Approved: April 6, 2000
Date

MINUTES OF THE HOUSE COMMITTEE ON ENVIRONMENT.

The meeting was called to order by Chairperson Joann Freeborn at 3:30 p.m. on March 14, 2000 in Room 231-N of the Capitol.

All members were present except: Rep. Dennis McKinney - excused

Committee staff present: Raney Gilliland, Kansas Legislative Research Department
Mary Torrence, Revisor of Statute's Office
Mary Ann Graham, Committee Secretary

Conferees appearing before the committee: Dr. W. L. Hargrove, Director of KCARE, Kansas State University, 044 Waters Hall, Manhattan, KS 66506
Dr. Jay Ham, Associate Professor, Department of Agronomy, Kansas State University, Manhattan, KS 66506
Dr. Alan Schlegel, Professor, Southwest Research-Extension Center, Kansas State University, Manhattan, KS 66506
Dr. Ronald Hammerschmidt, Director, Division of Environment, KS Dept. Health and Environment, Forbes Field, Bldg 740, Topeka, KS 66620-0001

Others attending: See Attached Sheet

Chairperson Joann Freeborn called the meeting to order at 3:30 p.m. She called the committee's attention to a document that had been distributed from Secretary of Agriculture, Jamie Clover-Adams, regarding the Governors' Ethanol Coalition. Attached is a letter from the Governor of Iowa and the Governor of Nebraska. (See attachment 1) She pointed out the last paragraph of the letter which she found to be very interesting and also the paragraph from Ms. Browner, Environmental Protection Agency.

The Chairperson recognized Rep. Gerry Ray, Chairman for the sub-committee on **SB568**, and thanked members of the sub-committee, Rep. Bill Light, Rep. Laura McClure, Rep. Clay Aurand, and Rep. Tim Tedder, for their hard work and effort.

Rep. Gerry Ray had copies distributed of the Sub-committee Report (See attachment 2) to all committee members. She announced that **SB568** was used as a vehicle for the report on deer issues and that she probably will recommend a substitute bill for **SB568**, so that the bill can be cleaned up.

Mary Torrence, Revisor of Statutes, explained the bill, point by point. Questions and discussion followed. Secretary Steve Williams, Kansas Department Wildlife and Parks, was in attendance to answer questions.

Rep. Douglas Johnston made a motion to adopt the sub-committee report. Rep. Clay Aurand seconded the motion. Motion carried.

Rep. Sharon Schwartz made a motion in Section 3, pg 6 to include language for annual report on deer/vehicle accidents. Rep. Henry Helgerson seconded the motion. Motion failed.

Rep. Laura McClure made a motion to delete new section (o), pg. 3 . Rep. Vaughn Flora seconded the motion. Motion failed.

Rep. Gerry Ray made a motion on pg. 7, line 9, to change language to read "after its publication in the Kansas Registrar". Rep. Clay Aurand seconded the motion.

Rep. Douglas Johnston made a motion the new substitute for **SB568** be recommended favorable for passage as amended. Rep. Sharon Schwartz seconded the motion. Motion carried.

MINUTES OF THE HOUSE COMMITTEE ON ENVIRONMENT, Room 231-N of the Capitol at 3:30 p.m. on March 14, 2000.

Rep. Gerry Ray thanked the committee and the sub-committee for their hard work on the sub-committee report.

Chairperson Freeborn announced that due to the lack of time the committee will not have final action on **SB469** and **HCR5069** today.

The Chairperson welcomed Dr. Bill Hargrove, Director of KCARE, Kansas State University, to the committee. He introduced Dr. Jay Ham, Associate Professor, Department of Agronomy and Dr. Alan Schlegel, Professor, Southwest Research-Extension Center. They presented an Update and Summary of Research and Extension Programs in Animal Waste Management and Utilization. (See attachment 3)

Dr. Jay Ham briefed the committee, with the help of overhead slides, the evaluation of lagoons. (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. (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. (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 (ie, 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. (See attachment 4)

Dr. Ham showed the committee an example screen from a computer software program that provides site-specific design recommendations for waste treatment lagoons. By entering lagoon information the computer will calculate maximum seepage rates, and determine how the lagoon liner would need to be constructed. (See attachment 3) Questions and discussion followed.

Dr. Alan Schelgel was welcomed to the committee. He discussed soil sampling in cropped fields where waste has been applied. (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. (See attachment 4) Questions and discussion followed.

The Chairperson thanked Dr. Hargrove, Dr. Ham, and Dr. Schelgel, for their presentation.

Dr. Ronald Hammerschmidt, Director, Division of Environment, KDHE, was welcomed to the committee. He commented that there has been a lot of discussion about lagoons and briefed the committee on how the Department handles waste in the state, which range from simple septic systems to the modern low flow waste systems which are usually buried. In some suburban areas with everyone on a septic system you may have a very concentrated system in a small area. If these people are also on domestic water wells there could be a problem with contamination of drinking water. He discussed mechanical anaerobic waste water systems which are used by most municipalities in the state. One of the best ones in the state was built north of the City of Topeka. There are many varieties of lagoon systems, some are designed to be three stages, while others are a single system. Most of these systems are not helped mechanically. An anaerobic system means a lack of oxygen and many of the systems are anaerobic. Not all of the lagoon systems are alike even though they may look alike. In some parts of the state, especially the western part, they are seeing some dependence on evaporative lagoon systems. The water is not going anywhere, it is being evaporated into the atmosphere and require more maintenance. There is a broad range of lagoon systems in the state and you really have to look at the area you are in, how much water you have to deal with, what the species are, and a whole variety of different situations. If he was asked at this particular time what the single most common methodology used in the state for handling waste water, he would say a lagoon system of some sort. If he was asked the single highest most volume of waste water that is treated for municipalities, he would say mechanical, being that larger cities tend to use mechanical systems of some sort, usually anaerobic, where as, smaller cities tend to use lagoon systems. (No written testimony) Questions and discussion followed.

The Chairperson thanked Dr. Hammerschmidt for his comments.

The meeting adjourned at 5:55 p.m. The next meeting is scheduled for March 16, 2000.

HOUSE ENVIRONMENT COMMITTEE GUEST LIST

DATE: March 14, 2000

NAME	REPRESENTING
Anne Hargrove	
ANTHONY GARZA	
Bob Hargrove	
Ann Durkes	DOB
Jim Allen	Seaboard
Alan Schlegel	K-State
STEVE WILLIAMS	KDWP
Clint Riley	KDWP
Grover + Betty Sanders	
TOM KNEIL	KS CHAPTER OF THE SIERRA CLUB
LARRY ROSS	Southwind Gp. – Sierra Club
Larry Kleeman	League of KS Municipalities
Carl Folsom	Rep. Ray
Tom Bruno	Allen & Assoc.
John Garlinger	KS Dept. of Ag
Jamie Clover Adams	"
Bill Hargrove	KCARE/K-State
JAY HAM	KSU
Steven Graham	K-State Research + Extension

Charles Benjamin — KNRC/Sierra Club

HOUSE ENVIRONMENT COMMITTEE GUEST LIST

DATE: March 14, 2000

NAME	REPRESENTING
Mike Jensen	KS Pork
Mike Beam	Ks. Lvstk. Assn.
Greg A. Foley	KDHE
M.S. Mitchell	KBIA
Bill Fuller	Kansas Farm Bureau
EDWARD ROWE	League of Women Voters/KS
Rich McKee	KLA
[illegible] M. [illegible]	KBAP

STATE OF KANSAS

BILL GRAVES, GOVERNOR
Jamie Clover Adams, Secretary of Agriculture
109 SW 9th Street
Topeka, Kansas 66612-1280
(785) 296-3558
FAX: (785) 296-8389

KANSAS DEPARTMENT OF AGRICULTURE

MEMORANDUM

TO:	Senator Corbin	Representative Freeborn
	Senator Morris	Representative Johnson
	Senator Umbarger	Representative Schwartz
	Senator Biggs	Representative McClure
	Senator Stephens	Representative Weiland

FROM: Jamie Clover Adams Jamie

DATE: March 13, 2000

RE: Governors' Ethanol Coalition

As you are aware, Governor Graves was chair of the Governors' Ethanol Coalition this past year. Through this organization, the State of Kansas promotes the use of ethanol in an effort to enhance the value of our agricultural commodities.

Over the past year, the GEC has worked diligently with EPA and the State of California to secure a place for ethanol in the California fuel market. The attached letter outlines much of that work. In light of your consideration of S.B. 469, which would phase-out the use of MTBE in Kansas, Administrator Browner's statement to Governors Vilsack and Johanns that an EPA position on MTBE would be forthcoming is of particular interest.

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

House Environment
3-14-00
Attachment 1

MAR. 10. 2000 1:23PM
TO: JAMIE CLOVER ADAMS

NO. 1745 P. 1/1
FROM: 1600

Governors' Ethanol Coalition

March 6, 2000

The Honorable Bill Graves
Governor's Office
Capitol Bldg., 2nd Floor
Topeka, KS 66612

Dear Governor Graves,

We thought we would bring you up to date on a recent meeting held with Carol Browner and staff at the U.S. Environmental Protection Agency relating to ethanol.

The purpose of the meeting centered on our continued effort to advocate on behalf of ethanol. We reminded Ms. Browner of the promise made last summer to have the EPA's ruling on the Reid Vapor Pressure limit. The EPA appears ready to announce its preliminary decision, but under an executive order the decision requires an interagency review that could take until April, 2000.

Ms. Browner professed support for ethanol and its future role in meeting America's future fuel needs. She suggested that the ruling may not be all we want, but may well be more support than we now have for ethanol use. We are hopeful that April will bring some decision.

We had a candid conversation about California's request for a waiver of the oxygenate standard. During the discussions, the California request for a full waiver or, in the alternative, a partial waiver was outlined. The partial waiver request would result in the reduction of the standard and would enable California to meet the standard by annualizing their use. The result, if approved, would lead to increased use of ethanol in some but not all months of the year and would result in no ethanol use in a few months. Governor Gray Davis advised the EPA that the limited waiver would generate a need for an additional 320 million gallons of ethanol.

The timing of the California decision all depends on the speed at which the agency reviews the detailed models accompanying the California application. Ms. Browner does not expect an answer until the summer at the earliest.

We were encouraged to provide information to the EPA so that staff is fully informed before a decision is made. Of particular interest will be information that documents the industry's ability to meet demand. Ethanol opponents have strongly questioned the ability to meet demand and we must strongly respond. Any information you feel is available in your state relating to production/capacity that you believe supports the argument that demand can be met needs to be sent to us as soon as possible.

Ms. Browner advised that an agency position on the phase out of MTBE could be forthcoming. Such a position may renew debate in Congress to remove the oxygenate requirement. We have opposed such a move and will continue to do so; however, an alternative has surfaced.

The EPA may well support, at the appropriate time, the elimination of the air oxygenate standard to be replaced by a renewable fuel standard. Such a standard would mandate that a percentage of gasoline sales by volume contain renewable fuels. We need to be prepared with a reaction if Congress proceeds in this direction. Please provide us feedback.

We appreciate your continued support and look forward to future chances to promote ethanol.

Sincerely,

Thomas J. Vilsack
Governor of Iowa

Mike Johanns
Governor of Nebraska

P.O. Box 95085, Lincoln, NE 68509-5085, Phone 402-471-2867, Fax 402-471-3064, Internet www.ethanol-gec.org

1-2

[As Further Amended by Senate Committee of the Whole]
As Amended by Senate Committee

Subcommittee Report

House Environment
3-14-00
Attachment 2

SENATE BILL No. 568

By Senators Umbarger, Becker, Bleeker, Bond, Brownlee, Clark, Corbin, Donovan, Emert, Hardenburger, Harrington, Huelskamp, Jordan, Kerr, Langworthy, Lawrence, Morris, Oleen, Praeger, Pugh, Ranson, Salisbury, Salmans, Steffes, Tyson, Vidricksen and Vratil

2-3

AN ACT concerning big game; relating to ~~nonresident~~ deer permits; ***~~concerning reduction of certain deer populations; relating to disposition of certain fees;~~*** ~~amending~~ K.S.A. 1999 Supp. 32-937 ***and 32-965*** and repealing the existing ~~section~~ ***sections***.

concerning reduction of deer-related motor vehicle accidents; relating to penalties for certain crimes; amending K.S.A. 32-1032 and

Be it enacted by the Legislature of the State of Kansas:

Section 1. K.S.A. 1999 Supp. 32-937 is hereby amended to read as follows: 32-937. (a) When used in this section:

(1) ``Landowner" means a resident owner of farm or ranch land of 80 acres or more located in the state of Kansas.

(2) ``Tenant" means an individual who is actively engaged in the agricultural operation of 80 acres or more of Kansas farm or ranch land for the purpose of producing agricultural commodities or livestock and who: (A) Has a substantial financial investment in the production of agricultural commodities or livestock on such farm or ranch land and the potential to realize substantial financial benefit from such production; or (B) is a bona fide manager having an overall responsibility to direct, supervise and conduct such agricultural operation and has the potential to realize substantial benefit from such production in the form of salary, shares of such production or some other economic incentive based upon such production.

(3) ``Regular season" means a statewide big game hunting season authorized annually which may include one or more seasons restricted to specific types of equipment.

(4) ``Special season" means a big game hunting season in addition to a regular season authorized on an irregular basis or at different times of the year other than the regular season.

(5) ``General permit" means a big game hunting permit available to Kansas residents not applying for big game permits as a landowner or

tenant.

(6) ``Nonresident landowner'' means a nonresident of the state of Kansas who owns farm or ranch land of 80 acres or more which is located in the state of Kansas.

(7) ``Nonresident permit'' means a big game hunting permit available to individuals who are not Kansas residents.

(b) Except as otherwise provided by law or rules and regulations of the secretary and in addition to any other license, permit or stamp required by law or rules and regulations of the secretary, a valid big game permit and game tags are required to take any big game in this state.

(c) The fee for big game permits and game tags shall be the amount prescribed pursuant to K.S.A. 32-988, and amendments thereto.

(d) A big game permit and game tags are valid throughout the state or such portion thereof as provided by rules and regulations adopted by the secretary in accordance with K.S.A. 32-805 and amendments thereto.

(e) Unless otherwise provided by law or rules and regulations of the secretary, a big game permit and game tags are valid from the date of issuance and shall expire at the end of the season for which issued.

(f) The secretary may adopt, in accordance with K.S.A. 32-805, and amendments thereto, rules and regulations for each regular or special big game hunting season and for each management unit regarding big game permits and game tags. The secretary is hereby authorized to issue big game permits and game tags pertaining to the taking of big game. Separate big game permits and game tags may be issued for each species of big game. No big game permits or game tags shall be issued until the secretary has established, by rules and regulations adopted in accordance with K.S.A. 32-805, and amendments thereto, a regular or special big game hunting season.

(g) The secretary may authorize, by rule and regulation adopted in accordance with K.S.A. 32-805, and amendments thereto, landowner or tenant hunt-on-your-own-land big game permits. Such permits and applications may contain provisions and restrictions as prescribed by rule and regulation adopted by the secretary in accordance with K.S.A. 32-805, and amendments thereto. ~~*[The secretary, upon written request from a landowner or tenant, shall issue two special hunt-on-your-own-land deer permits for each 80 acres owned or leased by such applicant. The owner or tenant may assign such permits, by endorsement thereon, with or without consideration, to any licensed resident or nonresident hunter.]*~~

(h) The secretary may authorize, by rule and regulation adopted in accordance with K.S.A. 32-805 and amendments thereto, special landowner or tenant hunt-on-your-own-land deer permits. Such special permits shall not be issued to landowners or tenants in possession of a hunt-on-your-own-land deer permit as authorized in subsection (g). The special permits shall be transferable to any immediate family member of the landowner or tenant, whether or not a Kansas resident, or the permit may be retained for use by the landowner or tenant. The special permits shall be transferable through the secretary at the request of the landowner or tenant and by paying the required fee for a general deer permit. The special permits and applications may contain provisions and restrictions as prescribed by rule and regulation adopted by the secretary in accordance with K.S.A. 32-805 and amendments thereto. For the purposes of this subsection, ``member of the immediate family" means lineal or collateral ascendants or descendants, and their spouses.

(i) Fifty percent of the big game permits authorized for a regular season in any management unit shall be issued to landowners or tenants, provided that a limited number of big game permits have been authorized and landowner or tenant hunt-on-your-own-land big game permits for that unit have not been authorized. A landowner or tenant is not eligible to apply for a big game permit as a landowner or as a tenant in a management unit other than the unit or units which includes such landowner's or tenant's land. Any big game permits not issued to landowners or tenants within the time period prescribed by rule and regulation may be issued without regard to the 50% limitation.

(j) Members of the immediate family who are domiciled with a landowner or tenant may apply for a big game permit as a landowner or as a tenant, but the total number of permits issued to a landowner or tenant and a landowner's or tenant's immediate family shall not exceed one permit for each 80 acres owned by such landowner or operated by such tenant. The secretary may require proof of ownership or tenancy from individuals applying for a big game permit as a landowner or as a tenant.

resident

landowner or tenant hunt-on-your-own-land or special hunt-on-your-own-land

for each big game species

(k) The secretary may issue permits for deer or turkey to nonresident landowners, but any such permit shall be restricted to hunting only on lands owned by the nonresident landowner.

(l) The secretary may issue turkey hunting permits to nonresidents in turkey management units with unlimited turkey hunting permits available.

(m) The secretary may issue deer hunting permits to nonresidents, subject to the following limitations:

(1) The total number of nonresident deer firearm permits of each type specified by rules and regulations that may be issued for a deer season in a management unit ***and which may be used to take antlered deer*** shall not exceed ~~5%~~ *10%* of the total number of resident deer firearm permits of such type authorized for such season in such management unit; and

(2) the total number of nonresident deer archery permits of each type

specified by rules and regulations that may be issued for a deer season in a management unit ***and which may be used to take antlered deer*** shall not exceed ~~5%~~ [~~10%~~] of the total number of resident deer archery permits of such type authorized for such season in such management unit.

15%

Nonresident deer archery permits may be restricted to a particular deer species without regard to resident deer archery permit species restrictions, or lack thereof.

If an unlimited number of resident deer permits ***that may be used to take antlered deer*** is authorized for a deer season or management unit, the percentage limitations of subsections (m)(1) and (m)(2) shall be based upon the total number of resident firearm permits ***that may be used to take antlered deer*** and the total number of archery permits ***that may be used to take antlered deer***, respectively, issued in the management unit during the most recent preceding similar season. If in a management unit there are ~~an unlimited number of game tags available to residents~~ ***an unlimited number of resident permits that may be used to take only antlerless deer***, the secretary, in the secretary's discretion and in accordance with rules and regulations, may authorize the issuance ~~of an unlimited number of deer tags for such unit to nonresidents~~ ***of an unlimited number of nonresident permits that may be used to take only antlerless deer.***

(n) Any nonresident deer hunting permits authorized under subsection (m) that remain unissued due to an insufficient number of nonresident applications as of a deadline determined by the secretary, shall be made available to residents.

(o)The secretary shall issue nonresident deer permits pursuant to subsection (m) to landowners and tenants applying for such permits, except that the total number of nonresident deer permits of each type specified by rules and regulations that may be issued to landowners and tenants for a deer season in a management unit shall not exceed 50% of the total number of nonresident deer permits of such a type authorized for such season in such management unit. A nonresident deer permit obtained by a landowner or tenant shall retain the permit's original designation, except that such permit shall be transferable, with or without consideration, to any resident or nonresident through the secretary at the request of the landowner or tenant. A landowner or tenant purchasing a nonresident deer permit pursuant to this subsection shall pay the established fee for a nonresident deer permit.

The provisions of this subsection shall expire on June 30, 2004.

[reletter remaining subsections accordingly]

(o) No big game permit issued to a person under 14 years of age shall be valid until such person reaches 14 years of age, except that a person who is 12 years or 13 years of age and has been issued a certificate of completion of an approved hunter education course may be issued: (1) A deer archery permit if the person submits to the secretary evidence, satisfactory to the secretary, of completion of a bow hunting safety education course; or (2) a wild turkey firearm permit. Such deer archery permit or turkey firearm permit shall be valid only while the individual is hunting under the immediate supervision of an adult who is 21 years of age or older.

(p) A big game permit shall state the species, number and sex of the big game which may be killed by the permittee. The secretary may furnish an informational card with any big game permit and, at the conclusion of the open season, each permittee receiving such card shall return the card to the department, giving such information as is called for on the card.

(q) The permittee shall permanently affix the game tag to the carcass of any big game immediately after killing and thereafter, if required by rules and regulations, the permittee shall immediately take such killed game to a check station as required in the rules and regulations, where a check station tag shall be affixed to the game carcass if the kill is legal. The tags shall remain affixed until the carcass is consumed or processed for storage.

(r) The provisions of this section do not apply to big game animals sold in surplus property disposal sales of department exhibit herds or big game animals legally taken outside this state.

Sec. 2. K.S.A. 1999 Supp. 32-965 is hereby amended to read as follows: 32-965. (a) As used in this section, terms have the meanings provided by K.S.A. 32-701 and amendments thereto.

(b) It shall be a goal of the department to manage big game populations in the state at levels consistent with existing habitat and landowner and community tolerance. For this purpose, the secretary is authorized to issue big game control permits, in addition to big game permits and game tags issued during regularly designated hunting seasons.

(c) For each big game control permit issued, the secretary may designate the period of time, the location and the number and type of big game that may be harvested. Use of any big game control permit shall require the permission of the landowner or tenant of the property where it is to be used.

(d) The secretary shall consult with representatives of farming and ranching organizations, county and city government associations and hunting organizations in the development, modification and implementation of a big game control permit program.

(e) The secretary, in accordance with K.S.A. 32-805 and amendments thereto, may adopt such rules and regulations as necessary to implement to the provisions of this section. Such rules and regulations shall not require an applicant for a big game control permit to attempt to alleviate a problem with big game using any means other than hunting during the regular firearms season for the appropriate species of big game animal.

(f) The secretary shall establish a toll-free telephone number for landowners and tenants to report property damage caused by ~~deer~~, request information regarding big game control permits and obtain information regarding any other programs that assist in reduction of high local ~~deer~~ populations, including, but not limited to, programs that refer landowners and tenants to hunters willing to hunt on a landowner's or tenant's land and programs that provide for departmental lease of lands for public hunting.

big game

The provisions of this subsection shall expire on June 30, 2004.

(g) The secretary shall cause to be published quarterly, in newspapers having general circulation in areas experiencing high deer populations, information regarding big game control permits and programs that assist

in reduction of high local deer populations, including, but not limited to, programs that refer landowners and tenants to hunters willing to hunt on a landowner's or tenant's land and programs that provide for departmental lease of lands for public hunting. Such information shall be published in a manner calculated to give actual notice to the public and shall be placed in a section other than the classified advertising section of the newspaper. The provisions of this subsection shall expire on June 30, 2004.

New Sec. 3. The secretary of wildlife and parks and the secretary of transportation shall cooperate in developing a management plan to address reduction of motor vehicle accidents involving deer in those areas of the state experiencing high numbers of such accidents. The management plan shall include methods to identify those areas and methods to inform and communicate with landowners and tenants in those areas regarding measures to reduce local deer populations. The management plan shall be completed on or before January 1, 2001, and the joint report of the secretary of wildlife and parks and the secretary of transportation shall be submitted to the senate standing committee on energy and natural resources, the house standing committee on environment and the governor on or before February 1, 2001.

~~*New Sec. 4. (a) There is hereby created in the state treasury the walk-in hunting area fund.*~~

~~*(b) On or before the 15th day of each month, the secretary of wildlife and parks shall certify to the director of accounts and reports the total of all amounts received by the secretary during the preceding month from issuance of nonresident deer permits in excess of the number of such permits that the secretary would have been authorized to issue but for the amendment to K.S.A. 32-937, and amendments thereto, by this act. Upon receipt of the certification, the director of accounts and reports shall transfer the amount certified from the wildlife fee fund to the walk-in hunting area fund.*~~

~~*(c) Moneys in the walk-in hunting area fund shall be used only for paying expenses of the walk-in hunting area program of the department of wildlife and parks, including expenditures for costs of leasing lands for use in the program and costs of administering the program.*~~

~~*(d) On or before the 10th of each month, the director of accounts and reports shall transfer from the state general fund to the walk-in hunting area fund interest earnings based on:*~~

~~*(1) The average daily balance of moneys in the walk-in hunting area fund for the preceding month; and*~~

~~*(2) the net earnings rate of the pooled money investment port-*~~

7-8

~~*folio for the preceding month.*~~

~~*(e) All expenditures from the walk-in hunting area fund shall be made in accordance with appropriation acts upon warrants of the director of accounts and reports issued pursuant to vouchers approved by the secretary.*~~

Insert section 4, attached, and renumber remaining sections

Sec. ~~2.~~ ~~*5.*~~ *[4.]* K.S.A. 1999 Supp. 32-937 ~~is~~ ***and 32-965 are*** hereby repealed.

K.S.A. 32-1032 and

Sec. ~~3.~~ ~~*6.*~~ *[5.]* This act shall take effect and be in force from and after its publication in the statute book.

Sec. 4. K.S.A. 32-1032 is hereby amended to read as follows: 32-1032. (a) Violation of any provision of the wildlife and parks laws of this state or rules and regulations of the secretary relating to big game permits and game tags is a misdemeanor punishable by a fine of not less than $250 nor more than $1,000 or by imprisonment in the county jail for not more than six months, or by both.

(b) In addition to any other penalty imposed by the convicting court, if a person is convicted of a violation of K.S.A. 32-1002, 32-1003 or 32-1013, and amendments thereto, that involves taking of a big game animal, or if a person is convicted of a violation of K.S.A. 32-1005, and amendments thereto, that involves commercialization of a big game animal, the court shall order:

(1) Upon the first such conviction, forfeiture of the person's hunting privileges for one year from the date of conviction and: (A) Revocation of the person's hunting license, unless such license is a lifetime hunting license; or (B) if the person possesses a lifetime hunting license, suspension of such license for one year from the date of conviction.

(2) Upon the second such conviction, forfeiture of the person's hunting privileges for three years from the date of conviction and: (A) Revocation of the person's hunting license, unless such license is a lifetime hunting license; or (B) if the person possesses a lifetime hunting license, suspension of such license for three years from the date of conviction.

(3) Upon the third or a subsequent such conviction,

forfeiture of the person's hunting privileges for five years from the date of conviction and: (A) Revocation of the person's hunting license, unless such license is a lifetime hunting license; or (B) if the person possesses a lifetime hunting license, suspension of such license for five years from the date of conviction.

(c) If a person convicted of a violation described in subsection (b) has been issued a combination hunting and fishing license or a combination lifetime license, only the hunting portion of such license shall be revoked or suspended pursuant to subsection (b).

(d) Nothing in this section shall be construed to prevent a convicting court from suspending a person's hunting privileges or ordering the forfeiture or suspension of the person's license, permit, stamp or other issue of the department for a period longer than provided in this section, if such forfeiture or suspension is otherwise provided for by law.

2-9

K-STATE
Kansas State University

REPORT TO THE ENVIRONMENT COMMITTEE, KANSAS HOUSE OF REPRESENTATIVES

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

Kansas Center for Agricultural Resources and the Environment
K-State Research and Extension
Kansas State University
(785) 532-7103 <kcare@ksu.edu>

HOUSE ENVIRONMENT
3-14-00
Attachment 3

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.

Waste Containment in Anaerobic Lagoons - Laboratory and Modeling Investigations, 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.

Vegetative Reclamation of Abandoned Lagoons, 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.

Transport of Water and Solutes from Animal Waste Lagoons, 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).

Reddi, L.N. and Davalos, H., 1999. "Animal Waste Containment in Anaerobic Lagoons Lined with Compacted Clays," ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol. 126, No. 3

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)

Ham, J.M., and T.M. DeSutter. 2000. "Towards Site-Specific Design Standards for Animal-Waste Lagoons in the Great Plains: Protecting Groundwater Quality," J. Environ, Qual. (submitted) (KAES 00-251-J)

Trooien, T. P., F. R. Lamm, L. R. Stone, M. Alam, D. H. Rogers, G. A. Clark, and A. J. Schlegel 2000. "SDI dripline performance using livestock wastewater." Applied Engineering in Agriculture (submitted). (KAES 00-198-J)

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)

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 R.

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.

<u>Input Data and Site Investigation</u>

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

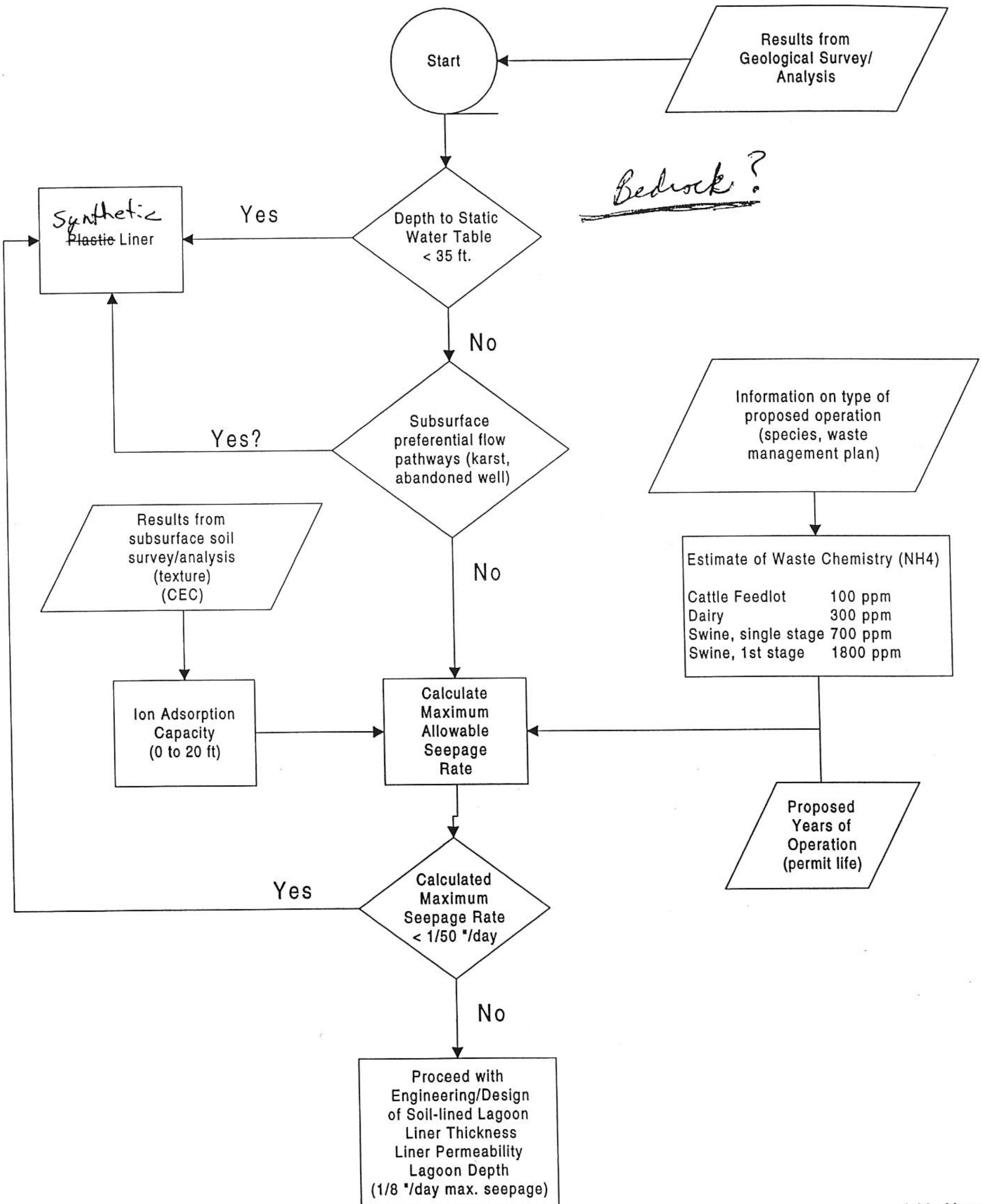
Research shows that seepage losses from lagoons are more pronounced along the side embankments where erosion and frequent wetting and drying often increase soil permeability. Thus, new lagoons should have side embanks with a maximum slope of 3:1 to reduce erosion by waves. Geocloth, plastic, or some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

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



J.M. Ham
7/6/99

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

Labor

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

Lab Analyses

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).

II. Certification Training Required by House Bill 2950 and Other Educational Efforts

Team Leader

James P. Murphy, Biological and Agricultural Engineering

Summary

House Bill 2950 (HB2950) was passed during the 1998 legislative session. HB2950 defines the environmental regulations for large (greater than 1,000 animal units) Kansas swine producers. During the 1999 legislative session, technical, best management practices, and general swine production information were delivered to various environmental committees, which were reviewing the implementation of the bill. The Kansas Center for Agricultural Resources and the Environment (KCARE) coordinated specialists from civil engineering, biological and agricultural engineering, animal science and industry, and agronomy departments to supply the research information on swine manure storage, lagoon seepage, odors, dead pig disposal, facility closure, and application of manure to land. As a requirement of HB2950, in 1999, Kansas swine producers were to receive training on feeding/ nutrition effects on swine manure and methods of collection and applying swine manure to land to reduce environmental damage.

Impact

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. These meetings also 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 application plans for those producers over 1,000 animal units. A team composed of Dave Whitney, Gary Pierzynski (Agronomy); Kevin Dhuyvetter (N.E. Ag. Economics); Bill Hargrove (KCARE); James P. Murphy (Biological and Agricultural Engineering); Garry Keeler, Dale Lambley (Kansas Department of Agriculture); Tim Stroda and Mike Jensen (Kansas Pork Producers Council) developed the necessary guidelines and spreadsheets for the 5-year nutrient application 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/Harner, Kansas Department of Agriculture and KDHE. 139 attendees were certified.

Next Steps

Our goal for next year is to make sure that the environmental regulation (KDA and KDHE) departments have the most recent and applicable research to make their regulations and assessments. As the various environmental and nutrient/ land application plans of the swine producers unfold, we will monitor the plans to determine areas of needed research/extension effort to aid in protecting our Kansas environment.

III. Seepage Rates and Nitrogen Losses from Animal Waste Lagoons: Potential Impacts On Groundwater Quality

Research Update: January 31, 2000

Principal Investigator:
Jay M. Ham, Ph.D., Associate Professor, Department of Agronomy

Summary

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, 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 ions 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 five 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).

However, 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 is 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).

Introduction

Anaerobic lagoons are used for collecting, storing, and treating manure waste at animal feeding operations (AFOs). Most animal-waste lagoons consist of excavated earthen basins that are between 0.5 and 5 acres in area, are 10 to 20 ft deep, and have compacted soil liners between 12 and 24 inches thick.

At cattle feedlots and dairies, wastewater entering a lagoon is runoff from precipitation that has fallen on the open-air pens. Washwater from veterinary hospitals and milking barns also may be drained into lagoons. Lagoons at swine sites usually receive wastewater collected in shallow pits directly beneath animals living on slatted floors. Periodically, the operator pulls a plug and drains the waste into an anaerobic lagoon located adjacent to the production barns. Conversion of organic matter to methane and carbon dioxide gases (via anaerobic digestion) 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 from the lagoon surface by ammonia volatilization . The remaining wastewater eventually evaporates or is applied to nearby farmland, whereas undigested organic solids and sediments (soil from wind and water erosion) slowly accumulate on the bottom of the basin. Despite the efficiency and convenience of anaerobic lagoons, the liquid waste contains nitrogen, salts, bacteria, viruses, pharmaceuticals, hormones, and other potential contaminants. Thus, under certain conditions, seepage losses from the sides and bottoms of earthen lagoons could potentially pollute soils and groundwater near AFOs.

Kansas State University is conducting research to determine the relationship between lagoon use and groundwater quality near AFOs. Components of the research project include: (1) measurement of whole-lagoon seepage rates and subsurface nitrogen losses from commercial lagoons, (2) a survey of lagoon effluent chemistry at different types of AFOs (3) collection and analysis of soil cores from zones beneath existing or abandoned lagoons, and (4) the development of a logical framework for making site-specific lagoon design recommendations. This report provides an abbreviated update on these activities. Results represent progress to date and are not final conclusions. More detailed results are provided elsewhere (see references).

Whole-Lagoon Seepage Rates

Regulations in Kansas stipulate that soil-lined lagoons used for animal waste should be constructed so that seepage is less than 1/4 or 1/8 inch per day, depending on where and when the facility was built. Kansas State University developed instrumentation to measure whole-lagoon seepage rates using water balance methods. New research by Ham (1999) and Ham and DeSutter (1999) shows that this technique can measure seepage to within $\pm$ 0.02 inch per day. To date, these methods have been used to collect data from 15 lagoons (Table 1). The average seepage rate from the lagoons tested was 1/20 inch per day; but, rates ranged from 0.01 to 0.09 inch per day between sites. Ham (2000) and Ham and DeSutter (1999) found that organic sludge on the bottom of the lagoon apparently reduced the permeability of soil liners, especially in medium- and coarse- textured soils. Detailed measurements of sludge depth were made at a 5-year-old swine waste lagoon using a "freeze" sampler. The average depth of sludge atop the compacted liner was 10.2 inches.

In summary, seepage losses from most earthen lagoons in Kansas are probably less than 1/16 inch per day. However, seepage rates from soil-lined lagoons are not zero, and questions remain regarding the movement of nitrogen and bacteria that penetrate the liner and move into the subsoil. Additional seepage studies will be conducted in 2000 in areas with sensitive groundwater.

Waste Chemistry

Constituents in lagoon waste that could contaminate groundwater include nutrients, salts, bacteria, pathogens, hormones, and pharmaceuticals. The types and concentrations of these compounds are dependent on species, diet, veterinary care, location (climate), time of year, and the characteristics of the waste handling system. Soluble nutrients, especially nitrogen, often are found in groundwater in agricultural regions. Table 2 shows the concentration of nitrogen and other nutrients in cattle and swine waste lagoons in Kansas. Because the lagoons are anaerobic, almost all the nitrogen is in the form of ammonium (NH_4^+-N). Concentrations of NH_4^+-N ranged from over 2000 mg L^{-1} in a first stage swine-waste lagoon to as low as 10 mg L^{-1} in a cattle feedlot lagoon, but considerable variability occurred within species as well. On average, however, NH_4^+-N in swine waste lagoons was almost seven times higher than that at cattle sites. Cattle lagoons contain runoff from precipitation that falls on the open-air pens; thus, the effluent is typically more dilute than waste from a pull-plug swine system. Other nutrients and salts, like phosphorus, sodium, and chloride, also varied by as much as sixfold between sites. Table 2 shows that nutrient concentrations in lagoons vary tremendously from site to site, with some trends prevailing between species. Other researchers have shown similar variability in regard to the prevalence of pathogens like bacteria, viruses, and protozoa. Development of new treatment technologies like chemical-physical treatment, liquid-solid separation, and biological treatment also could affect the potential toxicity and chemical concentration of lagoon effluent. Clearly, a good site-specific approximation of waste characteristics is necessary before the risk of groundwater contamination can be assessed.

3-29

Subsurface Nitrogen Losses Into Soil Under Lagoons

The rate at which soluble components move from the lagoon into the underlying soil (i.e., input loading) is another critical aspect of assessing risk. Ammonium seepage losses into the soil from the lagoons ranged from 0.02 to 0.52 kg m^{-2} y^{-1} , which in case of the largest flux, was equivalent to applying over 4600 lbs. of N fertilizer per acre per year. Calculations showed that nitrogen losses potentially could exceed 1 million lbs. per site over 25 years of operation. However, there was huge variation in nitrogen export between sites. For example, ammonium nitrogen losses from one of the swine lagoons was 35 times higher than that at one of the cattle feedlots. There also were large differences in N export at lagoons serving the same facility (e.g., first stage lagoon vs. second stage lagoon). Again, these data show that seepage losses and input loading are very lagoon specific. Similar calculations could be performed to estimate the input loading of any soluble compound or organism in the waste (e.g., bacteria, pharmaceuticals). Input loading, rather than seepage rate alone, is a better criterion for rating lagoon performance, because it is more proportional to the risk of contamination.

The movement of effluent-nitrogen into the soil surrounding the lagoon is not only dependent on the seepage rate and the nitrogen concentration, but also is affected by the chemical and physical properties of the soil. Ammonium has a positive charge, while clay particles in soil are negatively charged. Objects with opposite charges attract; thus, NH_4^+ ions that leak from a lagoon are often strongly adsorbed onto the surface of clay particles in the soil profile. Conversely, negatively charged ions, such as chloride, are not attracted to soil particles and tend to move through the soil profile unimpeded. The ability of a soil to adsorb positively charged ions is described by the Cation Exchange Capacity (CEC). Soils with high clay contents have CECs near 30 meq/100 g and very sandy soils have CECs near 5 meq/100 g.

Soil cores were collected beneath six lagoons in Kansas using direct-push soil-sampling equipment (Concord Environmental Equipment, Hawley, MN). Study sites included three cattle feedlots, a dairy site, and one municipal lagoon. In most cases, the soil cores were collected from the bottom of the basins after the lagoons had been dried and the organic sludge removed. Core samples extended from the top of the compacted liner to depths between 8 and 16 ft beneath the liner. When possible, soil cores were collected at multiple locations in each lagoon. Samples are being analyzed for a wide range of nutrients, salts, and bacteria. However, to date, only the nutrient analyses are complete. Figure 1 shows the average NH_4^+ concentration from the five lagoons. 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 compacted soil liners. However, ammonium decreased rapidly with depth, and most of it was still trapped in a 5- to 15-ft-thick soil zone beneath the lagoons. In four cases, ammonium movement had been restricted to a shallow zone only 2 to 5 feet thick. Nitrate concentrations were negligible at all the sites, suggesting that minimal nitrification was occurring or that nitrates were being converted rapidly to harmless nitrogen gas. However, preliminary analysis at one site suggested that organic nitrogen may be also accumulating under the lagoon. Additional work on organic nitrogen is planned for 2000. In summary, preliminary data suggest that nitrogen losses through a lagoon liner will, in many cases, be deposited as ammonium in a rather shallow soil zone near the periphery of the lagoon liner. The amount of nitrogen and size of the deposit will be dependent on the seepage rate, concentrations of nitrogen in the waste, CEC of the underlying soil, soil hydraulic properties, and lagoon age.

Logical Framework For Site-Specific Lagoon Design

Assessing the risk of groundwater contamination should consider the effect of waste toxicity, rates of input loading, and the vulnerability of the underlying aquifer. All of these factors vary depending on location, species, and type of waste handling system. Although some states consider local hydrology and soil conditions when awarding lagoon permits, these data are used mainly in a qualitative fashion to avoid construction of soil-lined lagoons above vulnerable groundwater. No science-based framework exists for collecting site-specific input data and calculating the appropriate design criteria (i.e., maximum allowable seepage rate) for each individual lagoon.

Ham and DeSutter (2000) have proposed a logical framework for determining optimal lagoon design on a site by site basis (Figs. 2 and 3, Table 3). The rationale for the framework is protecting groundwater from N contamination, but could be expanded to include other potential contaminants. Site-specific data on soil type and depth to water table are combined with information from the lagoon permit application to calculate what level of seepage (if any) will still provide long-term protection of groundwater resources. The key to any successful approach will be to design a system that gives engineers and producers 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 should result in lower construction costs (e.g., soil-lined vs. plastic-lined lagoons). Thus, a site-specific design strategy for lagoons should be implemented so the general public is assured that lagoons are being used safely near vulnerable aquifers, while the agricultural community is economically rewarded for proactive stewardship when siting, building, and managing AFOs in the Great Plains.

Future Research

The Kansas State University research team will continue to study waste treatment lagoons in 2000. A research priority will be studying both animal and municipal waste lagoons in sensitive groundwater areas. Work will continue on the development of a logical framework for site-specific lagoon design.

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Table 1. Whole-lagoon seepage rates from 14 animal waste lagoons in Kansas.

Lagoon	Species	Waste Depth m (ft.)	Lagoon Area ha (acre)	Seepage Rate mm/d (in./d)
1	swine	5.5 (18)*	0.7 (1.7)	1.4 (0.06)
2	swine	5.8 (19)*	2.3 (5.7)	2.0 (0.08)
3	swine	5.3 (17)*	2.2 (5.5)	0.8 (0.03)
4	swine	5.4 (18)*	2.2 (5.5)	0.9 (0.03)
5	swine	4.9 (16)*	2.9 (7.2)	1.5 (0.06)
6	swine	2.1 (7)	0.5 (1.2)	1.3 (0.05)
7	swine	4.4 (14)	1.5 (3.7)	0.6 (0.02)
8	cattle	2.3 (8)	1.8 (4.5)	0.2 (0.01)
9	cattle	1.2 (4)	2.8 (7.0)	2.4 (0.09)
10	swine	4.9 (16)*	2.9 (7.2)	1.5 (0.06)
11	swine	5.5 (18)*	2.4 (6.0)	1.7 (0.07)
12	swine	1.2 (4)	2.0 (5)	1.3 (0.05)
13	swine	1.2 (4)	0.5 (1.2)	0.9 (0.03)
14	swine	1.5 (5)*	0.5 (1.2)	0.8 (0.03)
Mean		3.7 (12)	1.8 (4.5)	1.3 (0.05)

* near maximum capacity

Table 2. Selected chemical characteristics of waste in anaerobic lagoons used to contain animal waste. Data are averages of 15 swine sites and 8 cattle feedlots in Kansas. At most sites, samples were collected on multiple dates during a 2-year period.

	Lagoon Type					
	Swine			Cattle		
Parameter (ppm)	Max.	Min.	Avg.	Max.	Min.	Avg.
Nitrate-nitrogen	<1	<1	<1	<1	<1	<1
Ammonium-nitrogen	2070	180	775	260	10	122
Total N	2530	210	888	480	65	222
Organic N	460	30	112	220	65	100
Total P	329	22	81	110	45	52
Sodium	420	90	273	200	45	133
Chloride	945	195	399	822	155	461

Table 3. Required input data, decision points, and calculations required to determine site-specific lagoon design using the logical framework in Figure 2. (Letters and numbers correspond to node labels on the flowchart). From Ham and DeSutter (2000).

Input Data

(a) Geological assessment and vadose-zone soil analysis of proposed site, including depth to water table; proximity to surface water, wells, and flood plains; and presence of undesirable geologic formations (e.g., karst). Soil analysis of region beneath the proposed construction site, including sampling and analysis for soil texture and cation exchange capacity (CEC) in the 3 m zone that will reside under the bottom of the lagoon.

(b) Information on the type of proposed facility (e.g., species) and method of waste handling and treatment.. Proposed years of operation (permit life).

Decisions and Calculations

(1)

Estimate the concentration of ammonium nitrogen in the lagoon effluent based on the proposed type of operation and waste handling system (e.g., single stage anaerobic lagoon).

(2) Calculate the minimum allowable distance (X) between the lagoon and the seasonal high water table. Calculate the minimum distance (Y) between the lagoon and a water well.

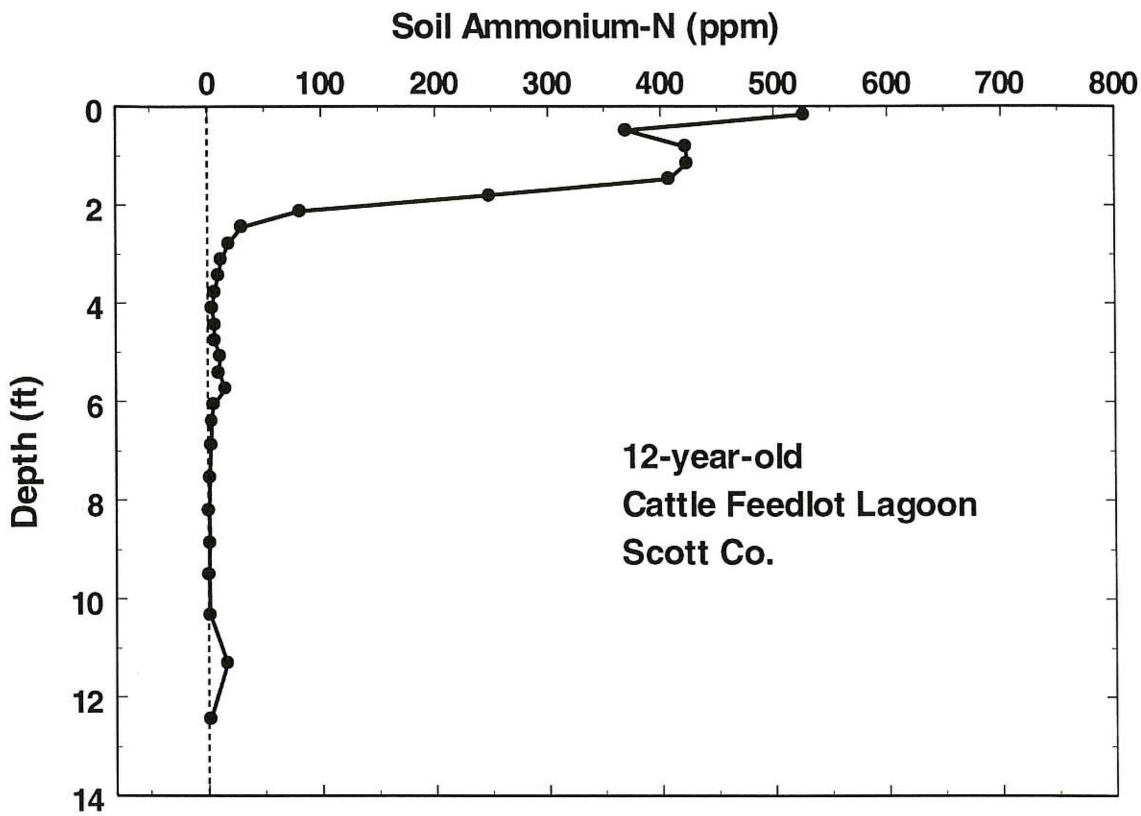
(3) Is the seasonal high water table within X m of surface? Is a water well within Y m of the lagoon in the down gradient direction? Are there subsurface features that will allow preferential flow from the surface to the groundwater? If yes to any of these questions, consider plastic-lined lagoon or alternative manure storage.

(4) Use results from soil analysis to calculate the NH_4^+-N ion adsorption capacity of the 3-m soil zone that will be under the lagoon (i.e., total maximum adsorptive capacity, TMAC).

(5) Given the TMAC, expected concentration in the waste, and proposed permit duration; calculate the maximum allowable seepage rate from the lagoon such that the TMAC will not be exceeded at expiration of the permit.

(6) If the calculated maximum allowable seepage is less than 0.2 mm d^{-1}, then consider a plastic-lined lagoon or alternative storage.

(7) Proceed with design of a soil-lined lagoon with liner properties and depth to meet the maximum allowable seepage requirement.



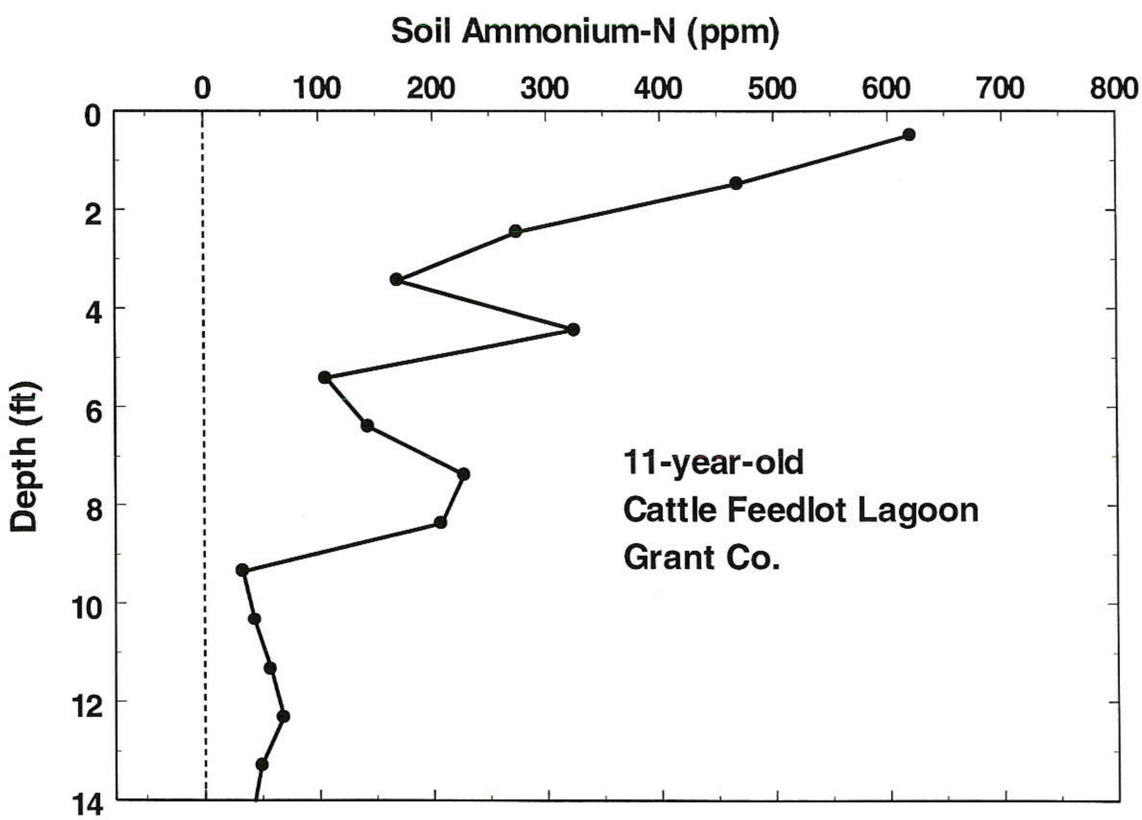


Figure 1. Ammonium-nitrogen concentrations in soil beneath anaerobic waste treatment lagoons.

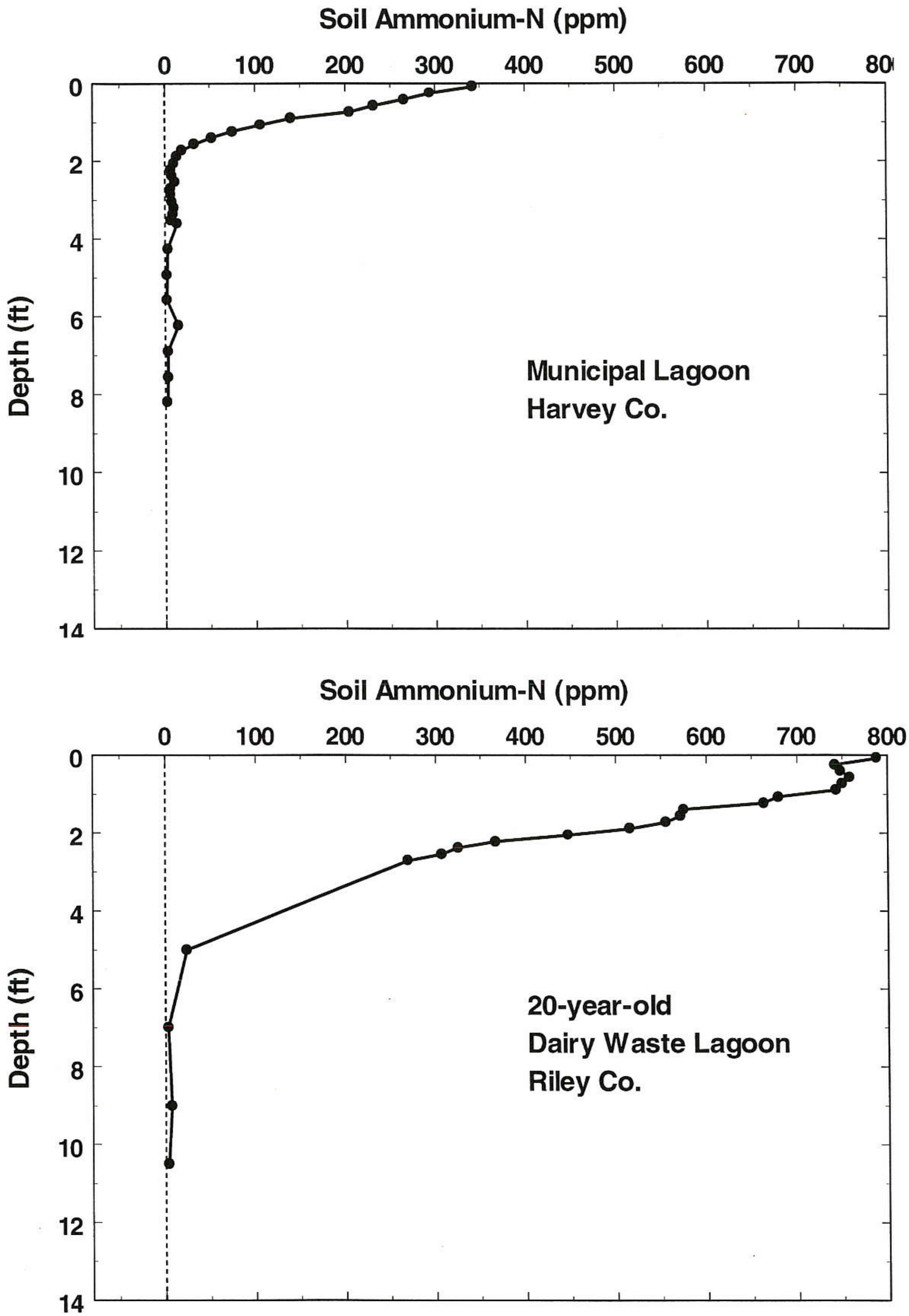


Figure 1. (continued) Ammonium-nitrogen concentrations in soil beneath anaerobic waste treatment lagoons.

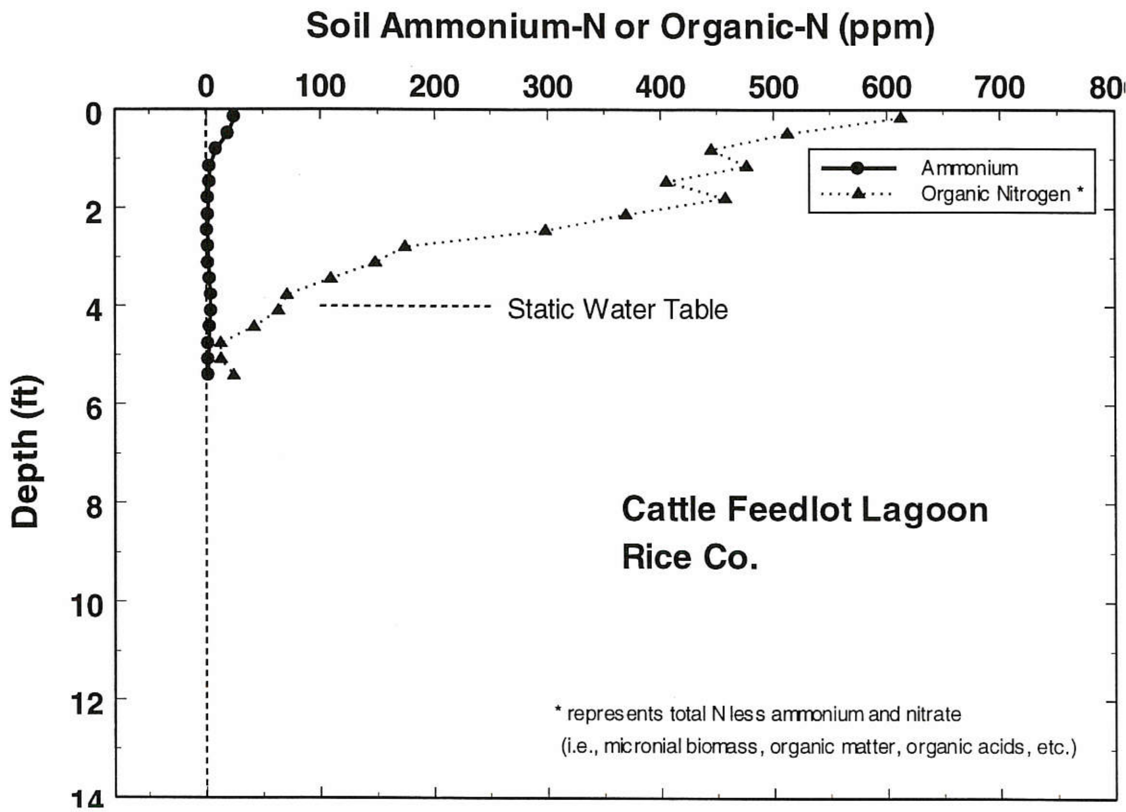


Figure 1. (continued) Ammonium-nitrogen concentrations in soil beneath anaerobic waste treatment lagoons.

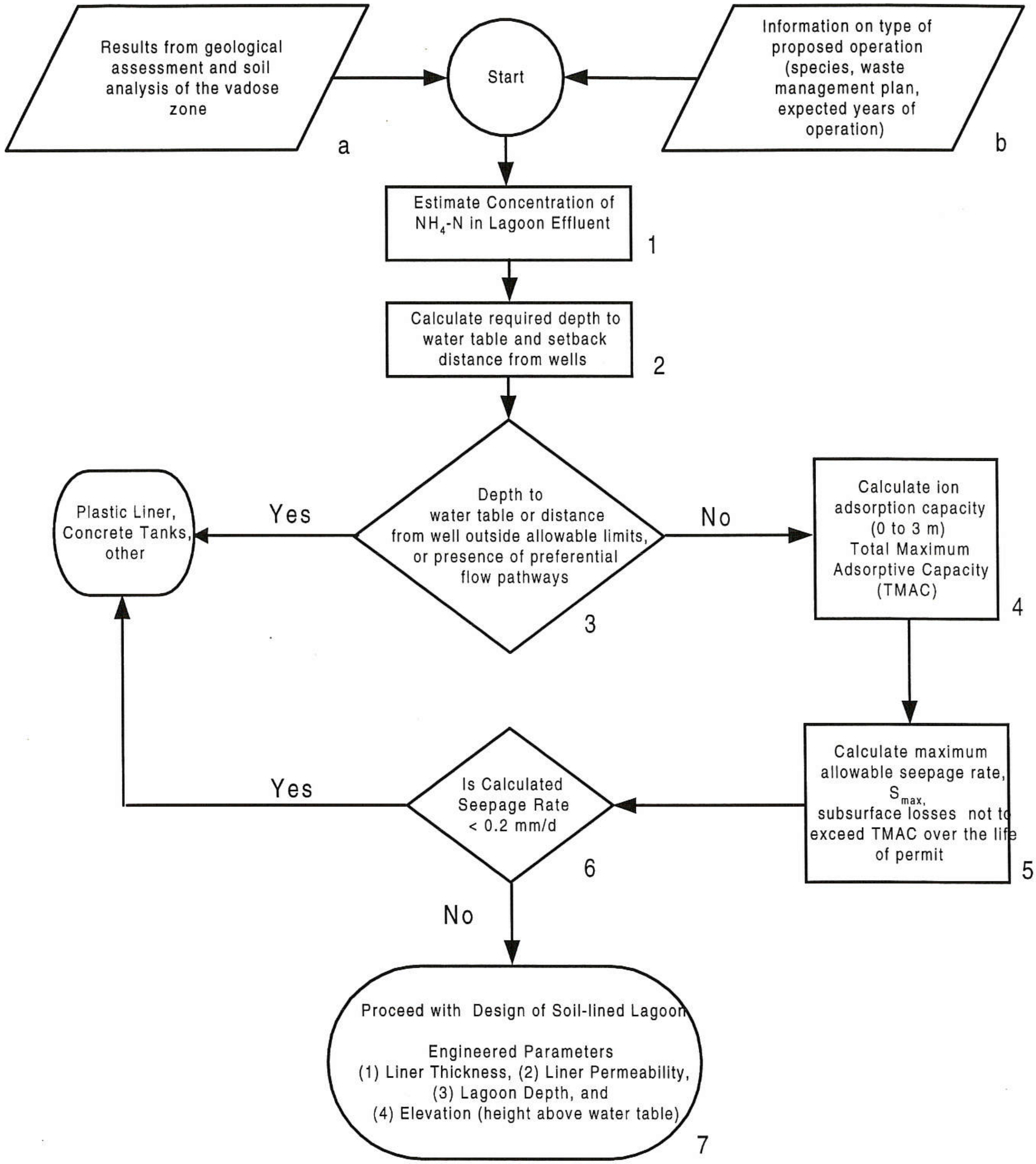


Figure 2. Logical framework for determining site-specific lagoon design. The symbols in the framework represent the following: the circle is the start of process, trapezoids represent input data, rectangles represent calculations or models, triangles represent yes/no decision points, and ovals represent output of results. Nodes in the decision tree are described in Table 3. From and Ham and DeSutter (2000).

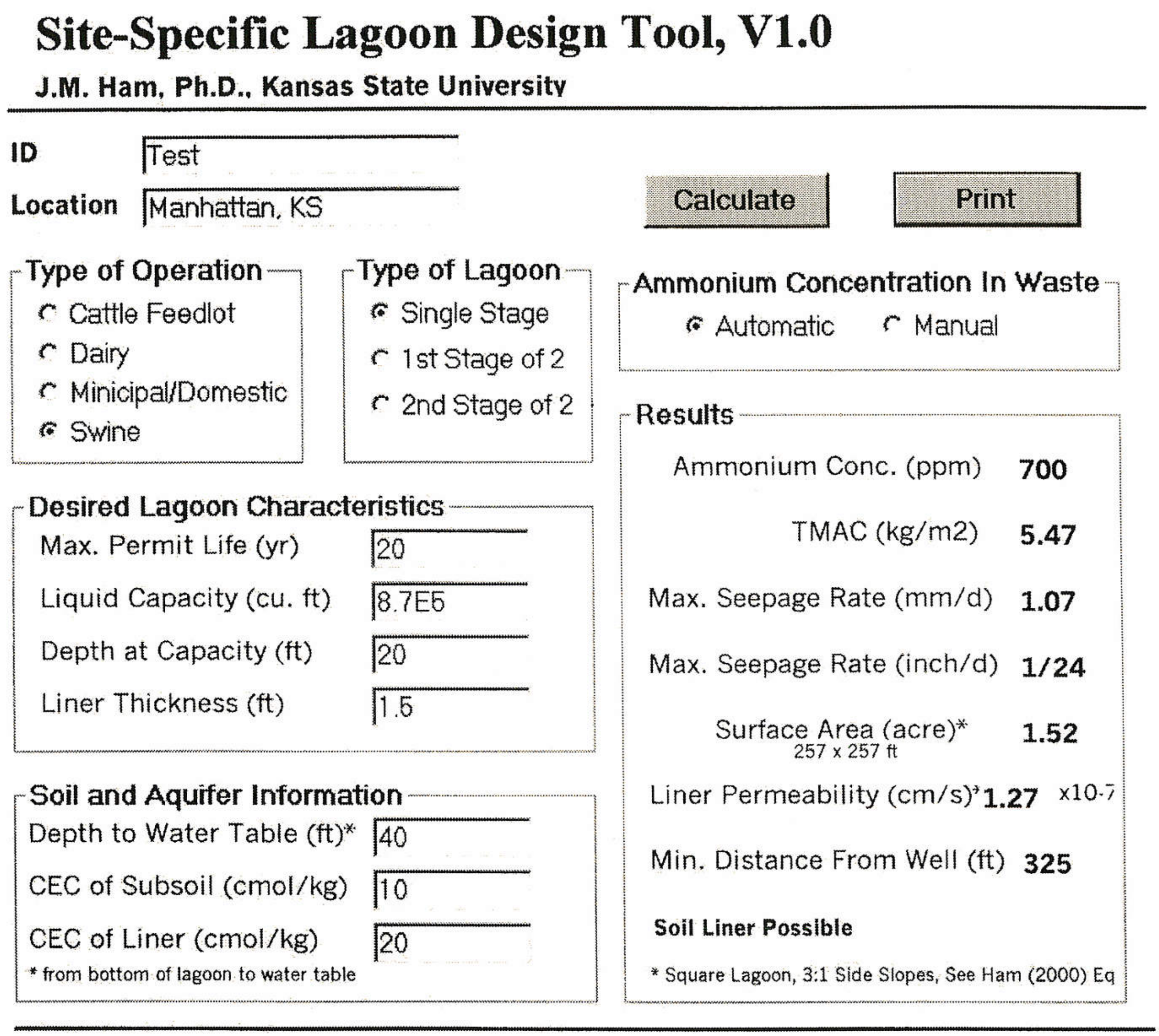


Figure 3. Example screen from a computer software program that provides site-specific design recommendations for waste treatment lagoons. The variable labeled "Max. Seepage Rate" represents the site-specific design recommendation for the lagoon (replacing the 1/4 or 1/8 inch/day standard). Thus, in this example, the lagoon liner would need to be constructed so that seepage is less than 1/24 inch per day.

IV. Animal Waste Containment in Anaerobic Lagoons - Laboratory and Modeling Investigations

Principal Investigator

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Summary

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.

Introduction

Animal waste from concentrated animal operations involving cattle, swine, and poultry is usually stored in earthen lined, anaerobic lagoons or storage basins. The animal waste is often in the form of liquids with suspended solids/organic matter containing high concentrations of nitrogen. Ninety five percent of the nitrogen in lagoon waste is in the form of ammonium (NH_4-N) ranging from 130 mg/L to greater than 1000 mg/L. In order to protect the underlying soil and groundwater resources, the seepage through the bottom of the lagoon is regulated to a maximum of 0.25 inch/day by the KDHE. The purpose of this study was to assess if this regulatory standard could be met when Kansas soils are used in construction of clay liners and to evaluate the impact of lagoons on groundwater quality.

Approach and Methods

Soils from the southwest region of Kansas were acquired for this study. The soils were thoroughly characterized for their engineering properties. In particular, the compaction characteristics of the soils were determined using the Proctor compaction method. The permeabilities of the compacted specimens with respect to water were determined using compaction permeameters. A subset of the samples was subsequently permeated with cattle waste from lagoons. The effluent from these tests was characterized for the Nitrogen concentrations and microbial counts. The tests were continued until breakthrough of NH_4-N was noticed in the effluent samples. In a more recent study, samples of geomembranes and geosynthetic clay liners were subjected to waste streams to assess their diffusion characteristics.

In the modeling investigations, a finite element model (SWMS-2D) was used to simulate the hydrogeology surrounding lagoons and assess the impact of waste containment on groundwater quality. The numerical model was used to simulate the NH_4-N transport in a two-layer system – the lagoon liner and the underlying natural soils. Several hypothetical simulations were carried out to assess the sensitivity of groundwater quality to liner design, lagoon operation parameters and hydrogeological characteristics, viz., thickness and hydraulic conductivity of the liner, operating head of the lagoon, properties of soils surrounding the lagoon, and depth to the groundwater table.

Results and Discussion

The permeabilities of the Kansas soils used in this investigation varied in a range of two orders of magnitude with the maximum and minimum coefficients of permeability being 4.95×10^{-7} cm/s and 4.75×10^{-9} cm/s, respectively. For this range, the field lagoon liners will meet the KDHE standard of 0.64 cm/day (0.25 inch/day) even if the liner thickness is as low as 0.5m. Sharp increases in microbial counts were observed in the effluent when lagoon waste liquid was used as the influent. However, the biomass growth inside the samples did not seem to be sufficient to bring down the permeability of the samples. This indicates that it may not be a conservative design practice to assume time-dependent reductions in permeability of clay liners due to biological clogging. In general, high concentrations of ammonium and chloride were observed in the effluents of all the samples. Breakthrough was achieved relatively faster in the case of chloride than in ammonium. The transport of NH_4-N was associated with significant retardation and possible decay. In view of the numerical simulations in the modeling part of the investigation, the transport characteristics of chloride and ammonium were obtained fitting the solution of an advection-dispersion type equation to the experimental data.

The sensitivity analyses conducted using the numerical model (SWMS-2D) have all shown predictable trends as the properties of the two layers are varied. Although an increase in the operating head of the lagoon quickens the arrival of the contaminant at the groundwater table, its effect is not as significant as the effect of increasing the liner thickness. The results indicate that the engineering properties of the liners (permeability, diffusion, and decay coefficients) play larger role in the travel times and the end concentrations than in seepage rates. A broad range in the normalized concentrations (at the groundwater table) of 0.7 to 0.025 is possible with liners molded from the same soil type. The effect of liner thickness on travel times and final concentrations of NH_4-N, is equally significant. The extent of possible retardation, decay, and saturation levels of NH_4-N in clay liners, observed in this study, suggests that properties such as CEC (cation exchange capacity) and microbial uptake, which influence mass transfer of NH_4-N, should be given an important consideration in designing liners for animal waste lagoons. Several simulations were also carried out to assess the effect of scraping and replacing a portion of the liner material on NH_4-N transport. The sensitivity analysis using these simulations suggests that higher scraping depth and frequent replacement of the top of the liner could significantly reduce the ammonium concentrations leaching out of the liner.

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V. Manure Composition from Kansas Swine Lagoons

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Summary

In phase I or 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. 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.

Introduction

Manure application to cropland compared to direct application of inorganic fertilizer is an important economic consideration for producers. Soil characteristics of structure, tilth, and water holding capacity are improved when manure is applied. Although applying swine manure to cropland is a common practice, active participation in environmental stewardship must be a top priority. Currently, no database for manure nutrient concentrations exists from Kansas swine lagoons, therefore values from other sources are used to compare Kansas concentrations. Many potential problems with using these values exist, because these concentrations possibly were generated in other geographic locations with no uniform sampling technique and from samples collected many years ago. Furthermore, changes in management practices (i.e., phase-feeding, decreased particle size) and dietary factors such as feeding milo and wheat, which have greater available P than corn, also may affect the composition of Kansas swine lagoons. Therefore, a need exists for a database from samples of manure to determine the level of nutrients and minerals in Kansas swine lagoons. The objective of this survey was to determine mean concentrations of major and minor nutrients in swine lagoon samples from analysis filed in nutrient management plans at the Kansas Department of Agriculture in accordance with of HB 2950.

Procedures

Analyses of swine manure from 41 Kansas swine lagoons were obtained from the Kansas Department of Agriculture. Manure samples were obtained in 1999 from farrowing to finishing, sow, nursery, weaning to finishing, and finishing operations. The manure samples were collected by the individual operations for chemical analysis. Therefore, the sampling technique, time of year, type of lagoon, sample handling prior to analysis, and the laboratory used were not controlled among operations participating in this survey. Average concentrations of specific nutrients and minerals from all lagoons were summarized to obtain a database for mean values. In addition, the standard deviation (SD) of the mean for each nutrient and mineral was calculated. One SD indicates that 68% of the samples are ± 1 standard deviation from the mean. A range of two SDs would include 95% of the samples.

Results and Discussion

The nitrogen contents of the manure from Kansas lagoons (Table 1) were higher than previously reported values from sources located in other states (Table 2). For ammonium nitrogen (NH_4-N), which is available to plants during the growing season, Kansas lagoon concentrations were 709 ppm compared to 375 ppm from the Nebraska Cooperative Extension Service. The SD for NH_4-N was 398 ppm. This indicates that 68% of the samples have a range of 310 to 1,107 ppm concentration of NH_4-N. The amount of organic nitrogen (OrgN), which is nitrogen that is slowly released from the manure into the soil, was 190 ppm with an SD of 209 ppm. In addition, the amount of nitrogen in the nitrate form was less than 1 ppm. The total nitrogen in the manure, which is the sum of ammonium-nitrogen, organic-nitrogen, and nitrate-nitrogen, was 899 ppm with an SD of 584 ppm. This compares to the values from Nebraska and the Midwest Planning Service of 500 and 625 ppm, respectively.

For phosphorous concentration, the level of phosphate (P_2O_5) was 371 ppm. This mean is similar to the reported value of 375 ppm from the Midwest Planning Service. But, with an SD of 549 ppm, many of the manure samples would have concentrations under the Midwest Planning Service values. Elemental phosphorus, which is calculated by multiplying P_2O_5 by .44, had a mean of 163 ppm.

Potash (K_2O) levels were double the previous reported concentrations: 1,043 ppm compared to 500 ppm for both Nebraska and the Midwest Planning Service. For potassium, which is calculated by multiplying K_2O by .83, Kansas swine lagoons had a mean of 847 ppm. However, the SDs of 617 ppm for K_2O and 519 ppm for potassium indicated a high degree of variability among samples in this survey.

Our summary of the lagoons in Kansas also includes additional nutrients and mineral concentrations. Currently, we are not aware of any other sources with which to compare these major and minor nutrients concentrations. However, high SDs for the majority of these nutrients and minerals indicated a high variation between samples.

In order to determine how different types of operations compare in manure concentrations, as well as to increase the current knowledge of swine manure content, we are planning a second phase of this study to further analyze nutrients in swine waste. This will allow determination of manure content from different phases of production with a uniform sampling technique to reduce possible variation between samples. A brief outline of our experimental plan of work is provided as an appendix to this report.

Application of manure to farmland is an environmentally and economically feasible practice for swine producers. Results for 1999 manure concentrations from Kansas swine lagoons indicate the importance of individual manure analyses of all manure storage facilities. In addition to management and dietary factors that could contribute to the variation in manure composition, variation between laboratories may exist. The Minnesota Department of Agriculture has established a certification process for laboratories conducting manure analysis. Producers are recommended to have certified labs analyze their samples to ensure accuracy of manure composition. This practice will allow proper amounts of manure to be supplied to cropland for optimal plant growth, as well as increase environmental stewardship by swine producers.

Table 1. 1999 Nutrient and Mineral Concentrations of Kansas Swine Lagoons[a]

Item, ppm	Mean	SD	Minimum	Maximum
Nitrogen				
Total nitrogen, N	899	584	76	2,361
Organic-nitrogen, OrgN	190	209	12	1,107
Ammonium-nitrogen, NH_4-N	709	398	64	1,702
Nitrate-nitrogen, NO_3-N	< 1	0.0	< 1	< 1
Major Nutrients				
Phosphorus, P	163	241	13	1,209
Phosphate, P_2O_5	371	549	30	2,748
Potassium, K	847	519	164	2,069
Potash, K_2O	1,043	617	190	2,400
Sulfur, S	44	43	10	200
Calcium, Ca	154	85	40	345
Magnesium, Mg	60	82	6	226
Magnesium oxide, MgO	76	81	10	330
Minor Nutrients				
Zinc, Zn	6.2	8.9	1	32
Iron, Fe	19.0	25.4	2	67
Manganese, Mn	2.0	2.9	0	9
Copper, Cu	1.6	2.3	0	12
Boron, B	1.2	.8	0	3
Other Constituents				
Sodium, Na	243	112	90	400
Chloride, Cl	390	248	73	1,149
Carbonate, CO_3	< 1	0.0	< 1	< 1
Bicarbonate, HCO_3	3,943	1,609	714	5,868
PH	8.0	.6	6.1	8.8

[a]Values represent the means of 41 swine lagoon samples. These analyses were sent into the Kansas Department of Agricultural as part of compliance with KHB 2950.

Table 2. Nutrient Concentrations of Swine Lagoon Manure

Item, ppm[a]	Nebraska[b]	Midwest Planning Service[c]
Nitrogen		
Total nitrogen, N	500	625
Ammonia-nitrogen, NH_4-N	375	NR[d]
Major Nutrients		
Phosphate, P_2O_5	250	375
Phosphorus, P[e]	110	165
Potash, K_2O	500	500
Potassium, K[f]	415	415

[a]Converted from lb/1,000 gal.
[b]Nebraska Cooperative Extension Service, EC 89-117, Lincoln, NE.
[c]1993.
[d]Not reported.
[e]Converted by multiplying P_2O_5 by .44.
[f]Converted by multiplying K_2O by .83.

APPENDIX

MANURE COMPOSITION FROM KANSAS SWINE LAGOONS

PHASE II

Introduction

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

Procedures

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: February, April, June, August, October, and December. In addition, samples will be taken from various geographic locations in Kansas. The different operations will include: 1) nursery, 2) wean to finish, 3) finishing, 4) sow, 5) farrow-to-finish, 6) deep pit (finishing), and 7) hoop structures. For each segment of production, 6 to 8 different sites will be tested.

The initial manure sample will be taken by K-State Research and Extension personnel. 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. For 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. These samples will be taken approximately 18" from the outside of the pile.

Results of chemical analyses will be summarized by operation type as well as evaluated for seasonal variation. These data should provide useful benchmarks for nutrient composition of different types of swine production facilities

VI. Impact of Land Application of Animal Wastes on Soil Chemical, Biological and Physical Properties

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Dr. Mahbub Alam, Assistant Professor, Southwest Area Extension

Summary

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 content 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.

Introduction

Application of animal or municipal wastes (collectively called biosolids) can enhance soil chemical, physical, and biological properties and serve as a valuable nutrient source for crop production. However, improper use of biosolids can adversely affect the environment. Two concerns associated with land application of biosolids are phosphorus loss in runoff of surface water causing eutrophication of streams and lakes and nitrate leaching through the soil profile into the groundwater. The purpose of this study was to sample fields that have received land application of biosolids and compare the soil chemical, biological, and physical properties to similar fields that have not received waste applications.

Approach and Methods.

Soil samples were collected from 8 fields in south-central Kansas (Harvey County), in cooperation with local landowners, which had 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 and type of waste, number of years of application, and soil type varied from site-to-site. The longest history of application was about 35 years. Two sites received swine wastes, 2 sites received cattle manure, 2 fields received municipal sludge, and 2 received commercial fertilizer (without any animal or municipal waste). Soil types ranged from fine sandy loam to silty clay loam. The fields were divided into 3 subfields (except for one field that received municipal sludge that was not divided). In each subfield, 3 soil cores to a depth of 10 ft were collected, divided into 12-inch increments (except for the surface foot which was divided into 0-6 inch and 6-12 inch samples), and composited. The soil samples intended for chemical analyses were dried and sent to the KSU Soil Testing lab for analyses for N, P, and other macro- and micro-nutrients. Determinations of soil biological properties from moist samples are in progress with results not available at this time.

Another aspect of this research was initiation of a project to compare the impact of swine and cattle wastes to commercial fertilizer on soil and crop parameters under controlled conditions at the KSU-Southwest Research Extension Center near Tribune. Three rates of swine waste (effluent water from a lagoon) and 3 rates of cattle waste (solid manure from a beef feedlot) along with 4 rates of commercial fertilizer were applied in the spring of 1999. Baseline soil measurements (chemical, physical, and biological) were made before treatment application. Earthen berms were constructed around each plot to control effluent and irrigation water movement. Corn was planted in May; unfortunately it was severely damaged by hail in July and yielded only a few bushels/acre. This study will be repeated in 2000 and continue for several years.

Results and Discussion

Two fields (both fine sandy loam soils) were sampled that had received applications of solid cattle manure. Soil P levels were increased to 145 ppm Bray-1 P (0-6 inch depth) at one site and 180 ppm Bray-1 P at the other site. These soil test levels are greater than needed for optimum crop growth (30 to 50 ppm are sufficient for optimum crop growth), but do not pose a problem for plant health. Both sites had received cattle manure over a number of years (>35 years for one site). In a field with a similar soil type that had not received any animal wastes, the soil P level was 30 ppm, which is considered a high testing soil with little or no additional fertilizer P recommended for crop production. Soil nitrate levels were not increased by the application of cattle waste compared to the non-manured field. Other chemical properties (potassium, sodium, zinc, and chloride) were also similar for the manured and non-manured fields.

Two fields received liquid swine wastes, one a sandy loam soil and the other a silty clay loam soil. Phosphorus levels in the surface of the lighter textured soil (sandy loam) were about 200 ppm Bray-1 P. This site had received swine wastes since 1965 and dairy waste for 8 years prior to then. The other field with a medium-textured soil (silty-clay loam) had received swine wastes for about 10 years and the soil P levels were about 100 ppm Bray-1 P. Similar to the fields receiving cattle wastes, all other chemical properties were similar between the manured and non-manured fields.

Municipal wastes were applied to two fields as sludge from city sewage treatment plants. Both sites had medium textured soils (silt loam or silty-clay loam). The first site had received municipal sludge for about 15 years. At this site, soil P levels were 25 ppm, which were the same as in the non-treated fields. Most other chemical properties were similar except for zinc and copper levels, which were higher following sludge application. Zinc levels were about 12 ppm in the sludge-treated field compared to less than 2 ppm in the control fields while copper levels were about 40 ppm following sludge applications compared to about 2 ppm or less in the control fields. At the other municipal site, sludge had been applied 30 years or more but not in the past 7 years. Chemical properties were considerably different in this field than the other sludge-treated field. Soil test levels for phosphorus, zinc, and copper were 500, 100, and 300 ppm, respectively. These levels are far in excess of crop requirements. This site also had considerable nitrate accumulation deep in the soil profile with 15-30 ppm nitrate-N at the 7-10 ft depth. The application of municipal sludge also increased the organic carbon content at this site to 10% compared to 1-2% in all of the other fields.

VII. Evaluation of Near-Surface Soil Physical Properties Following Land Application of Animal Wastes

Principal Investigators
Dr. Loyd R. Stone, Professor, Department of Agronomy
Dr. Jay M. Ham, Associate Professor, Department of Agronomy
Dr. Alan J. Schlegel, Professor, Southwest Research-Extension Center

Summary
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.

Introduction
Soil quality is defined as the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health. The capacity of soils for application of animal wastes is varied and depends on physical, chemical, and biological properties of both the soil and waste material. Measurement of changes that occur in soil quality are needed if preservation of soil quality is a goal in long-term management of land application of animal wastes. Several standard field and laboratory procedures can be used to measure changes in soil quality and serve to quantify the impact of management practices on soil quality. The purpose of this study was to sample 12 paired fields (six fields that have received land application of animal wastes and six fields that have received no added animal wastes) and determine soil physical and chemical properties that relate to soil quality.

Approach and Methods
Soil samples were collected in the fall of 1998 from six irrigated fields in western Kansas (in cooperation with local landowners) that had a history of manure application. The rate and type of manure, number of years of application, and application method varied among the six locations. The longest history of application was about 30 years. Three sites received solid manure (cattle). Three sites received effluent water from wastewater lagoons (two cattle and one swine). Soil samples were also collected from six similar fields that had not received manure (identified by the

landowner). Each of the 12 fields was divided into three subfields. From each subfield, a composite, disturbed soil sample (about 20 pounds) was taken from the surface (0 to 6 inch depth). The samples were immediately dried and then transported to Manhattan for laboratory determination of selected physical and chemical properties.

During August 1999, infiltration properties were determined in four fields (two manured and two non-manured) of the 12 sampled in the fall of 1998. At each of the four locations, three double-ring infiltrometers with inner ring diameter of 36 inches and outer ring diameter of 49 inches were installed to a depth of 5 inches. Six tensiometers were installed within the inner ring, two at each of 6, 12, and 18 inch soil depths.

Results and Discussion

Total nitrogen and organic carbon concentrations were determined by the KSU Soil Testing Laboratory on the 36 surface soil samples (12 fields and three subfield samples per field). If significant amounts of animal wastes have been added to soil, one would expect the total nitrogen and organic carbon concentrations to be increased. Of the six field pairs, four had significantly greater concentrations of total nitrogen and organic carbon in the manured than in the non-manured sample. With animal waste application and the expected increase in organic matter concentration, one would expect an increase in the soil's specific surface. Water content at a matric potential of -15 bars is increased by an increase in the soil's specific surface. From our six field pairs, five had increased water content at -15 bars, and one had decreased water content, in the manured soil relative to the non-manured. Although a numerical pattern did exist, none of the six differences within pairs was statistically significant.

Two measurements of structural stability were made on soil of the six field pairs — modulus of rupture and wet-aggregate stability. With manure applications, the increased organic material would tend to promote stable soil aggregates. However, with manure applications there is risk of a change in the salt balance of a soil and an increase in the ratio of monovalent cations (sodium and potassium) to divalent cations (calcium and magnesium). This increase in the ratio of monovalent to divalent cations would increase the dispersion potential of a soil and possibly lead to dispersed soil particles and reduced aggregate stability. With moderate and controlled manure additions, the increase in organic matter would likely promote more stable aggregates and improved soil structure. If manure additions are excessive for the soil and climate (water) conditions, the ratio of monovalent to divalent cations would likely increase to the point of soil particle dispersion, aggregate collapse, and reduced conditions of soil structure. An increased proportion of stable aggregates is reflected by a decrease in modulus of rupture (break strength of molded soil) and by an increase in the mean weight-diameter of water-stable aggregates. From our six field pairs, two had no significant difference within pairs in modulus of rupture or mean weight-diameter of aggregates. Three field pairs had a significant difference within pairs in modulus of rupture (a lower break strength) and mean weight-diameter of aggregates (a greater proportion of large, stable aggregates) — both conditions associated with the manure applications. These measured differences in modulus of rupture and mean weight-diameter are expected if manure use has increased the organic matter content to promote aggregation but has not increased the ratio of monovalent to divalent cations to the point of dispersion and aggregate collapse. In one of the six pairs, there was a significant increase in modulus of rupture, and a significant decrease in mean weight-diameter of water-stable aggregates, in soil receiving effluent water from a cattle wastewater lagoon. This would indicate that the cattle wastes have been applied in a manner that has increased the ratio of monovalent to divalent cations to the point of soil particle dispersion and aggregate collapse.

In an associated study of these same 12 fields, detailed soil chemical analyses were completed by the KSU Soil Testing Laboratory. In only one of the six field pairs was there a significant difference in the ratio of monovalent to divalent cations (milliequivalent weight basis). In that pair, the difference in ratios was highly significant, with the manured soil having a ratio five times greater than the non-manured soil. That field pair was also the only field pair that had a significant increase in modulus of rupture and a significant decrease in mean weight-diameter of water-stable aggregates associated with waste application. That same field pair, had an increase in mean electrical conductivity (indicator of soluble salt content) from 0.38 mmhos/cm in the non-manured soil to 3.03 mmhos/cm in the manured soil. That difference is highly significant. The highest mean electrical conductivity in the other 10 fields was 0.79 mmhos/cm.

At one of the six locations, livestock waste has been applied at an excessive rate, there has been a raising of the soluble salt content and an increase in the ratio of monovalent to divalent cations, leading to aggregate collapse and decreased soil structural conditions. At two of the locations, there is no significant difference in soil structural conditions between manured and non-manured soils. At three of the six locations, there has been a significant improvement in soil structural conditions associated with livestock waste application.

In neighboring fields of one county, steady-state infiltration rate was 15.9 mm/hour in a non-manured field and 31.7 mm/hour in a field that had received cattle manure. In neighboring fields of a second county, steady-state infiltration rate was 21.0 mm/hour in a non-manured field and 10.0 mm/hour in a field that had received effluent water from a swine wastewater lagoon. In one pair the field receiving animal waste had better infiltration properties and in the second pair the field receiving waste had worse infiltration properties. Steady-state hydraulic conductivity values followed the same pattern as infiltration rates, with greater hydraulic conductivities associated with greater infiltration rates. From our digging in the upper foot of the four soils and the observation of compacted zones, it was apparent that in these four soils the infiltration properties were influenced more by plant residue management and tillage practices than by animal waste application.

VIII. Using Subsurface Drip Irrigation (SDI) with Beef Lagoon Wastewater

Principal Investigators

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Summary

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 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.

In a supplemental filtration study, wastewater from 11 different lagoons was tested for speed of clogging disk filters. Wastewater was pumped from lagoons through disk filters of mesh sizes 80, 120, 140, and 200 until they were clogged. Volume of water required to reduce the flow rate through the filter by 10% was correlated to the solids (total suspended solids plus total dissolved solids) in the wastewater.

Introduction

Use of subsurface drip irrigation (SDI) with water from animal waste lagoons has many potential advantages. They include but are not limited to less human contact with wastewater; no runoff of wastewater into surface waters; placement of phosphorus-rich water beneath the soil surface where it's less prone to runoff; greater application uniformity resulting in better control of the water, nutrients, and salts; less irrigation system corrosion; fewer climatic application constraints (especially high winds and low temperatures); and greater flexibility in matching field and irrigation system sizes. But the very small emitters used for SDI may be prone to clogging. The challenge, then, is to gain the benefits of SDI while preventing emitter clogging. Given that challenge, the objective of this project was to measure the performance of five different dripline types as affected by irrigation with filtered but untreated water from a beef feedlot runoff lagoon.

One of the questions arising from the research at Midwest Feeders is, "How do I best manage the filtration of lagoon wastewater?" Such management includes the frequency of backflushing. The mesh size of the filter will be recommended by the manufacturer of the dripline. If the filter becomes clogged excessively, the SDI system will not operate properly and the wastewater will not be distributed uniformly. This could result in water stress to the crop, nutrient stress to the crop, or adverse environmental impacts due to nonuniformity of application. The objective of this supplemental research project was to measure the clogging of disk filters of various mesh size equivalents to develop recommendations for the backflushing of those filters.

Approach and Methods

The five tested driplines had emitter flow rates of 0.15, 0.24, 0.40, 0.60, and 0.92 gal/hr/emitter. This wide range of emitter flow rates was chosen to determine the optimum emitter size- one that would be less prone to clogging- for use with wastewater. The agricultural applications of SDI in the Great Plains with fresh, clean groundwater are normally associated with the smaller emitter flow rates.

The wastewater was filtered with a disk filter. A controller was used to automatically backflush the filter after every hour of operation or when differential pressure across the filter reached 7 psi. Acid and chlorine were also injected into the system approximately biweekly to help keep bacteria and algae from growing and accumulating in the driplines. Driplines were flushed occasionally to remove accumulations of silt or clay particles and biological materials.

To test the system, daily irrigations of 0.20 to 0.40 inches were applied during the 1998 growing season and daily irrigations of 0.30 to 0.40 inches were applied in 1999. Each plot received the same amount of water daily and for the growing season. Nearly 21 in of wastewater were applied in 1998 and 15 inches were applied in 1999.

Emitter flow rates for entire plots were measured weekly. Pressure gauges at the head and tail end of the plots were used to measure the pressure within the driplines. Totalizing flow meters measured the amount of wastewater flow for each plot. Flow rates were measured by hand-timing the flow to each plot.

For the supplemental filtration project, wastewater was pumped from a lagoon through four filters via a manifold. Inlet pressure was maintained and excess flow was relieved with a pressure sustaining valve. The pump was able to develop an inlet pressure of 20 psi when all four filters were clear at the start of each test. The inlet pressure was allowed to increase to 30 psi as the filters clogged. The pressure sustaining valve maintained the inlet pressure at 30 psi. Pressures at the inlet (one measurement) and at the outlet of each of the four filters (four measurements) were measured at one, two, or three minute intervals, depending on the speed of clogging. Flow volume through each of the four filters was recorded by totalizing the number of gallons through each filter at the same frequency as the pressure measurements. A data logger was used to automatically record these data. When all four filters were clogged or the test had run for 24 hours, whichever came first, the filters were removed and replaced with clean filters. Filters were cleaned by hand between each test. Eleven lagoons were tested. Five lagoons contained beef feedlot runoff wastewater, 4 lagoons contained swine wastewater, and two lagoons contained dairy wastewater.

Results and Discussion

Of the five dripline types tested, the three higher-flow emitter sizes (0.40.0.60, and 0.92 gal/hr/emitter) showed little sign of clogging. Flow rates at the end of the test for those emitters were within 4% of the initial flow rates, indicating that very little clogging and resultant decrease of flow rate had occurred. The absence of clogging indicates that emitters of these sizes may be adequate for use with lagoon wastewater.

The two lower-flow emitter sizes (0.15 and 0.24 gal/hr/emitter) showed some signs of emitter clogging during both growing seasons. Within 30 days of system completion in 1998, the flow rates in plots with both smaller emitter sizes began to decrease. The 0.15 gal/hr/emitter plots showed a gradual decrease of flow rate throughout the remainder of the test. By November 17, 1998, the flow rate had decreased by 15% of the initial rate. The 0.24 gal/hr/emitter plots showed a decrease in flow rate of 11% of the initial rate by September 2, 1998. The decrease amounts during the 1999 growing season were 22% and 14% for the 0.15 and 0.24 gal/hr/emitter driplines, respectively.

Following the 1998-99 winter idle period, all flow rates recovered to the initial flow rates. Possible explanations for this include (a) the longer time that the acid and chlorine remained in the driplines allowed better control of biological clogging agents or (b) the cooler temperatures during the winter resulted in partial control of the biological clogging agents and the acid and chlorine were then more effective at cleaning up the remaining agents.

Other management procedures might be employed to prevent performance degradation in the lower flow-rate emitters. Such procedures might include more frequent flushing, flushing with fresh water, and more frequent and concentrated chemical-injection treatments. However, the objective of this study was to compare the different driplines under difficult but identical conditions. Further studies are warranted to determine if the lower flow-rate driplines can be maintained at a higher performance level with more aggressive management.

Corn grain yields were highly variable both years and not related to dripline type. Yields in 1998 ranged from 170 to 190 bu/ac. Yields in 1999 were lower and even more variable.

In summary, the dripline performance was similar during two growing seasons, but questions still remain about the long-term, multiseason performance of SDI systems using livestock wastewater. These concerns are especially important in light of the decrease in flow rates of the two smallest emitters during both growing seasons. Long-term reliable performance probably will be necessary to justify the high investment costs of SDI systems.

Clogging of disk filters was correlated to the solids content of the wastewater (plus total suspended solids [TSS] plus total dissolved solids [TDS]). Analyzing the 9 swine and beef lagoons together with regression analysis, TSS+TDS accounted for 71% to 81% of the clogging variability, depending on the mesh size. The two dairy lagoons responded somewhat differently to filtration and were separated from the other lagoons for analysis.

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More details can be found in the "K-State Reports" section of the K-State SDI web site: http://www.oznet.ksu.edu/sdi

Publications in 1999

Trooien, T. P., F. R. Lamm, L. R. Stone, and M. Alam. 1999. Irrigating corn with subsurface drip irrigation and lagoon wastewater. Irrigation Journal 49(5):6-7.

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IX. Vegetative Reclamation of Abandoned Lagoons

Principal Investigators

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Summary

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 from under the lagoon by harvest and removal of plant tops with accumulated contaminants.

Introduction

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 may convert to nitrate, and this highly mobile nitrogen form may 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.

Approach and Methods

Soil collected in layers from an abandoned 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 to create a range of soil and crop conditions and leaching potentials. 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.

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 constituents.

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.

X. Transport of Water and Solutes from Animal Waste Lagoons

Progress Report on Modeling Water Seepage from Lagoons

Principal Investigator

David R. Steward, Kansas State University, Department of Civil Engineering

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:

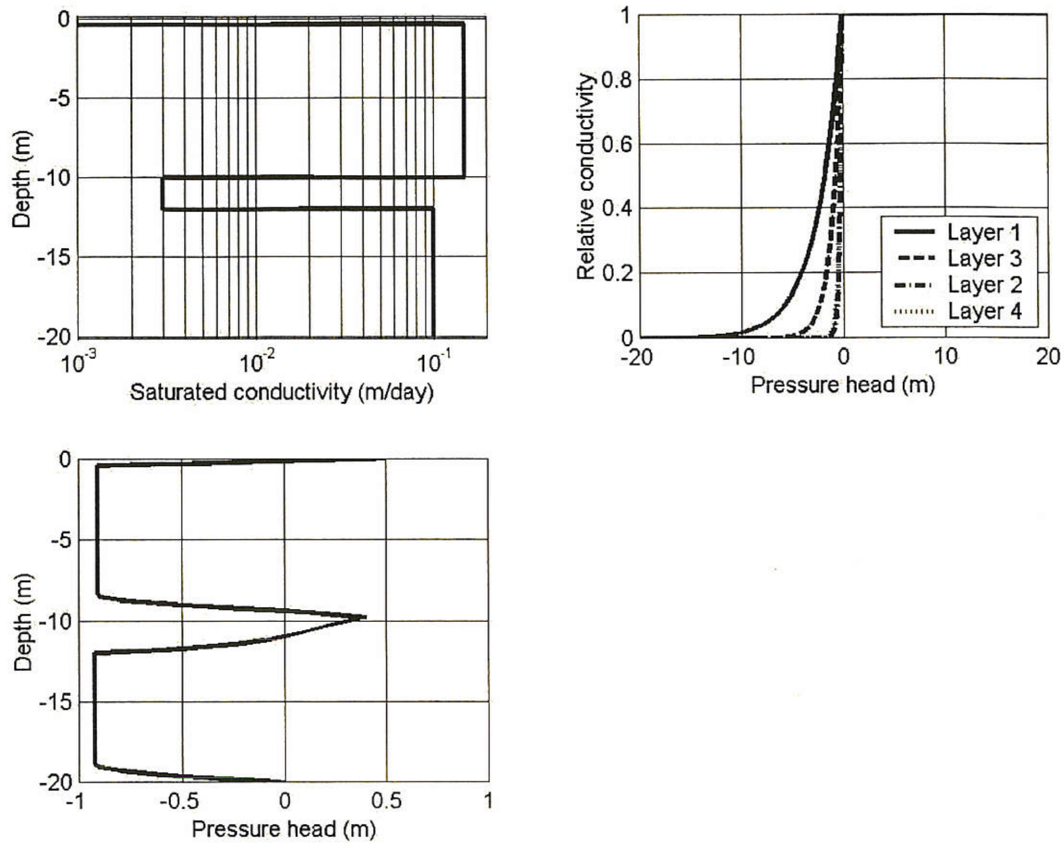
- The depth to groundwater,
- The thickness of distinct geological layers (including the compacted clay liner and underlying soil),
- The saturated hydraulic conductivity of each layer (this indicates how quickly water can travel through pore spaces between soil particles),
- The relationship between 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 is included. The depth to groundwater is 20m (60 feet). The upper layer represents the compacted clay liner. The second and fourth layers have parameters representative of very fine sand. The third layer is representative of silt.

The pressure distribution as a function of depth is shown in the lowest figure.

Once this model is fully tested and validated, it will be used to estimate flow and pressure distributions under lagoons in Kansas. This information will be used when predicting the fate and transport of nutrients. It is expected that this model will lead to better understanding of the hydraulic properties of compacted clay liners. This model may also be used to better understand and predict the occurrence of perched water conditions under lagoons in Kansas. (Perched water conditions indicate that the soil is fully saturated.) This is important, as the fate and transport of nutrients may differ between the fully saturated conditions existing in a perched aquifer and the unsaturated conditions existing in the absence of perched conditions.


Depth (m)
Saturated conductivity (m/day)
Relative conductivity
Pressure head (m)
Layer 1
Layer 3
Layer 2
Layer 4
Depth (m)
Pressure head (m)

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.

House Environment
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Attachment 4

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.

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† 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.

What 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).

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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."

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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