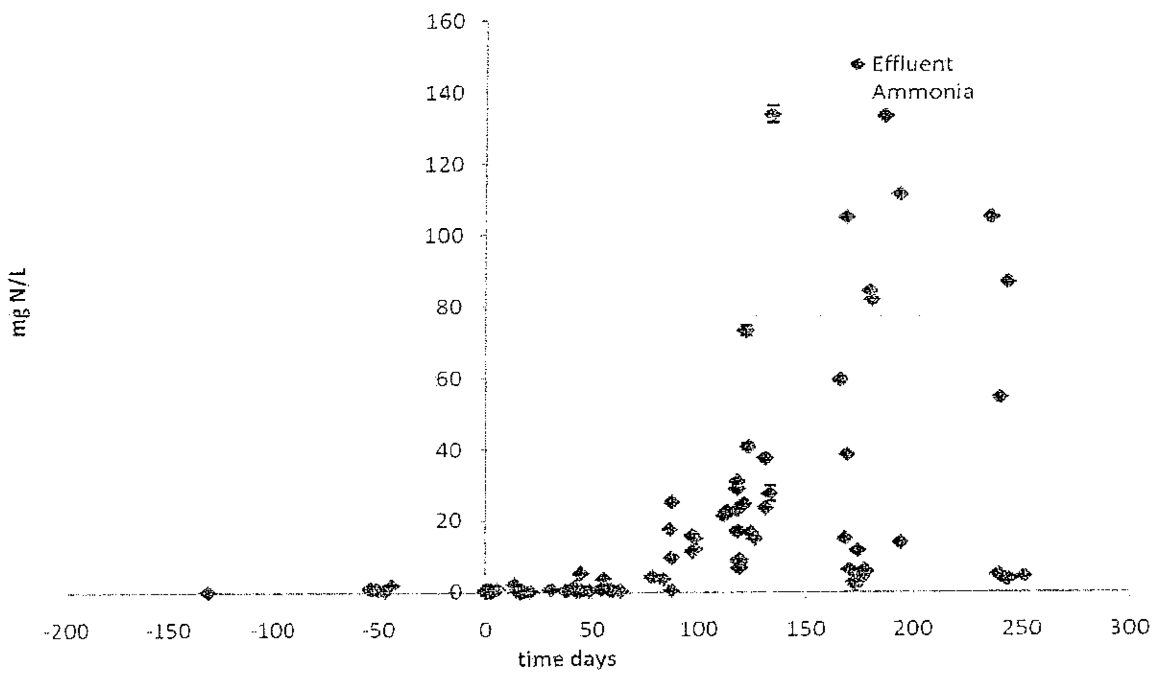
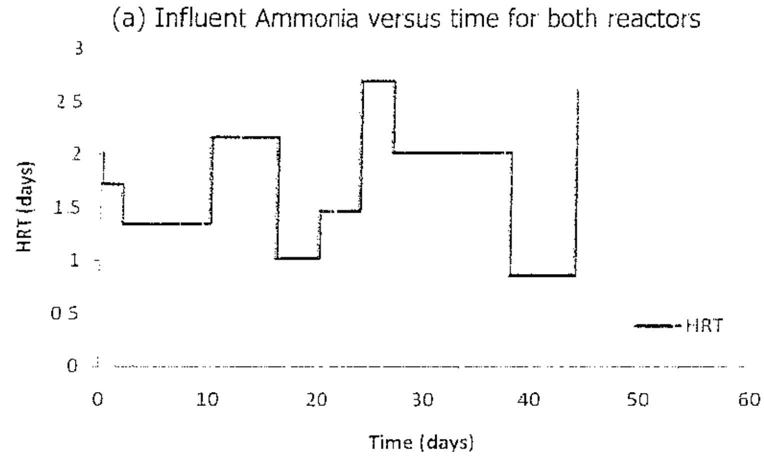
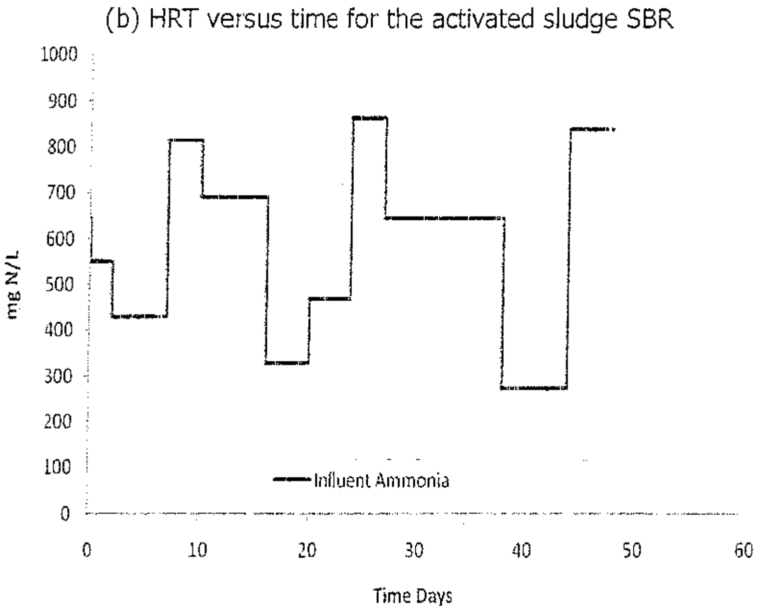
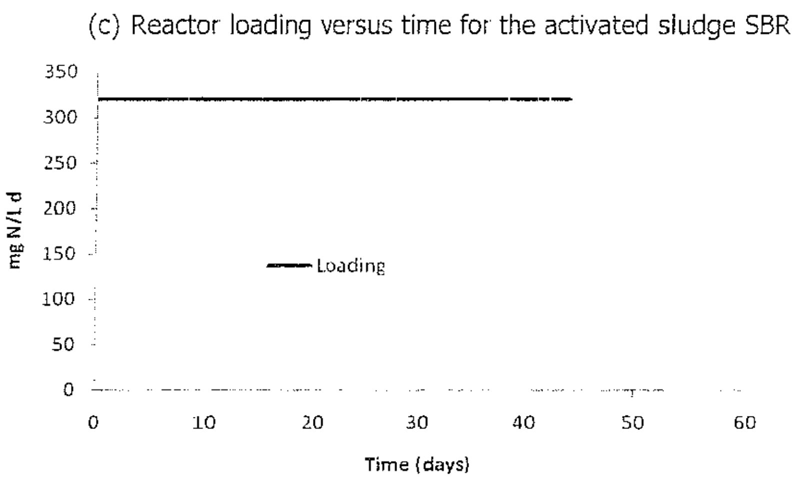


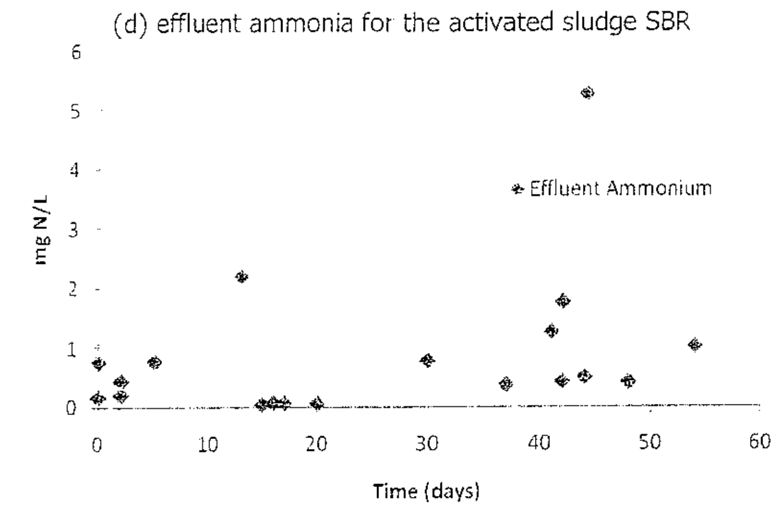
Figure 3: Effluent ammonia concentrations for phases 1 – 5 for the activated sludge SBR.

Detailed results from phase 4 for the activated sludge SBR are presented in Figure 4. The ammonia concentration of the separated swine manure varied between 200 and 1,000 mg N/L. By adjusting the HRT, the reactor could be operated with a constant ammonia loading rate of 320 mg N/L d Figure 4(d) demonstrates that the ammonia effluent was below 5 mg N/L as NH_3 and generally less than 1 mg N/L as NH_3 during phase 4. Overall, the reactor was able to oxidize more than 98% of the influent ammonia to nitrite and nitrate. At least 32% of the influent ammonia was converted to nitrite, and more than 66% of the influent ammonia was converted to nitrate. During stable operation, 99% conversion of ammonia to nitrate and nitrite was achieved. The spike at day 44 was the result of the influent ammonia concentration changing from 275 to 840 mg N/L. For one cycle after that influent change, the HRT had not been adjusted, so that the ammonia loading was unintentionally increased by a factor of 3. In response to the loading spike on day 44 both ammonia and nitrite accumulated in the activated sludge SBR. The increased ammonia concentration on day 13 was caused by temporary problems aerating the reactor resulting in low reactor dissolved oxygen concentrations. The activated sludge reactor was operated with a HRT between 1 and 3 days. The overall variability of the influent ammonia concentrations in separated effluent batches collected from the ISU farms is shown in Figure 4(a). The Mixed Liquor Suspended Solids (MLSS) was between 2,000 and 2,800 mg/L VSS in phase 4. Under stable operating conditions a complete conversion of ammonia to nitrate can be expected. But with variable process loading a temporary accumulation of nitrite can occur. For the case of discharging treated effluent into a stream (as is the case with municipal wastewater treatment) an accumulation of nitrite must be avoided due to toxicity of nitrite to organisms in the receiving waters.


(a) Influent Ammonia versus time for both reactors
HRT (days)
Time (days)
HRT
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60


(b) HRT versus time for the activated sludge SBR
mg N/L
Time Days
Influent Ammonia
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60


(c) Reactor loading versus time for the activated sludge SBR
mg N/L d
Time (days)
Loading
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60



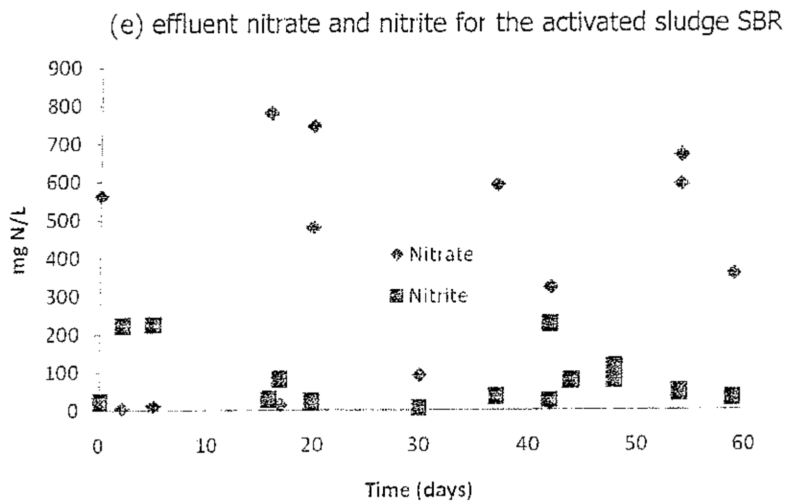


Figure 4 (a) Influent Ammonia versus time for both reactors, (b) HRT versus time for the activated sludge SBR, (c) Reactor loading versus time for the activated sludge SBR, (d) effluent ammonia for the activated sludge SBR, (e) effluent nitrate and nitrite for the activated sludge SBR.

While stable ammonia oxidation was observed during phase 4, nitrite and nitrate concentrations in the activated sludge SBR were more variable (Figure 4e). This variability could be the result of changing influent ammonia concentrations Increased nitrite concentrations were observed on days 42 and 2. After the change to separated influent as the feed, the higher ammonia loading at day 0 caused an increase in nitrite concentration. The cycle was not long enough to oxidize all the ammonia to nitrate, so residual nitrite remained.

A practical question that was evaluated in the current study was to evaluate the influence of acid production as the result of ammonia oxidation (Eq. 1) on the performance of the SBR. The reactor was shown to have base additions at the beginning of the cycle, and acid additions at the end of the cycle when the pH range was originally 7.80 to 7.20. To evaluate the feasibility of operating with reduced acid/base addition, the pH range was increased to pH 6.9 to 8.3. It was found that this pH control range avoided the initial acid addition to the reactor after adding separated effluent, and, for most of phase 4, there was no acid or base additions in the activated sludge SBR with the larger pH range.

An example of the pH in the reactor with the increased pH range is shown in Figure 5. It can be seen that initially the pH in the SBR is around pH 7. After the separated effluent was added, the pH increased to over pH 8. Over the next 5 hours the pH decreases to pH 6.9 as the ammonia is metabolized and acid is produced No negative impact of less than neutral pH was observed on nitrification in the system. For practical application, however, pH should be monitored as a reduction of pH much below pH 6.9 should be avoided. In our original proposal we had suggested to use biological denitrification to recover some of the consumed alkalinity. As we were able to demonstrate, stable nitrification without the need for pH adjustment was possible under strictly nitrifying (i.e., aerobic) conditions and the effect of denitrification was not further evaluated. But full-scale operations should have some form of alkalinity addition such as a lime mixture similar to water treatment plants in order handle dynamic influent characteristics which could change the influent alkalinity. Thereby, the need to add base or alkalinity would arise.

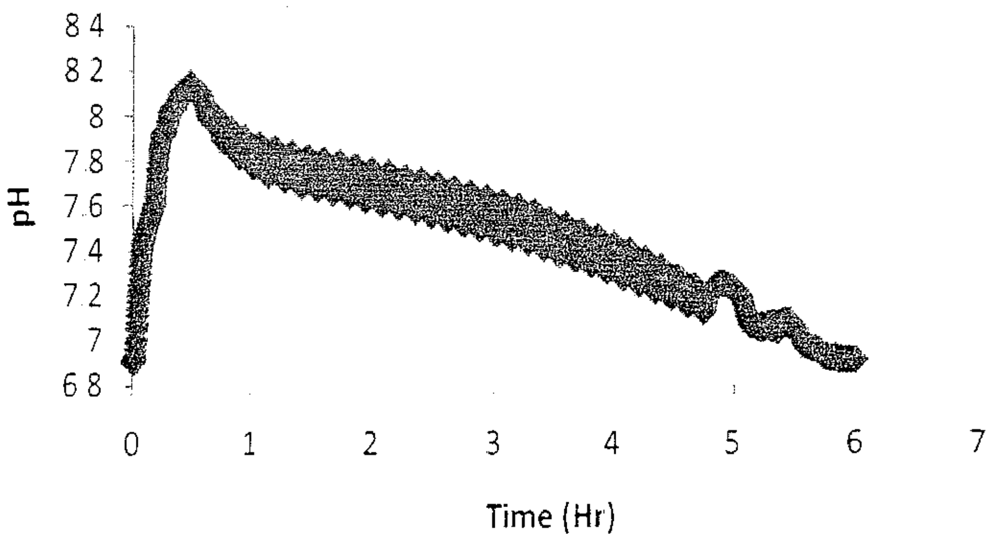


Figure 5 pH versus cycle time for the activated sludge reactor. pH was controlled between 6.9 and 8.3 on day 52.

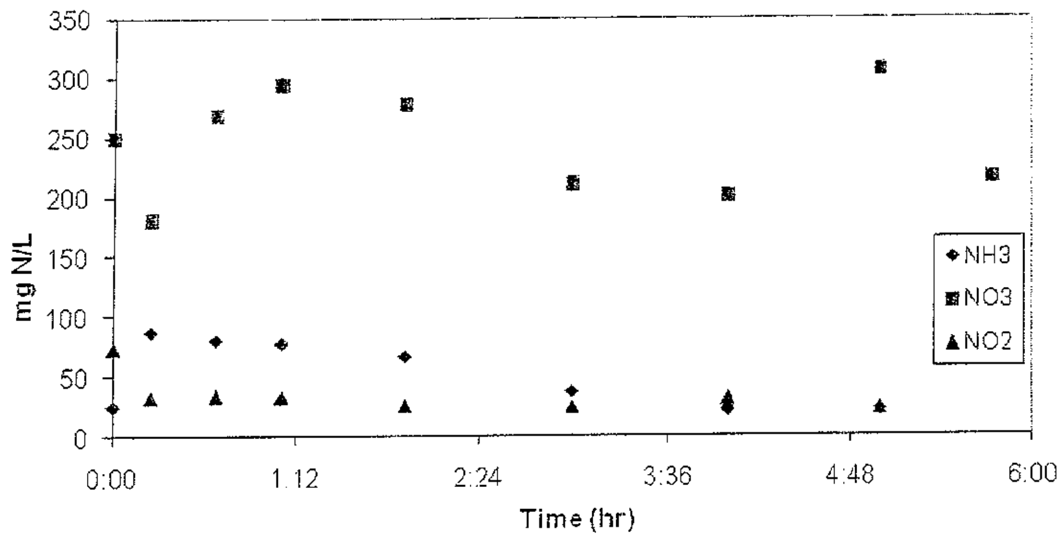


Figure 6 Cycle Profile for Activated Sludge Reactor on day 87.

In Figure 6 ammonia, nitrite, and nitrate concentrations throughout a 6 hour reactor cycle are presented for a cycle during phase 5. During phase 5 the reactor was operated with a constant HRT and, as a result, variable ammonia loading rates. The cycle in Figure 6 is an example of a likely worst case example of reactor performance where increased effluent ammonia concentrations are the result of sudden increases of influent ammonia loading rates. The initial concentration of ammonia in the reactor on day 87 was 25 mg N/L. After the fill period, the ammonia concentration was 87 mg N/L. This value corresponds well with the expected ammonia concentration of 85 mg N/L with an influent ammonia concentration of 526 mg N/L and a volumetric exchange ratio (f_{ex}) of 12%.

The ammonia concentration gradually decreased during the reactor cycle to 20 mg N/L The nitrite concentration was initially high in the reactor, 74 mg N/L. The nitrite concentration was stable after 0.5 h into the cycle As ammonia was being oxidized, a constant nitrite concentration means that nitrite was oxidized at the same rate that nitrite was produced by ammonia oxidation. The nitrate levels do not reflect a continuous increase due to nitrite oxidation. Nitrate concentrations in the reactor were much higher than the amount of nitrate produced during each cycle Taking into account measurement errors for nitrate, it was not possible to account for the amount of ammonia oxidized in the changes of nitrate in the reactor.

NITRIFICATION IN THE BIOFILM SBR:

In addition to evaluating a conventional activated sludge SBR, we also chose to evaluate a biofilm SBR. Expected benefits of such an activated sludge SBR are that reactor operation is independent of flocculent biomass settling properties as all active biomass is retained in the biofilm Also, it is expected that bacteria in a biofilm are more resistant to inhibitory compounds or inhibitory levels of ammonia in the reactor These potential advantages are coupled with increased costs for biofilm support media that has to be added to the reactor.

The effluent concentrations of the biofilm SBR are shown on Figure 7. Initially, the biofilm reactor was operated as an activated sludge reactor until day 37. At day 37, the Kaldnes support media was added to the reactor. The reactor was operated without a settle phase and an HRT of 12 hours to washout nitrifying bacteria. After the conversion, the ammonia effluent concentration increased to over 200 mg N/L. The biofilm had not grown on the support media, nitrifying bacteria in the suspended biomass were washed out, and, as a result, there was not sufficient capacity to oxidize all influent ammonia. To avoid ammonia inhibition, 80% of the reactor volume was removed and replaced with tap water on day 39. Subsequently, the reactor was then able to grow enough of a biofilm to oxidize the ammonia At day 63, the aeration of the reactor was interrupted to simulate an influent shock. This shock increased the biofilm reactor concentration to almost 100 mg N/L. The reactor was then shown to withstand that shock, and return to operating at a effluent ammonia concentration below 25 mg N/L. Therefore, the biofilm reactor was shown to be able to absorb influent shocks, and effectively oxidize ammonia in the separated effluent.

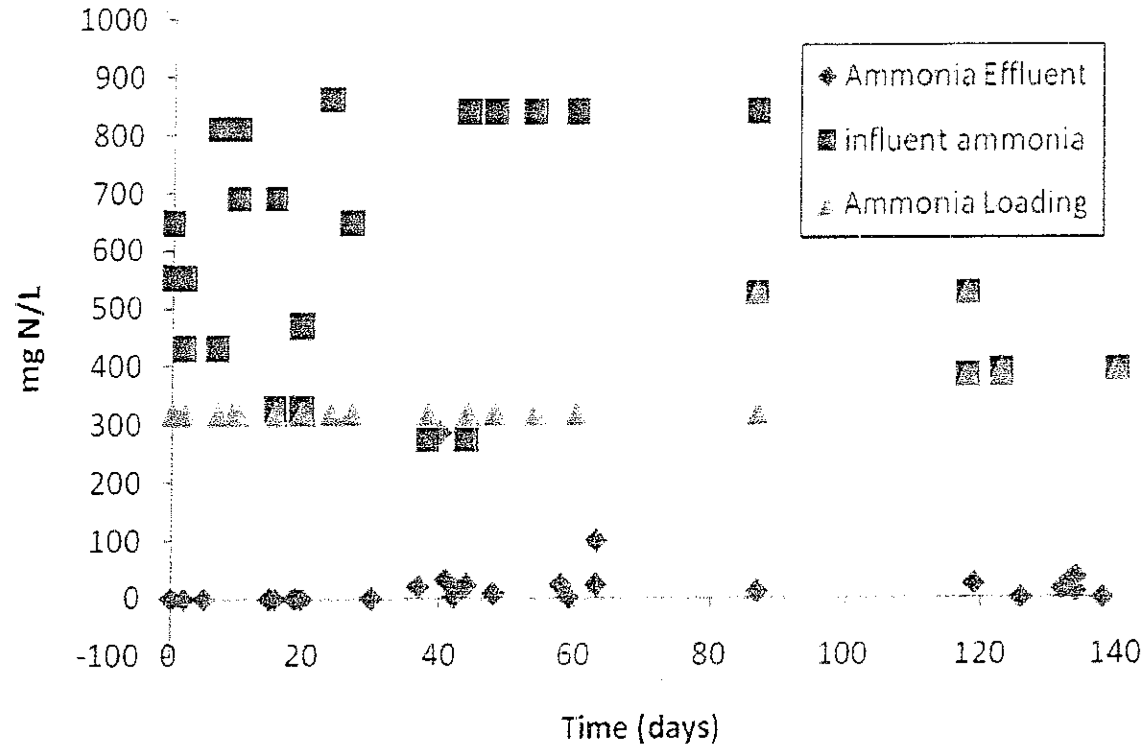


Figure 7 Effluent concentration of ammonia versus time for the biofilm reactor. Biofilm support media was added to the SBR on day 37. Thus, the reactor was operated as a normal activated sludge SBR from day 0 to 37, and as a biofilm SBR from day 37 to 140.

INHIBITION:

One motivation for the laboratory scale experiments was to evaluate possible inhibitory compounds, in the separated swine manure at ISU. Enhanced polymer assisted solid liquid separation is performed at ISU after adding polyacrylamide (PAM) to raw swine manure. Another potential source of inhibitory compounds is the use of antimicrobials in animal production. Since batches of separated effluent were taken approximately every month, the levels of antibiotics most likely varied from month to month, but changes in reactor performance could not be correlated to different influent batches. In addition, the reactor was able to metabolize the ammonia in the separated swine manure, which indicated that the PAM did not significantly inhibit the nitrifiers. Finally, the previous work of Zhang et al. (2005) at Lund University used PAM to immobilize nitrite oxidizers to improve their activity which suggests that PAM does not hinder the activity of nitrite oxidizing bacteria.

CONCLUSION:

- The activated sludge SBR was able to nitrify ammonia from the liquid fraction of swine manure after polymer assisted solid-liquid separation. No inhibitory effects of chemicals added during solid-liquid separation and from the swine manure itself were observed.

- Effluent ammonia concentrations below 5 mg N/L were achieved in the activated sludge SBR with stable ammonia loadings of 320 mg N/L.d. Stable ammonia loadings were achieved by varying the hydraulic retention time of the reactor as influent ammonia concentrations varied by a factor of 5 In contrast, when operating the activated sludge SBR with constant hydraulic retention times and variable ammonia loadings, effluent ammonia concentrations could increase up to 140 mg N/L For practical applications of the activated sludge SBR the SBR should either be overdesigned to balance such sudden changes in the influent loading, the SBR can be preceded with an equalization tank that will help buffer influent fluctuations, or the SBR can be operated with variable loading/variable cycle times in response to changes in the influent composition

- Controlling the reactor pH between pH 7.2 and 7 8 required significant amount of acid and base addition. Adding the separated effluent at the beginning of the cycle increased the pH and acid was dosed to keep the pH below 7.8 As ammonia was oxidized the pH decreases and base had to be dosed. Allowing the pH to vary between pH 6 9 and 8.3 significantly reduced acid and base addition and had no negative impact on system performance For practical operation it is advisable to have the ability to add alkalinity (e.g , lime addition) as the reactor pH will depend on the alkalinity and the ammonia concentrations in the separated effluent that can vary over time

- Nitrification could also be established in the biofilm SBR but effluent ammonia concentrations increased up to 100 mg N/L after start-up. Reasons for the variability in performance of the biofilm SBR are unclear. It is concluded that adding biofilm support media does not provide sufficient benefit compared to the activated sludge SBR to justify the additional cost of adding support media.

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Effects of Land Application of Untreated and Treated Swine Slurry on Crop Production and Subsurface Water Quality

A series of 24 agronomic plots (1/7 acre each) in a randomized complete block design (6 x 4 factorial) of six treatments replicated four times (Figure 8) was established prior to initiation of the 319 Grant. The treatment applied in this study were the basis for the four treatments selected for field scale (40 acres each treatment) evaluation in the 319 Study. In the 319 Study raw slurry separated effluent, composted, separated biosolids and inorganic fertilizer were land applied to supply the amount of nitrogen. Because the 319 study was funded for only two years (the study will be continued for several years beyond the 319 funding period) not enough time has elapsed to detect significant changes in soil or ground water specifically do to treatment effects. Therefore, we are reporting the observed soil and ground water observations from the agronomic plot in addition to the two-year observations of field scale treatments to provide insight into the changes we expect to see longer term to the field scale treatments.

AGRONOMIC EXPERIMENTAL PLOTS WEST OF 2600E

A total of eight wells and four soil suction lysimeters have been installed on the experimental plots to the west of 2600E (Figure 8). Water samples were collected for chemical analysis from seven of the wells on ten occasions, approximately quarterly from August 2003 to September 2005, and again in April 2007. Samples for nitrate isotope analysis were collected from four wells (U-1, C-1, M-1, and F-1). Soil water samples were collected on five occasions, starting in August 2004. Samples of manure slurry and manure effluent were collected for chemical analysis on two occasions, May 2004 and May 2005. The manure and effluent samples were also analyzed for chlortetracycline at the University of Nebraska. Soil samples were collected from the manure and separated effluent plots for chlortetracycline analysis in June 2005. Appropriate QA/QC procedures were followed during sampling and analysis.

Nutrients (N, P, K), DOC, and some major ions (Ca, Na, Cl^-, alkalinity) are elevated in the manure slurry and separated effluent. Some minor elements, such as B and Sr, are also elevated. Synthetic inorganic fertilizer would also have elevated concentrations of nutrients. Despite these differences in water quality in the source materials applied to the plots, there were very few significant differences observed with respect to subsurface water quality. The only significant difference for well water quality was for Sr, with concentrations in the well down-gradient of the raw manure slurry plot (M-1) (mean 0 127 mg/L) significantly greater than for the synthetic fertilizer well (F-1) (mean 0.108 mg/L). Concentrations in the well down-gradient of the separated effluent well (E-1) had intermediate values (mean 0 116 mg/L). Nitrate-N concentrations were highest in F-1 (median 18.9 mg/L) and lowest in M-1 (9.80 mg/L), but the differences were not significant. Alkalinity concentrations had a similar pattern, highest in M-1 and lowest in F-1, but again not significant. Chloride and Na concentrations were very similar for these three wells. Potassium and P concentrations were very low because these ions readily adsorb in soil.

Nitrate-N concentrations have generally been decreasing in the groundwater samples since the start of the project (Figure 9) This is probably primarily due to the conversion of the plots from previous agricultural practices, i.e., from application of synthetic fertilizer across the entire site to the present experimental soil amendments. Chloride concentrations have also generally been decreasing (Figure 10). At the last sampling events, M-1 and E-1 had the highest Cl^- concentrations, which would be expected considering the manure amendments to these plots.

The soil water samples showed similar patterns to the groundwater. Curiously, NO_3-N concentrations have always been highest in samples taken from the control plot (CS-2) (mean 17.0 mg/L). The reason for this is still unclear. Nitrate-N concentrations from the synthetic fertilizer plot (FS-2) had a higher mean value than for the raw manure plot (MS-2) (10.5 vs. 4.05 mg/L, respectively), although the difference was not significant (Figure 11). Chloride, alkalinity, Ca, and Sr concentrations were higher in MS-2 compared to FS-2, with the difference being significant for alkalinity.

Nitrate isotopic results for the wells and lysimeters do not suggest any difference between synthetic fertilizer and manure sources, which was unexpected (Figures 13 and 14). There was little or no suggestion of manure sources in samples beneath the manure and effluent plots. Interestingly, the isotopic signature of the samples from the zero-rate plot was significantly different from the other plots, suggesting more of a synthetic fertilizer source than for the synthetic fertilizer plot (Figures 13 and 14). All the samples show some denitrification, especially those from the up-gradient well (U-1) There was no indication of seasonal differences.

Chlortetracycline and tetracycline were found in both the manure and effluent samples and most of the soil samples (Table 15).

This long term study suggests that when adoptive management practices (AMP are utilized such as applying soil amendments (inorganic fertilizer, manure or compost) at appropriate nitrogen rates manures offer similar or smaller water contamination risks compared to inorganic fertilizer In the agronomic study raw manure, separated effluent, inorganic fertilizer and the 20-ton equivalent rate of composted biosolids were applied to provide 1.33

pounds of nitrogen per bushel of expected corn yield. The fact that nitrate – N concentrations have been decreasing since the study began suggests that previous general farming practices at the site were over applying nitrogen and that balancing nitrogen application to meet crop requirements can decrease ground nitrate – N concentrations Also, this study may suggest that the phosphorus concentration concern regarding unprocessed manure application may be over emphasized as no changes in ground water phosphorus concentrations have been observed to date. This observation emphasizes the need for long term (7 – 10 year) studies to assess phosphorus changes due to fertilizer applications.

EXPERIMENTAL FIELDS FOR THE CIG STUDY:

Five shallow monitoring wells (13 feet deep) were installed in the spring of 2006 (well 1 had to be abandoned before it was sampled) (Figure 15). Subsequently, well 1 was re-drilled and data is currently being collected from well 1. The other 5 wells have been sampled 8 times since installation, approximately quarterly

Results are preliminary, since the conversion to the new applications only began in 2006. Preliminary results indicate considerable variability in the shallow groundwater quality. There are high levels of NO_3-N in wells 4 and 6 and no nitrate-N in well 2, and there is some temporal variability in the values (Figure 16). Nitrate-N concentrations have dropped considerably since the start of the project. Some of the nitrate isotope data suggest a manure source, especially for well 3 (Figure 17). All of the samples except those from well 4 showed some denitrification. Well 3 had the highest Cl^- (Figure 18) and alkalinity concentrations.

Little cause and effect relationship can be determined relative to ground water concentrations of selected elements in the field scale treatment fields because of the limited observation time (2 years). This will be continued for several years beyond the scope of the 319 Grant to assess any changes do to soil amendment treatments and AMP's.

Table 15: Results for antibiotic analysis for liquid manure and manure effluent samples collected.

Sample	Date	Tetracycline	Chlortetra-cycline	Oxytetra-cycline	Anhydro-tetracycline	Anhydrochlor-tetracycline
		ng/mL	*ng/mL*	*ng/mL*	*ng/mL*	*ng/mL*
Manure slurry	5/24/2005	15.3	105.2	< 5	< 10	< 10
Separated effluent	5/24/2005	9.0	23.0	< 5	< 10	< 10
		ng/g	*ng/g*	*ng/g*	*ng/g*	*ng/g*
Manure plot surface soil	6/13/2005	3.9	87.2	< 1	6.2	11.2
Manure plot soil 30 cm	6/13/2005	< 1	3.1	< 1	< 2	< 2
Effluent plot surface soil	6/13/2005	1.5	10.6	6.9	< 2	< 2

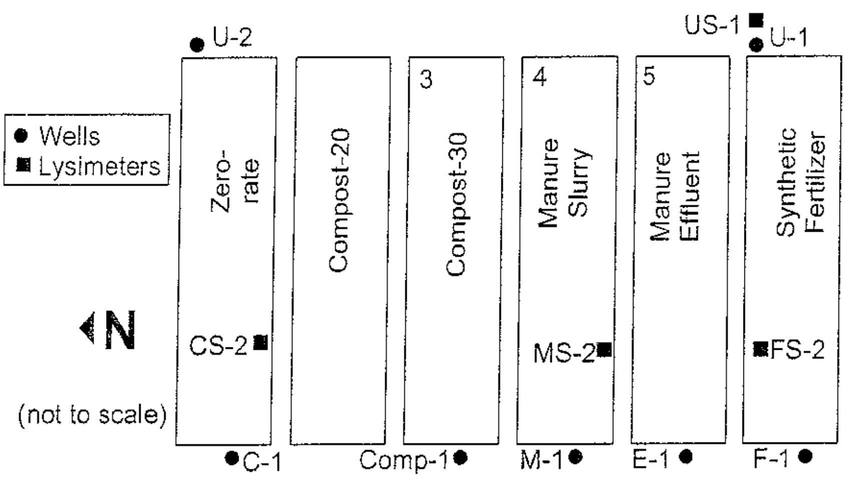


Figure 8 Field site west of 2600E showing location of monitoring wells and lysimeters.

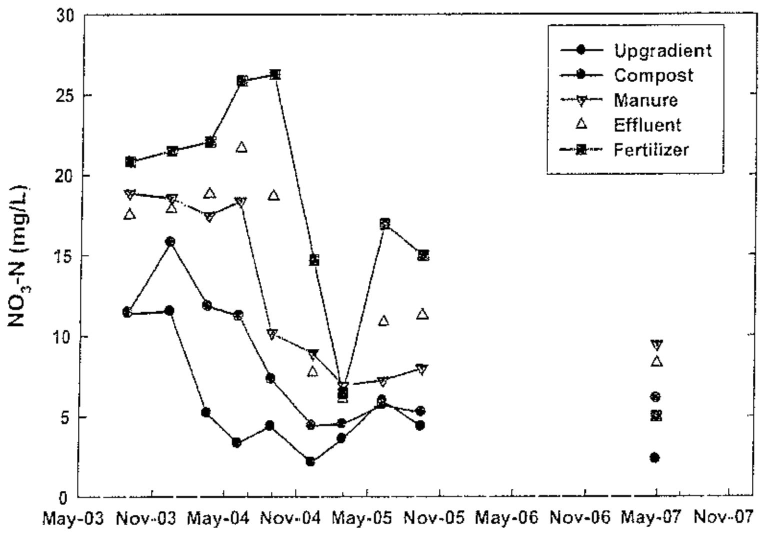


Figure 9 Nitrate-N concentrations from well samples collected to date.

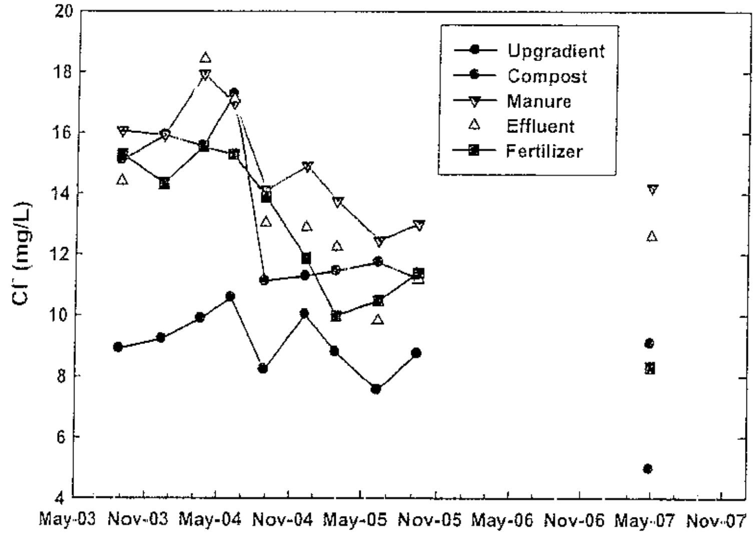


Figure 10 Chloride concentrations from well samples collected to date.

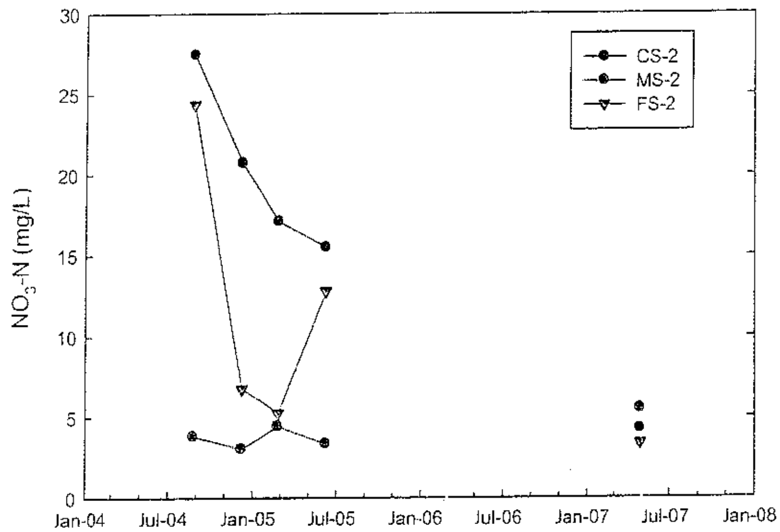


Figure 11 Nitrate-N concentrations from lysimeter samples collected to date

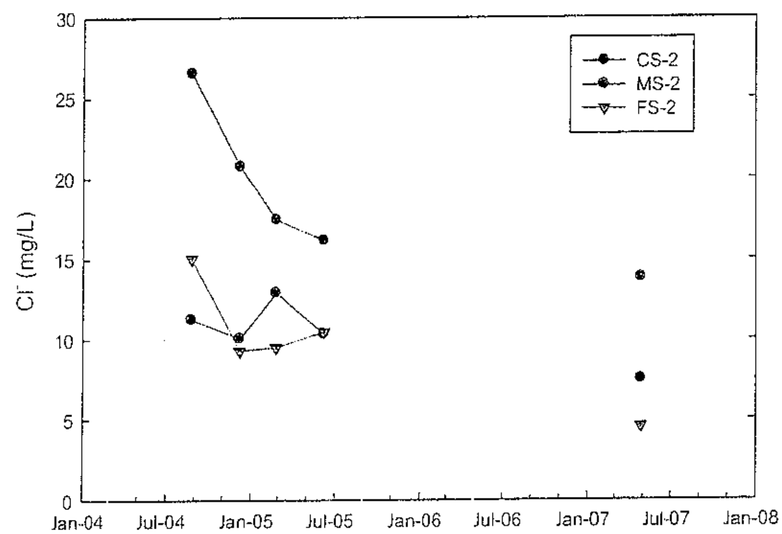


Figure 12 Chloride concentrations from lysimeter samples collected to date.

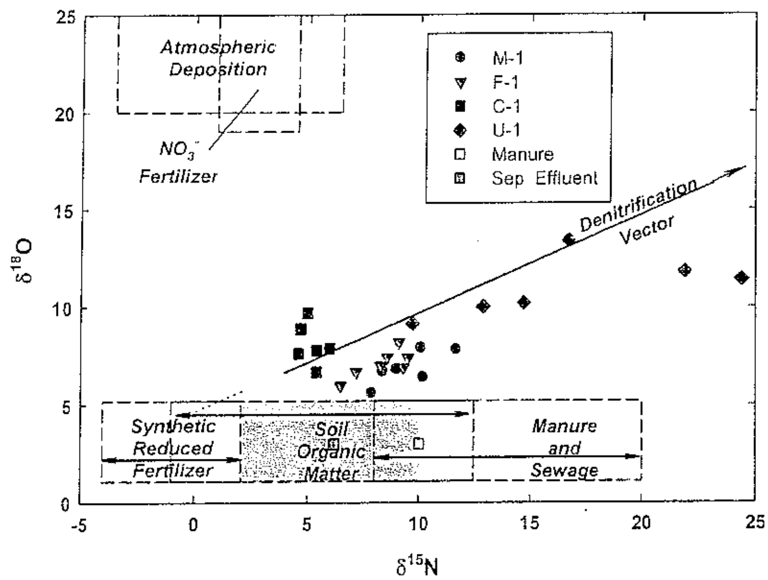


Figure 13 Nitrate isotope values for well samples collected between August 2003 and April 2007. Boxes outlined by dashed lines indicate isotopic ranges for potential sources of nitrate. The denitrification vector indicates the theoretical change in $\delta^{15}N$ and $\delta^{18}O$ values of residual nitrate after a fraction of the NO_3^- pool has been denitrified.

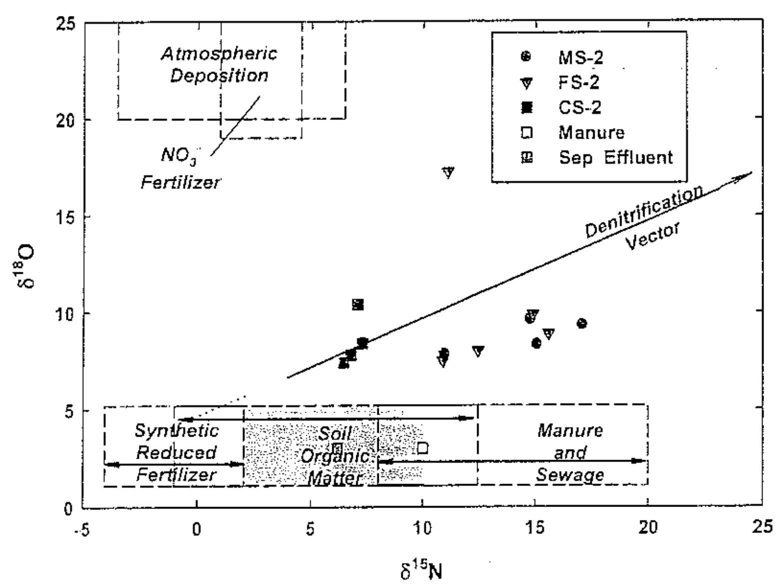


Figure 14 Nitrate isotope values for lysimeter samples collected between August 2003 and April 2007

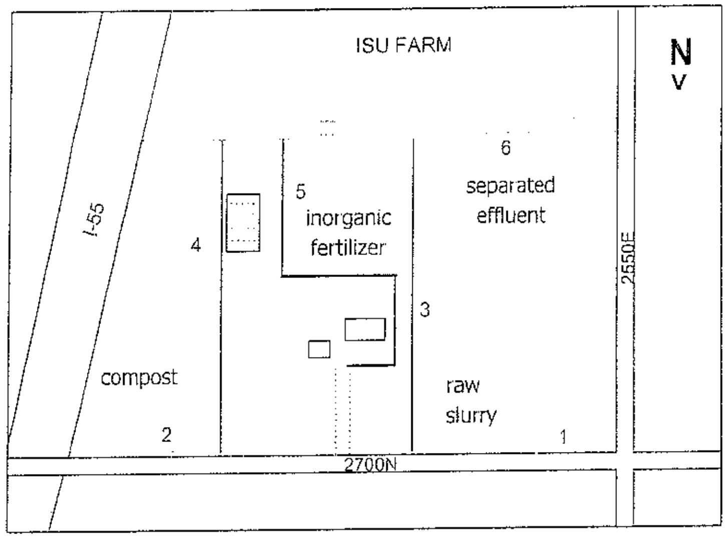


Figure 15 Locations of wells installed in 2006.

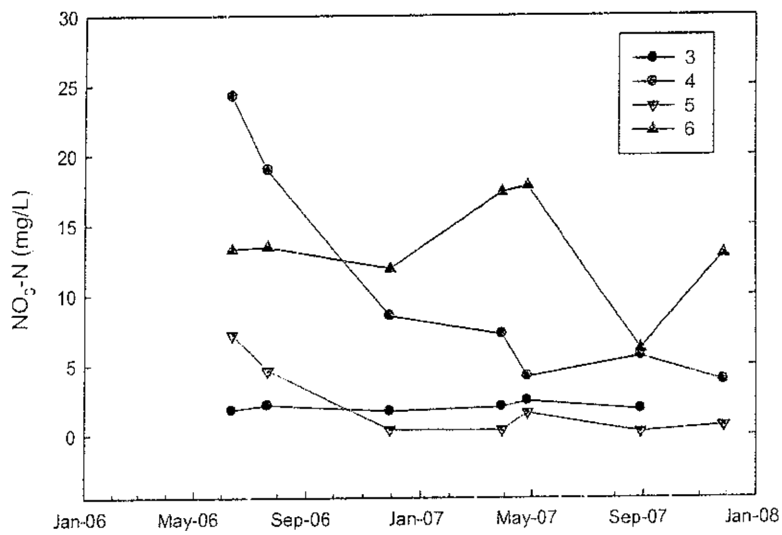


Figure 16 Nitrate-N concentrations in wells shown in Figure 15. Concentrations were always below detection in well 2.

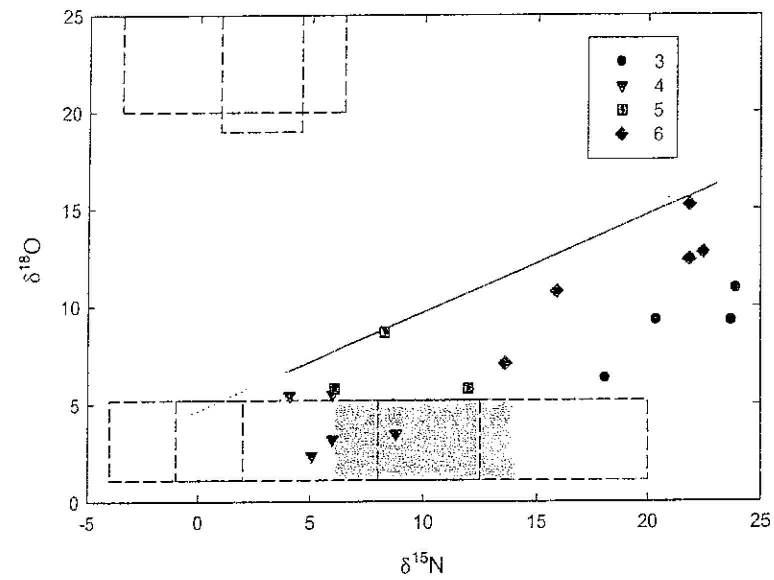


Figure 17 Nitrate isotope values for well samples. Boxes and vector same as in Figure 13.

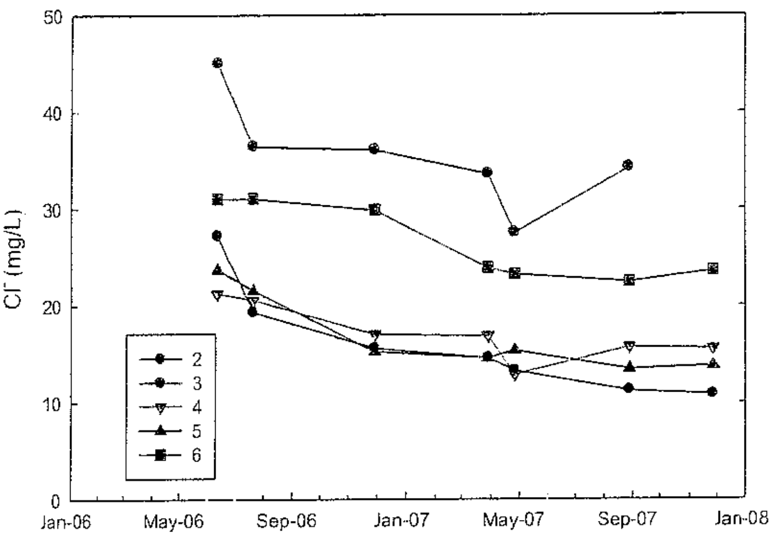


Figure 18 Chloride concentrations for wells.

APPENDIX

Attachment 1

News Release Promoting SWEETA Website

News Releases

New Website Highlights Practical Swine Waste Management Methods

FOR IMMEDIATE RELEASE
June 3, 2008

Many of us enjoy a fresh country ham and a pork chop dinner. But, few of us relish the odor and waste that comes with swine production In an effort to help producers and their neighbors live in harmony, researchers from Illinois State University, University of Illinois and Illinois State Water and Geological Surveys studied practical methods to handle the waste

Information about these methods can be found on the new website Swine Waste, Economical and Environmental Treatment Alternatives (SWEETA), www.sweeta.illinois.edu

Paul Walker, professor in animal sciences at Illinois State University and coordinator of the Livestock and Urban Waste management team, lead the project which included slurry separation, composting of solids, and applying waste liquids onto crop fields.

"Separation of municipal waste water into its solid and liquid components is a technology that has been used by municipal sanitation departments for decades," explains Walker "This technology has been adapted to economically separate liquid swine manure into its biosolid and liquid fractions "

Walker says this systems approach allows the biosolids fraction to be composted for ultimate use as either an on-farm or off-farm soil amendment, while producing a liquid fraction with low odor, low solids and low phosphorus concentrations that can be irrigated as a nitrogen fertilizer for row crops

"These waste handling methods are economical for livestock and grain farmers, and they are environmentally acceptable for the public," adds Duane Friend, University of Illinois Extension natural resources educator.

The SWEETA website includes economic comparisons of using inorganic fertilizer, raw slurry and compost as a soil amendment for corn production, based on actual costs and nutrient analyses Information regarding Illinois EPA permitting, local site approval and on-farm exemptions is also included The website even includes information on composting horse bedding and manure

Funding for the project was provided by the Natural Resources Conservation Service, through a grant awarded to Illinois State University

Source: Duane Friend, Extension Educator, Natural Resources Management,

Attachment 2

Slurry Separation A systems Approach to Manure Management

Application Costs

Total costs, including equipment, labor, polymer, fuel and application are between 1.3¢ and 1.4¢ per gallon depending on the type of separation equipment used.

Separation/Application Cost (¢:g)

Item	Cost for MS	Cost for GBT
Equipment	0.70	0.87
Electricity	0.004	0.005
Polymer	0.144	0.144
Labor	0.313	0.313
Total	1.16	1.33
Application (irrigator)	0.1093	0.1093
Total	1.2693 (1.3)	1.4393 (1.4)

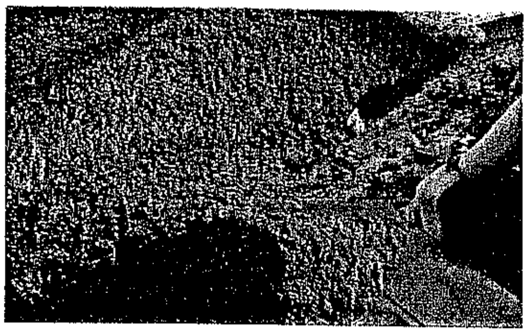
Total costs of separation and application are comparable to current land application costs for raw slurry, making this an economically viable alternative while providing additional environmental and operational benefits.

Land Application Costs for Raw Slurry

Less than 1 million gallons	= 2.01¢/gallon
1-4 million gallons	= 1.67¢/gallon
Greater than 4 million gallons	= 0.89¢/gallon

Slurry separation provides an efficient and cost effective system for managing the odor and nutrient overload associated with swine manure while improving animal welfare, reducing non-point source pollution concerns, and providing a source of beneficial soil amendments for crop production. For more information check out additional information at the Swine Waste Economical, Environmental Treatment Alternatives (SWEETA) website:

www.sweeta.illinois.edu



Separated solids

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DEPARTMENT OF AGRICULTURE

Slurry Separation A Systems Approach to Manure Management

Separation of municipal waste water into its solid and liquid components is a technology that has been utilized by municipal sanitation departments for decades. Removal of the biosolids fraction cleans the liquid portion sufficiently that the waste water can be added to the surface waters of Illinois and the U.S. Many city waste water treatment departments use polymer-assisted separation systems that combine the use of chemical flocculents, gravity belt thickeners and belt presses to remove the solids fraction from waste water. The Livestock and Urban Waste Research (LUW) Team has adapted this technology to economically separate liquid swine manure into its biosolid and liquid fractions. This systems approach allows the biosolids fraction to be composted for ultimate use as either an on-farm or off-farm soil amendment while producing a liquid fraction with low odor, low solids and low phosphorus concentrations that can be irrigated as a nitrogen fertilizer for row crops.

Separation System

All slurry pits in all the swine buildings at the ISU Farm farrow to finish swine operation are drained once or twice each week and recharged with 2-3 inches of separated effluent. The raw slurry is drained by an underground sewer line to the slurry processing building. The raw slurry is passed across a gravity screen-roll process separator to remove separable solids. The separated slurry is mixed with polymer and passed across a gravity belt thickener to remove suspended solids. The resulting biosolids are transported to the compost site, mixed with landscape waste and composted. The resulting separated effluent is stored in a slurry store ® until land applied during the corn/soybean growing season via a center pivot irrigator.

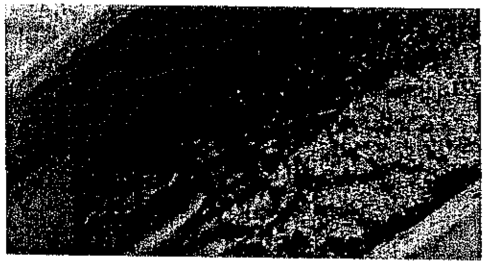
Slurry Processed

1,908,048 gallons Raw Slurry

1,793,565 gallons Separated Effluent [a]

114,483 gallons Biosolids

[a] 94% collection rate



Separable solids are removed using a gravity screen-rollpress separator

Separation

- Frequent separation of slurry
- Fresh slurry (no older than 7 days) is easier and lower cost (requires less polymer) to separate than anaerobic slurry
- Not all liquid manure is the same, slurry composition can vary
- Select a polymer specific to the slurry produced
- Have adequate storage for separated effluent
- Separation equipment should be housed in a heated building to allow year around processing
- Match equipment size (gallons:minute processed) to slurry production
- Have appropriate storage for separated biosolids or an adequate sized compost facility

Suspended solids are separated using a gravity belt thickener and chemical flocculent

Both the composted biosolids and the separated effluent provide a comparable alternative to using inorganic fertilizers for crop production.

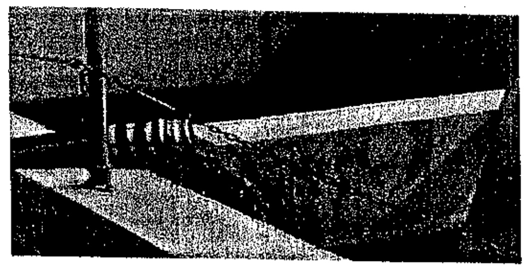
Separated effluent is applied using center pivot irrigation

Characteristics of Slurry, Effluent and Solids During 1st year of Separation

Item	% solids	[illegible]	[illegible]	[illegible]
RSI	3.65	1.0	0.53	1.9:1
RS	1.3	0.19	0.05	3.8:1
SE	0.4	0.08[b]	0.004	20.0:1
BS	10.4	0.9	0.64	1.4:1
Change [a]	-69.2	-60.6	-91.7	

[a] percent change from RS to SE

[b] [illegible]



Separated effluent is dramatically cleaner than the raw slurry

Attachment 3

Land Application of Separated Effluent from Swine Slurry

Total Separation and Application Costs

Total costs, including equipment, labor, polymer, fuel and application are between 1.3¢ and 1.4¢ per gallon depending on the type of separation equipment used.

Separation/Application Cost (¢:g)

Item	Cost for MS	Cost for GBT
Equipment	0.70	0.87
Electricity	0.004	0.005
Polymer	0.144	0.144
Labor	0.313	0.313
Total	1.16	1.33
Application (irrigator)	0.1093	0.1093
Total	1.2693 (1.3)	1.4393 (1.4)

Total costs of separation and application are comparable to current land application costs for raw slurry, making this an economically viable alternative while providing additional environmental and operational benefits.

Land Application Costs for Raw Slurry

Less than 1 million gallons	= 2.01¢/gallon
1-4 million gallons	= 1.67¢/gallon
Greater than 4 million gallons	= 0.89¢/gallon

Slurry separation provides an efficient and cost effective system for managing the odor and nutrient overload associated with swine manure while improving animal welfare, reducing non-point source pollution concerns, and providing a source of beneficial soil amendments for crop production. For more information check out additional information at the Swine Waste Economical, Environmental Treatment Alternatives (SWEETA) website:

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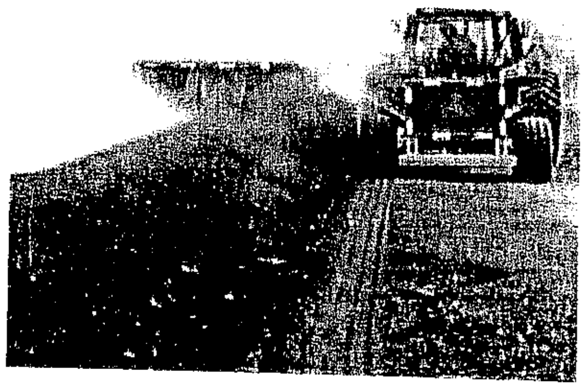

Turning the compost (biosolids and landscape waste or other carbon material).

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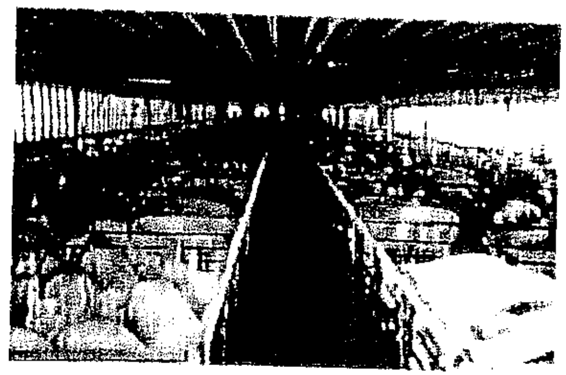
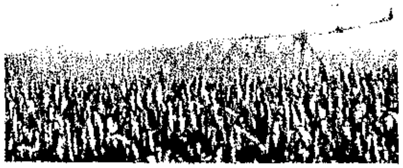
Land Application of Separated Effluent from Swine Slurry

The Livestock and Urban Waste Research (LUW) Team has developed a successful manure treatment system that couples polymer-assisted separation of liquid manure with composting. This solid-liquid separation of raw swine manure makes it possible to reuse the solid fraction with a high nitrogen and phosphorus content separately from the liquid fraction with a low solids and low phosphorus content. Separation consistently removes more than 90% of the solids and approximately 90% of phosphorus from liquid manure. The solids fraction is composted, producing a value-added coproduct that can be sold off-farm or transported longer distances for cropland application. The separated effluent is stored in holding tanks for subsequent land application. This direct utilization of the liquid fraction is advantageous because it is simple, has a low application cost, and allows for direct use of nitrogen. Most importantly, this adaptive management technology changes the nitrogen:phosphorous (N:P) ratio thereby minimizing environmental concerns regarding phosphorous contamination.



Land Application of Separated Effluent



Separated effluent is applied using center pivot irrigation

The separated effluent, which makes up 90-98% of the raw slurry volume, is transferred to a slurry store ® tank where it is aerated before being land applied using center pivot or subsurface irrigation. Because the total solids have been reduced by over 98% in the effluent, clogging in irrigation equipment and piping is not a concern. Additionally, no odor problems have been associated with the use of separated effluent even with above ground irrigation systems.

BMPs for Irrigating Separated Effluent

- Obtain nutrient analysis (NPK) of separated effluent
- Separated effluent must have 90% or more of the total solids removed to prevent odor
- Apply based on % N if ≥90% of the P has been removed
- Apply ¼ inch of separated effluent at a time to avoid burn
- Do not irrigate on frozen ground to avoid run-off
- Do not irrigate just prior to or during a rain to avoid runoff or leaching

Both the composted biosolids and the separated effluent provide a comparable alternative to using

Typical characteristics of raw slurry, effluent and biosolids after 3yrs of continuous separation

Item	% Solids	% N	% P	N:P
RS	0.82	0.12	0.02	6.9:1
SE-GB	0.44	0.09	0.008	11.1:1
SE-MS	0.39	0.08	0.007	11.9:1
BS-GB	7.45	0.54	0.17	3.2:1
BS-MS	7.73	0.49	0.17	2.9:1

Compost Characteristics

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	pH	[illegible]
1.5	0.3	0.6	2.4	50.0	7.3	5:1

Nitrogen and Phosphorous Supplied (lb:ac)

[illegible]	Yield[a]	Nreq[b]	Nappl	Ndiff	Preq	Pappl	Pdiff
IF	204	271	176	-95	44.9	40.9	-4.9
C	180	239	180	-59	39.6	136.7[d]	+97.1[e]
RS	179	238	214	-24	39.4	134.6	+95.2
SE	180	239	175	-64	39.6	7.8	-31.8
Target			180				

a bu:ac
b 1.33lb. N:bu = corn req.
c 0.22lb. P:bu = corn req
d 58.8 lb in year 2, 38.4lb in year 3
e 19.2lb excess, = 1.2lb deficit

Abbreviations

RS = Raw Slurry
SE-GB = Separated Effluent from gravity belt
SE-MS = Separated Effluent from microscreen
BS = Biosolids
BS-GB = Biosolids from gravity belt
BS-MS = Biosolids from microscreen
IF = Inorganic Fertilizer
C = Compost
% Solids = Percent solids
% N = Percent Nitrogen
% P = Percent Phosphorus
% K = Percent Potassium
% Ca = Percent Calcium

Land Application of Separated Biosolids

Slurry tank with injection tool bar for land applying biosolids

The biosolids, which make up 2-10% of the raw slurry volume, are collected, composted and then land applied.

BMPs for Land Application of Biosolids

- Obtain nutrient analysis (NPK) of biosolids
- Apply based on % P concentration
- Applying based on % N concentration will result in over applying P
- Do not apply to frozen ground to avoid runoff
- Do not apply just prior to or during a rain to avoid runoff or leaching
- Soil injection is preferable to surface broadcast to reduce odor and loss of N
- Apply based on % dry matter of biosolids

BMPs for Land Application of Composted Biosolids

- Obtain nutrient analysis (NPK) of compost
- Apply based on % P concentration
- Applying based on % N concentration will result in over applying P
- Apply based on % dry matter of compost

Composted manure can be spread

Attachment 4

Slurry Separation – Getting Started

Separation System Components

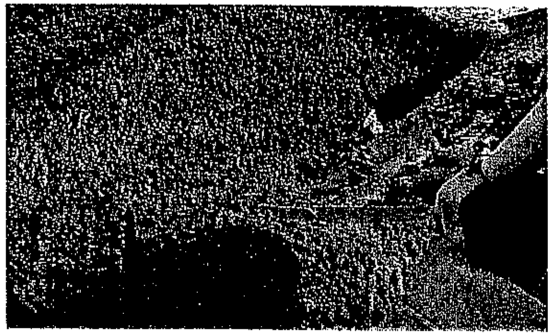
1. a holding tank for agitating slurry after draining slurry from a building pit
2. a gravity screen/roll press combination mechanical separator to remove approximately 30% of the separable solids producing what is referred to as separated slurry
3. a mixing tank for making a polymer premix
4. a mixing tank or an in-line venturi system for adding polymer to the separated slurry
5. a second separator for removing suspended solids producing what is referred to as separated effluent and biosolids. The second separator can be either a gravity screen separator, continuous gravity belt thickener or belt press separator. The gravity screen separator is the least cost separator
6. a holding basin for the separated biosolids or the biosolids can be discharged directly to a slurry wagon or manure spreader
7. a holding tank for the separated effluent. The LUW Team separation system has a separated effluent collection rate of 90+%. Therefore, if one million gallons is separated prior to land application, a 900,000 gallon holding tank for separated effluent is required. To minimize odor of the separated effluent during irrigation it is best to aerate the separated effluent on a continuous basis during storage.

Separated effluent is applied using center pivot irrigation

Benefits of Separation

Because effective separation can remove up to 90+% of the phosphorus and total solids concentration from slurry, separated effluent can be land applied (irrigated) based on its nitrogen concentration. Studies conducted at the ISU Farm have demonstrated that one million gallons can be land applied to 40 acres to provide the nitrogen requirement for corn production without over applying phosphorus. The cost of separation and land application of separated effluent via center pivot irrigation has been similar to the cost to land apply untreated slurry. For more information visit the Swine Waste Economical, Environmental Treatment Alternatives (SWEETA) website:

www.sweeta.illinois.edu



Separated solids

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Slurry Separation Getting Started

Points to consider when choosing a manure management system

Has it been a really wet winter and spring, and liquid manure storage tanks and pits are getting full? Are you are having trouble finding a window of opportunity dry enough to land apply slurry? That has not been a problem for the ISU Farm. If we have a few dry days in a row that allow the soil to dry just a little we can land apply separated effluent (SE) with our center pivot irrigator. Even if the soil is not dry enough for a tractor and slurry wagon to inject liquid manure, it is possible to irrigate because the SE has so little solids and phosphorus concentration neither runoff nor leaching are a risk.

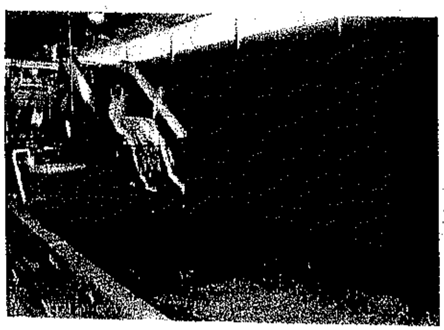
For some operators the cost for land application of liquid manure is reaching prohibitive levels. This may be especially so if slurry must be hauled more than one to two miles for land application. Many fields located near swine facilities where slurry has been land applied for several years have prohibitive phosphorus concentrations making it a necessity to haul slurry further away from the facilities. It costs approximately 1.0¢:gallon:mile to haul slurry. Some producers are logging up to 20,000 miles each year on semi tankers to haul slurry. That's up to $40,000 that could be utilized for other purposes.

Using Slurry Separation for Manure Management

Many city wastewater treatment departments use polymer-assisted separation systems that combine the use of chemical flocculants, gravity belt thickeners and belt presses to remove the solids fraction from wastewater. The Livestock and Urban Waste Research (LUW) Team has adapted this technology to economically separate liquid swine manure into its biosolid and liquid fractions. This systems approach allows the biosolids fraction to be composted for ultimate use as either an on-farm or off-farm soil amendment while producing a liquid fraction with low odor, low solids and low phosphorus concentrations that can be irrigated as a nitrogen fertilizer for row crops.

Issues to Consider in Adopting a Solid-liquid Separation System

- Volume of raw (untreated) slurry produced annually
- Current storage capacity, including building pit capacity and storage tank or lagoon capacity
- Type of slurry storage - building pit storage or external storage such as a lagoon or SlurryStore®
- Current slurry treatment, if any - this may include a 2 or 3 stage lagoon settling system
- Current cost of land applying slurry, including agitation, pumping, injection and hauling costs



Separable solids are removed using a gravity screen-rollpress separator

Important Points

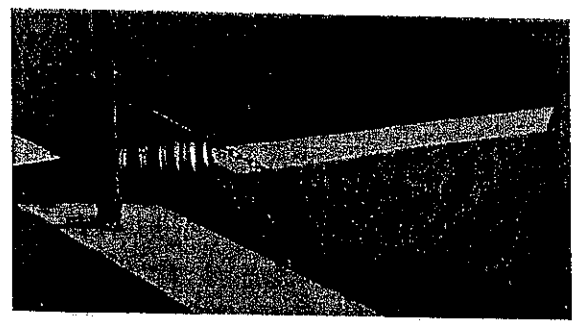
- The current costs for land applying slurry should be calculated as annual dollars:year and cents:gallon carried at least two decimal places (00.00¢:g).
- The separation process must include a chemical polymer (polyacrylamide or PAM) to flocculate the solids portion. Mechanical separation without PAM assistance is not sufficient.
- **The liquid produced during mechanical separation without PAM assistance still should be considered slurry with all the bad things associated with slurry, including odor, suspended solids, high phosphorus concentration, etc. The solids removed by mechanical separation are referred to as separable solids and usually represent 30 – 40% of the total solids concentration in raw slurry.**
- Separation by settling in a three stage lagoon system can be effective and can produce a desirable separated effluent, however, it is a slow process, (days to weeks) and has large volume storage requirements.
- Separation is most effective if the slurry is fresh i.e. no older than seven days. Slurry stored for prolonged periods has become anaerobic and requires the use of higher polymer concentrations, costs more per gallon to separate and does not remove as much of the solids fraction. Separating anaerobic slurry in comparison to fresh slurry, also, creates substantially more odor during the separation process.

Polymer Use Required

- Selection of the appropriate polymer is crucial to successful separation. There are hundreds of polymers available and not all liquid manures are the same. Therefore, there may be some trial and error is selecting the most efficacious polymer for each farm
- Selection of the correct polymer is not prohibitive nor that difficult. Chemical sales technicians and separation specialists can provide on-farm assistance in selecting the most appropriate polymer.

Frequency of Separation

- Pumping or draining manure pits once weekly for separation and then recharging each pit with approximately four inches of separated effluent or fresh water decreases odor of separation.
- Removing slurry from building pits on a weekly basis, also, improves the building environment substantially (decreases inside building odor, decreases building gas concentrations, increases pig performance and improves worker satisfaction).



Separated effluent is dramatically cleaner than the raw slurry

Attachment 5

Slurry Separation – Cost Considerations

Application Costs

otal costs, including equipment, labor, poly-
ner, fuel and application are between 1.3¢ and
.4¢ per gallon depending on the type of sepa-
ation equipment used.

Separation/Application Cost (¢:g)

tem	Cost for MS	Cost for GBT
quipment	0.70	0.87
lectricity	0.004	0.005
olymer	0.144	0.144
abor	0.313	0.313
Total	1.16	1.33
pplication (irrigator)	0.1093	0.1093
Total	1.2693 (1.3)	1.4393 (1.4)

otal costs of separation and application are com-
arable to current land application costs for raw
lurry, making this an economically viable alter-
ative while providing additional environmental
nd operational benefits.

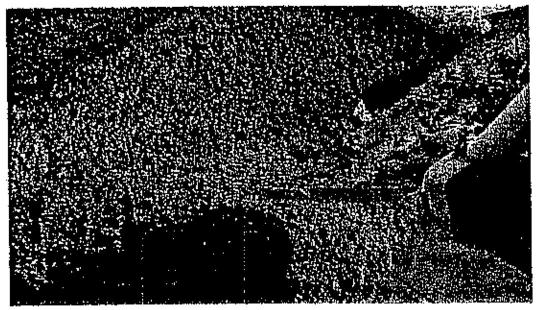
Land Application Costs for Raw Slurry

Less than 1 million gallons	= 2.01¢/gallon
1-4 million gallons	= 1.67¢/gallon
Greater than 4 million gallons	= 0.89¢/gallon

Sample ID	% DM	SS ml/L	TSS mg/L	pH	COD mg/L	% N	P ppm	NH3 ppm	N:P ratio
Raw	0.82	112.27	5610	7.28	7658	0.115	167.6	713	6.9:1
SE GBT	0.44	16.38	380	7.61	2794	0.088	75.7	809	11.6:1
SE MS	0.39	2.43	352	7.66	2352	0.078	67.6	743	11.8:1
Solids GBT	7.45	----	----	----	----	0.539	1678	----	3.2:1
Solids MS	7.73	----	----	----	----	0.494	1725	----	2.9:1
% change raw to SE	49.6	91.4	93.5	----	66.6	27.6	56.4	56.4	----

Slurry separation provides an efficient and cost effective system for managing the odor and nutrient overload associated with swine manure while improving animal welfare, reducing non-point source pollution concerns, and providing a source of beneficial soil amendments for crop production. For more information check out the website at:

www.sweeta.illinois.edu



Separated solids used for composting

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Slurry Separation Cost Considerations

The Livestock and Urban Waste Research (LUW) Team has adapted polymer-assisted wastewater separation technology to economically separate liquid swine manure into its biosolid and liquid fractions. This systems approach allows the biosolids fraction to be composted for ultimate use as either an on-farm or off-farm soil amendment while producing a liquid fraction with low odor, low solids and low phosphorus concentrations that can be irrigated as a nitrogen fertilizer for row crops. The cost considerations for implementing a separation system and an economic comparison to current disposal methods are critically important factors for producers in determining the best waste management system for their operation. The information contained in this brochure is based on processing slurry for one 10 hour work day once a week (48,000 gallons over an 8 hour period) producing approximately 2 million gallons of separated effluent per year. More total gallons could be processed by operating the system more frequently or by sizing up the equipment used.

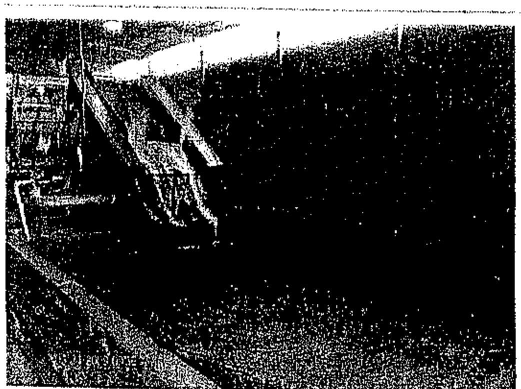
Farm which is processing up to 2 million gallons a year. Total costs include the "worst case scenario" of diesel fuel costing $4:gallon.

Minimum Equipment Requirements

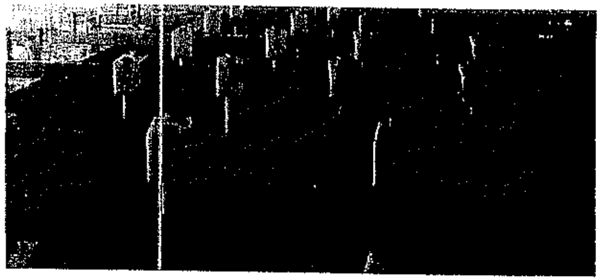
Items for both systems	Cost
Building	$50,000
Reception pit(25'x8' w/sump)	$15,000
Open prop agitator to stir pit	$6,000
Pump to supply primary screen	$6,000
Separator Model 250	$11,000
Effluent tank (15'x8' w/sump)	$12,000
Effluent pump w/ on-off level switch	$8,000
Feed pump for raw material	$5,000
Chemical injection pump for polymer	$4,000
Mixing tanks - 500 gal (x2) & controls	$6,000
Total =	$123,000

Plus either: Microscreen $17,000 = $140,000
or Gravity Belt $50,000 = $173,000

10 yr straight line depreciation (cost/10yrs)
Microscreen $14,000/2 million gallons = 0.70¢:g
Gravity Belt $17,300/2 million gallons = 0.87¢:g



Suspended solids are removed using a microscreen separator and polymer



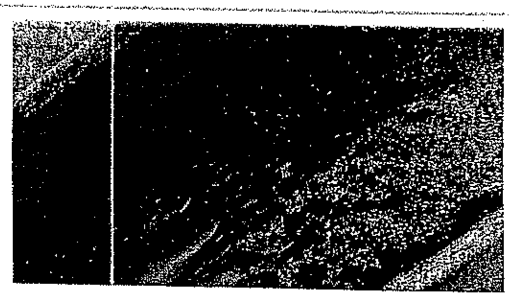
Suspended solids are separated using a gravity belt thickener and polymer

Operating Costs

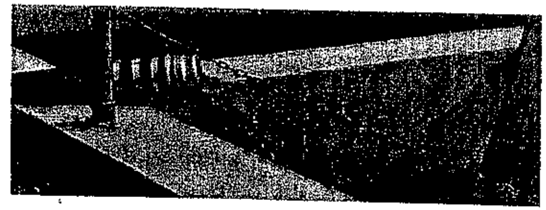
Electricity Costs
Ameren quoted 0.0795¢/kwh
GBT = 0.005¢/gallon
MS = 0.004¢/gallon

Polymer Costs
15 measurements were taken of both GBT and MS
Average gallons / # of polymer = 1707g
Cost of polymer = $2.45/#
$2.45/1707 gallons = 0.144¢/gallon

Labor Costs
Approximately 2 hours per day are needed for startup and shutdown
Daily operation of 8 hours is recommended
Total hours = 10
Rate of pay = $15.00/hr x 10 hours = $150.00
System is run at 100gpm (x60min x8hrs) = 48000g
$150.00/48000 gallons = 0.3125¢/gallon



Separable solids are removed using a gravity screen-rollpress separator



Separated effluent is dramatically cleaner than the raw slurry

Application Costs

Diesel fuel for irrigator
10 gallons of diesel fuel used to irrigate 500,000 gallons of SE
At $2:gallon of fuel, cost = 0.004¢:gallon of SE
At $4:gallon of fuel, cost = 0.008¢:gallon of SE

Electricity Costs for irrigator pump
Ameren quoted 0.0795¢/kwh
3,666 kwh to pump 217,982 gallons of SE over 12hrs
0.0168 kwh:gallon of SE x 0.0795¢/kwh
= .0013¢:gallon of SE

Irrigator, sized for 40 acres
20 year straight line depreciation
($40,000/20yrs = $2000)
$2,000/2 million gallons = 0.10¢:gallon

Total Application Costs
At $2:gallon of fuel, cost = 0.1053¢:gallon of SE
At $4:gallon of fuel, cost = 0.1093¢:gallon of SE

Separated effluent is applied using center pivot irrigation

Attachment 6

Evaluation of a PAM Assisted Solid/Liquid Separation System

Materials and Methods

All slurry pits in all the swine buildings at the ISU Farm farrow to finish swine operation were drained once or twice each week and recharged with 2-3 inches of separated effluent. The raw slurry (RS1) was drained by an underground sewer line to the slurry processing building where it was passed across a gravity screen-roll process separator to remove separable solids producing separated slurry (RS2). The RS2 was mixed with polymer and passed across a gravity belt thickener to remove suspended solids. The resulting biosolids (BS) were mixed with landscape waste and composted. The resulting separated effluent (SE) was stored in a Slurry Store ® until land applied during the corn/soybean growing season via a center pivot irrigator. The gravity screen-roll press separator used for this study was a Model 250, manufactured by Key Dollar Cab, Inc. (Milton-Freewater, OR) with a pore size of 1.59mm. For this study, the separator was operated at a rate of 227.1 ± 1.02 L/min. The gravity belt thickener was a Model GSC-1, Series III manufactured by Komline Sanderson (Peapack, NJ). The belt fabric permeability was 390 L/min. For this study, the belt separator was operated at a rate of 378.5 L/min. The proprietary liquid cationic polyacrylamide (PAM) polymer flocculant used in 2006 was Percol 757® (Ciba Specialty Chemical Water Treatments, Inc.; Suffolk, VA) which had a charge density of 58% at a concentration of 140 mg/L of RS2. The PAM used in 2007 was Zetag 8160® (Ciba Specialty Chemical Water Treatments, Inc.; Suffolk, VA) which had a charge density of 60% at a concentration of 2580 mg/L of RS2. Between May and October 2006 1,067,237 gallons (g) of RS1 were separated producing 971,160 g of SE and 96,077 g of BS with separation occurring approximately once every 7-10 days. During 2007 1,234,966 g of RS were separated producing 1,118,967g SE and 115,999g BS and separation was conducted twice weekly from May 1 until November 9. One liter samples of RS1, RS2 and SE were collected for analysis and analyzed for pH, dissolved oxygen(DO), chemical oxygen demand (COD), solids dry weight (SDW), settleable solids (SS), total suspended solids (TSS), total nitrogen (N), total phosphorus (P) and ammonia(NH_3). Samples were analyzed using procedures taken from Standard Methods for the Examination of Water and Wastewater, 20th edition (Eaton, 2000) and Association of Analytical Chemists (1975). Statistical analysis of COD, SDW, SS, TSS, N, P and NH_3 concentrations (dependent variables) were conducted for RS1, RS2, SE, and BS (independent variables) using a protected F-test (SPSS® software, 2007). Significance of differences between data values was determined at a $p<0.05$

Results

Results of RS1, RS2, SE and BS analysis for SDW, SS, TSS, pH, COD, N, P and NH_3 are presented along with the N:P ration in Tables 1 (2006) and 2 (2007). Based on Table 1 data it is apparent that during the 2006 sampling period concentrations recovered in the SE were significantly ($p<0.05$) reduced by >69% for SDW, >98% for SS and TSS, >89% for COD, >60% for N, and >91% for P, relative to RS1. Consistent pH levels in the range of 7.5 to 7.8 were found for RS1, RS2 and the SE generated. The N:P ratio increased from 4:1 in RS1 to 17:1 in SE. Reductions of >30% for SDW, >25% for SS, >18% for TSS, and >21% for N were found in RS2 relative to RS1, although these reductions were not statistically significant. Data presented in Table 2 indicate that in 2007 concentration reductions of >53% for SDW, >94% for SS, >80% for TSS, >62% for COD, >37% for N, and >70% for P were significant for SE relative to RS1. Consistent pH levels in the range of 7.29 to 7.63 were found for RS1, RS2 and SE. The N:P ratio increased from 5:1 in RS1 to 11:1 in SE. Reductions of >11% for SDW, >14% for SS, and >11% for N were found in RS2 relative to RS1, although these reductions were not statistically significant.

Table 1. Mean (± 1 SD) concentrations of evaluated water quality parameter (N:P) ratios for raw slurry, separated slurry, treated effluent and biosolids i

Sample type	% Solids Dry Weight	Settleable Solids mg/L	Total Suspended Solids mg/L	pH	Chemical Oxygen Demand mg/L	T
Raw slurry	1.3 (1.0) ª	95.4 (153.1) ª	876.5 (939.4) ª	7.5(0.3)	57127 (53344) ª	19
Raw after gravity screen	0.9 (0.2) ª	70.8 (25.0) ª	712.7 (817.3) ª	7.5(0.2)	55477 (46569) a	15
Effluent after gravity belt	0.4 (0.1) ᵇ	1.5 (1.5) ᵇ	15.9 (8.1) ᵇ	7.8(0.2)	5922 (4565) ᵇ	76
Biosolids	10.4 (1.7)	n/a	n/a	n/a	n/a	88

(1) Values are mean (standard deviation) for 13 raw, 20 effluent and 17 solids samples taken May 24 – August 31, 2006

a,b Different letters within columns indicate significant differences in means at p≤0.05 level

Table 2. Mean (± 1 SD) concentrations of evaluated water quality parameters an for raw slurry, separated slurry, treated effluent and biosolids in Year 2(1)

Sample type	% Solids Dry Weight	Settleable Solids mg/L	Total Suspended Solids mg/L	pH	Chemical Oxygen Demand mg/L	Total N ppm
Raw slurry	0.84 (0.28) ª	105.4 (36.7) ª	4329 (1200) ª	7.29(0.23)	5155 (6886) ª	1078 (
Raw after gravity screen	0.74 (0.26) ª	89.8 (47.9) ª	4377 (2077) ª	7.36(0.24)	5528 (10200) ªᵇ	964 (3
Effluent after gravity belt	0.39 (0.10) ᵇ	6.0 (6.2) ᵇ	825 (1341) ᵇ	7.63(0.24)	1919 (1924) ᵇ	684 (25
Biosolids	8.78 (1.92)	n/a	n/a	n/a	n/a	5153 (1

(1) Values are mean (standard deviation) for 32 samples taken May 22 – November 9, 2007.

a,b Different letters within columns indicate significant differences in means at p≤0.05 level

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Slurry separation provides an efficient and cost effective system for managing the odor and nutrient overload associated with swine manure while improving animal welfare, reducing non-point source pollution concerns, and providing a source of beneficial soil amendments for crop production. For more information check out additional information at the Swine Waste Economical, Environmental Treatment Alternatives (SWEETA) website:

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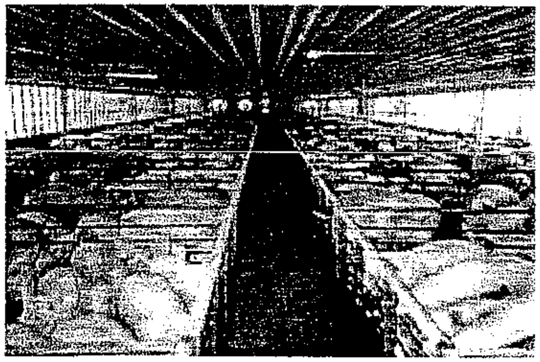

Acknowledgements

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Evaluation of a polyacrylamide (PAM) assisted solid/liquid separation system, consisting of a gravity screen and gravity belt thickener, coupled with separated solids composting for the treatment of swine waste.

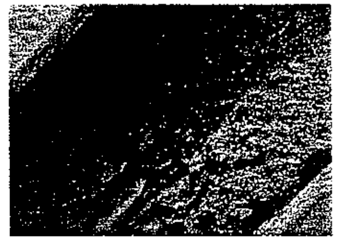
P.M. Walker[1], C.A. Wade[1], T.R. Kelley[2]

Abstract

Current methods for managing swine manure consist of holding tanks, settling lagoons and direct injection application on crop producing fields, but these methods create problems for the environment, the public and the pork producer. The 500 million tons of livestock manure generated annually in the US has consistently been identified as a major contributor to water quality impairment in surface waters. Failure of storage systems and mishaps during application can result in discharges leading to environmental degradation in both local waterways and those farther downstream. With the shift to high intensity confined animal feeding operations, the amount of waste generated may exceed the capacity of proximal and available agricultural lands for land application, resulting in "land-limited conditions". The high water content of the slurry makes it difficult to transport and handle, further limiting disposal options. The nutrient characteristics of untreated swine slurry, with a N:P (nitrogen to phosphorus) ratio of approximately 5:1, results in an over application of phosphorus when land applying based on N application rates and creates odor and hygienic concerns during storage and application. Pork producers need to implement low cost, efficient manure management systems that will address environmental and health concerns while creating economically viable products from the waste. By applying treatment technologies similar to those used in treating municipal wastewater, a low odor, more nutrient balanced effluent results (N:P ratio of 11:1) while biosolids are concentrated and can easily be composted to create a valuable fertilizer alternative. Our evaluation of a gravity screen in tandem with a polyacrylamide assisted gravity belt thickener for the treatment of swine waste showed reductions of 80.9% for Total Suspended Solids, 62.8% for Chemical Oxygen Demand, 37.0% for total Nitrogen and 70.9% for total Phosphorus in the treated effluent

Introduction

Separation of waste water into its solid and liquid components is a technology that has been utilized by municipal sanitation departments for decades. Removal of the biosolids fraction cleans the liquid portion sufficiently that the waste water effluent meets EPA standards for direct discharge to surface waters. There are several separation technologies that can be borrowed from municipal wastewater treatment operations, but there is a need to understand the operational practicalities and efficiency expectations of the various applications of these technologies to swine manure management. Swine waste is typically produced in both higher volumes and solids concentrations than municipal wastewater and the decentralized nature and the increased energy and labor-intensive waste management techniques of most swine waste production facilities relative to human sewage treatment facilities makes treatment more challenging and results in high treatment costs.



Separable solids are removed using a gravity screen-rollpress

Objective

This study evaluated the efficiency of a static gravity screen-roll press combination solids separator in conjunction with a polyacrylamide (PAM)-assisted gravity belt solids thickener reduce the concentration of solids and other commonly used aquatic pollution indicators in the treated effluent relative to the raw, untreated swine slurry(RS1). An analysis of the resulting data was then used to examine the feasibility of using this treatment system to reduce swine waste pollution indicators, determine suitability of treated, or separated, effluent (SE) for irrigation as a nitrogen fertilizer for row crops, and to evaluate the value of the biosolids (BS) fraction as a potential composted soil amendment.

Suspended solids are separated using a gravity belt thickener and chemical flocculent

Attachment 7

Compost Facility Permits

NOTE:

1. Exemption from local siting approval does NOT exempt a compost facility from IEPA permitting nor regulation.
2. No compost facility may pollute, whether operating under permit or an on-farm exemption.
3. If operating with an IEPA permit, expect at least two on-site inspections each year.
4. If operating an on-farm exemption IEPA will generally not provide on-site inspections unless IEPA receives a complaint.
5. A local siting exemption does not exempt the compost facility from IEPA regulations.

Questions about compost siting or other permits should be addressed to:

Illinois EPA
Bureau of Land
Bureau of Water
2200 Churchill Road
P.O. Box 19276
Springfield, IL 62794-9276

Telephone: (217) 524 3300
Website: www.epa.state.il.us

More information can be found at the Swine Waste: Economical and Environmental Treatment Alternatives web site

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Or by contacting Paul Walker
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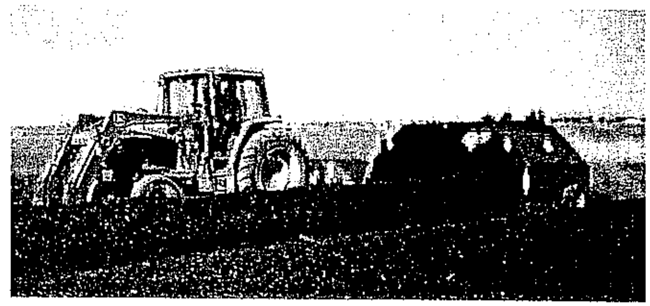
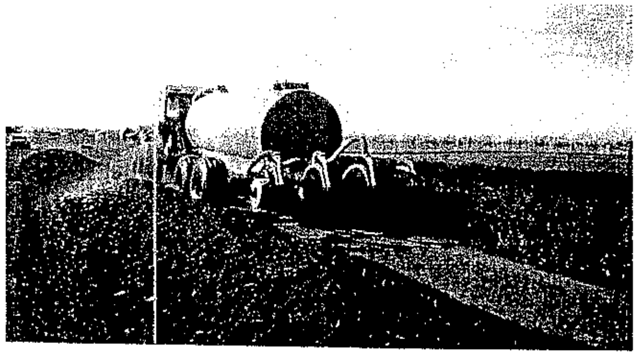
COMPOST FACILITY PERMITS

The Illinois Environmental Protection Agency (IEPA) is responsible for overseeing regulations involving the siting, development, operation and closure of all compost facilities in Illinois. Technically, within Illinois, compost facilities are considered Pollution Control Facilities. All Pollution Control Facilities must receive local (county or municipality) siting approval and permits from the IEPA for development and operation. Some exemptions for compost facilities are allowed.



Local Siting Approval/IEPA Permits Are Required If:

1. the one time total capacity of the compost facility is more than 30,000 cubic yards (including finished compost , composting material and raw material).
2. the size of the compost facility is larger than 2% of the acreage of the property.
3. the finished compost produced is sold (or given away).
4. if raw material is composted for someone else.
5. if the finished compost is not utilized by the owner/operator of the compost facility.
6. if landscape waste is a raw material and other additives such as manure are added in excess of 10% by volume..
7. if appropriate setbacks are not followed, including:
   - 200 feet from a well.
   - 5 feet above the watertable.
   - 1/4 mile from the nearest non-farm residence.
   - 1/2 mi. from the nearest populated area.
   - 660 feet from the nearest school or hospital.
   - located outside of the 10 year flood plain or is flood-proofed.



An On-Farm Compost Facility Exemption To Local Siting Approval / IEPA Permitting Applies IF:

1. the site is located on the farm on which the compost is applied.
2. the site is operated by the farmer of the property.
3. the farmland is in production of crops annually.
4. the size of the compost site is less than 2% of the acreage of the property.
5. the site is not owned or controlled by a waste hauler or commercial composter.
6. the farmer registers the site with the Illinois EPA by January 1st following commencement of operation and files a report each year thereafter.
7. if landscape waste is a new material and additives to the landscape waste such as manure do not exceed 10% by volume.
8. appropriate setbacks are followed.
9. if the finished compost is applied to farmland controlled by the owner/operator of the compost facility.
10. if livestock manure is mixed with other on-farm generated raw materials such as corn stalks, straws, hays, etc.

Local Siting Approval Not Required If:

Effective January 1, 2010

Compost Facilities are not considered Pollution Control Facilities and are exempt from local siting if:

1. livestock waste in the raw form or in the process of being composted does not exceed 30,000 cubic yards one time capacity of the facility.
2. all raw materials are placed in an enclosed air and temperature controlled vessel by the end of each day or if:
   a. all set backs are met.
   b. all raw material is processed into windrows or piles that prevent scavenging by birds and animals.

Attachment 8

Seminar Presented at CLM Training Workshops

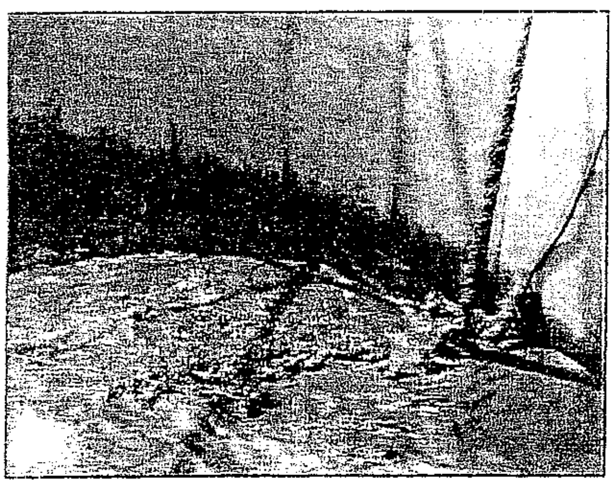
MANURE MANAGEMENT

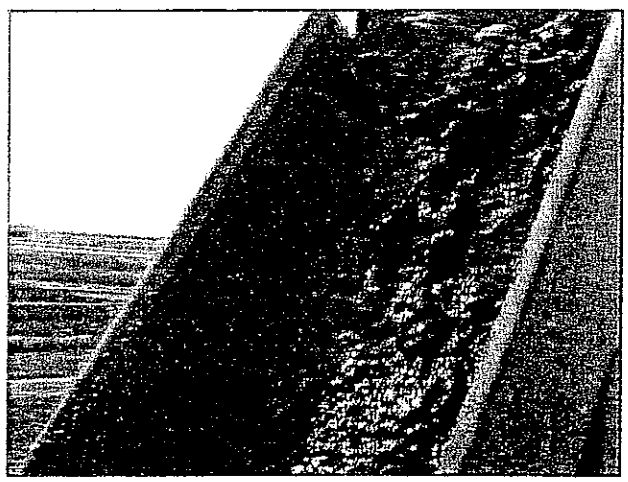
- NUTRIENT OVERLOAD
  - Right to operate

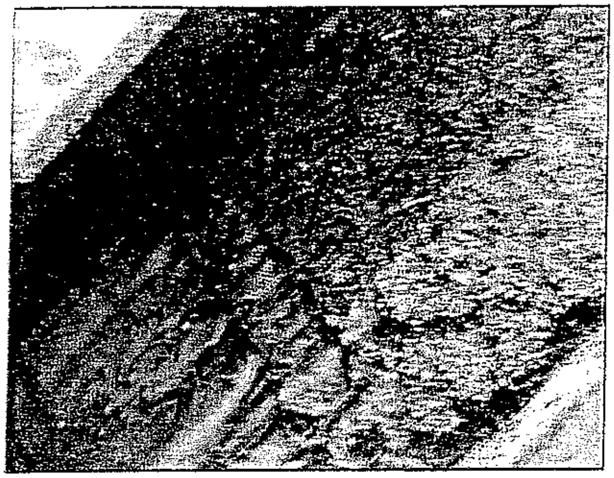
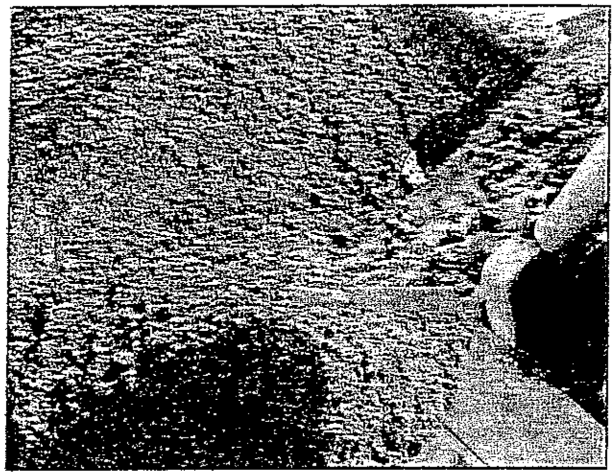
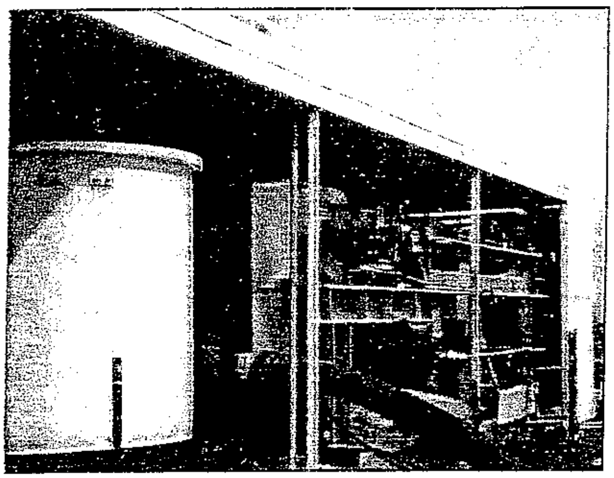
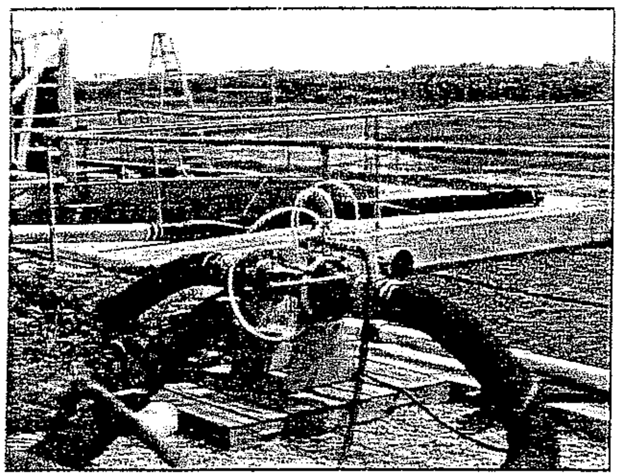
- ODOR
  - siting
  - rignt to exist

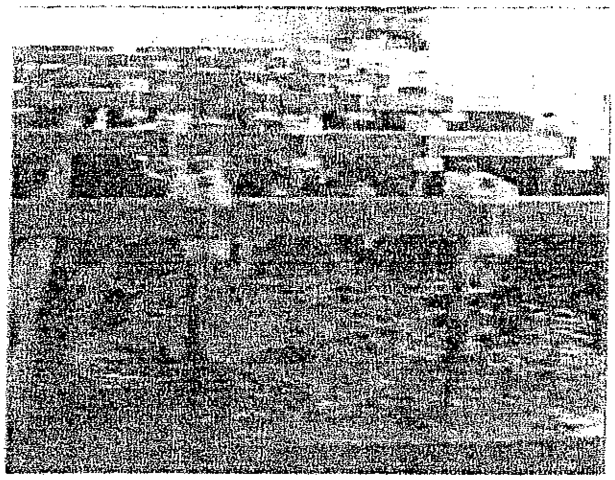
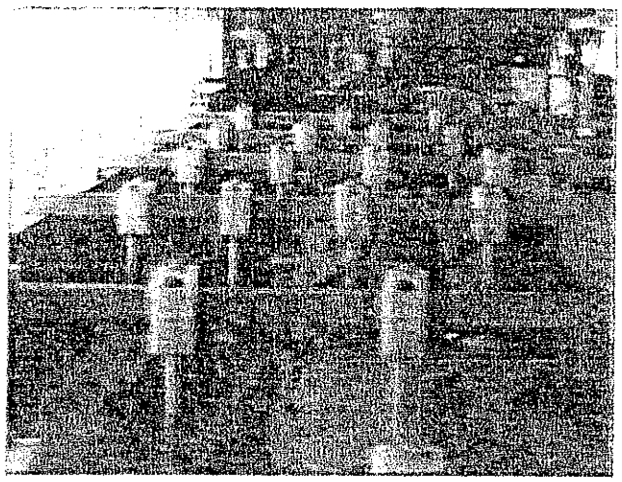
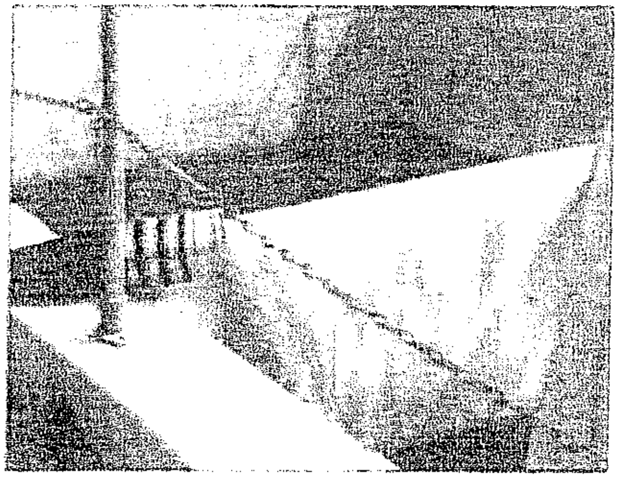
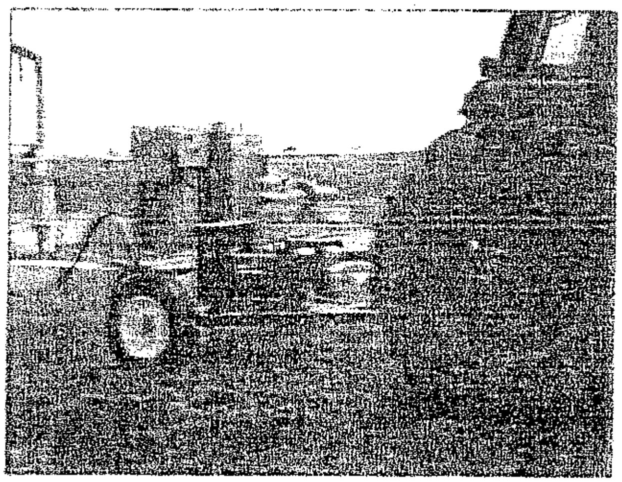
SYSTEMS APPROACH

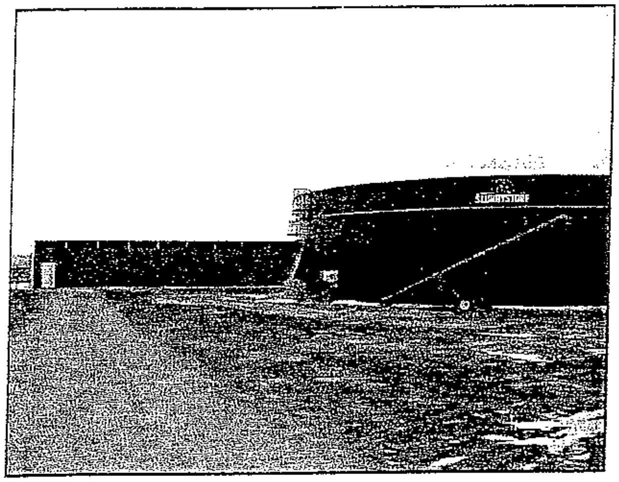
- Solid-liquid separation
- Compost solids/land apply solids
- Irrigate liquid

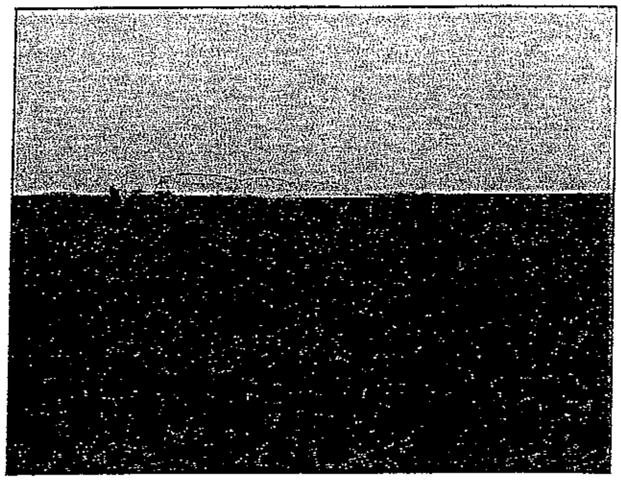








ABBREVIATIONS

IF = Inorganic Fertilizer
- Anhydrous Ammonia
- Potash
- Diammonium Phosphate (DAP)

RS = Raw Slurry
RS1 = Raw Slurry Before Processing Started
BS = Biosolids/Separated Solids
SE = Separated Effluent

MANURE PROCESSED (5-18/10-10)

1,067,237g RS

971,160 g SE[abc]

96,077 g BS

[a]91% collection rate
[b]47,959g:d SE, 52,702 g:d RS
[c]separated 16x, once:week

CHARACTERISTICS OF SLURRY, EFFLUENT AND SOLIDS (Year 1)

Item	DM (%)	SS ml:L	TSS mg:L	pH	DO mg:L	COD mg:L	N (%)	P (%)	N:P
RS1	3.65	788	1782	7 6	0 0	127 000	1 0	0 53	1.9:1
RS	1 3	95.4	878 5	7 5	0.0	57,127	0 19	0.05	3.8:1
SE	0.4	1 5	15 9	7.8	44 9	5 922	0 08[b]	0 004	20.0:1
BS	10.4						0.9	0.64	1.4:1
Change	-69 2	-98.4	-98.2	+4.0		-89 6	-60.6	-91 7	

[a]Percent change from RS to SE

[b]0.09% in irrigant

CHARACTERISTICS OF SLURRY, EFFLUENT AND SOLIDS (Year 2)

Item	DM (%)	SS ml:L	TSS mg:L	pH	DO mg:L	COD mg:L	N (%)	P (%)	N:P
RS	0.82	103.5	4125	7.3	0 0	5115	0 11	0.02	5 5:1
SE-B	0 39	5.2	326	7 7	0 5	1885	0.07	0.006	12:1
SE-MS	0.37	1 3	258	7.6	1 7	1414	0 06	0.006	10:1
BS-B	9 33						0 55	0.35	1.6:1
BS-MS	10.77						0.65	0 43	1.5:1
Change:									
BS-B	-52 4	-95.0	-92 1	+5.2		-63 1	-36.4	-70 0	
BS-MS	-54 9	-98 7	-93 7	+3.9		-72.4	-45.5	-70.0	

COMPOST CHARACTERISTICS

N	P	K	Ca	DM	pH	C:N
(%)	(%)	(%)	(%)	(%)		
1.5	0 3	0.6	2 4	50 0	7.3	21:1

INORGANIC FERTILIZER

Potash (0-0-60): $250/ton, $2.50/acre application

Anhydrous Ammonia (82-0-0): $449/ton, $6 00/acre application

Diammonium Phosphate or DAP (18-46-0) $332 32/ton, $2.50:ac application

SOIL AMENDMENT APPLIED (40ac)

Amendment	
IF	140 # N as A A 200 # DAP, 200 # Potash
C	1,708 tons - 42 7 t:ac/21 4 t:ac dry
RS	306,000 g - 7,650 g:ac
SE	971;160 g - 24,279 g:ac

NITROGEN AND PHOSPOROUS SUPPLIED (lb:ac)

Amendment	Yield[a]	N Req.[b]	N appl	N diff	Preq[c]	P appl	P diff.
IF	204	271	176	-95	44 9	40 9	-4 9
C	180	239	180	-59	39 6	136 7[d]	+97.1[e]
RS	179	238	214	-24	39 4	134 6	+95 2
SE	180	239	175	-64	39 6	7.8	-31 8
Target			180				

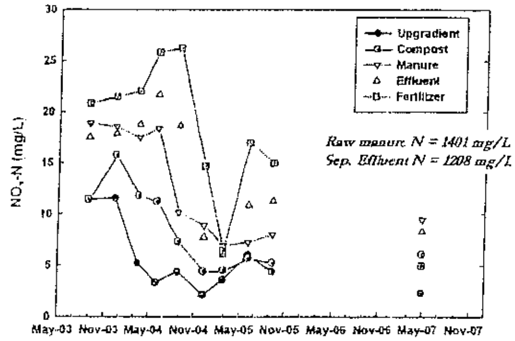
[a]bu:ac
[b]1.33 lb. N:bu – corn req.
[c].22 lb. P:bu = corn req.
[d]58.8 lb in year 2, 38 4 lb in year 3
[e]= 19 2 lb excess = 1 2 lb deficit

Yield Data (bu: ac)

	Corn	Soybean
IF	204	67 0
C	180	73 7
RS	179	57 8[a]
SE	180	55.9[a]

([a])= Late Planting Date

Nitrate-N in wells



COMPOST COSTS

Production	$10:ton	to	$35:ton
Application	$2 00:ac	to	$4 00:ac

SEPARATION COSTS

EQUIP	$100,000		
LABOR SE/RS	$15:h	.35/ 34¢/g	
POLYMER[a]	$1 60:lb	14/ 13¢/g	SE/RS
FUEL	$2 10:g	15/ 14¢/g	SE/RS
MAIN	2%:y	08/ 07¢/g	SE/RS
Depr (15 yr) SE/RS	6 7%:y	.27/ 25¢/g	

[a]560 mg:gal SE, 510 mg:gal RS

SEPARATION/APPLICATION COST (¢:g)

Item	Separation	Application	Total
RS	0 90	0 10	1 0
SE	0 99	0 10	1 09
RS	Direct Injection = 0 70 – 1 70		

COST OF SOIL AMENDMENT

Amendment	Yield (bu:ac)	Cost ($:ac)	Cost ($:bu)	Year 2 (actual)	Year 3 (projected)
IF	204	107 62	0 53		
C	180	512 40	2 85	1 03	0 80
RS	179	76 50	0 43		
SE	180	264 64	1 47		

EFFECTS

- Reduces Odor
  - Building environment improved
  - Application

- Reduces Nutrient Overload
- Cost Effective
  - Compost $10/ton
  - Separation 0.90 ¢/g – 0.99 ¢/g

Attachment 9

Seminar Presented at the 2007 Annual C-FAR Meeting
Springfield, Illinois

AS GREAT AS ETHANOL'S IMPACT

ANIMAL WELFARE

+

MANURE MANAGEMENT

MORE IMPORTANT!

Paul M Walker
Department of Agriculture
Illinois State University
ILLINOIS STATE UNIVERSITY

MANURE MANAGEMENT

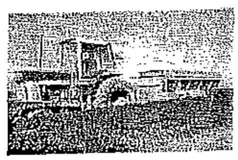
- NUTRIENT OVERLOAD
  - Right to operate
- ODOR
  - siting
  - right to exist

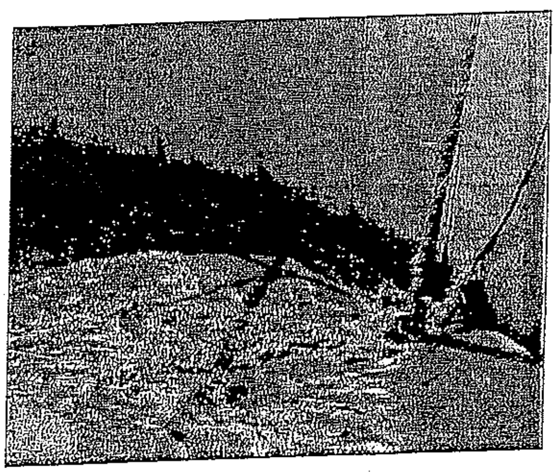
LUW TEAM

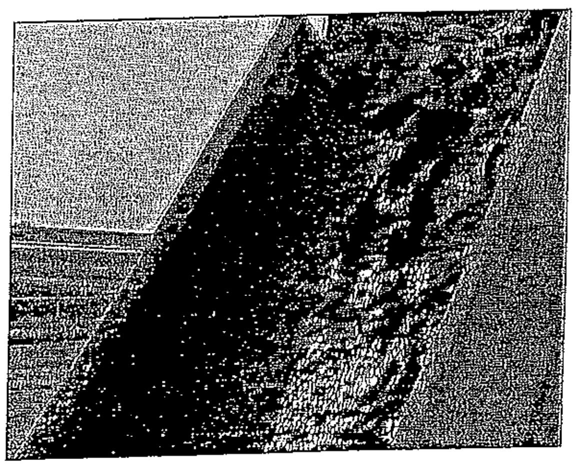
Dept AGR – ISU
Dept HSC – ISU
Dept AS – UIUC
University Extension
ISWS
ISGS

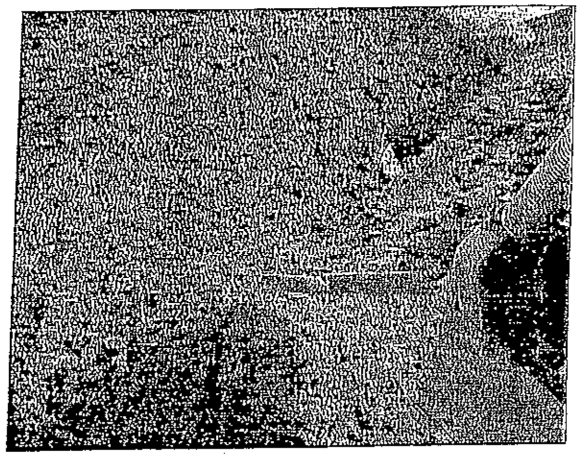
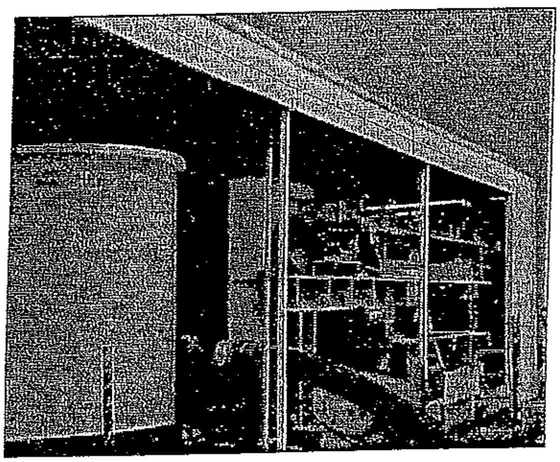
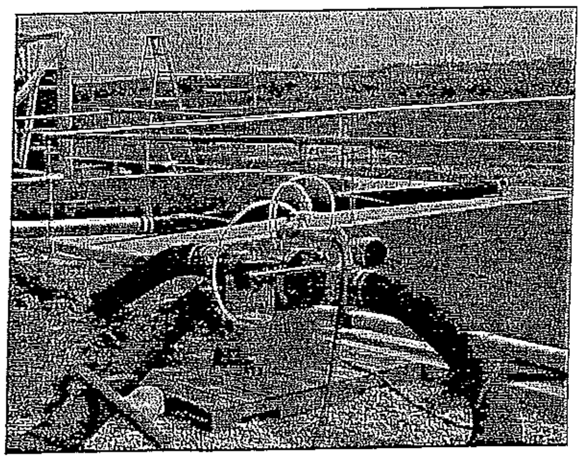
SYSTEMS APPROACH

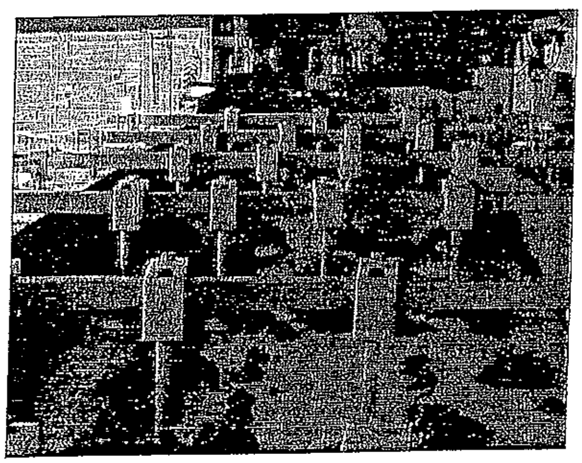
- Solid-liquid separation
- Compost solids/land apply solids
- Irrigate liquid

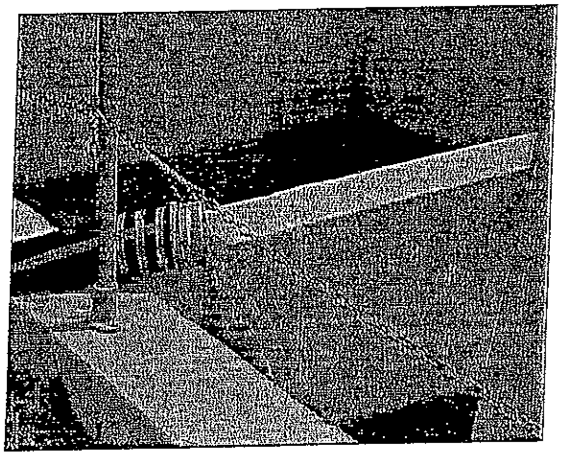


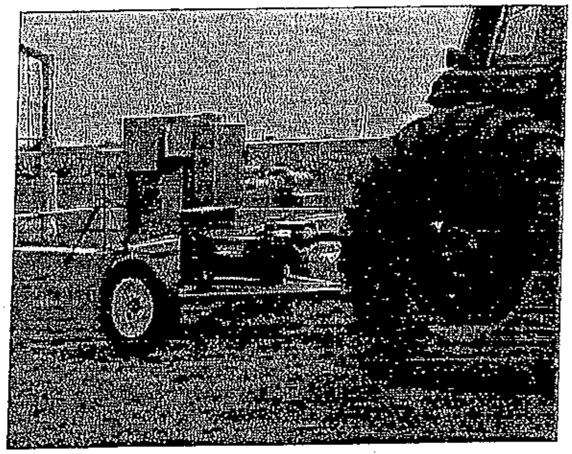


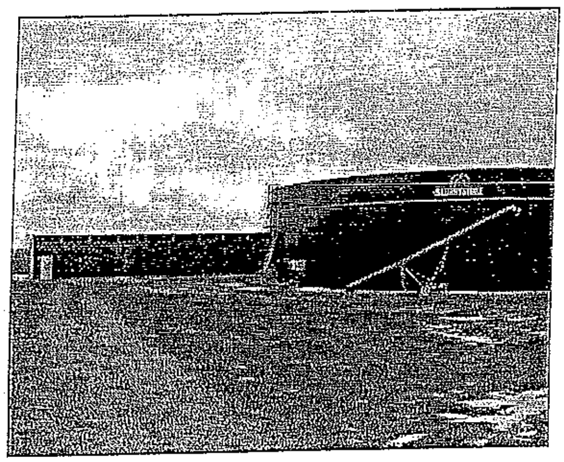


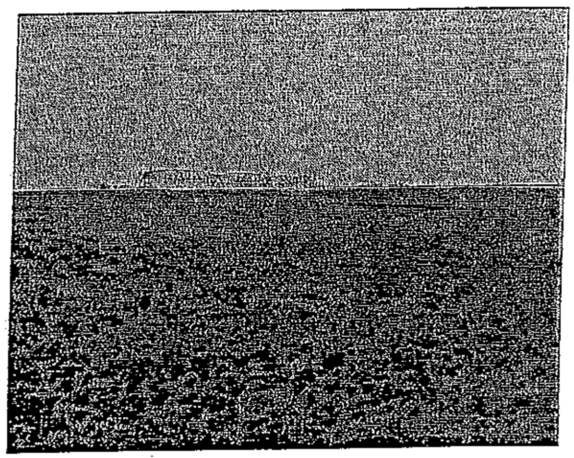





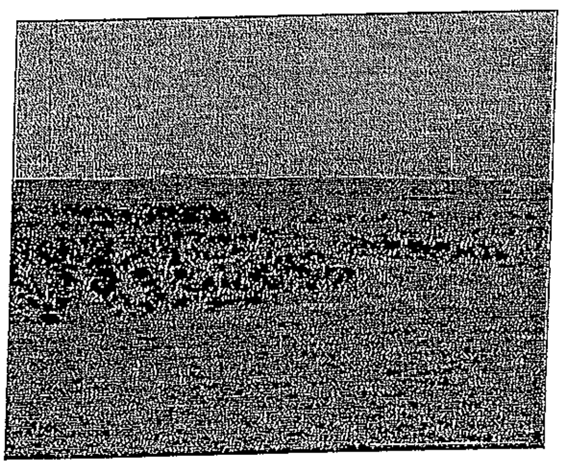












ABBREVIATIONS

IF = Inorganic Fertilizer
- Anhydrous Ammonia
- Potash
- Diammonium Phosphate (DAP)

RS = Raw Slurry

RST = Raw Slurry Before Processing Started

BS = Biosolids/Separated Solids

SE = Separated Effluent

MANURE PROCESSED (5-18/10-10)

1 067 237g RS

971 160 g SE[a,b,c]

96 077 g BS

[a]91% collection rate

[b]47,959g:d SE 52 702 g:d RS

[c]separated 16x, once:week

CHARACTERISTICS OF SLURRY, EFFLUENT AND SOLIDS

Item	DM (%)	SS ml:L	TSS mg:l	pH	DO mg:L	COD mg:l	N (%)	P (%)	N:P
RSI	3.65	786	1782	7.6	0.0	127,000	1 0	0 53	1 9:1
RS	1.3	95.4	878 5	7 5	0.0	57 127	0 19	0.05	3.8:1
SE	0.4	1 5	15 9	7.8	44 9	5 922	0.08	0.004	20.0:1
BS	10 4						0 9	0.64	1.4:1
Change[a]	-69 2	-98 4	-98.2	+4.0		89.6	-60.0	-91 7	

[a]Percent change from RS to SE

[b]0.09% in irrigant

COMPOST CHARACTERISTICS

N (%)	P (%)	K (%)	Ca (%)	DM (%)	pH	C:N
1 5	0 3	0 6	2 4	50 0	7 3	21:1

INORGANIC FERTILIZER

Potash (0-0-60): $250/ton $2.50/acre application

Anhydrous Ammonia (82-0-0): $449/ton, $6 00/acre application

Diammonium Phosphate or DAP (18-46-0) $332 32/ton, $2 50:ac application

SOIL AMENDMENT APPLIED (40ac)

Amendment	
IF	110 # N as A A 200 # DAP 200 # Potash
C	1 708 tons - 42 7 t:ac/21 4 t:ac dry
RS	306 000 g - 7 650 g:ac
SE	971 160 g 24 279 g:ac

NITROGEN AND PHOSPOROUS SUPPLIED (lb:ac)

Amendment	Yield[a]	N Req[b]	N appl	N diff	P req	P appl	P diff
IF	204	271	176	95	44 9	40 9	-4 9
C	180	239	180	59	39.6	136 7[d]	+97 1
RS	179	238	214	24	39 4	134.6	+95 2
SE	180	239	175	64	39 6	7.8	-31 8
Target			180				

[a]bu:ac

[b]1.33 lb N:bu = corn req

.22 lb. P:bu = corn req

[d]58.8 lb in year 2 38 4 lb in year 3

[e]= 19 2 lb excess = 1 2 lb deficit

COMPOST COSTS

Production	$10:ton	to	$35:ton
Application	$2 00:ac	to	$4 00:ac

SEPARATION COSTS

EQUIP	$100,000		
LABOR	$15:h	35/ 34¢/g	SE/RS
POLYMER[a]	$1 60:lb	14/ 13¢/g	SE/RS
FUEL	$2 10:g	15/ 14¢/g	SE/RS
MAIN	2%:y	08/ 07¢/g	SE/RS
Depr (15 yr)	6 7%:y	27/ 25¢/g	SE/RS

[a]560 mg:gal SE 510 mg:gal RS

SEPARATION/APPLICATION COST (¢:g)

Item	Separation	Application	Total
RS	0 90	0 10	1 0
SE	0 99	0 10	1 09
RS	Direct Injection = 0 70 – 1 70		

COST OF SOIL AMENDMENT

Amendment	Yield (bu:ac)	Cost ($:ac)	Cost ($:bu)	Year 2 (actual)	Year 3 (projected)
IF	204	107 62	0 53		
C	180	512 40	2 85	1 03	0 80
RS	179	76 50	0 43		
SE	180	264 64	1 47		

EFFECTS

- Reduces Odor
  - Building environment improved
  - Application

Reduces Nutrient Overload

Cost Effective

– Compost $10:ton

– Separation 0 90 c:g – 0 99 c:g

Leveraging from C-FAR ($629,954)

- Illinois EPA Section 3 19: $267,717
  - Combining Separation Nitrification/Denitrification, Composting and Irrigation as a Manure Management Option for Swine Producers to Reduce NPS Pollution 2005
- USDA CIG: $337,237
  - Field Scale Evaluation and Technology Transfer of Economically Ecologically Sound Liquid Swine Manure Treatment and Application Systems 2006
- Illinois Department of Agriculture Sustainable Agriculture Grant Program $25,000
  - Evaluation of Land Application Systems for Swine Manure to Reduce Non-Point Source Pollution 2006

CONTINUED RESEARCH

- Reduce polymer use
- Increase gal/min separated
- Implement Nitrification system
- Evaluate underground irrigation SE
- Evaluate long term effects on soil parameters
- Evaluate long term effects on ground water
- Technology transfer/BMP
- Can BS make oil? (Dr Zhang – UIUC)

Utilizing Processed Manure as a Soil Amendment for Soybean/Spring Small Grain Production

Livestock and Urban Waste Team
Illinois State University
Normal, IL 61790-5020

Introduction

This project will investigate separation of solids from liquid swine manure (separated swine effluent and separated solid compost) to safely utilize animal manure while ensuring minimal disruption to the soil environment. Data will be collected over several growing seasons to access the long-term effects of annual treatment application on soybean and spring small grain (wheat, barley, or oat) growth and productivity, as well as soil quality.

Objectives

1. Investigate the feasibility of composting livestock waste or isolating liquid swine effluent in an agricultural setting
2. Evaluate at least six treatments (see below) upon plant growth and productivity.
3. Determine the effect of treatments on soil health and quality by monitoring soil pH, organic matter, cation exchange capacity (CEC), and elemental concentrations

Treatments

Six treatments will be evaluated at this site:

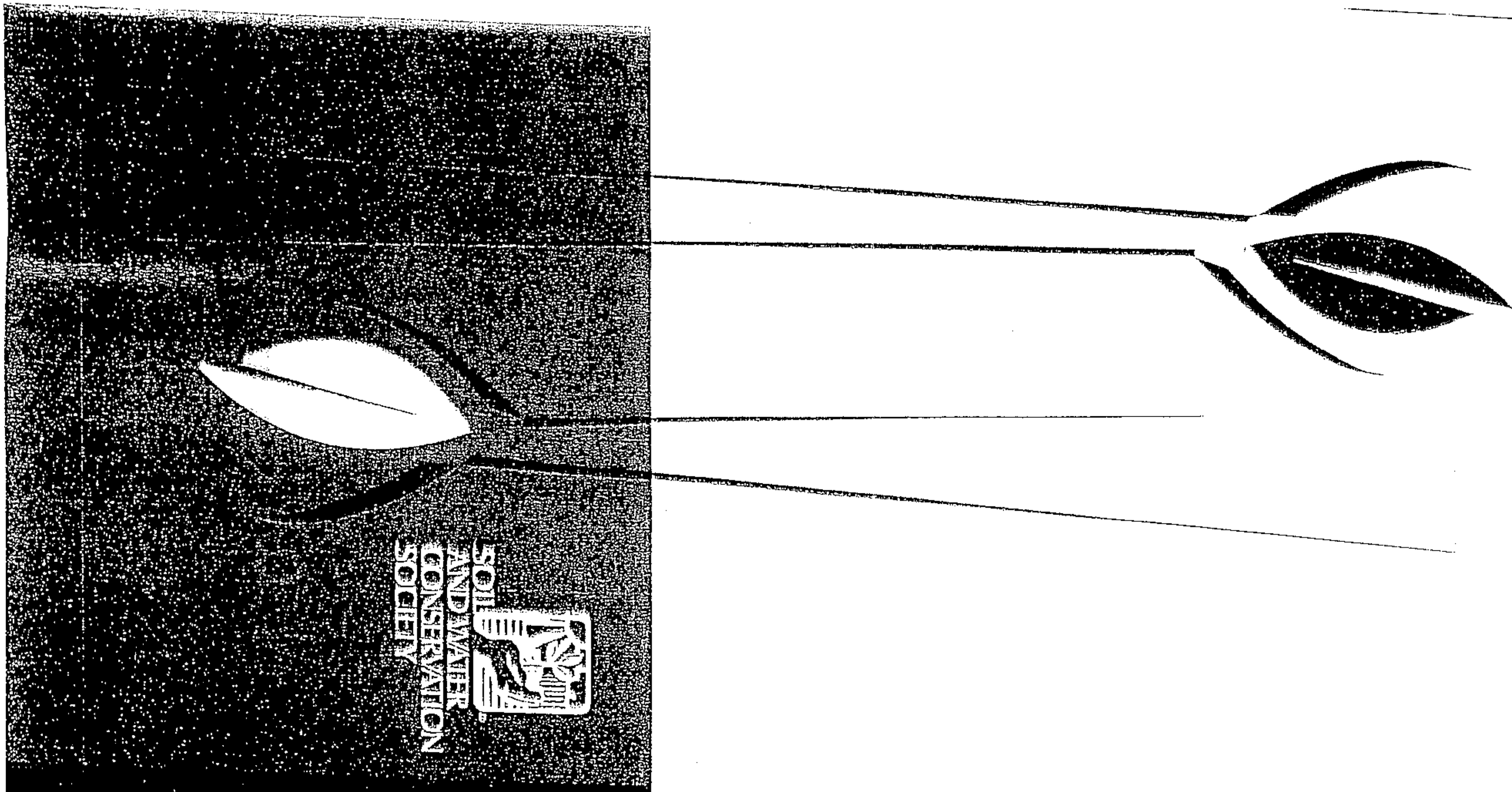
- zero rate control (no fertilizer applied)
- raw, unprocessed liquid swine manure, rate based on best management practices for phosphorus (may need to add fertilizer N to achieve rate equivalent to 180 lbs N/acre)
- processed separated solid swine compost (rate equivalent to 180 lbs N/acre)
- raw, unprocessed liquid swine manure, rate based on best management practices for nitrogen (rate equivalent to 180 lbs N/acre)
- processed separated liquid swine effluent (rate equivalent to 180 lbs N/acre)
- inorganic fertilizer (180 lbs N/acre; P and K rates determined by soil sample values)

Overview of methods

The field site (University Farm at Lexington, IL) has uniform soil (Parr-Lisbon-Drummer Association), with 1 to 2% slope, good drainage, soil pH of 6, organic matter content of 5%, and good fertility. Each plot consists of sixteen 30 inch crop rows by 80 feet in length. Four replicates are used in a randomized complete block design. Each replicate is separated by an 60 feet grass buffer strip, to avoid excessive compaction during treatment application. Initial soil parameters were measured prior to treatment application and yearly to determine the influence of treatment application on soil elements (P, K, Ca, Mg, S, Zn, Mn, and B), organic matter, pH, and cation exchange capacity (CEC). At physiological maturity, several representative soybean plants will be hand-harvested from each experimental plot, separated in vegetative growth and reproductive growth (seed), weighed, and dried. A dried subsample will be sieved through a 20 mesh screen and analyzed for plant nutrient concentration (N, P, K, Mg, Ca, S, Na, Cu, Mn, Fe, Zn, and B). Grain yield at harvest maturity for soybean will be measured with a small plot combine. Treatment means will be compared by calculating Fisher's protected least significant difference (FLSD) at 0.05 probability level.

Attachment 10

Abstract of Poster Presented at SWCS Conference



SOIL AND WATER CONSERVATION SOCIETY
2007 ANNUAL CONFERENCE
July 21–July 25 | Tampa, FL

Final Program & Abstract Book

intains the protocol and certifies qualifying product Red Tomato develops and coordinates systems for aggregation, transportation storage and marketing which have been lost to small scale producers in the Northeast through industry consolidation, and returns price premium and access to markets Red Tomato also hosts in-store tastings, educating thousands of consumers about the benefits of local, ecologically grown produce Since 2004 sales have increased by 300% to approximately 200 retailers including Whole Foods and Trader Joe's A 2005 post-season survey indicated 95% grower satisfaction; access to markets and price and net return were the most important benefits We have eliminated the most toxic pesticides as defined by our work group with specific reference to criteria set by recognized authorities including USDA, US EPA, International Agency for Research on Cancer, California EPA and others, and have increased adoption of conservation practices listed in the protocol The project has been funded by the USDA NRCS Conservation Innovation Grant Program, US EPA Region I Strategic Agriculture Initiative, USDA Crops at Risk Program, USDA Northeastern IPM Center, and an anonymous foundation

Thomas Anthony Green, Agflex and IPM Institute of North America Inc , tom green@bmpchallenge org

Economic Feasibility of Using Prescribed Summer Fire as an Invasive Brush Management Tool in Texas.

Urs P Kreuter, Texas A&M Unviersity; James Richard Conner, Texas A&M University; Dustin Van Liew, Texas A&M University

Abstract: This component of the CIG Summer Burning project evaluates the economic feasibility of using prescribed fire exceeding current NRCS technical standards as a rangeland restoration practice on privately owned land This study has three objectives: (1) evaluate the economic effectiveness of using prescribed summer burns compared to more commonly used restoration strategies; (2) provide economic research results that will facilitate the review of NRCS technical standards, specifications and policies with respect to prescribed fire; and (3) assess the economic effects of summer fire on livestock grazing and wildlife hunting lease rates The research covers four contiguous counties in each of three Texas eco-regions Focus group meetings were held with landowners and NRCS/Extension personnel to obtain preliminary information including common rangeland uses (livestock and/or wildlife), most problematic invasive brush species, and the most commonly used treatment practices and associated costs for controlling these invasive plants The primary invasive species identified in each eco-region include: Rolling Plains - Prickly Pear (Opuntia phaecantha); Edwards Plateau - Redberry and Ashe juniper (Juniperus ashei Buchh And J pinchotii Sudw., respectively); South Texas Plains - Huisache (Acacia smallii Isely) Mesquite (Prosopis glandulsa Torr) was identified as the secondary invasive species in each eco-region Preliminary results indicate that in all three regions summer fire was economically feasible and was the only treatment alternative that resulted in positive Net Present Values and Benefit-Cost Ratios greater than 1 for the investments in the treatments

Urs P Kreuter, Texas A&M Unviersity, urs@tamu edu

Erosion Prevention through Vegetated Swales for Water Infiltration

Rebecca Diane Thistlethwaite, ALBA

Abstract: The overall project goal is to prevent soil erosion by encouraging stormwater run-off to infiltrate into vegetated swales above cultivated fields or gullies in the erosion-prone Central Coast region of California. This practice also can enhance infiltration rates, thus promoting the regeneration of springs and seeps The non-profit ALBA has built 15 vegetated swales and 8 willow-waddle swales on the contour of the slope to reduce persistent soil erosion by 60% downstrea its Farm Training and Research Center in the environme sensitive Elkhorn Slough Watershed This low-cost and l tech field practice has widespread applicability througho watershed and surrounding region The project has invo the excavation of swales, installation of native grasses, se forbs and rushes, and consistent maintenance to assure t adequacy of established ground cover By July of 2007 w have two rainy seasons to evaluate the effects of the prac on the quality of infiltration, on erosion of farmland and farm operating costs Anecdotal evidence upon this writing indicate that the swales are increasing infiltration and downstream erosion has decreased

Rebecca Diane Thistlethwaite ALBA rebecca@albafarmers org

Field Scale Evaluation and Technology Transfer of Economically Ecologically Sound Liquid Manure Treatment and Application Systems

Paul Walker, Illinois State University; Robert L Rhykerd, Illinois State University

Abstract: The objective of this project is to: compare above ground center pivot irrigation and underground tile irrigation for applying separated effluent with direct injection of raw slurry and land application of composted separated solids on soil and ground water parameters This project also, includes the construction of a production scale facility to house one or more separation technologies and the installation of a field scale center pivot irrigator and modified controlled drainage system to land apply separated effluent Year one of this multi-year study compared the effect of adding inorganic fertilizer, composted slurry biosolids, raw unprocessed slurry

and separated effluent on corn yield selected soil characteristics and selected ground water characteristics Soil amendments were applied based on a targeted 180 lbs of actual N per acre with no regard to P or other elements except for the inorganic fertilizer treatment The inorganic treatment was applied according to a typical fertilizer program in this case using anhydrous ammonia potash and diammonium phosphate The separation process proved effective for removing 98-% of the solids and 91-% of the P from swine slurry The combined separation/application process was similar in cost to the cost of directly land applying raw slurry Inorganic fertilizer resulted in the greatest yield No differences in yield were observed between the raw slurry separated effluent or composted solids treatments The separated effluent treatment resulted in the least P application: acre Raw slurry had the least cost per bushel of yield but resulted in the second highest P application rate Compost had the highest cost per bushel in year one but is projected to be three times less by year three Ground water and soil samples are currently being analyzed and evaluated A web site is currently being developed and two on-site workshops/field days are being planned for 2007

Paul Walker, Illinois State University, pwalker@ilstu.edu

Heron Lake Watershed District Conservation Tillage Demonstration Project

Jan Voit, Heron Lake Watershed District

Abstract: Soil erosion from cropped agricultural land continues to be a major source of sediment in surface waters and also results in an irreversible loss in soil productivity Significant public investments have been made in structures (waterways and terraces) and in land conversion (CRP, RIM, and CREP) to reduce erosion effects Insufficient progress has been made, however, in reducing soil detachment and transport from row-cropped fields where soil is exposed to direct rainfall impact Soil detachment and transport can be effectively reduced in row-crops by maintaining plant residue of the previous crop until the new crop canopy closes One new method of tillage (strip tillage) is a promising new technology that removes residue in the fall only from a narrow strip where the row will be planted in the spring It conserves residue for soil protection between the rows, but facilitates soil drying and warming in the spring in the row area More research and proof is necessary to convince the farmers that conservation tillage will be of benefit to their operations The Heron Lake Watershed District, partnering with several private and public organizations, will demonstrate the economic and environmental benefits of six treatments of reduced tillage systems including strip till, on a farm in southwestern Minnesota Root pits, two years of design yield results and economic comparisons will be presented at field days and winter workshops for agricultural professionals Anticipated environmental effects include increased landowner producer awareness, increased crop residue less soil erosion and improved water quality

Jan Voit Heron Lake Watershed District hlwd@roundlk net

High Quality Fiber and Fertilizer as Co-Products from Anaerobic Digestion

Joe Harrison, Washington State University; Chad Kruger, Washington State University; Shulin Chen, Washington State University; Craig MacConnell, Washington State University

Abstract: Recently NRCS introduced new technical standards for anaerobic digesters (AD) as a practice to be used for animal waste management Despite many benefits, anaerobic digesters are capital-intensive structures and the typical EQIP cost share offered is inadequate to drive widespread adoption To make ADs more attractive, additional revenues besides methane are needed to improve the feasibility of the technology Additionally, the AD process alone contributes little to reducing manure nutrients Thus, complementary processes are required to meet excess nutrient related environmental issues The goal of this project is to improve feasibility of AD by producing high quality fiber and struvite ($MgNH_4PO_4 6H_2O$) The high quality fiber can be sold as a substitute for peat moss while the struvite, produced through precipitating P and N from liquid manure by adding Mg ions, can be used as a slow-release fertilizer These two co-products will 1) facilitate export of excess nutrients off farms, 2) creating additional revenue streams to provide adequate returns on investment for ADs, and 3) enhance both the economic and environmental sustainability of dairy farms across rural America The specific objectives are to: (1) establish fiber quality criteria and evaluate the fiber products from existing AD, (2) evaluate management practices and modify designs that improve the quality of AD fiber in order to satisfy high-value markets, (3) demonstrate and improve the struvite production process from the AD effluent, (4) conduct market and cost/benefit analysis of the fiber and struvite co-products in addition to methane, and (5) disseminate the technology and information

Chad Kruger, Washington State University, cekruger@wsu edu

Irrigator Pro Incentive Program

Lesia Irvin, Georgia Soil and Water Conservation Commission

Abstract: Next to land available water for crop irrigation is arguably the most important natural resource in production agriculture Irrigation in peanuts cotton and corn has stabilized crop yield and quality thus reducing farmer risks and sustaining farm income and survivability However, farmers must better manage irrigation scheduling to ensure sustainability Increasing demand for water resources, coupled

Attachment 11

Poster Presented at SWCS Conference

Field Scale Evaluation and Technology Transfer of Economically, Ecologically Sound Liquid Swine Manure Treatment and Application Systems

Paul Walker, Rob Rhykerd, Tim Kelley, and Ken Smiciklas, Illinois State University

Introduction: For swine feeding operations, 97.3% of all produced manure is land applied (1) and the composition of major nutrients in manure, nitrogen (N) and phosphorous (P), do not match the nutrient requirements for crop production (2), contributing to non-point source pollution (NPS). To respond to these concerns, the USEPA is encouraging (through regulation) change from the current practice, which almost entirely relies on direct land application to integrated treatment methods for manure management of CAFOs (3).

In order to treat slurry efficiently, economically, and in an environmentally responsible manner prior to disposal, application of modified traditional municipal wastewater treatment technologies to slurry may be considered. Mechanical screening of animal wastes for solids separation has been extensively researched (4, 5, 6, 7, 8). The Livestock and Urban Waste Management (LUW) Team has developed a successful systems approach to manure management (Box 1) that couples polymer assisted separation of liquid manure (PAS) with composting (9, 10). PAS consistently removes more than 95% of the solids and 90+% of phosphorus from liquid manure. The solids fraction is composted and can be sold off-farm or transported longer distances for crop-land application (11). The separated effluent is stored in holding tanks for subsequent land application. This direct utilization of the liquid fraction is advantageous because it is simple, has a low application cost, and allows for a direct use of N (12). Most importantly, this adaptive management technology changes the N:P ratio in unprocessed slurry from 4:1 to 11-15:1 in the separated effluent (13). A N:P ratio of 12-15:1 is reflective of the N:P ratio required by most plants during the growing season, thereby minimizing environmental concerns regarding P contamination. At current flow capacities, the cost to separate slurry into its solid and liquid components is 0.17¢ per L⁻¹ (LUW Team, 2005 unpublished data). Combining separation and irrigation, the separated effluent could be land applied for 0.20¢ L⁻¹, similar in cost to current injection methods for raw slurry with reduced potential for odor during application and less NPS pollution (14).

Box 1: Systems approach to manure management developed by the LUW Team.

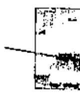
Manure is collected from a CAFO

Solids and liquids are separated using PAS

Solids are composted

Separated effluent

is stored



Separated effluent is irrigated by center pivot

or subsurface irrigation

"Drainage management" is a concept of draining water from fields and irrigating through a controlled underground tile system. The drainage management concept allows farmers to raise or lower the water table in a field as conditions warrant (Figure 1). The LUW Team has modified this technology and has recently begun pumping separated effluent through a drainage management system to provide nutrients for plant growth. Separated effluent may be used with the sub-surface irrigation system because 90+% of the solids and P have been removed and the effluent will not clog tile pores. Agrem Marketing LLC has designed a subsurface drainage management system that utilizes a computer software program to collect precision data from GPS units to regulate water (or separated effluent) flow. Applying separated effluent via subsurface irrigation should eliminate odors associated with land application of raw slurry, lower the cost of application (similar to surface irrigation) and reduce NPS pollution by targeting areas of nutrient need and application, and collecting drainage water in a reservoir for reuse.

This study was funded by the USDA-CIG program to evaluate the potential value of this systems approach under field conditions at production scale and transfer this technology to the private sector via a variety of outreach activities directed towards grain farmers, livestock producers, extension specialists and government agency staff.

Figure 1. Schematic diagram of the controlled drainage system. During wet periods, water is drained into a reservoir. During periods of drought the water can be pumped from the reservoir back into the field to irrigate crops. The LUW Team has modified this system to pump separated effluent from a slurry store (not shown) into the root zone (approximately 50 cm depth), which provides water and nutrients for crop growth. Diagram provided by AGREM Marketing LLC.

Innovation: This project is innovative in that it is the first time a controlled drainage system has been coupled with polymer assisted separation and subsequent subsurface irrigation of the resulting separated effluent to decrease odor and NPS pollution.

Project objectives: The specific objectives of this study are to:

1. Demonstrate and evaluate under production scale conditions new or improved adaptive management practices (AMP's) for slurry application that singularly or in combination result in reduced NPS pollution and improved water quality.
2. Develop educational materials, offer workshops/field days and provide outreach activities to inform farmers, educators (extension specialists, government agency staff, etc.), and the general citizenry of BMP's to reduce NPS pollution originating from the land application of manure.

Materials and Methods: Four plots are being used to demonstrate a corn/soybean rotation treated with the equivalent of 200 kg N ha⁻¹ from (1) separated effluent (SE) applied by center pivot irrigation (16 ha), (2) effluent applied through subsurface irrigation (7 ha) (Figure 2), (3) composted solids (CS) (16 ha) and (4) raw slurry (RS) applied via direct injection (16 ha). Data from these four plots will be compared with a plot receiving the equivalent of 200 kg N ha⁻¹ of N from inorganic fertilizer (IF). All plots, except for the controlled drainage plot, were established prior to the 2006 growing season. The controlled drainage system was established in the spring of 2007. Prior to application in the first year, manure and effluent samples were collected and analyzed for selected elements. Soil parameters will be measured yearly to determine the influence of treatment application on key soil elements. At physiological maturity, selected plants will be hand-harvested from each field, separated into grain and stover, and analyzed for nutrient content. Grain yield will be measured at maturity. Cost analyses will be conducted for two component parts of the manure handling system (separation and land application). Wells and suction lysimeters have been installed (by Illinois State Water Survey personnel) to monitor the subsurface water quality as a function of treatment type. A continuously monitored rain gauge and a rain-water collector have been installed. Analysis of pathogen indicators in untreated and treated slurry, soil, water, and plant samples using standard methods will be conducted. All data will be subjected to ANOVA using SAS and/or SPSS procedures to compare component effluent, compost, soil, water and vegetative parameters. Significance will be determined and reported at P<0.05 levels.

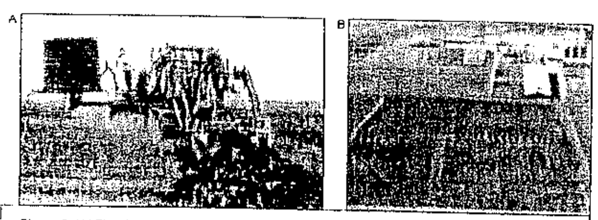


Figure 2. (A) The tile plow installing tile for the controlled drainage system and (B) aerial photograph showing the 7 ha (18 acre) field containing the controlled drainage system following installation. The contour lines show where the tile was installed. Photographs provided by Jay Kiefer, AGREM Marketing LLC.

Results and discussion: Data from the 2006 growing season indicate that separating raw slurry and composting the solids and irrigating with the separated effluent was an economically and environmentally acceptable method of managing manure. The PAS system processed 4,034,156 L of RS resulting in 3,670,985 L of SE and 363,171 L of biosolids. PAS consistently removed solids and phosphorus from liquid manure, resulting in a effluent with a N:P ratio of 20.0:1. Corn grain yield data from the plots were 11,225 kg ha⁻¹ for RS, 11,288 kg ha⁻¹ for both SE and CS, and 12,793 kg ha⁻¹ from the inorganic fertilizer plot. The cost to apply RS was 0.26 ¢ L⁻¹ and SE was 0.26 ¢ L⁻¹. The cost per metric ton of grain harvested from the plots was $6.86 T⁻¹ for RS, $23.44 T⁻¹ for SE, $45.45 T⁻¹ for CS, and $8.45 T⁻¹ for IF. The higher cost associated with CS will decrease in subsequent years because less compost will be necessary to provide the equivalent of 200 kg N ha⁻¹. Additionally the cost associated with SE is expected to decrease in subsequent years as techniques to separate the raw slurry become more efficient.

Outreach: A workshop was held June 28, 2007 at the ISU Farm, Lexington. Invitees included staff from Federal and State Agencies, the Illinois Department of Agriculture, and Illinois Extension. Approximately 25 individuals attended (Figure 3). A survey of the workshop attendees concluded that the event was valuable, informative, and that the research should continue, especially evaluating the effects of separated effluent on groundwater quality. The next outreach step will be technology transfer. Additional field days (workshops) will be held during the 2007, 2008, and 2009 growing seasons with an estimated attendance of 150+ at each field day, which is based upon attendance numbers from previous manure compost field days. Previous workshops have qualified for 1.5 Certified Crop Advisor credits in Soil and Water Management and 0.8 hours in Nutrient Management. The workshops will include formal presentation of project results, along with touring of the ISU swine facilities, slurry treatment process, plots, and AMP fields and discussion of individual AMP outcomes.

As data are collected, educational materials including brochures describing surface irrigation, the controlled drainage system, PAS of slurry, and composting, and guidelines for utilizing separation, irrigation, controlled drainage, and composting to reduce NPS pollution are being prepared. Additionally, crop yield data from the demonstration fields, environmental impacts, and economic analysis of the systems will be summarized in the materials.

A bi-annual email newsletter will be developed to disseminate information to livestock producers, media, and educators. An e-mail database of existing livestock producers will be developed with assistance from livestock organizations. Outcomes and results will be disseminated through the newsletter, and will include other information that relates to composting/manure management.

A web site is currently being designed that will describe this systems approach and provide access to the brochures and newsletters previously described.

Additionally, results from the production scale evaluation will be disseminated in popular press publications, such as Indiana Illinois Agri-News, FarmWeek, National Hog Farmer, Pork Magazine, BioCycle, Prairie Farmer, Manure Management, and Dairy Herd Management. Relevant manuscripts reflecting the scientific results of this project will be submitted to appropriate refereed journals for publication.

Figure 3. Dr. Ken Smiciklas discusses the environmental and agronomic impact of applying raw slurry, manure, and raw slurry to a corn/soybean rotation at the June 28, 2007 workshop.

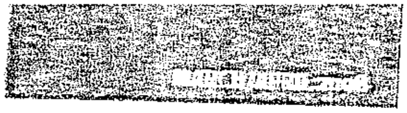
Expected Outcomes: The systems approach described should allow producers to capture the nitrogen component of separated effluent in a more stable form for use as a soil amendment without concern for the phosphorous component. Cost of application should be minimized and the total cost of processing plus application should be comparative to the current practice of raw slurry injection. In addition, the separated solids portion could be either composted or directly land applied for on/off-farm sale/use. The conclusions drawn from this study will be useful for developing and/or modifying regulations governing state livestock waste handling policies/laws, particularly those affecting nutrient load levels in soils and groundwater. The data collected from this study could provide documentation on several technologies' effectiveness to justify their inclusion on the acceptable technologies list for EQIP funding. Results of this project will be disseminated through the Illinois Extension Service and trade journals such as Illinois Farm Week (cir. 86,000), Manure Management (cir. 5,000) and Pork Magazine (cir. 98,000).

Attachment 12

Communication Brief Published in the Journal of Soil and Water Conservation, March/April 2008, Volume 63, Number 2

MARCH APRIL 2008

JOURNAL OF SOIL AND WATER CONSERVATION



JOURNAL OF SOIL AND WATER

VOLUME 63 NUMBER 2

The art and science of natural resource management for sustainability

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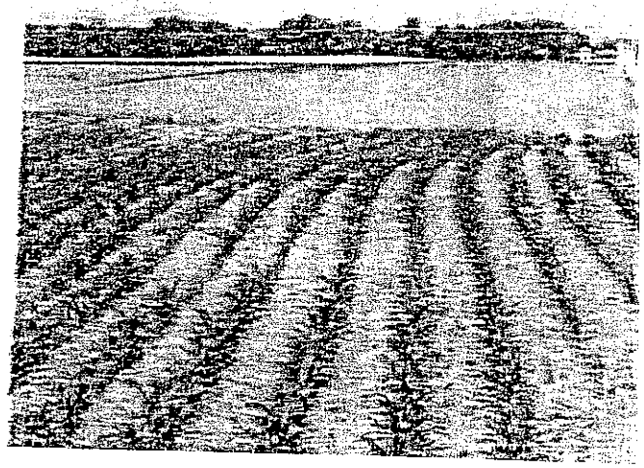


Gypsum may be used as soil amendment to no-tilled soil to reduce run volume and improve water quality related to nutrient runoff, particular where manure has been surface applied.

On the Cover
Tree reflections.
Photo by C Haggerty

INNOVATIONS

An economically and ecologically sound manure treatment and application system

Paul M. Walker and Robert L. Rhykerd

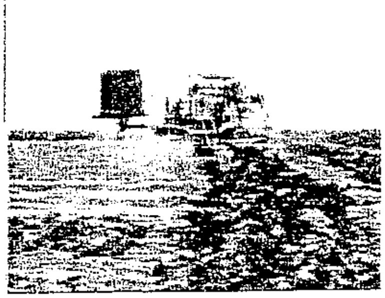
Future operation of concentrated animal feeding operations will require improved waste management strategies following more stringent regulations currently proposed by the US Environmental Protection Agency especially regarding odor and nutrient management The Livestock and Urban Waste Research Team at Illinois State University has developed a systems approach for treating liquid swine manure and land applying the separated effluent that meets these criteria

The solid/liquid separation system removes 98+% of the settleable solids, 98+% of the total suspended solids, 50+% of the nitrogen (N), and 90+% of the phosphorous (P) from raw slurry, and changes the N:P ratio from 4:1 to 20:1. The cost for separation plus irrigation of the separated effluent is less than 1.0¢ per raw gallon of slurry, comparable to current costs for direct land injection of unprocessed slurry The separated solids portion can be economically composted or hauled off-farm for land application Center pivot or surface irrigation is low cost (0.1¢/gallon) but may or may not contribute to nonpoint source pollution A revitalized concept controlled tile drainage has been modified by the Livestock and Urban Waste Research Team to function as a subsurface irrigation system for separated effluent Subsurface irrigation may or may not contribute to nonpoint source pollution

The team is currently comparing land application of separated effluent from swine slurry using (1) a modified underground controlled drainage system to an above ground center pivot irrigation system for separated effluent and (2) direct injection of raw slurry land applied as a soil amendment on nonpoint source pollution

The systems approach that has been developed should allow producers to capture the nitrogen component of separated effluent in a more stable form for use as a soil amendment without concern for the phosphorous component Cost of application should be minimized and the total cost of processing plus application should be comparable to the current practice of slurry injection In addition, the separated solids portion could be either composted or directly land applied for on/off-farm sale/use

The conclusions drawn from the study will be useful for developing and/or modifying regulations governing state livestock waste handling policies/laws, particularly those affecting nutrient load levels in soils and groundwater



Land application of separated effluent fro swine slurry

Paul M. Walker is coordinator of the Livestock and Urban Waste Research Team and professor of animal science and Robert L. Rhykerd is chair of the Department of Agriculture and professor of soil science at Illinois State University, Normal, Illinois.

Attachment 13

Invitation Letter to Liquid Swine Manure Separation Workshop

ILLINOIS' FIRST PUBLIC UNIVERSITY 150 years 1857-2007

DEPARTMENT OF AGRICULTURE • COLLEGE OF APPLIED SCIENCE AND TECHNOLOGY
Campus Box 5020 • Normal IL 61790-5020
Telephone: (309) 438-5654 • Facsimile: (309) 438-5653

May 18, 2007

Dear _____________:

Please accept this communication as your personal invitation to attend a Liquid Swine Manure Separation Workshop. This workshop is designed exclusively for agency directors, and commodity organization staff and board members

For the past several years the Livestock and Urban Waste Research (LUW) Team has been investigating solid-liquid separation coupled with irrigation of the separated effluent and composting of the biosolids as an alternative method for handling liquid swine manure. The LUW Team is composed of 14 investigators representing the Illinois State University, University of Illinois, Illinois State Water Survey and Illinois State Geological Survey. This research project has been supported with funding from Illinois C-FAR, IEPA, IDOA-SAGP and the USDA-NRCS-CIG program.

By modifying existing technology previously used successfully by municipalities and agriculture the LUW Team has been able to economically (approximately 1¢:gallon of raw slurry) remove 90+% of the solids and 90+% of the phosphorous from swine slurry. The resulting biosolids (containing 12-18% solids) has been composted for off-farm removal and the separated effluent has been irrigated with minimal odor, at low cost (0.1¢:gallon). This makes the LUW Team system competitively priced with direct injection land application of raw slurry—the current industry routine practice

The research objectives of this project are nearing completion and the technology transfer portion of this project is ready to begin. Planned dissemination efforts include development of a website (SWEETA—Swine Waste, Ecological and Environmental Treatment Alternatives), a bi-annual email newsletter and a series of field days for producers, news media, agency/extension staff and others

Therefore, prior to beginning outreach activities the LUW Team is seeking input from selected entities regarding several issues including who should be the target audience from various government support agencies, how to best reach potential endusers and what questions must still be answered (what research is still needed). One issue we hope this workshop will address is the potential for EQIP funding. Several swine producers have already expressed an interest in using separation technology but have been unable to use EQIP funding to support the acquisition/installation of separation technology.

We look forward to demonstrating this technology and visiting with you on Thursday, June 28, 2007 at the Illinois State University Farm, Lexington The workshop will begin at 9:00 a.m in the Farm Conference Building and will conclude by 2:00 p m Lunch will be provided If you or your representative plan to attend, please RSVP by contacting Paul Walker (pwalker@ilstu.edu; (309) 438-3881) or Robert Rhykerd (rrhyker@ilstu.edu ; (309) 438-8550) We look forward to hearing from you

Yours truly,

Paul Walker
Professor, Animal Science
Coordinator, LUW Team

Liquid Swine Manure Separation Workshop

9 am – 2:00 pm, June 28, 2007

Illinois State University Farm, Lexington

RSVP by June 20, 2007

To reserve your spot, complete the following and return this self addressed form by folding and stapling prior to mailing.

Your Name: ______________________________________

Address:

e-mail:

phone:

☐ Yes, I will attend

☐ No, I will be unable to attend

Or RSVP by e-mail or phone to:

Paul Walker (pwalker@ilstu.edu, 309-438-3881) or

Rob Rhykerd (rrhyker@ilstu.edu, 309-438-8550)

LIQUID SWINE MANURE SEPARATION WORKSHOP

June 28, 2007

Time		
8:30 – 9:00	REGISTRATION (Conference Center)	
9:00 – 9:10	WELCOME	Jeff Wood, Dean
9:10 – 10:30	TOUR FACILITIES	
	- Separation	Paul Walker
	- Compost Site	Paul Walker
	- Irrigation of Separated Effluent	Paul Walker
	- Subsurface Irrigation	Mark Miller
	- Field Trials	Walt Kelley
	- Plots Trials	Ken Smiciklas
10:30 – 10:45	BREAK (Conference Center)	
10:45 – 12:00	POWERPOINT PRESENTATIONS	
	- Separation Data	Paul Walker
	- Subsurface Irrigation	Mark Miller
	- Ground Water Analyses	Walt Kelley
	- Secondary SE Treatment	Blake Anderson
Noon – 1:00	LUNCH	
1:00 – 2:00	POTENTIAL DISCUSSION TOPICS	
	- EQIP Eligibility	
	- Illinois Fertilizer Act (exempt?)	
	- Additional Research Required	
	- Technology Transfer (Best Methods)	
	- Other Issues	

ILLINOIS STATE
UNIVERSITY

LIQUID SWINE MANURE SEPARATION WORKSHOP
Evaluation
6.28.07

Please place an "X" in the column of your choice:

	Strongly Agree 6	Agree 5	Somewhat Agree 4	Somewhat Disagree 3	Strongly Disagree 2	No Opinion 1
1 The purpose of the event was well defined						
2 The topics covered relate to your day-to-day activities.						
3 The program was organized in a logical manner						
4. Audio/Visual aids were used effectively						
5 Handouts were useful and informative.						
6 Teaching methods were effective in getting points across, building skills or confidence						
7 The facilities were favorable to learning						
8 The overall atmosphere was helpful to learning and discussion						
9 The afternoon session provided an opportunity to discuss policies related to swine manure application						
10 The investment of your time in attending this event will be beneficial.						

Comments:

12 What did you find to be the most valuable part of today's session?

____

____

____

13 Additional comments

____

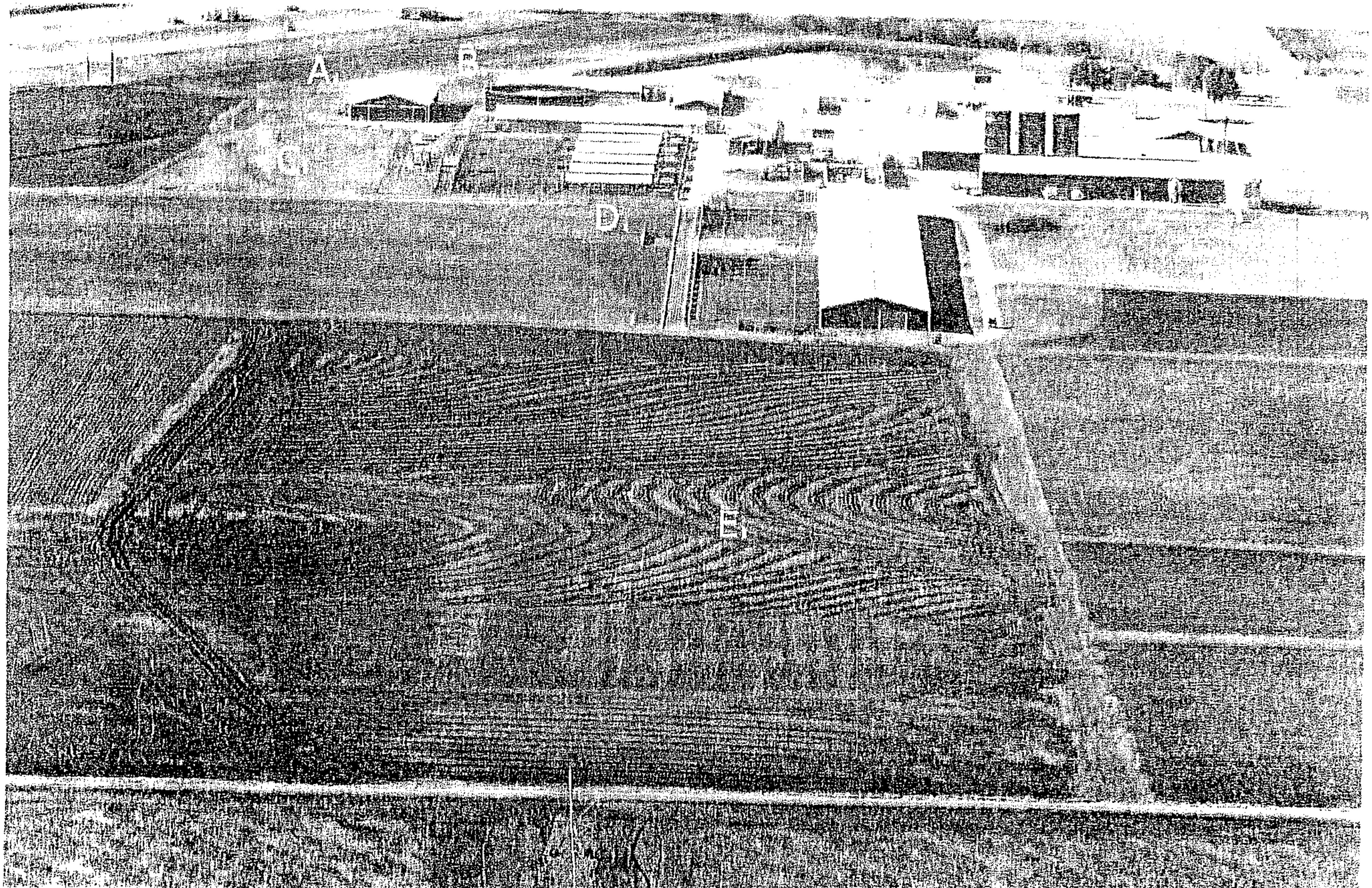
____

Attachment 14

Picture of Waste Handling Facilities at ISU Farm-Lexington

Legend

ISU FARM - LEXINGTON



LEGEND FOR PICTURE OF ISU FARM-LEXINGTON

A = Manure Processing Facility

B = Slurry Store® for Storing Separated Effluent

C = Vegetative Filter Strip for Runoff From Beef Cow Barn

D = Settling Basin for Runoff From Beef Cow Barn

E = Modified Underground Drainage System Will be Used for Subsurface Irrigation of Separated Effluent (17 Acres) (Titles Lines Follow Contour of Surface Landscape)

Attachment 15

Pictures of Separation Equipment

Picture 1: Manure Processing Facility Funded by 319 Grant

Picture 2: Unprocessed Slurry from Swine Buildings Draining into Holding Tank in Manure Processing Building

Picture 3: Stage One: Gravity Separator Removing Settleable Solids and Separated Slurry

Picture 4: System for Adding Polymer to Separated Slurry Prior to Separation Using the Gravity Screen Separator

Picture 5: Stage Two: Gravity Screen Separator Separating Biosolids and Separated Effluent from Separated Slurry

Picture 6: Gravity Belt Separator

Picture 7: Polymer Tanks for the Gravity Belt Separator

Picture 8: Venturi System for Mixing Polymer with Separated Slurry Prior to Separation Using the Gravity Belt Separator

Picture 9: Gravity Belt Separator Removing Separated Effluent from Biosolids from Separated Slurry

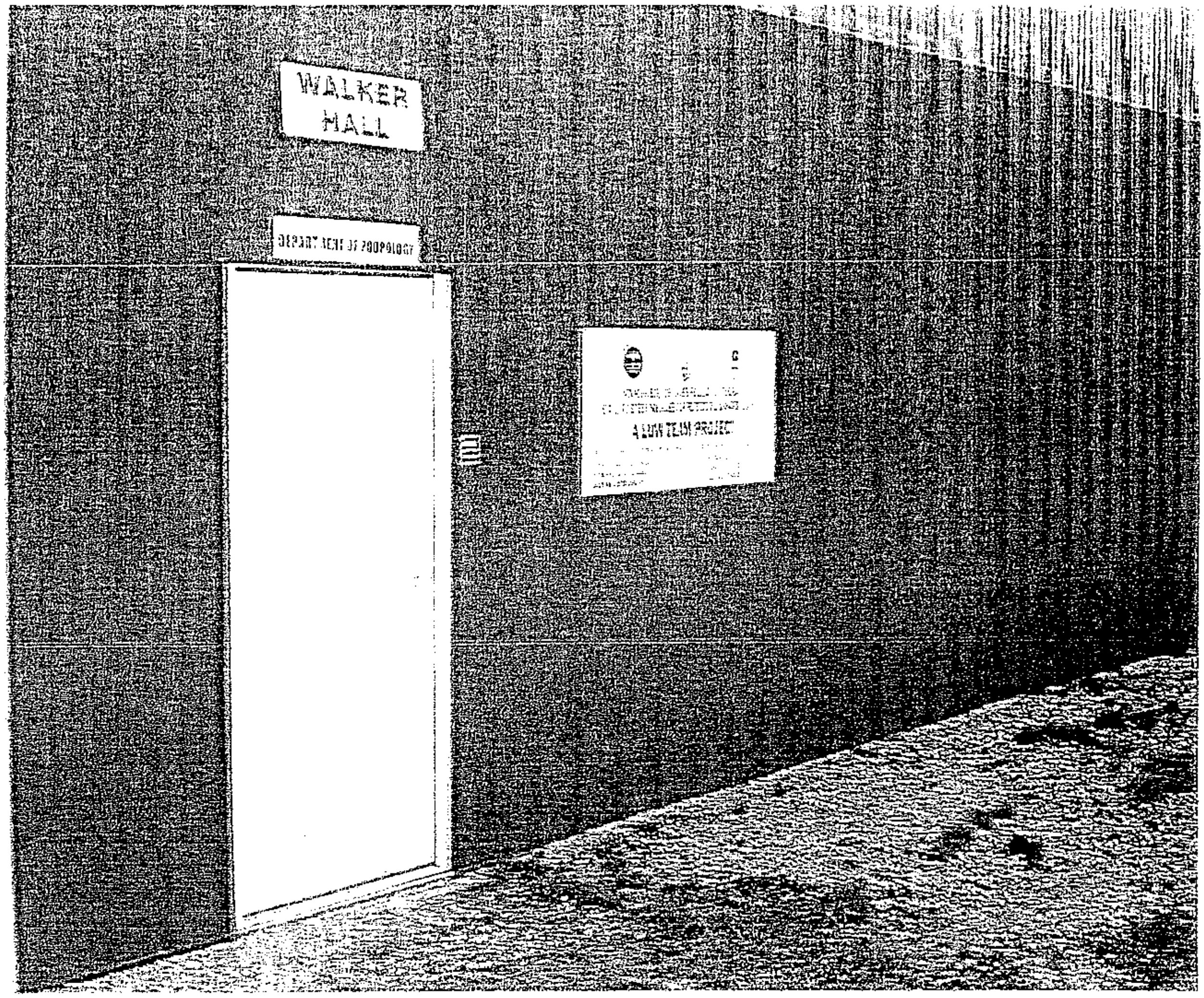
Picture 10: Separated Effluent Produced by Gravity Belt Separator and Gravity Screen Separator

Picture 11: Separated Effluent as Stored in the Slurry Store® Holding Tank

Picture 12: Land Application of Separated Effluent by Center Pivot Irrigation

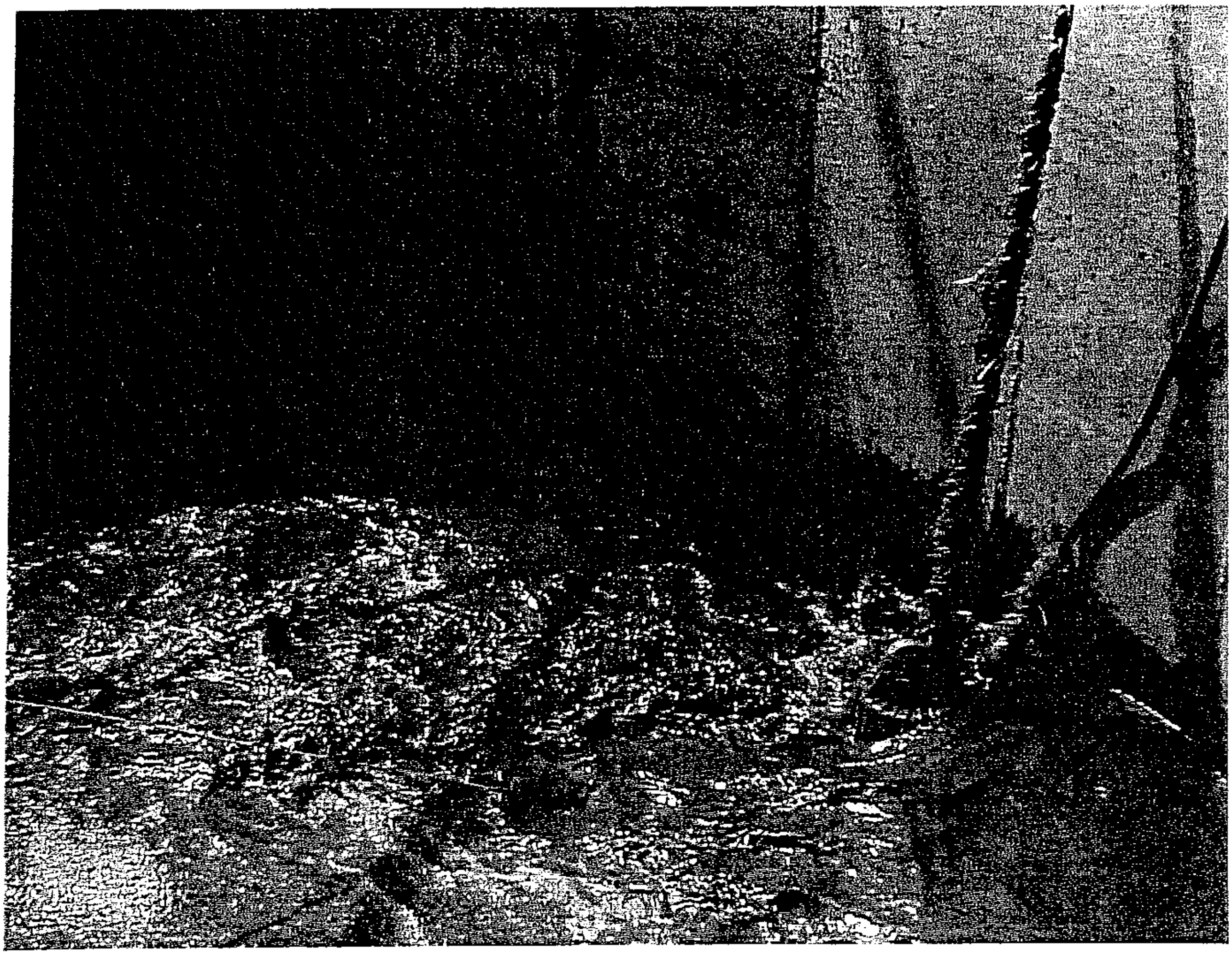
Picture 13: Addition of Separated Biosolids to Landscape Waste for Composting

Picture 1:



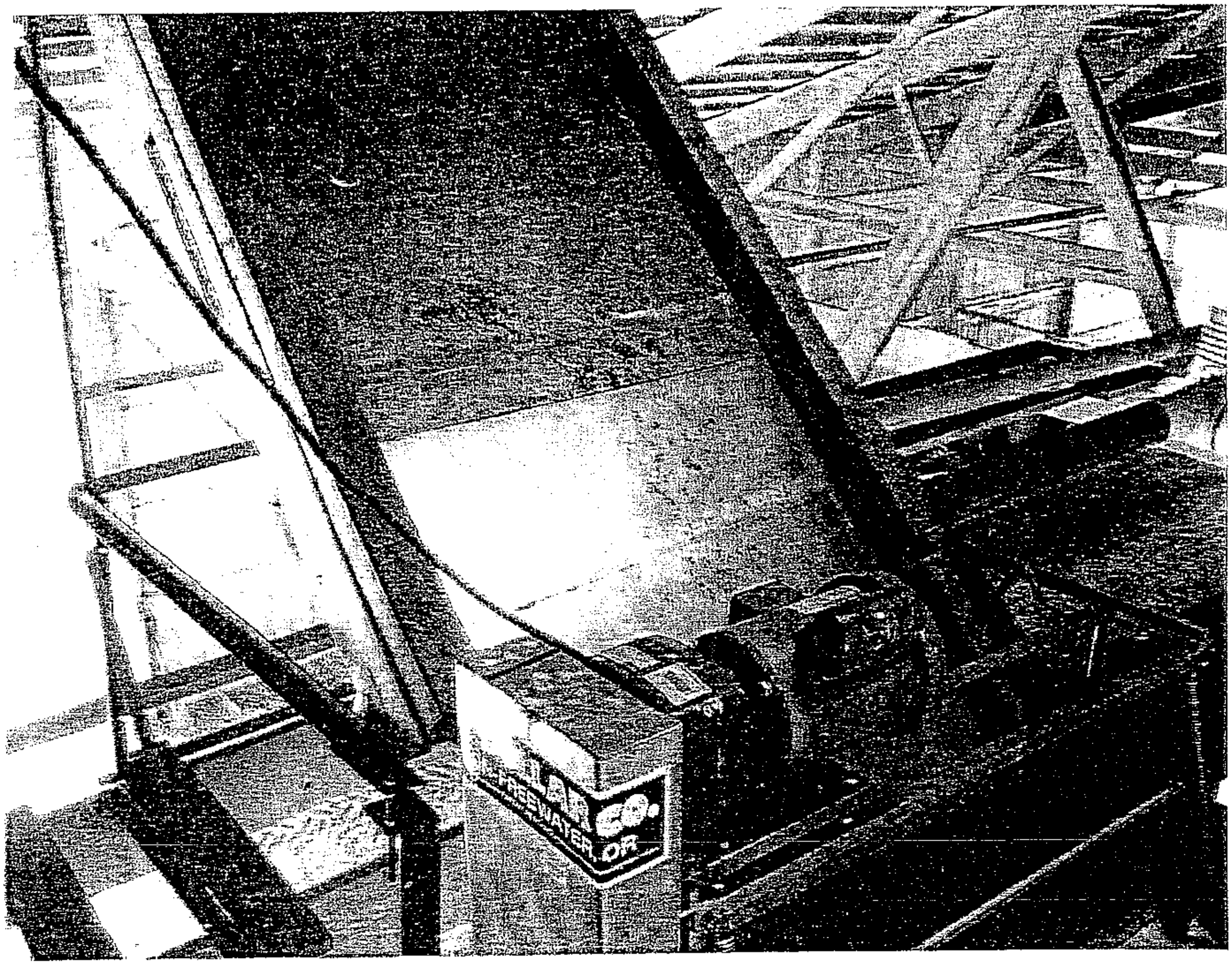
Manure Processing Facility Funded by 319 Grant

Picture 2:



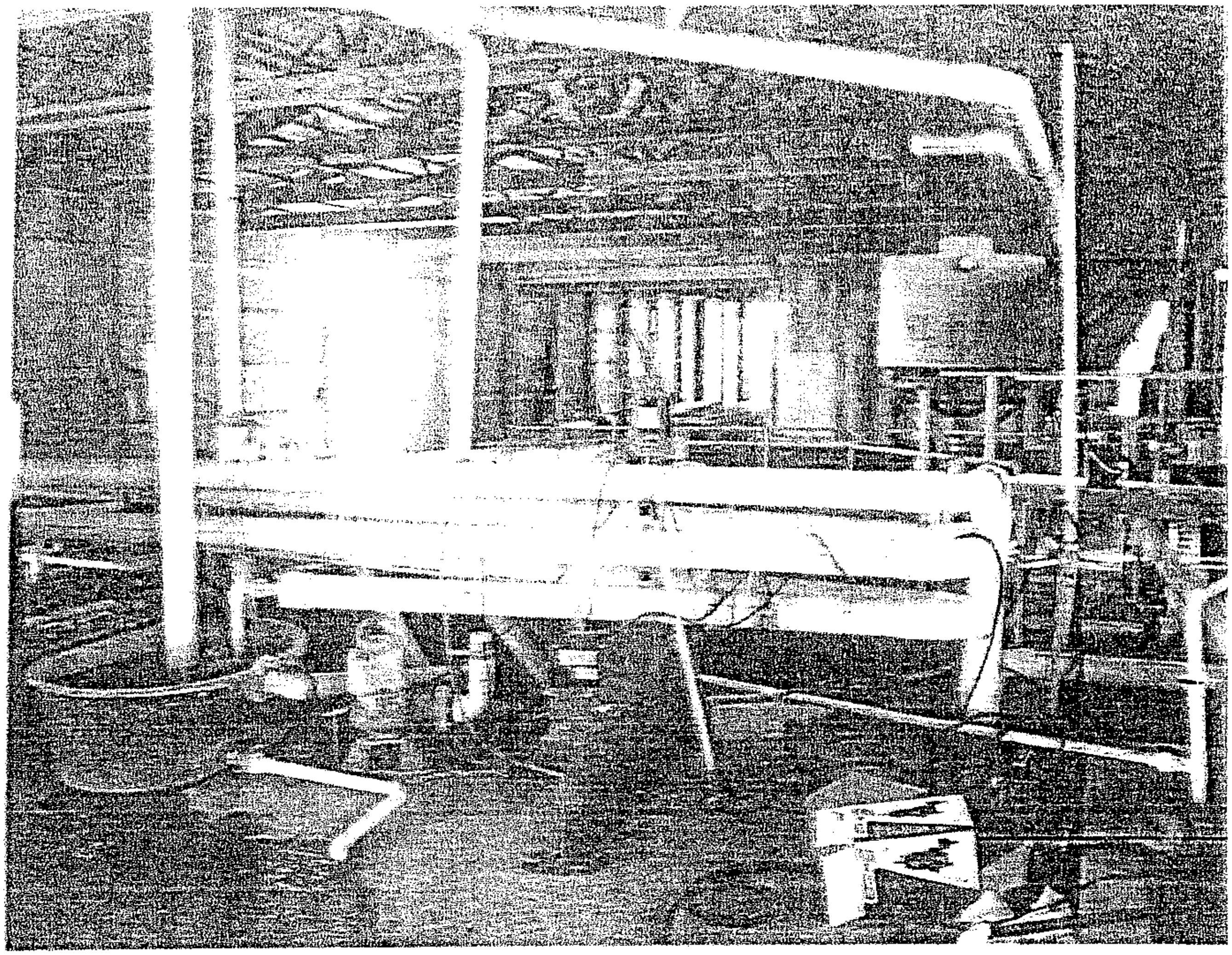
Unprocessed Slurry from Swine Buildings Draining into Holding Tank in Manure Processing Building

Picture 3:



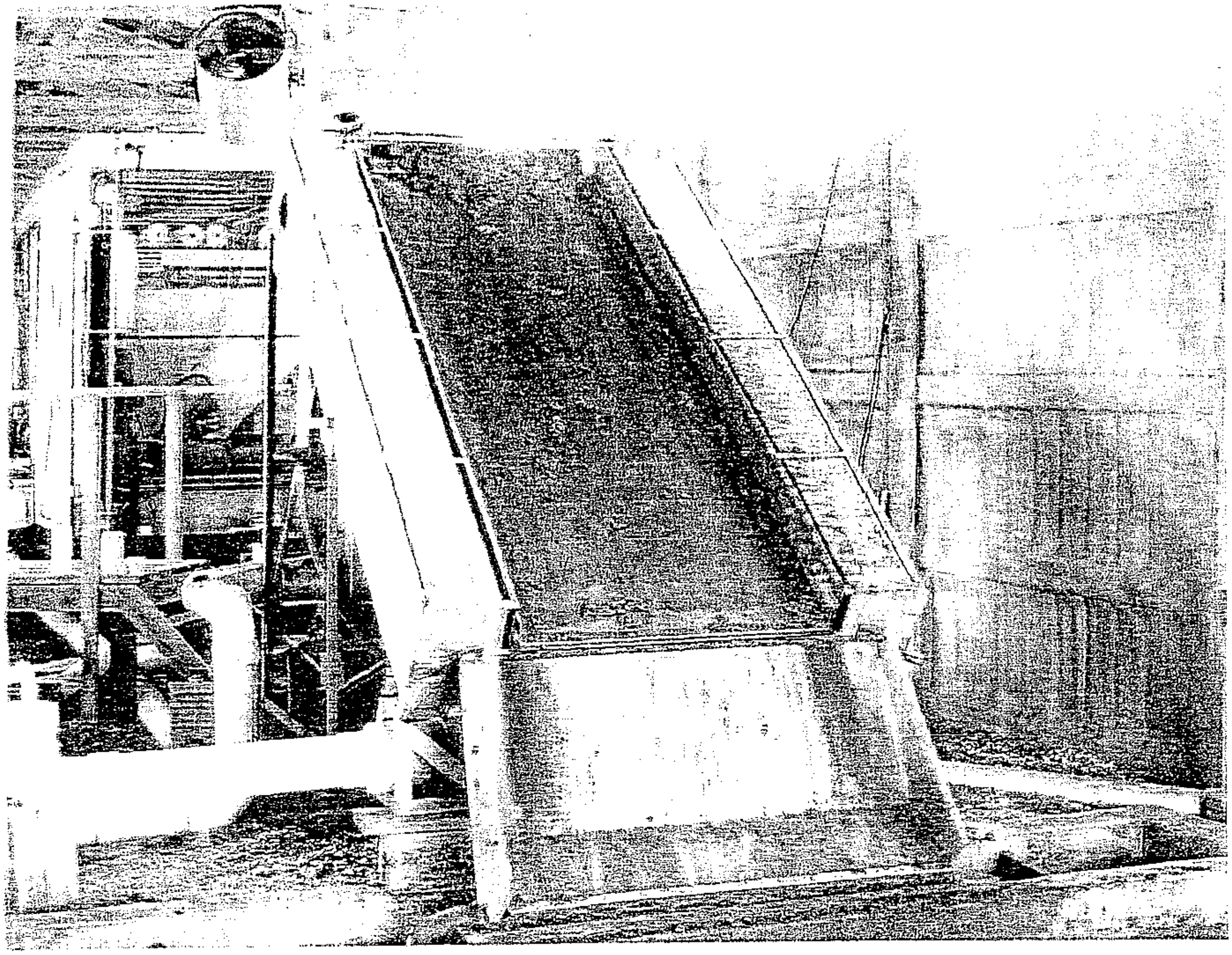
Stage One: Gravity Separator Removing Settleable Solids and Separated Slurry

Picture 4



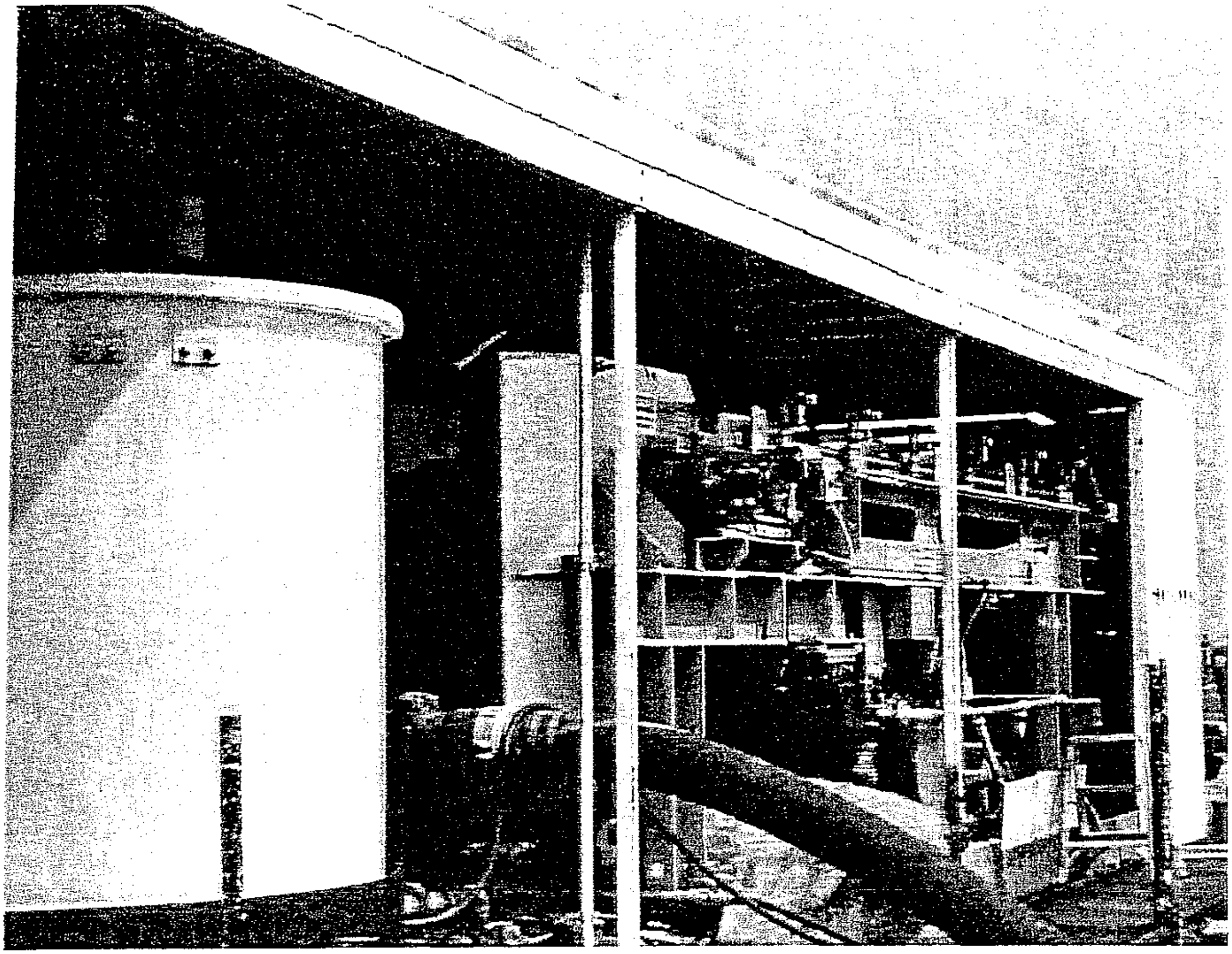
System for Adding Polymer to Separated Slurry Prior to Separation Using the Gravity Screen Separator

Picture 5:



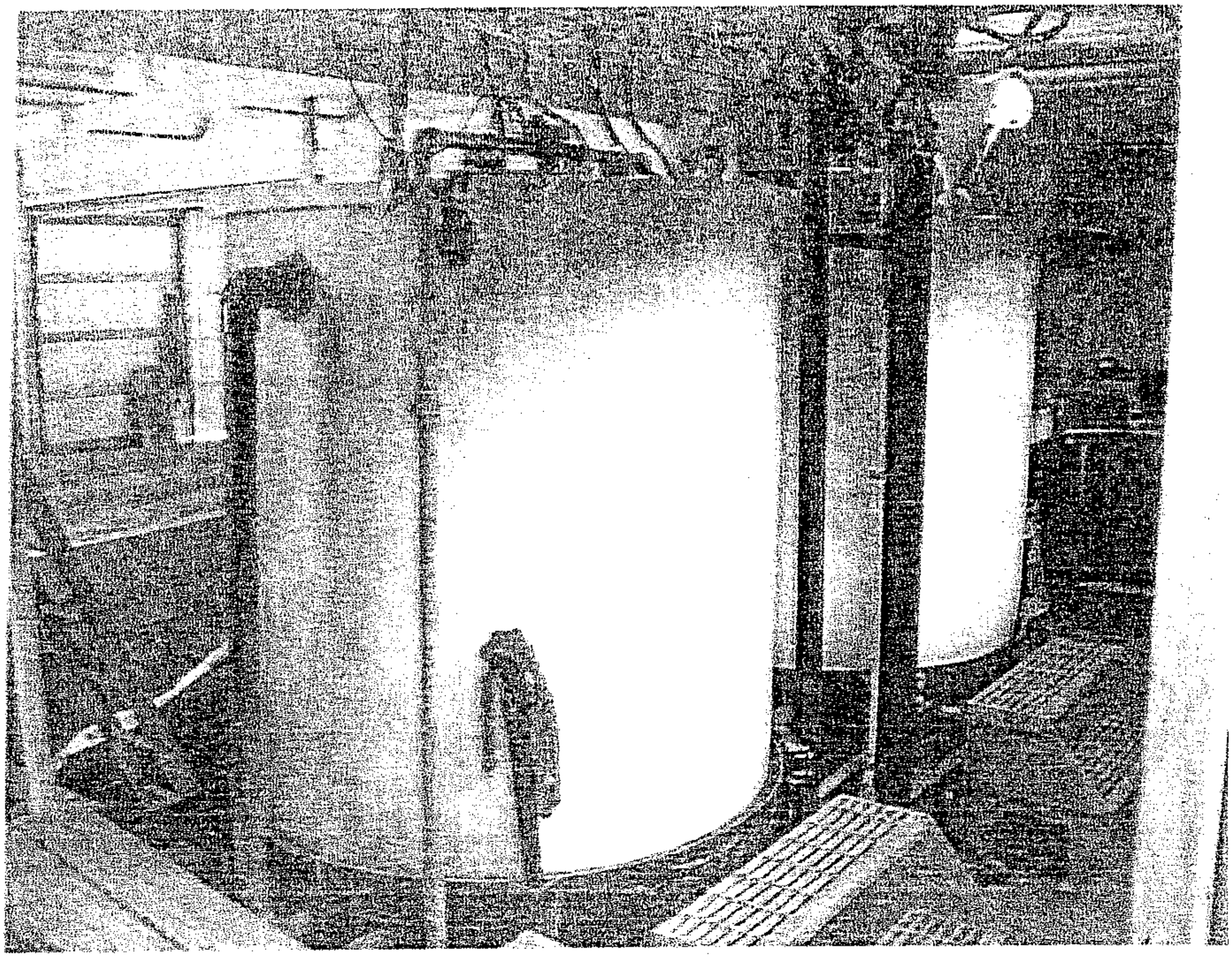
Stage Two: Gravity Screen Separator Separating Biosolids and Separated Effluent from Separated Slurry

Picture 6:



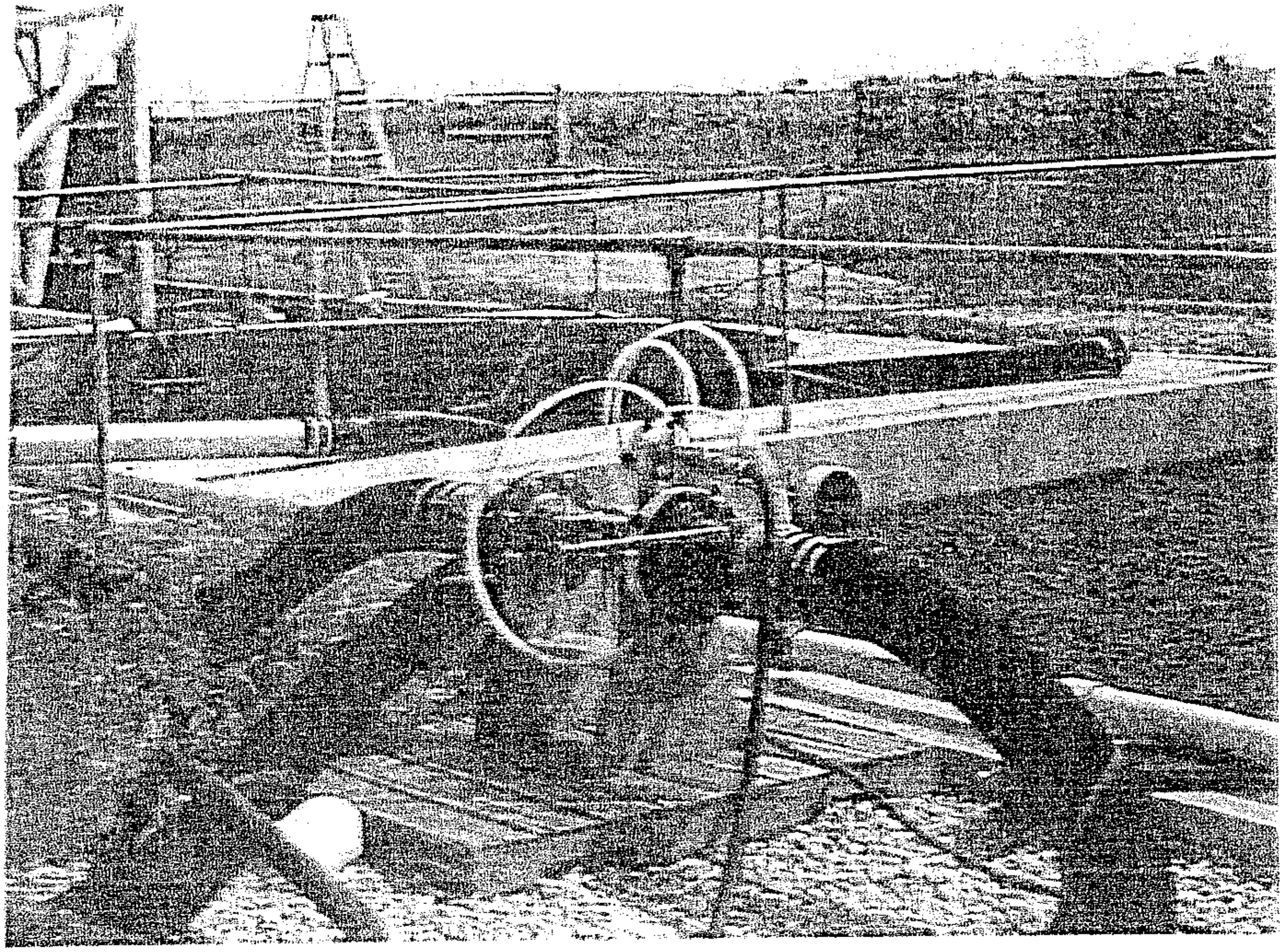
Gravity Belt Separator

Picture 7



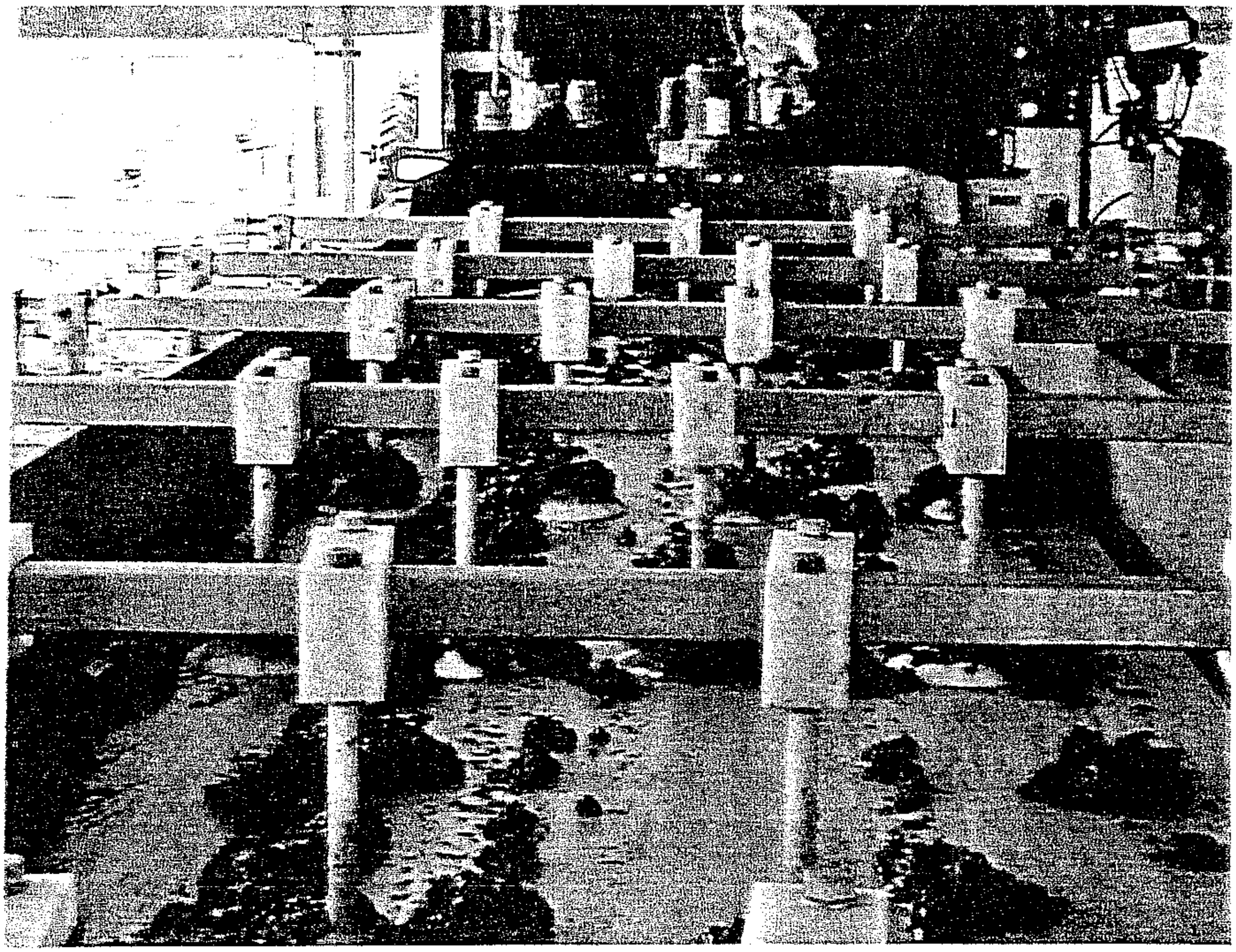
Polymer Tanks for the Gravity Belt Separator

Picture 6



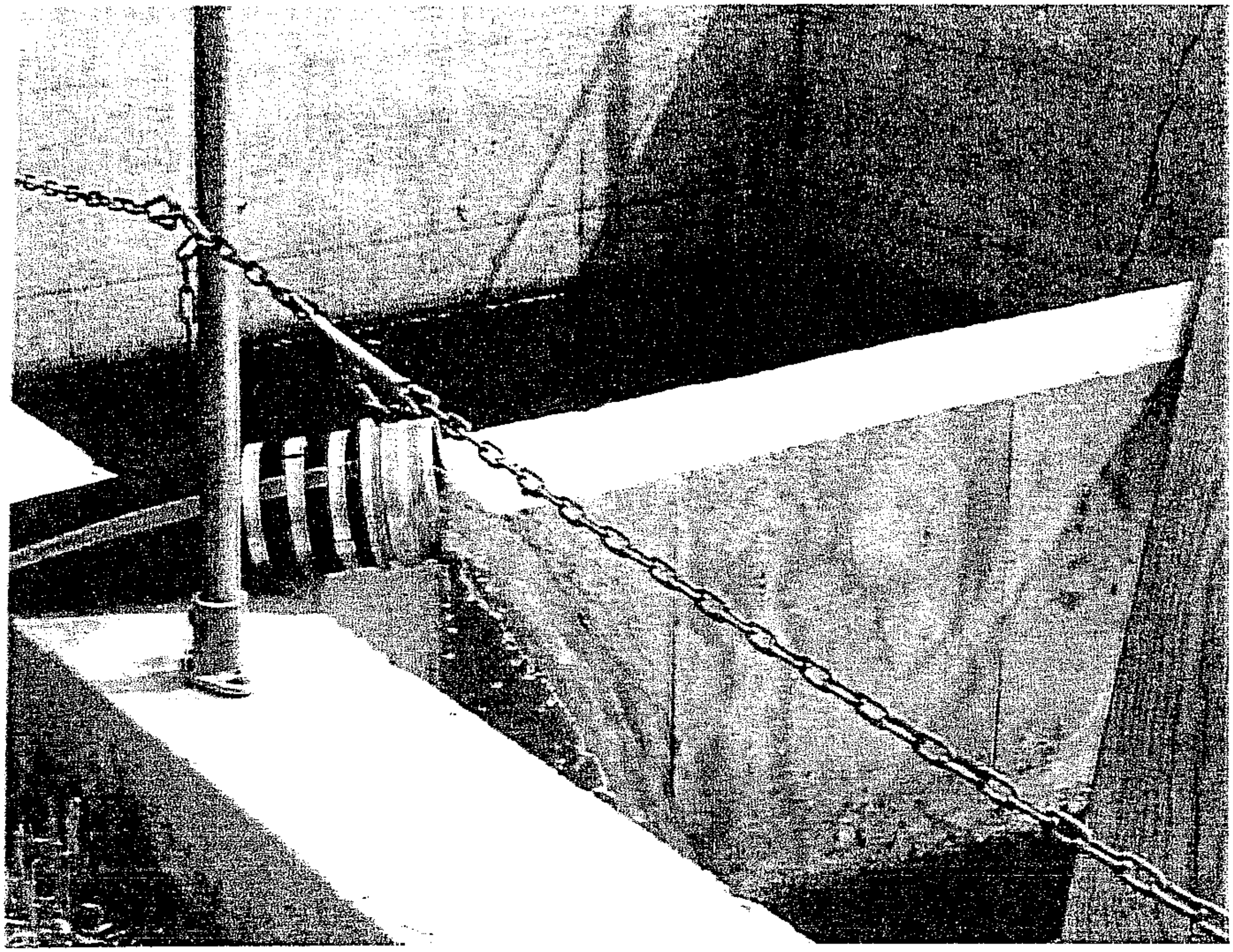
Venturi System for Mixing Polymer with Separated Slurry Prior to Separation Using the Gravity Belt Separator

Picture 9:



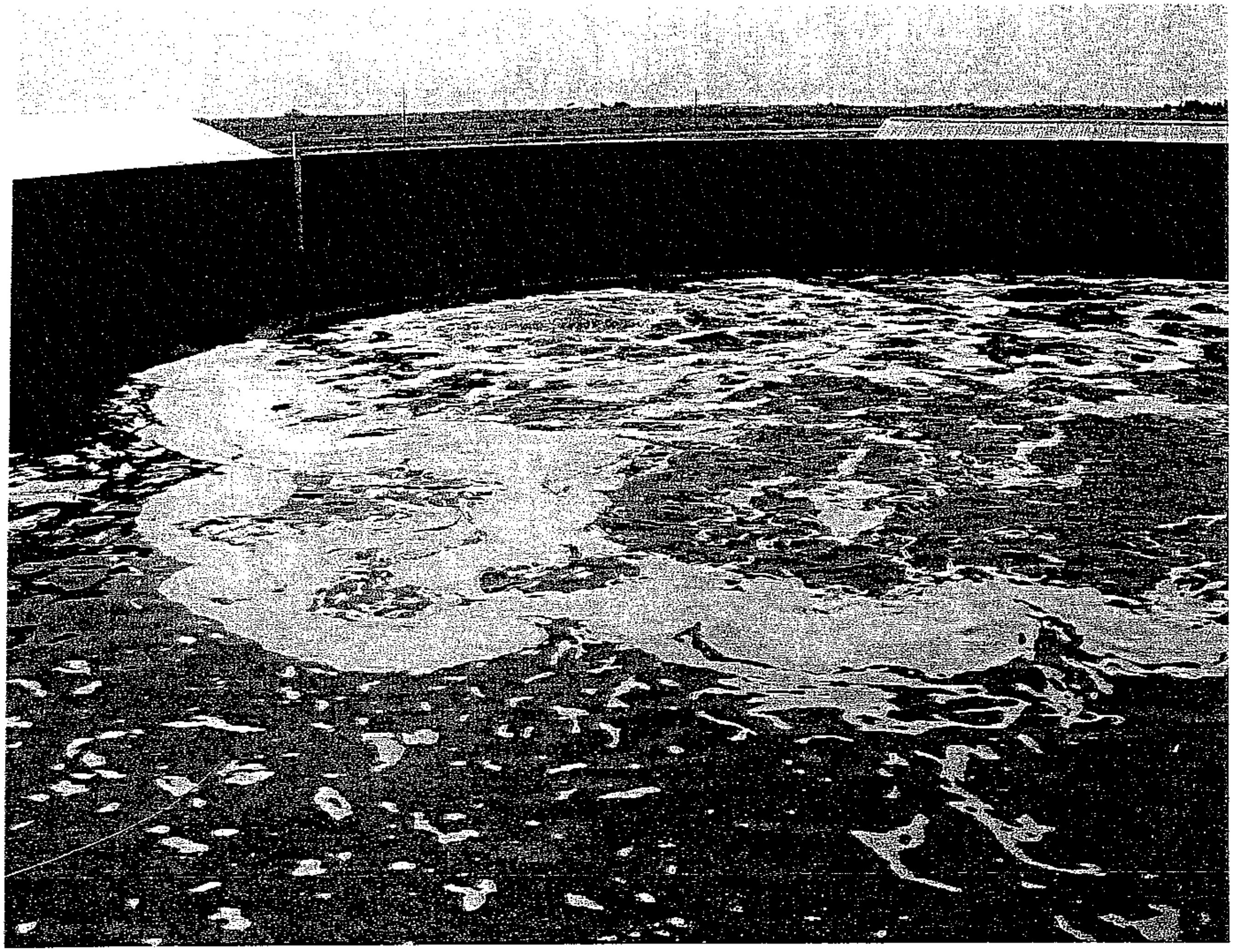
Gravity Belt Separator Removing Separated Effluent from Biosolids from Separated Slurry

Picture 10:



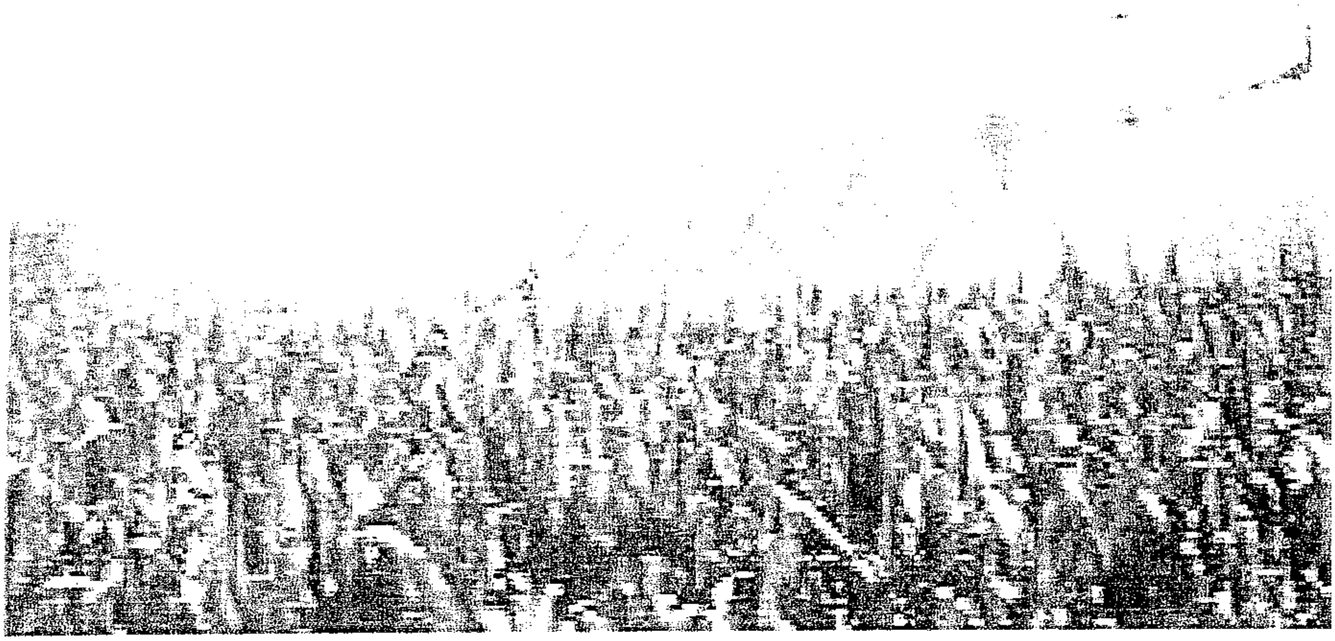
Separated Effluent Produced by Gravity Belt Separator and Gravity Screen Separator

Picture 11:



Separated Effluent as Stored in the Slurry Store® Holding Tank

Picture 12



Land Application of Separated Effluent by Center Pivot Irrigation

Picture 13.

Addition of Separated Biosolids to Landscape Waste for Composting

Attachment 16

Advanced Water and Effluent Management Systems Booklet

From: Rob Kerr [Rob.Kerr@illinois.gov]

Sent: Wednesday, May 26, 2010 3:29 PM

To: Reha, Lynn

Cc: Brian Durham

Subject: ICSPS Intend to Fund letter

Dear Lynn,

The Illinois Community College board intends to fund the Illinois State University-Illinois Center for Specialized Professional Support (ICSPS) in fiscal year 2011 The amount allocated to the ICSPS is $295,000 and includes an indirect cost rate limit of 8% Please note that all fiscal year 2011 funding is contingent upon pending state and federal allocations A reduction in funding may result in commensurate reductions in local program allocations

If you have any questions, please feel free to contact me.

Rob Kerr

Director of Career and Technical Education

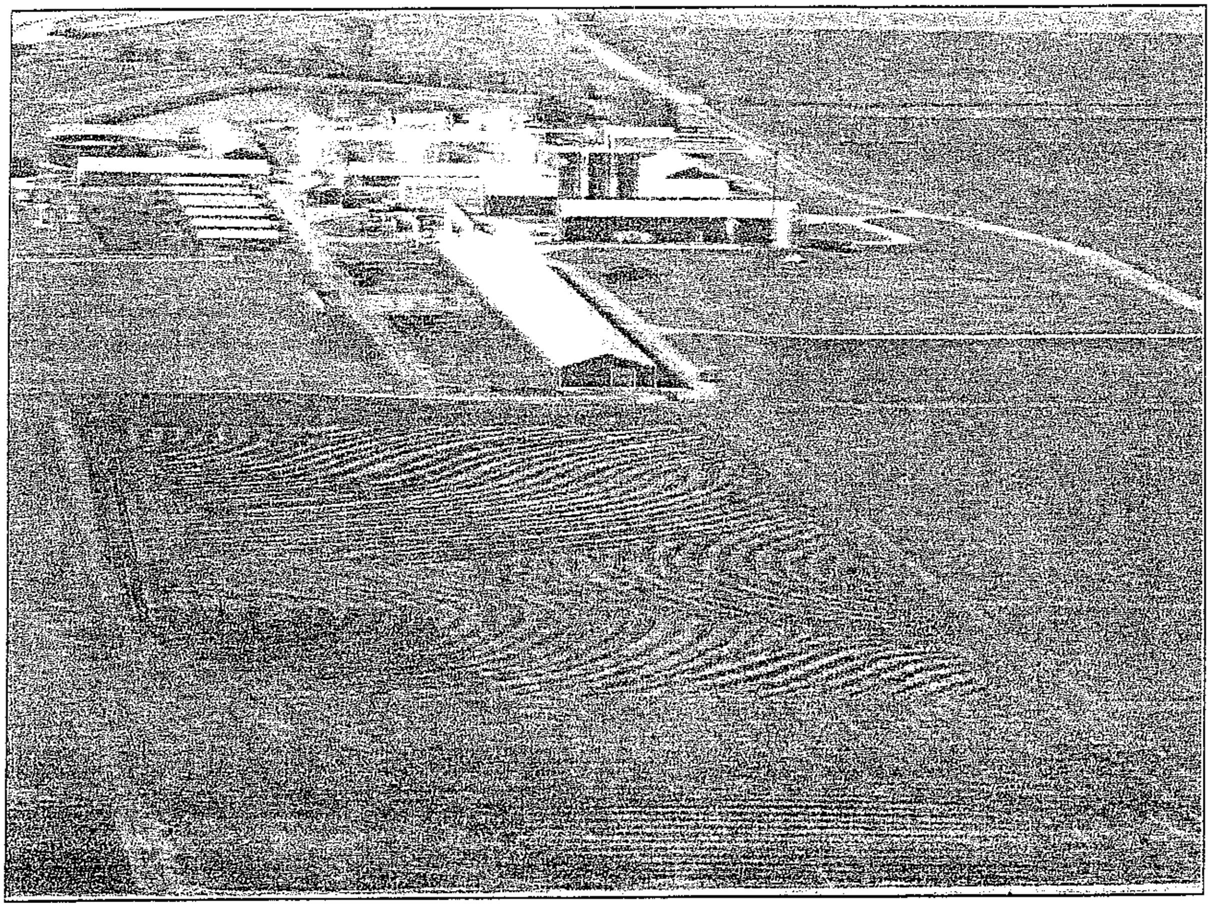
Illinois Community College Board

(217) 785-0068

rob.kerr@illinois.gov

AGREM LLC

AGREM Advanced Water and Effluent Management Systems



AGREM LLC
17122 N 3800 E
Anchor, IL 61720

Contact us at:
1 - 309 - 530 - 9270
1 - 309 - 723 - 3231

Email: agrem@agrem.com
On the web at:
www.agrem.com

This publication was developed with LUW Team assistance, but no USDA, NRCS, CIG funds were used to pay for this booklet Funding to produce this booklet was provided by AGREM LLC.

AGREM LLC

Imagine the possibilities...

Every business owner wants to keep their costs low and maximize their profits. AGREM LLC knows farmers are looking for innovative methods to do just that. AGREM Systems increase yields by giving the farmer control over his own water use. But AGREM goes a step further. AGREM Advanced Water and Effluent Management Systems are environmentally conscience systems that keep your operation green and go a long way towards reducing our "environmental footprint." As environmental issues become more pressing, we all need to consider what we can do to make the side effects of current agricultural practices more positive with respect to our environment. AGREM Advanced Water and Effluent Management Systems play a unique role in enhancing the profitability of farming while keeping waterways clean and usable.

By installing an AGREM system, you too will play an important part in making agriculture both profitable today and for future generations.

Who We Are

Robert Meiners started AGREM in 1984 as a computer software company geared towards the unique requirements of farmers, farm managers, and landowners. Since then, AGREM has expanded its services and developed software that incorporated new GIS technology making AGREM one of the first firms to provide precise, user friendly mapping software. By 2000, AGREM's GIS software had become the leading design system for the installation of systematic and grid tile drainage systems. Just after the turn of the 21st century, AGREM again expanded its product line and began offering contoured drainage, subirrigation, and effluent management systems. Also at this time, AGREM was incorporated, becoming AGREM LLC. AGREM LLC's product lines are custom designed to help farm operations become more environmentally friendly while keeping costs low and maximizing profits. Because AGREM Systems are custom designed, each system is unique and geared to meet your needs. We at AGREM work with you to design a system that works best for you.

Your continued growth is our success.

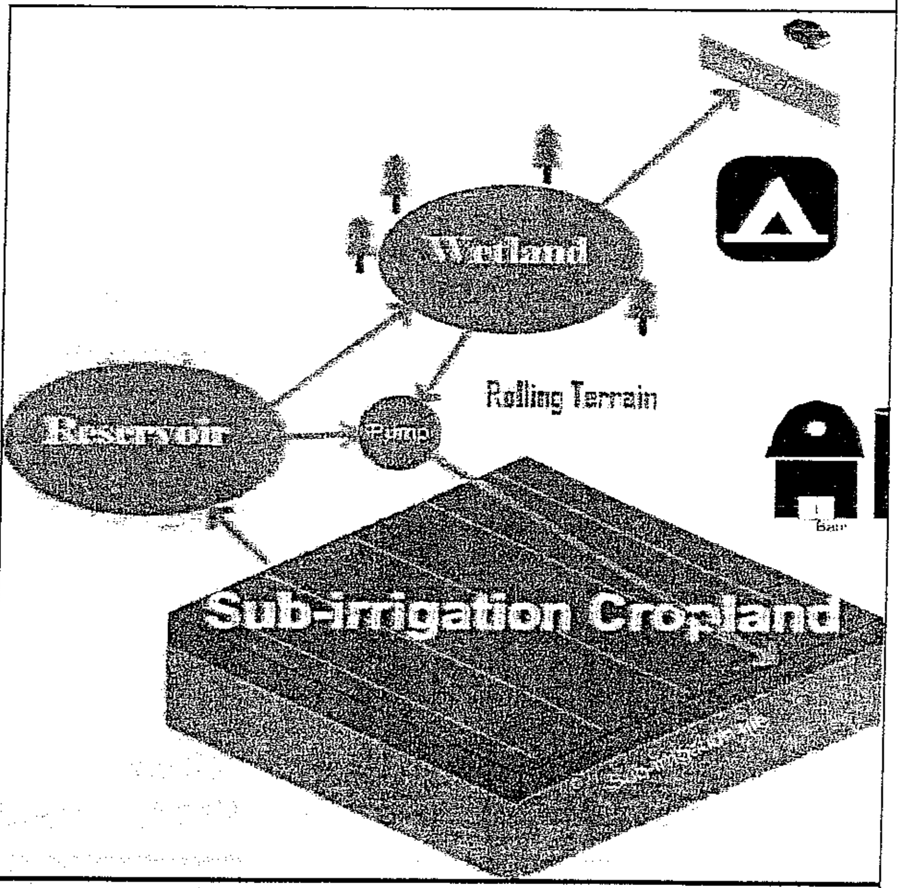
Company Profile

Bob Meiners - President and CEO

Bob's background in agriculture began as a child living on the M & W Gear Company family farm. Growing up around innovation impressed on Bob the need for continued progress as a means of ensuring agriculture's viability for the future. Considering this background, it is no surprise that as president of AGREM LLC, Bob is still actively involved in creating products that keep agriculture profitable

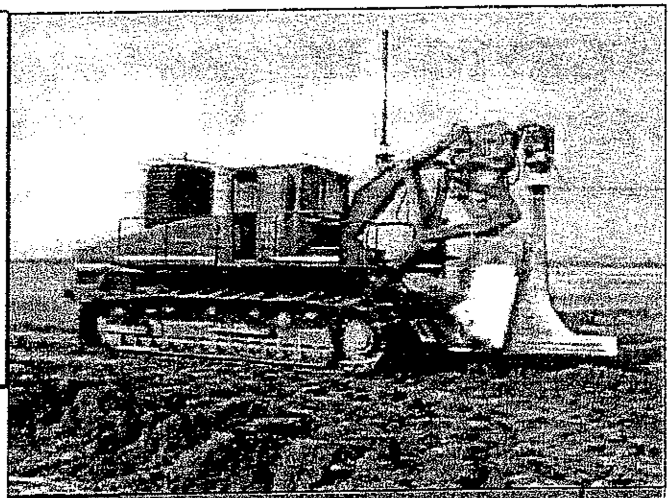
AGREM LLC: Your Partner in Water and Effluent Management

AGREM LLC specializes in creating custom systems for the unique needs of the modern farmer. In designing our systems, we focus on making a water and effluent management system that will best suit the demands of your operation. We will create a system for you that generates the greatest profit at the lowest possible cost. We will further strive to design a system that will be environmentally sustainable, due to rising concerns over how past agricultural practices have been negatively impacting our environment and the livelihood of our children. AGREM LLC believes that the best way to make agriculture sustainable today and in the future is by investing in new technologies that generate greater profits for farmers while reducing environmental costs of air and water pollution. We provide such systems.



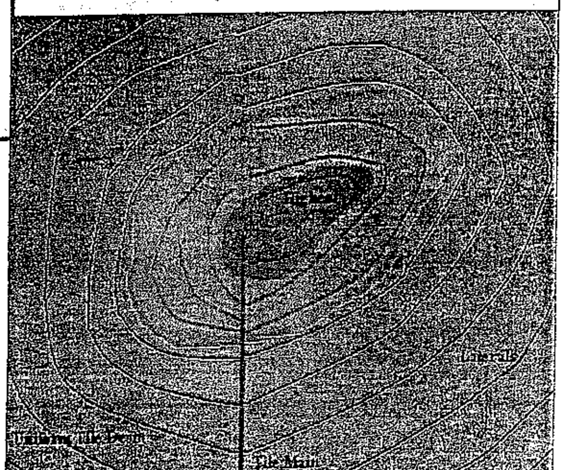
When you decide to work with AGREM LLC, you have chosen a partner that will work towards making you a profit today, tomorrow, and for generations to come.

AGREM
Contoured Drainage Systems



AGREM offers the latest in field tile drainage design, the AGREM Contoured Drainage System. Unlike systematic or grid tile drainage designs, AGREM Contoured Drainage Systems are designed according to your field's topology. By placing tile along the contours, our tile intercepts the flow of water in your field, thereby maximizing the effectiveness of the tile installed in removing excess water. Additionally, AGREM Contoured Drainage Systems can be upgraded to AGREM Controlled Drainage Systems or AGREM Subirrigation Systems, allowing for long term expansion of your water management needs.

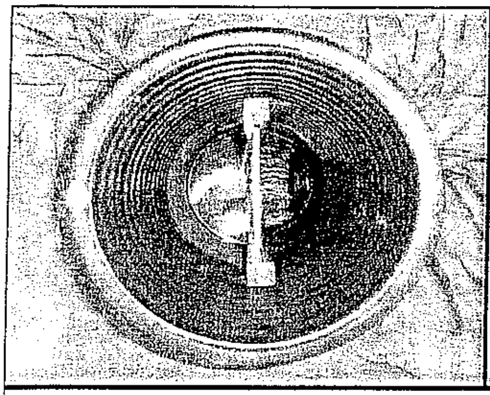
System drainage designs, as pictured above, place laterals without respect to your field's topology.



AGREM Contoured Drainage Systems as pictured above, are designed to the topology of your field

YOUR BENEFIT:

- Superior drainage
- Custom designed to field
- Uniform tile depth
- Intercepts water flow
- Reduced surface erosion
- Upgrade potential

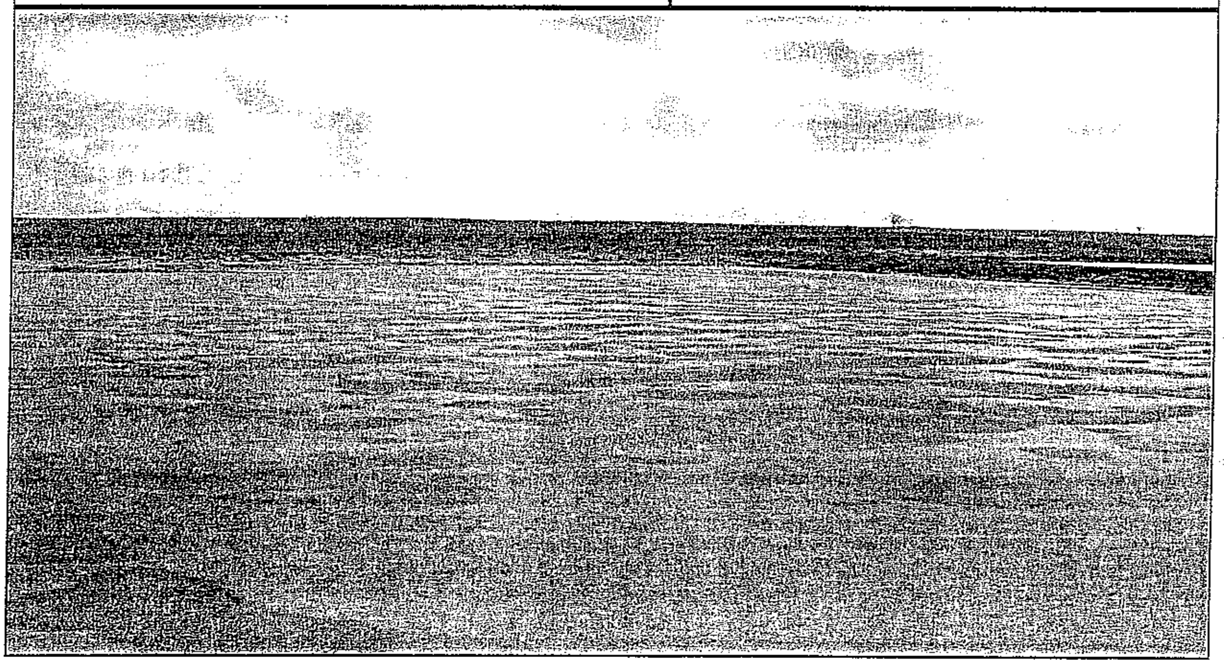


AGREM
Controlled Drainage Systems

Rising concerns over nitrogen runoff and the growing hypoxia problem threaten to jeopardize farmers' historic rights to install tile drainage. AGREM Controlled Drainage Systems, however, offer farmers the ability to reduce and control their nitrogen runoff. By applying control gates to the AGREM Contoured Drainage System, nitrogen can be retained on field and blocked from entering waterways. The installation of a reservoir or constructed wetland enables an additional check on nitrogen runoff, as well as creating an ideal habitat for migratory birds and fresh water aquatic life.

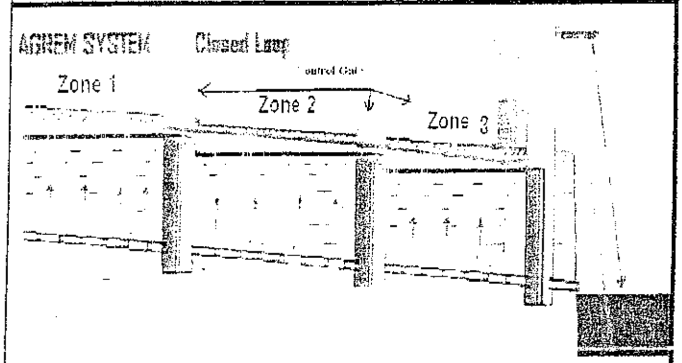
YOUR BENEFIT:

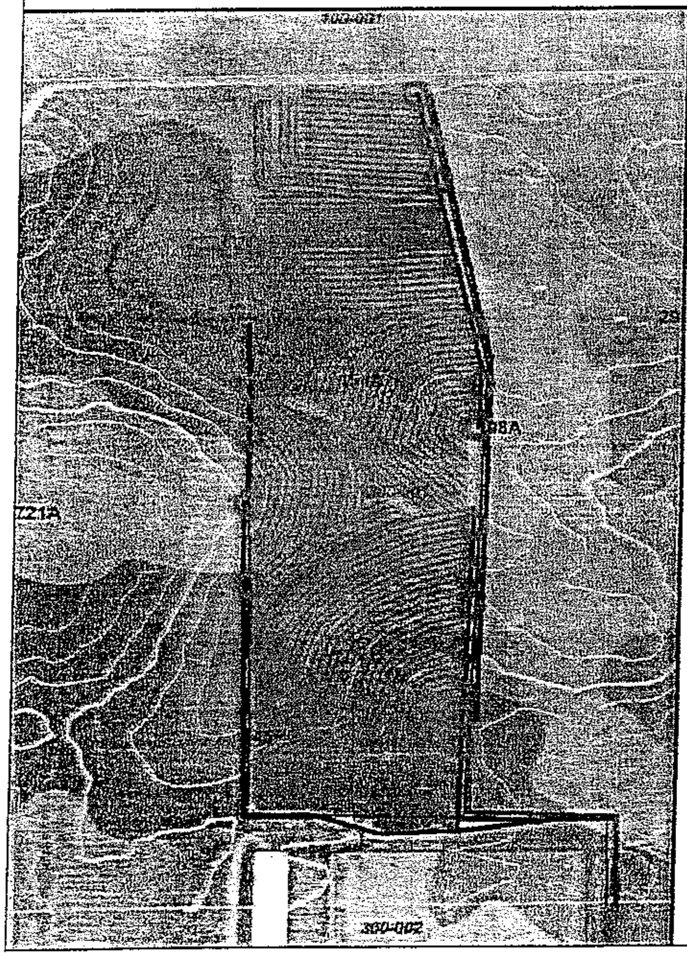
- Reduced nitrogen runoff
- Environmentally friendly
- Creates wildlife habitats
- Superior drainage
- Uniform tile depth
- Upgrade potential
- Can be applied to AGREM Contoured Drainage Systems



AGREM

Subirrigation Systems





The Ultimate Solution to Water Management.

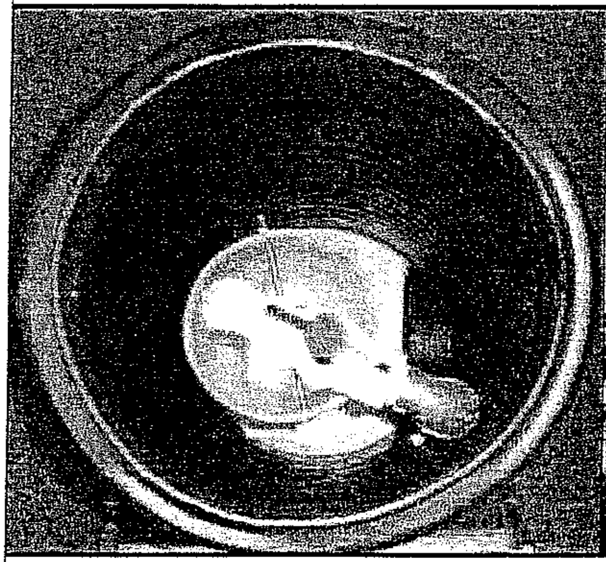
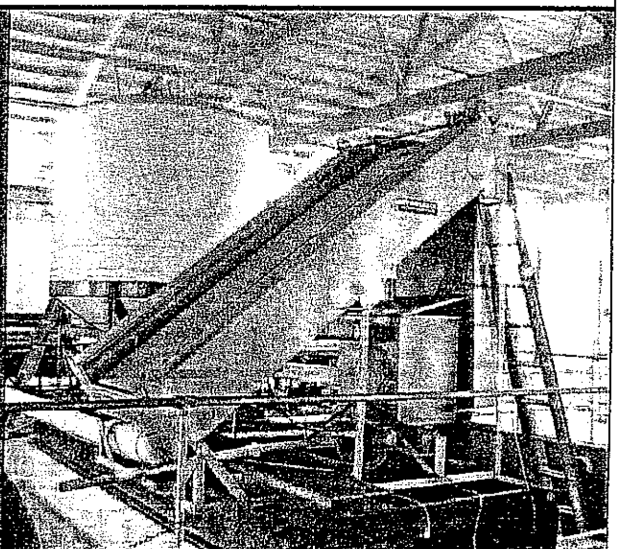
AGREM Subirrigation Systems combine the advantages of tile drainage with sub surface irrigation. Beyond draining your fields in the Spring and Fall and eliminating wet spots, AGREM Subirrigation Systems allow you to evenly apply water to your crops during the growing season. The added benefits of reduced labor costs in irrigating, low maintenance and repair costs, and little to no replacement costs only add to the superiority of AGREM Subirrigation Systems over conventional irrigation systems.

YOUR BENEFIT:

- Superior drainage
- Sub surface irrigation
- Uniform tile depth
- Low labor costs
- Low pumping costs
- Permanent system
- Upgrade potential
- Can be applied to AGREM Contoured Drainage Systems
- Can be applied to AGREM Controlled Drainage Systems

AGREM Effluent and Nitrogen Application Systems

The AGREM Effluent and Nitrogen Application System, the newest of AGREM Systems, adds a new dimension to water management By applying liquid nitrogen or liquid effluent through the AGREM Subirrigation System during growing season, the AGREM Effluent and Nitrogen Application System maximizes the benefit of your fertilizer while reducing the risk of environmentally damaging runoff Indeed, because of the incorporation of controlled drainage and a catch basin reservoir, this system offers the best means of controlling nitrogen and effluent runoff. Added benefits for effluent application include reduced odor, no application necessary during Spring or Fall, and low labor costs of application.

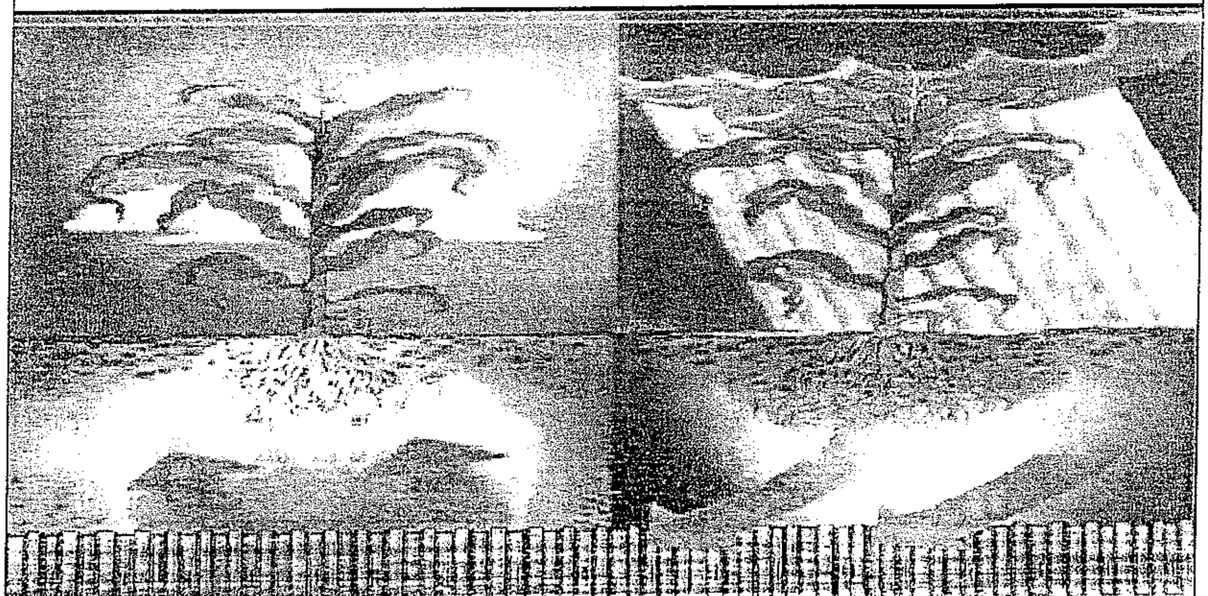
YOUR BENEFIT:

- Apply during growing season
- Reduced risk of runoff
- Reduced use of nitrogen
- No odor
- Low application costs
- Can be applied to AGREM Subirrigation Systems

AGREM SYSTEMS

The number one question any farmer asks before taking on an investment is how will this increase my yields and ultimately make me a profit By installing an AGREM System, you get the benefits of both superior drainage and irrigation in the same system. Superior drainage adds acres to your field by eliminating wet spots, reducing erosion, and allowing for earlier planting and harvesting. Beyond the normal returns to irrigation, sub surface irrigation lets you irrigate your crops uniformly over the growing season, reducing crop stress due to dry spells

Overall, AGREM Systems give you control over your water.



CONTOURED DRAINAGE AND YOUR YIELDS:

- Removes excess water at a faster rate
- Redistributes water across field
- Collects water for later use
- Allows for earlier planting and harvesting
- Eliminates problem areas
- Reduces soil runoff
- Upgradable to subirrigation

INCREASE YOUR YIELDS

SUBIRRIGATION AND YOUR YIELDS:

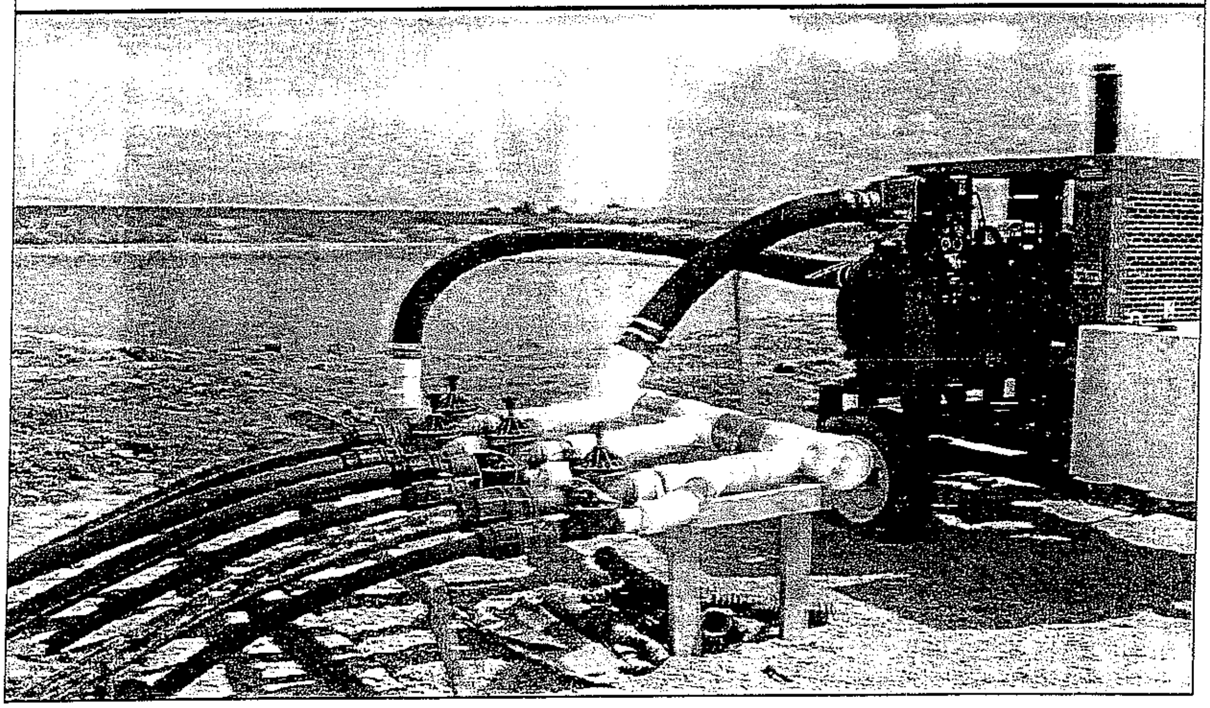
- Includes all benefits of contoured drainage
- Reduces crop stress due to drought
- Encourages deep root development
- Irrigates crops uniformly during application
- Reduces variability across field
- Consistent yields year to year

Both fields pictured were planted with the same variety, under the same weather conditions, and at the same time. On the left, the soil is a sandy loam with gravel pockets and an AGREM Subirrigation System. On the right, the soil is a dark loam rich with organic matter and no drainage or irrigation. Do you see the AGREM difference?

AGREM SYSTEMS, YOUR EFFLUENT, AND FERTILIZATION

BENEFITS OF AGREM EFFLUENT AND NITROGEN APPLICATION SYSTEMS:

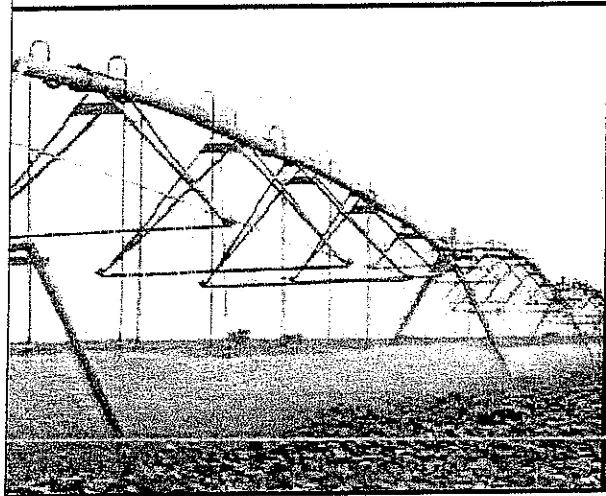
- Includes all the benefits of subirrigation
- Ease of effluent and nitrogen application
- Apply during the growing season
- Reduced risk of surface runoff
- Efficient use of nutrients
- Lower field compaction
- Reduced labor costs
- Better working conditions

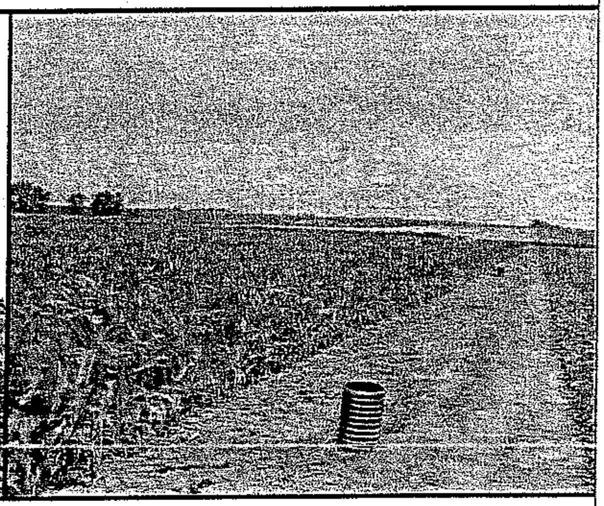


The AGREM Effluent Application System offers a sensible alternative to conventional practices.

The AGREM Effluent and Nitrogen Application System offers more to farmers than just the benefits of total water management. Application of nitrogen and liquid effluent during summer months more efficiently uses your fertilizer. Fertilizer is applied when your crop needs it most, and nitrogen loss due to Fall and Spring rain is reduced so that more of your fertilizer will stay on your field instead of flowing downstream. For effluent application, you will no longer need to apply during the Spring season. This greatly reduces the risk of field compaction and allows you to plant earlier. Last, sub surface effluent application greatly reduces odors associated with application, making a better work environment for you and your employees as well as keeping your neighbors happy.

How do AGREM Subirrigation Systems Compare to Conventional Irrigation Systems?



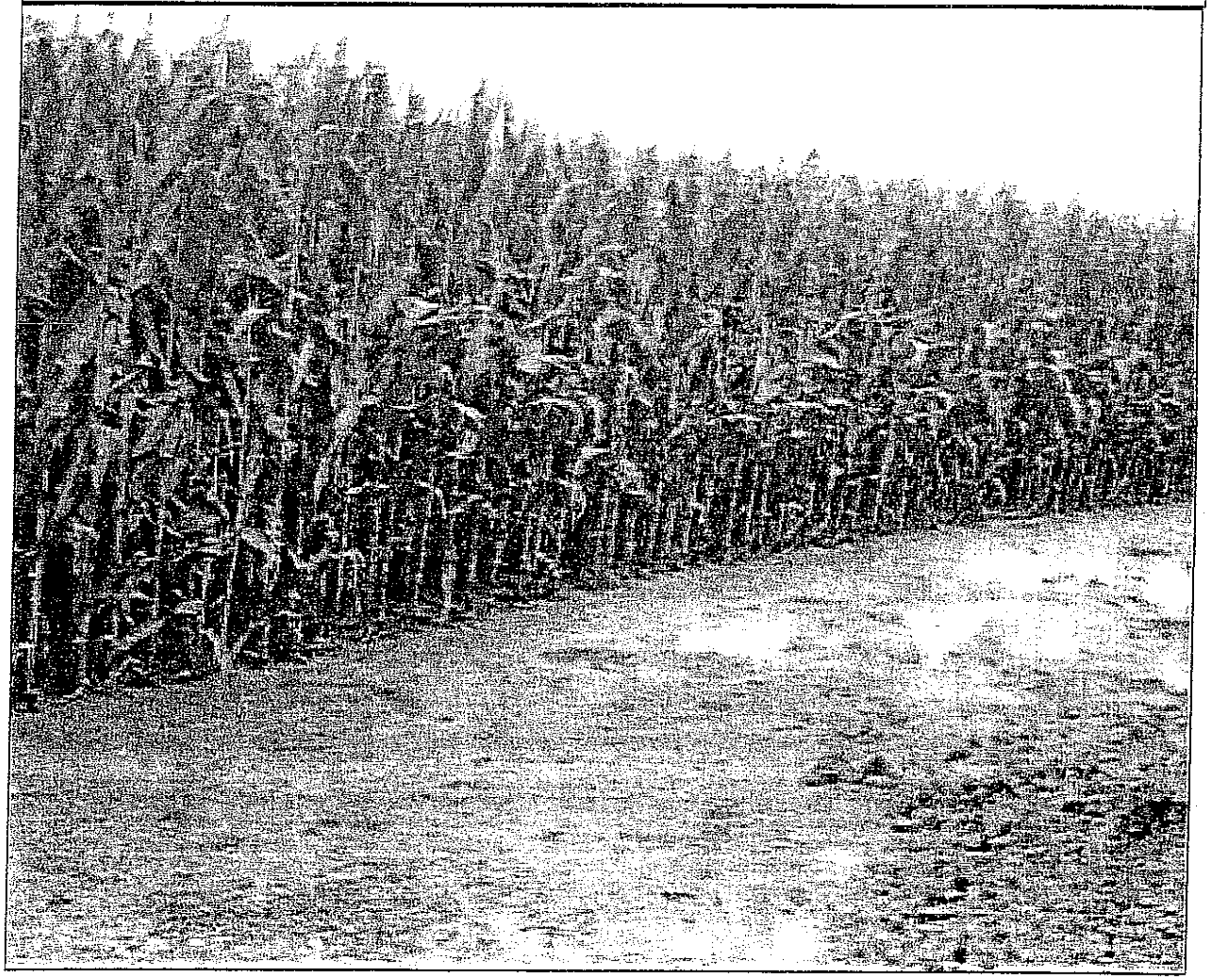


Compare for yourself...

Question	Conventional Methods	AGREM Subirrigation Systems
• Will I need to insure my system?	• Pivot irrigation is prone to damage from wind, hail, and extreme weather conditions. It is a good idea to insure against these events.	• The only damage that may occur to the system would be by accidentally hitting a control gate with an implement. Replacement costs are small though, so no insurance is recommended.
• How difficult is it to operate my system?	• Pivot irrigation systems require little more than activation. Damage, though, may occur during operation, such as a flat tire, that would lead to maintenance during irrigation season. Other irrigation methods require placing of hose lines and continuous observation of pumping.	• The only actions needed to operate the AGREM Subirrigation System is raising and lowering control gates twice a year and activating the pump. Observation of pumping every few days is recommended, but is not required.
• What maintenance will I have to perform on my system?	• Nozzles, tires, hoses, pumps, and piping should be inspected yearly and often require repair or replacement. Much of this can be done before irrigation season begins, but not always.	• Gates should be inspected each year, but replacement may only be necessary if the gate has been severely damaged by being hit by an implement. Otherwise, the only maintenance required is for the water pump.
• When will I need to replace my system?	• Pivot irrigation will need to be replaced between 8 and 20 years, depending on your usage. Drip and drag lines usually need to be replaced in 10 years or less.	• AGREM Subirrigation Systems are permanent and should last as long as you wish to farm.

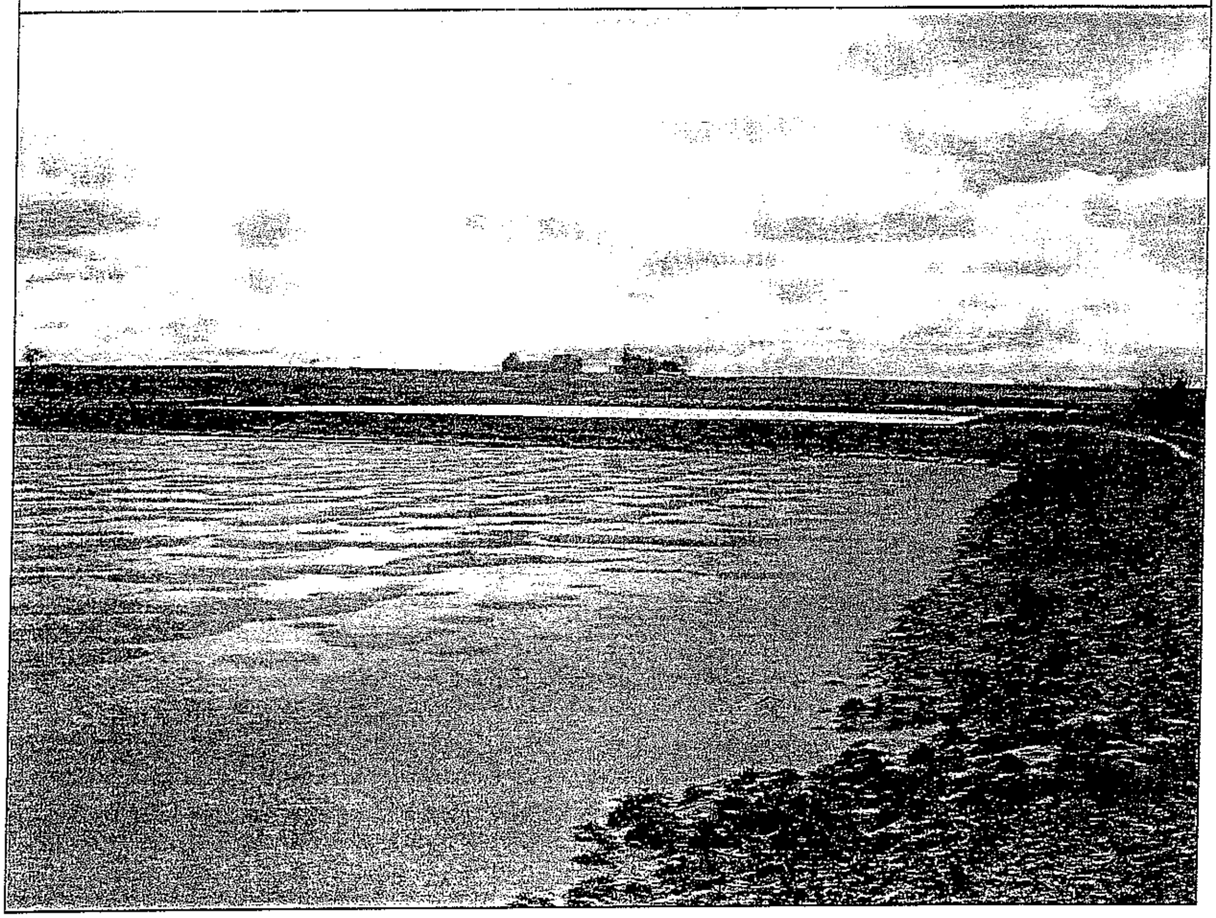
Financing an AGREM System:

AGREM LLC offers several alternatives to traditional financing methods available to farmers Major lending organizations, such as Wells-Fargo and SCI Leasing, approve investments in AGREM Systems and may provide financing. SCI Leasing further offers leasing options. Alternatively, you may opt to install AGREM Systems over the course of several years by upgrading AGREM Contoured Drainage Systems to AGREM Subirrigation Systems. Please feel free to contact us to discuss financing options and how we can best meet your needs. Any information you provide us will be considered confidential unless specified by you.



AGREM Effluent Application Systems and Environmental Protection:

AGREM LLC strives to design systems that are both economically beneficial to the farmer and environmentally sustainable In order to best suit your operation, we will design a system that most effectively meets your needs at the lowest possible cost We will further assist you in working with the DNR, NRCS, and other governmental regulation organizations to receive permission, grants, and/or permits for installation Please let us know of your situation in regards to manure and effluent management and the organizations that oversee your operation so that we may best assist you. All information you provide us on your farm and practices will be considered confidential unless specified otherwise by you.



AGREM IN THE NEWS

Have you seen the recent articles written on our systems?

If not, please check out the following articles:

Underground Irrigation
Farm Industry News, March, 2008
www farmindustrynews com

ISU Farm Tries to Tame Odors
Pantagraph, May 15, 2007
www.pantagraph.com

Sub-irrigation System Reduces Nitrate Loss, Conserves Water
Illinois Agrinews, Friday, Oct 21, 2005
www.agrinews-pubs.com

System Waters– and More
Pantagraph, Wednesday, August 10, 2005
www.pantagraph.com

If you don't have access to the internet or to these articles, please contact us. We will be happy to send you a copy.

Have More Questions?

Want to Schedule a Meeting?

Feel free to contact AGREM LLC at:

Address: 17122 N 3800 E
Anchor, IL 61720

Phone: 309 - 530 - 9270
309 - 723 - 3231

Email: agrem@agrem.com

Check out our websites at:

www.agrem.com
www.agremmarketing.com

Attachment 17

University of Illinois Extension Livestock Manure Management
Conference Series

University of Illinois
Dept of Agricultural & Biological Engineering
Rm 332K AESB
1304 W. Pennsylvania Ave
Urbana, IL 61801

Livestock Manure Management Conference Series

"Manure and Odor Management Tools, Regulation Updates, and Research Results You Can Use"

Please mark your calendar...

Tuesday, March 24, 2009

Effingham Knights of Columbus Hall
1501 W. Fayette Ave, Effingham, IL 62401
(217) 342-6565
For Directions: (217) 347-7773

Thursday, March 26, 2009

Wise Guys Bar & Grill Meeting Room
2205 N. Main St., Princeton, IL 61356
(815) 872-4897
For Directions: (815) 872-2878

UNIVERSITY OF ILLINOIS EXTENSION
College of Agricultural, Consumer and Environmental Sciences

University of Illinois Extension provides equal opportunities in programs and employment.

Workshop Registration

Register for the workshop of your choice by calling ACES Marketing & Distribution at 800-345-6087 by March 18, 2009.

Please have your credit card ready.
Registration without proper remittance will no be processed.

Workshop Costs per person:

Registration	$40.00
Walk-ins	$50.00

We cannot guarantee space for all walk-ins. Please pre-register by March 18, 2009 to guarantee your space!

If you would like to become an exhibitor, please contact:

Ted Funk
University of Illinois
Dept. of Agr. and Bio. Engineering
funkt@illinois.edu 217-333-9313

Randy Fonner
University of Illinois
Dept. of Agr. and Bio. Engineering
refonner@illinois.edu 217-333-2611

Materials/Program funded in part by: Illinois Environmental Protection Agency a the Illinois Pork Producers Association.

UNIVERSITY OF ILLINOIS EXTENSION

College of Agricultural Consumer and Environmental Sciences

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

ILLINOIS PORK PRODUCERS ASSOCIATION

Livestock Manure Management Conference Series

March 26, 2009

Princeton, IL

	Program Agenda
8:15 AM	Registration, coffee, meet exhibitors
8:55 AM	Welcome, housekeeping announcements
9:00 AM	IL NPDES permit re-issuance; weather related manure releases; US-EPA NPDES program update
9:40 AM	Livestock producers and the Farm Bill; new IL VTA standard
10:20 AM	**Break**
10:35 AM	Update on LMFA program numbers, review of facility capacity and NOITC requirements, CLM and waste management plan requirements; detail needed in beef and dairy NOITC applications
11:15 AM	Paul Walker Presentation Producer Panel #1: manure storage capacity planning (how we stayed out of trouble in unusual weather); manure storages monitoring systems, other planning tools
12:00 PM	**Lunch & visit with exhibitors**
1:15 PM	Paul Walker Presentation Producer Panel #2: manure marketing -- creative arrangements, composting, etc
2:00 PM	Status of key IL livestock court cases; pit wall penetration update
2:30 PM	**Break**
2:45 PM	Manure application technology: light bar and auto steer, GPS mapping
3:30 PM	Open discussion: runoff control systems for feedlots, feed storages; winter spreading; reduced manure volume (draft) rule; hoop buildings -- requirements for NOITC applications
4:00 PM	**ADJOURN**

Exhibitors →

Exhibitors

Alton Irrigation – Richard Alton

SGS Mowers Soil Testing Plus, Inc – Ryan Arch

WGB Marketing – Wayne Beath

Midwest Bio-Systems – Ernest Blossner

Plastic Fusion Fabricators, Inc. – Van Dobbs

Maurer Stutz, Inc – Jim Evans

ManPlan, Inc – Dennis Godar

Envirowaste Technology, Inc – Ed Puck

Cady, Inc – Steve Glassburn

Balzer – Mark VanHyfte

Illinois Department of Agriculture

Illinois Environmental Protection Agency

Attachment 18

Manure Management Workshop/Field Day Schedule
(2009) ISU Farm – Lexington

MANURE MANAGEMENT WORKSHOP/FIELD DAY

ILLINOIS STATE UNIVERSITY FARM
– LEXINGTON –
Tuesday, September 22
9:00 a.m.

Featuring the latest in liquid manure processing, odor control of stored slurry, composting, low and odorless land application of processed manure

SCHEDULE OF MINI SEMINARS AND FIELD DAY ACTIVITIES

8:30 a.m	Registration (Donuts, coffee, softdrinks)
9:00 a.m	ISU, CFAR Welcome
9:10 a.m	Optimizing the Fertilizer Value of Manure (featured speaker – John Lory, University of Missouri)
9:40 a.m	Manure Resources on the Web (Randy Fonner, University of IL Ext.)
10:00 a.m	What is new in Regulations (Kent Bohnoff – NRCS)
10:20 a.m.	Solid-Liquid Separation of Liquid Manure (Paul Walker, Illinois State University)
10:40 a.m	Break
10:55 a.m.	Composting as a Manure Management Alternative (Alan Dale – Midwest Bio Systems)
11:15 a.m	Underground Irrigation / Odorless Application of Processed Manure (Dr. Jeremy Meiners, AGREM, LLC)
11:35 a.m	Using Smart Earth Technology to Control Pit Odor (William Frederick, Enercon Engineering)
11:55 a.m	Biocovers for Control of Manure Odor (Ted Funk, University of IL Ext.)
12:15 – 1:15 p.m.	Lunch (provided)
1:15 – 3:00 p.m.	On-Site Demonstration of Alternative Manure Management Technology (solid-liquid separation, Smart Earth manure treatment, center pivot irrigation, composting, underground land application of processed slurry)
1:15 – 3:00 p.m	Plot Tours

Directions: Interstate 55 to Exit 178 at Lexington, follow signs to ISU Farm
For information telephone (309) 438-5654 or (309) 438-3881

Attachment 19

Popular Press Articles Related to Technology Transfer

[anure management field day to show alternative technology

llinois State University will host a livestock ure management field day Tuesday, Sept. 22, at university research farm near Lexington.

egistration will begin at 8:30 a.m. The morning ;ram will offer mini-seminars on optimizing fertilizer value of manure, new manure urces on the Internet, an update of Natural ources Conservation Service (NRCS) regula- s, innovative economical technologies to con- liquid manure odor, manure processing, and and no-odor methods for land applying essed liquid manure.

articipants will have an opportunity to inspect manure solid-liquid separation systems — one for controlling pit odor and another for underground irrigation of processed liquid manure. They also may view the ISU compost facility used to compost livestock manure.

ISU researchers have studied the benefits and drawbacks of composting livestock manure from beef, sheep and swine herds with landscape waste. The compost is used as fertilizer for corn and soybean production.

The ISU farm includes a 220-sow farrow-to-finish operation for which all of the liquid manure is separated into solid and liquid components. Each year, more than 2 million gallons of liquid manure is separated. The liquid portion is applied as nitrogen fertilizer through irrigation.

Field day attendees will be able to tour 40-acre fields of soybeans fertilized with separated effluent, composted biosolids, unprocessed swine slurry, and inorganic fertilizer.

Advanced registration is not required, and there is no charge. A meal will be provided. Funding for the activity is being provided by ISU's ag department, the Illinois Council on Food and Agricultural Research, the University of Illinois Extension, and NRCS.

For more information, call the ISU department of agriculture at 309-438-5654 or 309-438-3881.

Research, technology managing manure nutrients, odo[r]

BY KAY SHIPMAN
FarmWeek

Livestock producers will soon have more options to help them manage and benefit from manure nutrients, while reducing odor, according to researchers at several universities.

"The dream when you have manure is to get the full fertilizer value," said John Lory, an environmental nutrient management specialist with the University of Missouri.

Lory and other researchers discussed management practices and new research at a manure management field day on the Illinois State University (ISU) research farm near Lexington.

Additional resources on manure management are available at FarmWeekNow.com

Participants of a manure management workshop tour the Illinois State University (ISU) research farm's swine manure handling system near Lexington. ISU also applies polymers to separated solids, seen in the foreground, that are composted. (Photo by Kay Shipman)

The ISU farm uses solid-liquid separation systems to better manage nutrients, which are applied as effluent and as compost, and to reduce odor. Research results, along with related rules and other information, are available online at {www.sweeta.illinois.edu}. SWEETA is short for Swine Waste Economical and Environmental Treatment Alternatives.

"The whole issue of odor affects our right to site (livestock) facilities. It's also affecting our right to exist," said Paul Walker, ISU animal science professor.

ISU either applies composted manure biosolids to its fields or sells the compost to consumers. The separated effluent is applied by a center pivot irrigation system or an underground irrigation system.

Walker noted the nitrogen-phosphorous ratio of the effluent is "close to what a corn plant wants" and can be applied at higher rates than raw slurry without overloading soil phosphorous levels. The effluent has "remarkably low odor" when applied via a center pivot and no odor when applied through the underground system, Walker added.

Lory recommended farmers regularly sample and test their manure to obtain current nutrient values and then estimate the amount of available nutrients. "It's important to get test results converted into the right units, pounds per thousand gallons or pounds per ton," he said.

Livestock manure nutrient values are changing as the animals increase their feed efficiency and livestock diets change, Lory noted. For example, nitrogen levels in swine manure have decreased 30 percent; phosphorous, decreased 60 percent; and potassium decreased 10 percent.

Cattle diets with higher amounts of dried distillers grain (DDG) also are changing nutrients levels in manure, Lory said. As DDG dietary levels increase, phosphorous levels also increase in manure, he added.

"It's a good source of phosphorous (fertilizer) if you need it," Lory said.

Walker: New law favors composting

A new state law will make it more economical for livestock producers to compost livestock waste, according to Paul Walker, Illinois State University (ISU) animal science professor.

Gov. Pat Quinn signed the legislation, sponsored by Sen. Heather Steans (D-Chicago), that exempt certain types of compost facilities from regulation as pollution control facilities.

Compost facilities that have no more than 30,000 cubic yards of livestock waste continue to be regulated by the Illinois Environmental Protection Agency and must meet setback requirements, but no longer must also be sited by county governments, according to Walker.

"This makes it more economical to do composting," Walker said of the new law. He has researched composting of livestock waste as a management practice on the ISU research farm near Lexington. — Kay Shipman

Livestock producers may tap into information and funding

A variety of information and planning tools for manure management is available online, according to University of Illinois specialists.

To assist with nutrient management expenses, producers also may apply for Environmental Quality Incentive Program (EQIP) cost-share funds through the Natural Resources Conservation Service (NRCS).

U of I's Randy Fonner and McLean County NRCS' Kent Bohnhoff described several opportunities during a livestock manure management field day hosted by Illinois State University.

Manure management planning assistance is available online at {www.mmp.uiuc.edu}. The planning tool helps producers tailor plans for their operations. Fonner said the program was "modeled on Turbo Tax."

Producers may find livestock-related regulations at {www.ezregs.uiuc.edu}. The information covers rules related to environmental protection, livestock facility construction, facility management and siting, pesticide use, historic preservation, and endangered species.

One of the newer sites, Manure Share, is a forum for people wanting to exchange manure from farms or stables with others who need it for composting or field applications. Fonner said there is no charge to register at {www.ManureShare.illinois.edu}.

More than 100 people from across the state have registered, and more than 40 of those are looking for manure, according to Fonner. The registrants have a variety of livestock species, including beef and dairy cattle, sheep, goats, and horses, he noted.

On the funding side, producers may receive EQIP cost-share dollars for a variety of practices. But funding has been allocated for the current fiscal year, Bohnhoff said.

Producers who apply receive application points based on the conservation practice and environmental issues they plan to address, he explained.

Eligible livestock practices and tools include developing a comprehensive nutrient management plan, waste storage facilities, windbreaks, roof and gutters to reduce stormwater from entering waste storage areas, and vegetative treatment area for livestock waste.

Bohnhoff encouraged producers to contact their local NRCS offices for more information or an application. — Kay Shipman

Livestock

Important to apply manure to appropriate fields

By MARTHA BLUM
AgriNews Publications

LEXINGTON, Ill. — Since more than one-half of the nutrients in manure are in a form other than nitrogen, it is important to select fields for application that need nitrogen, phosphorus and potash to get the full value out of the manure.

"Manure is not only a macronutrient fertilizer, it is also a micronutrient fertilizer," said John Lory, associate professor at University of Missouri, who spoke during the Manure Management Field Day held at the Illinois State University farm.

Lory outlined several steps for producers to maximize the value of the manure. Those steps include applying where there is a demand for N, P and K; obtaining a quality manure analysis; estimating the nutrient availability; spreading at a target rate; and achieving a uniform application pattern.

"In order to make manure a good fertilizer, you've got to do all five of those things," Lory stressed. "If you break down in any one of those five points, you will have problems getting full value out of your manure."

Phosphate and potash are 100 percent available in manure, Lory said.

"Nitrogen is less than 100 percent available, so you have to make a calculation to adjust your total nitrogen content," he explained.

One of the challenges with manure testing is the information provided by labs may come in various forms.

"You need to get the manure test results converted into a format you can understand like pounds per 1,000 gallons or pounds per ton," the professor advised.

When determining a manure value, Lory stressed that all manure is not created equal.

"There is a lot of organic matter in manure, which can have an impact on organic matter levels in soil, but it is hard to put a dollar value on that," he said.

Some producers only consider the nitrogen value in manure.

"Last year when we had the high phosphorus prices, almost one-half of the value of the manure was in the phosphorus," Lory said. "So to get the value out of the manure, you've got to get it on fields that need P and K."

He encourages producers to test the manure at least twice a year, in order to do a good job.

"There is a pattern for total nitrogen and it is typically high in the spring and low in the fall," he explained.

The best time to take lagoon samples is the week the manure will be applied to fields. "Avoid the sludge layer on top of the lagoon, take the sample from below the surface," the speaker advised.

It is more challenging to obtain a representative sample from a slurry operation.

"It is best represented when it has been agitated, so producers typically take a sample as applying and use the historical values for that application," Lory said.

Before sending a sample to a lab, it is important to mix the sample well, put it in a sealed container that is clearly labeled and make sure the sample is not overheated.

"I try to send my samples during the early part of the week, so they don't spend the weekend sitting at the lab," the professor said.

"The area that I've seen obvious breakdown is uniformity of manure application," he reported. "When you don't do a good job of applying nutrients and there are gaps in the pattern, that's when you see decreased yield or yellow corn."

Lory identified several factors that effect uniformity in manure application including pressure fluctuations at the irrigator, elevation changes, changes in the length of the hose and nozzle size.

"Other factors include ground speed, pull spacing, closure of injection slits and variation in load fills," he added.

A systems approach has been developed at the ISU farm to handle manure.

"We separate the manure to a solid component and a liquid component, similar to what municipalities do," said Paul Walker, ISU animal science professor. "We compost the biosolids and we irrigate the separated effluent."

One of the "beauties" of the separated effluent is producers can put a lot of gallons on per acre and not worry about phosphorus overload, the ISU professor said.

"We are able to put on as much as 40,000 gallons per acre, without getting into a phosphorus problem," he added.

The ISU farm includes a 220-sow farrow-to-finish unit, which produces about 2 million gallons of manure per year.

When targeting a corn yield of 180-bushels per acre, Walker said, "when we put on raw slurry to meet the nitrogen needs, we were 93 pounds over for phosphorus."

If the field received an application of separated effluent, it was 32 pounds deficient for phosphorus.

"So by pulling out the phosphorus, that allows us to add manure based on the nitrogen value not on the phosphorus value," Walker said.

"When we balance the raw slurry with inorganic fertilizer or compost with inorganic fertilizer, we can meet the needs of the crop and not exceed phosphorus," he noted.

AgriNews photo/Martha Blum

John Lory, associate professor at the University of Missouri, outlined several steps for producers to maximize the value of manure from their livestock operations during the Manure Management Workshop.

Handling manure will be especially stressful this year

By PAUL WALKER
Illinois State University
Animal Science Professor

NORMAL Ill — For many swine producers fall is the time for land application of manure This year may prove challenging than most y...s due to the wet weather and excessive soil moisture

In fact due to a delayed grain harvest there may be little opportunity to land apply manure before freezing weather and frozen soil conditions set in

Even in those cases where farmers have been able to harvest corn and soybeans, wet soils increase the chances of nutrient leaching and run off during and after manure application Therefore, the following list should be reviewed as producers prepare fall manure application:

■ Review nutrient management plan — In order to prevent leaching or runoff resulting from manure application lower manure application rates may be warranted

Nutrient leaching may increase when injecting liquid manures, and solids runoff may increase when spreading ... manures during ...odes of high rainfall

Consequently, more acres of land and additional fields may be required for this falls manure application Using fields with flatter slopes and lower Phosphorous Index scores may be a good idea

Plan ahead. Manure may have to wait for application under emergency guidelines this coming winter when the ground is frozen

Review of your current nutrient management plan and noted application methods application rates and fields of choice may require revising for this year Making updates now while it is raining may save time energy and cost later;

■ Develop an application emergency plan — The incidence of manure spills increases when the weather is harsh Handling manure is bad enough on a sunny 80-degree day Near-freezing ...peratures wet weather a... muddy conditions increase the chances for something to go wrong

your manure management plan Remind your team of your plan Emphasize who to contact, safety issues and what to do when emergencies occur;

■ Take manure samples — If nutrient overload runoff or leachate is a potential problem as it is this year it is especially important to know the nutrient concentration of the manure High-nutrient loads mean more land area for application is required

In a wet year like this year, balancing nutrient application with potential for runoff is more important than normal to prevent environmental contamination Sampling ahead of land application helps plan which fields can be used

Sampling during land application or manure agitation may provide better results to use in future planning, but will not provide nutrient analysis results to use in planning application rates for this fall

It is important to build a history of nutrient analyses overtime for manure sampling to help manage the nutrients in manure for crop production over the years

Correct sampling technique is most important. A sample that is not representative of the manure volume is of little value

Slurry sampling is best accomplished using a probe of sufficient length to reach to the bottom of the storage tank Sampling should ... take place immediatel... following agitation and multiple samples from several locations should be collected and pooled especially if only one sample will be sent to a laboratory for analysis

For solid manure several grab samples from several locations in a manure pile both inside and outside of the stack should be collected and pooled;

■ Take soil samples — Soil samples should be taken prior to manure application If a field has not been sampled recently, then one sample for every 2 5 acres is best Generally one sample collected for every 10 acres is adequate especially on fields that are routinely sampled;

■ Calibrate application equipment — When applying inorganic fertilizer for crop production has the application equipment been calibrated? You bet it has!

Calibrating manure application equipment takes a little time, but in the long run it will help meet the correct application rate and make better use of manure nutrients

To determine how much solid manure a manure spreader applies layout a 56-square-inch sheet of plastic Spread manure at the desire rate of travel and spreader settings

The net weight in pounds collected on the plastic sheet is equivalent to tons per acre application rate Remember, nutrients are calculated b...ed on the dry matter weight of the manure — not the wet weight basis unless the laboratory has been given directions otherwise;

■ Timing of application — Application on dry soil is the best option This fall we do not have that choice Try to apply at least 24 hours before a substantial rainfall

This will help prevent runoff Injection of slurry is a necessity, but it requires drier soil conditions

Surface application of solid manure should be followed by some kind of primary tillage but even pulling a disk over freshly applied manure is more desirable than no tillage

Applying manure to snow covered or frozen ground may not be allowed except under emergency conditions, and this looks like it could be one of those years; and

■ Consider the neighbors — Yes manure does have odor. In blunt terms, it just smells bad That is not perception It is reality

Therefore inform your neighbors Let them know about manure application plans If possible, tell them how long it might take how you plan to apply the manure and how long they might expect to smell the manure

Inquire about any outdoor events in the neighborhood such as weddings and cookouts and try to avoid those times for application This will be extremely difficult this fall because we seem to have such small "windows of opportunity" to land apply manure

Most neighbors will understand Some won't but at least make an effort It may yield future dividends

C4 ILLINOIS AGRINEWS Friday, November 6, 2009

Livestock

Controlling odors vital for siting livestock operations

By MARTHA BLUM
AgriNews Publications

LEXINGTON, Ill. — It is important for livestock producers to focus on controlling odors from operations because it affects their right to site facilities.

"It is also starting to affect our right to exist," said Paul Walker, animal science professor at Illinois State University, who spoke during the Manure Management Workshop at the ISU farm. "Odor and manure handling effects whether or not we're going to be here the rest of this century."

During the program producers learned about techniques they can use to address odor issues including composting manure.

At the ISU farm, a solid-liquid separation system is used to separate manure to a solid and liquid component. The separated effluent is irrigated and the biosolids are composted and then applied to fields.

Alan Dale discussed his composting operation that he manages on his farm in Bureau County.

"I'm EPA permitted because I think that is the best of all worlds," he said. "I've engaged the EPA because this is a positive story to tell."

Dale's permit gives him the opportunity to use landscape waste, livestock manures and crop residues in his compost program.

"Most people think of compost as simply breaking down material, but that is the first stage as far as I'm concerned, and I'm able to accomplish that in two weeks," he said. "I took this to another level, and in 10 weeks we take feedstocks and put them into a humified, high-quality compost."

The farmer sells his compost for $140 per ton and he is sold out.

"I don't have enough to meet the market demand and needs of my farm," he noted.

Compost is not made by people or machines like turners, Dale said.

"We're creating an environment so the microbes can flourish — they're the ones that make the quality," he explained.

Feedstocks used in the compost operation include wheat and oat straw liquid hog manure, cornstalks and lawn waste from the town of Kewanee.

"The liquid hog manure is my primary nitrogen source," the farmer explained. "There are 10 million gallons of liquid hog manure located within five miles of my farm, and a lot of people are looking for a place to go with it."

Clay also is used in Dale's compost process.

"Clay is something very few people know about and it has the ability to take compost to a whole another level," he said. "That's where the quality comes from, and it is also great for dealing with odors."

At his four-acre site, Dale is permitted for a maximum of 32 windrows at any one time. Although composting can continue year around, he concentrates his operation from April to September.

"I have covers on all my rows, so that is a problem in the winter because the covers freeze to the ground and snow on the covers makes them very heavy," he explained.

Since 2001, Dale has conducted a lot of research on his farm.

"I put 1,000 pounds of compost on per year on fields that are in a corn-soybean rotation," the farmer said. "I've eliminated the application of P and K and cut my nitrogen in half."

So far, Dale has not seen any decreases in his soil tests.

"I put the compost on after corn stalks, which helps to get a little quicker nutrient recycling," he said.

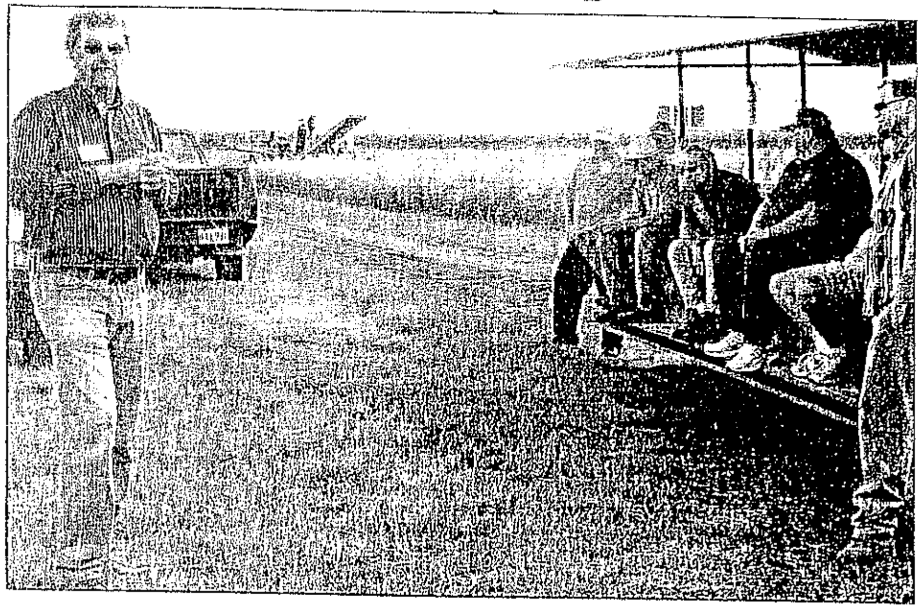
Another project at the ISU farm features the installation of a tile drainage system with a sub-irrigation system, by AGREM LLC.

"We think this system has a lot of promise and there is no odor with this system," Walker said.

"In a typical tile drainage system, the laterals are often spread wide apart and a lot of times, the laterals are parallel to the flow of water," explained Jeremy Meiners of AGREM LLC.

"But for our system, the tile is closer together and each lateral is placed so that when the water flows through your field, it will flow perpendicular to the way the laterals are placed."

In addition, AGREM positions the laterals along the contour of the field.



AgriNews photo/Martha Blum

Alan Dale talks about composting techniques to those attending the Manure Management Workshop at the Illinois State University farm. Biosolids are composted on the ISU farm, and the compost is either land applied or sold off the farm as a value-added product. Dale has managed a composting operation on his farm since 2001. He currently does not have enough of his humified, high-quality compost to meet the market demand and the needs of his farm.

"That way when the water flows down a hill, it's intercepted by as many lateral lines as possible and we also have them in a tighter spacing," Meiners said.

Control gates are placed for every two-foot difference in the field.

"A reservoir catches the water to be pumped back into the system," Meiners explained. "When you go to a sub-irrigation system, if you don't pump it back into the system, that reservoir will function much like a wetland."

Each lateral is placed two-feet below the surface.

"With our control weirs we create an underground tier system," Meiners said. "Each different zone is controlled by its own control gate."

When livestock effluent is applied, it should be 95-percent or greater solid-free effluent.

"Application occurs uniformly because it is mixed with irrigated water and pumped out to each zone," Meiners explained.

At the ISU farm, 900,000 gallons of effluent was applied this year through the system.

The AGREM technique will benefit farmers in both dry and wet years by reducing variability.

"In a dry year, you can put on more effluent," Meiners said.

"In a wet year, you have the combination of a superior drainage system and an irrigation system, so you will be able to get out in the field faster."

pork
THE BUSINESS MAGAZINE FOR PROFESSIONAL PORK PRODUCERS

Manure Application in Wet Year Requires Caution

By Pork news source (11/11/2009)

For many pork producers, manure application follows closely on the heels of the corn and soybean harvest. This year may prove more challenging than most, due to the wet weather and excessive soil moisture, according to Paul Walker, Illinois State University animal science professor

Walker says a delayed grain harvest means there may be little opportunity to land apply manure before soils freeze in some parts of the country "Even in those cases where farmers have been able to harvest corn and soybeans, wet soils increase the chances of nutrient leaching and runoff during or after manure application," he states Walker provides the following seven management practices to help producers prepare for fall manure application:

1 Review nutrient management plans To prevent leaching and/or runoff resulting from manure application, lower manure application rates may be warranted Nutrient leaching may increase when injecting liquid manure and solids runoff may increase when spreading solid manure during episodes of high rainfall. Consequently, additional land may be required for manure application this fall Using fields with flatter slopes and lower phosphorous index scores may be a good idea Plan ahead Manure application may have to wait until emergency application guidelines for frozen ground are applicable

Review your current nutrient management plan and noted application methods, application rates and fields of choice They may require revising for this year Making updates now may save time, energy and costs later

2 Develop an emergency application plan The incidence of manure spills increases when the weather is harsh "Handling manure is bad enough on a sunny, 80-degree day Near-freezing temperatures, wet weather and muddy conditions increase the chances for something to go wrong," Walker says Train employees in manure spill response Emphasize who to contact, safety issues and what to do when emergencies occur

3 Take manure samples If nutrient overload, runoff and/or leachate are potential problems, as this year, it is especially important to know the nitrogen, phosphorus and potassium concentration of the manure. High nutrient loads mean more land area required for application. In a wet year, balancing nutrient application with potential for runoff is more important than normal to prevent environmental contamination Sampling ahead of land application helps plan which fields can be used.

Sampling during land application or manure agitation may provide more accurate nutrient results for planning future application rates but it will not help plan application rates for this fall It is important to build a history of nutrient analyses over time for manure sampling to help manage the nutrients in manure for crop production over the years

Correct sampling technique is most important A sample that is not representative of the manure volume is of little value. Slurry sampling is best accomplished using a probe of sufficient length to reach to the bottom of the storage tank Sampling should only take place immediately following agitation and multiple samples from several locations in the pit should be collected and pooled, especially if only one sample will be sent to a laboratory for analysis For solid manure, several grab samples from several locations in a manure pile both inside and outside of the stack should be collected and pooled

4 Take soil samples Soil samples should be taken prior to manure application If a field has not been sampled recently, then one sample for every 2.5 acres is best Generally, one sample collected for every 10 acres is adequate for fields that are routinely sampled, Walker says

5 Calibrate application equipment "Calibrating manure application equipment takes a little time, but in the long run it will help meet the correct application rate and make better use of manure nutrients," according to Walker

To determine how much solid manure a manure spreader applies, Walker suggests laying out a 56-sq. in sheet of plastic Spread manure across the plastic sheet at the desired rate of travel and spreader settings The net weight in pounds collected on the plastic sheet is equivalent to the tons-per-acre application rate Remember, N, P and K are calculated based on the dry matter weight of the manure -- not the wet weight basis -- unless the laboratory has been given directions otherwise

6 Timing of application Manure application on dry soil is the best option. Try to apply at least 24 hours before a substantial rainfall to help prevent runoff Injection of slurry is a necessity, but it requires dryer soil conditions Surface application of solid manure should be followed by some kind of primary tillage, but even disking in freshly applied manure is more desirable than no tillage at all Applying manure to snow-covered or frozen ground may not be allowed except under

emergency conditions and, Walker says, this looks like it could be one of those years in some states

7. Consider the neighbors "Yes, manure does have odor It is reality. Therefore, inform your neighbors Let them know about manure application plans. If possible, tell them how long it might take, how you plan to apply the manure, and how long they might expect to smell the manure. Inquire about any outdoor events in the neighborhood such as weddings, cookouts, etc and try to avoid those times for application. This will be extremely difficult this fall because we seem to have such small windows of opportunity to land apply manure Most neighbors will understand Some won't, but at least make an effort It may yield future dividends," Walker concludes

See also Nov Pork magazine feature article, Manure Matters

Source Illinois State University

PRODUCTION

U of I researchers testing natural filter on swine odor

BY KAY SHIPMAN
FarmWeek

Two University of Illinois researchers are reducing the odor coming from swine buildings on the campus farm by sending the exhaust air through in-ground biofilters.

"We know the thing is working. We think it's something anybody could build," Ted Funk, U of I agricultural engineer, told livestock producers.

FarmWeekNow.com
Check out our photo gallery on in-ground biofilters at FarmWeekNow.com

Funk described his project during a recent manure management workshop on the Illinois State University research farm near Lexington.

Funk and Matt Robert, U of I research engineer, are testing the effectiveness of one biofilter filled with wood chips and hay and another filter filled with tree bark biomass.

Their biofilter is a shallow pit with a bottom layer of sand covered by a ground cloth then filled with organic material. Funk and Robert lined the pit sides with concrete and included a sump pump to remove excess water.

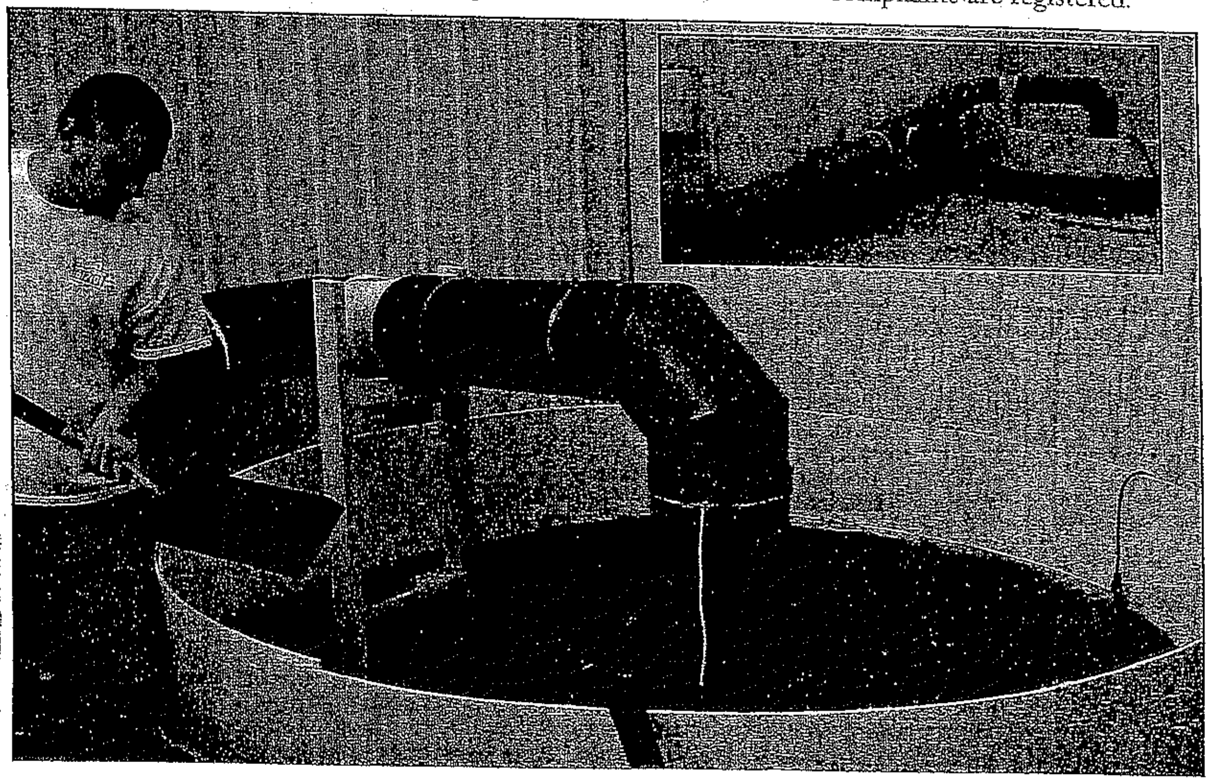
To be effective, the biofilter material must be moist, but not wet, and porous enough to allow air movement. The filter also needs to be the right size to retain the exhaust air for about five seconds, Funk added. Organisms in the filter material breakdown odor components in the exhaust air.

The cost for a U of I biofilter system was $3,836 and took 62.5 man-hours for construction. Funk noted a farmer wouldn't need a $99.95 water meter included in the U of I cost.

Farmers could further reduce construction costs by using recycled materials, such as recycled silo material, Robert added.

Annual operating cost estimates range from $5 to $15 per 1,000 cubic feet per meter of airflow.

The most effective use of the filters, Funk said, would be for producers to send building exhaust air through biofilters during times when air is stabilized — a time when most complaints are registered.



Converting waste into valuable nutrients

LUW TEAM demonstrates outstanding collaboration

By Eric Jome, Media Relations

Finding effective ways to deal with livestock manure. Turning landscape waste into a valuable soil amendment. Helping develop an environmentally sound system for disposing of animal carcasses. Working to improve water quality while generating alternative energy. Those are some of the projects undertaken in the past decade by Illinois State University's Livestock and Urban Waste (LUW) Research Team.

The LUW Team focuses its research on developing and implementing solutions to problems posed by waste from livestock operations, towns and cities.

"The team's work benefits municipalities, private companies and the general citizenry," said LUW Team Coordinator Paul Walker, Agriculture. "The LUW Team members use an interdisciplinary approach to solving waste problems. Applied research and technology transfer are a big part of our work."

That interdisciplinary approach to research is possible because LUW Team members come from varied research and applied technology backgrounds. Illinois State LUW Team members include Rob Rhykerd and Ken Smiciklas, Agriculture; Tim Kelley, Health Sciences; and John Sedbrook and William Perry, Biological Sciences. Other team members include researchers from the Illinois State Water Survey, Illinois State Geological Survey, the University of Illinois Department of Animal Sciences and the University of Illinois Extension.

LUW Team projects in the past decade have helped to divert massive amounts of municipal waste from landfills by converting it into valuable nutrient sources for livestock and soil. Food waste from University dining halls has been developed into sanitized, nutrient dense livestock feed. Municipal yard waste and livestock manure have been combined in a composting process that produces a rich fertilizer and soil amendment for gardens and row crops.

"The LUW Team has developed a process for separating the solid and liquid components of swine manure using technology similar to that employed by municipal sanitation departments. The solids portion is composted and the liquid portion is irrigated on corn fields," said Walker. "The process decreases or eliminates the traditional odor associated with land application of swine manure and eliminates environmental concerns regarding over application of phosphorus."

The LUW Team is also working with a private corporation to develop and test a portable incinerator for disposing of livestock carcasses without contaminating the environment.

The LUW Team's most recent project focuses on improving the water quality for the Village of Lexington while exploring ways to generate alternative energy on a local level. In the first stage of the project, LUW Team members are working with the Village of Lexington to develop a test plot for growing a variety of grasses and plants collectively referred to as biomass. The biomass will be irrigated by municipal wastewater in a three-stage settling lagoon. The plants will absorb nutrients from the effluent and act as a filter, thus improving the overall water quality for the area.

"This project is still in the early stages," said Walker. "However, we see real potential for this to be a model for wastewater treatment for small towns."

"The Village of Lexington has been very proactive in developing its sanitation district and we feel that we can help them create an even better system by using biomass to enhance the waste water treatment process."

LUW Team researchers are also investigating ways to use that same biomass to produce energy.

"There has been a lot of talk about converting biomass into ethanol, but the technology for that is not fully developed and so right now it is not a cost-effective option in a large scale production," Walker said. "However, the biomass irrigated by the municipal effluent can be a cost-effective energy source when combined with local livestock manure in a methane digester."

A later stage of the project will involve working with a dairy farm near Lexington to install a methane digester to dispose of livestock manure. The addition of biomass in the right proportions will greatly increase the production of methane which can be burned to generate electricity.

"This is an exciting project because research and technology applications are being used to protect the local environment," said Walker. "The project is improving water quality and providing livestock waste solutions while developing ways to produce electricity on a local level."

The team has secured more than $2 million in external grant funding to support its work and is currently awaiting word on the approval of $500,000 in federal funding to support the first stage of the biomass wastewater treatment project in Lexington.

The LUW Team has also received a number of environmental and service awards for their work, including the University's Outstanding Team Research Award, the Illinois Soil and Water Conservation Award, a Governor's Pollution Prevention Certificate and the Illinois Recycling Association Research Award.

'estructive soybean disease

St ı death syndrome a destructive dis- e associated with yield loss has been ected in some northern Illinois soybean ds

The disease is caused by a soilborne arium fungus that infects the soybean root tem early in the season (as early as two to ee weeks after plant- ı especially when ; are cool and wet disease produces a in resulting in rosis (yellowing. necrosis (death) of interveinal tissue of ves These foliar ptoms typically ear in late July and ly August usually ble after pods begin ıg

By Jim Morrison
Crop Systems
Extension Educator

'he disease appears to be favored by high- d environment, early planting early matu- compacted soil, poor drainage and cool wet litions during the summer. There appears ; an interaction between SDS and soybean ; nematode

Ŧ me comes from the fact that even ıg ; disease may need a few weeks to elop, the time from leaf defoliation to plant th is short SDS can affect the entire field, normally affects only scattered areas with- field

What are the symptoms of SDS infected ıts? Initial symptoms are usually scattered rotic spots that occur between the veins on es and the leaves may be cupped or curled se spots enlarge between veins to become ın lesions surrounded by chlorotic areas process continues until only the midvein major lateral veins remain green Leaves n drop from the top of the plant leaving the petiole (leaf stem attached to the main stem Severe foliar symptoms give affected field areas a brownish cast whereas healthy plants remain green Pod drop may also occur

The effect on yield depends upon the growth stage at the time of initial symptom develop- ment and the speed and severity of foliar symptoms

It is important to split the stem lengthwise and check the color of the pith to get a defini- tive diagnosis Plants with SDS will have white pith with no discoloration or decay There may be a slight gray-brown discoloration of the vas- cular system just inside the outer "bark" of the stem but the pith remains white

In addition to the above-ground symptoms SDS-affected plants will have rotted roots and diseased plants may be easily pulled from the ground This is due to the root rot phase of the disease initiated earlier in the growing season Other symptoms include necrosis of the plant crown Research has shown that it is possible to have infection of the root system without visible foliar symptoms

How does one prevent or manage the dis- ease? No in-season control of SDS exists But management begins with proper identification

Yield loss can be minimized by planting varieties with relatively high levels of toler- ance or resistance Many seed companies pro- vide resistance ratings for their varieties Variety information is also shown at this University of Illinois World Wide Web site — http://web.aces uiuc.edu/VIPS — including data from Southern Illinois University

If SDS is identified one should also take soil samples to determine the presence of soybean cyst nematode and, if it is detected plant a variety that is also resistant to SCN:

To help reduce risk of SDS, select varieties that mature at different times Delay planting (but not past the suggested time for your area) or extend planting so that all soybean are no at the same growth stage at the same time Plant fields with a history of SDS last Efforts to minimize soil compaction and improve drainage may help reduce disease severity

New Web site highlights practical swine waste management methods

Many of us enjoy a fresh country ham and a pork chop dinner But few of us relish the odor and waste that comes with swine production In an effort to help producers and their neigh bors live in harmony researchers from Illinois State University, the University of Illinois and the Illinois State Water and Geological Surveys studied practical meth- ods to handle the waste

Information about these methods can be found on the new World Wide Web site, Swine Waste: Economical and Environmental Treatment Alternatives (SWEETA), www.sweeta.illinois.edu.

By Duane Friend
Natural Resources
Extension Educator

Paul Walker, profes- sor in animal sciences at Illinois State University and coordinator of the livestock and urban waste management team, led the proj ect which included slurry separation, compost ing of solids and applying waste liquids onto crop fields

"Separation of municipal waste water into its solid and liquid components is a technology that has been used by municipal sanitation departments for decades," Walker explained "This technology has been adapted to economi cally separate liquid swine manure into its biosolid and liquid fractions"

Walker said this system's approach allows the biosolids fraction to be composted for ulti- mate use as either an on-farm or off-farm soil amendment, while producing a liquid fraction with low odor low solids and low phosphorus concentrations that can be irrigated as a nitro- gen fertilizer for row crops

These waste handling methods are econom- ical for livestock and grain farmers, and they are environmentally acceptable for the public

The SWEETA Internet site includes eco- nomic comparisons of using inorganic fertilizer raw slurry and compost as a soil amendment for corn production based on actual costs and nutrient analyses Information regarding Illinois Environmental Protection Agency per- mitting local site approval and on-farm exemp- tions is also included The site even includes information on composting horse bedding and manure

Funding for the project was provided by the Natural Resources Conservation Service through a grant awarded to Illinois State


MANURE
Manager
SEPTEMBER/OCTOBER 2008
APPLYING WITH STYLE
HOULE
5350
Innovations:
Skid steers
and loaders

ISU Farm defeats swine odor through aeration

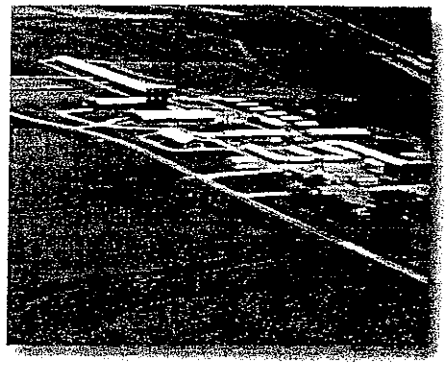
As an informal odor control experiment, ISU Farm management and researchers added a submersible aeration system to the slurry separation process chain.

The large-scale hog farms of today have brought a proportionate increase in environmental issues for this multi-billion dollar segment of the agricultural economy With some swine operations having hundreds even thousands of confined animals in various stages before market their waste management has become a catalyst for controversy and led some regulators to limit or cease issuing permits for construction of new or expanded hog farms Some experts even foresee the U.S Environmental Protection Agency adopting additional regulations affecting established manure management practices.

Researchers at the 610-acre Illinois State University (ISU) Farm near Lexington, Illinois, have been addressing the issue of manure and odor management with a number of demonstration initiatives at the facility s 200-sow farrow-to-finish unit The program has focused on polymer-assisted separation of manure solids from the much larger percentage of liquid in manure Other elements include producing marketable compost from the separated manure solids and using the separated effluent for land application at controlled rates and nutrient compositions on a cornfield

Most recently the ISU Farm has been experimenting with odor control of the separated effluent in light of complaints from neighboring property owners about objectionable smells

The operation's existing manure management program involves a solid-liquid separation system utilizing a polyacylamide flocculent in conjunction with passing the raw slurry through a belt thickener and gravity screen separator The two-step separation results in removal of up to 98 percent of the solids



Researchers at the 610-acre Illinois State University (ISU) Farm have been addressing manure and odor management issues with a number of demonstration initiatives at the facility's 200-sow farrow-to-finish unit.

ISU Farm research

The Illinois State University Farm s program strives to objectively analyze combined solid/liquid separation in tandem with solids composting to control odor and phosphorous contamination as well as to develop instruction materials and to host field days to demonstrate manure management practices for farmers academics consultants and government agency educators

Composting

The farm s composting program converts manure solids into 200 to 400 net cubic tons of compost a year at a 15-acre site Leaves yard waste and cattle bedding are added to produce a value-added product sold to homeowners and organic farms explained Russ Derango, ISU Farm manager

In addition to keeping the odor down in the solids we produce a value-added product that can supplement farm income he added

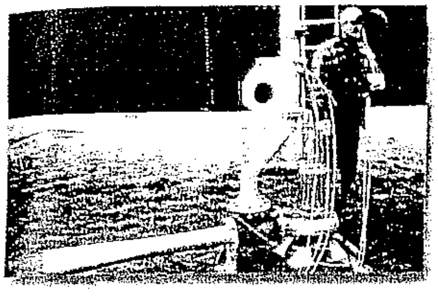
The cost for composting the manure solids has ranged from $10 to $20 per ton of finished compost As a comparison the farm can separate processed liquid manure for less than one cent a gallon

Crop research

Other research on the farm which is located in the heart of the U S cornbelt includes the use of raw and separated manure on crops

Past farm research has shown that applying enough raw slurry to cornfields to achieve yields of 180 bushels/acre reflects a 95-pound over-application of phosphorous By separating the liquid and solid fractions of the manure and applying the effluent alone researchers have shown that phosphorous is reduced to a 32-pound acre deficient making it a non-issue The N:P ratio shifts from 4.1 for unprocessed raw slurry to a range between 15 to 20:1 in separated effluent The corn plant requires a 15 to 16:1 N:P ratio

Dr. Paul Walker, a professor of animal science at ISU, says the ISU Farm can separate processed liquid manure for less than one cent per gallon and the liquid is so clean that clogging does not occur along the center pivot system MM



A single nozzle aerator, driven by a 10-horsepower Flygt submersible N-pump, was installed in the farm's 900,000-gallon Slurrystore to help convert the anaerobic process within the tank into an aerobic environment.

Over the past two years, swine on the farm have produced two million gallons of raw slurry resulting in 1.8 million gallons of effluent and 200 000 gallons of solids While the liquid is stored in an above ground storage tank before being used for weekly gutter flushing or applied as irrigation water to crops, the separated solids are condensed into 10 to 12 percent dry matter and combined with landscape waste to produce 200 to 400 tons of marketable compost (see sidebar)

As an informal odor control experiment ISU Farm management and researchers recently added a submersible aeration system to the slurry separation process chain. A single nozzle aerator driven by a 10-horsepower Flygt submersible N-pump was installed in the farm's 900 000-gallon Slurrystore to help convert the anaerobic process within the tank into an aerobic environment A Flygt specialist in agriculture arranged for loan of the system

'A submersible aerator works much better than a surface mixer which only stirs the liquid and pulls some oxygen off the top but not in significant enough amounts to create the desired aerobic results' explains Ron Skinner agricultural market manager for Flygt. The aeration system used at the farm employs a Venturi effect ejector that pulls air deep into the tank to more fully oxygenate it That reduces the odor along with the amount of nitrogen as a result of the transfer'

According to farm management, the additional aeration almost immediately improved the separated liquid, which always retained a certain degree of objectionable odor during prior irrigation use despite being a nearly clear fluid following the separation process

"Although we didn t conduct a really scientific trial of the aerated liquid the addition of aeration within the storage tank delivered an immediate odor reduction in the separated liquid" said Dr. Paul Walker, a professor of animal science at ISU. The field hands noticed it when working on the irrigation system and equally important so did the neighboring farmer

It clearly passed the sniff test Dr Walker concluded

A 40-acre cornfield - with 180/bushel yield as the production goal - received the aerated effluent through a center pivot and newly installed underground irrigation system

Dr Walker anticipates that public opposition to hog farm odor emissions will result in the U S Environmental Protection Agency (EPA) encouraging – through regulation – changes in the customary storage and land application practices It s hoped that research conducted at the ISU Farm including the informal aeration demonstration can help benefit manure management programs at both large and small swine operations

The aeration experiment was less scientific than a practical attempt to overcome the significant odor off the center pivot that was reaching a downwind neighboring farm ' said Russ Derango ISU Farm manager We tried to show here that a swine operation can be a good neighbor.' MM

FarmWeek Page 8 Monday, July 7, 2008

Manure research results now on website

BY KAY SHIPMAN
FarmWeek

A multi-university research team, led by Paul Walker of Illinois State University, studied practical methods to handle and apply manure. Those research results along with related rules and other information are available in a new website dubbed SWEETA, short for Swine Waste: Economical and Environmental Treatment Alternatives.

SWEETA (www.sweeta.illinois.edu) information may be applied to all types of livestock operations, especially swine.

"We've got information for all types of livestock and for horse people," Walker added.

The main research focus is on separation of manure solids and liquids, field application of the liquids, and composting of the solids. The researchers applied the same technology that municipalities use to treat their waste.

Paul Walker

On SWEETA, producers will find descriptions of different separation methods and comparisons of the resulting manure nutrient components and separation costs.

The information includes comparisons of different application methods and composting. The researchers offer best management practices and suggestions on the methods better suited for different types of livestock operations.

Duane Friend, University of Illinois Extension natural resources educator who worked on the project, envisioned SWEETA being useful for producers seeking alternative methods to manage or apply manure. "The big thing that Dr. Walker included was the economic side of things," Friend added.

Producers also will find information on applicable rules, such as Illinois composting regulations, and any required permits.

SWEETA is a work in progress, and new information will be added periodically. In the next several weeks, Walker will post results of a December-January survey of manure waste haulers. Survey results will include such information as their costs and hauling volumes.

Walker also anticipated posting of electronic newsletters on related issues, such as the economic value of nutrients from manure.

@ITEMHEAD:New Waste Management System Reduces Land Requirements

@BODYTEXT:A swine waste management system, in use for three years at a 200-sow Illinois State University (ISU) hog operation, adapts urban technology to the farm The system involves separating out solid material for composting The liquid portion is applied to crops through a center-pivot or sub-irrigation system

"Separation removes phosphorus, so the liquid can be applied to land without building up excessive P levels in the soil," says ISU's Paul Walker, who led the research team that developed the system It included members of several state agencies and land grant universities

"We can apply 1 million gal of liquid on 40 acres of land, based on nitrogen fertilizer requirements, and still have a phosphorus deficit in the soil," says Walker "When we applied the waste as a slurry, without separating out the solids, we needed 200 acres."

"The compost can be applied to fields, based on phosphorus fertilizer requirements," Walker adds "As a dry product, it can be safely transported to distant fields Or it can be sold off the farm"

Walker believes the technology can fit any size swine operation, and he thinks it also will work for dairy and beef cattle finishing operations You can learn more at www.sweeta.illinois.edu/index.cfm Soon, the site will include a spread sheet in which you can insert your own cost figures to set up a similar system

Livestock

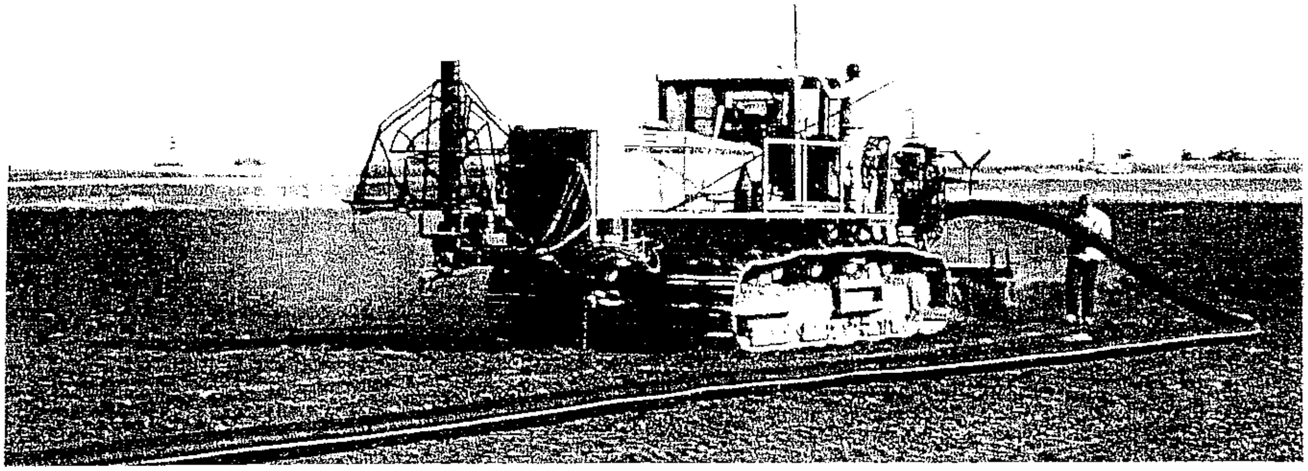
Swine waste website now available

URBANA, Ill. — Alternative methods for handling livestock manure in economical and practical ways are shared on a new University of Illinois Extension website, the result of cumulative research efforts ongoing since the 1990s.

Swine Waste Economical and Environmental Treatment—SWEETA www.sweeta.illinois.edu/ was prepared by the Livestock and Urban Waste Research Team, currently composed of 12 investigators who represent diverse but complementary disciplines.

Paul Walker of Illinois State University is the program's coordinator. U of I members are Duane Friend, Extension natural resources management educator; and Eberhard Morgenroth and David Williams, U of I faculty members with expertise in environmental microbiology and composting, respectively.

The website focuses on a systems approach for processing and land-applying liquid swine manure that is also applicable to liquid dairy and beef cattle finishing manure stored below slatted floor pits or in slurry stores and/or lagoons.



A LASER-GUIDED tile plow buries lines 2 to 3 ft deep maintains a one-tenth grade, and can follow field contours

Underground irrigation

This patented subsoil irrigation system drains and irrigates land all year long [illegible]

AN AGREM system installed at Illinois State University will test the system's ability to subirrigate crops using effluent from ISU's hog confinement operation.

BOB MEINERS has developed and patented an underground irrigation system that literally can go where no system has gone before.

Under the company name Agrem, Meiners developed software that accurately maps soil profiles and field typography and integrated it with state-of-the-art tile machines to design and install subirrigation systems that work as well on the contours of hillsides as they do on level ground

Crop farmers and livestock producers alike benefit from the system's ability to spoon-feed nitrogen at the roots of a growing crop throughout the growing season to improve fertilizer efficiency and crop yield Because Meiners designs closed-loop systems, it's almost impos-

AGREM OWNER Bob Meiners first developed software to help land contractors manage their businesses His latest software develops highly detailed field maps used to design subirrigation systems that will work on rolling fields ible for nitrogen fertilizer to wash away from fields and end up in the Gulf of Mexico. The Agrem system won't eliminate the hypoxia problem, but neither will the addition.

The system also works to drain fields in the spring and fall when farmers want to reduce water levels in the field," Meiners says. "With improved drainage, farmers can plant fields a day or two earlier in the spring and avoid cutting ruts and creating compaction at harvest."

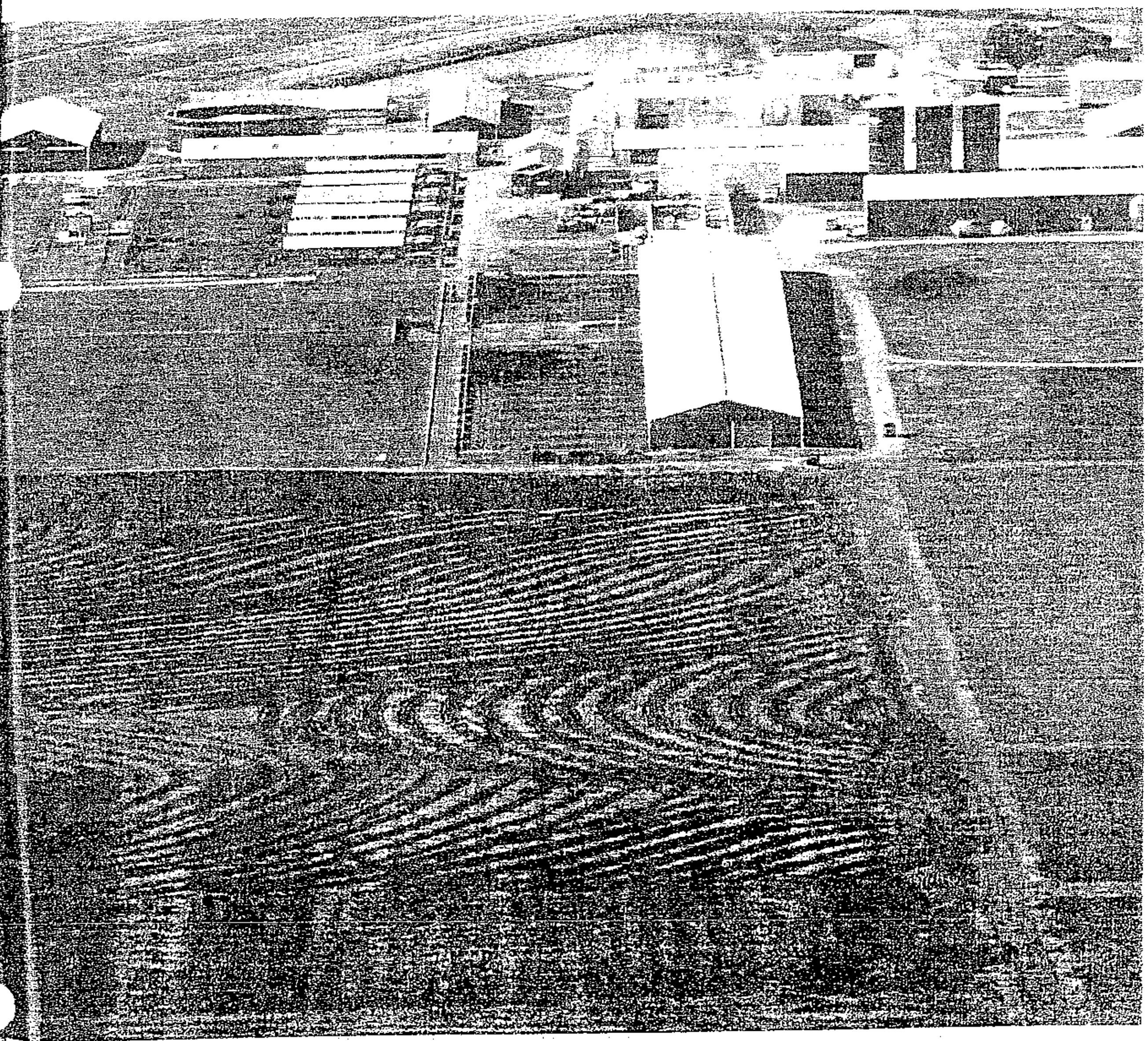
The system's biggest bonus, however, might be for confinement livestock producers who can use Meiners' system to pump effluent to fields 365 days a year regardless of the weather and without the neighbors smelling an odor.

How it works

"It takes a number of new technologies to make the Agrem system viable. Three things had to come together," Meiners explains. "We needed a tile machine that could keep an accurate grade of 1 ft per 1,000 ft, knife-cut tile that won't fall in and the highly defined topo maps."

Meiners, whose company is in Anchor [illegible] wrote the software. RMF [illegible] propelled the plow [illegible] manufactured and certified in Canada provide the necessary tiling accuracy, and Advanced Drainage Systems, Hilliard, OH, provides the tile.

Irrigation water for Meiners' subirrigation system comes from reservoirs that require an area that's 2 to 3% of the acreage to be irrigated. The reservoir collects rain and field runoff and prevents nitrogen and other farm chemicals from moving downstream. A wetland below the reservoir helps filter reservoir water if the reservoir level needs to be lowered.



It takes 20 to 60 hp to pump water through the buried 6- to 8-in. main lines and 3-in. laterals. Control gates, placed along field edges, direct water flow from the main tile line to each zone of the subirrigation system. The control gates can be operated manually or remotely by computer.

"You can choose an individual zone you want to irrigate or irrigate the entire system," Meiners says. "Depending on the size of the pump, it takes 24 to 36 hours to apply an acre inch of water. The subirrigation system uses about one-third the water that a center pivot uses. We bury the lines 2 to 3 ft deep, and our data so far show that yield doesn't vary across the field, either over the top of the lines or in between them."

Yield and safety

Meiners' system isn't just theory. He partnered with The Nature Conservancy to test its yield and environmental safety potential on a 20-acre project, near Colfax, IL. The Agrem system was installed in the fall of 2005 and produced its first crop in 2006.

Testing the Agrem system is just part of a much larger project that The Nature Conservancy has managed since the late 1990s in the Bray Creek and Frog Alley watersheds that drain into the Mackinaw River watershed, according to Maria Lemke, aquatic ecologist for the Illinois Chapter of The Nature Conservancy.

"It's a paired watershed project [each drains about 10,000 acres] where we apply best management practices [BMPs] in one and then compare the results of the treatment watershed to the reference one," she explains. "We've got monitoring equipment set up throughout each watershed to test if the applications impact the system the way we think they do."

Initial research showed that BMPs such as conservation tillage, grass waterways and filter strips didn't significantly change the amount of nitrogen and phosphorus leaving the farm fields and entering the watershed.

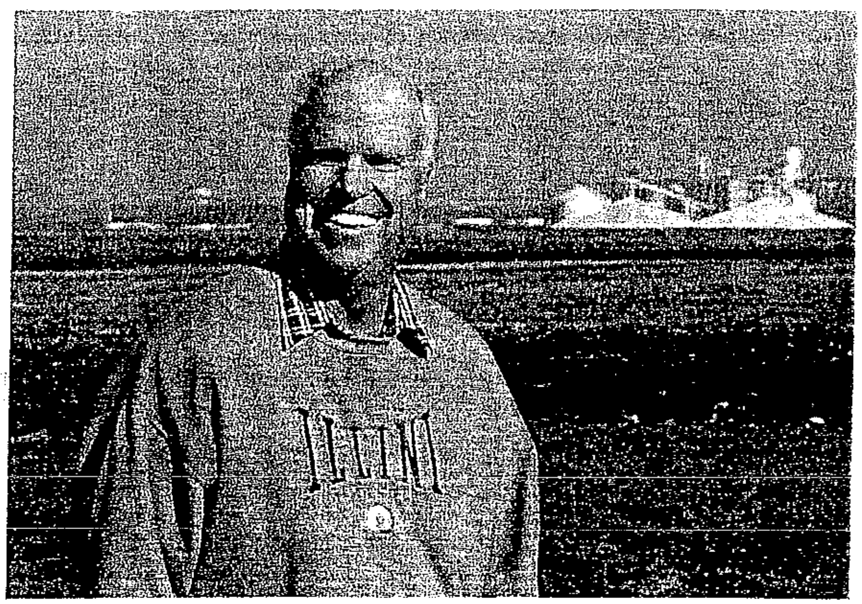
"Most the fields in the watersheds are tiled for drainage and the water was moving right underneath all the improvements we'd made on the surface," Lemke says. "So we've started to look at practices that intercept the water from the drainage tile before it enters the watershed. That's how we met Bob."

The Nature Conservancy, Ducks Unlimited, two McClean County conservation agencies and a number of area universities are all involved in the continuing project.

In addition to the Agrem system, the project is evaluating constructed wetlands as an alternative way to intercept drainage water from field tiles. "We want eventually to be able to give farmers a number of options," Lemke says. "We want to be able to say, 'This is what works. This is how well it works. And this is what it costs.'

"The preliminary results are encouraging," Lemke continues. "There are too many variables to be able to come to any conclusions at this point. We need a few more years of data. But there are a lot of potential benefits."

From a farmer's viewpoint, the initial data from the project look good, according to Meiners. "From the fall of 2005 through the spring of 2006, the field received just 3 in. of rainfall," he says. "Then, from May through the first week of August, only 2.4 in. more rain fell on the field. Through the growing >



ILLINOIS FARMER
John Leonard installed an Agrem system on 200 acres in 2006 and thinks the technology might be a better deal than buying more high-priced land.

> "It seems like a good option. The reservoir covers about one acre in a part of the field that was difficult to farm anyway. With the improved efficiency of the drainage, we actually got in the field two days earlier and it was the first field we planted."
> John Leonard, Gibson City, IL

we applied 3.65 in. of water through subirrigation and made three applications of nitrogen fertilizer (46 lbs actual nitrogen each application) in addition to the 45 lbs of nitrogen surface applied at planting. We applied approximately 1 gal. of 28% liquid fertilizer per 200 gal. of irrigation water."

Yield checks at harvest showed the highest-yielding areas of the field averaged 285 bu./acre with the lowest-yielding area of the field coming in at 197 bu., according to Meiners. "In adjacent farm fields, yields averaged from 45 to 113 bu./acre." he says.

The yield differential was less dramatic in 2007 under more normal rainfall conditions. Yields in the test field ranged from 236.4 to 329 bu./acre, while adjacent fields ranged from 175 to 224 bu./acre.

Farm application

John Leonard, a farmer from Gibson City, IL, considered subirrigation good risk management for the acres where he grows hybrid seed corn. "We put in a system on 200 acres," he says. "I looked at center pivot irrigation, but I didn't have enough water to run a system."

The Agrem system cost Leonard approximately $800/acre installed because Meiners was able to adapt the existing tile system into his plan. A new system costs $1,700 to $2,200/acre, depending on the design criteria according to Meiners.

The price tag doesn't worry financial institutions. Wells Fargo will finance the purchase of an Agrem system, or it can be leased through SCI Leasing Group, according to Meiners.

"It seems like a good option," Leonard says. "The reservoir covers about one acre in a part of the field that was difficult to farm anyway. With the improved efficiency of the drainage, we actually got in the field two days earlier and it was the first field we planted."

No yield data are available from Leonard's 2007 crop, his first subirrigated crop, which was harvested as hybrid seed. "But the seed company was happy and that makes me happy," he says. "The system raises production and returns higher gross dollars per acre."

While subirrigation systems are a significant investment, land prices without a top in sight may give growers second thoughts about which one is the better deal. "When you compare the costs, investing in a subirrigation system on land you already own may be more attractive than buying additional land," Leonard says.

New research project

A research project under way at Illinois State University will take a close look at the economics of the Agrem system. Rob Rhykerd, an associate professor in agronomy specializing in soil science, and Paul Walker, professor of animal science, are working together on the project.

"We installed an Agrem system in 2007 on 18 acres of rolling ground about one-fourth mile from the one-million-gallon storage tank we use for the 200-sow farrow-to-finish hog operation on our research farm at Lexington, IL," Rhykerd says. "In 2008 we'll compare the yield performance, environmental protection and economics of the Agrem system with effluent applied through a center pivot system, applying raw slurry and applying composted manure."

The scientists will test for nutrients and pathogens in field runoff and nutrient and pathogen levels in ground water and will give each system a subjective sniff test for odor. "We've already pumped effluent through the center pivot system and could barely detect any odor," Rhykerd says. "I'm anticipating that with the tile lines buried 20 in., we won't have any odor with the subirrigation system."

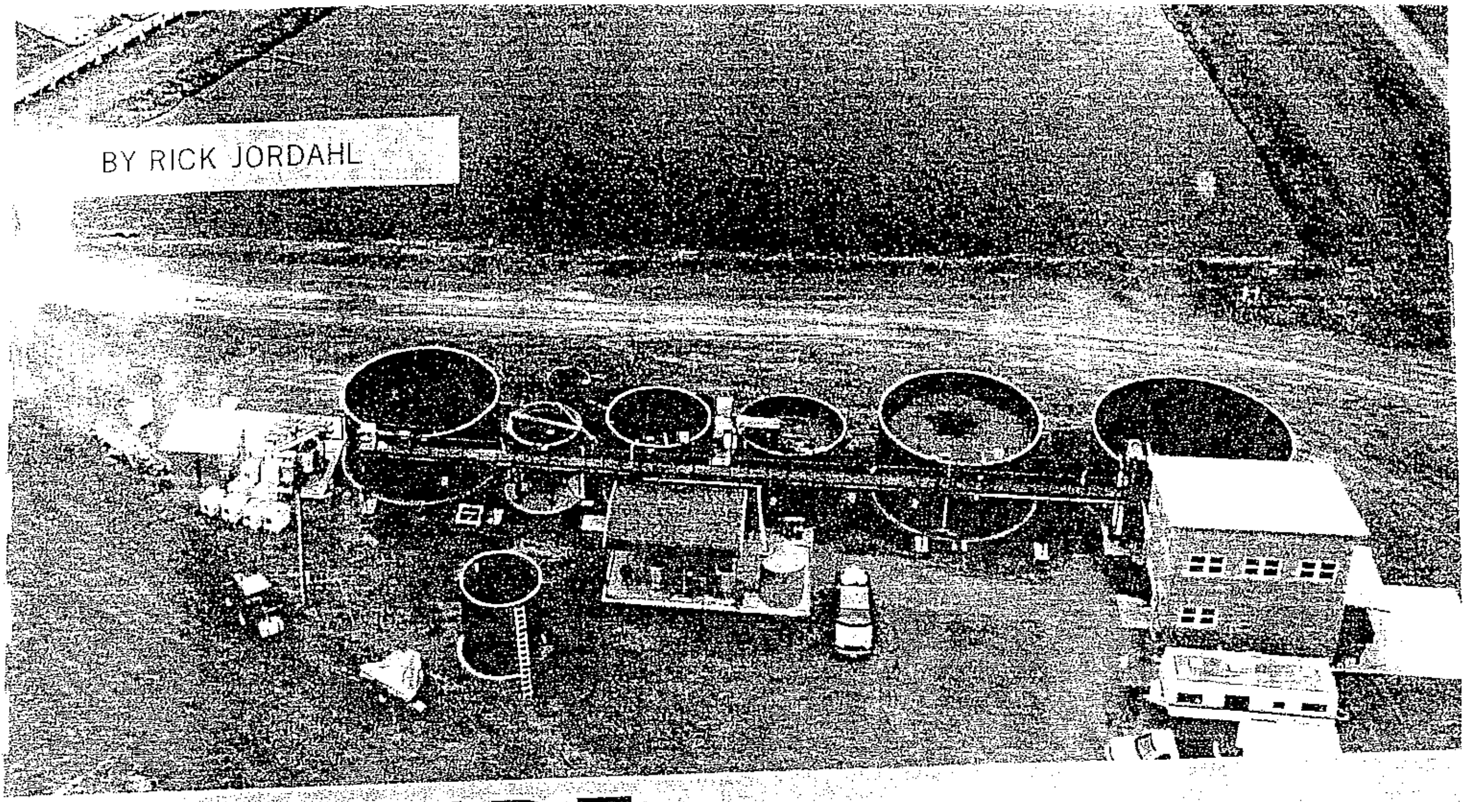
The ISU scientists have installed a mechanical separator at the hog buildings that removes roughly 95% of the solids (and about 50% of the nitrogen and 90% of the phosphorus) from slurry pumped out of the building's manure pits. The solids are composted and spread on research farm fields or sold.

The resulting effluent is stored until it's used as irrigation water. "It's dirty water," Rhykerd says. "It has enough nitrogen, phosphorus and pathogens in it that you wouldn't want to put it directly in a creek."

"It was fascinating to watch the subirrigation system installed," he says. "The tile machine lifts the soil, sets the tile underneath and lays the soil back down. You don't get much mixing of the subsoil with the surface. The system was installed by the end of May and we were able to disk the field lightly and plant soybeans. The crop ended up yielding close to 60 bu./acre with no effluent applied. It's really unique."

To learn more about Agrem subirrigation systems, visit www.agrem.com. Or contact Agrem LLC, Dept. FIN, 17120 N 3800 East Rd., Anchor, IL 61720, 309/723-3231, visit www.freeproductinfo.net/fin, or circle 109.

BY RICK JORDAHL



MANURE: THE NEW BLACK GOLD

[T]he hog manure collecting in your lagoons or pits is more valuable today than ever. While it was always a useful resource, many pork producers now consider manure's value a significant contribution to the facility's cash flow.

Skyrocketing commercial fertilizer prices have certainly directed more attention your way, and your operation's manure capture and application strategy can help determine how you mine this new black gold. Whether you are selling manure to crop producers or using the byproduct to fertilize your own corn crop, you need to determine a value for this hot commodity.

According to the Swine Waste Economical and Environmental Treatment Alternatives Web site, the nitrogen, phosphorous and potassium cost to fertilize 1 acre of corn rose from $121.92 in 2006 to $222.09 in 2008. The same dramatic increase in commercial fertilizer cost also influences the value of liquid manure.

Capturing liquid manure's maximum value, however, is not automatic. So how can you make sure you are getting the slurry's full value?

Your nutrient-management plan is the place to start, and this means evaluating soil and slurry nutrient levels regularly. Matching the crop's nutrient needs as closely as possible will maximize the manure's value. If the nutrient level in the manure is higher than crop requirements, the excess is simply wasted.

For example, if slurry is applied in amounts targeted to supply 100 percent of a crop's nitrogen requirement, both phosphorous and potassium will likely be over-applied. In that case, you will not get the most out of the manure, plus it may create crop and environmental problems such as reduced yield or nutrient runoff.

In the opposite case, if the manure falls short of the crop's nutrient requirement, yields will suffer, as will the manure's value. Reduced manure nutrient levels also reduce its value.

Efficient use of nutrients in swine diets means that the total amount of nutrients entering the manure storage has decreased, according to John Lory, environmental nutrient-management specialist and principal author of a University of Missouri soil-management bulletin. (See sidebar.) In this case, producers who use the manure to fertilize their fields may lose money because they need to purchase more fertilizer to compensate for the lower nutrient levels in the manure.

rests

largely on maximizing the utilization of the nutrients it contains. If those nutrient levels don't match your crop's needs, the manure may be more valuable to another producer whose crop needs would better utilize what it offers.

It may be easiest, however, to get full fertilizer value for the manure by applying it to land under your control. This allows you to substitute manure for fertilizer that you would have otherwise purchased, thus allowing you to get nearly full fertilizer value for the manure, Lory says

Another option is to use a combination approach. That involves applying manure at a lower rate than crop needs call for and then adding supplemental commercial fertilizer in the spring. This approach offers the potential for more acres to receive a yield and soil enhancement benefit from the manure. In this case manure value is increased.

A quick calculation shows the importance of properly utilizing manure's nutrients to capture its full value. According to SWEETA, when slurry was applied to meet 100 percent of corn's nitrogen requirements at 2008 prices, slurry had a calculated value of 3 cents per gallon. When slurry was combined with anhydrous ammonia and potash to meet nitrogen and phosphorous requirements, the 2008 calculated value rose to 9.56 cents per gallon.

This variation in manure value was illustrated in a research study titled "The Other Fertilizer," conducted by Robert Koehler and William Lazarus, University of Minnesota. (See sidebar.) The study involved 15 pork production sites in 2005, 22 in 2006 and 10 in 2007.

When valued at projected fertilizer prices in early 2008, the study estimated manure's value at three levels. It showed that manure value can depend on many factors, but the net value realized on these farms came in at a maximum of $95 per acre. The average was $37 per acre and the minimum was minus $23 per acre. "These amounts would be higher today with the increase in fertilizer prices that has occurred since early 2008," Koehler adds.

the phytase factor

The use of phytase in swine diets can adversely affect the manure's value by reducing phosphorous levels. However, according to Koehler's study, typical application rates of 3,500 gallons of swine finishing manure per acre will supply enough phosphorous even if the level of the nutrient is only 20 pounds per 1,000 gallons.

The study goes on to explain that "University of Minnesota-recommended P_2O_5 phosphorous fertilizer application rates for ... do not suggest more than those amounts ... soil test levels are in the low to very low range." The study concludes that "many fields, especially those that have received manure in the past, should not be negatively affected (by the use of phytase in swine diets) and the feed-cost savings will not be lost in reduced fertilizer replacement value."

Other important factors that influence manure's value include application timing. "Ideally, manure is applied in spring, close to corn planting time," according to Lory. "Spring applications reduce the potential for nitrogen loss between application and the time the crop needs nitrogen."

The slurry's water content is another significant value reducer. Water from drinkers, pressure washing or cooling sprinklers can reduce dry matter percentages in slurry, thereby reducing its nutrient levels.

"Producers should evaluate their management to avoid dilute manures unless other offsetting benefits are gained," Lory says. "The economic value of dilute manure is significantly less due to hauling many more gallons to achieve the required crop nutrient levels."

Measuring manure's value is largely dependent on the value of commercial fertilizer it replaces. "The reality is that these numbers have been changing quickly," Lory says. "Current fertilizer prices are around 75 cents per pound for nitrogen, $1.20 per pound for phosphate and 55 cents per pound for potassium. However, I suspect that nitrogen prices will ease somewhat, which should be expected because gas prices are falling too."

Swine manure has long been under-valued as a pork production byproduct and as a soil amendment. While today it's getting more attention, it may offer the greatest value to your operation as part of a combination fertilizer application program. This means a nutrient-management plan as well as regular soil and slurry nutrient testing play key roles in maximizing the value of this new black gold.

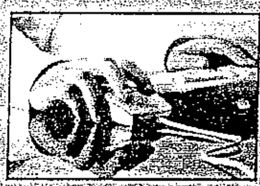
SLURRY: A FISTFUL OF DOLLARS

Manure's economic value varies by the nutrients it contains and the utilization of those nutrients. John Lory, University of Missouri environmental nutrient-management specialist, suggests these keys to maximizing the value:

1. Rotate fields receiving manure from year to year.
2. Apply manure to cropland under your control, thereby reducing or eliminating the need to purchase commercial fertilizer.
3. Minimize the amount of water in the manure storage, which decreases the cost and time required for manure application.
4. Slurry manure is most valuable as a nitrogen fertilizer when it is injected into the soil as close as possible to the time that the crop will need the nutrients.

"We recommend applying manure based on nitrogen need but then rotating manure application off that field until the excess phosphorous and potassium from the manure has been used by subsequent crops," Lory says. "This maximizes the phosphorous and potassium value of the manure while allowing the producer to use manure as the complete nitrogen source in the year of application."

TO FIND OUT MORE...



Web site resources offer help and extensive information for determining swine manure's value. They also can assist you in getting the most economic return for your operation. For management strategies and a spreadsheet that can help determine the contribution to your cash flow, go to *www.porkmag.com/environment*.

To access a University of Minnesota Extension bulletin, "The Other Fertilizer," that outlines methodology for determining manure value and reports results of a three-year study of manure values as seen in Minnesota pork production systems, go to *www.porkmag.com/environment*.

For SWEETA's Web site and information on the value of liquid manure as a fertilizer for corn production, see the link at *www.porkmag.com/environment*.

For a copy of "Optimizing Fertilizer Value of Manure From Slurry Hog Finishing Operations" by John Lory, University of Missouri, go to *www.porkmag.com/environment*.

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Attachment 20

Illinois Pork Producers Association Email Newsletter Related to Manure Management/Technology Transfer

Slurry Separation
A Systems Approach to Manure Management
LUW Team
ILLINOIS STATE UNIVERSITY
DEPARTMENT OF AGRICULTURE

It has been a really wet winter and spring, and liquid manure storage tanks and pits are getting full Many operators are having trouble finding a window of opportunity dry enough to land apply slurry That has not been a problem for the ISU Farm We've had a few dry days in a row that have allowed the soil to dry sufficiently to allow us to land apply separated effluent (SE) with our center pivot irrigator. While the soil has not been dry enough for a tractor and slurry wagon to inject liquid manure, it has been possible to irrigate because the SE has so little solids and phosphorus concentration neither runoff nor leaching are a risk

For some operators the cost for land application of liquid manure is reaching prohibitive levels This may be especially so if slurry must be hauled more than one to two miles for land application Many fields located near swine facilities where slurry has been land applied for several years have prohibitive phosphorus concentrations making it a necessity to haul slurry further away from the facilities. It costs approximately 1 0¢:gallon:mile to haul slurry. Some producers are logging up to 20,000 miles each year on semi tankers to haul slurry That's up to $40,000 that could be utilized for other purposes.

Separation of municipal waste water into its solid and liquid components is a technology that has been utilized by municipal sanitation departments for decades. Removal of the biosolids fraction cleans the liquid portion sufficiently that the waste water can be added to the surface waters of Illinois and the U.S. Many city wastewater treatment departments use polymer-assisted separation systems that combine the use of chemical flocculants, gravity belt thickeners and belt presses to remove the solids fraction from wastewater The Livestock and Urban Waste Research (LUW) Team has adapted this technology to economically separate liquid swine manure into its biosolids and liquid fractions This systems approach allows the biosolids fraction to be composted for ultimate use as either an on-farm or off-farm soil amendment while producing a liquid fraction with low odor, low solids and low phosphorus concentrations that can be irrigated as a nitrogen fertilizer for row crops

Several issues must be studied as a producer considers whether or not to adopt solid-liquid separation as an alternative manure management strategy The issues that must be considered are:

1 volume of raw (untreated) slurry produced annually.
2 current storage capacity, including building pit capacity and storage tank or lagoon capacity

3 type of slurry storage. Is it building pit storage or is it storage external to the buildings such as a lagoon or Slurry Store®?

4 current slurry treatment, if any This may include a two or three stage lagoon settling system

5 current cost of land applying slurry This includes agitation, pumping, injection and hauling costs.

The current costs for land applying slurry should be calculated as annual dollars:year and cents:gallon carried at least two decimal places (00.00¢:g). In order for solid-liquid separation to be effective and timely, the separation process must include a chemical polymer (polyacrylamide or PAM) to flocculate the solids portion. Mechanical separation without PAM assistance is not effective. The liquid produced during mechanical separation without PAM assistance still should be considered slurry with all the bad things associated slurry, including odor, suspended solids, high phosphorus concentration, etc. The solids removed by mechanical separation are referred to as separable solids and usually represent 30 – 40% of the total solids concentration in raw slurry. Separation by settling in a three stage lagoon system can be effective and can produce a desirable separated effluent. However, settling separation by gravity alone is a slow process, (days to weeks) and has large volume storage requirements.

Separation is most effective if the slurry is fresh i.e. no older than seven days. Slurry less than 7 days is generally aerobic (contains some oxygen). Separation of manure stored in deep pits or outside holding tanks for periods longer than one week is not as effective as separation of fresh slurry. Slurry stored for prolonged periods has become anaerobic and requires the use of higher polymer concentrations, costs more per gallon to separate and does not remove as much of the solids fraction. Anaerobic slurry can be separated but the separation process requires substantial agitation prior to adding the polymer to produce as uniform solids concentration as possible. Agitation alone is never completely successful in creating uniform solids concentration in slurry. Separating anaerobic slurry in comparison to fresh slurry, also, creates substantially more odor during the separation process.

Selection of the appropriate polymer is crucial to successful separation. There are hundreds of polymers available. Not all liquid manures are the same. Therefore, there may be some trial and error is selecting the most efficacious polymer for each farm. However, selection of the correct polymer is not prohibitive nor that difficult. Chemical sales technicians and separation specialists can provide on-farm assistance in selecting the most appropriate polymer.

Pumping or draining manure pits once weekly for separation and then recharging each pit with approximately four inches of separated effluent or fresh water decreases odor of separation. Removing slurry from building pits on a weekly basis, also, improves the building environment substantially (decreases inside building odor, decreases building gas concentrations, increases pig performance and improves worker satisfaction)

There are seven components to the separation system developed by the LUW Team:

1. a holding tank for agitating slurry after draining slurry from a building pit
2. a gravity screen/roll press combination mechanical separator to remove approximately 30% of the separable solids producing what is referred to as separated slurry
3. a mixing tank for making a polymer premix.
4. a mixing tank or an in-line venturi system for adding polymer to the separated slurry
5. a second separator for removing suspended solids producing what is referred to as separated effluent and biosolids The second separator can be either a gravity screen separator, continuous gravity belt thickener or belt press separator. The gravity screen separator is the least cost separator
6. a holding basin for the separated biosolids or the biosolids can be discharged directly to a slurry wagon or manure spreader
7. a holding tank for the separated effluent The LUW Team separation system has a separated effluent collection rate of 90+%. Therefore, if one million gallons is separated prior to land application, a 900,000 gallon holding tank for separated effluent is required. To minimize odor of the separated effluent during irrigation it is best to aerate the separated effluent on a continuous basis during storage

Because effective separation can remove up to 90+% of the phosphorus and total solids concentration from slurry, separated effluent can be land applied (irrigated) based on its nitrogen concentration. Studies conducted at the ISU Farm have demonstrated that one million gallons can be land applied to 40 acres to provide the nitrogen requirement for corn production without over applying phosphorus The cost of separation and land application of separated effluent via center pivot irrigation has been similar to the cost to land apply untreated slurry. For more information visit the website (www.sweeta.illinois.edu)

SURVEY OF ILLINOIS COMMERCIAL MANURE HAULERS AND APPLICATORS

Have you ever wondered how much other producers are paying to have their manure hauled and land applied? Have you ever considered how far manure is hauled before it is land applied? In an effort to discover the average cost producers are paying to haul and land apply manure in Illinois, a survey was conducted of the custom manure haulers and applicators listed on the "Illinois Commercial Manure Haulers and Applicators" web site. The address of this web site is: http://web.extension.uiuc.edu/clmt/haulers_list.cfm

Currently the LUW Team is separating the solid and liquid portions of liquid swine manure and land applying the separated effluent (liquid portion) at a cost of 1.0 – 1.1¢:gallon. In order to compare the cost for separation and land application to the traditional injection method for unprocessed slurry the LUW Team needed to know the average costs for injecting slurry.

The survey was conducted during December 2007 and January 2008, therefore, as the cost of a barrel of oil has continued to rise so may have the custom application rates increased since the survey was conducted. Thirty-eight custom operators were listed on the web site. Of the 38, three had retired or were no longer custom applying manure. Of the remaining 35 operators, 19 responded to the one page, 14 question survey for a response rate of 54.3%. Fifteen or 78.9% of the respondents were full time custom operators and manure hauling/applying was just one aspect of a multi-service business for 63.2% of the operators. Of the operators, 89.5% provided multiple services i.e. pit or lagoon agitation, pumping, hauling and land application. Only 10.5% limited their service to just land application, or to just hauling and application. About one half of the operators provided services on a year around basis while the other one half offered their services seasonally (spring, summer and fall, or spring and fall, but not winter).

The following table references the types of manure the operators handled.

Manure Type	Percent of Operators
Swine	94.7
Poultry	15.8
Beef	47.4
Dairy	57.9
Other	10.5

The volume of manure applied per year ranged from four million gallons to 380 million gallons. The average per operator was 60.1 million gallons:year. One operator, also, handled solid manure and this amounted to 30,000 tons per year. The average amount of liquid manure land applied per day of operation was 728,235 gallons and ranged from a high of 2 million gallon:24

hours to a low of 175,000 gallons:day The mean volume land applied per customer was 5 4 million gallons:year and ranged from 25 million gallons down to 500,000 gallons The average number of customers per custom operator was 26 producers

The following table outlines the method of land application used by the custom operators

Method of Application	Percent of Operators
Box Spreader	21 0
Injection	78 9
Drag Line	63 2
Slurry Tank	36 8
Surface Application	31 6
Other	5 3

The average cost per gallon to land apply unprocessed slurry was 2.0¢:gallon and ranged from 0 6¢:gallon to 15 0¢ per gallon depending primarily on the total volume land applied and other services offered The mean cost for land application only was 1 7¢:gallon if the volume applied was between one and four million gallons. If the volume applied was greater than four million gallons the average cost was 0.9¢:gallon These average costs included land application only for 78 9% of the custom operators If hauling manure from the storage site to the application site was required these operators charged an additional fee Nearly 40% of the operators did not charge an additional hauling fee if the site of land application was within .5 to 3.0 miles (1.25 miles was the average) of the manure storage site All custom operators charged a hauling fee if the slurry was hauled more than 3 0 miles to a land application site Approximately 26% of the custom operators charged an hourly rate for the truck(s) used to haul manure while 63.1% charged a fee based on cost:gallon hauled One operator charged according to tons of manure hauled The average cost per gallon hauled was 1 8¢:gallon and ranged from 0.8¢:gallon to 1.5¢:gallon hauled Those custom operators who charged by hour of truck use had an average cost of $67:hour of truck use (ranging from $45:hour to $100:hour) The cost for hauling by the one operator who charged by the ton hauled was $7:ton.

The average cost to separate raw slurry into its solid and liquid fractions including land application of separated effluent via center pivot irrigation for 2006 and 2007 was 1.0¢:gallon of raw slurry processed The cost to separate and land apply by irrigation is expected to increase for 2008 but should still be comparable in price to traditional land application by injection Costs for separation and land application in 2008 will be available in the fall For more information check out the LUW Team web site: www.sweeta.illinois.edu

Value of Liquid Swine Manure as a Fertilizer for Corn Production

This email newsletter is provided by the Livestock and Urban Waste Research (LUW) Team with assistance from the Illinois Pork Producers Association (IPPA) as part of our outreach efforts. This newsletter represents the first of several newsletters the LUW Team will be providing through the IPPA email

The Livestock and Urban Waste Research (LUW) Team has conducted several research studies evaluating solid-liquid separation of swine slurry, composting of the separated biosolids, the land application of unprocessed (raw) slurry, separated effluent, compost and traditional inorganic fertilizer, and the effects of land application of these soil amendments on soil characteristics and ground water The information contained in this communication compares the cost and economic value of using inorganic fertilizer, raw slurry, and compost as a soil amendment for corn production based on actual costs and nutrient analyses

A list of abbreviations used throughout this narrative and within the tables is shown as Table 1 The N, P and K values for RS, C, POT, DAP and AA are provided in Table 2. The composition of RS and C reflect average analyzed values for the years 2006 and 2007. The data shown in Table 3 are the actual purchase prices paid for AA, DAP, and POT The application costs provided are actual costs charged by commercial applicators for the Lexington, Illinois area.

The data of Table 4 reflect calculated application rates required to produce 180 bushels of shelled corn: acre assuming each bushel of shelled corn produced requires 1.33 pounds of N and 0.22 pounds of P. The base fertilizer rate, then, to produce 180 bushels of shelled corn: acre is 252 lb. of AA, 176 lb. of DAP and 200 lb POT. This fertilization rate does not result in any carry-over N or P The application of RS assumes that 35% of the N in RS is available during year one, 18% is available during year two and 9% is available during year 3 The same three availability estimates were assumed for compost application Compost application is based on the dry matter content but cost analyses are based on the wet weight of compost assuming compost is 40% DM Because the N in RS and C varies in its availability an average application rate for four years was calculated and used to estimate nutrient carry-over and cost In actually, heavier RS or C application rates: acre are required in year one, decreased in years two and three then rise again for year four, repeating the cycle to infinity assuming the N and P concentrations of RS and C do not change over time This cyclic pattern emphasizes why yearly analyses of RS and C for nutrient concentration are so important if the producer desires to balance nutrient application with nutrient use and nutrient carryover, while maximizing profits

The data of Table 5 show the implications of applying RS and C for their N content alone Row 1 represents IF applied to equal N and P utilization, without regard to K. At the application rates shown in Table 4 and row one of Table 5, the amount of K supplied equals 120 pounds K

This represents a typical POT application rate for the soils at the ISU Farm-Lexington. When compost is applied to supply 100% of the corn's N requirement, P is over applied by 54 lbs. and K is over applied by 47.2 lbs. When RS is applied to supply 100% of the corn's N requirement, P is over applied by 139.4 lbs and K is over applied 49.7 lbs. As future regulation prevents over application of P, applying RS or C to supply 100% of the corn's N requirement will be illegal and could pose environmental P contamination problems. Therefore, the last two rows of Table 4 and Table 5 represent combining RS and IF to supply the same N, P and K as supplied in row one with IF alone. Accordingly, the amount of N supplied equals 239 lb, P supplied equals 39.6 lb and K supplied equals 120 lb. These application rates result in no carry-over P, assuming a 180 bushel corn yield. The data of Table 6 tells the real story and reflects how the value of manure and compost can change based on the cost of inorganic fertilizer. The cost to fertilize one acre of corn for N, P, K rose $100.17 from $121.92 in 2006 to $222.09 in 2008. As the cost of AA, DAP and POT increases so does the relative, comparative value of the RS and C. Perhaps more importantly, applying RS and IF to meet, without exceeding, the requirements for N and P results in greater value per gallon for RS compared to applying RS as the sole N source. The down side to utilizing RS and IF in combination to meet the corn plants requirements for N, P and K is that 5.5 times more acres are required to land apply the RS, comparing RS application rates of 5,156g:ac to 934g:ac. These data suggest that RS and C both have more value supplying P and K requirements than as a sole supplier of N. Sometimes doing the right thing environmentally pays off economically as well.

Applying RS and IF in combination to satisfy the N, P, and K requirements is more efficacious than over applying RS to meet N requirements alone. When RS was applied to meet 100% of the N requirements at 2006 prices, RS had a calculated value of 1.36¢:g. When RS was combined with AA and POT to meet N and P requirements, the 2006 calculated value of RS rose 4.42¢;g. When RS was applied to meet 100% of the N requirements at 2008 prices, RS had a calculated value of 3.0¢:g. When RS was combined with AA and POT to meet N and P requirements, the 2008 calculated value of RS rose to 9.56¢:g. A similar trend was found for applying C and IF in combination.

Liquid swine manure has been an under-valued soil amendment for producing corn. Liquid swine manure has even greater value as part of a combination fertilizer application program. For more information visit our web site www.sweeta.illinois.edu.

Table 1. ABBREVIATIONS

C =	compost
RS =	raw slurry
DAP =	Diammonium phosphate
AA =	Anhydrous Ammonia
IF =	Inorganic fertilizer
g =	gallon
ac =	acre
lb =	pounds
T =	Ton
DM =	Dry matter
N =	Nitrogen
P =	Phosphorus
K =	Potassium
POT =	Potash

Table 2. NPK COMPOSITION (%)

	N	P	K
POT			60 0
AA	82 0		
DAP	18 0	46.0	
C	1.5	0.3	0.6
RS	1.0	0.53	0 46

Table 3 SOIL AMENDMENT COST

	2006		2008	
	Purchase	Application	Purchase	Application
AA	$449:T	$6 00:ac	$730:T	$6.50:ac
DAP	$332:T	$2.50:ac	$715:T	$5 00:ac
POTASH	$250:T	$2.50:ac	$506:T	$5 00:ac
C	?	$2 00:ac	?	$4.00:ac
RS	?	1.0¢:g:ac	?	1.3¢:g:ac

Table 4 SOIL AMENDMENT APPLIED (lb:ac)

IF	252 lb AA	176 lb DAP	200 lb POT
C	15 6T DM or 39.0T wet wt basis		
RS	5156 g or 41,248 lb		
RS + IF	934 g or 7472 lb RS; 200 lb AA		143 lb POT
C + IF	6.6 T DM or 16.50 T wet wt	50 lb AA	68 lb POT

Table 5. N and P SUPPLIED (lb:ac)

Amendment	Yield	N req	N supp	P req	P supp	P excess
Range +	180	239	239	39.6	39.6	0
IF	180	239	239	39 6	39.6	0
C	180	239	239	39 6	93.6	54
RS	180	239	239	39.6	179.0	139 4
RS + AA + POT	180	239	239	39.6	39.6	0
C + AA + POT	180	239	239	39 6	39.6	0

Table 6. FERTILIZER COST ($:ac)

	2006		2008	
Fertilizer	purchase	application	purchase	application
IF	110 92	11 00	205.59	16.50
C	119.92	2.00	218 09	4.00
RS	70.36[a]	51.56	155.06[a]	67 03
RS/IF	41.25	80.67[b]	89.27	132 72[d]
C/IF	91.67	30.25[c]	171.14	50.95[e]

[a]Corresponds to 1.36¢:g for 2006 and 3 00¢:g for 2008 which represents the maximum value of RS relative to the cost of IF:ac minus the cost of applying RS

[b]Reflects application cost for RS, AA + POT and purchase cost for AA + POT; value of RS = 4 42¢:g:2006 and 9.56¢:g:2008

[c]Reflects application cost for C, AA + POT and purchase cost for AA + POT; value of C = $5.56:T:2006 and $10.37:Ton:2008

MORE REGARDING THE FERTILIZER VALUE OF LIQUID SWINE MANURE

This email newsletter further addresses how we can arrive at a justifiable value for liquid swine manure in comparison to wholesale/retail costs for traditional inorganic fertilizers.

Inorganic fertilizer prices are at record or near record highs. Current prices for anhydrous ammonia (AA), Potash (POT) and diammonium phosphate (DAP) are $1155:ton (5.8¢:lb.), $920:ton (46¢:lb.) and $1131:ton (56.6¢:lb.), respectively. Typical application costs for AA, POT and DAP are $7.00:acre, $3.25:ac and $3.25:ac. As a result, many grain producers are looking for alternative soil amendments as sources for N, P and K. One of these alternative soil amendments is liquid swine manure or slurry. Slurry has some obvious advantages including lower cost, a good source of N, P and K, local availability, high organic matter content and the ability to enhance soil characteristics. However, just because swine slurry may be lower priced (cheaper) than inorganic fertilizer does not necessarily imply slurry is a more economical soil amendment for the environment. Historically manure has been land applied as a sole source soil amendment (fertilizer) for N, P and K. Applying manure to meet the crops N requirement and thereby over applying P can result in soil P buildup. Whether or not this increase in localized soil P has contributed to surface water hypoxia may be debated. Certainly more research clarifying this issue is required. Regardless, management of liquid swine manure has become an important issue in American agriculture. The potentially negative environmental consequences for handling and land application of swine slurry must be addressed in relationship to the same consequences for using inorganic fertilizer sources. These consequences, including the runoff to surface water and leaching to ground water of nutrients (especially N, P and K) must be assessed from a scientific perspective based on actual data collection and not on theoretical projections. The LUW Team is currently conducting or has planned several studies designed to evaluate these issues. In order to correctly design studies to evaluate the energetic, environmental and economic impacts of utilizing slurry, we must first recognize what we already know.

What do we know? Assume the following scenario, a farmer has four grow-finish buildings, each with a one-time capacity of 1100 hogs and a turn-over rate of 2.25 times:year producing 9,900 finishers and generating 2,409,000 gallons of slurry:year. The gallons of slurry generated:year is based on an average pig in the buildings weighing 200 pounds producing 1.5 gallons of slurry:day containing 0.06 lbs. N, 0.02 lbs. P and 0.04 lbs. K: gallon. Total N, P, K production for the operation in one year is 144, 540 lbs N, 48, 180 lbs. P and 96,360 lbs. K. We know that one bushel of shelled corn production requires 1.33 lbs. N, .22 lbs. P and 1.10 lbs. K. In this scenario, 180 bushels of shelled corn:acre requires 239 lbs. N, 39.6 lbs. (40 lbs.) P and 198 lbs. K.

For this scenario, the inorganic fertilizer choices are Potash (60% K_2O, 50% K), A.A. (82% N) and DAP (18% N, 19% P). Accordingly, 246 lbs. A.A., 208 lbs. DAP and 396 lbs. POT costing $142.68, $118.56 and $182.16, respectively are required. Total inorganic fertilizer cost:acre including application ($13.50:ac) is $456.90 if land applied today (November, 2008).
If the 2,409,000 gallons of slurry are land applied to satisfy the 180 bushel:acre corn yield based on total N requirement (144,540 lb. N ÷ 239 lb. N:ac) each acre requires 3,982 gallons of slurry applied over 605 acres; based on total P requirement (48,180 lb. P ÷ 40 lb. P:ac) each acre requires 1980 gallons of slurry applied over 1217 acres; and, based on total K requirement (96,360 lb. K ÷ 198 lb. K:ac), each acre requires 4947 gallons of slurry applied over 487 acres. Based on a survey of manure applicators in Illinois conducted during the fall of 2007 (www.sweeta.Illinois.edu), the average cost to land apply slurry via injection is 2.01¢:gallon for less than one million gallons, 1.67¢:gallon for 1 – 4 million gallons and 0.9¢:gallon for more than 4 million gallons. Therefore, for this scenario the cost to land apply slurry is 1.67¢:gallon.

If the slurry is applied to meet the N requirement, N is met at exactly 239 lbs. N:ac, P is over applied by 40 lbs:ac or 2 times the required amount and 159 lbs. of K are applied which is 39 lbs short of the required amount. Therefore, 78 lbs. of POT is needed costing $39.13 (including application cost). Subtracting the cost:acre to land apply slurry (3,982 gallons x 1.67¢ = $66.50:acre) and the cost of POT ($39.13) from the total cost to apply inorganic fertilizer ($456.90), slurry has a fertilizer value of $351.27:acre or 8.82¢: gallon returning $212,473 to the swine operator (2,409,000 gallons x 8.82¢:gallon). But, the operator over applied P.

If the slurry is applied to meet the P requirement, P is met at exactly 40 lbs. P:acre, N is deficient 120 lbs. and K is deficient 119 lbs. Therefore, 146 lbs. of A.A. costing $94.68 (including application cost) and 238 lbs. of POT costing $112.73 (including application cost) is needed. Subtracting the cost:acre to land apply slurry (1980 x 1.67¢ = $33.07:acre), slurry has a fertilizer value of $219.42:acre or 11.08¢:gallon ($456.90 - $94.68 - $112.73 - $33.07 = $219.42) returning $266,917 to the swine operator (2,409,000 gallons x 11.08¢:gallon). Applying slurry to meet P requirements and supplementing slurry to meet N and K requirements provides a nutrient balanced fertilizer program and returns the most potential income to the swine operator.

If the slurry is applied to meet the K requirement, K is met at exactly 198 lbs:K acre, and N and P are applied in excess (+ 58 lbs. N:acre; + 59 lbs. P:acre). In other words, slurry is applied as a sole source of fertilizer to guarantee the minimum amount of N, P, K required to grow 180 bu:acre of shelled corn. Applying 4947 gallons of slurry to meet the K requirement costs $82.62:acre (4947 x 1.67¢) and the fertilizer value for slurry (not counting the excess N and P applied) is $374.28:acre or 7.57¢:gallon of slurry ($456.90 minus $82.62). This rate of application returns $182,361 to the swine operator (2,409,000 gallons x 7.57¢). However, regulations for nutrient management plans (NMP) in most states limit manure application:acre to the amount of N required to grow the specific crop and many NMP's are beginning to prohibit applying excess P:acre above what the crop requires In several states the soil P rating (low, medium or high) provides a recommendation(s) to not limit P application (lb:acre) if the P soil test is low (in Illinois ≤ 50 lb:acre), to limit P application to the amount required for crop production if the P soil test is medium (in Illinois between 50 and 70), and to not apply any P if the P soil test is high (in Illinois above 70 lbs:acre)

From a fertilizer perspective, slurry has greatest economic value per gallon if it is applied to satisfy the crops P fertilizer requirement Applying less slurry per acre provides more value per gallon but requires more acres to apply a given amount of slurry If costs for transporting slurry to the field are included, more acres translates to less total return to the swine operator Applying slurry to meet N or K requirements may not be allowed under NMP guidelines and may not be environmentally sustainable

What do we not know? We do not know the effect of 1.) utilizing slurry as the sole source of fertilizer or 2.) utilizing slurry in combination with inorganic fertilizer compared to using inorganic fertilizer as the sole source of soil amendment on the following: crop growth and yield, soil structure, soil cation exchange capacity, soil organic matter, nutrient overload in ground water, net dollar return per acre and net dollar return for slurry generation Hopefully the LUW Team studies will help provide answers to what we do not know.

Suggestions for land applying slurry. 1.) Obtain pit specific slurry samples for chemical analyses prior to land application Slurry composition varies by storage method Slurry stored in lagoons is more dilute than slurry stored in deep pits Fresh slurry (less than 2 weeks old) is more dilute than slurry stored for prolonged periods Slurry from shallow pits where pit flushing and/or pit recharging with water is used is more dilute than slurry stored in deep pits for prolonged periods. The liquid manure generated by sows, nursery pigs and grow-finish hogs varies in nutrient composition and N, P, K concentration. The concentration of solids and N, P, K will vary substantially from pit to pit. Separate samples from each pit are required. 2.) How samples are obtained affects N, P, K concentration analyses The solids are concentrated on the bottom of a pit or lagoon The effluent containing little biosolids is on top. Therefore, constant and complete agitation of the slurry is important to obtain a representative sample. Even with agitation a slurry probe should be used to collect truly representative slurry samples Be sure the probe can reach to the bottom of the pit 3.) Obtain multiple samples from each pit/lagoon. Collect probe samples from multiple locations within the pit/lagoon Obtain a minimum of one sample for every 50,000 gallons if multiple pits are sampled If one large slurry storage facility (one million gallons or more) is sampled, obtain one sample for every 200,000 gallons. 4.) Be sure to use the slurry analyses when calculating how much slurry to apply:acre. Do not average all samples to determine how much slurry to add per acre Only average the sample values for each storage facility When the source of slurry is changed, use the analyzed values from that specific storage facility and re-calculated gallons of slurry required per acre

Fall 2009 Manure Application

For many swine producers fall (post corn and soybean harvest) is the time for land application of manure This year may prove more challenging than most years due to the wet weather and excessive soil moisture In fact due to a delayed grain harvest, there may be little opportunity to land apply manure before freezing weather and frozen soil conditions set in Even in those cases where farmers have been able to harvest corn/soybeans wet soils increase the chances of nutrient leaching and run off during/after manure application

Therefore, the following top 7 list should be reviewed as producers prepare/wait for fall manure application

1 Review nutrient management plan.
   In order to prevent leaching and/or runoff resulting from manure application, lower manure application rates may be warranted Nutrient leaching may increase when injecting liquid manures and solids runoff may increase when spreading solid manures during episodes of high rainfall Consequently more acres of land and additional fields may be required for this falls manure application. Using fields with flatter slopes and lower Phosphorous Index scores may be a good idea Plan ahead, manure may have to wait for application under emergency guidelines this coming winter when the ground is frozen Review of your current nutrient management plan and noted application methods, application rates and fields of choice may require revising for this year Making updates now while it is raining may save time, energy and cost later

2 Develop an application emergency plan.
   The incidence of manure spills increases when the weather is harsh. Handling manure is bad enough on a sunny, 80 degree day Near freezing temperatures, wet weather and muddy conditions increase the chances for something to go wrong Train employees in manure spill response This information should be part of your manure management plan Remind your team of your plan Emphasize who to contact, safety issues and what to do when emergencies occur

3 Take manure samples.
   If nutrient overload, runoff and/or leachate is a potential problem, as it is this year, it is especially important to know the nutrient (N, P, K but especially N and P) concentration of the manure High nutrient loads mean more land area for application is required In a wet year like this year, balancing nutrient application with potential for runoff is more important than normal to prevent environmental contamination Sampling ahead of land application helps plan which fields can be used

Sampling during land application or manure agitation may provide better results to use in future planning, but will not provide nutrient analysis results to use in planning application rates for this fall It is important to build a history of nutrient analyses overtime for manure sampling to help manage the nutrients in manure for crop production over the years.

Correct sampling technique is most important A sample that is not representative of the manure volume is of little value Slurry sampling is best accomplished using a probe of sufficient length to reach to the bottom of the storage tank Sampling should only take place immediately following agitation and multiple samples from several locations should be collected and pooled, especially if only one sample will be sent to a laboratory for analysis. For solid manure, several grab samples from several locations in a manure pile both inside and outside of the stack should be collected and pooled

4 Take soil samples.
Soil samples should be taken prior to manure application If a field has not been sampled recently, then one sample for every 2.5 acres is best. Generally one sample collected for every 10 acres is adequate especially, on fields that are routinely sampled

5 Calibrate application equipment.
When applying inorganic fertilizer for crop production, has the application equipment been calibrated? You bet it has! Calibrating manure application equipment takes a little time, but in the long run it will help meet the correct application rate and make better use of manure nutrients.

To determine how much solid manure a manure spreader applies layout a 56 square inch sheet of plastic Spread manure at the desire rate of travel and spreader settings The net weight in pounds collected on the plastic sheet is equivalent to tons per acre application rate Remember nutrients (N, P, K) are calculated based on the dry matter weight of the manure – not the wet weight basis, unless the laboratory has been given directions otherwise

6 Timing of application.
Application on dry soil is the best option This fall we do not have that choice Try to apply at least 24 hours before a substantial rainfall This will help prevent runoff. Injection of slurry is a necessity but it requires dryer soil conditions Surface application of solid manure should be followed by some kind of primary tillage but even pulling a disk over freshly applied manure is more desirable than no tillage. Applying manure to snow covered or frozen ground may not be allowed except under emergency conditions, and this looks like it could be one of those years

7 And lastly, consider the neighbors.

Yes, manure does have odor In blunt terms, it just smells bad That is not perception It is reality Therefore, inform your neighbors Let them know about manure application plans If possible, tell them how long it might take, how you plan to apply the manure, and how long they might expect to smell the manure Inquire about any outdoor events in the neighborhood such as weddings, cookouts, etc and try to avoid those times for application This will be extremely difficult this fall because we seem to have such small "windows of opportunity" to land apply manure Most neighbors will understand Some won't, but at least make an effort It may yield future dividends

Handling manure is always stressful This year it will be especially stressful

Attachment 21

Refereed Publications in Scientific Journals Related to Solid/Liquid Manure Separation and Land Application

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Research Paper: SE—Structures and Environment

Evaluation of a polyacrylamide assisted solid/liquid separation system for the treatment of liquid pig manure

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The effectiveness of a static gravity screen-roll press separator operated in tandem with a polyacrylamide assisted gravity belt thickener to separate solid and liquid components of liquid pig manure (raw slurry – RS) under production-scale conditions is evaluated. The system was operated from May to October in 2006 and 2007 each of two years processing 4 039 919 l in year 1 and 4 674 840 l in year 2 of raw slurry (RS1). The amount of biosolids produced was 363 690 l in year 1 and 439 103 l in year 2 resulting in a 91.8% collection rate of separated effluent (SE). Significant reductions were obtained in settleable solids (98.4% and 94.3%), total suspended solids (98.2% and 80.9%), total nitrogen (60.6% and 37.0%) and phosphorus (91.7% and 70.9%) concentrations comparing RS1 with SE for years 1 and 2, respectively. The N:P ratio of RS1 was improved from 3.6:1 to 17.1:1 in SE for year 1 and from 5.1:1 to 11.3:1 in SE for year 2. The cost to separate and land apply SE *via* centre pivot irrigation was 0.28 US¢ l^{-1}, comparative in price to the cost for direct injection of RS (0.24–0.44 US¢ l^{-1}). Utilising this system was similar in cost to existing land application technology while significantly reducing nutrient load in SE.

1. Introduction

Manure from livestock has long been recognised as a valuable resource for fertilising crops and, when properly managed, can be used to effectively recycle important nutrients back into the soil. Current methods for managing pig manure consist of holding tanks, settling lagoons and direct injection application on crop producing fields (Barker, 1996), but these methods create problems for the environment, the public and the pork producer (Cates et al., 2006). The 500 million tons of livestock manure generated annually in the USA has consistently been identified as a major contributor to water quality impairment in state assessed surface waters and has been targeted as a USEPA Compliance and Enforcement National Priority (USEPA, 2007). Failure of storage systems to adequately store or treat waste and mishaps during application can result in discharges leading to environmental degradation in both local waterways and those farther downstream. With the shift in

Abbreviations: PAM, polyacrylamide; RS, raw slurry; RS1, raw slurry before processing; RS2, raw slurry after gravity screen-roll process separator; SE, separated effluent (after gravity belt thickener); SE-GB, separated effluent from gravity belt; SE-MS, separated effluent from microscreen; BS, biosolids; BS-GB, biosolids from gravity belt; BS-MS, biosolids from microscreen; COD, chemical oxygen demand; SDW, solids dry weight; SS, settleable solids; TSS, total suspended solids; IF, inorganic fertiliser; C, compost; % Solids, percent solids; % N, percent nitrogen. Q1

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the 1980s and 1990s to high intensity concentrated animal feeding operations (CAFOs), the amount of waste generated in a given location is concentrated and may exceed the capacity of proximal and available agricultural lands for land application, resulting in "land-limited conditions" and an excess supply of waste products (Haywood, 1997). The high water content of the slurry makes slurry difficult to handle and transport long distances to reach available lands, further limiting disposal options. Manure can be used as a valuable soil amendment, but the nutrient characteristics of untreated swine slurry, with a N:P (nitrogen to phosphorus) ratio of approximately 5:1, results in an over application of P when land applying based on N application rates (USDA, 2005). These nutrients and other physical and chemical components can lead to ground and surface water contamination, eutrophication of waterways, and can create odour and hygienic concerns during storage and application. Increased concerns from government and citizens about water quality and odour impacts (USEPA, 2007; Pew Commission on Industrial Farm Animal Production, 2008) have recently brought these issues into sharper focus.

Separation of wastewater into its solid and liquid components is a technology that has been utilised by municipal sanitation departments for decades. Removal of the biosolids (BS) fraction can clean the liquid portion sufficiently that the wastewater effluent meets Environmental Protection Agency (EPA) standards for direct discharge to surface waters. There are several separation technologies that can be borrowed from municipal wastewater treatment operations (Melse and Verdoes, 2005; Burton, 2007), but there is a need to understand the operational practicalities and efficiency expectations of the various applications of these technologies to pig manure management (Lorimor et al., 2006). Full scale, multi-step processes that combine solids separation, denitrification, and phosphorus removal to produce discharge-quality effluent have been proposed for treating pig waste slurry (Martinez-Almela and Barrera, 2005; Vanotti et al., 2007), but surveys have shown that pork producers need, if they are to be persuaded to implement these management practices, a simple, low cost, easily operated system that addresses the most pressing environmental and health concerns while creating more beneficial, easily utilised products from the waste (Cates et al., 2006; Walker, 2008).

Many city wastewater treatment departments use polymer-assisted separation systems that combine the use of chemical flocculants, gravity belt thickeners and belt presses to remove the solids fraction from wastewater. However, pig waste is typically produced in both higher volumes and solids concentrations than municipal wastewater, due to the increased waste production relative to management practices involving *ad libitum* pig production feeding, reduced dilution rates when compared to human sewage, and liquid waste concentration in pits and/or lagoons. The decentralised nature and the increased energy and labour-intensive waste management techniques of most pig waste production facilities relative to human sewage treatment facilities make treatment more challenging and result in high treatment costs relative to revenues generated. Other concerns with pig waste include increased off-odours relative to human sewage due to higher concentrations of NH_3, H_2S, and other volatile compounds (Ritter and Chirnside, 1990; Burkholder et al., 1997; Haywood, 1997; Hammer and Hammer, 2001). Pig slurry may be defined as a mixture of solid and liquid pig manures with or without water added to facilitate pumping or flushing. In order to treat swine slurry efficiently, economically, and in an environmentally responsible manner prior to disposal, application of modified traditional wastewater treatment technologies to pig slurry may be considered. Several studies have explored the use of polyacrylamide (PAM) to coagulate solids in both pig and dairy waste and some have shown promising results when combining PAM use with separation screens, screw presses, and separation tanks (Sievers et al., 1994; Vanotti and Hunt, 1999; Hammer and Hammer, 2001; Vanotti et al., 2002; Walker and Kelley, 2003, 2005; Westerman and Arogo, 2005).

This study evaluated the efficiency of a static gravity screen-roll press combination solids separator operated in conjunction (tandem) with a PAM-assisted gravity belt solids thickener under production-scale conditions to reduce the concentration of solids and other commonly used aquatic pollution indicators in the treated effluent relative to the raw, untreated pig slurry (RS1). An analysis of the resulting data was then used to examine the feasibility of using this treatment system to reduce pig waste pollution indicators, determine the suitability of separated (treated) effluent (SE) for irrigation as a nitrogen fertiliser for row crops, and to evaluate the nutrient composition of the BS fraction as a potential raw material for composting. Total costs for separation and land application were calculated and compared to the cost of current practices where raw slurry (RS) is directly injected into fields.

2. Material and methods

2.1 Slurry separation

RS generated from gestation, farrowing, nursery and grow-finish swine buildings located on the Illinois State University (ISU) Farm at Lexington, IL, USA was utilised for this study. RS was drained by an underground sewer pipeline from building pits to an in-ground 53 371 l concrete holding tank 1.83 m deep located in the slurry processing building. All slurry pits in all the swine buildings at the 220 sow farrow to finish swine operation were drained once or twice each week and recharged with 50–75 mm of SE. Whilst in the holding tank, RS1 was continuously stirred until it was pumped from the bottom of the pit and passed across a static gravity screen-roll process separator to remove separable solids producing separated slurry (RS2). A PAM premix was infused into RS2 prior to the mixture passing across a gravity belt thickener to remove total suspended solids (TSS). The resulting BS were transported to the compost site, mixed with landscape waste and composted. The resulting SE was stored in a Slurry Store® (Engineered Storage Products Company, DeKalb, IL, USA) until land applied during the corn/soybean growing seasons *via* a centre pivot irrigator.

The gravity screen-roll press separator used during this study was a Model 250, manufactured by Key Dollar Cab. Inc. (Milton-Freewater, OR, USA). The screen pore size was 1.59 mm, and the maximum capacity of the separator was

757 l min^{-1}. For this study, the separator was operated at a rate of 227.1 ± 1.02 l min^{-1}. The gravity belt thickener used was a Model GSC-1, Series III manufactured by Komline Sanderson (Peapack, NJ, USA). The belt fabric permeability was 390 l min^{-1} and the maximum capacity of this system was 567.8 l min^{-1}. For this study, the belt separator was operated at a rate of 227.1 ± 1.02 l min^{-1}. The proprietary liquid cationic PAM polymer flocculant used in year 1 was Percol 757® (Ciba Specialty Chemical Water Treatments, Inc.; Suffolk, VA, USA) which had a charge density of 58%, an intrinsic viscosity of 6–8 units, and percentage active solids of greater than 99.9%. RS was modified to provide a final flocculent concentration of 0.014%, or 140 mg l^{-1} of RS. The PAM flocculant used in year 2 was Zetag 8160® (Ciba Specialty Chemical Water Treatments, Inc.; Suffolk, VA, USA) which had a charge density of 60%, an intrinsic viscosity of 6–8 units, and percentage active solids of greater than 99.9%. Polymer premix was made with Zetag 8160® at a concentration of 0.26%, or 2580 mg l^{-1} of water. The premix was then added to the RS to provide a final average concentration of 66 mg l^{-1} of RS. The flocculent and flocculent concentrations chosen were based on previously-determined optimal concentrations for swine slurry (Walker and Kelley, 2003) and as determined by "in-field" operation observations. Between May and October of 2006, separation occurred approximately once every 7–10 days for 16 separation periods during the 145 day time span. During 2007, separation was carried out twice weekly from May 1 until November 9. Slurry was separated on-site under typical production-scale conditions at the ISU Farm.

2.2 Laboratory analysis

One-litre samples of RS1, RS2 and SE were collected for analysis and stored at 4 °C. Prior to sampling, slurry was agitated to re-suspend settled solids. Initial RS1 samples were collected from the bottom of the holding pit using a 2.40 m probe. The RS2 samples were collected as the liquid was discharged from the gravity screen-roll press and final SE samples were randomly collected as the SE was discharged from the gravity belt thickener. Sub-samples were analysed for pH, dissolved oxygen (DO), chemical oxygen demand (COD), solids dry weight (SDW), settleable solids (SS), TSS, total N, total P and NH_3. A Corning® pH meter, model 7 (Corning Inc., Corning, NY, USA) was used to measure pH in standard 0–14 pH scale units and DO was measured using a Hanna® (Hanna Instruments, Woonsocket, RI, USA) DO meter. COD was determined by Hach method 8000 microdigestion procedure and read using a Hach® DR 2000 Colorimeter (Hach Corporation, Loveland, CO, USA). SDW was determined by drying samples at 103–105 °C according to Method 2540 B in Standard Methods for the Examination of Water and Wastewater, 20th edition (Eaton 2000). Settable solids were determined by transferring samples to 1.0 l Imhoff cones according to method 2540F in Standard Methods for the Examination of Water and Wastewater, 20th edition (Eaton, 2000). TSS were determined by Hach method 8006 using a Hach® DR700 Colorimetre (Hach Corporation, Loveland, CO). Total N was analysed by a LECO® nitrogen determinator, model FP528 (LECO Corporation, St Joseph MI, USA). Phosphorus was determined by the nitric acid/hydrogen peroxide digestion method described by the Association of Analytical Chemists (1975) and subsequent analysis using an IRIS Plasma Spectrometer (ICP) model number 13283200, (Thermo Jarrell Ash, Franklin, MA, USA). NH_3 was determined by Hach method 10001 using a Hach® ammonia probe, model 51927-00 and a Hach® sension2 ISE meter, model 5172518 (Hach Corporation, Loveland, CO USA).

2.3 Cost calculations

The components of the separation system (gravity screen-roll press separator, gravity belt thickener and all accessory pumps) were powered by electric motors. All electrical power was provided by a tractor PTO generator. Therefore, itemised costs included diesel fuel as a power cost rather than electricity. The total costs of all component parts of the separation system were grouped together and are shown as equipment with a 15 year straight-line depreciation schedule. Maintenance costs as a percentage of initial equipment cost was estimated as no repair or maintenance costs were required during the first two years of operation. Polymer cost was calculated based on actual rate of polymer used, 140 mg l^{-1} during year 1 and 66 mg l^{-1} during year 2. Labour cost per hour reflects an estimated value but actual hours of labour required were used. The cost of land application of SE via centre pivot irrigation was based on estimated commercial irrigation costs to pump and irrigate well water (personal communication, R.J. Alton, Alton Irrigation, Inc. Rockfalls, IL, USA).

2.4 Statistical analysis

Statistical analysis of COD, SDW, SS, TSS, N, P and NH_3 concentrations (dependent variables) were conducted for RS1, RS2, SE, and BS (independent variables) using a protected F-test (SPSS® software, 2007). Significance differences between data values were determined at a $P < 0.05$ level.

3. Results

During year 1, 4039919 l of RS were separated producing 3676229 l of SE and 363690 l of BS. This represents a collection rate for SE of 91.0%. An average of 199498 l d^{-1} of RS was separated during each operational run producing an average of 181544 l d^{-1} of SE over an 8–12 h period of time. During year 2, 4674840 l of RS were separated producing 4235738 l SE and 439103 l BS giving collection rate of 91.0% for SE. An average of 194785 l of RS was separated weekly producing an average of 177255 l of SE over a 12 h period per week.

Results of RS1, RS2, SE and BS analysis for SDW, SS, TSS, pH, COD, N, P and NH_3 are presented along with the N:P ratios in Tables 1 and 2. Data collected during year 1 are contained in Table 1, whilst Table 2 contains data collected during year 2. During year 1, concentrations recovered in the SE were reduced ($P < 0.05$) by 69.2% for SDW, 98.4% for SS, 98.2% for TSS, 60.6% for N, and 91.7% for P, relative to RS1. Consistent pH levels in the range of 7.5–7.8 were found for RS1, RS2 and the SE generated. The N:P ratio increased ($P < 0.05$) after treatment, from 4:1 in RS1 to 17:1 in SE. Reductions of 30.8% for SDW, 25.8% for SS, 18.9% for TSS, and 21.2% for N were found in RS2

Table 1 – Mean (±1 SD) concentrations of evaluated water quality parameters and N:P ratios for RS, separated slurry, treated effluent and BS in year 1[a]

Sample type	% SDW	SS, mg l^{-1}	TSS, mg l^{-1}	pH	Total nitrogen ppm	Total phosphorus, ppm	N:P ratio
RS1[b]	1 3 (1.0)	95 4 (153 1)	878 5 (939 4)	7 5 (0 3)	1938 (1597)	543 (342)	3 6:1
RS2[c]	0 9 (0 2)	70 8 (25 0)	712.7 (817.3)	7 5 (0 2)	1527 (824)	635 (269)	2 4:1
SE[d]	0 4 (0 1)^1	1 5 (1 5)^1	15 9 (8 1)^1	7 8 (0 2)	763 (557)^1	45 (18)^1	17 1:1^1
BS[e]	10 4 (1 7)^2				8833 (1286)^2	6439 (1630)^2	1 4:1

1 2 Means within a column with different superscript numbers differ ($P < 0$ 05)
a $N = 13$ raw 20 effluent and 17 solids samples taken May 24 to August 31 2006
b Unprocessed RS
c RS after gravity screen
d SE after gravity belt
e Biosolids

Q5

relative to RS1, although these reductions were not statistically different ($P > 0$ 05) Data presented in Table 2 indicate that year 2 concentration reductions of 53 6% for SDW, 94 3% for SS, 80.9% for TSS 62 8% for COD, 37 0% for N and 70 9% for P were significant for SE relative to RS1 Consistent pH levels in the range of 7.29–7 63 were found for RS1, RS2 and SE The N:P ratio increased ($P < 0$ 05) after treatment, from 5:1 in RS1 to 11:1 in SE Reductions of 11 9% for SDW, 14 8% for SS, and 11 1% for N were found in RS2 relative to RS1, although these reductions were not statistically significant

Significant concentration reductions were consistently generated for COD, SDW, SS, TSS, N, and P in SE relative to RS1, using the static gravity screen-roll press and the PAM-assisted gravity belt thickener in tandem Significant concentration reductions were consistently generated in SE relative to RS2 using only the PAM-assisted gravity belt thickener in both years 1 and 2 (Tables 1 and 2) No significant reductions were generated for any parameters using only the static gravity screen-roll press

BS were significantly higher than RS1, RS2 and SE in percent SDW, and N and P concentration The high N and moisture content of the BS suggest they are suitable for use as a raw material providing a source of N for aerobic composting when mixed with a high carbon, low N and low moisture material such as woodchips, tree leaves or corn stalks (Walker *et al*, 2008)

4. Discussion

The results of this study indicate that the combination gravity screen-roll press and PAM-assisted gravity belt thickener separation system was effective in achieving solids separation from RS, in reducing water quality pollutant indicators in the SE, and in improving the N:P ratio in the SE. The N:P ratio of SE more closely approximates the sufficiency range of these two nutrients in the whole corn plant (Voss, 1993) This suggests that SE is more suitable for land application as a soil amendment for corn production than RS1 and it should minimise the potential for nutrient overload The separation efficiencies are comparable to those found in previous studies (Sievers *et al*, 1994; Zhang and Westerman, 1997; Zhang and Lei, 1998; Vanotti and Hunt, 1999; Vanotti *et al*, 2002; Walker and Kelley, 2003; Walker and Kelley, 2005; Szogi and Vanotti, 2007) and improvement in the N:P ratio is similar to the increase found by Vanotti *et al* (2002) Previous separation efficiencies were more consistent with smaller standard deviations (SDs) reported for SDW, TSS and COD (Walker and Kelley, 2005) but the volume of RS1 processed in the previous study was much lower comparing 26 496 l to the 3 676 229–4 039 919 l used in this study Larger SDs in concentrations of water quality parameters would be expected as the volume treated is increased and as the duration of separation is extended over

Table 2 – Mean (±1 SD) concentrations of evaluated water quality parameters and N:P ratios for RS, separated slurry, treated effluent and BS in year 2[a]

Sample type	% SDW	SS, mg l^{-1}	TSS, mg l^{-1}	pH	COD, mg l^{-1}	Total nitrogen, ppm	Total phosphorus, ppm	Ammonia, mg l^{-1}	N:P ratio
RS1[b]	0 84 (0 28)	105 4 (36 7)	4329 (1200)	7 29 (23)	5155 (6886)	1078 (359)	206 3 (69 1)	587 (218)	5 1:1
RS2[c]	0 74 (0 26)	89 8 (47 9)	4377 (2077)	7 36 (24)	5528 (10 200)	964 (352)	204 9 (78 9)	600 (168)	4 6:1
SE[d]	0 39 (0 10)^1	6 0 (6 2)^1	825 (1341)^1	7 63 (0 24)	1919 (1924)^1	684 (252)^1	59 98 (17 81)^1	651 (216)	11 3:1^1
BS[e]	8 78 (1 92)^2					5153 (1821)^2	3285 (1178)^2		1 6:1

1 2 Means within a column with different superscript numbers differ ($P < 0$ 05)
a $N = 32$ samples taken May 22 to November 9 2007
b Unprocessed RS
c RS after gravity screen
d SE after gravity belt
e Biosolids

longer periods of time (several months vs a few weeks) During warmer weeks pigs waste more drinking water trying to stay cool diluting RS1 resulting in lower solids concentrations making separation easier Less water wastage by pigs during cooler months can increase the solids concentration of RS1

While treatment by the gravity screen alone did not produce statistically significant reductions in solids and pollutant indicators, this step was critical to the process The solids composition of the RS1 became more uniform subsequent to gravity screen separation and therefore the polymer amount was more easily regulated, resulting in more effective and efficient separation of RS2

Nitrogen balance of RS1 and SE was not addressed in this study Only total N data were available during year 1 as an error in NH_3 analysis made the data collected inaccurate Only total N and NH_3 were measured and reported for year 2 Combining the separation system evaluated in this study with a method of nitrification such as the procedure described by Martinez-Almela and Barrera (2005) could reduce the volatilisation of NH_3–N from SE during storage increasing the nitrogen fertiliser value of the SE

The itemised costs of separation (including equipment, labour, polymer, fuel and depreciation) are shown in Table 3 Total cost for separation was calculated by basing it on the total volume of RS1 processed and based on the volume of SE produced Evaluating costs based on the volume of RS1 processed allows direct comparison to traditional land application systems (i e , direct injection) for RS1 relative to the size of the operation (number of pigs and volume of RS1 generated) Calculating costs based on the volume of SE produced allows direct comparison to land application of RS1 relative to cost of application and fertiliser value Costs were approximately 10% higher for RS than SE because the collection rate for SE was 91% the amount of RS processed (the difference being the volume of BS produced) Table 4 shows the total cost for separation and land application of SE relative to the amount of SE produced and RS processed The cost for land applying SE is compared to the actual cost for land applying RS *via* direct injection with either a drag line system or a portable slurry tank system. The cost for land applying SE *via* centre pivot irrigation is within the reported range for land applying RS *via* direct injection (Walker, 2008)

Table 3 – Separation costs for effluent produced and RS processed[a]

Item	Value	SE, US¢ l^{-1}	RS, US¢ l^{-1}
Labour	\$15 h^{-1}	0 09	0 08
Polymer	US\$ 3 52 kg^{-1}	0 04	0 03
Fuel	55 US¢ l^{-1}	0 04	0 04
Maintenance	2% per annum	0 02	0.02
Depreciation (15y)[b]	6 7% per annum	0 07	0 07
Total		0 26	0 25

a Costs reflect 2007 prices
b Based on initial equipment cost of \$100 000 and a straight-line depreciation schedule

Table 4 – Total separation and application costs for SE produced and RS processed compared to direct injection[a]

Item	Separation cost, US¢ l^{-1}	Application cost, US¢ l^{-1}	Total cost, US¢ l^{-1}	Direct injection, US¢ l^{-1}
RS	0 25	0 03	0 28	0 24–0 44
SE	0 26	0 03	0 29	

a Costs reflect 2007 prices

5. Conclusion

The adaptation of waste treatment technology consisting of a gravity screen operating in tandem with a PAM-assisted gravity belt thickener was used to effectively separate liquid swine manure into its biosolid and liquid fractions while improving the N:P ratio and reducing water quality pollutant indicators in the SE This systems approach results in economically beneficial product development by allowing the BS fraction to be composted for ultimate use as either an on-farm or off-farm soil amendment while also producing a liquid fraction with low solids and low phosphorus concentrations that can be irrigated as a nitrogen fertiliser for row crops The use of these post-treatment end products, instead of using RS for field application, reduces the potential for nutrient overload and eventual surface and groundwater pollution It also reduces the amount of land required for slurry disposal Additionally, this systems approach is an economically viable process for producers with total separation costs, including equipment, labour, polymer and fuel of 0 26 US¢ l^{-1} of RS

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ENGINEERING IN AGRICULTURE

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COMPARISON OF THE EFFECTIVENESS AND ECONOMIC COSTS OF TWO PRODUCTION SCALE POLYACRYLAMIDE ASSISTED SOLID/LIQUID SEPARATION SYSTEMS FOR THE TREATMENT OF LIQUID SWINE MANURE

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Comparison of the Effectiveness and Economic Costs of Two Production Scale Polyacrylamide Assisted Solid/Liquid Separation Systems for the Treatment of Liquid Swine Manure

P M Walker, C A Wade

ABSTRACT *This study evaluated and compared the effectiveness and economic costs of a polyacrylamide (PAM) assisted continuous gravity belt thickener and a PAM assisted inclined stationary gravity screen separator equipped with a backwash spraybar, each in tandem with an inclined stationary gravity screen-roll press separator to separate the solid and liquid components of liquid swine manure (raw slurry) under production scale operating conditions The separation systems were operated from June through December processing 7,222,725 L (1,908,048 gal) of raw untreated slurry (RS1). Both treatments, gravity belt thickener and gravity screen, showed significant reductions of 84 9% and 97 8% for Settleable Solids, 93.2% and 93.7% for Total Suspended Solids 63.7% and 69.5% for Chemical Oxygen Demand, 23 3% and 31.8% for total Nitrogen, and 52.3% and 60 5% for total Phosphorus, respectively, in the treated effluent The cost for separation with the gravity belt thickener system was 0 474¢ per L (1 791¢ per gal) of raw slurry The separation cost for the gravity screen system was 0 402¢ per L (1.518¢ per gal) of raw slurry Application costs for irrigating the separated effluent generated from either system added another 0.061¢ per L (0 234 ¢ per gal) of raw slurry Either of these solid liquid separation systems would be an effective and economically viable alternative to current disposal methods while providing additional operational and environmental benefits*

Keywords. *Swine manure, Solids separation, Polyacrylamide Gravity screen, Gravity belt thickener, Economics*

Current methods for managing swine manure consist of holding tanks, treatment lagoons, and direct injection application on crop producing fields (Barker, 1996), but these methods create problems for the environment, the public, and the pork producer (Cates et al , 2006) Failure of storage systems to adequately store or treat waste and mishaps during application can result in discharges leading to environmental degradation in both local waterways and those farther downstream (Burkholder et al., 1997) When managed properly, manure from livestock can be used as a valuable resource for fertilizing crops and for effectively recycling important nutrients back into the soil The nutrient characteristics of untreated swine slurry, with a N:P (nitrogen to phosphorus) ratio of approximately 3 1:1, results in an over application of phosphorus when land applying based on N application rates (USDA, 2005) There are several separation technologies that can be borrowed from municipal wastewater treatment operations to improve the quality of the effluent while extracting solids that can be used for composting (Melse and Verdoes, 2005; Burton, 2007), but there is a need to understand the practicalities and efficiency expectations of the various applications of these technologies to swine manure management (Lorimor et al., 2006) Small-scale treatment using minimal technology has been investigated but efficiency results were low and actual producer costs could not be calculated (Westerman and Arogo, 2005) Full-scale, multi-step processes that combine solids separation, denitrification, and phosphorus removal to produce discharge-quality effluent have been proposed for treating swine waste slurry (Martinez-Almela and Barrera, 2005; Vanotti et al , 2007), but surveys have shown that pork producers need a simple, low-tech, low cost, easy-to-operate system that creates more beneficial and easily utilized products from the waste if they are to invest in a treatment system (Cates et al 2006; Walker, 2008).

This study evaluated the separation effects, efficiency and economic inputs of an inclined gravity screen-roll press combination separator operated in conjunction (tandem) with either a polyacrylamide (PAM) assisted continuous gravity belt thickener, System 1. or a PAM assisted inclined stationary gravity screen separator equipped with a backwash spraybar, System 2, under production scale conditions The reductions in the concentrations of solids and other commonly used aquatic pollution indicators in the treated effluent relative to the raw, untreated swine slurry (RS1) were measured Costs for initial setup and ongoing separation operations using each system were compared. An analysis of the resulting data was then used to examine the feasibility of utilizing each of these treatment systems to reduce swine waste pollution indicators and to compare the two systems in terms of efficiency and cost during production scale operations.

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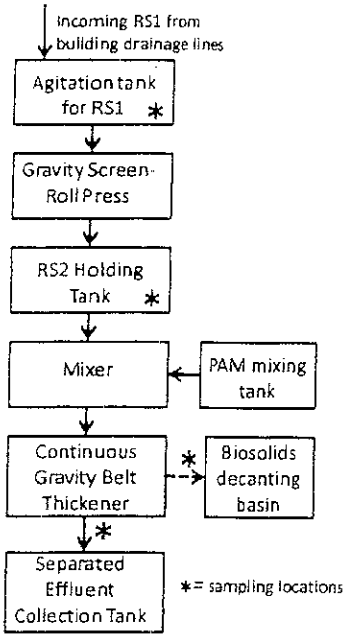

Figure 2. Flow chart of System 1.

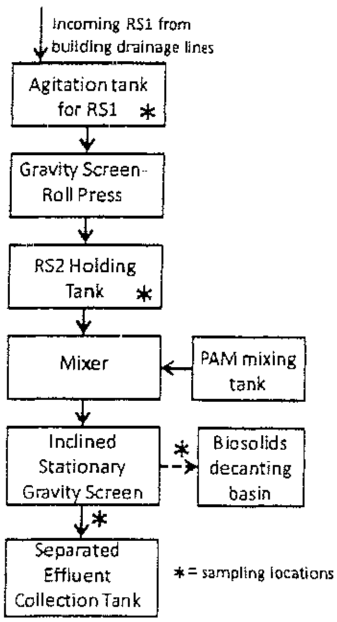

Figure 3. Flow chart of System 2.

with an average Zetag 8160® concentration of 66.0 mg/L. The polymer and polymer concentrations chosen were based on previously-determined optimal concentrations for swine slurry (Walker and Kelley, 2003, 2005) and as determined by "in-field" operation observations. Between June and December, separation occurred once or twice a week during the 170 day time span. Slurry was separated on-site under typical production scale conditions at the ISU Farm.

Laboratory Analysis

One-liter samples of RS1, RS2, SE-S1, and SE-S2 were collected for analysis and stored at 4°C. Prior to sampling, slurry was agitated to re-suspend settled solids. Initial RS1 samples were collected from the bottom of the holding pit during agitation using a 2.40-m probe. The RS2 samples were collected as the liquid was discharged from the GSR separator. Final SE-S1 samples were randomly collected as the SE-S1 was discharged from System 1 and final SE-S2 samples were randomly collected as the SE-S2 was discharged from System 2. Sub-samples were analyzed for pH, dissolved oxygen (DO), chemical oxygen demand (COD), solids dry weight (SDW), settleable solids (SS), total suspended solids (TSS), total nitrogen (N), total phosphorus (P), and ammonia (NH_3). A Hach pH probe, model 51910, and sension2 ISE meter, model 5172518 (Hach corporation, Loveland, Colo.) was used to measure pH in standard 0- to 12-pH scale units and DO was measured using a Hanna® (Hanna Instruments, Woonsocket, R.I.) DO meter. Chemical Oxygen Demand was determined by Hach method 8000 micro digestion procedure and read using a Hach® DR 2000 Colorimeter (Hach Corporation, Loveland, Colo.). Solids Dry Weight was determined by drying samples at 103°C to 105°C according to Method 2540 B in *Standard Methods for the Examination of Water and Wastewater* (Eaton, 2005). Settable Solids were determined by transferring samples to 1.0-L Imhoff cones according to method 2540F in Standard Methods for the Examination of Water and Wastewater (Eaton, 2005). Total Suspended Solids were determined by Hach method 8006 using a Hach® DR700 Colorimeter (Hach Corporation, Loveland, Colo.). Total nitrogen was analyzed by a LECO® nitrogen determinator (model FP528, LECO Corporation, St. Joseph, Mich.). Phosphorus was determined by the nitric acid/ hyrdrogen peroxide digestion method described by the Association of Analytical Chemists (1975) and subsequent analysis using an IRIS Plasma Spectrometer (ICP) (model number 13283200, Thermo Jarrell Ash, Franklin, Mass.). Ammonia was determined by Hach method 10001 using a Hach® ammonia probe, model 51927-00, and a Hach® sension2 ISE meter model 5172518 (Hach Corporation, Loveland, Colo.).

Cost Calculations

The components of both separation systems were powered by electricity and costs in kwh/L (kwh/g) were calculated based on the rate quote from Ameren IP, Decatur, Illinois, for the Bloomington-Normal, Illinois service area of 7.95¢/kwh for the period of time during which operations occurred. Total costs of all component parts specific to the operation of each of the separation systems, including the building, were grouped together and are shown as equipment with a 10 year straight line depreciation schedule. Polymer cost was calculated based on actual rate of polymer used, 66 mg/L (0.55 lb/1000 g) of raw slurry for both systems, and market price ($2.45/lb) as quoted by Ciba Inc. (Suffolk, Va.). Labor cost per hour reflects an estimated value ($15.00/h) but actual hours of labor required were used. The cost of land application of SE via center pivot irrigating was calculated using quoted costs for irrigator equipment, diesel fuel and electricity during the time period of the study. Total separation and application costs were compared to current market costs to pump, transport and inject raw slurry as indicated by surveyed producer responses (Walker, 2008).

produced per day can be calculated from the listed N and P_2O_5 equivalents The calculated mean N:P ratio is 3 1:1 and ranges from 2 9:1 for growing pigs to 3 4:1 for finishing pigs The Soil Fertility Manual (Potash & Phosphate Institute, 1999) reports the N and P requirements per bushel of shelled corn produced as 603 82 and 99 88 g (1 33 and 0 22 lb), respectively. These requirements equate to a 6 04:1 ratio of N:P The Illinois Agronomy Handbook (Hoeft and Peck, 2002) suggests that the critical corn plant nutrient levels for N and P are 2 9% and 0.25% respectively These percent plant compositions correspond to a N:P ratio of 11 6:1 Removing more P relative to N from liquid swine manure (23.3% to 31 8% for N and 52 3% to 60 5% for P in this study, and 70.8% for N and 96 1% for P in a previous study (Walker and Kelley, 2005) results in a SE N:P ratio more similar to the corn plants concentration and requirement for grain production Increasing the N:P ratio can allow higher land application rates (L/acre or gal/acre) of SE to meet N requirements for corn growth without concomitant increases in P application

The separation efficiencies of this study are comparable to those found in previous studies (Sievers, et al, 1994; Zhang and Westerman, 1997; Zhang and Lei, 1998; Vanotti and Hunt, 1999; Vanotti et al. 2002; Walker and Kelley 2003 and 2005; Szogi and Vanotti 2007). It is important to note that pollutant concentrations in the RS1 generated in this study are lower than raw slurry analyses in similar studies due to the recharging of swine building pits with SE subsequent to each separation and to maintaining relatively fresh RS1 Recharging pits with SE reduces solid build up in the pits over time and generates a more diluted, cleaner raw slurry stream While treatment by the GSR separator alone did not produce statistically significant reductions in solids and pollutant indicators, this step was critical to the process because the solids composition of the raw slurry (RS1) became more uniform as RS2 and, therefore, the amount of polymer required was more easily regulated, resulting in more effective and efficient separation.

The itemized costs of separation (including equipment and building depreciation, labor, polymer, and fuel) are shown in table 2 For System 1 the cost was 0 474¢/L (1 79¢/gal) of raw slurry The cost of separation for System 2 was 0 402¢/L (1 518¢/gal) of raw slurry Application costs for irrigating the separated effluent generated from either system via center pivot irrigation are shown in table 3 and added another 0 061¢/L (0 234¢/gal) of raw slurry Costs are approximately 6 0% higher for SE than RS because the collection rate for SE was 94% the amount of RS processed. Table 4 shows the total cost for separation of RS and land application via center pivot irrigation of SE based on (liters) gallons of RS processed for each system and is compared to the actual cost for land applying raw slurry via direct injection with either a drag line system or a portable slurry tank system. The cost for separating RS and land applying the resulting SE via center pivot irrigation is within the reported cost range of land applying RS via direct injection for the volume of RS separated in this study (Walker, 2008) Based on the survey of Illinois Commercial Manure Haulers and Applicators (Walker, 2008), the average price to land apply swine slurry was 0 53¢/L (2.01¢/gal) for up to 3 785,300 L (1 million gal) and 0 44¢/L (1.67¢/gal) when applying between 3,785,300 and 15,141,200 L (1 and 4 million gal) If land applying more than 15,141,200 L (4 million gal), the cost was 0.235¢/L (0.89¢/gal) The time required to separate the 7,222,725 L (1,908,048 gal) in this study was one to two days per week utilizing 8-h days Neither of the two separation systems evaluated in this study required continuous monitoring by a monitor; therefore, under normal production scale operating conditions an operator could separate slurry and conduct other duties simultaneously, such as feeding, proving pig care etc A decision for several producers, since separation and land application of SE is cost neutral to traditional land application then, is whether the environmental advantages and reduced acreage required for land application recognized for separation justifies separation as a weekly operational strategy compared to traditional land application of RS once or twice per year Future EPA regulations regarding P application rates and odor assessments along with producer desire to adopt environmentally beneficial technologies will impact producer decisions

CONCLUSION

The adaptation of waste treatment technology consisting of an inclined stationary gravity screen rollpress combination separator in tandem with a polyacrylamide assisted continuous gravity belt thickener or with a polyacrylamide assisted inclined stationary gravity screen separator with backwash spraybar was used to effectively separate liquid swine manure into its biosolid and liquid fractions while improving the N:P ratio and reducing water quality pollutant indicators in the separated effluent This systems approach results in economically beneficial product development by allowing

Table 2. Separation costs for separated effluent produced and raw slurry processed in ¢/L(¢/gal).[a]

Item	Separated Effluent System 1	Separated Effluent System 2	Raw Slurry System 1	Raw Slurry System 2
Labor[b]	0 088 (0 333)	0 088 (0 333)	0 083 (0 313)	0 083 (0.313)
Polymer[c]	0 038 (0 144)	0 038 (0 144)	0 036 (0 135)	0.036 (0 135)
Electricity[d]	0 133 (0 503)	0 104 (0 394)	0 125 (0 473)	0 098 (0.370)
Depreciation[e]	0 244 (0 926)	0 197 (0 745)	0 230 (0 870)	0 185 (0 700)
Total	0.503 (1.906)	0.427 (1.616)	0.474 (1.791)	0.402 (1.518)

[a] Costs reflect 2008 prices

[b] $15/h.

[c] $2.45/lb

[d] 7 95¢/kwh

[e] Based on initial equipment and building cost of $173,000 for the continuous gravity belt thickener and $140 000 for the inclined stationary gravity screen and using a straight-line 10-year depreciation schedule

Walker P 2008 Survey of Illinois Commercial Manure Haulers and Applicators Swine Waste Economical and Environmental Treatment Alternatives website University of Illinois Extension Available at: www sweeta illinois edu Accessed 19 September 2008

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June 23, 2010

U S. Department of Agriculture
Natural Resources Conservation Service
Attn : Sheila Parker-Darby
Grants and Agreement Team
Management Services Division
1400 Independence Avenue, SW
Room 5221 South Building
Washington DC 20250

RE: NRCS Agreement 68-3A75-6-166
RSP# 06C216

Dear Ms Parker-Darby:

Enclosed is the final report for the project, "Field Sçale Evaluation and Technology Transfer of Economically, Ecology Sound Liquid Manure Treatment and Application Systems" under the direction of Paul Walker from the Department of Agriculture at Illinois State University. The support for this project is sincerely appreciated

If you have any questions, you can reach me at the number above or electronically at jgouche@ilstu.edu.

Sincerely,

Janet L. Goucher
Assistant Director of Research

enclosures

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Phone: (309) 438-2528
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January 13, 2012

Natural Resources Conservation Service
P.O. Box 2890
Washington, DC 20013

RE: NRCS Agreement 68-3A75-6-166
RSP# 06C216

Dear Ms. Minor,

Enclosed are copies of the Final Performance Report and Final SF 425 – Federal Financial Report previously mailed on January 23, 2010 for the project, "Field Scale Evaluation and Technology Transfer of Economically, Ecologically Sound Liquid Swine Manure Treatment and Application Systems" under the direction of Paul Walker from the Department of Agriculture at Illinois State University.

If you have any questions, you can reach me at the number above or electronically at jgouche@ilstu.edu.

Sincerely,

Janet L. Goucher
Assistant Director of Research

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