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SYMPOSIUM OF THE HOG ENVIRONMENTAL MANAGEMENT STRATEGY (HEMS)

DECEMBER 10 AND 11 , 1999

NEATBY BUILDING
AGRICULTURE AND AGRI-FOOD CANADA
OTTAWA, ONTARIO

PROCEEDINGS

Posters and Displays in separate file - hems2_posters.pdf

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AGENDA

Friday, December 10th, 1999

8:00 Breakfast & coffee

8:30 **Opening speech**
Description of the agenda
Jurgen Preugschas, Chairman of the symposium

REDUCING GAS EMISSIONS

9:00 **Toward Objective Measurement of Malodours from Livestock Sources.**
R. York, B. Trybula, M. King, University of Manitoba

9:35 **Reduction of odor gas emissions from grower/finisher barns and manure storage & Objective measurement of odour emissions from manure storage systems and measuring odour dispersion.**
J. Feddes, University of Alberta

10:10 Break and visit of the posters

10:40 **Formulation of Swine Diets on the Basis of True Digestible Phosphorus Supply.**
M. Z. Fan, University of Guelph

11:15 **Efficacy of Various Microbial Urease Inhibitors on Controlling Ammonia and Hydrogen Sulfide Emission from Swine Manure.** M. Z. Fan, University of Guelph

12:00 Lunch and visit of the posters

13:30 **Manipulation of Hindgut Fermentation to Reduce the Excretion of Selected Odor-Causing Compounds in Pigs.** E. J. Squires and M. Z. Fan, University of Guelph

14:05 **Reduction of odour and gas emissions from swine buildings: Construction and testing of the experimental setup.** S. Lemay, Prairie Swine Centre

14:40 Break and visit of the posters

15:00 **Development of a Negative Air Pressure Cover System for Earthen Manure Storages.**
S. Danesh, D. Small and D. G. Hodgkinson, DGH Engineering.

15:35 **Novel Technology for Remediation of Hog Manure Odour Control/Remediation.**
M. Zaworotko, University of South Florida

16:10 **Evaluation of Solid-Liquid Manure Separation Methods.**
R. Gordon, Nova Scotia Department of Agriculture & Marketing

MANURE TREATMENT

16:45 **Literature Review on the Use of Artificial Marshes for Manure Treatment.**
S. Pigeon, BPR and G. Roch, Fédération des producteurs de porcs du Québec (FPPQ)

17:20 Adjournment

Wine and cheese

Saturday, December 11th, 1999

8:00 Breakfast & coffee

SOIL AND WATER QUALITY

8:30 **Seepage and Contaminant Transport from Earthen Manure Storage Ponds in Alberta: Traditional and Innovative Investigation Techniques.**
B. MacMillan and D. Helmer, AAFRD

9:05 **A new technology for sealing of earthen manure storage structures.**
A. E. Ghaly (Dalhousie University), A. Madami and R. Gordon (Nova Scotia Agricultural College).

9:40 **Reduced environmental impact of pig production by improved mineral utilization.**
C. Forsberg, Guelph University

10:15 Break and visit of the posters

10:45 **Optimizing Use of Liquid Hog Manure on Sandy Soils with Respect to Groundwater Protection.** M.O. Gasser, M.R. Laverdière, R. Lagacé (Université Laval), G. Barnett (AAFC, Lennoxville) et J. Caron (Université Laval).

11:20 **Liquid swine manure used in vegetable production systems: harvest yields and salubrity.** M. Leblanc (IRDA), C. Côté (UPA Lanaudière), and S. Quessy (Université de Montréal)

12:00 Lunch and visit of the posters

HEALTH ISSUES

13:30 **Literature Review on the Impacts of Hog Production on Public Health.**
S. D'Allaire, L. Goulet, J. Brodeur (Université de Montréal) and G. Roch, Fédération des producteurs de porcs du Québec (FPPQ)

COMMUNICATION

14:05 **National Environmental Communications Strategy Planning Meeting Proposal.**
S. Bradshaw, Ontario Pork

14:40 Break and visit of the posters

15:00 **Environmental Issues Resource Centre.** L. D. Whittington, Prairie Swine Centre

15:35 **Guide to an Agro-environmental Approach to Swine Production & Development of Plans for Agro-environmental Intervention in Swine Production.**
C. Foulds, H. Perrault, M. Beaubien, FPPQ

WRAP-UP

16:10 Discussion

17:00 Closing statement

HEMS - Background Information

The Hog Environmental Management Strategy (HEMS) is a partnership between the federal government, the hog industry and the provincial governments. It is being led jointly by the CPC and AAFC, with the objective of developing a concerted national approach to finding effective and affordable solutions to the environmental challenges confronting the industry.

The first step toward developing a strategy was to learn more about the current situation in the industry and define the environmental challenges by consulting with key players. Provincial consultations with producers and provincial government representatives were recently held across the country to identify the most pressing environmental issues and explore options for addressing them.

These consultations confirmed that there is generally a high level of support for a national initiative addressing the environmental issues related to hog production. Each provincial government and industry group indicated that it saw value in involvement of the federal government and the CPC in such an initiative, although the suggested form and extent of this involvement varied by province.

It was strongly felt that HEMS must be integrated with, or at least complementary to, existing and proposed initiatives of provincial governments and industry associations. Provincial governments are especially sensitive to the possibility that federal programs and activities may detract from or duplicate their own efforts. Interest was also expressed in a regional coordination role for AAFC in regard to hog-related environmental initiatives in the three Prairie provinces and the three Maritime provinces.

The key environmental issues identified during the consultations were odours and water quality. The latter includes the risk of contamination of surface and ground waters by nitrates from manure and, in some areas, by phosphates and bacteria. Air quality was also specified as a concern in the Lower Mainland of British Columbia, in relation to ammonia emissions.

Water quality is often the stated environmental issue in many cases when the greatest concern is actually odours. This is because complaints over odours are not recognized under provincial right to farm legislation if the odours are emitted in the course of normal farm practices. A further complicating factor is that broader social, economic and public health issues often underlie environmental concerns.

A recurrent message in the consultations, particularly in the industry sessions, was that there is a need to better inform the public of the actual environmental risks associated with hog production, as well as the technologies and management practices that are being implemented to minimize these risks. It was suggested that communications and public education programs be developed to counter alleged misinformation in the media.

The consultations identified three areas in which HEMS can make a significant contribution:

- on-going research into hog-related environmental topics such as odour mitigation, land suitability and crop requirements for manure applications. Related functions are the coordination of research activities across Canada to encourage collaboration and avoid duplication, and dissemination of research findings to provincial governments and industry;
- screening of new technologies and management practices to identify innovations which are effective and affordable;
- assistance to provincial producer associations in developing and implementing effective communications and public education strategies and programs.

The next step in developing a national strategy was to hold a workshop bringing together various players from across the country in both government and industry to lead to the development of an action plan.

The specific objectives of the workshop were to:

- Report back on the consultation process and the findings it produced regarding national gaps in existing

strategies.

- Delineate the initiatives required to fill these gaps.
- Develop an implementation plan for the national elements required to fill in the gaps identified in existing strategies.

Toward Objective Measurement of Malodours from Livestock Sources

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Roberta K. York, M.Sc. Canadian Food Inspection Agency, 501 University Crescent, Winnipeg, MB, R3T 2N6
Q. (Chong) Zhang, Ph.D. Department of Biosystems Engineering, University of Manitoba, Winnipeg, MB, R3T 2N2

Profile: The project is entitled: Developing Odour Sensitive Fabric and Establishing Test Protocols for an New Approach to Standardized Sensory Analysis of Livestock Malodours

The project involves the standardization of the sensory methodologies for quantitative measurement of malodour intensity - for laboratory, animal research, and on-site environmental testing. This will provide a new standard test and protocols to evaluate odours and allow meaningful cross-comparisons of the results from different test situations. It will also provide the basis for a provisional standard for regulatory testing.

REACH

The impact of a comprehensive standardized test protocol is expected to include:

1. The provision of the ability to collect objective quantitative data on malodour intensity for use in malodour management.
2. The ability to have meaningful comparisons of data from different testing situations:
    a. laboratory analyses of waste product malodours and their components,
    b. research and development on waste treatment effectiveness and on animal research, e.g. nutritional supplements to reduce waste odour production,
    c. on-site testing in barns, holding facilities, lagoons, etc.
    d. regulatory standards for odour emissions from production facilities
3. The provision of guidelines for all the steps and controls needed for sensory analyses to be applied by other organizations which may be participating in this work at the development or monitoring stages, e.g. private industry, consulting firms, etc.
4. The provision of a mechanism to facilitate communication of the results of testing of airborne malodours to stakeholders.
5. The provision of a basis of regulatory testing of livestock malodours.

DISCUSSION

Areas which have been explored to date in co-operation with other work in this area include

- sensory panel methodologies regarding panel selection and training,
- sample preparation using a laboratory sampling system designed for the delivery of standard samples to the fabric swatches.

This work focuses on the fabric swatches and the nature of the surface characteristics in affecting the uptake and release of odour as samples are taken and then analyzed. Test fabrics used represent natural and synthetic fibres, different weave structures and surface topographies. Other factors which influence this are chemical characteristics such as the composition of the polymer and surface finishes. These parameters, which are responsible for different adsorption capacities, are being explored.

Reduction of odour/gas emissions from grower/finisher barns and manure storage

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PROFILE

Goals/Purpose: Since over 70% of the manure produced by the pig population originates from grower-finisher pigs, we are targeting the control of odour from these facilities. We are proposing that the manure be stored up to 12 months within this confinement facility, however, the pit airspace will be isolated from the pig/worker airspace. When including the manure storage within the building, the traditional odour sources (building and earthen manure storage) will be reduced to one source, the building. The proposed design for a grower-finisher barn will be modified to include two independent airspaces, each with an independent ventilation system. In this way, the gases/odours from the dunging/pit area can not escape to the pig/worker air space. The ventilated odour/gas emissions from the pit/dunging area will be directed through a biofilter prior to being discharged to the outdoor environment. We have assumed that gas/odour production from the pit will be substantially less than that from an equivalent earthen manure storage since it is undisturbed due to lack of air movement and lack of intermittent loading. This proposed design also will improve the air quality of the worker/pig airspace since the odours from the dunging/manure storage area have been isolated from it.

Benefit: The end-result from this proposed research will be no outdoor earthen manure storage for grower/finisher pigs, reduced odour emissions from the barn and improved air quality for the workers in these facilities. By dividing the airspace within the building into two-airspaces, the air from the dunging/pit airspace can be treated by a biofilter. This will be a low air flowrate compared to the much higher ventilation rate required to maintain temperature or relative humidity in the pig/worker airspace.The only new technology being considered is a biofilter application which has been developed for other applications.

RESULTS

A) Design and testing of enclosed dunging area

During the summer of 1999, twelve pens were modified to include the EDA (enclosed dunging area) design. The doorway into the EDA consists of non-destructive rubber strips with metal cleats attached to the bottom of the strips. Some of the pigs were observed to sleep in the EDA and dunging occurred outside the EDA. The EDA has been modified to discourage pigs sleeping in the EDA by placing a 12-inch grid of ¾ inch rod on the concrete slates. Also, a second doorway has been installed. This has resulted in cleaner floor surfaces. The flow rate through the biofilter may need to be increased from 20 to 40 L/s/pen to ensure a slight negative pressure across doorways. The EDA's are currently equipped with a sprinkler and a light. These may be removed depending on the dunging behavior of the pigs.

By including the manure storage within the building and by having two independent airspaces within the room (the main airspace and a EDA), it is suggested that total building gas and odour emissions would be reduced if the air of the EDA is treated with a biofilter. This building concept would drop the number of odour sources from 2 to 1 (building and manure storage to building only) and is expected to improve air quality in the main airspace in decreasing total gas and odour emissions inside and from the pig building.

The initial and operating costs of a biofilter are directly related to the air volume that needs to be treated over a specific retention time. To optimise the biofilter design, the EDA configuration will aim at reaching the best contaminant containment with the lowest ventilation rate. Laboratory tests on different types of doorways to ensure two separate airspaces were necessary to achieve this EDA design optimisation

B) Design and testing of biofilter material

The objective of this study was to measure the effect of water application to the biofilter as well as its effect on air flow through the medium and on the background pressure necessary to push the air through the medium. Also, both peat moss and ground polystyrene were studied as filter materials for removing odour from an odourous stream of air from an existing manure storage. Peat moss is an effective material for removing odours, however, it becomes compact over time resulting in high static pressures necessary to move the odourous air through the medium.

Two trials have been completed under different conditions with peat moss. The results of these tests indicate that peat moss reduced odours by 59% when applying both water and microorganism nutrients to the media. In another trial, peat moss reduced odours by 33% when no water or microorganism nutrients were applied. When using ground polystyrene as a medium, odours were reduced by 20% with the application of water and microorganism nutrients. Eventhough, the odour was only reduced by 20% the character of the odour or hedonic tone was more pleasant. However, the hedonic tone was difficult to quantify. The airflow in the coarse peatmoss was significantly reduced over the trial period (90%) and the static pressure increased to six inches whereas the airflow through the ground polystyrene did not change.

DISCUSSION / CONCLUSION

The projects are ongoing at this time. The pigs dunging behavior requires further investigation since the pigs are not showing a strong preference to dung in the EDA. The doorway configuration on the EDA requires further work to encourage the pigs to use the EDA for dunging. The doorways work satisfactorily to maintain a slight negative pressure and a separate airspace at an airflow of 20 L/s/pen. The biofilter material that will be used for this application will be ground polystyrene with 10-25% course peatmoss. This will increase the pleasantness of the odour and result in a low static pressure requirement for the EDA exhaust fan.

Objective measurement of odour emissions from manure storage systems and measuring odour dispersion

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PROFILE

Goals/Purpose: Intensive livestock production can result in odour problems to nearby land users. Therefore it can become an environmental constraint to expanding the pig industry, especially in areas where feed may be grown, water is available and transportation costs are reasonable. Prediction of down-wind odour concentrations and mapping the intensity of the odour in an area of intensive livestock production could provide an important means for better planning of animal unit locations along with designing and managing the facilities for odour control.

The long term objective of this study is to determine the rates and characteristics of odour emissions from available manure storage/treatment systems. These data, along with the data on the odour emissions from pig confinement units at the Prairie Swine Centre, Saskatoon, Saskatchewan, will be used to validate existing odour dispersion models.

The specific objectives are as follows: (a) to evaluate the operation of a commercially-available odour intensity measuring device (electronic nose) based on olfactometer measurements; (b) to characterize odour from outside manure storages, building air and land application with the electronic nose; (c) to validate an existing computer model that predicts odour intensity downwind from numerous pig operations, with measured odour emission rates; (d) to determine the effects of intermittent and continuous loading on odour emissions from manure storages located outside and; (e) to evaluate odour emissions from lagoons loaded with liquid that has been mechanically separated from the solid fraction.

Benefit: This study will characterize odour emissions from pig production facilities, manure storage, and field application. The dispersion model will be used to predict odour concentrations downwind as a result of a new or expanded operations or the introduction of odour control technology. From weather records, the probability of odour intensities exceeding a certain value will be predicted. With the aid of odour measurement instrumentation, concentrations can be measured at various distances from an odour source. We expect that the criteria for defining minimum separation distances between source and receptor will eventually be based on these quantitative data rather than existing qualitative data.

The key longterm benefit will be to enable the confident use of a computer model as a tool in deciding where to locate new pig operations, the acceptability of facility expansions and the degree of odour abatement required to meet acceptable odour levels at the location of potential complainants. Initially, acceptable odour levels will be based on European recommendations. With the local pig industry expecting to increase in size by a factor of three, or greater, over the next number of years, prediction of odours at receptor sites surrounding a pig operation will become critical.

RESULTS

Design and testing of olfactometer

Implementation of odour abatement programs, odour policy and regulations requires an objective, reliable, and accurate measurement with acceptable repeatability within a laboratory and reproducibility among olfactometer laboratories. The most important and subjective parameter for describing odour is odour concentration.

Odour concentration is measured by olfactometry, comprising of an olfactometer and a human panel. It utilizes the human sense of smell as the basis for detecting an odour. The olfactometer dilutes a sample of odorous gas with a neutral gas at a prescribed ratio and presents the mixture to the panelists. The dilution at which the odour is detected is refered to as the threshold dilution and is used to determine the concentration of the odour expressed as odour units

(ou).

Although research on the development of a dynamic olfactometer has occurred over a 30 yr period, only two kinds of olfactometers are commercially available. These are the St. Croix Sensory ISO olfactometer (AC'SCENT, Inc. Website) developed in the United States and, the TO7 olfactometer (Ecoma GmbH Website) developed in Germany. Both olfactometers use a limited number of panelist-stations (1 for the St. Croix Sensory ISO olfactometer and 4 for the TO7 olfactometer). Consequently, samples must be run two or more times to satisfy standard requirements specified in ASTM E679 (Standard practice for determination of odour and taste thresholds by a Forced-Choice Ascending Concentration Series Method of limits, 1979.) and the proposed CEN standard (Air-quality-determination of odour concentration by dynamic olfactometry, 1998. Draft prEN, CEN/TC264/WG2/N222/e). Thus it is imperative to design and build an olfactometer with more panelist stations, less contaminant potential, less psychological bias, and at lower cost.

An 8-panelist-station, single-sniffing port, triangular forced-choice ascending concentration series olfactometer (UA olfactometer) was designed and constructed. Compared with the most recently designed conventional olfactometers, the UA olfactometer has the advantages of less odour contaminant potential, higher odour sampling rate (10 samples an hour), lower sample requirement and less psychological bias. In addition, it can be used to measure the hedonic tone of odours, i.e., when the degree of pleasantness or unpleasantness of an odour sample is required.

The UA olfactometer was calibrated with a tracer gas (carbon dioxide). Results of the calibration tests indicated that suitable mixing occurred between the neutral gas (air) and odourous gases and, airflow distribution was uniform across the eight panelist stations. Overall, the U of A olfactometer is considered to perform satisfactorily conforming with the ASTM and CEN standards.

Olfactometer – Electronic nose relationship

The olfactometry method consisting of an olfactometer and an odour panel is the most precise method for quantifying odours at present. However, using the human nose as a sensor to measure odour concentration is labour intensive, time consuming, and presents difficulty if on-site measurements are desired.

On the other hand, the electronic nose (Aromascan) is only capable of characterizing odours using an array of 32 sensors along with the humidity of the odour sample and of reference air. Thus, a function was developed to convert the electronic nose measurements into odour concentration using artificial neural networks (Adaptive Logic Network – ALN).

A total of 480 odour samples and 44 trained panelists were used to obtain odour concentration measurements in order to develop the conversion function. Results from tests showed that the electronic nose can measure odour concentration with a mean absolute error of about 20%. With further development, it may be possible to use the electronic nose for odour concentration measurements in place of the olfactometry.

Emission rates from manure storages

The objective of this part of the study is to: (a) determine odour emission rates from an earthen manure storage loaded with liquid manure that has been gravity separated from the solid fraction, and (b) determine odour emission rates from an earthen manure storage loaded with liquid manure intermittently or continuously.

Three 3m x 3m (dia.) in-ground holding tanks have been installed at the University of Alberta's Edmonton Research Station and filled with manure from a nearby grower/finisher barn. To measure odour emission rates, three sealed odour hoods were constructed from 20.8 x R34 radial tractor tubes boarded on one side with ½ in plywood. The vented hood was 0.27 m^3 in volume and covered an area of 0.8 m^2 . Excess air was exhausted from the top of the hood through a gate valve to prevent bubbling from underneath the hood.

Preliminary investigations were conducted to determine an airflow rate suitable for flushing the space enclosed by the hood. The effects of 0.5 $L.s^{-1}$, 1 $L.s^{-1}$ and 1.5 $L.s^{-1}$ were compared. It appeared that 1 $L.s^{-1}$ was sufficient to achieve equilibrium between the release of odours into the hood from the manure and removal of odours from the hood by the flushing air after about 20 min.

Odour samples were collected using a "lung". The "lung" was constructed from a plastic container, 0.4 m diameter x 0.5 m high. A battery-operated vacuum cleaner (VP, Black & Decker) was mounted on the lid of the "lung". When the vacuum cleaner was operated a negative pressure was created within the "lung". This enabled odourous air to flow from the space enclosed by the hood through a 13 mm teflon tube into two 10 L tedlar bags inside the "lung". The 13 mm teflon tube was flushed with fresh air prior to sampling to remove any residual odours in the line. Olfactometric measurements on the samples were conducted using the U of A olfactometer.

Two methods of determining odour emission rate, the continuous flush and the non-continuous flush, were investigated. In the continuous flush method, the odour hood was flushed for 30 min and then odour samples were collected while still flushing. Odour emission rate, E_{cf}, was determined using the following (Smith and Watts, 1994),

$$E_{cf}=C_oQ/A_h \qquad (1)$$

Where:
C_o, is the concentration of the odour samples (ou),
Q, is the flowrate of the flushing air ($m^3.s^{-1}$) and,
A_h, is the cross-sectional area of the liquid surface enclosed by the hood (m^2).

In the non-continuous flush method, the odour hood was flushed for 30 min and then odour samples were collected while still flushing. Flushing was stopped for about $15^{\pm 2}$ min to allow odour build-up in the hood and then resumed and a second odour sample collected. Odour emission rate, E_{ncf}, was determined using the following equation,

$$E_{ncf}=C_{ncf} / (t_{ncf} * A_h) \qquad (2)$$

Where:
$C_{ncf,}$ is the difference in odour concentration between the first and second samples (ou) and,
t_{ncf}, is the odour build-up time (secs).
This method attempts to determine odour emission rates by eliminating the effect of diluting the odour sample by flushing.

In addition to investigating the continuous and non-continuous methods of determining odour emission rate, the effects of manure depth and age and, of agitation were also investigated. Two tanks were filled with manure. Manure in one tank was used as a control (TC) while manure in the other tank (TA) was agitated for at least 30 min before odour samples were collected. Tests were conducted with the tanks filled to depths of about 0.9 m and 1.8 m and were repeated when the manure was 7 days old.

DISCUSSION

Odour emission rates determined using the continuous and non-continuous flushing methods are shown in Table 1. Since the measurement of odour concentration relates to the threshold dilution, the odour emission rates presented only give an indication of the true intensity emitted by the source.

Under the continuous flush method, the results show that the emission rates in the control treatment, TC, increased with with age at the two manure depths . On the other hand, the emission rates in the agitated treatment, TA, decreased with age at the two manure depths. The different changes in emission rate of TC and TA may relate to differences in the apparent rates of decomposition of the manure.

It appears that although the decomposition rate in TC increased with time resulting in higher emission rates after 7 days, the decomposition rates in TA were much higher, peaking quickly and by day 7 had already begun to decline. Possibly, agitation of the manure enabled excess gas release to occur unlike TC.

Under the non-continuous flush method, the results seem to suggest that odour intensity increased in which the emission rates were positive or decreased (negative values). Thus, with manure aging the emission rates in TC and TA decreased irrespective of depth. However, these results may only be presented in relation to the odour intensity or

concentration of the odour sample measured. Similar to the observations made from the results of the continuous flush method, the odour intensity or concentration of manure increased with age in TC but decreased with age in TA.

It does not appear that any relationship can be established between the two methods of determining odour emission rate. The continuous flush method appears to present the odour intensity at the time of measurement. On the other hand, it seems the non-continuous flush method may be used as a tool to predict the odour intensity with time.

Table 1. Swine Manure Odour Emission Rates Determined Using Different Flushing Methods

Manure			**Continuous Flush**	**Non-continuous Flush**	
Depth (m)	Age (days)	Tank (treatment)	Emission Rate ($ou.m.s^{-1}$)	Odour concentration* (ou)	Emission rate ($ou.m^{-2}.s^{-1}$)
0.9	1	TC	0.26	218(319)	0.13
		TA	0.74	615(451)	-0.21
	8	TC	0.63	522(574)	0.09
		TA	0.55	451(366)	-0.14
1.8	3	TC	0.49	406(467)	0.08
		TA	0.77	638(555)	-0.11
	10	TC	0.66	545(569)	0.03
		TA	0.75	621(621)	0

*Values in parentheses represent the odour concentration of the second sample collected using the non-continuous flush method
TC – Control – no mixing/agitation
TA – Mixing/agitation

SUMMARY / CONCLUSION

The olfactometer design is now complete. The design required serious modification when used to measure the high odour concentrations above the manure surface. More time had to be included for flushing between samples and some valve components were changed that absorbed odours.

The electronic nose can be used to measure odour concentrations with 80% accuracy. The electronic nose is portable, inexpensive to operate and provides a fast response.

Emission rates are expressed in terms of odour dilutions at the threshold detection level by odour panelists. More work is required to convert these emission rates to equivalent emission rates at the non-diluted odour intensity. Furthermore the relationship between the continuous and non-continuos methods of determining odour emission rates is not quite understood and needs to be studied further.

REFERENCES

Smith, R.J. and P.J. Watts, 1994. Determination of Odour Emission Rates from Cattle Feed lots: Part 1, A Review. Journal of Agricultural Engineering Research, 57: 145 – 155.

Formulation of Swine Diets on the Basis of True Digestible Phosphorous Supply

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Financial support: Ontario Pork Producers Marketing Board (OPPMB-Ontario Pork) and Agriculture and Agri-Food Canada (AAFC) and Canadian Pork Council (CPC) multi-partner Hog Environmental Management Strategy (HEMS) program.

Background

It has been recognized that excretion of phosphorous in manure from intensive pork production is a major environmental issue. Accumulation of phosphorous in the soil, together with leaching and runoff causes eutrophication of fresh water sources. Evidence is accumulating which suggests that phosphorous is the second nutrient following nitrogen that limits land application of manure in intensive swine producing areas. To minimize environmental pollution, the excretion of phosphorous by swine should be maximally reduced. Accurate evaluation of bioavailability of phosphorous in feedstuffs and formulation of swine diets on the basis of bioavailable phosphorous supply are essential to ensure efficient utilization of phosphorous in pigs.

The slope-ratio assay and the digestibility assays are the two major evaluation systems for assessing the bioavailability of phosphorous in feedstuffs for pigs. The slope-ratio assay provides a combined estimation of digestion and post-absorptive utilization of phosphorous at the tissue level. However, many other factors including nutrient balance, Ca/P ratio, genotype and physiological stage can influence bone formation, mineral deposition and therefore affect the assay results. In principle, estimates of availability of phosphorous in single feedstuffs as measured by the slope-ratio assay are more variable and are restricted to experimental conditions. Furthermore, there is no information on the additivity of the availability values measured in single feedstuffs when used in diet formulation.

On the other hand, digestibility assay indirectly estimates phosphorous availability by measuring its digestive utilization. It is known phosphorus digestibility values can sensitively reflect the bioavailability of phosphorous in feedstuffs for pigs. It is also known that phosphorus digestibility values measured in single feedstuffs were additive when mixed in diet formulation, suggesting phosphorous digestibility values should be measured for the purpose of diet formulation. However, measurements obtained with this assay are confounded by the presence of endogenous phosphorous in ileal digesta or feces. Thus, apparent phosphorous digestibility values have been determined in a wide variety of feedstuffs for pigs (e.g., Jongbloed *et al*., 1991). There is a large variation in the apparent phosphorous digestibility values within the same feedstuffs; for example, the digestibility values ranged between 16-51% in barley samples and between 15-34% in soybean meal samples (Jongbloed *et al*., 1991). Moreover, apparent phosphorous digestibility values likely underestimate their corresponding true values in feedstuffs by about 15-25% due to the relative high contribution of gastrointestinal endogenous phosphorous recovery in pigs. Therefore, true rather than apparent phosphorous digestibility values should be determined in feedstuffs for pigs**.** The formulation of swine diets should be based on the true digestible phosphorous supply. At present, only phosphorous availability values measured by the slope-ratio assay have been listed in some feedstuffs for pigs in the recently revised NRC (1998).

The central issue is to measure true phosphorous digestibility. To date, there are no literature reports on the determination of endogenous phosphorous recovery and true phosphorous digestibility values in feedstuffs for pigs. A valid methodology needs to be developed for this purpose. Furthermore, quantitative relationships between exogenous microbial phytase supplementation and true phosphorous digestibility values are not established. All these factors cause large confusion and inaccuracy in swine diet formulation.

Anticipated goals

The three-phase project has three major objectives: 1) developing a valid methodology for the determination of true

phosphorous digestibility; 2) investigating factors affecting true phosphorous digestibility values; 3) establishing quantitative relationship between exogenous phytase supplementation and formulation of diets with true digestible phosphorous supply on total phosphorous excretion in swine manure.

IMPACT

The Ontario and Canadian swine feed industry and pork producers will first and directly benefit from the research results that are being generated from this project in the following areas: 1) reduction in the use of inorganic phosphorous in diet formulation and associated costs; 2) expected decrease in phosphorous excretion in swine slurry; 3) increased sustainability of swine production. Indirectly, this project will lead to the reduction in phosphorous-associated pollution to our environment. University professionals, feed industry nutritionists, the Canadian Pork Council, provincial pork producers marketing boards and provincial swine specialists can be involved in technology transfer and extension.

RESULTS

This is a three-year project. This project has been funded by OPPMB and the HEMS program by CPC since April, 1999. For phase 1 studies (the first year), we have been focusing on developing a valid methodology for the determination of true phosphorous digestibility and on investigating factors affecting true phosphorous digestibility values. We have conducted two animal trials to develop a methodology for the measurements of true phosphorous digestibility in feedstuffs for pigs. In the first animal trial with weanling piglets, we have formulated semi-purified diets containing graded levels of phosphorous from monobasic potassium phosphate to determine true phosphorous digestibility and endogenous phosphorous recovery with phosphorous-free diet approach. Unfortunately, we found that pigs were very sensitive to phosphorous status. Pigs, especially weanling piglets could not maintain normal physiological functions under the phosphorous-free diets.

We have thus concluded that phosphorous-free diet is not a valid approach for the measurements of gastrointestinal endogenous phosphorous recovery and true phosphorous digestibility values. Alternatively in the second animal trial with weanling pigs, we have chosen to use soybean meal as a "model feed ingredient" to examine whether the regression analysis technique, a technique that we have used previously for the determination of true ileal amino acid digestibility in feedstuffs (Fan et al. 1997), is suitable for the determination of true phosphorous digestibility in feedstuffs. In this study, four corn starch-based semi-purified diets were formulated to contain graded levels of phosphorous from soybean meal at the inclusion levels of 13.6, 27.3, 40.9 and 54.6%, on as-fed basis, respectively.

The reason for choosing soybean meal is that, firstly, phosphorous content in soybean meal is relatively high (0.6-0.7% on as-fed basis). Secondly, soybean meal is the major protein supplement for most hog producers. Therefore, reliable results on true phosphorous digestibility values in soybean meal will result in immediate and important implication in the hog industry in terms of phosphorous nutrition, feed costs and ecological significance. Apparent and true ileal and fecal phosphorous digestibility values in soybean meal have been determined in weanling piglets (8-20 kg), as shown in Figures 1 and 2. As clearly demonstrated, apparent ileal and fecal phosphorous digestibility values are significantly affected by the inclusion levels of the assay ingredient (soybean meal) in assay diets (Figures 1 and 2) because of the relatively large contribution from the endogenous phosphorous recovery.

These results explained the real reason for the large variation in apparent fecal phosphorous digestibility values within the same feedstuffs for pigs that were mainly reported by researchers in the Netherlands. For example, apparent fecal phosphorous digestibility values in soybean meal were 15-34% for growing-finishing pigs (Jongbloed et al., 1991). Although intrinsic factors such as processing conditions and differences in phytate-phosphorous content were, in part, responsible for the variation, a large portion of the variation was likely due to the measurement condition, i.e., the inclusion levels of assay ingredients in experimental diets. Furthermore, true ileal and fecal phosphorous digestibility values in soybean meal were determined to be 47.6%±8.1 and 43.4%±5.8, respectively, in weanling pigs from this study.

Furthermore, there were no differences ($P > 0.05$) between true ileal and fecal phosphorous digestibility values, suggesting that the large intestine does not contribute to additional phosphorous digestion and absorption in weanling pigs. Phosphorous availability in soybean meal, as determined by the slope-ratio assay, was 31% in growing-finishing pigs as reported by the new NRC (1998). The average phosphorous digestibility in soybean meal was reported to be 24%±8 in growing-finishing pigs by the Dutch scientists (Jongbloed et al., 1991). Therefore, we can conclude that the

current parameters of phosphorous bioavailability in soybean meal for growing-finishing pigs are underestimated by at least 15-22%. This is also likely true for all other feed ingredients. These results support our original hypothesis that phosphorous digestibility values in feedstuffs are currently overestimated by about 15-25%. Assuming a saving of $1.00 for marketing each pig by using 20% less inorganic phosphorous, this represents about $1.95 million alone in Ontario (4 million pigs) and $8.1 million for all Canadian hog producers (using the figure of 17 million pigs) in swine feed costs. The dietary strategy of formulation of diet on the basis of true digestible phosphorous supply represents huge net profits ($1.95 million for Ontario hog producers and $8.1 million for all Canadian hog producers) annually. Furthermore, because of reduction in phosphorous input into hog production system, we expect about 20% reduction in phosphorous excretion in swine slurry (about 740 tons P/year in Ontario and 3145 tons P/year in Canada), a significant contribution to the protection of our environment.

INFLUENCING FACTORS

We have now established a valid methodology for the measurement of true digestive utilization of phosphorous in feedstuffs for pigs. We have also proven that the current data of phosphorous digestibility and availability values are underestimated by about 20%. Therefore, extensive funding support is needed to determine true phosphorous digestibility values in commonly used feed ingredients for different types (weanling, growing-finishing and breeding pigs) and different breeds of pigs to ensure that diet formulation can be formulated on the basis of true digestible phosphorous supply according to established new data. Therefore, funding support is crucial for the expansion and more efficient conduction of the proposed project.

DISCUSSION AND CONCLUSIONS

We have established a valid mehodology for the determination of true phosphorous digestibility values in feedstuffs for pigs. As determined with our "model feedstuff" (soybean meal), phosphorous digestibility in feedstuffs is underestimated by at least about 20%. Formulation of swine diets on the basis of true digestible phosphorous supply will significantly cut down the feed costs. This dietary strategy will also significantly reduce phosphorous pollution related pressure to our hog production system and to our environment. In order to carry out this dietary strategy, it is essential to have sufficient funding support to determine true phosphorous digestibility values in different feedstuffs and in various types and breeds of pigs.

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ACKNOWLEDGEMENTS

We are grateful to Ontario Pork Producers Marketing Board (OPPMB) and Agriculture and Agri-Food Canada (AAFC) and Canadian Pork Council (CPC) multi-partner Hog Environmental Management Strategy (HEMS) program for financial support. We would also like to thank Dr. W. Douglas Morrison for his time and input in preparing this manuscript.

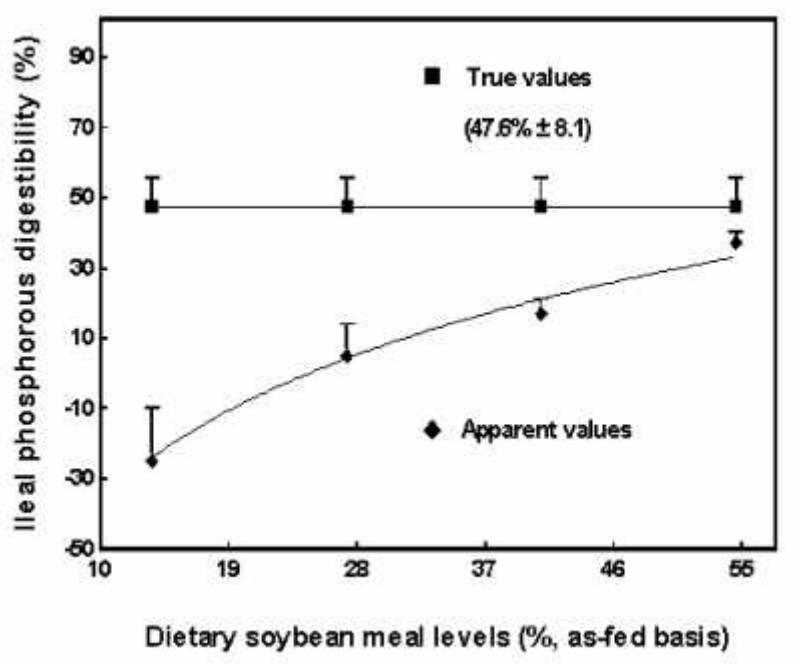

Figure 1. Apparent and true ileal phosphorous digestibility values in soybean meal for weanling pigs as determined at different inclusion levels of soybean meal.

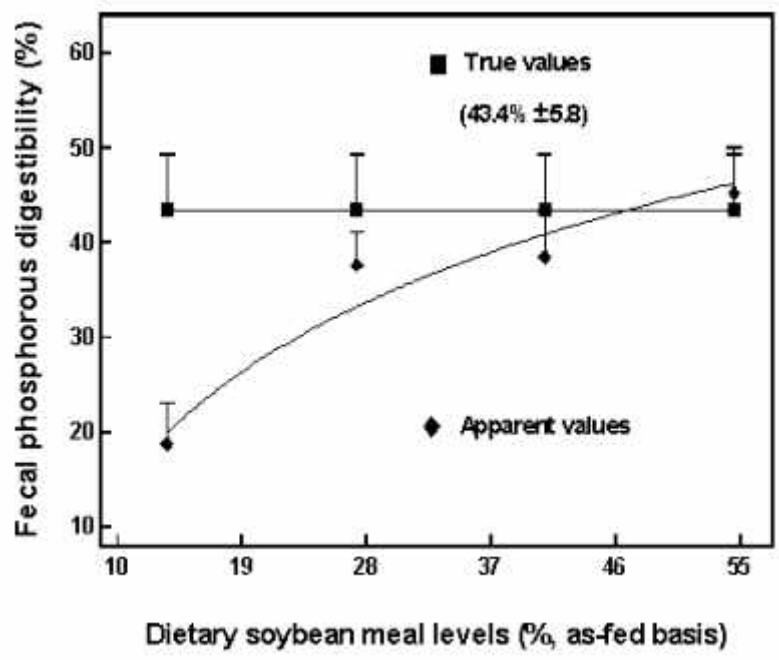

Figure 2. Apparent and true fecal phosphorous digestibility values in soybean meal for weanling pigs as determined at different inclusion levels of soybean meal.

Efficacy of Various Microbial Urease Inhibitors on Controlling Ammonia (NH_3) and Hydrogen Sulfide (H_2S) Emission from Swine Manure

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Background: More than 50% of the nitrogen from swine manure slurry is excreted as urinary urea. By the action of microbial urease, most of the urea nitrogen is readily converted to ammonia and vaporized into the atmosphere during storage and spreading. Ammonia along with hydrogen sulfide results in the deposition of nitrate and sulfate, creating acid rain that pollutes fresh water resources and acidifies soils and woodlands. Ammonia and hydrogen sulfide emission contribute to odor, a major disturbance to local residents. In addition, the loss of ammonia largely reduces the fertilizer value of swine slurry for crops. Therefore, strategies that can stabilize swine manure urea nitrogen and prevent ammonia loss will reduce pollution and swine odor and improve the fertilizer value of swine manure for crops.

Anticipated goals: Various microbial urease inhibitors (i.e., acetohydroxamic acid, AHA; cyclohexylphosphoric triamide, CHPT; phenyl phosphorodiamidate, PPDA; and n-(n-butyl) thiophosphoric triamide, NBPT) are potentially effective in inhibiting microbial urease activity and preventing ammonia-nitrogen losses from swine slurry. Reduction in ammonia emission likely changes the pH of manure slurry; thus the use of urease inhibitors may also decrease the emission of hydrogen sulfide, another major odor-causing compound. The purpose of this project is to assess the relative efficacy, effective application dosages and frequency of application of various urease inhibitors on the control of ammonia emission from swine slurry. A secondary objective is to examine whether application of urease inhibitors can also decrease hydrogen sulfide emission from swine slurry.

IMPACT

Ontario and Canadian pork producers will first and directly benefit from the research results that have being generated from this project in the following areas: 1) reduction of ammonia and nitrate pollution to air in swine barn conditions; 2) increased fertilizer value of swine slurry; 3) increased sustainability of swine production. Indirectly, this project will lead to the reduction in ammonia emission and associated nitrate pollution to our environment. University professionals, the Canadian Pork Council, provincial pork producers marketing boards and provincial swine specialists can be involved in related technology transfer and extension.

RESULTS

This is a one-year project. This project has been funded by OPPMB and the HEMS program from CPC since April, 1999. We have added an additional endpoint measurement of hydrogen sulfide emission, as this compound is also a key pollutant. There are two stages for this project. For phase 1, we have developed an in vitro NH_3 and H_2S trapping system for quantitative measurement of NH_3 and H_2S emission from a known amount of swine slurry at room temperature. Specifically, six aliquots of 1.5 kg of slurry treated with different levels of a urease inhibitor were placed into six glass filtration flasks connected to a vacuum source. Airflow rate (8 L/h) is controlled by a flow meter. The air leaves the filtration flask and goes through a corresponding trapping solution in a trapping flask. The trapping solutions are 2% boric acid for NH_3, and cadmium sulfate-based solution for H_2S. Sample solutions (50 mL for NH_3 and 50.6 mL for H_2S) from the trapping flasks are taken at different time points for the determination of NH_3 and H_2S concentrations.

The concentration of NH_3 in the trapping solution is measured through titration with 0.1 N HCl. The concentration of H_2S in the trapping solutions is measured according to a spectrophotometric-based procedure. Using this system, the effects of various urease inhibitors on ammonia and hydrogen sulfide emissions from swine slurry can be investigated at different dosages and time points under relatively stable temperature condition. Since the amount of fresh slurry and its dry matter content placed in each flask is known, effective dosages of urease inhibitors, potential costs for urease inhibitors, duration of application time and expected reduction in NH_3 and H_2S emission can be quantified and then extrapolated to hog farm situations.

We are now in phase 2 stage of the project. We are in the process of testing the effects of the first urease inhibitor, n-(n-butyl) thiophosphoric triamide (NBPT), on ammonia and hydrogen sulfide emissions. We plan to repeat the dose-response experiment four times for each urease inhibitor, thus we expect to finish the project in May, 2000. The preliminary urease inhibitor dosages used are 0, 0.2, 0.4, 0.6, 0.8 and 1.0 g/kg dry matter (DM) slurry. The use of urease inhibitor at the designed levels changed slurry pH slightly. pH values in the treated slurry ranged from 7.8-8.3. As shown in Figure 1, treatment of swine slurry with 0.8 g NBPT/kg DM slurry had the most significant inhibition of ammonia emission. This inhibition could persist for at least up to two days (Figure 1). Ammonia emission rates (g NH_3/kg fresh slurry.24h) under different dosages of urease inhibitors are presented in Figure 2. Use of as little as 0.8 g/kg DM slurry reduced ammonia emission rates from 0.31 g (control) to 0.14 g/per kg fresh slurry in one day (Figure 2). However, this is our first experiment. Studies are still going on to examine effects of much higher dosages of this urease inhibitor on ammonia emission and to repeat a few more times to confirm the observation. Furthermore, under the same experimental condition, effects of the urease inhibitor (NBPT) on hydrogen sulfide emission were also examined (Figure 3). It was likely that treatment of swine slurry with urease inhibitor could inhibit hydrogen sulfide emission, however, the results of this preliminary study were not consistent (Figure 3).

INFLUENCING FACTORS

Our project is being conducted according to scheduled milestones. We believe that the results that are being obtained from our established trapping system in our laboratory conditions will be reliable to provide information on effects of application of urease inhibitors in swine slurry on costs, economical and ecological benefits. Thus, once efficacy, effective dosages and frequency of application have been established, recommendations for on-farm application shall be made. Currently, we are conducting the experiments with various urease inhibitors purchased from chemical companies. We are looking into other commercial fertilizer companies for long-term supply at much lower costs. Furthermore, in addition to comparing the efficacy of various urease inhibitors on the control of ammonia emission, we will also be looking into any possible side effects from these urease inhibitors. A suitable urease inhibitor will be selected and recommended for practical use on the basis of many of these factors. Since this is only a one-year project, continued funding support in this area of research will help develop effective strategies for the control of ammonia and hydrogen sulfide emission for hog producers.

DISCUSSION AND CONCLUSIONS

Our preliminary results indicate our newly established trapping system is very economical, efficient and effective to study strategies for the control of ammonia and hydrogen sulfide emission. Urease inhibitors are potentially very effective in controlling ammonia emission from swine slurry. Effective dosage of application will lead to reduction in ammonia-nitrogen losses and associated detrimental effects to the environment.

ACKNOWLEDGEMENTS

We are grateful to Ontario Pork Producers Marketing Board (OPPMB) and Agriculture and Agri-Food Canada (AAFC) and Canadian Pork Council (CPC) multi-partner Hog Environmental Management Strategy (HEMS) program for financial support. We would also like to thank Dr. W. Douglas Morrison for his time and input in preparing this manuscript.

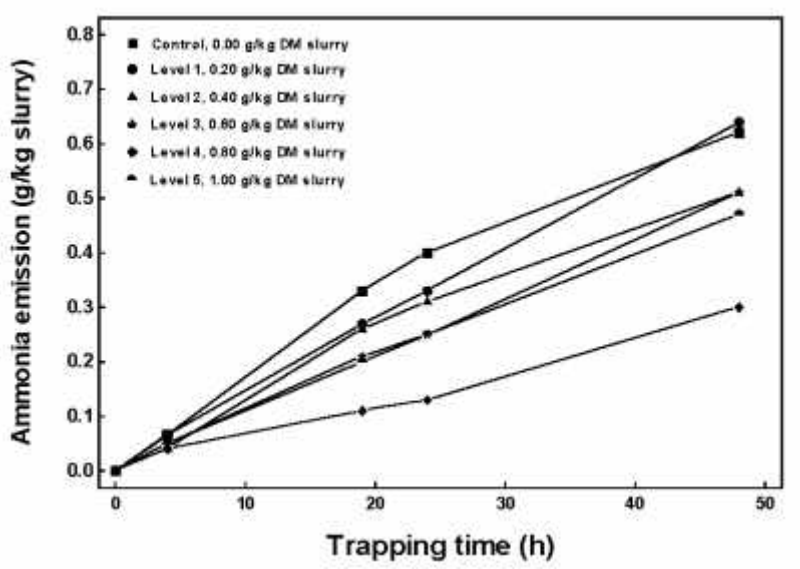

Figure 1. Time course of treating swine slurry with a urease inhibitor (n-(n-butyl) thiophosphoric triamide, NBPT) at various application dosages on ammonia (NH_3) emission measured with a trapping system recently established in our laboratory.

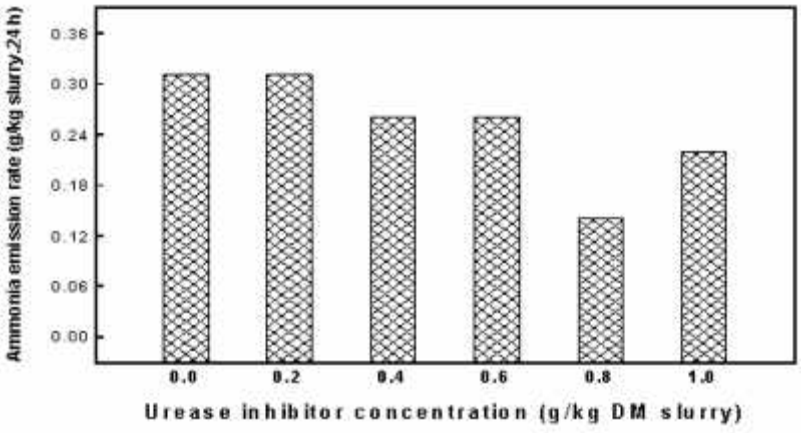

Figure 2. Effects of treating swine slurry with a urease inhibitor (n-(n-butyl) thiophosphoric triamide, NBPT) at various dosages on ammonia (NH_3) emission rates measured with a trapping system recently established in our laboratory.

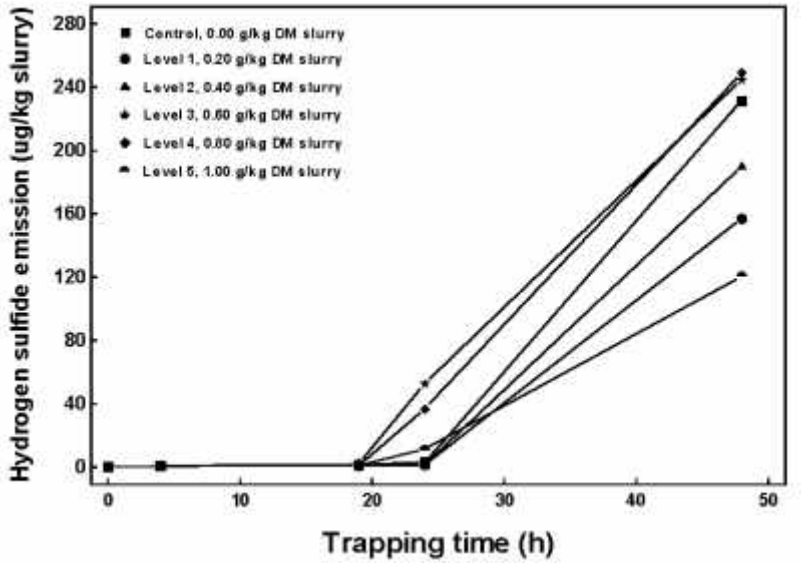

Figure 3. Time course of treating swine slurry with a urease inhibitor (n-(n-butyl) thiophosphoric triamide, NBPT) on hydrogen sulfide (H_2S) emission measured with a trapping system recently established in our laboratory.

Manipulation of Hindgut Fermentation to Reduce the Excretion of Selected Odor-Causing Compounds in Pigs

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Financial support: Agriculture and Agri-Food Canada (AAFC) and Canadian Pork Council (CPC) multi-partner Hog Environmental Management Strategy (HEMS) program.

Background

Odor associated with hog production has become a global environmental issue facing the Canadian pork industry. Nutritional strategies that can potentially decrease odor output from hog feeding operations will alleviate the pressure of hog feeding on the environment and enhance the sustainability of the hog industry. It has been well established that many volatile organic compounds emitted from swine manure are responsible for swine odor. These compounds are mainly ammonia, volatile sulfide compounds (e.g., hydrogen sulfide), short chain fatty acids, indoles (e.g., 3-methyl indole or skatole) and phenol compounds (e.g., p-cresol). This project is designed to investigate effects of several dietary strategies on reduction in the excretion and emission of some key odor-causing compounds from pig manure. These dietary strategies include adding suitable levels of water soluble and insoluble fibers, binding agents, organic acids or bicarbonate, anti-microbial agents, and lowering the crude protein levels by supplementing synthetic limiting amino acids in diets.

Anticipated goals

This is a 2-phase project. For phase-1 studies, we will first determine, under controlled feeding conditions, the treatment effects on the excretion and emission of some key odor-causing compounds in feces of individual pigs fed in metabolic crates. For phase-2 studies, we will then determine the best combination of treatments for odor reduction that will then be tested with a larger number of pigs under field conditions.

IMPACT

Control of odor problems was identified as a major research priority of many provincial swine producers marketing boards and the Canadian Pork Council as well as various organizations and agencies in the US swine industry and government. Reducing odor from hog production will remove a major nuisance factor and ensure a positive public perception of the hog industry. Public perception of hog production, particularly environmental impacts due to manure, is one of the most important factors affecting the Canadian pork industry's ability to meet market opportunities. This research program is a first major step in reducing the odor from hog production. University professionals, Canadian Pork Council, provincial pork producers marketing boards and provincial swine specialists can potentially involve in related technology transfer and extension.

RESULTS

This project has been founded by the HEMS program from CPC since January, 1999. For phase-1 research, three separate studies are being conducted to determine the effect of dietary sources and levels of fibers, binding agents, anti-microbial compounds and pH modifiers on the excretion and emission of some key odor-causing compounds from swine manure and slurry. The major odor-causing compounds (i.e., short chain fatty acids, skatole and p-cresol etc) in

fecal samples from pigs under different diet conditions will be measured by a gas chromatography-mass spectrometer (GC-MS) based procedure recently established in our laboratory. Ammonia/ammonium and hydrogen sulfide contents in fecal samples collected from different diet conditions are measured by spectrophotometric method.

The emission of ammonia and hydrogen sulfide not only contributes to causing acid rain, greenhouse effects and pollution to water resources, but also to odor. Thus, emission of ammonia and hydrogen sulfide from swine slurry (1 part fresh feces to 2.5 parts of urinary sample) collected from different feeding conditions are subsequently measured with a trapping system recently established under our laboratory conditions. For each study, five to six Yorkshire barrows (40-100 kg) are used. Each study is carried out according to a 5 x 5 or 6 x 6 Latin Square design. Three factors are involved in each study: treatments, animals and periods. Each experimental period will last for 14 days with 10 days of adaptation and 4 days of collection of representative fecal and urinary samples. Fecal samples will be quickly frozen, pulverized to be homogenous under liquid nitrogen and stored at -75°C for future analysis of ammonium/ammonia, hydrogen sulfide and several odor-causing compounds.

Study 1. This trial has examined the effect of two levels (4.5% and 9.0%) and two sources of dietary fibers (Solkafloc, a cellulose product and water insoluble fiber, pectin) on ammonia and hydrogen sulfide emission and the excretion of odor-causing compounds (acetic acid, propionic acid, 2-methylpropionic acid, hexanoic acid, 3-methylbutyric acid, 2-methyl butyric acid, pentanoic acid, P-cresol and skatole) in fresh feces. All experimental diets contained the same protein sources and levels of amino acids. We are still in the process of summarizing the data. Some preliminary results are presented here.

For ammonia and hydrogen sulfide emission, all results are currently expressed on the basis of wet weight of slurry and will be converted to dry matter slurry basis in the future (Figures 1 and 2). P-Cresol and skatole results are representatively presented for odor compounds (Figures 3 and 4). As shown in Figure 1, adding 4.5% cellulose and pectin to a regular corn and soybean meal based diet tends to decrease ammonia emission from swine slurry. However, only adding 9% cellulose to the basal diet could decrease hydrogen sulfide emission from swine slurry. Furthermore, adding these two types of fibers in the basal diet showed a trend to decrease the excretion of two key odor-causing compounds (P-cresol, Figure 3 and skatole, Figure 4) in fresh feces. However, at this time, no statistical analysis has been done on these data.

Trial 2. This trial has examined the effect of two sources of natural binding compounds (Diatomaceous earth and Zeolite) added at different levels (1.2, 2.4 and 3.6% and 0.6 and 1.2%, respectively) in the corn and soybean meal basal diet on ammonia and hydrogen sulfide emission and the excretion of odor-causing compounds (acetic acid, propionic acid, 2-methylpropionic acid, hexanoic acid, 3-methylbutyric acid, 2-methyl butyric acid, pentanoic acid, P-cresol and skatole) in feces. All experimental diets contained the same protein sources and levels of amino acids.

The major targeting odor-causing compounds are still being analyzed in our laboratory. At this time, we have presented the data on ammonia and hydrogen sulfide emission in response to different dietary treatments. It appeared that adding Diatomaceous earth and Zeolite to the basal diets could decrease ammonia emission from swine slurry (Figure 5). However, adding Diatomaceous earth and Zeolite in the basal diet did not seem to affect hydrogen sulfide emission (Figure 6).

Trial 3. This trial is still in the planning stage and will investigate the effects of adding two types of anti-microbial compounds and two pH modifiers to the same basal diet on ammonia, hydrogen sulfide emission and the excretion of key odor-causing compounds in growing-finishing pigs.

INFLUENCING FACTORS

Our ongoing studies clearly show that dietary manipulation does have effects on ammonia and hydrogen sulfide emission and the excretion of major odor-causing compounds. However, on the other hand, we can not expect to completely abolish the detrimental effects associated swine slurry through feeding strategies. Other methods to reduce and control odor emission from swine manure are also essential.

DISCUSSION AND CONCLUSIONS

Our preliminary results suggest that adding extra fiber to growing-finishing pig diets likely reduce ammonia emission from slurry during its early storage. Furthermore, feeding extra fiber to pigs likely decrease the production, excretion

and emission of major volatile odor-causing compounds to the environment. On the other hand, sine skatole and possibly some other volatile odor compounds are also responsible for the "off-flavor" in pork, feeding pigs with some extra fiber may also improve pork quality. In addition, feeding Diatomaceous earth and Zeolite can reduce ammonia emission from swine slurry.

ACKNOWLEDGEMENTS

We are grateful to Agriculture and Agri-Food Canada (AAFC) and Canadian Pork Council (CPC) multi-partner Hog Environmental Management Strategy (HEMS) program for financial support.

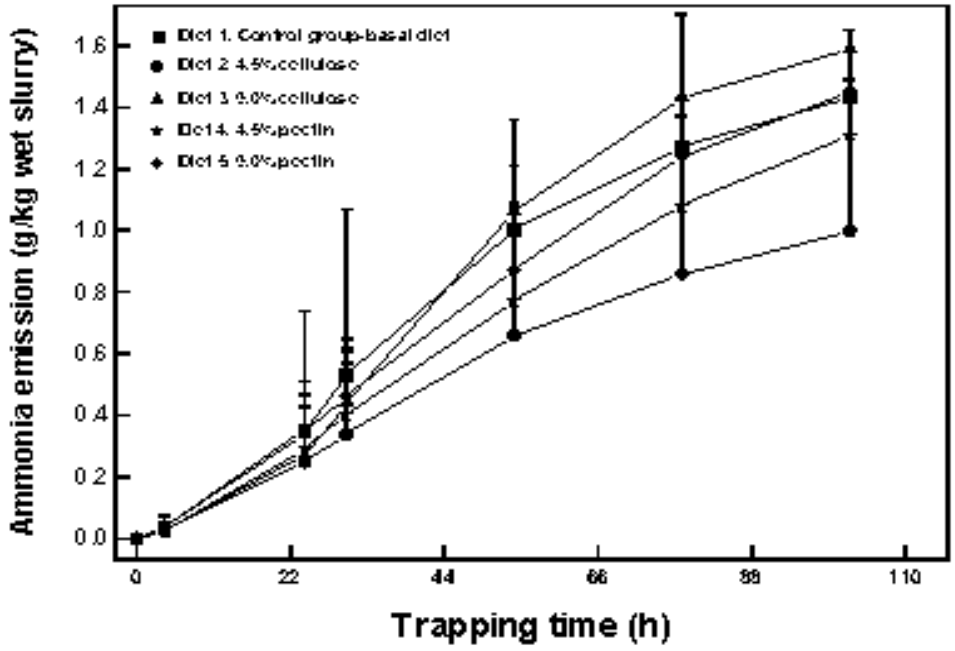

Figure 1. Effects of adding two sources of fiber (cellulose and pectin) in a corn and soybean meal basal diet on ammonia emission (mean ± SE, n = 5) from swine slurry.

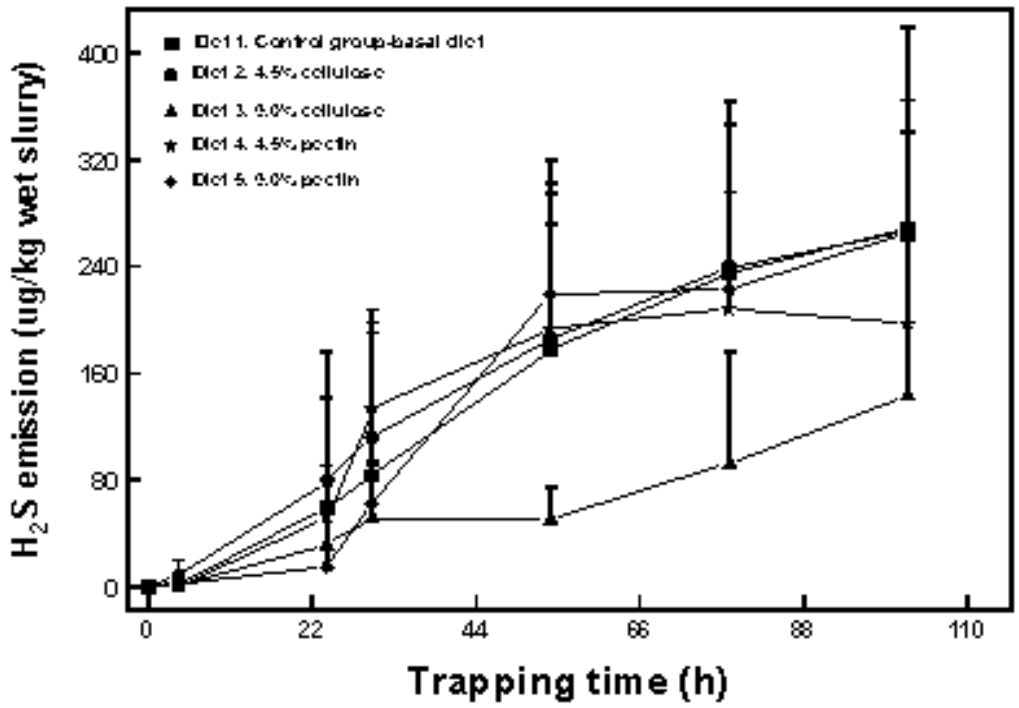

Figure 2. Effects of adding two sources of fiber (cellulose and pectin) in a corn and soybean meal basal diet on hydrogen sulfide emission (mean ± SE, n = 5) from swine slurry.

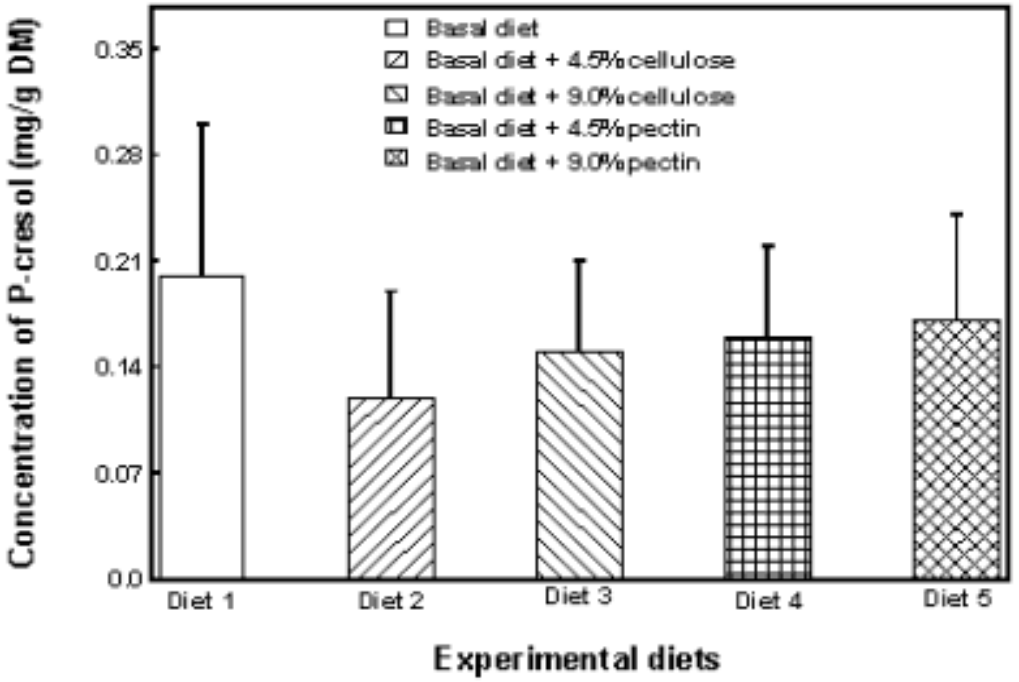

Figure 3. Effects of adding two sources of fiber (cellulose and pectin) in a corn and soybean meal basal diet on an odor compound (P-cresol) excretion (mean ± SE, n = 5) in feces.

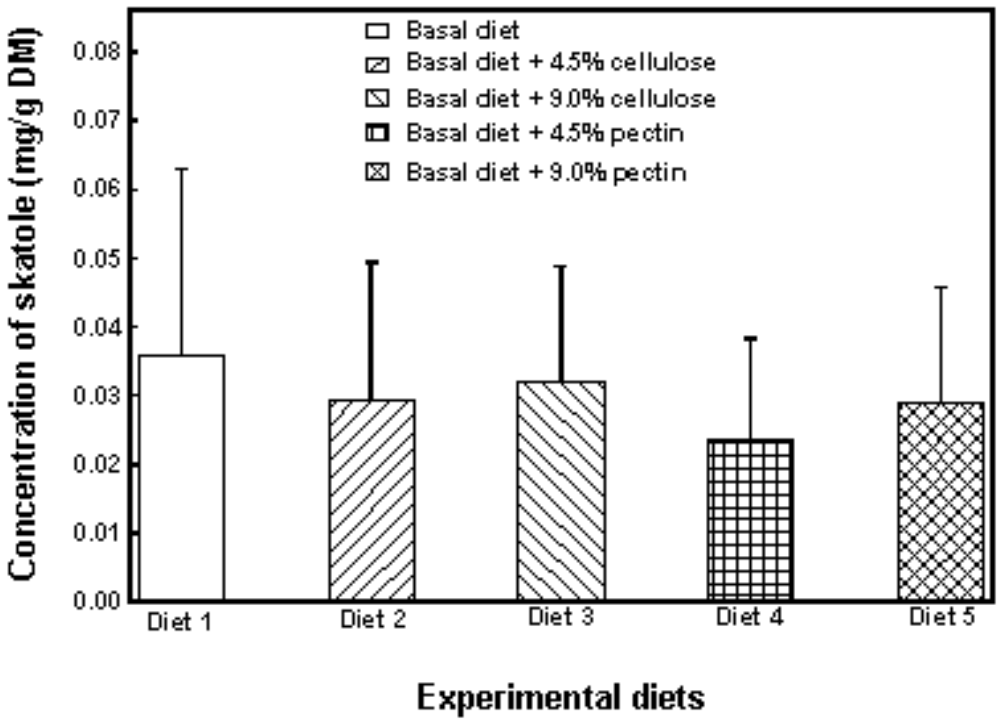

Figure 4. Effects of adding two sources of fiber (cellulose and pectin) in a corn and soybean meal basal diet on an odor compound (skatole) excretion (mean ± SE, n = 5) in feces.

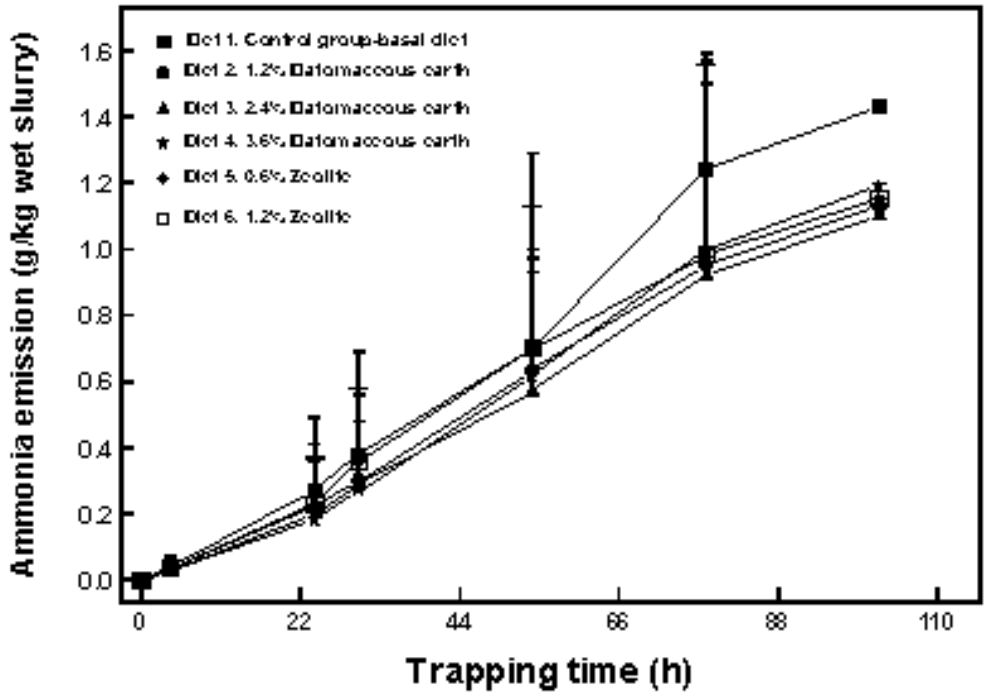

Figure 5. Effects of adding two types of binding agents (Datomaceous earth and Zeolite) in a corn and soybean meal basal diet on ammonia emission (mean ± SE, n = 5) from swine slurry.

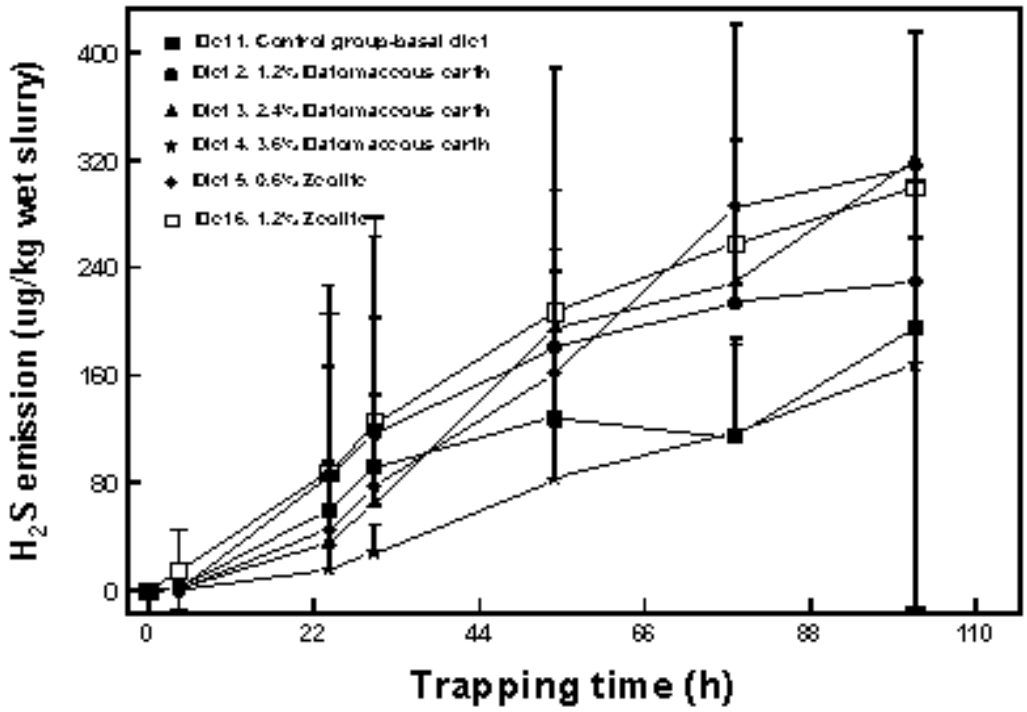

Figure 6. Effects of adding two types of binding agents (Datomaceous earth and Zeolite) in a corn and soybean meal basal diet on hydrogen sulfide emission (mean ± SE, n = 5) from swine slurry.

Reduction of odour and gas emissions from swine buildings: Construction and testing of the experimental setup

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OBJECTIVES

The overall goal of this project is to develop a combined engineering and nutrition strategy to reduce odour and gas emissions from swine buildings without impairing the pig performance. By reducing dust levels in pig barns, canola oil sprinkling combined with a specific dietary regime is expected to provide a significant reduction of odour and gas emissions from swine facilities. The specific objectives are:

Part I: Bench Scale Experiment

- To determine the interaction of four canola oil application rates and three experimental diets on odour, dust and gas emissions (CO_2, NH_3, H_2S) from bench scale finisher chambers.
- To determine the interaction of canola oil application rates and experimental diets on chemical manure composition as a function of time.

Part II: Full Scale Experiment

- To measure odour, dust and gas emissions (CO_2, NH_3, H_2S) from a full scale grower-finisher swine building using the optimum canola oil application rate and experimental diet regarding odour, dust and gas emission reduction.

The bench scale experiment is currently being completed at IRDA in Québec and the full scale experiment will be ran at PSCI over years 2 and 3 of this three years project.

REACH

Pork producers and the general public will directly benefit from that project. A reduction of building emissions by oil sprinkling and dietary manipulations will help swine producers to establish and maintain good relationships with neighbours and communities. Decreasing the industry potential impact on the environment will support current developments and assist Canadian pork producers to reach their full expansion potential. At the same time, the general public will enjoy more pleasant and sustainable environmental conditions. Although this research is primarily oriented toward pork production, proper dust control and nutrient management would certainly provide positive benefits regarding the environmental impact of other industries like dairy and poultry productions. Prairie Swine Centre Inc. supports technology transfer with a comprehensive program and a full time Manager-Information Services (Mr. Lee Whittington) and technology transfer is one of the CDPQ mission statements in Québec. The following publications will be considered for disseminating project results: PSCI quarterly newsletter and Annual Research Report, "Porc Québec" magazine which is distributed to pork producers and swine industry people (4500 copies five times a year), "Bulletin des agriculteurs" in Québec, the "Pork Producer" in Ontario, and the "Western Hog Journal" in the Prairies. Research results will also be presented to scientific conferences and industry symposia.

METHODOLOGY – PART I

Experimental Design

To determine the interaction of four oil application rates and three experimental diets, a 4 x 3 factorial design will be used and repeated four times. Twelve chambers are available allowing each treatment combination to be tested in each trial. Measurements will be collected over four trials providing four replicates for each treatment combination. Treatment combinations (oil application rate and diet) can be randomly allocated to chambers. Each chamber houses four pigs with an average weight ranging from 50 to 80 kg over four weeks, for each trial.

The Chambers

Twelve independent chambers (1.2 m x 2.44 m x 2.44 m) have been built. Each chamber is provided with an independent manure pit (0.3 m depth) which can be drained to a depth pit with a particular plug system. The floor is made of commercial concrete slats. Chamber walls have been built with conventional wood structure and plywood sheets and a polyethylene layer has been provided on both sides of the wall to ensure air tightness. All cracks between plywood sheets have been caulked carefully. Each chamber has its own individual door to give access to the room with a viewing window. The dry feeder can be filled from outside the chamber via an inclined plastic pipe. One water bowl per chamber ensures the water supply.

The ventilation rate is set to be identical in each chamber. Air inlet and outlet are located on the ceiling and a preheating duct ensures that a uniform temperature is being maintained in the chambers. Lighting schedule is 10 hr/day and incandescent bulbs are being used.

Measurements and Data Collection

Chamber air temperature and relative humidity are measured with type T thermocouples and electronic humidity sensors (Model CHG-UGS, TDK Corporation of America, IL). Total dust mass concentration and CO_2, NH_3, and H_2S concentrations are also monitored. All the instruments are connected to a centralised datalogger system (Model CR-7, Campbell Scientific Canada, AB). For the blank trial, each sensor is being scanned every 10 s and the average is recorded every 3 min. Gas concentrations are sequentially analysed every 15 min. Therefore, one measurement per chamber is being recorded every 3 hr.

For gas concentration measurements, air is sampled with a vacuum pump through teflon lines going from the chambers to the gas analysers. All sampling lines have been installed in a duct where the air temperature is maintained at 35°C to avoid any absorption through condensation. Carbon dioxide and NH_3 are measured with non-dispersive infrared spectroscopy and H_2S is evaluated with an electrochemical process. Total dust measurements are completed in collecting particles on a filter installed in a cassette for industrial air quality assessment. Dust mass concentration is established in weighing the amount of dust collected over a specific period of time at a known sampling rate (2 L/min).

Air samples for odour analysis are collected once a week in 80 L Tedlar bags and sent to the olfactometry laboratory of the Agriculture Canada Dairy and Swine Research and Development Centre at Lennoxville, QC. Six panelits evaluate odour threshold, intensity and hedonic tone for each air samples within 24 h of the collection time.

Calibration and Testing

Different tests have been completed to verify the air ventilation rate and air tightness of each chamber. The air speed at each individual air inlets was calibrated with a hot wire anemometer and some smoke tests allowed for checking any leakage from the chambers. Based on those tests, the chambers are very tight and provide a similar air exchange rate.

The blank trial was initiated on November 22nd, 1999 which means that only few observations can be presented here. Figure 1 shows the air temperature and relative humidity in two chambers for three days (before and after pigs were brought in). We can see that on the first day (without any pig in the chambers), similar temperature and relative humidity were observed in both chambers. When pigs came in, more heat and moisture were produced and the value of both parameters increased. An expected increase in CO_2 production can also be noticed on Figure 2. The NH_3 concentration went up and down at the same period of the day and it has not been explained yet.

INFLUENCING FACTORS

The cost of implementing this combined strategy to reduce building odour and gas emissions can be a determining factor to its adoption by the industry. If the highest oil application rate needs to be combined with the low crude protein diet to have sufficient impacts on emissions, the cost of using this strategy will become significant. In this case, it will be implemented only in extreme conditions where the producer will be forced to control emissions.

The public perception on swine odours can also represent a key factor. Even if a 50 to 60% emission reduction is achieved with this strategy, a fraction of the population may still complain about pig barn odours and the risk of an environmental impact. In some circumstances, the strategy will likely be of limited assistance to address concerns of unpleased neighbours.

DISCUSSION

This three years project evaluates the impact of four different canola oil application rates combined with specific diet formulations on odour and gas emissions from grower-finisher swine buildings. This strategy, combining engineering and nutrition expertise, is expected to significantly reduce the potential impact of the pig barn on its surroundings.

Over the first year of the project, an experimental setup of twelve independent chambers housing four finisher pigs was built. Those chambers are provided with uniform heating and ventilation rates, and with various instruments to continuously measure temperature, relative humidity, dust particles and gas concentrations and to collect odour samples.

This laboratory setup will be used to measure effects of different treatment combinations. The whole setup was calibrated and is now being tested over a complete blank trial to fine tune experimental procedures and data collection system and processes. Laboratory measurements will be collected over four trials, lasting four weeks each, and all those results are expected to be available in July 2000. Based on the treatment efficiency with the laboratory setup, the most promising combination of oil application rate and diet formulation will be selected for the full-scale experiment at PSCI scheduled from September 2000 until August 2001. The final report will be available in spring of 2002.

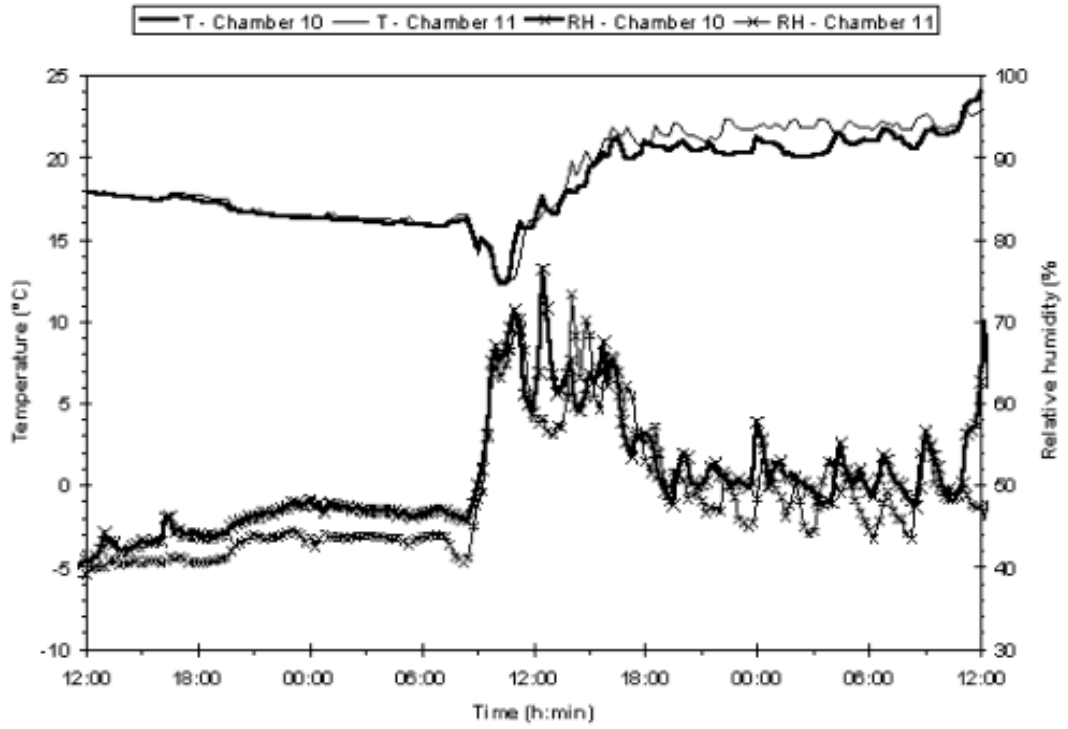

Figure 1. Air temperature and relative humidity in chambers 10 and 11 from November 21 st to 23 rd , 1999.

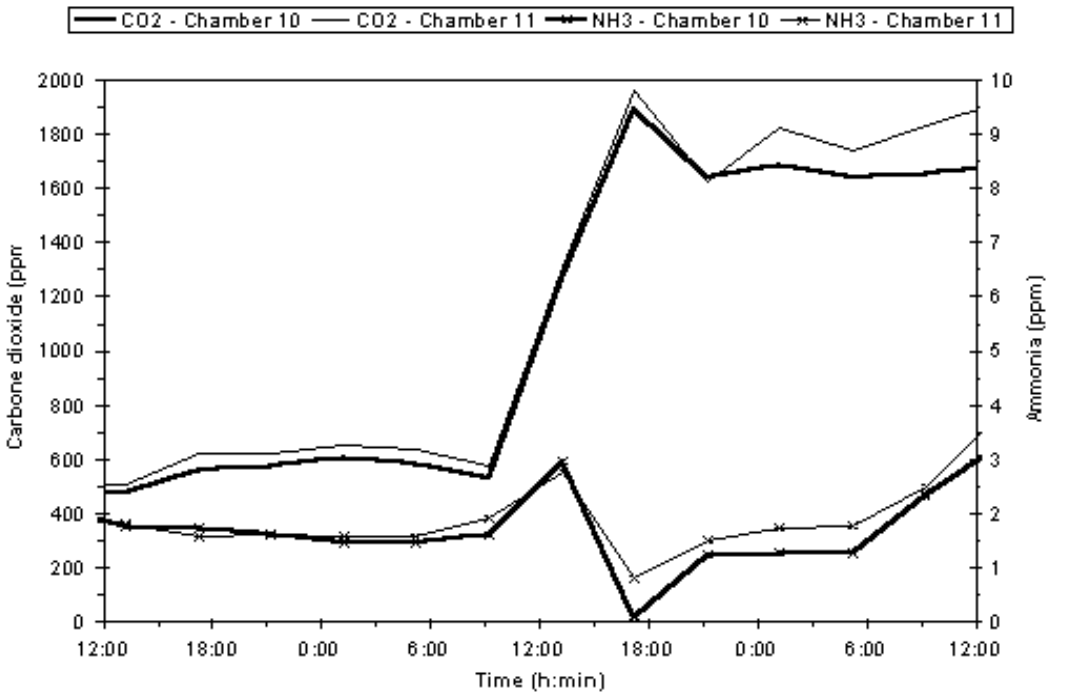

Figure 2. Carbon dioxide and ammonia concentrations in chambers 10 and 11 from November 21 st to 23 rd , 1999.

Development of a Negative Air Pressure Cover System for Earthen Manure Storages

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Canada R1A 3N5

PROFILE

Description:

Controlling odour is the major challenge facing expansion of the livestock industry in Western Canada. One of the major sources of odours in livestock operations, counting for approximately 30% of odour complains, is manure storage facilities. The use of covers can reduce odour and gas emissions from manure storage basins by 70-95%.

In this project the feasibility of a negative air pressure cover concept for earthen manure storages was demonstrated in a full-scale field trial. The selected site for the project was a 600 sow, farrow to finish, barn near Winnipeg, Manitoba. The earthen manure storage on the site consists of two cells, a primary cell with dimensions of 140' x140' x10' and a secondary cell with dimensions of 140' x390' x10'. The manure storage cells were covered with 20 mil reinforced polyethylene plastic sheets. The cover on the first cell was anchored and sealed around the edges by using sandbags. Sandbags permit temporary removal of cover for agitation and pump-out. The cover of the second cell was permanently sealed around the edge by trenching and backfilling. The negative air pressure was provided by a system of perforated pipe and fans. The perforated pipe (4 inches diameter) was located under the covers around the perimeter of storage basins. The pipe system of each basin was then connected to a high pressure fan (1/3 hp) stationed outside the cover.

The performance of this cover system with regard to cover stability, the negative air pressure system, the perimeter anchorage system, the fans' exhaust-air composition, and the impact on odour reduction were evaluated for a period of one year.

Name of Participants:

- Manitoba Livestock Manure Management Initiative
- Canadian Pork Council
- Triple S Community Future Development Corp.
- DGH Engineering Ltd.

Project Objectives:

- Demonstration and performance evaluation of the negative air pressure cover system under field conditions.
- Investigation of the cover reliability considering the effects of wind, snow and ice.
- Evaluation of different system for anchorage of the cover's edge
- Impact of the cover on odour reduction around the storage area

REACH

The use of a plastic cover anchored with negative air pressure will provide livestock producers with a simple/inexpensive method to eliminate the odours associated with manure storages. This cover system will significantly improve waste storage management strategies for livestock facilities especially those that are near more densely populated areas. The technology will enhance the quality of life of those people who live in the vicinity of livestock production units. The public is the indirect benefactor of this technology due to the reduction of potential odours, flies and greenhouse gases. Farmers will benefit from the additional nutrients available for crop production.

RESULTS

Both covers were extremely stable under a variety of weather conditions. Since the installation of the covers there have been several periods of high winds with wind gust velocities of approximately 115 km/hr. In spite of these winds, the covers were held tightly in place. The main force holding this cover system was the negative air pressure generated by the fans and the perforated pipe system. Negative air-pressure at the fans' inlet of both cells were in the range of 1 to 3 inches of water. Air flows in the exhaust systems of the covers were in the range of 100-350 cfm.

The evaluation of odour around the storage basins and the exhaust fans' outlets in this project was performed subjectively. The cover system virtually eliminated odour year round. During the summer months, a slight odour was detectable downwind and very close to the fan outlets. The cover system reduced odour because: 1) there was no direct exposure of stored manure to the air, 2) the surface of manure storage could not be disturbed by wind action, and 3) the gases and odourous compounds were gradually discharged at low air flows of approximately 100-350 cfm.

Accumulation of gas under the cover was observed from time to time in the form of separated gas pockets. The number and size of these gas bubbles and the frequency of their occurrence varied significantly depending upon weather conditions, the amount of precipitation accumulated on the top of the covers and the level of the manure in the storage basins. The gas bubbles were not persistent. Under windy conditions, especially when the levels of manure in the basins were high, the number and sizes of the bubbles decreased to almost zero as the wind pushed the bubbles to the sides of the basins where the gases could be released to the atmosphere through the perforated pipes and the exhaust fans.

The quality of the exhaust gas was measured in the fans' inlet pipes for ammonia (NH3), hydrogen sulfide (H_2S) and methane (CH_4) on a regular basis using Drager tubes. Ammonia and hydrogen sulfide had concentrations of less than 5 and 2 ppm, respectively. Methane showed concentrations of less than 0.5% by volume in the exhaust gas. The low concentration of the measured gases, however, is not an indication of a lack of biological activities. Low concentrations are most likely due to a very low release of gas at the times that measurements were being taken. Moreover, a significant portion of the fan exhaust was probably the result of leakage at the cover perimeter seal. This leakage is clean ambient air and results in the dilution of the manure gases being monitored.

Precipitation in the form of rain accumulated on top of both covers in the spring and summer, at a depth that varied between approximately 0 to 12 inches depending on the rainfall intensity and evaporation. Snow accumulations following a snowfall were quickly removed by wind with the exception drifts that accumulated at the bottom of the berm. The accumulation of snow, ice and rainfall did not have any impact on the stability and performance of the cover system.

The sandbags provided a relatively stable anchorage system. However, they deteriorated over the year due to exposure to ultraviolet light. The trench and backfilling provided an excellent anchorage for the cover of the second cell. Trenching and backfilling is probably the most reliable and cost-effective method of anchorage when the cover is permanently located and there is no need for its removal.

INFLUENCING FACTORS

The concept for a negative air pressure cover was conceived by DGH Engineering Ltd. and tested through a prototype project funded by CMAAS (Canada Manitoba Agreement on Agricultural Sustainability). In this project a literature search determined that the concept had apparently never been tested. A one-year field test of a prototype proved the principle.

This full scale demonstration was made possible by funding agencies listed earlier. In addition the assistance and co-operation of the plastic supplier; Nilex Inc, as well as the farmer co-operator; Van Aert Farms was instrumental to the success of this project.

DISCUSSION, CONCLUSION

As a result of this project, the feasibility and practicality of the negative air pressure cover system was proven under Manitoba climatic and field conditions.

The developed cover system proved to have many advantages including:

- Year round control of odour from manure storage basin
- Cost-effectiveness ($0.40 to $0.50/$ft^2$, installed)
- Increase in the fertilizer value of manure due to the reduction in ammonia volatilization
- Prevention of precipitation entering the storage basins
- Elimination of a breeding habitat for flies

The odour production from the storage was negligible. During the summer when the storage was nearly full and the manure was warmest, the odour discharge from the fans was detectable downwind from and within a short distance of the fans. Otherwise odour was virtually not detectable.

The success of this project has resulted in DGH Engineering Ltd. patenting the technology. Commercialization of the technology has initiated with the installation of additional covers over one earthen storage in Manitoba and one in Alberta this fall. The technology is also undergoing evaluation as a cover for straw and forage stacks.

Novel Technology for Hog Manure Odour Control/Remediation

Principal Investigator: Mike Zaworotko, Ph.D.
University of Winnipeg*
Research Associate: Konstantin Domasevitch, Ph.D.
Research Assistant: Brian Moulton, B.Sc.
Undergraduate Research Assistants: Juli Nachtigall
Sarrah Carruthers
Teresa Wawrykow
Holly Gudbjartson

PROFILE

Preamble: Crystal engineering is a rapidly emerging cross-disciplinary field that, as its name implies, concerns the development of protocols for predicting and controlling the structure, and therefore the functional properties, of solids. Such properties range from the obvious, e.g. color, solubility and melting point, to polarity, porosity and conductivity. All of these properties are of great relevance to materials scientists and physicists. The recent emergence of crystal engineering can be attributed to the corresponding importance of supramolecular chemistry (i.e. how) and its relevance to areas as diverse as polymorphism in pharmaceuticals and dyes, nonlinear optics and high Tc superconductors (i.e. why). To practice crystal engineering it is necessary to understand the basic principles of molecular recognition, computational chemistry, applied spectroscopy, structural methods, synthetic strategy and applications of custom designed solids. The objective of this research project is twofold:

- to exploit the principals of crystal engineering to design and develop a novel class of porous solids that demonstrate specific sorption of gases typical in a manure rich environment
- to develop improved sensors for humidity, as well as for specific toxic emissions such as hydrogen sulfide or ammonia.

REACH

The primary target clients for this project will be manufacturers of agricultural control systems, in particular manufacturers of sensors that can either monitor the quantity of a known pollutant, or determine the composition of unknown samples. Identification and detection of pollutants from manure is critically important for developments in the areas of odor control and air and water pollution. The state-of-the-art in sensor technology in this context is inadequate and limits the effectiveness of control systems. The premise of the research is that "smart" porous materials with custom sorption properties can be designed using "crystal engineering". Such sensors should inevitably lead to a new generation of tailor-made sensors that could revolutionize technology related to odor problems that arise from storage and transportation of manure.

RESULTS

Short-term outcomes

The results to date have been largely of a scientific nature and concern the following:

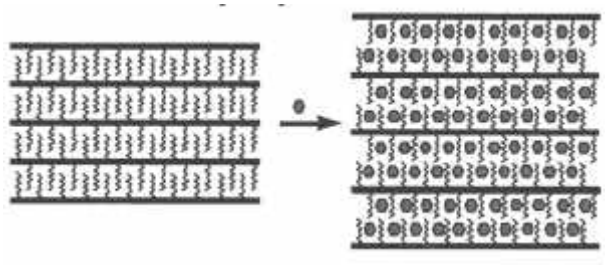
- evaluation of the relationship between structure and function in crystal engineered materials
- determination of the stability of crystal engineered materials in the presence of corrosive gases

Organic clays vs. coordination polymers: Two classes of materials were investigated: organic laminates or clays (i.e. based upon purely organic components) and metal-organic coordination polymers (i.e. based upon metals and organic molecules). The design of these materials is based upon the principles of crystal engineering i.e. the exploitation of the non-covalent bond to enable the assembly of chemical components into predictable networks.

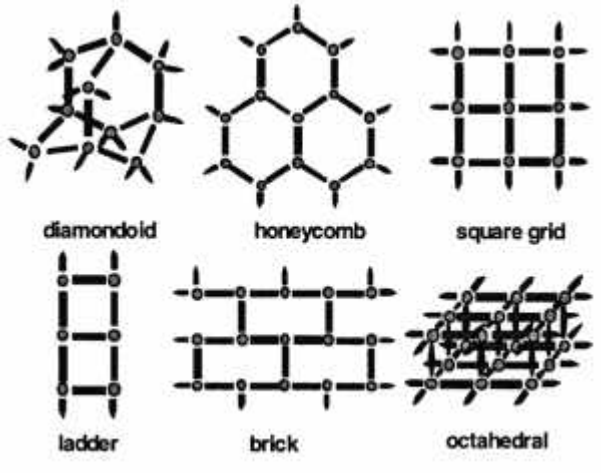
Organic laminates are designed by assembling polyfunctional carboxylic acids and disubstituted amines (Scheme 1), whereas metal-organic coordination polymers are assembled from metal nitrates (commonly nickel and cobalt) and polydentate bridging ligands (Scheme 2).

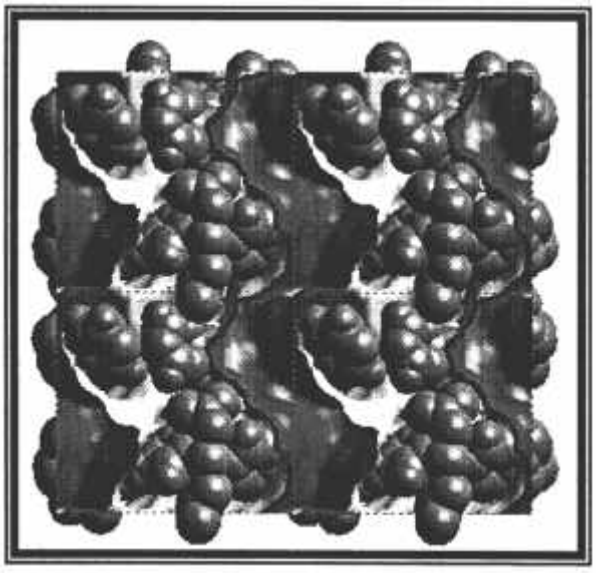
The organic laminates form 'sheets' that allow sorption of pollutants between the layers, which are able to expand like clays to accomodate chemicals or "guests" of various sizes. The substituents on the amine component of the sheet extend into the space between the layers and overlap with substituents from an adjacent sheet. The metal-organic materials form `channels' through which pollutants can be selectively adsorbed/ desorbed (Figure below).

Scheme 1. Organic clays and schematic of sorption properties



Scheme 2





Structure-function: Varying the nature of the substituents on the amine component of the organic laminates affords control over selectivity towards a target chemical. In principle, the sorbent materials can be designed to be hydrophilic or hydrophobic, or to have affinity towards a specific class of chemicals. For example, by using dibenzylamine in organic clays the materials preferentially adsorb small to large aromatic compounds. The metal-organic materials offer more flexibility in design and control of sorption properties. There are many different structures that can be formed depending on what metal is used, what bridging ligand is used, and what reaction conditions are used during the synthesis. Each structure has a fundamental difference in its sorption properties, and by selecting the appropriate

starting materials selectivity can be further fine-tuned. For example, three structural classes were tested for their relative adsorption of gaseous phenol with respect to activated carbon (the industry benchmark).

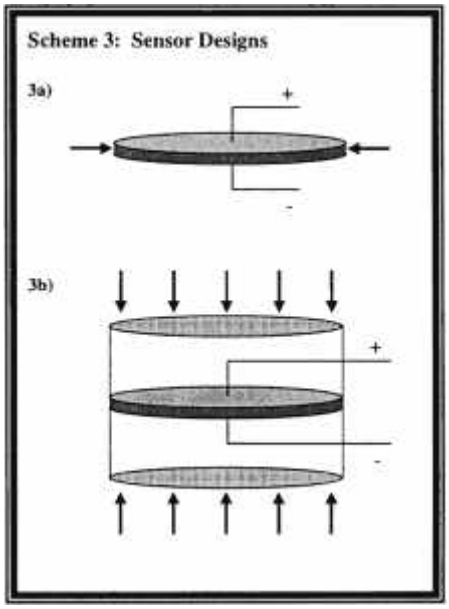
One structural class exhibits negligible adsorption, another is equivalent to activated carbon, and the third is nearly 3 times more effective than the industry standard.

Stability: The two classes of materials have a fundamental difference in their relative stability in an aqueous environment. Although both materials are slightly soluble in deionized water, the metal-organic coordination polymers are observed to be insoluble in alkali solutions and more soluble in acidic solutions, whereas the organic laminates are observed to be insoluble in acidic solutions and more soluble in alkali solutions. Therefore, any application of these materials for treatment of wastewater would require the use of the metal-organic class of material because the presence of ammonia, phosphates and nitrates in the water result in an alkaline environment. Both classes of materials have been shown to be indefinitely stable in the presence of high concentrations of ammonia and hydrogen sulfide gases. Further studies on thermal by TGA analyses revealed that metal-organic clays are stable to ca. 250°C whereas organic clays appear to be stable to 170°C.

The above means that these materials could be implemented in gaseous environments as sensors or filters.

Long-term outcomes

These materials might be incorporated into a prototypal sensor (Scheme 3). This schematic shows two possible designs for sensors based on our materials. 3b is the preferred design as it has a much greater surface area of exposed material and should therefore perform more efficiently and accurately. These designs are based upon an existing humidity sensor that is similar to 3a where a thin wafer of fiberglass separates two copper discs. The application of a sinusoidal voltage across the copper plates allows the monitoring of capacitance of the device, which changes with respect to the surrounding environment. In its current application the sensor is simply exposed to the air and changes in humidity can be correlated with a change in capacitance. 3a is a basic modification of this device that affords added control. The incorporation of our material allows sorption of a target gas into the wafer, thereby affecting the material's dielectric constant and consequently the capacitance of the device. Not only will this allow the device to be used in applications outside humidity sensing, but it should also improve upon the humidity sensing capabilities of the current device. **3b** exploits the properties of the existing technology without modification. The material surrounds the device and is placed in a porous container exposing a large surface area of the material to the environment, which allows efficient sorption. The capacitance of the device is monitored and changes are correlated with changes in the dielectric of the material as it adsorbs target gases. This device can be modified to detect specific target gases and can also be calibrated to yield information with respect to quantity.



INFLUENCING FACTORS

Several factors directed the research towards gas sensing devices:

- materials required for remediation of corrosive gases require the target gas to remain in the material; the sensors discussed above require materials that dynamically adsorb and desorb the target gas, meaning the physical properties of the compounds are related to the concentration of a target gas at any given time; ammonia and hydrogen sulfide tend towards the latter.
- discussions with LV Control (agricultural control systems engineering - Winnipeg, Manitoba) indicated inadequacies with current sensory technology.
- uncertainties in the solubility of the materials suggested gaseous applications as being more immediately advantageous.

It should be noted that these materials could be readily adapted to aqueous and remediation applications. More research needs to be done in these areas, however, before constructive conclusions can be drawn.

DISCUSSION, CONCLUSION

The materials developed during the course of this project show promise for application in agricultural control systems, particularly in new sensory devices. The materials are inexpensive and have proven to be both chemically and thermally stable to the extent that they would endure conditions present in a commercial application. Prototypal devices would have to be developed and tested with many of the new materials in order prior to commercial use. The thermal stability of the metal-organic clays could become important for practical purposes since it permits removal of even high boiling, non-volatile molecules. This would facilitate recycling of sensors if they have become saturated with organics: in principle, they could simply be placed in an oven for several minutes. New materials that "trap", as opposed to dynamically adsorb/ desorb, a target gas, which are as thermally stable, represent a possible alternative for selective remediation of manure related toxins/odors.

Future work, if this research were to be continued, could include:

- A detailed analytical evaluation of the materials developed in this project. Dr. Marc Lamoureux (Professor, Saint Mary's University – Halifax, NS) would be ideally situated for this research. Dr. Lamoureux has been involved in related projects, and has developed a protocol that can routinely test materials for their sorption with respect to activated carbon. The results, and subsequently the direction of the research, should be reviewed conjointly with a liaison from a company interested in sensory technology.
- Direct company involvement by assigning a devoted researcher to sensor development.
- Continued collaboration/consultation with the principal investigator.
- Protect the intellectual property in an appropriate manner. A patent application for composition of matter and applications of organic and metal-organic clays has been approved pending minor modification of the patent application. Additional intellectual property stemming from this research should be protected in a similar fashion.

Evaluation of Solid-Liquid Manure Separation Methods

R. Gordon, Nova Scotia Department of Agriculture & Marketing

Project team:

- Ms. Margaret Trias, Graduate Student, Department of Civil Engineering, DalTech, Halifax, N.S.
- Mr. Henry Vissers, Executive Director, Pork Nova Scotia, Truro, N.S.
- Dr. Robert Gordon, Associate Professor, Department of Agricultural Engineering, N.S. Agricultural College, Truro, N.S..
- Mr. Laurie Cochrane, Agricultural Engineer, N.S. Dept. of Agric. and Marketing, Truro, N.S.
- Dr. Graham Gagnon, Assistant Professor, Department of Civil Engineering, DalTech, Halifax, N.S.
- Dr. Ali Madani, Professor, Department of Agricultural Engineering, N.S. Agricultural College, Truro, N.S.
- Mr. Vernon Rodd, Manure Research Scientist, Agriculture and Agri-food Canada, Nappan, N.S.
- Mr. Carl Esau, Agricultural Engineer, N.S. Dept. of Agric. and Marketing, Truro, N.S.
- Mr. Bruce Bishop, Swine Specialist, N.S. Dept. of Agric. and Marketing, Truro, N.S.
- Mr. Robert Anderson, Environmental Technologies, N.S. Dept. of Env., Halifax, N.S.

Background:

The hog industry in North America is facing many economic challenges which are exacerbated by increased environmental pressures. These pressures include nuisance odours and water quality deterioration related to both nitrogen (N) and phosphorous (P) loading. Waste management strategies must be developed and tested to allow producers to comply with stringent environmental regulations while maintaining economically feasible farming operations.

Several possible waste management strategies in hog production systems can benefit from effective manure solid-liquid separation. This is due to the fact that separation provides a liquid fraction that is easily irrigated and requires less agitation than semi-solid manure. On the other hand, the solid fraction can be readily composted and has a tendency to retain a large portion of manure phosphorous and other nutrients. A possible swine manure management system could include: (i) storage of the liquid fraction in a aerobic treatment lagoon prior to being irrigated onto crop land or loaded into a constructed wetland system for final treatment and; (ii) economic and safe stabilization of the solid fraction (eg. composting to produce a valuable and possibly saleable end product).

As a result of the increased environmental challenges facing the hog sector and the surplus of precipitation (increasing the difficulty and costs of manure storage and handling) in Atlantic Canada, the use of solid-liquid separation systems has the potential to be an extremely beneficial management system for the industry. The difficulty is that little or no regional information exists on the performance of different separation systems. More specifically information is lacking on the ease of separation, its feasibility, the characterization of both fractions (i.e. moisture content, volume, N, P, pathogens, etc.) and the evaluation of both fractions in relation to their compostability (solid fraction) and possible treatment through constructed wetland systems (liquid fraction).

Project objectives and goals:

The overall goal of this investigation is to perform evaluations on various solid-liquid hog manure separation systems (mechanical and gravity). This includes the following objectives:

- perform a thorough literature review of various solid-liquid manure separation systems;
- evaluate the performance of various systems including: labour costs, ease, separation efficiency as well as the solid and liquid fractions in relation to the manure (i.e. N, P, pathogens, volume, mass, and moisture content); and
- perform an economic assessment of various systems.

A recent survey which focused on the identification of on-farm environmental management issues indicated that manure management is the primary issue facing the Atlantic Canada hog industry. This research investigation is providing individual hog producers with fundamental information on the performance and feasibility of solid-liquid hog manure separation systems. If viable, these systems can be implemented as integral components of hog operation management systems.

PROJECT RESULTS

This project was initiated this past April. To date the following activities related to the completion of the project by March 31, 2001 have been achieved:

- a thorough literature review of previous research on solid-liquid manure separation methods has been performed;
- monitoring protocols for system performance has been established;
- links with other research agencies and institutions throughout North America with similar research interests have been initiated;
- detailed monitoring to identify baseline performance of conventional gravity-based solid-liquid manure separation systems in Nova Scotia has been performed; and
- a detailed monitoring program of three mechanical systems on a single hog farm for the spring of 2000 has been organized.

Short-term communication activities:

Communication of project results to individual hog producers are being delivered through both Pork Nova Scotia and the Nova Scotia Department of Agriculture and Marketing. This will be achieved through the following activities:

- Pork Nova Scotia, Nova Scotia Agricultural College and Nova Scotia Department of Agriculture and Marketing newsletter articles;
- presentations at County and Provincial Federation of Agriculture Meetings, Pork Nova Scotia Annual Meeting and the Maritime Pork Conference; and
- preparation of a factsheet on solid-liquid separation methods.

Long-term deliverables and implications to the Atlantic Canada hog industry:

- a regional understanding and experience with hog manure solid-liquid separation systems;
- an understanding of the constituents of both the solid and liquid manure fractions from separated hog manure including fractional volumes, nitrogen concentrations, percentage solids, phosphorous concentrations, etc.;
- an understanding of the potential and feasibility of the separated solid fraction to be utilized as a soil amendment as either a compost or manure; and
- an understanding of the potential for the separated liquid fraction to be treated (12 month) in a constructed wetland system or irrigated onto existing farmland.

When completed we also anticipate that this project will assist with several on-farm manure management issues including:

- reducing plugging of manure transfer pipes;
- the phosphorous contained in solid fraction can be more easily managed;
- the development of an environmentally acceptable manure treatment system;
- the development of potential new markets offered by compost;
- increased manure storage capacity;
- reduced labour and maintenance costs for manure; and
- reduced on-farm odour.

Literature Review on the Use of Artificial Marshes for Manure Treatment

S. Pigeon, BPR and G. Roch,
Fédération des producteurs de porcs du Québec (FPPQ)

ANTICIPATED CONTRIBUTION

- All the hog producers in Quebec who have to cope with manure surpluses and have recourse to separation or a treatment.
- The hog production advisors are also targeted by the dissemination plan because of their important role ir transferring knowledge to the producers.

RESULTS

Short-term Impacts

- Dissemination of the results in the August 1999 *Porc Québec* journal through an interpretive article which deals with the principles of constructed wetlands and making the report on the literature review available to the producers and stakeholders in the agricultural sector.

Long-term Impacts

- Raising the producers' awareness of the use of constructed wetlands as a refining step prior to dumping previously treated breeding operation effluents into the waterways.
- Technology transfer of the knowledge about an agro-environmental hog production practice.
- Reduction of the constraints to the development of Quebec hog production in regions with a surplus.
- Improvement of the demand for pork because of an improved image of hog production.

DETERMINING FACTORS

The factors capable of hindering or encouraging recourse to constructed wetlands in hog production are:

- setting up efficient and cost-effective hog manure treatments;
- producers' economic situation;
- land-sharing status in the rural setting;
- government funding programs for the adoption of techniques to reduce the impact of hog production on the environment.

DISCUSSION

In the regions with high concentrations of breeding operations, the treatment of farm fertilizers seems to be an unavoidable solution for facilitating the export of excess fertilizer loads over great distances. Seeking effective and economic channels adapted to regional problems therefore constitutes a major issue.

In that context, the treatment of hog manure is aimed at extracting the greatest portion of its fertilizing load in an easily exported solid fraction. However, the great majority of the treatment technologies examined by the Technology Transfer Group generate at the same time a liquid fraction whose load is too high to be dumped directly into the waterway. This liquid fraction must therefore undergo a refining treatment prior to dumping. In this respect, the constructed wetland

represents an interesting solution for the refining of breeding operation effluents.

If the constructed wetland concept is attractive at first glance, its use nevertheless raises various types of questions, especially its efficiency under Quebec climate conditions, the problem of the system's saturation (loss of efficiency, useful life span, etc.), the level of contamination of the wetland's soil under hog operation conditions, as well as the real capital and operating costs.

A literature review was therefore carried out by BPR Groupe-conseil to collect the most recent information concerning the efficiency of this type of treatment under our conditions and to suggest recommendations to the various stakeholders in the field.

In the present context, the name "constructed wetland" encompasses all the artificial expanses where hog manure circulates and which are designed to treat it in a more or less complete manner. This treatment by constructed wetlands is performed primarily by different species of living organisms: bacteria, algae, plants, zooplankton, fish, etc. In this respect, it is meaningful to make a distinction between the following types of treatment: conventional lagooning, intensive lagooning, filtering wetlands and the reed field.

The use of constructed wetlands, known for many years for the treatment of urban or small community effluents, is relatively new for the treatment of hog manure. In this context, the following observations can be identified:

- The treatment of hog manure can be performed by a well-designed constructed wetland.
- Constructed wetland treatment is primarily biological in nature, with the result that its treatment performance is, generally speaking, highly influenced by the temperature.
- Because of the size of the surface area required for the treatment of raw manure, especially in the cases of conventional and intensive lagooning, the use of constructed wetlands should be contemplated for the final treatment (refining) of pre-treated hog manure.

On the other hand, reed field treatment stands out in several respects from other constructed wetlands. It requires a smaller surface area, is more efficient during the winter months and limits the emission of nauseating odours and the production of insect larvae. Furthermore, several avenues are emerging for improving its performance, as much for the life span of the system (enriched soil) as for the treated organics load (cascading treatment) and the recovery of the elements contained in the saturated soil. In spite of these advantages, it is necessary to consider the eventual saturation of the soil in a reed field and the turnover of that field. This involves the disposal of soil enriched with phosphorus and different minerals, as well as the reconstruction of the field.

As for the cost associated with this type of treatment, it varies primarily with the level of pre-treatment carried out on the raw hog manure. The construction cost would be in the range of $20 to $25 per square metre of field. On the other hand, maintenance is reduced to a minimum (no reed harvest) and consists primarily of maintaining the margins of the field.

Dissemination Plan

The dissemination of the findings of the constructed wetlands review started in August 1999 and is aimed at the producers and stakeholders in the field.

The dissemination activities completed in 1999 are:

- Article in the August 1999 Porc Québec journal.
- Submission of the final report of the Literature Review to the Technology Transfer Group.

Seepage and Contaminant Transport from Earthen Manure Storage Ponds in Alberta: Traditional and Innovative Investigation Techniques

W.R. (Bill) MacMillan,
Environmental Engineer, Alberta Agriculture, Red Deer, AB

PROFILE

Participating Organizations:

1. Alberta Agriculture, Food and Rural Development (AAFRD)
2. Prairie Farm Rehabilitation Administration (PFRA)
3. Alberta Pork
4. University of Alberta (U of A)

Background

A pilot project was done in 1987/88 to investigate the use of geophysical techniques (EM 31, 34 and 38 and ERT) to investigate seepage and groundwater contamination from EMS ponds. In that project the techniques were shown to produce fast and reasonably reliable results. The three ponds that were investigated showed electromagnetic anomalies that were later shown to indicate groundwater contaminant plumes though conventional drilling and analysis. All of the seepage patterns discovered in the pilot were limited in their extent and severity, indicating that there may be preferential flow along fractures or other soil anomalies. It was determined from the pilot that a more thorough and careful evaluation is needed to investigate the mechanisms of seepage and to develop a protocol for interpretation of geophysical investigation results. This project is designed to meet these objectives.

The Earthen Manure Storage (EMS) Seepage Study was accepted for funding by Alberta Pork in fall of 1998. The objectives of the project are:

1. To determine the vertical and lateral extent of seepage and contaminant transport from EMS ponds sited on medium to fine textured, clay based soil parent materials for hog operations in Alberta.
2. To determine the factors that contribute to the potential for EMS ponds sited on medium to fine textured, clay based soil parent material to seep and transport contaminants to groundwater.
3. To determine if the GEONICS EM-31 electromagnetic inductance conductivity meter can be effectively used to investigate the possibility and extent of seepage and contaminant transport from EMS ponds sited on medium to fine textured, clay based soil parent material.
4. To determine if the GEONICS EM-31 electromagnetic inductance conductivity meter can be used effectively to assist in the design of an investigative drilling program aimed at determining the actual extent of seepage and contaminant transport from EMS ponds.

This study will proceed in a stepwise format that includes site selection, geophysical survey, drilling investigation (piezometer installation), sample analysis, data tabulation, data analysis and reporting of results. There are several funded components of the project that, when integrated, should ensure it's overall success. The HEMS program funding was awarded to augment the drilling investigation and laboratory analysis components of the study.

REACH

Due to long periods of cold weather conditions that result in frozen and snow covered ground conditions it is necessary to provide storage for liquid hog manure in Alberta. Earthen ponds are the single most used liquid manure containment

system used in Alberta due to economics and convenience. Recently, the pubic has been asking questions about the security and potential environmental impact of these, often unlined manure reservoirs. There is considerable evidence throughout the literature that physical, biological and chemical interactions at the manure-soil interface of EMS ponds create a hydraulic seal that retards seepage from these structures (Fonstad, 1996).

However, while the literature ensures us these seals do form, there are questions concerning the long-term durability and integrity of the sealing affect under field conditions (Hills, D.J., 1976, Barrington and Jutras, 1987 and Fonstad, 1996). Further, very little research has been done to investigate seal formation or seepage and contaminant transport from EMS ponds under Alberta's soil, climatic and hydrogeologic conditions. Research is needed to show whether or not, and under what conditions, these sealing mechanisms can be relied upon to prevent seepage from EMS reservoirs in Alberta.

This research project will focus on the factors that effect seepage and contaminant transport from EMS reservoirs in medium to fine textured soils. It will seek to identify the physical site characteristics that affect the potential for these ponds to leak and to develop construction protocols for developing EMS systems in these soil types. It will also attempt to answer questions about the field reliability of the sealing mechanisms previously shown to reduce seepage from these storage reservoirs

Considerable cost savings will be realized by the hog industry in Alberta if it can be shown that EMS ponds are a safe alternative for liquid manure storage. Construction protocols and investigative standards can be developed to reduce the cost of EMS development where secure site conditions prevail. An understanding of the factors governing seepage (or sealing) from EMS ponds will improve siting, design, and construction criteria for these facilities. Scientific evidence will help to assure the public that these structures do not pose a substantial risk to environmental quality. Improved public confidence in the environmental security of the hog production facilities should increase community acceptance while saving time and money for the hog industry and governments. This should also help to alleviate some of the reluctance demonstrated by neighbouring residences about new or expanding hog operations.

The research will also help to confirm the validity of using geophysical techniques for investigating suspected seepage from existing EMS reservoirs. Having simple, affordable investigation methods available will allow improved monitoring of existing and potentially problematic EMS ponds. Operators and the public can be offered peace of mind where the integrity of suspect EMS ponds can be quickly and affordably. Where the geophysical survey confirms a seepage problem, the technique can be used to focus the investigation on potential plume locations, thus saving considerable time and drilling costs.

Finally, full characterization of the site conditions of several EMS ponds that are shown to leak will allow computer-based models to be calibrated for future use. These models will be useful to predict seepage and contaminant transport rates from proposed ES ponds and answer, *what if?,* scenarios to improve storage design and reduce environmental risks. Models can also be used to analyze other EMS reservoirs with known seepage problems to predict the extent of contamination expected in the future and estimate the effectiveness of potential solutions.

RESULTS

To begin the site selection process Alberta Pork supplied us with their producer database. This database provided us with the land location and number of hogs marketed through the agency by just over twelve hundred (1200) producers. This database was arbitrarily culled to about six hundred (600) by assuming that only producers that market more that 900 hogs per year would be likely to have some form of liquid manure storage. A GIS system with the AGRASID soils database was used to identify the soil parent material at the location of each operation to identify the soil parent material for each site.

By consulting municipal maps and matching names to land locations, producers were identified by name. Phone numbers were then located by using the 411 directory on the Internet. Once names and phone numbers were secured a telephone survey was conducted to procure producer cooperators. Producers were asked; if they used an EMS pond, the age and size of the pond, when and how often they spread manure and if they would allow us to conduct an investigation at their site. To encourage cooperation, producers were offered a letter to confirm their participation in the study. Where an EMS site was found not to leak the letter will confirm that. Where seepage is suspected the cooperator will be given notice in confidence and provided with technical assistance to help resolve the problem.

About one hundred (100) producers agreed to cooperate in the study. Of these about thirty-five (35) site have been surveyed using the EM–31 to test for increased electrical conductivity (EC) levels. About three (3) of the sites surveyed showed evidence of elevated EC levels, indicating a seepage plume away from the EMS pond. A drilling investigation has been conducted on these three (3) sites and an equal number of sites that were not shown to leak. The geophysical data was used to design the drilling program on the suspect sites. Piezometer installations were arranged to allow determination of flow direction and velocity in the horizontal and vertical directions.

Soil samples are being analyzed for chemical, physical and biological characteristics relevant to the detection of animal manure seepage plumes and for validation of geophysical survey results. Table 1 lists the soil parameters being measured to determine if seepage is occurring from the EMS. Chemical and biological data will be used to indicate the likelihood of seepage and contaminant movement from the ponds. Physical data will be used to characterize the soil and site conditions.

An equal number of sites that did not show an indication of seepage from the geophysical survey were also investigated. Drilling at these "negative" sites consisted of one hole on each side of the pond to a depth of eight meters. Samples were taken from each meter of depth for subsequent laboratory analysis. Soils data from both the "negative" and "positive" sites will be compared to the EM-31 survey data to assess the reliability of the geophysical investigation for detecting seepage plumes.

Chemical	Physical	Biological
CEC	Bulk Density	Fecal Coliform
Sodium Adsorption Ratio (SAR)	Hydraulic Conductivity	Total Coliform
pH	Particle Size Distribution	
Electrical Conductivity (EC)	Atterberg Limits	
Nitrate	Moisture Content	
Ammonia	Porosity (Calc.)	
TK- Nitrogen		
Potassium		
Chloride		

Table 1: The laboratory measured parameters of soil samples taken from the EMS sites

Samples of the data received from the first site investigation are presented in the Appendix. As very little data has been returned from the laboratory the discussion will focus on understanding the data received from the one site for which data is available.

INFLUENCING FACTORS

One of the major influencing factors on this project has been the difficulty that we have experienced in procuring cooperators. Low pork prices and fears regarding public perceptions and legal liability combined to result in reluctant and often angry producers that lack enthusiasm to cooperate with either government or Alberta Pork.

Other factors that have slowed our progress on this project are staff shortages, unusually wet summer weather, lack of laboratory results, biosecurity protocols and funding timeliness. Although necessary, biosecurity protocols often prevent us from expediently proceeding between site locations. As we are never actually entering any barns, I sometimes question the necessity of the strict security rules that we are sometimes subjected to by cooperating producers.

DISCUSSION

The figures in the Appendix show data for Site #1. Figure 1 shows an EC spike at about 6.5 to 7.5 meters. This test hole was located in the center of the plume projected by the geophysical investigation. The EM-31 measures average EC levels to a depth of about 6 meters, so the EC spike was expected at this location but was should have been higher within the profile. The EC spike coincides with a spike in the Calcium content of the soil. Oddly chloride concentrations decrease at this depth compared to those higher in the profile. Nitrate and ammonia concentrations were also very low at this depth, as they were throughout the profile. The soils at the bottom of the test hole were classified as loamy sand and are characterized by a low CEC of 6.9 meq/100 g, making the calcium concentration spike difficult to explain.

Figure 2 show the relationship between soil texture, Ksat and moisture content. Soil moisture content increased as depth throughout the profile at this test location indicating a downward moisture flux. Soil hydraulic conductivity was relatively high (> 10-6 cm/sec), due to the sandy soils at this location, further indicating that soil water can be expected to move rapidly into the profile. The exception to this rule is the soil at the 0.6 – 1.2 meter depth, where the conductivity was less that 10-7 cm/sec. Figure 3 indicates that the 0.6 – 1.2 meter deep sample also had a spike in potassium concentrations. If seepage is occurring periodically from the pond into the sandy soils the increased potassium concentration here may result from adsorption of the ion by the sandy loam soil as it has a relatively high CEC (16.9 meq/100g). The soil may be absorbing and accumulating the potassium molecule as the result of historic of contaminated seepage events form the EMS pond.

A most striking feature of this site is the fact that the soils surrounding the reservoir were found to contain about 80% sand. One would expect to observe seepage and contaminant transport from the storage pond under these soil conditions. The literature suggests that under sandy soil conditions, even where hydraulic sealing does occur, manure nutrients are transported into the surrounding environment (Hart and Turner, 1965, Barrington and Jutras, 1987). However, in this case, the data does not indicate any obvious major nutrient transport phenomena. One possible explanation is that, since the soils are so course, seepage is occurring vertically through the bottom of the pond. All of our samples were taken from borings done along the sides of the storage facility. Therefore it is possible that we may have missed the seepage plume from this facility.

Some evidence of this may be found by examining the soil log and sample analysis of soils from a borehole completed into a swale well below the elevation of the storage (not shown). This log indicates that at this location, the sandy soils are underlain by a low permeability medium plastic clay loam soil (Ksat = 10-9 cm/sec). This soil had a relatively high CEC and displayed very high potassium and calcium concentrations (K = 96.5 mg/l, Ca = 30.2 mg/l). The sandy loam soil just above the clay layer was saturated and contained elevated levels of chlorides (21 mg/l) and potassium (70 mg/l). However, calcium concentrations here remained at levels similar to those found in the other soil logs. If this heavier clay layer exists as a continuous formation below the storage pond, one could theorize that seepage has occurred vertically through the bottom of the pond through course soil layers to the interface with the heavier clay oil zone. Contaminated groundwater flow could then have continued horizontally along the surface of the clay layer where cations were exchanged by diffusion into the clay layer, thus accounting for the elevated concentrations of calcium and potassium in the underlying clay soil zone.

CONCLUSION

The data available for the first site investigated with the use of conventional drilling and laboratory analysis is somewhat inconclusive. With some speculation and interpretation one can theorize about the possible explanation for the results. However, no positive conclusions about the source and mechanisms of seepage or contaminant transport from this EMS pond are possible. By employing sophisticated numerical modelling techniques, combined with the physical data w now have, one may be able to gain some further insight concerning the complex and somewhat confusing data gleaned from the investigation. The sampling protocol used at this site was somewhat unstructured and too much focus was placed on funding preservation. In hind sight one can see that a more structured sampling protocol would likely assist in the interpretation of the data. As a resulting of this experience a protocol has now been developed with an aim to ensure that data from future investigations will more fully characterize the sites and allow a more complete interpretation of our findings. That being said, the author still believes that the final results from this extensive investigation will allow some firm conclusions about the environmental risks related seepage from EMS ponds in Alberta. Results should also allow improved site assessment and EMS design criteria. This, in turn, will allow responsible and economic development of the hog industry in Alberta.

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APPENDIX

A NEW TECHNOLOGY FOR SEALING OF EARTHEN MANURE STORAGE STRUCTURES

A. E. Ghaly, Dalhousie University
A. Madami and R. Gordon, Nova Scotia Agricultural College

Introduction

The advantages of earthen manure storage structures have been well documented. Although considerable cost savings compared to concrete systems are possible, they require additional storage capacities (i.e. their side slopes increase precipitation collection). Furthermore, several field studies have indicated that substantial deep seepage of manure constituents into the groundwater from earthen manure storages often occur. As a result, some Canadian provinces and American states have placed moratoriums on their construction. In Nova Scotia, however, their use has been extremely popular with approximately 50% of the manure storages on hog farms being earthen systems. Very little attention, however, has been paid to evaluate their potential for ground water contamination.

Deep seepage and contaminant movement below earthen manure storages depends on (a) the level and longevity of soil sealing; and (b) the manure dilution effect from precipitation. Sealing of earthen manure storages is accomplished by the physical clogging of soil pores by the fine solids present in manure. These fine solids, under the hydraulic pressure of the liquid manure, penetrate the soil macropores causing reduced hydraulic conductivity. Soil sealing can also result from chemical processes. Chemical sealing refers to the modification of the pore geometry of the soil by chemical reactions or ionic exchange resulting in reduced fluid movement. Additional soil sealing can also be achieved through biological processes. Some strains of bacteria produce water insoluble polysaccharides which appear to be promising selective plugging agents.

Objectives

The goal of this project is to expand the biological sealing technology for earthen manure storages. Specific objectives include: (a) producing a biological sealing agent under laboratory conditions and optimizing its production, (b) developing a methodology for the application of the sealing agent to earthen storage systems, and (c) rigorous testing of the sealing agent under field conditions.

Hog Industry Priorities

The priorities of the hog industry at the national and regional levels included: (a) research priority gaps that were identified by the Hog Environmental Management Systems Discussion Group include effective, low cost storage of manure with minimal environmental risks, (b) Research Strategy for Hog Manure Management in Canada has indicated that safe storage of swine manure is a high priority, (c) Nova Scotia Agricultural Industry Research Strategy has indicated that for the swine sector, identification of better/new waste management systems is a high research priority, and (d) Agricultural Engineering Research Priorities of the Atlantic Canada Committee on Agricultural Engineering have indicated that the development of environmentally sustainable manure management systems are a high research priority.

Relation to the Provincial Environmental Action Plans

A recent survey by the Nova Scotia Federation of Agriculture regarding on-farm environmental management issues suggested that manure management is the primary issue facing the Nova Scotia Agri-food industry. This investigation will provide Nova Scotia hog producers with fundamental information on low cost and effective means of storing swine manure.

Implications for the Hog Industry

Successful completion of this project will result in the following benefits: (a) the economics of farming can be beneficially impacted through the use of a low cost effective environmentally friendly earthen storage manure facilities, (b) the demand for expensive energy-consuming fertilizers will be substantially reduced through utilization of properly stored (during the winter months) organic fertilizer (manure), and (c) the project will help to improve the competitiveness and efficiency of the pork industry and open the door for creating employment through the development and

implementation of a new technology.

Experimental Work

Research into the development of enhanced biological sealing mechanisms for earthen manure storages is being carried out in two phases. In the first phase, a biological specie whose metabolic end product (polymer) could be used as a selective plugging agent is being cultured. Selection of the microorganism used was based on pathenogenicity, size and type of polymer produced, and competition with naturally occurring microorganisms. In the second phase, the *in situ* production of the sealing agent in various agricultural soils and the effectiveness of the developed biological sealing mechanism in reducing the hydraulic conductivity and the manure leachate are being evaluated.

Laboratory Experiment: The aim of the Laboratory study is to evaluate the feasibility of producing sufficient quantities of microbial culture required for the development *of in situ* biological sealing mechanisms. This includes optimization *of* the bio-reactor in order to minimize production costs *of* these microorganisms. Environmental factors such as temperature, pH, sugar concentration and micro-nutrients are being investigated and manipulated to create the simulated *in situ* conditions. Possible interference, from natural organisms, in the production of the sealing agent will be investigated. This phase was initiated in the Biological Engineering Department at Dalhousie University, Halifax, Nova Scotia in July 1999 and will continue through January, 1999.

A Freeze dried culture *of Leuconostoc mesenteroides* (NRRL B-512 strain) obtained from the American Type Culture Collection (ATCC, Rockville, Maryland, USA) was revitalized in Bacto° nutrient Broth (Difco Laboratories, Detroit, Michigan, USA) following ATCC protocol. The reactivated bacteria were transferred aesceptically to MRS agar (Oxoid Ltd., Basinstoke, England) and plate count agar (Difco Laboratories, Detroit, Michigan, USA) and incubated at 30°C for 48 hours to increase numbers and confirm purity and identity. Cultures were then transferred to 250mL flasks containing 150 mls MRS broth (Oxoid Ltd., Basinstoke, England) and placed on a rotary shaker for 12 hours (200 rpm, at 30°C) to increase numbers and serve as innoculant for the batch reactors. Four plexiglas batch reactors with a working volume of 4.8 L (Figure 1) were used to produce the bacteria required for the experiment.

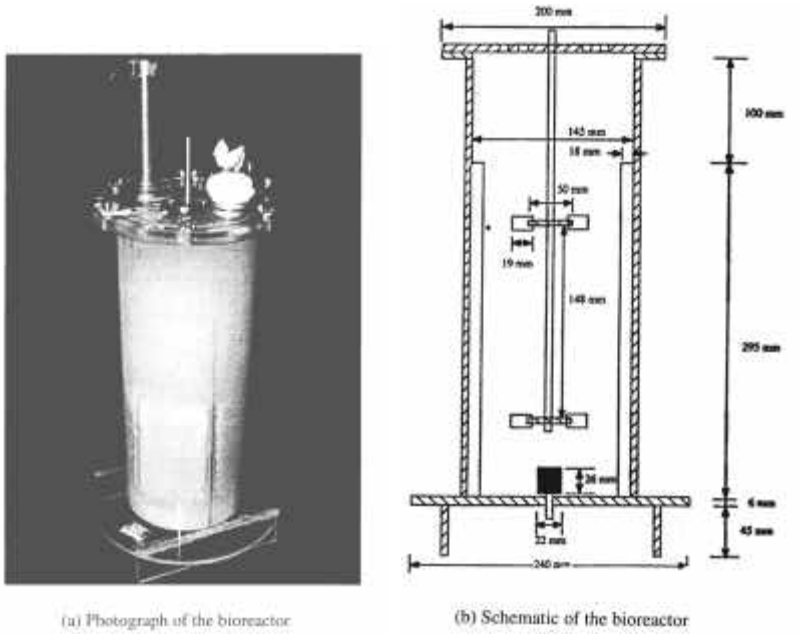

Figure 1. The bioreactor used to produce bacteria

Each reactor contained MRS broth and was injected with 10% by volume of a homogenous mixture of the shake flask cultures. The reactors 64 were operated at 30"C with constant aeration and mixing for 14 hrs, after which the reactors were placed in cold storage at 4°C while preparations were made to take them to the field site. A plate count test revealed that there was approximately 8.24 x 10'° microbial cells per ml. Figure 2 shows sucrose utilization, bacterial growth and dextran production. The bacterial culture grew exponentially during the first few hours. The concentration of sucrose decreased while the production of dextran took place during the period of exponential growth.

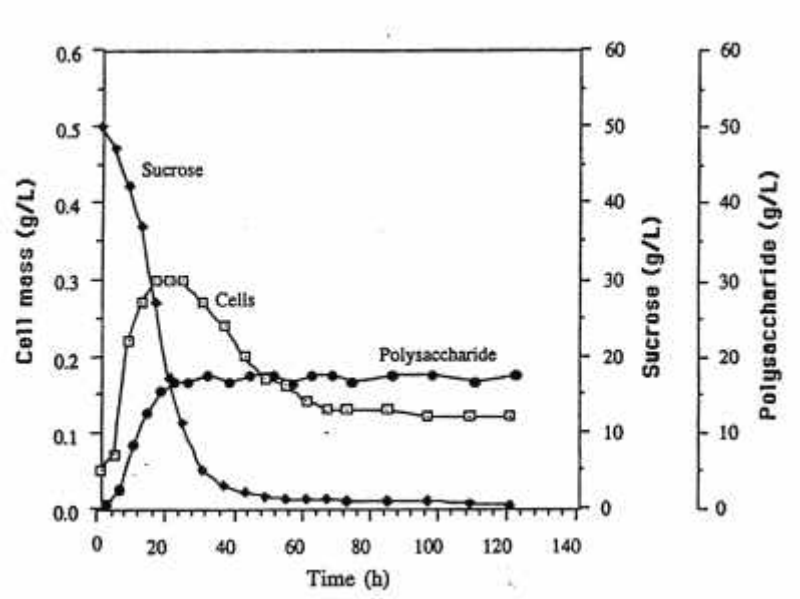

Figure 2. Cell growth, sucrose utilization and dextran production

Field Experiment: The field study included a complete environmental evaluation of deep seepage contaminants from earthen manure systems with and without sealing agents. This was accomplished by constructing 4 earthen model systems (Figure 3) beginning in September, 1999. The model lagoon systems are located at the NSAC/DalTech BioEnvironmental Engineering Centre (Truro, Nova Scotia). Each lagoon consisted of two concrete septic tank halves holding approximately 4.5 m^3 of hog manure (6 m^3 total volume, 1.5 m^3 soil. Perforated pipe covered with fine crushed gravel were placed in the bottom of each to collect leachate. Each pipe leads to a sheltered bucket to facilitate sample collection. The soil type used was a sandy loam soil with approximately 12% clay (66% sand and 22% silt) collected from The Nova Scotia Agricultural College Farm. The soil within the structures was compacted over the gravel with a soil compacter.

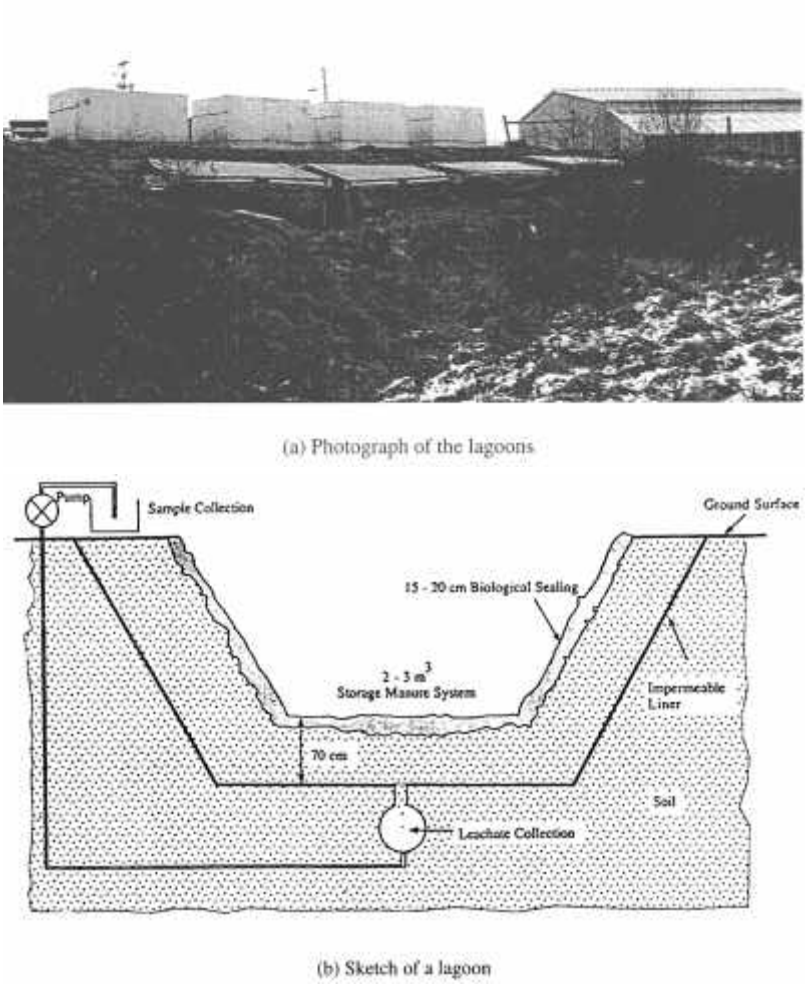

Figure 3. Model earthen lagoon systems

The structures have vertical plywood barriers, treated with an impermeable coating, at the base of the side slopes. This allows for collection of leachate samples from the base as well as both side slopes independently to evaluate lateral movement of contaminants.

The four reactors were combined to form a homogenous mixture. Each of the two treated lagoon systems received 8.5 L of bacteria culture. The culture was applied evenly over the entire soil surface using a portable compressed air sprayer. Care was taken to ensure that the liquid infiltrated the soil surface and did not run off. The 8.5 L of MRS broth with no bacteria was applied to a third lagoon in the same fashion to serve as a media-no-bacteria treatment. Each of these three lagoons then received a total of 17 L of a 10% sucrose (technical grade, Fisher Scientific, Nepean, Ontario, Canada) solution divided evenly over three application dates (5.67 L every five days) to provide the substrate for dextran production. The fourth system served as a control and received no bacteria, media or sucrose solution.

Fresh liquid hog manure (approximately 5-6% solids) obtained from the Nova Scotia Agricultural College Swine Unit was pumped into the bottom half of each system. A plastic tarp was laid over the soil surface as a shield against the force thus preventing disturbance of the treated surfaces. Once the bottom half was filled the tarp was removed and the top half of each septic tank was craned in place. The tanks were then filled to full capacity with hog manure. This study is still in progress.

Conclusion

Sufficient bacterial culture have been produced in the laboratory and used for the in situ production of the polysaccharide. The field experiment is in progress. The data collected will be analysed and used for the planning of the second field study next Spring/Summer.

Reduced environmental impact of pig production by improved mineral utilization

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Description: A project for the production of pigs with enhanced mineral utilization to reduce environmental pollution by the hog industry

Research Fund: Ontario Pork

Purpose/Goal: To reduce the environmental impact of hog production by decreasing the content of phosphorus in the fecal material

REACH

The target clientele is pork producers in Canada and eventually pork producers throughout the world. The technology developed at Guelph will be distributed via Ontario Pork, first to Canadian swine breeders and subsequently to major multinational breeding companies.

The benefactors of this technology will include both pork producers and the general public. The beneficial effect will result from a reduction in pollution caused by the accumulation of high phosphorus in soils from spreading of manure on land and runoff into streams, rivers and lakes during wet weather.

RESULTS

Approximately 50 to 70 % of phosphorus in cereal grains, soybean meal and canola meal is in the form of phytate phosphorus (inositol hexakisphosphate). It is not digested by the pig instead is excreted in the fecal material in a more concentrated form that is a major source of pollution. The current best approach to deal with this problem is feeding of a ration supplemented with the microbial enzyme phytase that cleaves phytate releasing inorganic phosphate and inositol in the stomach. The phosphate then is absorbed in the small intestine and the phosphorus content of fecal material is reduced by 20 to 50%.

We proposed to introduce into the pig a gene coding for the enzyme phytase to circumvent the need of continually feeding of phytase, and to ensure the continuous presence of the enzyme in order to improve overall digestive efficiency for phosphorus and other minerals. To accomplish this we have undertaken a research program consisting of five phases: (i) development of a phytase transgene; (ii) generation of transgenic mice containing the phytase transgene; (iii) generation of pigs containing the transgene; (iv) testing of transgenic pigs for the utilization of phytate phosphorus; (v) breeding of transgenic pigs to test for transfer of the gene, and to select the best line for development of a new breed of pig producing a salivary phytase.

Transgenes were constructed to contain a salivary gland specific promoter linked to a phytase gene from Escherichia coli. Transgenic mice were then produced to determine whether production of a phytase in the salivary gland would have a deleterious effect on reproduction or growth of mice. Transgenic mice generated by standard microinjection of single cell embryos produced a high titer of salivary phytase and were healthy, a result which encouraged us to initiate phase III of the project, generation of transgenic pigs. Founder pigs were generated using the phytase transgene designed for expression in the salivary glands. To date several founder transgenic pigs have been obtained. A range of salivary phytase levels have been observed in these pigs. During growth of the transgenic pigs and their non-transgenic pen-mates, we are testing for salivary phytase, weight gain, and fecal phosphorus content during the weanling, grower and finishing phases of growth.

We have just begun outcrossing of the founder pigs to determine whether the transgene will be transmitted. Future plans are to breed sufficient pigs of each founder line to conduct digestibility and feed utilization trials, and to test carcass characteristics and tissue distribution of the phytase. This information will serve as the basis for selection of a line of pigs that will be subjected to feeding trials, carcass evaluation, and toxicity testing. The data collected from this line will be submitted to the Canadian Food Inspection Agency and Health Canada to obtain approval for use the transgenic phytase synthesizing pigs for human consumption.

We anticipate the long term impact of this research will be the production of pigs that synthesize salivary phytase leading to a substantial improvement in cereal phosphorus utilization and a 30 to 35% reduction in fecal phosphorus excretion.

DISCUSSION

The research is in progress. Our results are very encouraging and we are confident of an eventual positive outcome. Unfortunately, we cannot share details of the current research as openly as we would like because protection of the proprietary information is incomplete. However, within a year we will be able to release all of our information, and at that time we should be able to provide a good assessment the overall success of the project.

Optimizing Use of Liquid Hog Manure on Sandy Soils with Respect to Groundwater Protection

M.O. Gasser[1], M.R. Laverdière[2], R. Lagacé[2], G. Barnett[3] and J. Caron[2]

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The impact of spreading manure on sandy soils cannot help but present some hazards for the quality of groundwater. In the Portneuf region, monitoring nitrate concentrations in leached water beneath the root zone of potato and grain crops appears to indicate that spreading manure results in an increase in nitrate losses. In this region, up to 85% of the spreading of pig manure occurs on the sandy soils used for potato production, at the time of rotations with grain. Furthermore, the new standards imposed to limit soil phosphorus saturation require producers to work under this new restriction.

This research project aims first at evaluating, through a network of drainage lysimeters installed on the farms since 1995, the agro-environmental efficiency of conventional manure spreading with respect to plant uptake, nitrogen leaching and phosphorus migration. In order to establish manure management practices which would result in a reduction of environmental repercussions, a second network of lysimeters, installed beneath some experimental plots, was put into operation in 1999. The fertilizing and agro-environmental efficiency of 3 manures (low-level dryness, high-level dryness and mechanical separation), applied at seeding or post-emergence, was compared in two crops, barley and canola. They were compared with respect to their capacity to take up nitrogen originating in the manure. Nitrogen and phosphorus profiles were carried out for each crop in order to obtain a form of management that makes it possible to increase the fertilizing value of the manures and reduce the risks of nitrate and phosphorus leaching. Efforts will also be made with a view to adapting and/or developing models which would make it possible to depict accurately the processes related to the nitrogen cycle in the case of what pig manure can bring to crops in sandy soils.

The results of this research primarily address the managers who spread pig manure on sandy soils. The spreading managers at the farms involved in our monitoring in the Portneuf region will be the first to be informed of the results of this research. The dissemination of the results to all producers and professionals will be carried out through the "Colloquium on Swine Production" [tr] held annually by the CPAQ (Conseil de la production animale du Québec), plant production (grains, potatoes) or thematic colloquiums (manure management, soil conservation, water management) organized by the CPVQ (Plant Production Council of Quebec). At the Canada-wide level, the dissemination and transfer of the results will primarily use the scientific publications route in Canadian or American journals (Canadian Journal of Soil Science or Journal of Environmental Quality). This research is being carried out with a view to being able to transfer the results to other agricultural areas in which the constraints of sandy soils prevail. The development of models which make it possible to analyze the agro-environmental impacts remains a future avenue for helping the manager choose from the most appropriate spreading scenarios. Lastly, the methodology which will be developed in it will also be able to be transferred to other cultivation systems that benefit from the application of pig manures as a means of fertilization.

Agro-environmental monitoring under 5 cultivation plans for sandy soils in the Portneuf region

The concentrations and mass of leached nitrate at a depth of 1 m in the soil were measured for 4 years in 15 drainage lysimeters (with an area of 1 m2) installed in 1995 on 5 farms in the Portneuf region. Most of the crops evaluated during this monitoring (potatoes, barley, wheat, clover and timothy fields) produce nitrate concentrations that exceed the acceptable standard for raw water (>10 mg $N\text{-}NO_3$/L), except for the field. In a 4-year summary made between May 1, 1996, and September 1, 1999, the applications of nitrogen in the form of mineral fertilizers vary from 186 to 495 kg N/ha at the 5 sites, while the applications of nitrogen from farm manure ranged between 160 to 640 kg N total/ha. The losses in the form of leached nitrates varied from 83 to 487 kg $N\text{-}NO_3$/ha and are, in many cases, equivalent to the quantity of nitrogen applied in the form of mineral fertilizer. The average concentrations of nitrogen in the runoff water at a depth of 1 m appear to range between 14 to 46 mg $N\text{-}NO_3$/L, while the least significant losses are recorded in a field rotated to barley and potato crops. The analysis of the change in the nitrate concentrations at each site reveals the possibility that spreading pig manure seems to contribute to increasing the concentrations of nitrates in the water collected at a depth of 1 m in the soil, even a year after spreading. Insofar as the spreading of manure on sandy soils appears to

represent a risk of contaminating the water table with nitrates, spreading on grass fields should be promoted at the expense of the other crops, given their greater evapotranspiration process and the presence of a root mass capable of sampling nitrogen over a longer period during the year.

Optimization of pig manure spreading practices on sandy soils

In order to improve spreading practices on cultivated crops in view of the nitrate leaching, some trials were conducted in 1999 at the Lennoxville experimental station on 30 parcels of 50 m2 equipped for monitoring the quality of runoff water and drainage water. Ten treatments were distributed randomly within 3 blocks, 2 of which were equipped with drainage lysimeters in addition. Six parcels were cultivated in barley, while the other 4 were cultivated in canola. In the barley, the fertilization treatments were: 1- no nitrogen application; 2-application of mineral fertilizer (80N); 3- pre-emergence application of low dryness manure (6.5% SM, 120 kg total N/ha); 4- pre-emergence application of high dryness manure (13% SM, 120 kg total N/ha); 5-post-emergence application of high dryness manure (13% SM, 120 kg total N/ha); 6- post-emergence application of mechanically separated manure (8% SM, 120 kg total N/ha).

In the canola, the fertilization treatments were: 1- application of mineral fertilizer (110N); 2 - pre-emergence application of low dryness manure (6.5% SM, 165 kg total N/ha); 3 - pre-emergence application of high dryness manure (13% SM, 165 kg total N/ha); 4 - post-emergence application of mechanically separated manure (8% SM, 165 kg total N/ha).

The average above ground biomass produced in the barley reached 2.3 µg/ha, while it was 9.6 µg/ha in the canola. Some dry periods that followed the seeding had a greater effect on the barley whose performance reached an average of 1.2 µg/ha, whereas it was 2.6 µg/ha in the canola. The post-emergence application of mechanically separated manure had a harmful effect on the growth of the barley and the canola. In fact, most of the canola seedlings were destroyed by the application of this manure in post-emergence and these parcels were reseeded. The barley production was also affected by the post-emergence application of mechanically separated manure, but without compromising the seedlings' survival. On the other hand, the application of conventional manure in post-emergence did not produce the same yield losses. Neither did the mechanical separation of the manures' solid stage >0.5 mm improve the N/P ratio of the liquid stage.

Liquid swine manure used in vegetable production systems : harvest yields and salubrity.

Caroline Côté, agr., M. Sc.
Fédération de l'UPA de Lanaudière (FUPAL)

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no text available

PUBLIC HEALTH

Literature Review on the Impacts of Hog Production on Public Health

S. D'Allaire, L. Goulet, J. Brodeur, Université de Montréal,
and
G. Roch, Fédération des producteurs de porcs du Québec (FPPQ)

PROFILE

In November 1996, the Fédération des producteurs de porcs du Québec (FPPQ), as well as the 25 agencies associated with the hog sector participating in the *Table Filière*, endorsed the development of an agro-environmental plan whose objective is to practice and develop environmentally friendly hog production by reconciling economic and social imperatives.

The nature of discussions held by different citizens' groups on the hog sector's responsibility regarding the degradation of the environment and the health of the population living in proximity to hog farms has led the people responsible for the Plan to form a "Health" task force to shed some light on part of this problem. This multidisciplinary task force is composed of three researchers and their research team and specialize in toxicology, epidemiology and animal health: Dr. Jules Brodeur, Toxicologist; Dr. Lise Goulet, Epidemiologist; and Dr. Sylvie D'Allaire, DVM.

The mandate entrusted to this task force was to conduct a review of the scientific literature on the impacts of hog production on public health and to propose some research avenues to improve knowledge.

ANTICIPATED CONTRIBUTION

Bring the knowledge up to date and propose research avenues to improve the knowledge.

DISCUSSION

In order to carry out its mandate, this task force identified three types of contaminants. The nature of these contaminants are: microbiological; chemical, and the volatile compounds at the source of the odours released by hog production. In all, 393 reference documents were selected for performing this literature review.

None of the documents was able to scientifically demonstrate that hog production affects the health of rural populations living near the production sites when good practices are employed. However, hog production, like many other industrial or human activities, constitutes an environmental pollution hazard.

Microbiological Contaminants

In order to perform the study on the microbiological contaminants, a list was drawn up of 125 infectious agents that are found in hogs world-wide. The infectious agents on this list were then classified according to certain criteria in order to identify those that present a health risk to people that live near hog production sites in Quebec.

Although there is no scientific study illustrating a link between spreading pig manure and waterborne health problems in humans, the task force cannot deny that a potential risk exists. It was necessary to classify the microorganisms in order to determine the significance of this risk and to identify those that present a genuine health risk. Of the 125 agents listed for hogs, 8 agents were selected as possibly constituting a risk for the general population in Quebec. However, it was impossible to assess this risk with the information currently available.

List of agents potentially transmissible to the general population
Campylobacter coli and jejuni *Escherichia coli* *Leptospira spp.* *Salmonella spp.* *Yersinia enterocolitica* *Cryptosporidium parvum* *Giardia intestinalis*

Considering the nature of the agents selected, the level of knowledge and their mode of action, the task force recommends establishing the prevalence of these agents in the Quebec hog herds and assessing the survival rate of these agents in the environment. These measures will enable, where necessary, suitable recommendations to be made to the hog industry. Furthermore, it recommends monitoring disease evolution within the herds by maintaining a good epidemiological surveillance and diagnostic laboratories system.

Chemical Contaminants

In the case of chemical contaminants, a list was drawn up of the characteristics and the elements constituting manure. Pig manure, by its very composition, is an important source of nutrients for plants. It can replace commercial fertilizers in agriculture. Its beneficial effects as a fertilizer are well documented. However, the toxicological data pertaining to the management of pig manure are inconsistent. Therefore, the work carried out by the committee was to index the chemical substances emanating from pig manure and to assess their potentially harmful effects and impact on the health of the general population.

The principal mineral elements that form manure are the following: nitrogen, phosphorus, potassium and the trace minerals. The characterization of the chemical constituents of manure is important for achieving optimal management while accommodating crop needs and soil content. An optimal and rational spreading of manure will mitigate pollution. However, the physico-chemical nature of the substances contained in the manure entails some contamination hazards for two environments, that is, air and water.

Air Contamination

There is a risk of air contamination by more than a hundred substances present in the form of gases or volatile compounds. The substances encountered are divided into two groups: the malodorous substances and the substances with a toxic trait. The toxic substances, emitted during manure's fermentation, have irritating and asphyxiating effects. However, while these substances are found in relatively high concentrations at certain sites in a hog operation (Storage Tank), they do not represent a direct health problem for the production site's neighbouring populations because of their rate of dilution in the air.

Water Contamination

Spreading manure on agricultural land as a fertilizer is the most advantageous way of disposing of it. If this spreading abides by certain practices, it is proven to be very beneficial for the soil structure, plant growth and has no significant impact on the environment. Conversely, poor manure management during storage and spreading can negatively affect the quality of the environment.

As is the case for microbiological contaminants, it is under the action of the runoff and infiltration phenomena that certain chemical contaminants originating in manure can be found in surface and ground water. At that time, if the contamination is significant, they could be the source of health problems for the populations neighbouring production sites who consume this water. The principal contaminants that warrant specific attention are nitrates, the N-nitroso compounds, the trihalomethanes and the minerals, especially copper, manganese and zinc.

In terms of chemical contaminants, the literature review made it possible to better understand the potential health risks that certain contaminants may have when the dosages are fairly high. However, the level of current knowledge is

thwarted by the estimate of the risk incurred by the populations exposed to low doses of chemical contaminants ingested via drinking water.

The committee therefore suggests establishing a surveillance program focusing on potable water originating from supply sources located in proximity to pig manure spreading sites contaminated by nitrates, nitrites, trihalomethanes and the metals. This surveillance program should span a period of three years so that it reflects the seasonal and annual variations. In addition, systematic research on certain compounds in epidemiological literature, focusing on the existence of a relationship between exposure to contaminated water and the appearance of cancers or teratogenic effects, should be undertaken.

Volatile Compounds and Odours

For several years now, the health impact of odours emanating from hog operations has been the subject of much questioning. The potentially harmful nature of the odours emitted raises fear in many members of the communities in which hog production activities take place. Many residents seem to attribute to the odours the existence of various physical and psychological symptoms such as nausea, headaches, fatigue or depression.

The committee's work was to discover the extent of scientific knowledge about odours, by evaluating the link between odorous volatile compounds originating from hog farms and the people's health on one hand, and, on the other, to understand in what way the volatile compounds and the odours could affect people's health.

The first observation that stands out in the analysis of the documents consulted is the lack of scientific knowledge concerning the relationship between the odorous volatile compounds (odours) emitted by hog farms and people's health. The research group concentrated on understanding how odorous volatile compounds in general might affect the health of the population. Four mechanisms were identified. It appears that the reactions of annoyance seem to be one of the mechanisms that may have an impact on an individual's physical and mental health. However, to date there is no scientific proof in the case of the odour emanating from hog houses. The problems associated with the odours generated by hog production are therefore unique and complex. One major question, *Do the inhabitants of the communities in which we find hog production activities exhibit more discomfort or health problems than those in other communities?* The impact of the odours on the health of rural populations, as well as the analysis of the behaviours in the face of them, should be the subject of a more thorough analysis.

Overall, this literature review made it possible to reveal that certain risks have been overstated. However, the updating of the knowledge and the evaluation of the genuine risks associated with certain microbiological and chemical contaminants in a Quebec hog production context are some of the major recommendations by the "Health" task force.

Short-term Impacts

- Dissemination of the results in the October 1999 Revue Porc Québec in an article dealing with the conclusions of the literature review on the impact of hog production on public health and making the report of the literature review available to producers and agricultural sector stakeholders.

Long-term Impacts

- Implementation of research projects to improve documentation on the situation and to recommend to the industry, where necessary, some measures for minimizing the impact of hog production on public health.
- Technology transfer of knowledge.
- Reduction of the constraints to Quebec hog production development in regions with a surplus.
- Growth in the demand for pork because of an improved image of hog production.

Dissemination Plan

The dissemination of the conclusions of the literature review regarding the impacts of hog production on public health started in September 1999 and is aimed at hog producers and stakeholders.

The dissemination activities completed in 1999 are:

- Presentation of the results to the Board of Directors of the FPPQ and the commitment of the FPPQ to implement projects that will allow the report's short-term recommendations to be met.
- Presentation to the producers through the FPPQ regional offices.
- Article in the October 1999 *Revue Porc Québec*.
- Submission of the final report of the Literature Review to the Technology Transfer Group.
- Mailing of the full report to the following stakeholders:

    - Table filière porcine
    - Swine production and agro-environmental teaching institutions
    - Order of Agrologists of Quebec
    - Association des biologistes (du Québec)
    - Environmental groups
    - Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ): regional directors and local offices
    - Ministère de l'Environnement du Québec (MENV); regional and local offices
    - Research institutes
    - Ministère de la Santé et des Services sociaux
    - Association des vétérinaires en industrie (AVIA)
    - Ordre des vétérinaires du Québec
    - Groupe d'intervention en santé publique du Québec

Communications

National Environmental Communications Strategy Planning Meeting Proposal.

S. Bradshaw, Ontario Pork

Project Title: Pork Producers "Get the Message Out Conference"

Mission:

To provide national leadership and a pro-active, thinking session to encourage all provinces to work together to develop and share resources dedicated to educating and informing the public and the agri-food sector on environmental issues.

Objectives:

- To organize a national meeting in the summer of 1999 for all provincial pork producer associations regarding environmental communications efforts.
- To compile and categorize existing resources. (including brochures, posters, videos, classroom materials)
- To develop a national communications strategy, including an action plan for development and distribution of new resources for the future.
- To establish provincial roles in development and cost sharing, with defined milestones for achievement.

Participants:

Communications and promotions staff from every province and the Canadian Pork Council

Target audiences:

Public (urban, rural non-farm), pork producers, farmers, government, media, agri-food industry

Results:

Provincial and national political representatives and communications personnel from the pork industry met in Niagara-on-the-Lake in August to discuss communications challenges that our sector must face. The purpose of the meeting was to build a national communications framework, including strategies, messages, and action plans. *

- The number one priority identified by the attendees was the need for a national study of consumer attitudes, both rural and urban, towards pork producers. Negative media coverage, special interest groups allegations, and a growing distance between farmer and consumer have accumulated to create a void in accurate information about what really happens on today's farms.

The National Study:

Research Objectives:

The overall purpose of the study was to gauge the non-farming publicsattitudes toward pork production. The results of this study will be used to establish guidelines for a national communications strategy and as a benchmark for the future.

More specifically:

- To identify rural and urban Canadians' attitudes towards hog farm practices.
- To determine how well informed Canadians are about hog farming.
- To determine sources of information on farm practices and prioritize them in order of credibility.
- To identify and prioritize which aspects of pork production are of most concern to Canadian consumers.
- To identify which target audiences are most concerned about farming and food issues.
- To explore possible messages and messengers.
- To measure messages' credibility, relevance and effectiveness**.**

The Angus Reid Group completed a national study of public attitudes toward pork production during October of 1999.

The results of this survey will be made available at the Symposium.

Existing resources, from each Province represented at the meeting, (including brochures, posters, videos, and classroom materials) were compiled, categorized, and catalogued.

Environmental Issues Resource Centre

Lee Whittington, Manager-Information Services, Prairie Swine Centre Inc.
Technical consultation and research team includes:
Dr. Stephane P. Lemay, Ms. Liliane Chenard, Mr. Ken Engele.

PROFILE

The Environmental Issues Resource Centre is an Internet-based review of the published literature on environmental issues surrounding the pork industry. The pork boards of Ontario, Manitoba, Saskatchewan and Alberta in conjunction jointly fund this project with the HEMS funding.

The project reviews the literature currently published in scientific journals, conference and symposium proceedings, industry journals and electronic scientific databases. The information is then synthesized to provide an overview of the current state of knowledge on each of 14 environmental issues. The result is a fully referenced chapter that provides a single information source detailing what is known, who is contributing to the body of knowledge and what questions still need to be answered.

The individual research papers and reports used to compile the chapters are then summarized in a few paragraphs. These summaries are placed into a database resident on the World Wide Web. The database can then be accessed using a variety of queries including author, title, or key words.

REACH

The original concept was initiated in consultation with the Environmental Committee of Ontario Pork to provide a reliable, unbiased resource for municipal councils and pork producers struggling with bylaw development, which impacted directly on intensive livestock units. The database was developed on the basis that the information is freely available to all people that may wish to know more about the facts concerning the interaction of the pork industry and intensive livestock in general and its environment. Thus the approach is an easy reading style combined with key definitions in each chapter. The audience for this project is, in order of priority, pork and other livestock producers, policy makers, researchers, and the general public.

As this database is located on the Web with free access it is open to all who want to use it, including those who oppose the expansion of intensive livestock units. This group is seen as a subset of the general public, and although they may have an interest in livestock farming, their information sources to-date may have been biased or incomplete. This technology transfer project currently housed at http://adminsrv.usask.ca/psci is available to pork boards, agriculture ministries and other web gateways to provide the information to the largest possible audience.

RESULTS

This is a Technology Transfer Project; no new research is being conducted under the mandate of this project. Instead this project seeks to make the current knowledge more available to a growing number of people interested in the pork industry.

The short term results include the classification and summarization of approximately 600 scientific papers and articles, the completion of 14 chapter summaries covering Legislation and Regulation, Siting, Odours, Gas Emissions, Manure Management, Nutrient Management, Soils, Water, Dust in Livestock Buildings, Human Health, Sociology, Noise, Traffic and Dead Animal Management.

These results provide a quick review of the issues using resources that are reliable and reputable. Users can be assured of the accuracy of the information and clearly defined gaps in the research available to-date.

Clients are advised of the web site’s existence via direct mail to pork producers from Prairie Swine Centre, feature articles in pork magazines and pork board newsletters. At pork industry trade shows in Ontario, Manitoba, Saskatchewan and Alberta a display introduces the Resource Centre and a ‘book mark" with the web site address is distributed.

Long-term plans for the site include translation of each of the 14 chapter summaries, and on-going literature research review to add to the database. Prairie Swine research staff and at least one reviewer with expertise in the discipline will review each chapter annually. Plans are underway to build a link between this site and several other proposed and functioning sites developed within Canada that serve to provide information on environmental issues, for example, Manure Net, Canada Pork Network.

INFLUENCING FACTORS

The increased availability of Internet access to rural Canada has meant large amounts of information can be stored, sorted and delivered to individuals regardless of where they live or when they want it. This is a 'pull' technology, meaning that the user determines the time, extent and form of information required. Thus the World Wide Web was selected as the best medium to maintain such a Resource Centre. The Internet allows for frequent, inexpensive updates, easy access by a large population, credibility as a public resource, and the ability to sort information to the needs of the individual making the inquiry.

DISCUSSION

Each chapter contains a glossary of terms, a general overview of the issue, a review of the current status of the world wide knowledge on the subject, a discussion of technologies where applicable, the role of the farm management, cost/benefit information where available, and identifies what questions still need to be answered through additional research. Each chapter is fully referenced throughout with references appearing at the end of each chapter. The complete publication is 130 pages in length and is available in hard copy in addition to the Internet version.

This three-year project provides a reliable, regularly updated resource for the industry. Researchers, policy makers and the general public can rely on this information resource to provide the facts in a clear and concise form to assist in the discussions on the environment which are often fraught with emotions, and questionable information.

Dissemination of the Guide to an Agro-environmental Approach to Swine Production

Chantal Foulds, Hélène Perrault and Marie Beaubien,
Fédération des producteurs de porcs du Québec

ANTICIPATED CONTRIBUTION

- All the hog producers in Quebec (4,000) are targeted by the dissemination plan.
- The swine production and crop management advisors are also targeted by the dissemination plan considering their important role in transferring knowledge to the producers.

RESULTS

Short-term Impacts

- Dissemination of the Guide to 4,000 hog producers in Quebec.

Long-term Impacts

- Raising the producers' awareness of the environmental impacts of swine production
- Technology transfer of knowledge about agro-environmental practices in swine production
- Reduction of the constraints to the development of swine production in Quebec
- Increase in the demand for pork because of an improved image of swine production

INFLUENCING FACTORS

The factors capable of hindering or helping the level of the Guide's penetration among the hog producers are:

- the economic status of swine production
- the status of proximity in the rural community
- the governmental funding programs for the adoption of techniques reducing the environmental impacts of swine production

DISCUSSION

Content of the Guide

The Guide, developed by the Centre de développement d'agrobiologie du Québec, proposes an approach that encourages the producer to:

- think of the farm's situation from an environmental viewpoint;
- undertake actions adapted to the farm's environmental problematics;
- evaluate the farm's environmental performance using a mineral status.

The approach presented in the Guide is based on a global management approach. Hence, the improvement of the farm's environmental efficiency occurs through a better management of its components: the livestock, manures, soils and crops.

The Guide sets environmental objectives to be reached by the hog farms and draws up a list of actions aimed at reducing the hog farm's nitrogen and phosphorus losses, minimizing the odours produced by the livestock and the manure spreading and rationalizing the use of herbicides for the crops.

Dissemination Plan

The distribution of the Guide started in March 1999 and is aimed at the milieu's producers and stakeholders. In order to ensure that the Guide is read, the distribution to producers is aimed at those who are looking for information on agro-environmental practices. With this outlook, the distribution is carried out as part of agro-environmental promotion/information activities.

The dissemination activities completed in 1999 are:

- Guide awareness sessions for the hog producers through the regional unions and agro-environmental promotion/information activities;
- Presentation to the media: press conferences, press releases, articles;
- Presentation of the Guide to the sector stakeholders: advisors in swine production, crop management and financial management and the suppliers of services and equipment;
- Mailing of the full Guide to the following stakeholders:

    - Table filière porcine;
    - Swine production and agro-environmental teaching institutions;
    - Ordre des Agronomes du Québec;
    - Association des Biologistes;
    - Regional environment councils (CRE);
    - Coopérative Fédérée (Board of Directors);
    - Environmental groups;
    - Manure management bodies;
    - Ministère de l'agriculture, des pêches et de l'alimentation du Québec (MAPAQ): regional directors and local offices;
    - Ministère de l'environnement du Québec (MENV): regional and local offices;
    - Research institutes.

- Mailing of the Table of Contents of the Guide to the following stakeholders:

    - Federal and provincial members of parliament;
    - Financial institutions;
    - Mayors;
    - Régie des assurances agricoles du Québec (RAAQ): regional directors;
    - Régie des marchés agricoles et alimentaires du Québec (RMAAQ);
    - Regional Health and Social Services Board;
    - Société de financement agricole (SFA).

Development of Plans for Agro-environmental Intervention in Swine Production

Chantal Foulds, Hélène Perrault and Marie Beaubien,
Fédération des producteurs de porcs du Québec

NATURE OF THE PROJECT

To follow up on the agro-environmental census carried out in 1997, the firm *BPR Groupe-conseil* was given a mandate to perform a thorough analysis of the data for each of the regions in Quebec in order to target some realistic improvements over five years. The relevance of the recommended interventions was validated by making use of comments by swine production and agro-environmental specialists.

For each of the regions, the objectives were to:

- clarify the farms' environmental portrait;
- target the on-farm, collective and research and development interventions;
- develop some agro-environmental indicators to make it possible to monitor improvements;
- evaluate the impact of the on-farm interventions on lowering nitrogen and phosphorus wastes and reducing odours.

ANTICIPATED CONTRIBUTION

Even though the project did not include distributing the plans, all the hog producers in Quebec (4,000) will eventually be targeted by the implementation of these plans.

RESULTS

Short-term Impacts

- Development of eleven agro-environmental intervention plans: one for each of the ten Quebec regions studied and one for the province.
- Development of eleven brochures that popularize the content of the agro-environmental intervention plans.

Long-term Impacts

- Through the agro-environmental intervention plans:
  - Technical support for the unions in defending regional matters involving swine production and the environment.
  - Establishment of agro-environmental research and development priorities for swine production in Quebec.
- Through the brochures:
  - Sensitizing the producers to the environmental portrait of swine production in their region and to the high-priority actions to be carried out on the farm and at the regional level.
  - Information for the producers on the costs and the environmental impacts of the interventions necessary on the farm.

- Reduction of the restrictions to the development of swine production in Quebec
- Increase in the demand for pork as a result of an improved image of swine production

INFLUENCING FACTORS

Section deemed non applicable to the project

DISCUSSION

In order to target the interventions, the environmental portrait of each region was assessed. The following elements can be found in the environmental portrait of the majority of the regions:

- A phosphorus over-fertilization of the soils;
- Large quantities of manure to be managed off the hog farms;
- Adequate protection against the pollution hazards of storage;
- High risks of odour emission in the buildings and during spreading.

Subsequent to the analysis of the environmental portrait of each region, a cost-benefits analysis made it possible to target some high-priority on-farm interventions as well as some implementation objectives for them. For example, Table 1 presents the implementation objectives of the priority on-farm interventions for the province.

Table1. Implementation objectives of the priority on-farm interventions in 2004 for all the hog farms in the province

	Units	Implementation (%)	
		Result of 1996 portrait	Objective in 2004
Fertilization plan	Cultivated area	56	85
Area receiving manure	Cultivated area	71	83
Use of phytase	Herd	12	72
Number of formulations - Sows: 2 formulations and over - Piglets: 2 formulations and over - Boars: 3 formulations and over	Herd	628053	7710075
Spreading by spray bar	Manure	25	58
Mixing manure with the spreading or in 24 hours and less	Manure	23	49
Water-saving bowls and hoppers / water bowl	Herd	47	68
(1) This intervention must be adopted as a priority by the farms that have manure tanks with less than 200 days of storage capacity.			

Reaching these objectives for the on-farm intervention implementation will have the following impacts on the environmental portrait of swine production between now and 2004:

- Phosphorus over-fertilization: 19% reduction
- Quantity of nitrogen to be managed off the hog farms: 8% reduction
- Quantity of phosphorus to be managed off the hog farms: 17% reduction

- Odour emissions in the buildings: 8% reduction
- Odour emissions during spreading: 14% reduction

For the large production regions, the on-farm interventions, although necessary, will correct only part of the environmental problem. Collective actions are therefore essential to further reduce the impact of hog farms on the environment. Some of these actions have already been undertaken and simply need to be reinforced. Others must be implemented.

In the case of regions that generate large quantities of manure to be managed off the farms, the main collective actions are:

- The optimization of the spreading of excess manure on a regional level. For this purpose, it is necessary for all the hog farms with surpluses to be members of the on-site manure management body (OGF);
- The implementation of the individual or collective treatment technologies to facilitate the export of manure surpluses from the farm. The technologies implemented must facilitate an optimal utilization of the manures by regional receivers and the export of excess fertilizer loads outside the areas with surpluses.

For the regions that generate smaller surpluses and have potential regional receivers, the principal collective action is to optimize spreading the surpluses at the regional level also, but through improved services to the manure receivers. Some examples of such services are the availability of manure with a higher concentration of fertilizing elements, a service to develop fertilization plans or even setting up transfer trenches for the manures.

For certain components of the environmental problem, the producers have no efficient and cost-effective techniques for resolving them. For example, the livestock buildings do not systematically incorporate efficient equipment for reducing the annoyances caused by the odours. Even though the priorities are not the same for all the regions, overall they involve reducing the nitrogen, phosphorus and odour loads generated by the hog farms. (Table 2)

Table 2. Research and development priorities for all the province's hog farms

Reduction of the nitrogen and phosphorus loads:

- Development of manure treatment technologies that facilitate exporting manures from the farms with surpluses. For surplus zones, the technologies must also enable the excess phosphorus to be exported over a great distance;
- The adaptation of varieties of corn with a lower plant phosphorus content for animal feed.

Reduction of odours:

- Development of building concepts incorporating technologies for reducing the odour emissions;
- Development of high-performance equipment for the application of manures to fields and pastures.