Approved: March 20, 2000
Date

MINUTES OF THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES.

The meeting was called to order by Chairperson Senator David Corbin at 8:00 a.m. on March 14, 2000 in 245-N of the Capitol.

All members were present except: All members were present.

Committee staff present:
Raney Gilliland, Legislative Research Department
Mary Ann Torrence, Revisor of Statutes Office
Lila McClaflin, Committee Secretary

Conferees appearing before the committee:
Margaret Fast, Kansas Water Office
Steve Adams, Kansas Department of Wildlife and Parks
Dr. William Hargrove, Kansas State University
Dr. Jay Ham, Kansas State University
Dr.Alan Schlegal, Kansas State University

Others attending:
See attached list.

The hearing was opened on **Sub for HB 2144**–Application of multipurpose small lakes program to certain projects; rules and regulations relating to recovery of certain costs.

Margaret Fast, Unit Manager, Kansas Water Office, supported the bill with some modifications. They would support language to clarify that financial participation in the restoration of recreational components would be confined to publicly owned lakes (Attachment 1). She responded to questions.

Tracy Streeter, Executive Director, State Conservation Commission, submitted written testimony for information purposes. His testimony encouraged the Committee to consider amending the bill to include recreation as a feature of renovation projects (Attachment 2).

Steve Adams, Kansas Department of Wildlife and Parks, opposed the section of the bill that omitted recreation facilities and requested the addition of recreation to the uses under renovated or reconstructed multipurpose dams would be both consistent with the current statute and address a need in local communities (Attachment 3).

The hearing on **Sub for HB 2144**–was closed.

Chairperson Corbin called on Dr William Hargrove, Director, Kansas Center for Agricultural Resources and the Environment, Kansas State University. Dr. Hargrove addressed the committee and a pressed release summarizing their progress and key findings in several important areas over the past twelve months was distributed (Attachment 4).

Dr. Jay Ham, Associate Professor, Department of Agronomy and Dr. Alan Schlegel, Professor, Southwest Research-Extension Center gave an update and summary of research they have done in the last two years in responses to **HB 2950** which was passed during the 1998 legislative session. A copy of their report to the Animal Waste Management and Utilization 2000 Annual Report to the Legislature (Attachment 5). Other information and brochures on the subject along with copies of the slide presentation are on file in the Kansas Legislative Research Department. In summary the committee was told that basically before building a lagoon you need to determine the type of soil under the potential lagoon site, consider the type and concentration of waste to be placed in the lagoon, know the depth to the water table and decide the length of time the lagoon will be used to hold waste. A new "lagoon design tool" has been introduced by Dr. Ham, that asks for such inputs as soil and aquifer properties and type of operation to build a site-specific lagoon. The committee was told the seepage losses from the lagoons they studied was an overall average of 0.05 inch/day (1/20th inch per day. The present state-mandated seepage rate for lagoons is currently).25 inch/day.

Dr. Schlegel said that livestock and municipal waste can be applied to crop land for years without causing problems, and his quote was: "The key is management. If a producer is dumping waste on the field, rather than properly managing it, there is some danger. Applying the amount needed by crops and regularly soil testing will avoid problems. It is not the type of waste you put on, it's how you manage it." In the next year they plan to focus their research on lagoon closure, and they are investigating the use of new technologies, such as sub-surface drip irrigation, to apply livestock waste to crop land. They were asked to supply copies of Dr. Hamm's slides. The presenters responded to questions regarding their research.

The meeting adjourned at 9:00 a.m. The next scheduled meeting will be on Wednesday, March 15, 2000.

SENATE ENERGY & NATURAL RESOURCES COMMITTEE GUEST LIST

DATE: 3/14/2000

NAME	REPRESENTING
Dale Lambley	Ks. Dept. of Agric.
Ron Hammerschmidt	KDHE
Clyde Graeber	KDHE
Rich McKee	KLA
Jim Allen	Seaboard
Tom Bruno	Allen & Assoc
Sue Peterson	K-State
Tery Duwall	KWO
[illegible]	Ks Pork
Bill Hargrove	KCARE/K-State
Alan Schlegel	K-State
Greg A. Foley	KDHE
Steven Graham	K-State Research and Extension
John Rosmann	League of KS Municipalities
Christine Downey	Senate
Sharon Watson	KDHE
Craig Volland	Spectrum Technologists
Charles Benjamin	KNRC/Sierra Club
Gary Keeler	Ks Dept of Ag

SENATE ENERGY & NATURAL RESOURCES COMMITTEE GUEST LIST

DATE: 3-14-00

NAME	REPRESENTING
Marci Ross	Sedgwick County
David Miles	Associated Press
Steve Adams	Dept. of Wildlife + Parks
Dana Zenger	House Majority Leader's Office
Paul Johnson	PACK
V Olsen	KS Ag Res. & Comm.

STATE OF KANSAS

Bill Graves, Governor

KANSAS WATER OFFICE
Al LeDoux
Director

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TESTIMONY TO SENATE COMMITTEE ON ENVIRONMENT ON SUBSTITUTE FOR H.B. 2144

March 14, 2000

by Margaret Fast, Unit Manager
Kansas Water Office

The Kansas Water Office supports Substitute for H.B. 2144 with some reservations. There are three basic areas I would like to address: rules and regulations for the program, financial assistance in public water supply storage, and recreation.

Rules and Regulations

This bill would give the Kansas Water Office the responsibility to develop rules and regs governing the state costs incurred in providing public water supply storage in multipurpose small lakes. We support this change. Under the current program, the Water Office is charged with determining the need for future water supply in new lakes.

Financial Assistance in Public Water Supply Storage

The bill defines a multipurpose small lake as renovation or reconstruction of an existing dam or lake to provide flood control or water supply. In defining renovation in the bill, any financial participation by the state in the public water supply portion is precluded. Currently, the state may participate in adding water supply storage that may be needed in the area in the next 20 years that is over and above that amount of water supply storage needed by the sponsor. The current statute provides for the state's recovery of the cost through the sale of the storage and associated water rights.

We would recommend that Substitute for HB 2144 be amended to allow the state to participate financially in the renovation of the water supply portion of an existing lake. We support actions that would protect and restore storage that currently exists. House Substitute for Senate Bill 287 (1999 session) assigned to the Kansas Water Authority a study of siltation rates in public water supply lakes. This study is underway and the results will be reported to the Legislature by Jan 8, 2001. This study will identify lakes that might be potential candidates for restoration.

State financial involvement in restoration would occur under specific conditions in order to be consistent with the *Kansas Water Plan* and the existing multipurpose small lakes program statutes.

1. A cost benefit analysis of alternatives is required under the existing statute. The

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sponsor would have to show that restoration of the existing lake is a cost effective and viable option for water supply.

2. The current statute requires a local nonpoint source management plan for the watersheds draining into the lake. This helps assure that the state investment is protected from premature lake aging.
3. The lake to be restored should either be identified in the study required under House Substitute for SB 287 or be identified in a regional water supply strategy as a viable component of the area's water supply or be identified as a critical component of the public water supply entity's need to meet the capacity devolvement strategy of the state.
4. There should be a requirement for the local sponsor to participate financially. We would recommend up to a 50-50 cost share.

Recreation

Substitute for H.B. 2144 does not allow the state to participate financially in the restoration of recreation components of a lake. The *Kansas Water Plan* includes an objective to increase public recreation activities at Kansas lakes and streams. The current Multipurpose Small Lake Program allows state financial participation in recreational features of a multipurpose small lake. I should also mention that House Substitute for SB 287 also included impact on recreation in the siltation study request.

In the hearing in the House on H.B. 2144 last year, we supported renovation or restoration of the recreational components of small lakes. It is our understanding renovation of recreation was removed from the bill as amended by the House due to concern about private developers. We believe the existing definition of sponsor as an entity with eminent domain and taxing authority would preclude private developer involvement in the program. However, we would support language to clarify that financial participation in the restoration of recreational components would be confined to publicly owned lakes.

In summary, we support this bill with some modifications. This program is intended to maximize reservoir sites and to use financial resources in the most efficient manner. We believe this will allow us to continue to make recommendations to fulfill those purposes.

SCC KANSAS

State Conservation Commission

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Topeka, KS 66612-1299
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MEMORANDUM

March 13, 2000

MEMO TO: Senate Energy and Natural Resources Committee

FROM: Tracy Streeter, Executive Director Tracy Streeter

SUBJECT: Substitute for HB 2144

The State Conservation Commission administers the Multipurpose Small Lakes Program (MPSLP). The Kansas Water Office and the Chief Engineer, Division of Water Resources is also charged with specific duties as prescribed in the MPSLP Act.

The MPSLP provides state financial assistance for the construction or renovation of a lake containing at least two of the following purposes: 1) Flood control, 2) Water supply, 3) Recreation. The statute requires flood control to be included in all projects. The statute also establishes the cost-share arrangements for each purpose as follows:

1) Flood control – Up to a 100 percent grant for the flood control storage portion of the project.
2) Water Supply – Based upon a future need determination by the Kansas Water Office, the state may pay for up to 100 percent of the water supply if no local water supply sponsor is identified. The state may recover its cost through the sale of all or a portion of the water right.
3) Recreation – Up to a 50 percent grant for the recreation storage, recreation land rights and facilities.
4) Non-Point Source Pollution – Each funded project must have a NPS pollution management plan for the lake's drainage area. Cost-share funding may be provided through the MPSLP to protect the lake from NPS pollution.

The proposed amendments contained in Substitute for HB 2144 address two issues: 1) rules and regulation authority and 2) eligibility requirements for renovation projects. The first provides the Kansas Water Office with the authority to develop rules and regulations for the portion of the Act for which they are responsible. I support this language as written.

The second issue relative to renovation projects is well intended as the language attempts to allow greater opportunities for existing lakes to receive renovation assistance. However, the bill, as written, would have limited applicability to existing Kansas lakes in need of renovation assistance. The amended language allows

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flood control to be an optional feature for renovation projects, but excludes recreation as an eligible purpose for renovation assistance. I will try to explain the significance of each of these proposed changes.

Most of Kansas' lakes constructed prior to the1950's do not contain flood control storage. In other words, runoff entering a lake with normal water levels is allowed to pass through the spillway with a minimal amount of detention. In order to be eligible for renovation assistance, these lakes would be required to add dam height to detain runoff from a 25 year, 24 hour runoff event. In addition to dam enhancement, additional land adjacent to the existing lake would have to be acquired to temporarily store the floodwater. Existing infrastructure, roads, parks, buildings, and in some cases, homes would have to be moved to provide for the additional flood storage. As a result of these issues, I believe the addition of flood control to an existing reservoir would be unacceptable to local sponsors and could be cost prohibitive. Therefore, making flood control an option rather than a requirement, will allow renovation projects to be considered without flood control.

A number of the older, existing lakes do provide public water supply storage. These lakes have lost capacity over the years due to siltation and in some cases, have dam and spillway repair needs. The proposed language does provide an opportunity to address lakes containing water supply storage, however, the portion of the MPSLP which sets forth the procedures for this purpose requires the funding to be paid back prior to the local sponsor using the water supply. In addition, the state would possess a portion of water right for the lake until the funds used for this portion of the renovation were paid back. As a result, I do not envision a renovation project applying for, or receiving water supply assistance.

The MPSLP is currently capable of providing recreation assistance for both new and renovation projects. Most existing lakes provide some form of water-based recreation and as such, I believe the MPSLP should be capable of providing assistance for the renovation of lakes possessing recreation features. If recreation is not eligible for renovation assistance as proposed by this bill, it is doubtful that any existing, non-flood control lakes would qualify for, or receive future MPSLP funding.

In summary, I believe the state of Kansas should provide assistance to local sponsors for the renovation of existing lakes and further believe that Substitute for HB 2144 was drafted with that intention in mind. In order for the MPSLP to assist in lake renovation efforts, recreation must be included as an eligible purpose. I encourage the Committee to consider amending this bill to include recreation as a feature of renovation projects.

Thank you for the opportunity to provide information. I will be pleased to answer questions at the appropriate time.

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SUBSTITUTE FOR HOUSE BILL 2144

Testimony Provided to
Senate Committee on Environment
March 2000

This legislation amends the statutes pertaining to the Multipurpose Small Lakes Program administered by the State Conservation Commission. The current form of the legislation provides for the renovation or reconstruction of dams under the Multipurpose Small Lakes Program to provide either increased or restored flood control or public water supply. However, this legislation omits the renovation or reconstruction of recreation features.

As we understand it, recreation features were omitted in response to concerns the State would possibly fund facilities that would be utilized by private development. We share the concern the State should not fund recreation facilities for private developments. However, we do not believe this would be an issue because Sub. H.B.2144 defines a Sponsor as . . . " any political subdivision of the state which has the power of taxation and the right of eminent domain;".

In addition, we believe there are a number of structures within the state which might qualify under this program where recreation facilities are important to the local community. In particular, county and city lakes which provide multiple benefits to the community. In recent years we have seen a number of examples of reconstruction or renovation of community lakes where recreation has been an important part of the project. These include Warnock Lake in Atchison, Yates Center city lake, Lake Afton in Sedgwick County.

In conclusion, the addition of recreation to the uses under renovated or reconstructed multipurpose dams would be both consistent with the current statute and address a need in local communities.

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K-State Report: Animal Waste Management and Utilization Research

Mailed: March 14, 2000

TOPEKA, Kan. - K-State researchers studying animal waste management and utilization summarized their progress and key findings in several important areas over the past twelve months as they reported to Senate and House committees on March 14.

Seepage losses from anaerobic lagoons have been studied at more than 20 animal feeding operations across Kansas. Whole-lagoon seepage rates from 15 lagoons ranged from 0.01 to 0.09 inch/day, with an overall average of 0.05 inch/day (1/20th inch per day). The present state-mandated seepage rate for lagoons is currently 0.25 inch/day.

Chemical concentrations in the lagoon effluent varied substantially between locations. Ammonium concentrations ranged from 10 ppm at some cattle feedlots to 2000 ppm at one swine waste lagoon. On average, the ammonium concentrations were 122 ppm and 775 ppm at the cattle and swine sites, respectively. Other chemical constituents like chloride and sodium also varied by as much as six fold between locations.

"Ammonium movement in soil under lagoons was dependant on soil texture (i.e. clay content), soil cation exchange capacity (CEC), and soil hydraulic properties," explained Jay Ham, the project's leader at Kansas State University. Ammonium trapped on soil particles is not absorbed permanently and could potentially convert to nitrate or nitrogen gas under certain environmental conditions (especially after lagoon closure).

Soil cores, between 10 and 15 ft. deep, were collected beneath six waste lagoons that were 11- to 30-years-old, including one municipal lagoon. There was large site to site variation but, in general, the highest soil ammonium concentrations (800 to 900 ppm in some cases) were found immediately beneath the lagoon "floor" (compacted soil liners). However, ammonium decreased rapidly with depth, with most trapped in the first 5-10 feet below the floor. Ammonium contamination of groundwater is unlikely except in regions with very shallow water tables and sandy soils.

"There are a lot of good soils in Kansas and the Great Plains for building lagoons," Ham said. "That doesn't mean there are not some bad places to build lagoons, because there are. You can certainly find places with good clay content in the soil and good depth to the water table, even in the Equus Beds. At the same time, even in other regions of the state, you will find areas where the soil is sandy and the water table is not far from the surface."

"Basically, before building a lagoon, we need to determine the type of soil under the potential lagoon site, consider the type and concentration of waste to be placed in the lagoon, know the depth to water, and decide the length of time the lagoon will be used to hold waste."

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Last year, K-State determined that the differences in lagoon site characteristics dictated potential for groundwater contamination, an idea that could lead to design and management recommendations specific to every Kansas farm or municipality. On Tuesday, Ham introduced a "lagoon design tool," or a computer program that asks for such inputs as soil and aquifer properties and type of operation to build a site-specific lagoon.

"Often on a single tract of land or even on the same farm, there is a much better place to build a lagoon than others," Ham said. "This [the computer program] will help the producer or municipality explore land areas and find the place of lowest risk. What you'd like to do is have your site in an area where the soils will trap the material seeping through and keep it close to the bottom of the lagoon, so that when the lagoon is eventually closed, the owner can remediate that site more easily," he said.

In another study reported Tuesday, K-State Research and Extension agronomist Alan Schlegel, said that livestock and municipal waste can be applied to crop land for years without causing soil chemical problems. Farmers must be good managers, applying the waste at recommended rates.

"Land application of animal and municipal waste is a good way to utilize it," Schlegel said. Farmers apply waste to land because it is a fertilizer for crops and can enhance soil quality.

"The key is management. If a producer is dumping waste on the field, rather than properly managing it, there is some danger. Applying the amount needed by crops and regularly soil testing will avoid problems."

The K-State research analyzed four fields where livestock waste was applied, and two municipal waste sites. One municipal waste site showed elevated nutrient levels, compared to the other municipal and animal waste fields.

"It's not the type of waste you put on, it's how you manage it," Schlegel said.

K-State also is investigating the use of new technologies, such as sub-surface drip irrigation, to apply livestock waste to cropland.

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Pat Melgares
News Coordinator
K-State Research and Extension

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KSTATE
Kansas State University

REPORT TO THE ENERGY AND NATURAL RESOURCES COMMITTEE, KANSAS SENATE

14 March, 2000

Update and Summary of Research and Extension Programs in Animal Waste Management and Utilization

Marc A. Johnson, Dean and Director
Steven M. Graham, Assistant to the Dean and Director

Presenters

Bill Hargrove, Director of KCARE
Jay Ham, Associate Professor, Department of Agronomy
Alan Schlegel, Professor, Southwest Research-Extension Center

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KCARE

Senate Energy & Natural Resources
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Date: 3-14-2000

ANIMAL WASTE MANAGEMENT AND UTILIZATION
2000 ANNUAL REPORT TO THE LEGISLATURE
EXECUTIVE SUMMARY

Prepared by
W.L. Hargrove
Kansas Center for Agricultural Resources and the Environment (KCARE)
K-State Research and Extension
Kansas State University

Introduction

We are in our second year of work in meeting our obligations set out in HB2950 and in responding to governor's office, legislative, state agency, and citizen concerns over the issues related to livestock waste management and application to land. In the past few months, we have been requested by the governor's office and KDHE to focus our efforts in the remainder of this year and next year on the Equus Beds region of the state. We already have made some progress in response to this request. We have attached to this summary an updated Plan of Work that describes our objectives and plans for additional work in the Equus Beds. We also attach a budget showing our obligations for the current fiscal year (99/00) and a proposed budget for next fiscal year (00/01), the final year of our planned work in response to HB2950. In the following pages, we summarize our progress and key findings in several important areas over the past twelve months.

Certification Training Required by HB2950 and Other Educational Efforts, Prof. Pat Murphy, Department of Biological and Agricultural Engineering.

In January and February of 1999, a series of state-wide educational meetings in conjunction with the KS Department of Agriculture and the Kansas Pork Producers Council were conducted to update producers on the nutritional options for reducing the amount or changing the composition of swine waste. Information on the effects of different systems of manure storage and land application was also discussed. Also, these meetings explained the regulatory requirements and the environmental plans required by HB2950. On-farm evaluations of waste management options for individual producers were conducted. An additional requirement of HB2950 was to aid in the development of information to develop nutrient management plans for those producers over 1,000 animal units. A team composed of Dave Whitney, Gary Pierzynski (Agronomy); Kevin Dhuyvetter (Ag. Economics); Bill Hargrove (KCARE); Pat Murphy (Biological and Agricultural Engineering); Garry Keeler, Dale Lambley (Kansas Department of Agriculture); Tim Stroda, and Mike Jensen (Kansas Pork Producer Council) developed the necessary guidelines and spreadsheets for the 5-year nutrient management plans. HB2950 required swine manure applicators to be certified. Seven educational meetings were held throughout the state to certify applicators. The 6-hour programs were conducted by Murphy and Harner of K-State Research and Extension, Kansas Department of Agriculture and KDHE; a total of 139 attendees were certified.

Seepage Rates and Nitrogen Losses from Animal Waste Lagoons: Potential Impacts on Groundwater Quality, Dr. Jay Ham, Agronomy Department.

Seepage losses from anaerobic lagoons have been studied at more than 20 animal feeding operations (AFOs) across Kansas. Counties included in the study were: Grant, Gray, Hodgeman, Morton, Scott, and Stevens (in western KS); Harvey, McPherson, Rice, Reno, and Stafford (in central KS); and Coffey,

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Dickinson, and Riley (in eastern KS). Whole-lagoon seepage rates from 15 lagoons ranged from 0.01 to 0.09 inch/day with an overall average of 0.05 inch/day (1/20th inch per day).
Chemical concentrations in the lagoon effluent varied substantially between locations. Ammonium concentrations ranged from 10 ppm at some cattle feedlots to 2000 ppm at one swine waste lagoon. On average, the ammonium concentrations were 122 ppm and 775 ppm at the cattle and swine sites, respectively. Other chemical constituents like chloride and sodium also varied by as much as six fold between locations.

Soil cores, between 10 and 15 ft deep, were collected beneath six waste lagoons that were 11- to 30-years-old, including one municipal lagoon. Ammonium movement in soil under lagoons was dependent on soil texture (i.e., clay content), soil cation exchange capacity (CEC), and soil hydraulic properties. Therefore, there was large site to site variation in soil ammonium profiles. In general, the highest soil ammonium concentrations (800 to 900 ppm in some cases) were found immediately beneath the lagoon "floor" (compacted soil liners). However, ammonium decreased rapidly with depth, and most of it was still trapped in 5- to 10-ft-thick soil zones under the lagoons. Thus, initial findings showed that ammonium contamination of groundwater is unlikely except in regions with very shallow water tables and sandy soils. Constructing soil liners with bentonite and other high CEC materials (that adsorb potential contaminants) could reduce the risk of groundwater contamination. Ammonium trapped on soil particles is not adsorbed permanently and could potentially convert to nitrate or nitrogen gas under certain environmental conditions (especially after lagoon closure).

More research is needed to determine the long-term effect of nitrogen trapped under lagoons. Because of the large site to site variation in waste chemistry, soil type, and aquifer vulnerability; results suggest that lagoon design and permitting should be site specific and performance based. A logical framework and computer program are being developed that can optimize lagoon design using site-specific inputs (e.g., soil characteristics, depth to water table, species, type of lagoon). Research in 2000 will focus on determining lagoon impacts and formulating best management practices for regions with sensitive groundwater (e.g., shallow water tables, alluvial aquifers).

Manure Composition from Kansas Swine Lagoons, Dr. Robert Goodband, Animal Science Department.
In phase I of our project, analysis of 41 manure samples from Kansas swine lagoons revealed that some nutrient concentrations were slightly higher than previously reported values from the Nebraska Cooperative Extension Service and the Midwest Planning Service, but considerably less than the book values currently being used by KDA. In addition, high standard deviations indicated that considerable variation exists in composition of waste in swine lagoons. Although means from some lagoons were lower, most producers had manure that analyzed slightly higher in some nutrients than previously published values from other sources. These data reveal the importance of individual analysis of lagoons for proper application to cropland to maximize yield and environmental stewardship. Additional research, phase II, is currently in progress to provide a more detailed understanding of nutrient concentrations from manure samples in Kansas.

Impact of Land Application of Animal Wastes on Soil Chemical, Biological and Physical Properties, Dr. Alan Schlegel, Southwest KS Research & Extension Center, Tribune.
Soil samples were collected from 8 fields in south-central Kansas (Harvey County) with a history of animal waste or municipal sludge applications and compared to similar fields that had not received any application of animal or municipal wastes. The rate of application, number of years of application (up to

35 years), and soil type (sandy loam to silty clay loam) varied from site-to-site. Two sites received swine wastes, 2 sites received cattle manure, 2 fields received municipal sludge, and 2 fields did not receive any animal or municipal wastes (control fields). Soil phosphorus (P) levels (0-6 inch depth) were 100 to 200 ppm (Bray-1 P) in the fields receiving swine or cattle waste, indicating that application rates exceeded crop P demands, although one of the control sites also had P levels of 140 ppm. Soil test P levels of 30-50 ppm are sufficient for optimum crop growth. The highest soil test levels (500 ppm) were on a site that received municipal sludge. Application of swine and cattle wastes had little effect on soil nitrate levels compared to the control fields. However, elevated soil nitrate levels (20 ppm at the 7-10 ft depth) were observed at one municipal sludge site (the same site with the elevated soil P levels). Extractable copper contents were about 2 ppm or less in the control fields and the fields that had received swine or cattle waste compared to 40 and 300 ppm in the fields receiving municipal sludge. Extractable zinc was also much higher in the municipal sludge fields (up to 100 ppm) than at the other sites (less than 10 ppm). In general, soil chemical properties were impacted more by application of municipal sludge than from application of swine or cattle wastes.

Evaluation of Near-Surface Soil Physical Properties Following Land Application of Animal Wastes, Dr. Loyd Stone, Agronomy Department

Physical properties were determined on soils from six western Kansas fields having a history of animal waste application. Three fields had received solid manure (cattle) and three had received effluent water from wastewater lagoons (two cattle and one swine). Physical properties were also determined on six similar (companion) fields with no history of animal waste application. A modulus of rupture test measures break strength of molded soil briquets. An aggregate stability test determines mean weight-diameter (relative size) of water-stable aggregates. Of the six field pairs, two had no difference within pairs in modulus of rupture or mean weight-diameter of water-stable aggregates. Three field pairs had differences within pairs in modulus of rupture (a lower break strength) and mean weight-diameter of aggregates (a greater proportion of large, water-stable aggregates) — both conditions in the manured soils. In one of the six pairs, there was an increase in modulus of rupture and a decrease in mean weight-diameter of aggregates in the manured soil. That same pair was the only pair with a significant increase in the ratio of monovalent to divalent cations due to manure. That same field pair had an electrical conductivity of 0.38 mmhos/cm in the non-manured soil and 3.03 mmhos/cm in the manured soil. At that location, waste has been applied at excessive rates, raising the soluble salt content and increasing the ratio of monovalent to divalent cations, leading to aggregate collapse and decreased soil structural conditions. At three of the six locations, there has been an improvement in soil structural conditions associated with livestock waste application. At two locations, there is no significant difference in soil structural conditions between manured and non-manured soil.

Using Subsurface Drip Irrigation (SDI) with Beef Lagoon Wastewater, Dr. Freddie Lamm, Northwest KS Research Center, Colby; and Dr. Todd Trooien, Southwest KS Research Center, Garden City.

Five different dripline types, each with a different emitter flow rate and size, were tested with beef feedlot lagoon runoff wastewater for two growing seasons. The flow rates of the two smallest emitter sizes, 0.15 gal/hr/emitter and 0.24 gal/hr/emitter, decreased during the growing season, indicating that some clogging of the emitters was occurring. The magnitudes of the decreases in 1999 were 24% of the original flow rate for the 0.15 gal/hr/emitter driplines and 14% of the original flow rate for the 0.24 gal/hr/emitter driplines. During the winter idle period, the flow rates of these two smallest driplines recovered to their initial values. The flow rates of the three largest driplines, 0.40, 0.60, and 0.92 gal/hr/emitter, did not decrease during the growing season. These results show that the drip irrigation laterals used with SDI have potential for use with lagoon wastewater. However, the smaller emitter sizes normally used with groundwater sources in western Kansas may be risky for use with lagoon wastewater.

<u>Waste Containment in Anaerobic Lagoons - Laboratory and Modeling Investigations</u>, **Dr. Lakshmi Reddi, Civil Engineering Department.**
The main objectives of this investigation were to: a) assess the range of seepage quantities for lagoon liners constructed with Southwest Kansas soils, and b) to evaluate the transport characteristics of nitrogen in the ammonia form (NH_4-N) through compacted clays and the underlying soils. To achieve these objectives, several compacted specimens of Kansas soils were tested in the laboratory with animal waste as the influent. A computer model (SWMS-2D) was used to simulate transport of Nitrogen in the liners and the underlying soils.

In general, the natural clayey soils available in the Southwest region of Kansas were found to be capable of meeting the KDHE seepage standard of 0.25 inch/day. The results indicate that biological clogging may not be a prominent mechanism during the time period it takes for breakthrough of NH_4-N. Considering the side liners of lagoon facilities which may offer no opportunity for particulate clogging or organic sludge formation, it may not be appropriate to assume reductions in the natural permeability of clay liners. Tests using geomembranes showed no deterioration of the liner with prolonged contact with NH_4-N. Results from the modeling phase showed drastic differences in travel times and end concentrations of NH_4-N among liners prepared from the same soil type. The potential for significant retardation, decay, and saturation levels of NH_4-N in clay liners suggests that liner thickness is an important parameter.

It was concluded that mass transfer characteristics of liner material, cation exchange capacity (CEC) and microbial uptake in particular, should be important considerations in the design of animal waste lagoon liners. Results also indicate that the ammonium concentrations were significantly reduced in the underlying soil profiles with frequent scraping and replacement of the top portion of the liner. Higher scraping depth and frequent replacement of the top of the liner reduced the ammonium concentrations leaching out of the liner significantly.

<u>Vegetative Reclamation of Abandoned Lagoons</u>, **Dr. Kyle Mankin, Biological and Agricultural Engineering Department; and Dr. Mary Beth Kirkham and Dr. Jay Ham, Agronomy Department.**
Over the next 18 months, this project will evaluate the degradation in soil, uptake by plants, and transport to groundwater of several important contaminants (ammonium, phosphorus, chloride, copper, and zinc) in an abandoned lagoon after initial closure. Fifteen, 3-ft deep, soil columns are being instrumented in the greenhouse and subjected to different rainfall conditions. The columns will be filled with contaminated lagoon soils collected during clean-out of a working lagoon, and planted with poplar trees. It is anticipated that plants will a) slow the percolation of water below the lagoon by transpiring much of the infiltrated water, b) create a soil environment that encourages more rapid degradation of contaminants, and c) help remove contaminants by harvest and removal of plant tops with accumulated contaminants.

<u>Transport of Water and Solutes from Animal Waste Lagoons</u>, **Dr. David Steward, Civil Engineering Department.**
A computer model of water flow through the compacted clay liner of a lagoon and the underlying soil is being developed. Accurate estimation of flow rates and pressure distributions under a lagoon are

important since these quantities control the movement of nutrients from a lagoon to groundwater. This computer model incorporates the following parameters that control flow:

- The depth to groundwater,
- The thickness of distinct geological layers (including the compacted clay liner and underlying soil),
- The saturated hydraulic conductivity of each layer (this indicates how quickly water can travel through pore spaces between soil particles),
- The relationship between the hydraulic conductivity and the pressure in each layer (water flows more quickly through pore spaces that are completely filled with water than through those that are partially filled with air).

The layers in this model correspond to soils with distinct hydrological properties that were deposited over different geological periods. The computer model is now capable of simulating flow and pressure in a layered media. The computer program MATLAB is being used to produce graphical results. Testing and validation of the model are underway. An example of flow from a lagoon to groundwater through four layers has been completed. Once this model is fully tested and validated, it will be used to estimate flow and pressure distributions under lagoons in Kansas.

Recent Publications

Bonala, M.V.S., and Reddi, L.N. 2000. "Ammonium Transport through Lagoon Liners - Modeling Studies," Geotechnical Special Publication, Geo-Denver 2000 conference. Under review.

Bonala, M.V.S., Reddi, L.N., and Davalos, H., 1999. "Scrape-and-Replace Lagoon Liner Technique to Minimize Ammonium Transport from Animal Waste Lagoons," ASCE Practice Periodical of Hazardous, Toxic and Radioactive Waste Management Vol. 4, No.2

Bonala, M.V.S., and Reddi, L.N. 2000. "Clogging of Animal Waste Lagoon Liners - An Overview," Am. Soc. Civil Eng. Monograph (submitted).

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Reddi, L.N., Davalos, H., and Bonala, M.V.S. 2000. "Seepage and Transport through Anaerobic Lagoon Liners," Am. Soc. Civil Eng. Monograph (submitted).

Ham, J.M. 1999. "Measuring evaporation and seepage losses from lagoons used to contain animal waste," Transactions of the ASAE. 42:1303-1312. (KAES 99-326-J)

Ham, J.M., and T.M. DeSutter. 1999. "Seepage losses and nitrogen export from swine-waste lagoons: a water balance study," J. Environ. Qual. 28:1090-1099. (KAES 99-138-J)

Ham, J.M. 2000. "Evaluating Seepage Losses and Liner Performance At Animal-Waste Lagoons Using Water Balance Methods," Am. Soc. Civil Eng. Monograph (submitted) (KAES 00-122-B)

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Trooien, T. P., F. R. Lamm, L. R. Stone, and M. Alam. "Irrigating corn with subsurface drip irrigation lagoon wastewater." Irrigation Journal 49(5):6-7. (KAES 99-520-T)

CONCLUSIONS OF THE K-STATE STUDY OF ANIMAL WASTE MANAGEMENT AND UTILIZATION
July 1, 1998 - March 1, 2000

From the evaluation of lagoons (Dr. Jay Ham):

1) The average seepage rate from 15 lagoons in Kansas was 1/20 inch per day. The existing 1/4 or 1/8 inch per day design standards can be achieved with soil-lined lagoons at most locations in Kansas.

2) Analysis shows that the risk of groundwater contamination is very site- and species-specific. Research results suggest that lagoon integrity and the potential to contaminate groundwater is affected by waste concentration and toxicity, aquifer and soil properties, and the expected life of the facility. A logical framework can be used to determine lagoon design for new facilities on a site-to-site basis rather than using "blanket" specifications for the entire state. A prototype site-specific design tool has been developed by KSU. Plastic lined lagoons or alternate manure storage might be needed at sites with very vulnerable groundwater.

3) Significant quantities of ammonium nitrogen tend to accumulate under anaerobic lagoons. The mass and thickness of the contaminated soil zone is dependent on the quantity and quality of the seepage, soil type, and lagoon age. The long-term potential impact of this material should be considered when a facility is abandoned or closed. Thus, site-specific closure plans can be developed for all new lagoons at the time of permitting, and could be accompanied by periodic inspection. Furthermore, best management practices should be developed to educate producers on the best way to close older, existing lagoons.

4) New lagoons reach a stable seepage rate after 6 to 18 months of use. Whole-lagoon seepage rates from new lagoons should be measured after a facility is operational for 18 months, to determine if the lagoon meets the design specifications.

5) In general, research at more than 30 waste lagoons shows that the risk of groundwater contamination from soil-lined lagoons is minimal except in areas with vulnerable aquifers (i.e., shallow water tables , sandy soils). This statement assumes that the soil underlying lagoons is properly remediated at the time of lagoon closure, regardless of location or aquifer depth.

From the soil sampling in cropped fields where waste has been applied (Dr. Alan Schelgel):

6) Good management is the key to minimizing environmental impact from land application of waste materials.

7) Livestock wastes can be applied to soil for a long period of time without causing soil chemical problems, if applied at agronomically appropriate rates.

8) Soil physical properties are generally improved by application of animal wastes when applied at agronomically appropriate rates.

9) Excessive applications of livestock or municipal wastes can cause very high nutrient levels and degrade soil physical properties.

From the study of nutrient content of manure from Kansas swine producers (Dr. Bob Goodband):

10) Nutrient content of manure from Kansas swine producers is considerably less than the book values currently in use by KDA (book values from Ohio State Univ.), but comparable or slightly higher than values from the University of Nebraska or Midwest Plan Service. We plan to expand our analysis of nutrient content of manure under Kansas conditions to develop an adequate data base upon which new book values for use by KDA may be determined.

From the study of wastewater recycling by subsurface drip irrigation (Drs. Freddie Lamm and Todd Trooien):

11) Beef cattle feedlot lagoon wastewater has been successfully recycled through subsurface drip irrigation when the emitter size was 0.40 gal/hr/emitter or greater; smaller emitter sizes (0.24 gal/hr/emitter or less) commonly used in SDI, showed evidence of clogging over time.

Field Investigation of Seepage Losses from Animal Waste Lagoons†

Updated: 16 December 1999

Jay M. Ham, Ph.D., Department of Agronomy, Kansas State University, Manhattan, Kansas

What is an animal waste lagoon?

Anaerobic lagoons are used throughout Kansas to collect, store, and treat waste at animal feeding operations. Most lagoons are earthen basins lined with 12 to 18 inches of compacted soil or clay to limit seepage losses. At cattle feedlots and dairies, wastewater entering a lagoon is runoff from precipitation that has fallen on open-air pens. Washwater from veterinary hospitals and milking barns may be drained into lagoons. Lagoons at swine sites usually receive wastewater collected in shallow pits directly beneath animals. Periodically, the operator pulls a plug and drains the waste into an anaerobic lagoon located adjacent to the production barns. Conversion of waste to methane and carbon dioxide gases has proven to be an effective way to remove 50 to 80 % of the manure solids that initially enter a lagoon. Furthermore, up to 80% of the nitrogen in the raw waste is lost into the atmosphere as ammonia. The remaining wastewater eventually evaporates or is applied to nearby farmland, while undigested organic solids and sediments (soil from wind and water erosion) slowly accumulate on the bottom of the lagoon.

How did K-State get involved with lagoon research?

In 1997, Kansas State University was asked to determine if animal waste lagoons, built according to KDHE standards, would meet the ¼ inch per day seepage standard that was recommended by the state. This concern was stimulated by the expansion of corporate hog farming in southwestern Kansas. Large swine waste lagoons (e.g. 5 acres, 20 ft deep) were being built across the region, and there was a concern that seepage losses might pollute the drinking water. It is important to realize that Kansas, like most states, sets "design standards" not "performance standards". That is, a lagoon must be designed to seep less than some specified amount, but no one measures the seepage rate after it is built to see if it performs within the standard. K-State was asked to measure actual seepage from working lagoons across the state.

How did you measure seepage from lagoons?

The best way to measure seepage from an existing lagoon is by using the water balance method. We ask the cooperator not to add or remove waste from the lagoon for about one week. We then use very sensitive instruments to measure the change in depth and evaporation over time. If it does not rain or snow, we calculate seepage as the difference between the change in depth and evaporation. For example, suppose we measured the water balance of a lagoon for one week and detected a total depth change of 1.5 inches with an evaporation loss of 0.8 inches. The seepage rate would then be (1.5 inches – 0.8 inches) / 7 days or 0.1 inches per day. Because changes in depth must be measured very precisely, we developed custom sensors and instruments for the lagoon project. Our sensors can monitor lagoon depth every 10 seconds, 24 hours a day with a resolution greater than 1/100th of an inch.

What were the seepage rates from the lagoons you studied in Kansas?

We have conducted seepage studies on 14 lagoons in Kansas (12 swine and 2 cattle feedlots). Seepage rates have ranged between 0.02 inches/day to 0.1 inches/day . The average of all 14 sites was 0.047 inches/day (1/21"). Thus, all of the lagoons we have studied so far have seeped less than the ¼ inch/day standard. A new study of 28 lagoons in Iowa shows almost the same results.

Your data show that seepage from lagoons is probably less than ¼ inch per day, but are those seepage rates safe? Could very low rates of seepage still contaminate drinking water?

That is a good question, but a very complicated one from a scientific standpoint. When considering the potential effects of lagoons on groundwater, three areas must be considered: (a) toxicity and concentration – what are the constituents in the lagoon waste that pose a threat to water quality and public health, (b) input loading – at what rate does waste seep from a lagoon under field conditions, and (c) aquifer vulnerability – how does soil properties, geology, and water table depth affect the risk of waste movement from the lagoon to the groundwater? K-State research is trying to address all of these issues.

What in a lagoon might affect groundwater quality ?

There are several things in a lagoon that might impact groundwater quality. Potential contaminants include: nutrients, bacteria, viruses, pharmaceuticals, and hormones. It would take a long time to go through all of these in detail, but in the majority of cases, we are concerned most about nitrates and fecal bacteria. Nitrates can cause infant methemglobinemia and have been linked to types of gastric cancer. Cases of methemglobinemia are extremely rare. Bacteria like fecal streptococci and fecal coliform are very common in lagoon waste and can cause acute gastric problems if consumed in drinking water. Cases of bacteria seeping through the soil profile and contaminating groundwater are also very rare.

† This paper is written in dialogue format – questions and answers. This is an unusual way to present scientific information; however, this document addresses actual questions that have been posed by citizens across the state. For a more detailed discussion, please refer to the references listed at the end of the report. This document will be revised as new information becomes available.

W..at have you found from analyzing the liquid waste in lagoons?

We have sampled the liquid waste in lagoons across Kansas. As an agronomist, I have focused on nutrients, especially nitrogen. One of the most important things we have discovered is that there is tremendous site-to-site variability in nutrient content in the waste. Ammonium, which accounts for almost all the leachable nitrogen in lagoons, ranged from 20 ppm at some cattle feedlots to as high as 2000 ppm at one swine waste lagoon. On average, the ammonium concentration in swine waste lagoons was about 6 to 7 times higher than at cattle feedlots. This is important, because it affects input loading. That is, if a typical swine and cattle feedlot lagoon were seeping at the same rate, seven times more nitrogen would leak from the swine site. This does not mean the seepage from swine lagoons is dangerous and that cattle lagoons are safe. It simply shows that these differences exist between species. It is important to recognize that lagoon waste is not uniform. There are big variations between sites even within the same species. Some producers have waste management plans that help reduce concentrations in the waste. This greatly reduces the chance for groundwater contamination.

What happens to the nitrogen and other soluble contaminants that seep from a lagoon?

The movement of material in the zone under the lagoon is highly dependent on the properties of the soil and the hydrology of the location. Some components of the waste are readily adsorbed onto soil particles and become immobile. For example, ammonium-nitrogen is a positively charged ion that tends to stick to clay minerals, which are all negatively charged. The ability of soil to adsorb positively charged ions is proportional to the soil's cation exchange capacity or CEC. The CEC of a soil is dependent on its clay content. Clayey soils are good traps for ammonium-nitrogen, while sandy soils can only adsorb about one fourth to one sixth as much ammonium. Thus, all things being equal, contaminants from a lagoon built above sandy soils will penetrate to deeper depths compared to a lagoon above loamy or clayey soils. Other ions, such as chloride and nitrate, are negatively charged and do not stick to the soil and move more freely. The movement of negative ions and bacteria is very dependent on soil water content (soil wetness) immediately below the lagoon liner. The zone of soil between the lagoon liner and the water table is called the vadose zone. In most places in Kansas, the vadose zone becomes unsaturated (some pores are air filled) immediately below the compacted liner. In unsaturated soil, bacteria tend to be caught in microscopic air-water interfaces between soil particles. Other soluble contaminants also move very slowly in unsaturated soil. Thus, the amount of precipitation and the depth to water table in a region will strongly affect the chances of lagoon contaminants reaching the groundwater. For this reason, the risk of contamination is typically much lower in the western portion of the state where conditions are more arid and the depth to groundwater often exceeds 150 ft.

What have you found from analyzing soil cores collected beneath lagoons?

We have collected soil cores beneath five older lagoons that have been emptied and cleaned of sludge. The sites included three cattle feedlots, a dairy, and one municipal lagoon. We are still analyzing the soil samples, but we do have some preliminary results. Data show that most of the ammonium nitrogen has been adsorbed within a few feet of the lagoon. A lot of the ammonium was trapped in the clay materials that were used to make the compacted liners. In one case, the ammonium concentrations exceeded 800 ppm near the original bottom of the lagoon; however, at this same site, which had clayey soils, none of ammonium had penetrated more than 6 ft below the lagoon. This demonstrates the importance of soil CEC and clay content. We have found some ammonium at depths near 16 ft beneath lagoons when soil in the vadose zone had high sand content and minimal clay; however, this was rare and the concentrations were quite low. One must be careful not to assume the any lagoon built above sandy soil is source of pollution. For example, we found virtually no ammonium in soil beneath an 11-year-old cattle feedlot lagoon where the water table was only about 4 ft below the bottom of the lagoon. It happened that concentrations of ammonium in the lagoon effluent at this site were extremely dilute because the operator had good management practices. Thus, the aquifer was vulnerable, but the toxicity of the lagoon effluent was so low it did not affect groundwater quality. More analysis of the soil cores will be presented in later reports.

Have you been able to reach any conclusions regarding lagoons and groundwater quality?

Our research clearly shows that the potential impact of lagoons is very site specific and species specific. Earthen-lined lagoons probably can be used safely at many locations throughout the state; however, we need to develop design tools to customize lagoon requirements at each facility. Plastic-lined lagoons may be needed in certain areas. I recently completed a manuscript that describes a logical framework for arriving at site-specific lagoon designs. Soil properties and water table depth at the proposed construction site are combined with data on species and waste management plans to calculate a maximum allowable seepage rate. The approach is quite simple and user friendly. The key to any successful approach will be to design a system that gives engineers and producers the flexibly to explore many possible approaches to lagoon design. Building a lagoon in regions of low environmental risk or employing waste treatment technologies that reduce toxicity must be rewarded with lower construction costs (e.g., soil lined vs. plastic-lined lagoons).

References

Ham, J.M. 1999. Estimating evaporation and seepage losses from lagoons used to contain animal waste. Trans. of ASAE 42:1303-1312.

Ham, J.M., and DeSutter, T.M. 1999. Seepage losses and nitrogen export from swine waste lagoons: A water balance study. J. Environ. Qual. 28:1090-1099.

Ham, J.M., L. Reddi, L. and C.W. Rice. 1999. Animal waste lagoon water quality study. Kansas Center for Agric. Resources and the Environment. College of Agric., Kansas State University, Manhattan, KS.

Animal Waste Management and Utilization 2000

Table of Contents

Executive Summary

I. ANIMAL WASTE MANAGEMENT AND UTILIZATION
UPDATED PLAN OF WORK
K-STATE RESEARCH AND EXTENSION
October, 1999

Introduction
We have about eight months remaining in our 3-yr contract with the Kansas Water Office, and about 20 months of funding from special state appropriations from HB2950. Recently, the Governor's Office and KDHE have requested a focus on the Equus Beds Region of the state for the coming months. We have analyzed our current commitments and workload and propose to make the following adjustments to our Plan of Work in order to respond to the Governor's and KDHE's request.

Animal Waste Lagoons and Water Quality

Liner Construction - Dr. Lakshmi Reddi, Department of Civil Engineering
We plan to develop site-specific configurations for liners and to evaluate chemical sealants, geomembranes, and geo-composite liners. Details of this work are presented in Attachment A, "General and Region-Specific Recommendations for Siting, Construction, and Operation of Animal Waste Lagoons in the State of Kansas".

Waste Chemistry - Dr. Jay Ham, Agronomy Department
We plan to continue survey sampling of lagoons for chemical composition. We will determine the chemical composition of all lagoons that we are allowed to study in the Equus Beds Region. Methodologies are outlined in our previous report.

Seepage Rates - Dr. Jay Ham, Agronomy Department
Plans are in place to measure the seepage rate on three lagoons this year, 2 swine lagoons and 1 beef cattle feedlot lagoon. Two of these are located in the western part of the state (Finney and Mead Counties) and one is located in the east (Osage County). None are located in the Equus Beds Region. We are currently trying to locate swine producers who will cooperate with us to allow seepage rate measurements in the Equus Beds Region. We would like to study two or three swine lagoons if we can find cooperators. Methodologies are outlined in our previous report.

Coring Underneath Lagoons - Dr. Jay Ham, Agronomy Department
Plans are in place to core underneath a total of eight lagoons: 1 beef, 3 swine, 3 human, and 1 mixed. The locations are in Finney, Mead, Osage, Harvey, McPherson, and Riley Counties. Of these, one swine and three human lagoons are in the Equus Beds Region. We would like to core underneath additional swine lagoons in the Equus Beds Region if we can find cooperators. Methodologies for this work are outlined in our previous report.

Logical Framework for Lagoon Siting and Liner Requirements - Dr. Jay Ham, Agronomy Department

Dr. Ham has developed a prototype logical framework for lagoon siting and liner requirements based primarily on depth to groundwater and characteristics of the soil at the site. He will be testing and validating this framework through the chemical characterization, seepage rate, and coring work described above. A draft description of the logical framework is presented as Attachment B, "Towards Site-Specific Guidelines for Animal-Waste Lagoons in Kansas."

Lagoon Closure - Dr. Jay Ham and Dr. Mary Beth Kirkham, Agronomy Department, and Kyle Mankin, Biological and Agricultural Engineering Department

We have initiated studies on use of vegetation to remediate lagoon sites with high concentrations of salt and ammonium. We are screening plants for their ability to grow and absorb the excess nutrients at these sites. A description of this work is presented as Attachment C, "Initial Crop Growth in So8il Beneath Animal waste Lagoons". We are also conducting leaching studies on soil columns (sandy soil type) collected from a swine lagoon in McPherson County. This work is described in Attachment D, "Vegetative Reclamation of Abandoned Swine Lagoons."

Land Application of Livestock Waste

Soil Sampling - Dr. Alan Schlegel, Agronomist, Southwest KSU Research-Extension Center, Tribune, KS

We plan to sample about 6 site in Harvey and Reno Counties where waste has been applied for many years. Sites where livestock waste and sites where municipal waste have been applied will be sampled. We also plan to review other data from previous projects done in the areas. Methodologies are reported in our previous report.

Nutrient Content of Manure - Dr. Bob Goodband, Dr. Mike Tokach, Dr. Jim Nelssen, Animal Science Department and Gary Keeler and Dale Lambley, KDA

We are conducting a review and analysis of the KS Department of Agriculture data base on nutrient content of lagoons submitted as a part of permit applications. This is to verify or change the book values that are being used for nutrient content of manure. We are also collecting additional samples from KS producers for analysis. We will also sample different waste handling systems for nutrient content to improve our data base for use in nutrient management planning. Details of this project are presented as Attachment E, "Chemical Composition of Manure in Kansas Swine Lagoons."

Air Quality

Air Quality Monitoring System to Evaluate Setback Distances - Dr. Jay Ham, Agronomy Department

We plan to evaluate the setback distances required in Hb2950 by establishing an air quality monitoring system at several swine production sites. A proposal for this work is presented as Attachment F, "An Air Monitoring Network for Determining Optimal Setback Distances for Concentrated Animal Operations."

1999/2000 - Animal Waste Management Initiative

	Personnel	Operating	Total
Allocations **Carryover** **Total Available**	**$189,780** **74,598** **$264,378**	**$47,445** **0** **$47,445**	**$237,225** **74,598** **$311,825**
Obligations to Date			
Waste Lagoon Evaluation	-------	$20,000	$20,000
Seepage Rates & Coring	$35,309	------	$35,309
Modeling	$25,521	------	$25,521
Land Application of Manure	------	$27,445	$27,445
Evaluation of Rates/Deep Soil Sampling	$80,783	------	$80,783
Nutrient Content of Manure	$8,700	------	$8,700
Wastewater Recycling through SDI	$6,039	------	$6,039
Facility Closure	$12,594	------	$12,594
Extension/Communications	$62,762	------	$62,762
Total	**$231,708**	**$47,445**	**$279,153**
Non-Obligated	**$32,670**	**$0**	**$32,670**

2000/2001 - Animal Waste Management Initiative

	Personnel	Operating	Equipment	Total
Proposed Allocations	**$144,780**	**$47,445**	**$45,000**	**$237,225**
Waste Lagoon Evaluation	------	$20,000	------	$20,000
Seepage Rates & Coring	$35,309	------	------	$35,309
Modeling	$25,521	------	------	$25,521
Land Application of Manure	------	$27,445	------	$27,445
Evaluation of Rates/Deep Soil Sampling	$40,396	------	------	$40,396
Wastewater Recycling through SDI	$6,039	------	$45,000	$51,039
Facility Closure	$12,594	------	------	$12,594
Extension/Communications	$24,921	------	------	$24,921
Total	**$144,780**	**$47,445**	**$45,000**	**$237,225**

Attachment A

GENERAL AND REGION-SPECIFIC RECOMMENDATIONS FOR SITING, CONSTRUCTION, AND OPERATION OF ANIMAL WASTE LAGOONS IN THE STATE OF KANSAS

Lakshmi N. Reddi, Professor
Mohan V.S. Bonala, Post-Doctoral Research Associate
Department of Civil Engineering, Kansas State University

Introduction

Research conducted during the past two years revealed that the integrity of lagoon liners is controlled primarily by the materials used in the construction and by the hydrogeology of the site. Much of the work during this period focused on Southwest Kansas and on selected animal waste streams. A three-year study is proposed herein to extend the scope of work and make general recommendations on animal waste containment considering the range of soil types and hydrogeologies in the State of Kansas. The broad objective of this proposed work is to aid the practice of animal waste containment by providing region-specific and waste-specific guidelines for siting, construction, and operation of animal waste lagoons in the State of Kansas. The specific questions that will be addressed in this research are as follows.

Considering the wide range in soil types of Kansas, what procedural differences could be suggested for liner material selection? What site-specific configurations of liners could be recommended? Is natural soil available at the site adequate for liner construction? Could there be a method developed to serve as a screening procedure for siting new lagoons and for monitoring existing lagoons based on the region-specific hydrogeologies in the State of Kansas? This requires a thorough study of the surficial soil types in the State of Kansas and a few computer simulations for risk assessment. In general, the liner configurations may include compacted clays, natural liners (where in-situ low permeability strata serve as liners), geomembranes, and geo-composite liners (GCLs). A cursory survey of soil types in the State of Kansas reveals that there are some regions blessed with natural strata with very low permeabilities. However, majority of the regions in the state require either natural material remolded and compacted to a desired thickness, or the natural material amended with other materials (including commercialized chemical agents). In some regions, placement of geomembranes and GCLs might be the only choice to be recommended. A systematic taxonomy of the soil groups (USDA grouping system) and the associated permeabilities for the State of Kansas is needed to address this question.

What role does the groundwater table elevation play on the design parameters (permeability, thickness, and elevation) of lagoon liners? When one considers the vast differences in the groundwater table elevation in the State of Kansas (ranging from hundreds of feet in the Southwest Kansas to less than ten feet in some areas of the Northeast), this question becomes very relevant and important. Computer model simulations, which are currently being carried out, reveal that the travel times of contaminants to the groundwater table are dependent on the liner thickness and the liner permeability for a given groundwater table elevation. These model simulations need to be extended to cover the wide range of conditions in the State of Kansas and to develop region-specific recommendations for liner design parameters.

What role does the animal waste type play in the selection of liner materials and configurations? Based on research conducted thus far, some types of animal waste are associated with a higher degree of mass transfer in soils than others. While clays provide more adsorptive capacity for Ammonia and retard its transport, use of geomembranes may be more ideal for other types of waste for which mass transfer is not required. Laboratory testing program undertaken during the past three years looked into livestock waste only with limited number of experiments on swine waste. This program needs to be extended to include all major types of waste in order to systematically figure out the waste-specific capacity of the liner material to attenuate the transport of waste into the underlying aquifers.

What construction procedures are adequate for a given region or soil type? Construction of liners must be done such that the permeability of the liner is minimal. Geomembrane or Geocomposite liner (GCL) placement must be done with due regard to the underlying soils (the leakage due to pinholes and other construction deficiencies depends on the nature of the subgrade and underlying soils). In the cases where compacted clays are chosen as the liner materials, the compaction procedures – kneading, roller, or pneumatic, must be selected based on the soil type available at the site.

What methods of construction monitoring could be recommended given the liner design? Field methods for monitoring the integrity of liner construction may include a statistical protocol for sample collection and dry density or permeability testing. The statistical protocol will necessarily serve as a quality control and quality assurance (QC/QA) procedure. As a minimum, the protocol must include the layout and the number of samples to be collected and the nature and method of laboratory/field testing. Likewise, if geomembrane or GCL is the liner material of design, what layout and seaming procedures could be recommended?

What recommendations could be made from a regulatory standpoint? 0.25 inches/year, or site-specific and waste-specific liner parameters? While it is possible to check compliance of the current regulatory limit of seepage (0.25 inches per year) during lagoon operation phase (perhaps using surface water balance methods), it is not possible to check whether a given design meets the regulatory limit during the lagoon construction phase. It is perhaps simpler and easier to check the compliance with respect to design and construction related parameters such as the liner material, configuration, thickness, and placement elevation. The proposed work, by addressing the site-specific risk assessment with respect to these parameters, will put a useful and rational tool in the hands of the regulators to ensure sound containment of animal waste.

The research will be carried out with the assistance of the post-doctoral research associate, Dr. Mohan V.S. Bonala, who has been involved in this research project since its inception. He is also expected to participate in lagoon closure research as a parallel activity. The budget request for this research, covering part of Dr. Bonala's salary and minimal summer time for Dr. Reddi, is $35,000. No funds are requested for laboratory permeameters or other equipment, since they are available from the previous research tasks.

Attachment B.

Towards Site-Specific Guidelines for Animal-Waste Lagoons in Kansas

Jay M. Ham, Ph.D.
Department of Agronomy, Kansas State University, Manhattan, Kansas 66506

July 13, 1999

Concept

Site-specific guidelines could be developed for constructing and operating animal-waste lagoons in Kansas. Information on soil properties, geology, depth to water table, and type of animal operation could be used in a logical framework (risk assessment) to arrive at a maximum allowable seepage rate for a given location. Compacted soil liners would remain an acceptable alternative at many locations, but plastic liners might be required at others. This report presents a framework for arriving at site-specific lagoon guidelines that is scientifically sound and logistically feasible. However, this draft is preliminary and should be revised as additional research results and input from other interested groups becomes available.

Introduction

Anaerobic lagoons are used at many concentrated animal operations (CAOs) in Kansas to collect, treat, and store waste. Lagoons contain high concentrations of nitrogen, phosphorus, salts, and other nutrients that are often applied to farmland as liquid fertilizer. However, while the waste is being stored and treated in the lagoon, subsurface seepage losses could potentially affect soil and water quality near the facility. Of particular concern is the movement of nitrates into local drinking water supplies. There is little argument that lagoons should be constructed and operated in a manner that prevents seepage losses from contaminating ground water. Unfortunately, it is difficult to specify a single, statewide set of lagoon requirements that adequately protect the environment in a way that properly considers the wide range of conditions at different CAOs across the state. The geographic diversity in geology, soils, and climate in Kansas makes the risk of water contamination location dependent. Furthermore, there is variation in the types of animal operations and waste handling systems, which also affects risk. Thus, blanket regulations for the whole state would tend to over regulate some producers and under regulate others. Reports by Ham et al. (1998, 1999) suggest that the risk of ground water contamination could be reduced if the guidelines for lagoons were site-specific and species-specific. Site-specific recommendations hinge on understanding the key factors affecting risk and how these factors change across the landscape and between different types of operations (cattle feedlots, dairies, and swine production sites). In the past, lack of information on lagoon performance made it almost impossible to employ a site-specific approach to lagoon design. However, new research now makes it feasible to take a "first look" at what site-specific guidelines might entail. This brief report presents a logical framework for tailoring lagoon design standards for a specific location and CAO type using a relatively simple set of input data. Other general recommendations are made for earthen-lined lagoons based on the work of Ham et al. (1998, 1999).

Rationale

The framework for site-specific lagoon guidelines is based on the rationale that nitrogen that seeps from a lagoon (if any) should remain sufficiently close (e.g., 20 ft.) to the facility as to be recoverable using some form of remediation/cleanup process after the lagoon is closed or abandoned. Research has shown that over 99% of the nitrogen in lagoon effluent is ammonium, a positively charged ion that is readily adsorbed by clay particles in the soil. Over 20-plus years of operation, ammonium tends to build up in the soil zone under the lagoon. When a lagoon is closed or abandoned, the ammonium can convert to nitrate and more readily move to lower depths (towards the ground water). Research suggests that most of the effluent nitrogen within about 20 ft. of the lagoon could be efficiently and economically remediated using bioremediation (plants), excavation, or processes that promote denitrification (i.e., conversion of nitrate to harmless nitrogen gas). Thus, lagoons should be designed with a seepage rate that insures that 80% of the leachate nitrogen does not travel more than 20 ft. from the bottom of the lagoon over the life of the facility. When the water table is close to the bottom of the lagoon, ammonium can move directly into the ground water and be transported away from the site rather quickly. In these cases, a plastic liner may be required to meet the above-mentioned criteria.

In summary, the rationale for site-specific design is based on taking long-term responsibly for virtually all the leachate nitrogen lost in the seepage. This can be accomplished with soil-lined lagoons that are built to keep the nitrogen relatively close to the facility or, if necessary, plastic-lined lagoons that keep all material within the confines of the lagoon walls. Although other contaminants, such as fecal bacteria, could be used to form the guidelines, nitrogen is much easier to measure and detect. Many of the factors affecting the risk of nitrogen contamination (e.g., depth to ground water) also govern risks associated with other waste constituents. Thus, by designing the lagoon for safe storage of nitrogen, adequate containment of other waste components will be achieved.

Framework

A logical framework (decision tree) for the site-specific lagoon design is provided in the attached figure. The approach hinges on first deciding if a plastic-lined or soil-lined lagoon should be used. If a compacted-soil liner is allowable, then the maximum seepage rate (design criteria) is computed by formula.

Input Data and Site Investigation

Input data required to make site specific requirements for lagoon design are:
Depth to Static Water Table
Soil Cation Exchange Capacity (CEC) 0 to 20 feet below the bottom of the lagoon
Type of Operation (Cattle, Dairy, Swine)
Type of Waste Handling System (multi stage lagoons, liquid-solid separator, etc.)
Desired years of operation (permit life)

Steps For Site-Specific Lagoon Design

1. Acquire input data from permit application (type of operation, years of operation)
2. Conduct site investigation and soil analysis (depth to water table, soil CEC)
3. Apply logical framework (decision tree)
3. Depth to water table < 35 feet ?
   If Yes, plastic liner; If No, proceed with soil-liner design
4. Are there subsurface/preferential flow pathways ?
   If Yes, plastic liner; If No, proceed with soil-liner design
5. Calculate maximum allowable seepage rate
   A simple formula would be used. Inputs to the equation would be
   a. CEC and soil texture of 20 ft. subsoil zone under lagoon
   b. Estimated ammonium concentration in lagoon effluent
   c. Proposed years of operation
6. Is the calculated allowable seepage less than 1/50 inch/day?
   If Yes, plastic liner;
   If No, then soil-liner acceptable; Soil liner should be desgned to limit seepge to number calculated in step five and would range between 1/50 to 1/8 inches/day.

Other Recommendations

Soil Liners

All compacted soil liners should be 18 inches thick or greater regardless of their initial hydraulic conductivity. If the soil used to make the liner has a clay content less than 20 %, then bentonite (9.8 kg/m^2) should be mixed into the lowermost 6 inch layer of the liner. The average CEC of the compacted soil liner should be greater than 20 cmol/kg.

Seepage Rates

Data from Ham et al. (1998, 1999) shows that modern earthen lagoons can easily be constructed to seep less than 1/8 inch per day. Thus, the maximum allow able seepage rate for all lagoons should be reduced to 1/8 inch per day or smaller depending on site-specific requirements.

Lagoon Depth

There would be several advantages to reduce the maximum waste depth of soil-lined lagoons to 15 feet. It is better to have a shallow lagoon that covers a large area than a deep lagoon that covers a small area. Maximum depth for plastic-lined lagoons should remain at 20 ft.

Side Embankments

Research shows that seepage losses from lagoons are more pronounced along the side embankments where erosion and frequent wetting and drying often increase soil permeability. Thus, new lagoons should have side embanks with a maximum slope of 3:1 to reduce erosion by waves. Geocloth, plastic, or some other material should be used to cover the side embankments.

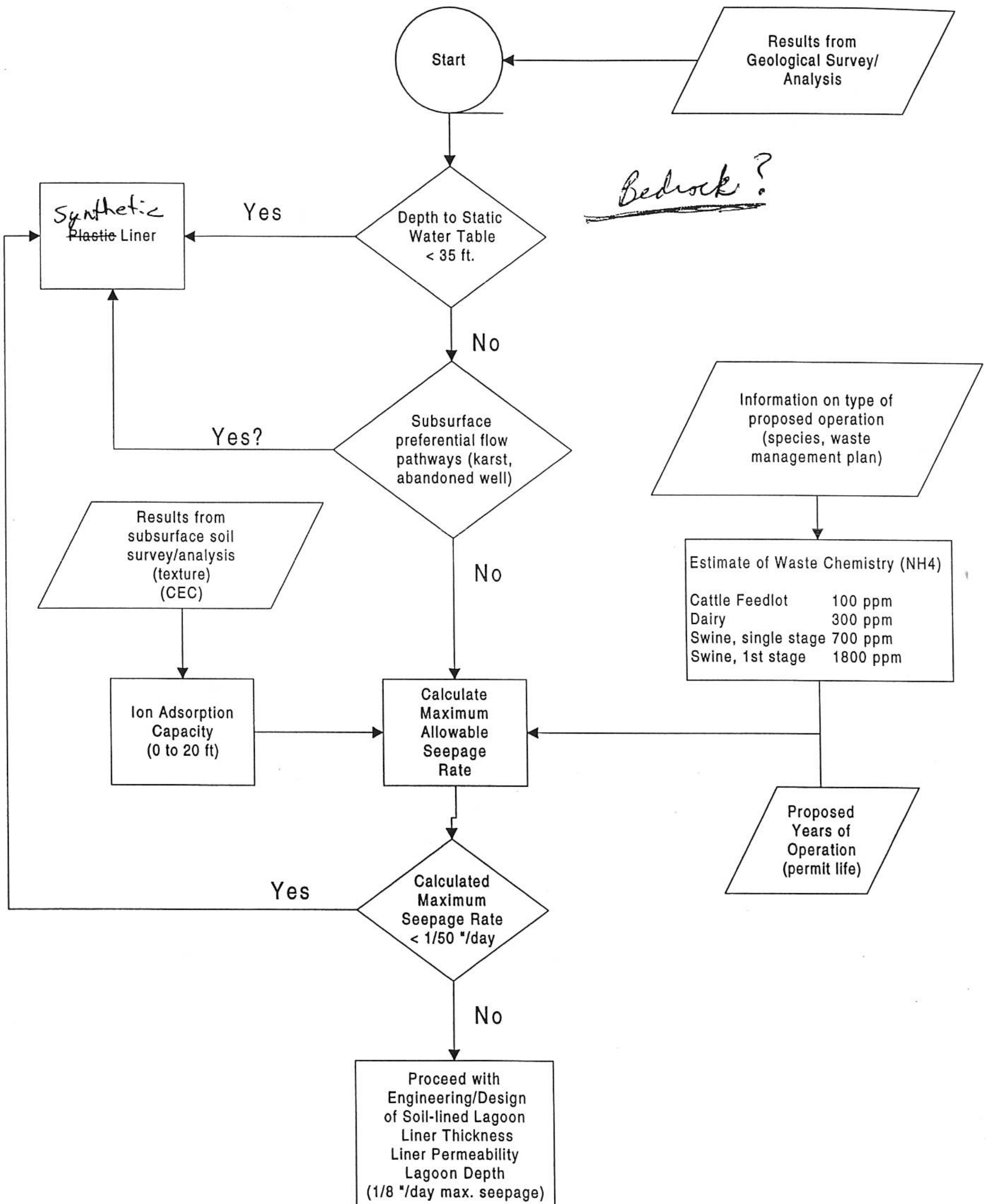
References

Ham, J.M., L.N. Reddi, C.W. Rice, J.P. Murphy. 1998. Evaluation of Lagoons for Containment of Animal Waste. A report submitted to the Kansas Dept. of Health and Environment, Topeka, KS. Available From the Kansas Center For Agriculture Resources and the Environment, Kansas State University, Manhattan, KS.

Ham, J.M., Reddi, L.N., and C.W. Rice. 1999. Animal Waste Lagoon Water Quality Study. A report submitted to the Kansas Water Office, Topeka, KS. Available From the Kansas Center For Agriculture Resources and the Environment, Kansas State University, Manhattan, KS.

B.

Logical Framework For Site-Specific Design of Animal-Waste Lagoons



J.M. Ham
7/6/99

Attachment C

Initial Crop Growth in Soil Beneath Animal Waste Lagoons

Objectives

The overall objective of the research is to determine if plants can be used to remediate contaminated soil at abandoned animal waste lagoons after initial closure. While in use, large amounts of ammonium nitrogen are deposited in soil near the bottom and sides of the earthen basin. Once a pond is abandoned, the nutrient-laden soil will dry, and the ammonium ion converts to nitrate. Nitrate is highly mobile and can move toward the groundwater. We want to see if we can plant crops in abandoned lagoons to take up excess nutrients, and, thereby, remediate the soil with minimal environmental damage.

Approach

The project will be done in three phases. In the first phase, greenhouse studies will be done with plants, representing a variety of species, in pots of soil treated with different concentrations of NH_4^+ and salts. Plants will include barley, a salt-tolerant plant, sunflower, forage sorghum, sorghum/sudan hybrids, and reed canarygrass. We shall determine what levels of NH_4 and salt permit growth. During the second phase, plants will be grown in soil collected from lagoons, but it will be remediated with different amounts of $CaCO_3$, to see what amount of $CaCO_3$ needs to be added to ensure growth in the material. At the same time, physical characteristics of the material will be determined, such as the modulus of rupture, and chemical characteristics, such as salt balance. During the third phase of the study, the rhizotron, an unique facility of the Soil and Environmental Physics Group in the Department of Agronomy at Kansas State and located at its Ashland Bottoms research site near Manhattan, Kansas, will be used. It consists of 22 underground boxes each of which is 77 cm long, 37 wide at the top, and 180 cm deep. Using it, we shall determine the NH_4^+-uptake ability of two crops that show, from the greenhouse study, ability to grow in the NH_4- and salt-treated soil. We shall fill 18 of the boxes with soil that has NH_4 and salt contents similar to those found in soil under three kinds of lagoons: swine, cattle, dairy. We shall have three replications for each treatment. We shall keep a constant water content in the soil by irrigating when tensiometers, one installed in each box, read 50 centibars at the 50-cm depth. We shall monitor growth and yield. We shall obtain a nitrogen balance to determine how much nitrogen the crops take up over a three year period as the soil changes in the presence of roots. We shall attempt to quantify the potential for denitrification to determine how fast nitrate, once formed, is reduced to molecular nitrogen (gaseous nitrogen).

Keywords

ANIMAL WASTE; PHYTOREMEDIATION; EVAPOTRANSPIRATION; GROWTH; YIELD; CROP-DAMAGE; SURVIVAL; MODULUS OF RUPTURE; SALT BALANCE; CALCIUM CARBONATE

Attachment D

Vegetative Reclamation of Abandoned Swine Lagoons

Kyle R. Mankin and Mary Beth Kirkham
An Honors Project for Kim Precht

Background

This project builds on the work proposed in the Kansas AES Project "Initial Crop Growth in Soil Beneath Animal Waste Lagoons" (Kirkham, Ham, Stone). The justification and literature review for that project also pertain to this study. In summary, large amounts of ammonium nitrogen are deposited in soils beneath animal waste lagoons during their active life. Once these lagoons are abandoned, the soils dry, the ammonium converts to nitrate, and this highly mobile nitrogen form can readily enter and contaminate groundwater. Phytoremediation (the managed use of plants to remove pollutants) may represent a viable, low-cost, low-maintenance option to remediate these abandoned lagoons.

We plan to assess the effectiveness of one plant species (at this time, poplar is the leading candidate) in creating an environment to reduce the pollution potential of abandoned lagoons. The study will use replicated soil columns in the greenhouse to monitor soil, plant, and leachate fractions of various contaminants (primarily nitrogen) over time under a range of climatic and simulated precipitation conditions. The interaction of these parameters is critical toward achieving an effective remediation. For example, the balance between precipitation and plant transpiration governs soil moisture levels and movement, and can impact or control contaminant transformations and movement in the soil.

Objectives

Evaluate the degradation in soil, uptake by plants, and transport to groundwater of several important contaminants (ammonium, phosphorus, chloride, copper, and zinc) in an abandoned swine lagoon after initial closure.

Methods

Soil collected in layers from an abandoned swine lagoon in Kansas will be used to recreate the contaminated soil profile in soil columns. The leading candidate for soil is a lagoon near the Equus Beds identified by Jay Ham that is scheduled for cleaning. These soils are sandy and represent a serious potential for leaching and groundwater contamination. Sandy soils also tend to respond well to water management and function well in soil column experiments. The Department of Biological and Agricultural Engineering has 15 soil columns, each constructed of 38 cm (15 in.) dia., 90 cm (3 ft) tall, PVC pipe mounted on a concrete base with a drain for leachate collection. Six of these columns also have side ports in which suction lysimeters can be used to collect profile soil water samples. Soil columns will be placed in a greenhouse and planted to poplar seedlings. Greenhouse conditions will allow study of remediation during an extended growing season.

Soil columns will be surface irrigated according to 3 schedules designed to create a range of soil and crop conditions and leaching potentials (Table 1). Monthly mean rainfall amounts for one region of Kansas for the 6 months from April to September will be used to simulate *normal* growing season conditions. The *dry* and *wet* conditions will be created using 90% and 10% probability monthly rainfall amounts, respectively, to create a range of potential natural rainfall conditions. This 6-month pattern will be repeated 3 times in each column over the 18-month study. These conditions will demonstrate the relationship between rainfall, evaporation, and soil leaching as they relate to degradation, uptake, and transport of the target contaminants during active plant growth. Though the climatic regime of rainfall and temperature does not mimic field conditions exactly, it does represent a reasonable range of conditions under which lagoon remediation will operate.

D.

Samples from the original contaminated soil will be collected from 0-15, 15-30, 30-60, and 60-90 cm layers and analyzed for total N, ammonium, nitrate, total P, chloride, copper, and zinc. A similar set of soil cores will be collected from the experimental soil columns and analyzed every 6 months for 18 months. Leachate will be collected, if present, after each irrigation event and analyzed for the same suite of consituents.

Table 1. Experimental design: Allocation of 12 soil columns showing treatments and replication.

	Treatments		
	Dry	**Normal**	**Wet**
Poplar	1,2,3	4,5,6	7,8,9
No plant	10	11	12

Plant shoots will be harvested at the end of each 6 month season and analyzed for total N, total P, chloride, copper, and zinc. In addition, chlorophyll will be monitored monthly using a leaf chlorophyll meter to help assess plant tissue nitrogen accumulation.

BUDGET – Vegetative Reclamation of Abandoned Swine Lagoons

October 1, 1999 to June 30, 2000

Personnel—Hourly undergraduate students	$2500
Operations—Lab analyses, supplies, travel, publication	$4750
TOTAL	**$7,250**

July 1, 2000 to September 30, 2000

Personnel—Hourly undergraduate students	$2500
Operations—Lab analyses, supplies, travel, publication	$5550
TOTAL	**$8,050**

Attachment E

Chemical Composition of Manure in Kansas Swine Lagoons

Introduction

Active participation in environmental stewardship is a responsibility on all swine producers. However, little information is available to producers to compare their operation with other operations from other states, as well as within Kansas. Currently, there is a need for a database from samples of manure to determine the concentration of nutrients and minerals.

The objectives for this project are broken into retrospective and prospective areas. First, our retrospective approach will focus on data currently available by the Kansas Department of Agriculture. Secondly, the prospective segment will pertain to the sampling of manure from various sites in Kansas. This will allow the determination of differences in manure composition between different phases of production and seasons of the year.

Phase 1

To summarize nutrient and mineral concentrations of manure storage facilities sampled from Kansas swine producers. Sample analyses will be provided from the Kansas Department of Agriculture from producers whom meet the 1,000 AU level required by law. This information will be used as a database to help evaluate the composition of manure from swine farms located in Kansas.

Phase 2

To analyze manure samples from specific sites in different geographic locations to determine nutrient and mineral concentrations. Samples will be taken six times over a one year period to help determine seasonal changes in manure composition. Different types of operations will be monitored based on the phase of production located on that individual site.

Procedures

Phase 1

Analyses of swine manure from Kansas swine producers will be obtained from the Kansas Department of Agriculture. Average concentrations of specific nutrients and minerals will be summarized to obtain an initial database for average values of all samples.

E.

Phase 2

Samples from seven different production systems will be taken six times a year to help determine changes in nutrient and mineral concentrations in relation to the time of year. The months that will be sampled include: January, March, May, July, September, and November. In addition, samples will be taken from various geographic locations in Kansas. The different operations will include: 1) nursery 2) wean to finish 3) finisher 4) sow 5) farrow to finish 6) deep pit 7) hoop structures. For each segment of production, 6 to 8 different sites will be tested.

The initial manure sample will be taken by personnel of the Kansas Extension Service. A designated individual of each operation will be trained at that time and will be responsible for sampling for the remainder of the year. A uniform sampling technique will be administered to ensure sampling consistency between all sites. For a 1 acre lagoon (220' x 220'), four samples from various sectors will be taken, thereupon, the samples will be mixed and subsampled for analyses. Lagoons larger than 1 acre in size, additional samples (up to eight) will be taken and subsampled for analyses. Five different samples from manure piles of hoop structures will be taken and subsampled for analyses. Theses samples will be taken approximately 18" from the outside of the pile.

Personnel

Kansas State University:

Joel DeRouchey (785-532-1270)
Bob Goodband (785-532-1228)
Jim Nelssen (785)-532-1251)
Mike Tokach (785-532-2032)
Pat Murphy (785-532-5813)

Kansas Department of Agriculture:

Garry Keeler (785-296-3786)

Kansas Pork Producers Council:

Mike Jensen (785-776-0442)

Budget

<u>Labor</u>

Graduate student stipend	(one-half supplement for one year)	$ 5,800

<u>Lab Analyses</u>

Analyses of manure samples	(336 samples @ $30/sample)	$10,080
Total		$15,880

Attachment F.

Research Pre-Proposal

February 2, 1999

An Air Monitoring Network For Determining Optimal Setback Distances for Concentrated Animal Operations

Jay M. Ham, Department of Agronomy, Kansas State University, Manhattan, KS 66506

Questions to be Answered

- What setback distances from concentrated animal operations (CAOs) are required to protect public health and comfort when living and working in areas adjacent to CAOs?
- What are the important gaseous compounds and particulate matter that are emitted from CAOs and how far do they travel from the operation? What are the emissions from agriculture fields where waste has been applied? How do concentrations of ammonia, methane, and hydrogen sulfide vary in space and time (seasonally) around a CAO?
- How does weather, terrain, and surrounding vegetation affect how far odorous compounds travel from a CAO (i.e., eastern vs western Kansas)?
- What are the differences in ammonia, methane, and hydrogen sulfide emissions from swine and cattle operations in Kansas? Should they have different setback distances ?

Research Plan (Two Year Study)

An air sampling network will be established around a swine and a cattle-feedlot operation in both eastern and western Kansas (4 sites total). Ammonia will be monitored continuously at approximately 20 locations at various distances and directions from each CAO. A combination of diffusion tubes (passive) and acid-tube denuders will be used to sample air at each location. Each month, the network of air samplers will be retrieved and analyzed to quantify the average monthly ammonia concentrations at different distances from the CAO. Ammonia was selected for intensive study because: (1)it is emitted in high concentrations, (2) it is a known odorous compound, and (3) it has recently been shown to be a outdoor health hazard by acting as a nucleus for the formation of fine particulate (new EPA research thrust). In addition to the permanent ammonia monitoring network, additional grab samples of air will be collected from barns, lagoons, and open cattle pens. Also, grab samples will be collected by families living near the CAOs. The cooperating family will be trained to collect samples of air when they think the odor is most offensive. Grab samples will be analyzed for ammonia, methane, and hydrogen sulfide.

Deliverables/Products

- Distance from the operation required to avoid 90% (or any other percentage) of the ammonia, methane and hydrogen sulfide emitted from a CAO
- Monthly contour maps of the ammonia concentration fields near swine and cattle production operations in both eastern and western Kansas.
- Data on emission rates from barns, anaerobic lagoons, and open pens (by season, by location)
- Identification of the scenarios most likely to cause an odor problem (landscape, time of year)

Budget

Analytical Laboratory Equipment	$25,000
Differential Global Positioning System	$6,000
Air Sampling Equipment	$24,000
Labor	$35,000*
Supplies	$9,000*
Travel	$9,000*
Total	$109,000

* requires funding in year 2 of study

Budget Justification

An autosampling steam distiller, colormetric system, or FTIR will be required to analyze air samples and ammonia denuders. A GPS system will be used to position the air sampling points around the CAOs. A network of passive (diffusion tubes) and active samplers (denuders, impingers) will be needed to establish the network. Some will require solar power and pumps. Manual gas sampling system will be also required to collect grab samples. Labor costs include a B.S. or M.S. level assistant scientist to service the air samplers and perform the chemical analyses. Supplies include general lab supplies, calibration gases, disposable field equipment, etc. Travel costs include, vehicle rental, travel to air sampling sites, and participate in meetings on air quality (state and national level).