EAS
MANURE MANAGEMENT TECHNOLOGIES

Advanced Manure Treatment Technology for Deerboine Colony

April 18, 2007

Good Afternoon Everyone.

My name is Mel Hofer and I am here to speak on behalf of the Deerboine Hutterite Colony. Our colony, which is located 7 miles north from the town of Alexander in the RM of Daly, has a population of 87 people made up into 16 families. We farm 6500 acres and practice the concept of minimum to zero till. This is done because of economic reasons.

Business operations within the colony include hogs, dairy and beef cows, bison, and poultry.

The core business activity, which supports us, is hog production. The hog business that which we currently operate is an 800 sow farrow-to-nursery. But because of the inflation in production costs such as: fuel, machinery, cost of living, etc., it has been necessary to upgrade and expand the operation to 800 farrow-to-finish in order to continue with our farming lifestyle.

As you have probably heard repeatedly, one of the key concerns with the hog industry now is manure management. How to safely and effectively treat and dispose the hog manure produced with such an industry.

Presently, the number of animal units on our farm is not considered a large animal unit, so it does not fall under the large animal unit guidelines of Manitoba Livestock Mortalities and Manure Management Regulations. We are still considered a small farm enterprise. After the hog expansion is complete, our farm operation will be considered a large animal unit. We will then be required to have an effective manure management plan in place.

It has always been our goal to leave as little negative impact on the Creation as we possibly can. It is our goal and duty to preserve the air that we breathe and the water that we drink.

For this reason, we have embraced the "green" concept of manure treatment, as opposed to manure disposal. This concept leaves only two product streams that I am reluctant to call waste streams, because they are not. One stream is that of treated wastewater, with the goal to have it cleaned up better than required for wastewater treatment plants in Manitoba. The other product stream is Class A compost, a product that is called NutriPlenish®, and proven to rejuvenate topsoil.

This concept will now be described in greater detail by Dr. Peter Hombach.

Advanced Manure Management

In his statement of May 20, 2004, with the title "*Large-Scale Livestock Nutrient Recycling: A Key Part of a Sustainable Nutrient Management Strategy*", Bruce T. Bowman, chair of the CARC Expert Committee on Manure Management defined the following goals:

"There are three key criteria to be met in facilitating large-scale nutrient recycling - the manure must effectively be:

1. *Odour-free,*
2. *Pathogen-free and*
3. *Dewatered (it is not economic to transport water)"*[1].

The innovative and environmentally friendly sustainable nutrient management concept described in this document combines and utilises advanced manure handling and treatment technologies such as chemical solids separation, wastewater treatment based on the activated sludge biological nutrient (BNR) process and CompoFlex™ in-vessel composting technology. The proposed concept has a goal "to close the loop on large-scale nutrient flows"[1], and its product NutriPlenish® compost is a way to convert waste into a beneficial soil enhancer and avoid ground water pollution problems and greenhouse gas emissions associated with manure storage.

Osorno Enterprises Inc., ("Osorno"), has previously submitted to the Deerboine Colony a concept proposal as an outline of treatment strategies for the Colony that could address the wastewater problems and add composting of agricultural waste, including manure. This has started an intense discussion of treatment options, and eventually extensive laboratory tests were undertaken on pig manure from the Deerboine Colony. The data gained from these tests have led to the changes to the initially presented concept, and have evetually led to the comprehensive treatment concept presented here. It is the primary goal to provide a "green technology" solution to the manure problem, meaning that the only outgoing product streams of the Advanced Manure Treatment Plant (AMTP) will be:

- ✓ treated wastewater suitable for re-use or discharge, and

1 Philip K. Barton, James W. Atwater; "Nitrous Oxide Emissions and the Anthropogenic Nitrogen in Wastewater and Solid Waste", J. Environ. Eng. 128, 137 - 150 (2002).

✓ hygienic compost material (NutriPlenish® quality)

✓ exhaust gas from plant operation that has undergone biological clean-up

The individual treatment steps of the AMTP are laid out in this document.

It must be pointed out that the individual steps of this treatment process are well-established technology. However, to the best of our knowledge, these have not been applied to date in Canada for the treatment of manure, adding an element of pioneer spirit to the overall treatment process.

Likewise, the second process step (flocculation) has only been tested in this combination under lab conditions, and is now being implemented full scale without the benefit of an interim pilot plant. Our team has been involved with a pilot project for composting various sludge materials including manure in the late 1990s in North Dakota, with batch sizes of approximately 15 tonnes, i.e. comparable size. This pilot study has cost the client at that time approximately $770,000 in US funds.

Given the high cost of an adequately sized pilot study, and considering that funds for a pilot study would essentially be lost and result ultimately in more than doubling the investment cost, it is advisable to build the system full-scale and do the required process optimisation at the full-scale system. We believe that the risks associated with omitting the pilot study are small compared with the costs of such study.

As will become evident from the following, the overall process has been designed to be relatively forgiving in terms of hydraulic residence times and flow rates, to accommodate a wide range of optimisation requirements.

Design Conditions

The hydraulic load to be handled within one year was given as 6 million imperial gallons. On this basis, the following ***hydraulic*** load data were calculated:

annual hydraulic load	26,400 m^3/y
daily hydraulic load	72.3 m^3/d

Based on this information, the AMTP was designed for an hourly flow of 5 m^3/h, meaning that the plant is regularly operating at about 60% of its maximum treatment capacity (24 hour operation).

Because of the flexibility for which this plant was designed, we also see no substantial problems in operating the plant at a higher throughput rate than 5 m^3/h.

Unfortunately, there was little information available on the ***BOD freight*** as a design basis. Reasonably assumed BOD values are used in the pertinent sections of this document.

Permitting Process

Samson Engineering, Inc., Brandon, MB, has prepared and submitted the document "Proposed Livestock Expansion – Land Use Report" as a report dated April 7, 2005, which provided the basis for the permitting process of Deerboine Colony. The contemplated treatment (AMTP) surpasses by far the criteria laid out in the report that served as the basis for the initial permitting process, as becomes evident in a comparison:

- The conventional method is storage of manure until it can be land-applied. During this extended storage period, the biologically very active manure releases substantial amounts of greenhouse gases (GHG), mainly methane, but also carbon dioxide. Methane has an atmospheric lifetime of 12 ± 3 years and a warming potential of 62 over 20 years (carbon dioxide: 1). By contrast, the AMPT process interrupts the release of methane by killing the methanogenic bacteria with oxygen through aeration in the lift station.

- The land application of stored, i.e. anaerobically digested manure returns nutrients such as phosphorous (as phosphate) and nitrogen (mainly as ammonia) back into the soil. However, natural agricultural soil is dominated by ***aerobic*** bacteria, and preliminary scientific evidence suggests that it may take more than one year for the natural bioflora of soil to recover after the injection of ***anaerobic*** material. During this time, some methane can still be developed, owing to the organic material in the soil that is entering the anaerobic decomposition process through the land application. Environmentally most problematic are:

  - The release of dinitrogen oxide. This is particularly damaging, because dinitrogen oxide has an atmospheric lifetime of 120 years and a warming potential of 296 over 100 years (carbon dioxide: 1).

- The persistence of pathogens under these conditions. The most extreme case would be the survival rate of helminth ova. After 10 years, viable helminth ova can still be found, according to literature reports.

- The leaching of chemicals (phosphate, ammonia) as well as the possible leaching of pathogens into groundwater. The latter largely depends on soil conditions, however, chemical pollution of groundwater can already be found everywhere in Manitoba.

By contrast, an AMTP produces environmentally favourable material:

- Biologically very active compost that can be used for the microbiological rejuvenation of soil with ***aerobic*** bacteria, including those that are capable of nitrogen-fixation, i.e. they reduce the need to apply nitrogen fertiliser.

- Treated water at a quality that can be re-used, and is likely of better quality than the receiving body of water in this part of the Province of Manitoba.

As one can see, the treatment quality is superior, and thus well within compliance with the plan outlined in the above-quoted report.

Process Step 1: Lift Station and Pre-Treatment

Manure is kept in hog barns under anaerobic conditions ("pits"). This causes the undesirable release of greenhouse gases such as methane and carbon dioxide. However, these are odourless and lead to less of an acceptance problem than the smell associated with any kind of anaerobic microbial activity. This is also a hygienic concern, because many pathogenic organisms have a relatively high survival rate under these conditions.

However, the improvement of barn conditions is not within the scope of this project. The highly anaerobic content of the pits will be discharged into a lift station, which also serves as the unit that stops the anaerobic decomposition by applying aeration. Oxygen is toxic for many anaerobic bacteria, especially for methane producers, so that this activity ends right in the lift station upon aeration. Likewise, the production of the highly odoriferous sulfur compounds (hydrogen sulfide, mercaptanes, thioethers) ceases, as does the production of smelly amines and ammonia. In fact, these compounds will be biologically destroyed if a sufficient amount of oxygen is present. In other words, one can expect that the odour generation ends at this pre-treatment step.

At the same time, aerobic micro-organisms will begin to thrive, and are expected to begin floc formation, an important step towards the separation in the following treatment step. The science behind this pre-treatment can be described as follows.

Many anaerobic micro-organisms rely on exo-enzymes, meaning enzymes that these micro-organisms shed to accomplish digestion of organic material outside of their cell, because these nutrients would otherwise not be able to pass into the cell. This results in a solubilisation of material that was previously suspended but not dissolved. As a consequence, the biological oxygen demand (BOD) increases drastically with anaerobic micro-organisms. Our team has measured BOD values in the vicinity of 14,000 mg/l with manure kept in tanks at the Colony. For comparison, municipal sewage is typically in the 300 - 500 mg/l range, and one can calculate from pig population and barn water usage that the BOD of fresh manure if it were available, would also be well below 1,000 mg/l.

Consequently, the main purpose of pre-treatment through aeration is ending the anaerobic activity, and taking the already dissolved BOD back into the micro-organisms, i.e. generating aerobic treatment floc.

The pre-treated liquid phase is pumped into the next treatment step, the flocculation step. A

Process Step 2: Flocculation

Mainly as a consequence of the activity of anaerobic bacteria (see **Process Step 1**), most of the organic nutrients and reduced carbon (C) materials in liquid swine manure are either dissolved or contained in fine suspended particles that are not separated by available mechanical separators.

Treatment with polyacrylamide (PAM) polymers prior to mechanical removal or gravity settling has the potential for enhancing solids-liquid separation, thus concentrating nitrogen (N), phosphorous (P), and organic C. With the polymer, the small particles in swine wastewater are agglomerated into larger particles or flocs. This effect is well known for the separation of floc formed by aerobic bacteria, i.e. floc formed through the oxygen delivery in the aerated liftstation.

Description of Features / Processes

The solids-liquids separation is the first treatment step in the manure management under the AMTP scenario.

The process has the following features:

- adding of flocculant,
- adding of coagulant,
- reaction of flocculant and coagulant with the pre-treated manure (this requires nominally 5 minutes contact time);
- settling of the coagulated sludge (this requires nominally 20 – 30 minuntes time),
- solids-liquid separation into approximately 75% wastewater and 25% sludge,
- sending the separated wastewater to the WWTP and moving the sludge to the composting facility,
- application of the energy-saving ControLogic™ system for hands-off automatic operation.

The sequence of operation for the solids-liquid separation system is as follows:

Lab testing has shown that the flocculant – coagulant addition removes approximately 75% of the BOD from the liquid phase and condenses it into approximately 25% of the volume, i.e. into the sludge that settles in the tank.

This treatment step is designed for continuous operation, i.e. flow-through mode. However, it may turn out that a batch operation is more advantageous, i.e. tanks will be filled and discharged sequentially. The mechanical design allows both mode of operation, making the selection essentially a function of the programming of the ControLogic™ control system. This follows Osorno's philosophy of maintaining maximum flexibility by having the choice on the software side, rather than by the geometry of mechanical components.

All components operate under ControLogic™, Osorno's proprietary control system. This program section will be installed and tested during the commissioning of the respective functional groups.

In addition to the flexibility to choose between continuous *vs.* batch operation, the contact tank and settling tanks have been sized to allow for a wide range of contact and settling times during the optimisation process.

Process Step 3: Wastewater Treatment

It is expected that the wastewater treatment step will be an almost conventional activated sludge treatment step, because the anticipated BOD concentration is within range of conventional municipal BOD concentrations. However, this could not be verified previously with lab testing, owing to the lack of a costly pilot study.

With the assumption that the inflow to the wastewater step is not fundamentally different from municipal wastewater, one must recognise the following differences:

- Because of the prior treatment steps, a primary clarifier is not required.
- Because this influent stream contains still a certain amount of coagulant, one can expect good floc formation.

Biological Nutrient Removal (BNR)

Most living organisms cannot survive in the presence of toxic chemicals. However, some micro-organisms actually thrive on and utilise the toxic components as a food source. These microbes have powerful metabolic capabilities that enable them to break down a large variety of organic compounds. These bacteria are then placed in an environment to digest and reduce most organic components in the waste stream.

All microbial systems operate on the same fundamental biochemical principles. Removal of wastes (BOD, TSS) results from oxidation to end products (CO_2 and H_2O), synthesis of new cells, and endogenous respiration. The differences between the systems lies in the environment imposed on by the physical and mechanical aspects of the system. This results in variations between microbial populations depending on what system is used, which in turn can influence the adaptation and performance of the micro-organisms.

Activated sludge BNR sewage treatment units are ideal for areas where a high treatment quality, optional water re-use, and a cost efficient process are of the essence. This BNR system (modified version of the well established BioCompact® technology) is a complete biological sewage treatment system, a down-sized version of the activated sludge process used in advanced municipal wastewater treatment plants, that offers ***a complete biological nutrient removal*** (BNR) treatment cycle, which includes nitrification / denitrification as standard features. Phosphate is eliminated biologically down to the limit set by pH and calcium content of the water. These BNR plants satisfy pertinent local discharge standards in terms of BOD_5, TSS, NH_3, TKN, P, and COD, if the composition of the influent stream does not substantially deviate from the composition of municipal sewage.

Currently, most environmental systems, including wastewater treatment plants, are not controlled, but rather left to proceed at their (usually slow) natural rates. Controlling the process means optimisation of the processes. In the activated sludge process, the oxygen utilisation rate is higher than the rate of natural replenishment, requiring artificial aeration. Through advanced electronic control of the treatment process, the timing and amount of oxygen so provided is optimised, which saves expensive electrical energy that otherwise would be needed for the compression of air, and substantially enhances the performance of the microbial population that is used to degrade the pollutants in the wastewater.

Benefits of the proposed BNR system include low maintenance costs.

It is important to understand that the performance of any unit largely depends on the process engineered inside (as well as the actual quality of the influent). Due to this, we are confident that our process, which is controlled by our proprietary ControLogic™ system, will optimise the natural biological degradation processes, thus yielding the best and lowest possible effluent values.

The delivery of air in the treatment process is controlled using a control system (ControLogic™) that allows an automatic adaptation to different loads. For fail-safe operation, ControLogic™ will switch automatically between various modes of operation, should one of the sensors fail from which ControLogic™ receives its information. The sewage treatment system unit includes a final settling compartment. The settled sludge is recycled back into the activated sludge compartment. Any floating sludge that appears is returned. The process design contains many features of proprietary design, most notably in the algorithms used in the ControLogic™, available only through companies of the Canadian Osorno group and its partners.

The treatment goal is to reduce BOD, TSS, nitrogen, and phosphate, and to reduce the numbers of pathogens for an overall reduction of health risks and environmental impacts.

The expected effluent composition of the proposed wastewater treatment plant is (composite 24-hr sample, homogenised):

BOD_5: < 30 mg/L

TSS: < 30 mg/L

TKN: < 10 mg/L

This means that effluent parameters are well in compliance with pertinent Federal and Manitoba standards. With this effluent quality, the treated wastewater may be considered for re-use. It is unusual to see spikes in the effluent even when hydraulic surges or surges of very high BOD loads get into the treatment plant.

Because the BioCompact® technology is well proven and in use for almost 30 years, the wastewater treatment unit builds on that technology.

Process Step 4: Composting

Composting is as old as nature itself. Composting is nature's recycling mechanism of bacterial digestion (decay) of organic wastes. Without the natural composting processes life on earth would not be possible - organic wastes from plant and animal life would have inundated the surface of the earth long before mankind appeared.

In decentralised agrarian societies, natural composting processes are largely adequate to maintain the natural balance of human/animal waste production and bacterial decomposition without any significant treatment process. In urban societies human and industrial wastes become concentrated and overload the natural decomposition cycle to destroy/decay the wastes in acceptable time frames without some type of central storage facilities.

The only technology that can maintain the natural cycle of decomposing and returning organic material back to nature in a highly useful and beneficial form is **composting**. To effectively meet the challenges of waste management, composting must be accomplished under controlled conditions in the shortest possible time frame. This has led to the development of "high-rate controlled environment" composting systems that allow the complete process to occur in a matter of days rather than months or years. Whereas, the recycling of other materials is now commonly accepted, these latest developments in composting now make the recycling of organic waste on a large-scale practical and economically viable.

Finally, the application of a well-prepared compost provides bio-augmentation to soils that are often rather depleted of benign micro-organisms through years of fertiliser application.

The most advanced of these composting technologies is the CompoFlex™ enhanced nutrient recovery process:

- ✓ aerobic in nature;
- ✓ operated at self-initiated high-temperatures (relative to most natural decay processes) in an electronically controlled environment;
- ✓ yields a hygienic, organic product that can be utilised in horticulture, agriculture, and silviculture without undue time lags;

- ✓ use biological methods of destroying odours and pathogens that may be emitted during the handling and composting of organic solid waste materials;
- ✓ insures that the final product - NutriPlenish® compost - is free of all weed seeds, nematodes, and any pathogens associated with organic waste materials.

CompoFlex™ Design Philosophy

The CompoFlex™ design is based on the full biological **nutrient recovery technique (NRT)**. The system involves controlled aeration, mixing techniques and an active odour control system. The results are "high-rate, controlled environment" composting systems that have composting times of less than a month and no troublesome liquid or gas effluents. The final product NutriPlenish® compost is safe and beneficial to the soil.

Advantages

The compost process performs the following functions:

- ✓ The conversion and reduction of organic wastes to a form readily incorporated into soil.
- ✓ Disinfection of the non-biodegradable waste.
- ✓ The production of a bacterial culture capable of restoring natural biological processes for the production of plant nutrients in the soil.

Description of Features / Processes

The CompoFlex™ facilities have the following features:

- ♦ The ControLogic™ system provides automated monitoring of the operation.
- ♦ The operating requirements are electronically determined, and power consumption of the blower depends on the actual load conditions.
- ♦ Low maintenance expenses.
- ♦ Superior treatment quality.

♦ Premium compost after nominally 12 days of treatment.

The system uses a “negative-pressure” aeration method that draws composting bay air down through the composting material. This air stream is then blown through an active biofilter for complete odour control. All air delivery to the composting material is controlled to operate the system in a manner that produces the highest rate of decomposition and the most hygienic product.

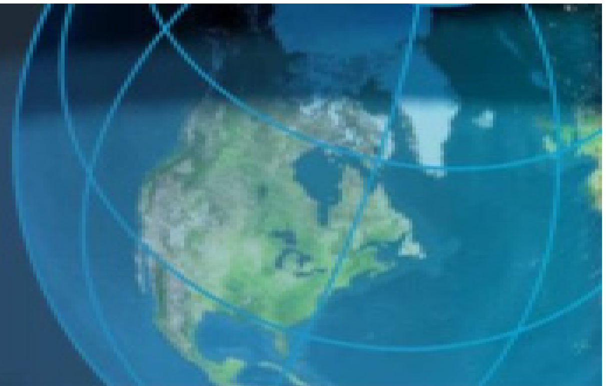
With the CompoFlex™ technology, oxygen depletion down to anoxic or anaerobic levels is not an issue; consequently odour production is minimised. All gas/vapour effluents are captured and disposed or destroyed in the biofilter. The final product is hygienic and contains a high value in terms of nutrient recovery and natural nutrient production as a soil enhancement material.

The air circulation and conditioning is controlled using an electronic control system (ControLogic™) that allows an automatic adaptation to different loads. For fail-safe operation, ControLogic™ will switch automatically between various modes of operation, should one of the sensors fail from which ControLogic™ receives its information. The process design contains many features of proprietary design, most notably in the algorithms used in the ControLogic™, available only through companies of the Osorno group, promoting advanced Canadian technologies.

Performance

Typical performance data are:

- Nominal composting time 12 days, nominal cycle time 14 days.
- Biologically generated heat peaks typically at 65 °C – 70 °C, efficiently destroying pathogens by a combination of heat and competitive biological pressure.
- Very low pathogen count, down to immeasurable quantities. Finished material contains no Escherichia coli, Salmonella ssp., pathogenic amoeba, and no viable helminth ova.
- Volume reduction of the organic matter is nominally 40%, often more.



Advanced Manure Treatment Technology for the Deerboine Colony

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OSORNO

Advanced Manure Treatment Technology

- Step 1: Aerated lift station - prevents GHG release
- Step 2: Flocculation / coagulation - compacts about 75% of the BOD load into about 25% of the volume
- Step 3a: Biological nutrient removal (BNR) from wastewater
- Step 3b: Composting of the sludge

OSORNO

Jar Test (different coagulants)

High-tech Composting: NutriPlenish® Compost

NutriPlenish ®

Windrow Compost

Technology Verification Project: Grand Forks, ND, engineer: KBM, Inc.

High-tech Composting

The demonstration facility holds batches of 20 t material, which are converted into compost in two weeks at temperatures of up to 70 °C in a partially oxygen-depleted atmosphere

OSORNO

Agricultural Benefit

Standard NPK fertiliser

NutriPlensish®, 5 t per acre

NutriPlensish®, 10 t per acre

NutriPlensish®, 20 t per acre

Durum showed a head weight increase of several hundred per cent. Other crop tested: flax, swiss chard, all with similar results.

Greenhouse tests by
Dr. Cehicek
North Dakota State University,
Fargo, ND