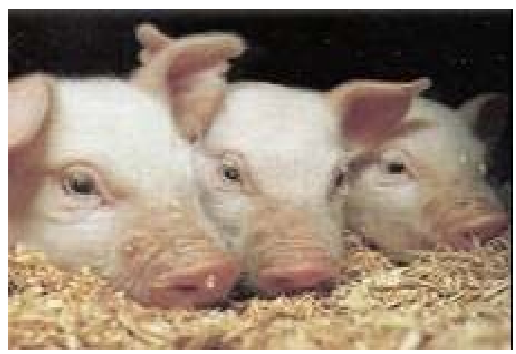
MANITOBA CONSERVATION

USE OF A CENTRIFUGE FOR LIQUID/SOLID

MANURE SEPARATION



Manitoba

EXECUTIVE SUMMARY

Manitoba Conservation administers the *Livestock Manure and Mortalities Management Regulation.* Manitoba Conservation strives to achieve voluntary compliance with the regulation, including the amendments related to allowable limits of phosphorus.

The purpose of the project was to test in Manitoba a technology that may potentially be used to separate solids and phosphorus from raw liquid manure. The centrifuge technology is currently used in Québec to achieve this separation process on pig operations. The centrifuge used in this project was brought in from IRDA (Institut de Recherche et Développement en Agroenvironnement) in Québec. The centrifuge is installed in a mobile trailer equipped with a mixing tank, laboratory and control panel.

The centrifuge performed as expected on site, and this manure treatment system might be an alternative in Manitoba to address phosphorus issues by pig operations in certain areas. Indeed, solids were removed at an average of 45%, and phosphorus was removed at an average of 63%. The solid fraction was at 67% moisture content and the following nutrient were found in significant amounts (kg per tonne) in the solid fraction: phosphorus (12 kg/tonne), nitrogen (11 kg/tonne), magnesium (9 kg per tonne), ammonium (7 kg per tonne), and calcium (4 kg per tonne).

The objective of this project was to demonstrate the efficiency of a centrifuge to remove solids and phosphorus from raw liquid manure. This report provides technical assessments of the effectiveness of this technology to address the phosphorus issue in Manitoba for livestock operators, mainly pig producers in certain areas.

Another important benefit will be the increased knowledge and leadership skills that can be developed by provincial staff, pig producers, researchers and commodity groups concerning manure treatment systems.

This project will support and promote innovation for the sustainable development of the pig industry in Manitoba and also encourage environmentally sound decisions and actions concerning phosphorus issues in Manitoba (re: Lake Winnipeg) and odours.

A Field Day was held on August 22, 2007 at Heritage Hog Farm. News releases were produced by FarmScape Online.

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ACKNOWLEDGEMENTS

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- Particular thanks to Gary Plohman, Manitoba Agriculture, Food and Rural Initiatives, for his valuable contribution in all technical aspect for this project.

1. INTRODUCTION

Manitoba Conservation administers *the Livestock Manure and Mortalities Management Regulation.* Primary responsibilities include investigation of complaints, inspections for manure and mortalities, annual inspections of permitted storage facilities, and enforcement of regulations.

Manitoba Conservation aims to achieve voluntary compliance of producers with the regulation, including amendments related to limits of allowable phosphorus.
The purpose of the project was to test in Manitoba a technology that may potentially be used to separate solids and phosphorus from raw liquid manure. The centrifuge technology is currently used in Québec to achieve this separation process on pig operations. The centrifuge used in this project was brought in from IRDA (Institut de Recherche et Développement en Agroenvironnement) in Québec. The centrifuge is installed in a mobile trailer equipped with a mixing tank, laboratory and control panel.

Test results were presented to a group including Puratone representatives, Manitoba Conservation and Manitoba Agriculture, Food, and Rural Initiatives (MAFRI), while visiting IRDA in Québec in May 2007. Due to:

- the promising test results showing capability of removing over 40% of solids and 70% phosphorus
- the cost, both capital and operation, and
- the mobility feature

the group agreed to collaborate in bringing this technology to a Puratone pig site in Manitoba and conduct all possible tests required to assess the effectiveness of this technology for Puratone and other Manitoba pig operations.

The mobile unit arrived on a Puratone finishing farm (Heritage Hog Farm) on June 18, 2007 for six weeks. Two IRDA technicians came with the unit and spent one week to install the unit and train one of Puratone's research technicians.

2. RESULTS AND DISCUSSION

2.1 Methodology for on-site operation

The ASSERVA 300 Decanter-Centrifuge mobile unit was used on a pig operation owned by Puratone in Manitoba. The Puratone pig operation is located at Heritage Hog Farm and is a growers/finishers barn of 6 000 places. During the six weeks in operation, the unit was used to process approximately 18 000 gallons of raw manure and a total of 45 sets of samples were collected and tested for effects of the technology on solids and phosphorus removal.

The unit mechanically separates solid from liquid in raw manure by using the principle of centrifugation. Solid/liquid separation takes place at high-speed rotation (4 500 rpm) causing suspended solid particles greater than 30 microns (μm) to move to the bowl wall. A scroll rakes over the centrifuged particles to the end of the bowl. The liquid is ejected at the other end by overflowing. The actual capacity of this centrifuge is between 1,3 to 2,5 m^3/hr for raw manure. The centrifuge is powered by an electrical motor of 7,5 kW (10 HP) requiring 600 volts (tri-phases) or equivalent. No chemicals (flocculants) were used prior to or during centrifugation. The ASSERVA 300 Decanter-Centrifuge unit costs about $ 80 000. The mobile unit system has a value of $ 300 000.

Appendix A: photos of the ASSERVA 300 centrifuge and the mobile unit (IRDA).

The unit was stationed on the lagoon bank next to the transfer manure well. The centrifuge was fed by raw manure from the transfer well using a sump pump. Solids separated by the centrifuge were collected and added to the Biovator for composting while finished liquid manure was discharged to the lagoon.

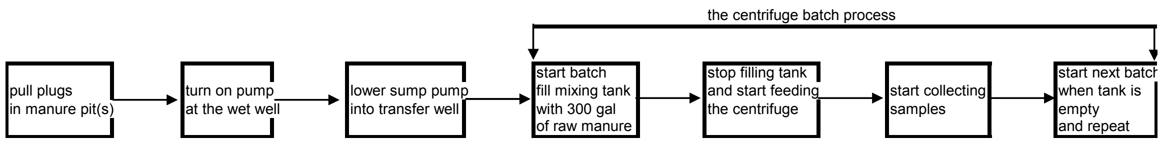
The centrifuge part of the operation (the separation) was based on a batch process described in the following diagram.

BARN

- Pull plugs in manure pit(s)
- Turn on pump at the wet well
- Lower sump pump into transfer well

MOBILE UNIT (CENTRIFUGATION)

- Fill mixing tank with 300 gallons of raw manure
- Stop filling tank and start feeding the centrifuge
- Start collecting samples
- When tank is empty, fill mixing tank again with 300 gallons of raw manure and repeat



The reason for following a batch process is to allow sufficient mixing of raw manure in the mixing tank before it is fed to the centrifuge and to facilitate the sampling procedure.

Continuous flow was tested in August 9 and 10, 2007, the results of which have shown that it is possible to continuously feed the centrifuge with the appropriate set-up.

Appendix B: a photo of the set up for the operation at Heritage Hog Farm.

2.2 Samples collection

Samples sets were collected for each batch. Each sample set consisted of:

- Raw liquid manure sample (before centrifugation)
- Finished liquid manure sample (after centrifugation)
- Separated solid manure sample (solid fraction)

Sample sets were composites of four sub-samples collected at four stages of the batch process. Samples were then sent to the lab to test for the following main parameters:

- % solids in raw liquid, finished liquid and solid fraction
- % phosphorus in raw liquid, finished liquid and solid fraction
- % nitrogen in raw liquid, finished liquid and solid fraction
- other parameters were also tested

2.3 Design of Experiment (DEO)

The DEO was conducted to test the simultaneous effects of a number of factors, e.g. the flow rate, the centrifuge setting and the solids in raw manure on the removed solids and phosphorus. The outcome of the DEO is a model describing such correlation.

2.4 Experimental Data

The removed solids ranged from 25% to 60% of solids in the raw liquid manure with an average value of 45%. The centrifuge experiment in Québec removed between 43% and 55% of solids in the raw liquid manure for a growers/finishers barn with an average value of 50%. The proper mixing of raw liquid manure before centrifugation is very important to get the most efficient removal of solids and avoid high variability. The most appropriate set-up will require a systematic mixing of raw liquid manure before entry in the mixing tank within the mobile unit (300 gallons tank) in order to homogenize the solids content. In our experiment, the use of the transfer well without previous mixing was not sufficient to get this homogeneity as shown by the high variability in solids removed.

The removed phosphorus ranged from 30% to 90% in the raw liquid manure with an average value of 63%. The centrifuge experiment in Québec removed between 38% and 72% of phosphorus in the raw liquid manure for a growers/finishers barn with average value of 58%. However, with raw liquid manure moisture content of 97% and less on Québec's pig farms, the centrifuge always removed an average of 70% of the phosphorus. Above this level (moisture content), the efficiency of phosphorus removal by the centrifuge decreases rapidly.

Moreover, by adjusting the inner liquid level in the centrifuge, moisture content of the solid fraction as well as efficiency of removal of nutrients, would be variable. Indeed, a low inner liquid level will generate a drier solid fraction with a lower rate of removal of nutrients than a high inner liquid level.

There was no significant difference in nitrogen content between the finished liquid fraction and raw liquid manure. However, average nitrogen content in raw liquid manure was at 2,63 kg/tonne and 2,33 kg/tonne for the finished liquid fraction. The centrifuge experiment in Québec removed between 21% and 34% of nitrogen in the raw liquid manure for a growers/finishers barn with an average value of 27%. The centrifuge would not remove most of the dissolved ammonium-nitrogen (NH_4^+) from raw liquid manure. Data on ammonium-nitrogen content of raw liquid manure and finished liquid fraction were not available in our experiment. However, data from our experiment seems to support this hypothesis (no significant difference between nitrogen content in raw liquid manure and finished liquid manure) that dissolved ammonium-nitrogen won't be removed by this centrifugation process. The finished liquid manure will therefore keep most of the available nitrogen.

The average moisture content of the solid fraction was 67%. The centrifuge experiment in Québec produces a solid fraction with moisture content between 57% and 65% for a growers/finishers barn with an average value 69%.

The average nitrogen and phosphorus content of the solid fraction was respectively 11 and 9 kg/tonne (tonne=1000 kg). The nitrogen and phosphorus content of a solid fraction from a growers/finishers barn in Québec was respectively 10 and 13 kg/tonne based on raw liquid manure at 93% moisture content.

The factors representing the linear correlation between percentage of solids removed and percentage of solids in raw liquid manure are significant. However, the linear regression model is not that significant. Thus, the model may be used to approximate the percentage of phosphorus removed if percentage of solids removed is known.

The efficiency of solids removed was around 50% for raw liquid manure for a growers/finishers barn in Québec at about 97% moisture content. Based on our experiment in Manitoba, the percentage of solids removed by the centrifuge predicted by the model would be about 40% for a similar moisture content of raw liquid manure.

Both the factors and the linear regression model for the relationship between percentage of phosphorus removed and percentage of solids removed are not statistically significant. However, the model may be used to approximate the percentage of phosphorus removed if percentage of solids removed is known.

In the experiment in Manitoba, the efficiency of removal of phosphorus seems to increase with the percentage of solids removed whereas in Québec, phosphorus removal by the centrifuge reaches a maximum of 70% at 97% or less moisture content in raw liquid manure. However, the percentage of phosphorus removed by the centrifuge at Heritage Hog Farm was 63%, which is fairly close to 70%.

Heritage Hog Farm also uses a straw filtering system during the experiment. Straw filtering was effective in removing solids but ineffective in removing phosphorus. However, removing part of the solids prior to the centrifuge treatment has definitely improved the centrifuge process as was demonstrated in the drop/consistency in pump's electric current draw.

In addition to phosphorus, other nutrients that were significantly removed using the centrifuge included: magnesium (80%), manganese (70%), aluminium (60%), molybdenum (60%), and copper (50%). The efficiency of magnesium and copper removal from raw liquid manure were respectively of 65% and 36% for a growers/finishers barn in Québec.

The following nutrients were found in significant amounts (kg per tonne) in the solid fraction: phosphorus (12 kg/tonne), nitrogen (11 kg/tonne), magnesium (9 kg per tonne), ammonium (7 kg per tonne), and calcium (4 kg per tonne).

The model produced using the DEO may be used to estimate percentage of solids removed if machine setting and flow rate as well as the percentage of solids in raw manure are known.

Table 1. Summary of test results by the centrifuge in Manitoba and Québec

Factors	**Manitoba (% Removal)**	**Québec (% Removal)**
	Average (Range)	**Average (Range)**
Solids	45 (25-60)	50 (43-55)
Nitrogen	n/a	27 (21-34)
Phosphorus (P)	63 (30-90)	58 (38-72)
Copper	50	36
	Solid Fraction Average (Range)	**Solid Fraction Average (Range)**
Moisture content (%)	67 (58-74)	69 (66-72)
Nitrogen (kg N/tonne=1000 kg)	11 (10-12)	10
Phosphorus (kg P/tonne)	9 (5-15)	13

As summarized in Table 1, the centrifuge is performing as expected in Manitoba (based on Québec's experiments on finishing farms), meaning that this manure treatment system might be an effective alternative in Manitoba to address phosphorus issues by pig operations in certain areas.

Since testing has been done on manure ranging anywhere from about two and a half percent solids to about nine percent solids, the technology is therefore applicable to the full range of manure typical for hog facilities all the way from farrowing to nursery to dry sow to finishing units.

However, by adjusting the inner liquid level in the centrifuge, moisture content of the solid fraction as well as efficiency of removal of nutrients, would be variable. Indeed, a low inner liquid level will generate a drier solid fraction with a lower rate of removal of nutrients than a high inner liquid level. As such, the experiment in Québec generated a drier solid fraction with a lower rate of nutrients removal than our experiment in Manitoba as expected by the manufacturer's specifications for this equipment.

Also, the moisture content of the solid fraction being at an average of 67%, this product would compost by itself or might be easily exported outside the operation (with most of the phosphorus as well).

The finished liquid fraction contains low levels of phosphorus (0.2 kg P/tonne) and keeps most of the nitrogen, thus the rate of application of this finished liquid fraction on land could be approximately at 6 000 gal/ac, and still meet nitrogen requirements and crop removal rate of phosphorus for grasses.

However, any manure treatment system must be carefully evaluated before implementation on farm.

2.5 Manure treatment systems – A step that takes planning

There are several reasons why an operation might consider introducing a treatment system. The primary objective is usually to render the agricultural operation compliant with the regulations. After treatment, the phosphorus usually ends up more concentrated in the solid fraction, which is exported, transformed, or spread outside regions with a phosphorus surplus. The farm's phosphorus surplus is thus absorbed and compliance achieved.

2.5.1 Agro-environmental diagnosis

Before one even starts to consider treatment scenarios, an agro-environmental diagnosis of the operation must be done. This information makes it possible to determine the phosphorus surplus and help zero in on the risk level of the operation based on the land it owns, the land it rents and the spreading agreement it has with third parties.

Determining the extent of phosphorus surplus is essential for guiding the operation towards the best possible solution. Chemical analysis of raw liquid manure, on-farm assessment of the volumes of manure produced, and the feed balance model allow an accurate picture of the nutrient load produced by the livestock operation.

The environmental vulnerability of the operation is in large part linked to the security of the agreements with receiving operations. Reliability, distance, cost, term and proportion of raw liquid manure volume are all variables that add an element of uncertainty.

2.5.2 Manure management strategy

Once the surplus situation has been validated, the operation must ensure that it has optimized phosphorus management by putting alternate solutions in place. These include reducing fertilization with mineral phosphates, reducing the phosphorus output of livestock, improving herd management and optimizing the management of water. If these actions are not enough to correct the farm's surplus situation, it is possible to optimize the phosphorus receiving capacity of the farm's soils through appropriate cropping practices or by increasing spreading surface areas. When all these actions have been verified and the surplus situation persists, then one can consider manure treatment systems.

Establishing the costs of conventional manure management is essential for making budget projections for various treatment scenarios. Each farm has a specific cost, based on its own particular characteristics. The volumes to be treated, spreading distances, equipment used, spreading and professional fees factor into the costs.

BEFORE CONTEMPLATING TREATMENT, THE OPERATION MUST ENSURE THAT IT HAS OPTIMIZED PHOSPHORUS MANAGEMENT BY PUTTING ALTERNATE SOLUTIONS IN PLACE.

2.5.3 Manure treatment system - Final strategy

In order to finally move to manure treatment technologies, it is essential to establish selection criteria based on the agro-environmental diagnosis, the expectations of the producer and the limitations of the farm. These criteria will help the owner of the operation to choose a process that suits him and provides a concrete solution to the environmental problem of its livestock operation.

THE CENTRIFUGE COMES AT THIS STEP

2.6 Attain benefits for the environment, community and economy

The objective of this project was to demonstrate the efficiency of a centrifuge to remove solids and phosphorus from raw liquid manure. This report provides technical assessments of the effectiveness of this technology to address the solids removal and phosphorus issues in Manitoba for livestock operators, mainly pig producers in certain areas.

Another important benefit will be the increased knowledge and leadership skills that can be developed by provincial staff, pig producers, researchers and commodity groups concerning manure treatment systems.

2.7 Project contributions to objectives of the sustainable development

This project will support and promote innovation for the sustainable development of the pig industry in Manitoba. It will also encourage environmentally sound decisions and actions concerning phosphorus issues in Manitoba (re: Lake Winnipeg) and improve the quality of life, in certain areas in Manitoba concerning the relationship between producers and the rural community by using new technologies to improve manure management and reduce odour issues. Indeed, much of the odour generated by liquid manure is due to the anaerobic decomposition of the solids in the manure. By separating the solids fraction from the manure, odours from the anaerobic decomposition of the liquid manure can be reduced. The solids fraction must be managed aerobically so that it does not become another source of odours.

2.8 Promotion and communication strategy

A Field Day was held on August 22, 2007 at Heritage Hog Farm. Approximately 50 representatives from commodity groups and the departments of Manitoba Agriculture, Food and Rural Initiatives, Conservation and Water Stewardship attended. News releases were produced by FarmScape Online (Episodes 2569, 2570 and 2571).

3. CONCLUSION

The purpose of the project was to test in Manitoba a technology that may potentially be used to separate solids and phosphorus from raw liquid manure. The centrifuge used in this project was brought in from IRDA (Institut de Recherche et Développement en Agroenvironnement) in Québec. The centrifuge is installed in a mobile trailer equipped with a mixing tank, laboratory and control panel.

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The objective of this project was to demonstrate the efficiency of a centrifuge to remove solids and phosphorus from raw liquid manure. This report provides technical assessments of the effectiveness of this technology to address the phosphorus issue in Manitoba for livestock operators, mainly pig producers in certain areas.

Another important benefit will be the increased knowledge and leadership skills that can be developed by extension peoples, pig producers, researchers and commodity groups concerning manure treatment systems.

This project will support and promote innovation for the sustainable development of the pig industry in Manitoba and also encourage environmentally sound decisions and actions concerning phosphorus issues in Manitoba (re: Lake Winnipeg) and odours.

APPENDIX A

Photos of the Mobile Unit (IRDA)

APPENDIX B

Photo of Heritage Hog Farm set-up