Pilot Testing of the Micronex™ System to Produce a Class A Biosolids

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Abstract: This paper presents the findings of a full scale pilot study to assess the feasibility of using the Micronex™ system to produce a Class A Biosolids. The Micronex™ system consists of a rotating mechanism inside a vertical cylinder through which dewatered biosolids are passed. Temperatures inside the cylinder are high enough to produce a Class A Biosolids. The Micronex™ process is not presently recognized as a Class A process under the British Columbia, B.C. Organic Matter Recycling Regulation. As part of the acceptance protocol, the Ministry of Environment requires that testing occur by spiking samples entering the Micronex™ unit with ascaris eggs and with the polio virus. Analyses of spiked data were carried out by Kari Fitzmorris, Sc.D., MSPH, Assistant Professor at Georgia Southern University and Janice Liotta, B.S. from the Parasitology Laboratory at Cornell University in Ithaca, New York, under the direction of Bob Reimers, Ph.D., QEP, Professor from Tulane University in New Orleans. Ron Thring, Ph.D., P.Eng. from the University of Northern British Columbia carried out an independent review of the pilot test work. Tests indicate that the Micronex™ system can consistently produce a Class A Biosolids. The economical feasibility of the system is currently being assessed.

Keywords: Class A sludge; pasteurization; Micronex™ heat treatment.

INTRODUCTION

The City of Prince George in British Columbia has conducted a pilot test on a new process to produce Class A Biosolids at their Lansdowne Wastewater Treatment Centre in order to increase disposal options. First American Scientific Corp., which has a unit called the KDS Micronex™ Processor, had shown significant potential in being able to efficiently convert Class B to Class A Biosolids. This was concluded on the basis of satisfactory preliminary testing of fecal coliform and salmonella samples that were processed in the Micronex™ unit in May, 2005 for the City under Dayton & Knight Ltd.'s direction. Dayton & Knight Ltd. subsequently assisted the City with overseeing the pilot study project at the Lansdowne facility to further test the Micronex™ system. The objective of the pilot study period was to establish whether or not the Micronex™ system can consistently produce a Class A Biosolids in accordance with the B.C. Organic Matter Recycling Regulation (OMRR).

This pilot testing work has involved various team members. These are listed in Table 1.

Table 1. Pilot Study Team Members

No.	Name	From	Position	Role
1	Marco Fornari	City of Prince George	Utilities Manager	Client
2	Norm Gobbi	City of Prince George	Supervisor of Wastewater Treatment Centre	Client
3	John Boyle, P.Eng.	Dayton & Knight Ltd.	Principal	Consultant
4	Alex Forrest, E.I.T., M.S.Sc.	Dayton & Knight Ltd.	Design Engineer	Consultant
5	Babak Rezania, Ph.D., QEP	Dayton & Knight Ltd.	Design Engineer	Consultant
6	Bob Reimers, Ph.D., QEP	Tulane University	Professor	Senior Spike Testing Program Director
7	Kari Fitzmorris, Sc.D.	Georgia Southern University	Assistant Professor	Spike Testing Program Director
8	Janice Liotta, B.S.	Cornell University	Parasitologist	Spike Testing Program Director
9	Ron Thring, Ph.D., P.Eng.	Prince George	Professor, University of Northern British Columbia	Independent Reviewer for Client
10	David Dungate, P.Eng.	First American Scientific	Program Manager	Micronex Supplier
11	John Flaherty	First American Scientific	Program Manager	Micronex Supplier
12	Ray Copes, Ph.D.	UBC Centre for Disease Control	Medical Director, Environmental Health	Protocol Approver
13	Dwight Bowman, Ph.D., M.S.	Cornell University	Professor of Parasitology	Ascaris eggs Advisor
14	Suresh Pillai, Ph.D.	Texas A&M University	Professor & Associate Director of Food Safety and Environmental Microbiology	Polio Virus & Enteric Virus Advisor
15	Jack Bryden, P.Eng.	Ministry of Environment	Environmental Management Officer	Protocol Approver

METHODS

a) Pilot Study Testing Requirements

The Micronex process is not directly correlated to any of the pathogen reduction processes listed in the British Columbia Organic Matter Recycling Regulation (OMRR).

OMRR is given authority under the B.C. Environmental Management Act, which is enforced through the Ministry of Environment and the Ministry of Health in British Columbia. Key contacts are:

Ministry of Environment (M of E): Mr. Jack Bryden, P.Eng. who has indicated that the process will require rigorous testing in a similar manner that processes are evaluated by the US Environmental Protection Agency's Pathogen Equivalency Committee (USEPA PEC).

Ministry of Health: Dr. Ray Copes is the Medical Director, Environmental Health, B.C. Centre for Disease Control (BCCDC) and Clinical Associate who also serves in an advisory role to the B.C. Health Authority on pathogen reduction requirements.

OMRR names acceptable processes known to produce a Class A Biosolids. Any new process requires rigorous testing. If the results from the tests from the new process were to receive the approval from the OMRR Regulators, then the new process would be additionally named as a process that is acceptable to produce a Class A Biosolids.

The Micronex™ system is a new process that is not presently recognized under OMRR to be an approved method of producing a Class A Biosolids.

Over the last fifteen years, the USEPA Pathogen Equivalency Committee (PEC) has evaluated various innovative biosolids treatment methods to determine their suitability for classification as a Class A process according to the USEPA CFR 503 Regulations. In accordance with CFR 503 requirements, the PEC is empowered to review and approve applications for alternate process schemes and sludge treatment processes which produce disinfected biosolids, which are determined to be equivalent to existing Class A processes.

The application must contain the necessary information to determine the equivalency of the process for classification by the PEC for a Class A certification. To apply for classification related to equivalency, the following protocol must be explained in the application.

1. Summary Fact Sheet
2. Introduction
3. Process Description
4. Sludge Characteristics
5. Process Characteristics
6. Product Description
7. Sampling Techniques
8. Spiking (Parasites/Viruses)
9. Analytical Method
10. Analytical Results
11. Quality Assurance
12. Rationale for Determining PSRP or PFRP Equivalency
13. Rationale for Vector Attraction
14. Appendices

The Pathogen and Indicator Organism Requirements for Class A Biosolids are summarized in Table 2.

Table 2. Pathogen and Indicator Organism Levels for Class A Biosolids According to CFR 503 Regulations

Class Requirements and Use Restrictions		
Factor	**Class A**	**Class B**
Indicator Bacteria		
Fecal Coliform	<1x10^3 organisms/gram of TS	<1 x 10^6 organisms/gram of TS
Reduction	5 log reduction	2 log reduction
Pathogen		
Bacteria	BDL	2 log reduction
Salmonella	<3 MPN/4 grams of TS	1.5 log reduction
Viruses	<1 PFU/4 grams of TS	2 log reduction
Protozoa	BDL	-
Helminth	<1 viable egg/4 grams of TS*	-

b) Micronex™ System

The following is a brief summary of the reported technical operation capabilities of the KDS Micronex™ System.

First America's KDS Micronex™ employs kinetic energy to grind and dry a wide variety of raw and recycled materials into extremely fine MicroFine™ powders comparable to talcum. It is possible to feed a blend of several different industrial and organic materials into the Micronex™, and produce a uniformly ground and blended product.

Raw material containing at least 40% oven dried solids (ODS) is dropped into the throat of the KDS Micronex™. The material enters the torus rotor chamber where it falls onto spinning chains and is subject to enormous centrifugal accelerations. The chains spin with a tip speed of about 640 kilometres per hour. The material is "fractured" as it impacts repetitively with the chains and the strike plates on the sides of the torus. Liquid water is also squeezed out of the material due to the compressive action of the impacts. Heat created from the kinetic energy of the impacts evaporates the moisture of the material. When appropriate particle size reduction is achieved, air flow in the torus lifts the particles upwards towards the classifier. Because the water removal happens due to mechanical forces, less energy is consumed than in thermal dryers – usually, only 1000-2000 Kj/kg (kilojoules per kilogram) of water removed – less than the latent heat of water evaporation. No heat input is used other than electricity. The total input horsepower of the pilot study unit was 233 kW. Selected particle sizes pass through the classifier and larger particles are forced back to the torus to repeat the impact process. Finished material is pneumatically conveyed out of the machine into the cyclone where the dry powdered finished material falls through the bottom air-lock gate to be packaged or placed in a bulk container. Water vapour and droplets leave the chamber through the vapour vents.

c) Field Testing

The field testing program to date has occurred in four phases:

I. Concept testing of the Micronex™ unit in Delta, B.C.

II. Establishment of pilot testing applications.

III. Initial pilot study testing in Prince George, B.C. for fecal coliform destruction.

IV. Spike testing of the pilot study equipment in Prince George, B.C.

RESULTS AND DISCUSSIONS

I. Concept Testing

This occurred at First America's facility in Delta. Biosolids at 20% (ODS) were handmixed with sawdust to approximately achieve at least a 40% (ODS) mixture (otherwise the biosolids product sticks to the inside of the Micronex™ processor).

Test observations were as follows:

- There was effectively, almost 100 percent pathogen kill for total coliforms, fecal coliforms, and E. coli. This brought the finished product well within the tolerance of 1000 MPN/g dry weight required for a designation of Class A Biosolids under the Organic Matter Recycling Regulation.
- Salmonella was not detected in any of the samples taken during the testing period. This included both the raw and finished samples.
- Samples were taken of the exhaust gas and measured for CO_2 and H_2S. Measurable amounts of CO_2 were found in every sample. Levels of H_2S were below the detection limit for every sample taken.

Following this concept testing work, it was decided to implement a full scale pilot study of the City of Prince George's Lansdowne Wastewater Treatment Centre.

II. Establishment of Pilot Study Apparatus

From the concept study work, it was recognized that even at the pilot study stage, that there was a need to automate the mixing stages. The constructed facility is illustrated on Figure 1.

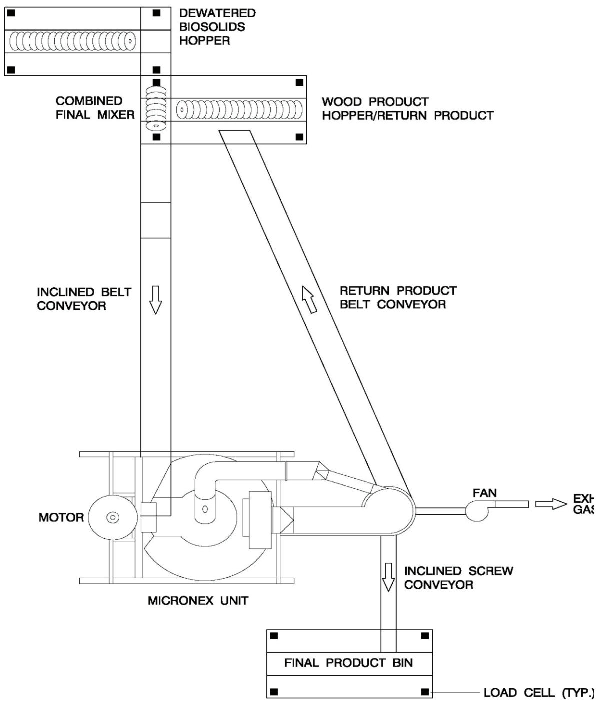

Figure 1

The principle behind the equipment layout is that the wood produce hopper is only used initially to provide the required 40% ODS mixture into the Micronex™ unit. As processed product is returned, less and less wood product is required and eventually only biosolids enters the Micronex™ unit.

III. Initial Pilot Study Testing in Prince George for Fecal Coliform Destruction

As with many pilot studies of this nature, considerable efforts were required to improve the mechanical operation of the conveyors and hopper mixing systems. A spreadsheet was developed to record all of the operating data on each trial run. Load cells were placed under each of the hoppers to enable a clear determination of weight change to be made of the various quantities being processed.

Heat loss in the Micronex™ chamber was initially significant. This was substantially improved by shrouding the main torus chamber and the discharge chamber with insulation. Test observations from this stage of the testing were:

- The optimum mixing ratio for the feed to Micronex™ was found to be a mixture of 13% raw biosolids and 87% final product. Sticking was a problem when a greater percentage of raw biosolids was used in the mixture.
- The average steady state processing temperature of Micronex™ was 68.4°C.
- The average raw biosolids and final product solids contents were 24% and 86%, respectively.

- The fecal coliform concentration in the raw biosolids (before mixing with the final product) was in the range of 6 to 8 million MPN/gram of dried solids. The fecal coliform concentration in the final product of Micronex™ was below the threshold requirement of 1000 MPN/gram of dried solids for a designation of Class A Biosolids under the Organic Matter Recycling Regulation.
- Samples were taken from the exhaust gas and measured for CO_2, H_2S and NO_2. All reported below the detection limit for every sample taken.
- Approximately 2 g/min of final product (powder) was carried over to the exhaust as dust.
- The Micronex™ was able to process 333 kg/h of raw biosolids on average.
- The finished product fecal coliform concentration was within the tolerance of 1,000 MPN/g dry weight required.
- The power consumption of Micronex™ was in the range of 170-180 kW.

Preparations were then made to carry out the spike testing work. Transporting the polio virus and returning the spiked samples across the Canada-US border involved numerous communications. The required permit was eventually obtained from the Public Health Agency and Food Inspection Agency of Canada.

The spike testing program consisted of carrying out two series of tests of 10 spike analyses of both *Helminth Ova* and *Enteric Virus* (10 is the minimum number needed for process approval by the USEPA PEC). The samples were also measured for fecal coliforms during the course of the spike testing work. The methodology was designed to determine if the *Helminth Ova* and *Eneteric Virus* become deactivated with the process and then to optimize both the processing time and operating temperature using fecal coliforms as indicators.

The analyses of the spike testing runs and data were detailed as follows:

- Two spiking runs were carried out.
- Run No. 1 was conducted at a temperature of 80ºC with the biosolids being held in the Micronex™ unit for 60 seconds.
- Run No. 2 was conducted at a temperature of 70ºC with the biosolids being held in the Micronex™ unit for 50 seconds.
- Both samples easily met the requirements of the EPA 503 Regulations for the polio virus spiking.
- The higher temperature Spike No. 1 test (80ºC) reduced the viable percentage of Helminth eggs to 0.36, which is below the EPA 503 limit of 1.
- Spike No. 2 test (70ºC) reduced the viable percentage of Helminth eggs to 1.16 which slightly exceeds the allowable EPA 503 limit of 1.
- The geometric mean of the fecal coliform results was 1.4×10^{-2} which is less than the allowable limit of 1×10^{3}.

Regarding the *coliphage* and *salmonella* tests, all were non-detectable (the *coliphage* test is one recommended by Dr. Reimers and is additional to that required by the USEPA.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions:

The Micronex™ system is capable of meeting the EPA 503 and OMRR Regulations for Class A pathogen reduction.

From the two spike tests carried out, it is apparent that to achieve or exceed the USEPA 503 Regulation requirements, that the Micronex™ system is required to operate at least at 80ºC for 60 seconds.

Mitigation of the generation of dust from the relatively fine final biosolids product and further improvements to increase throughput are the two key pilot study findings.

B. Recommendations including the following:

Design criteria should be established at temperatures in excess of 80ºC for 60 seconds. Temperatures of say 85ºC for 60 seconds are recommended.

Further investigations are required to reduce dust and increase throughput, following which an assessment should be made of the required number of units, along with the associated cost of a full scale system, including an energy balance. This will then enable the City of Prince George to make a decision on the feasibility of implementing a Micronex™ system for Class A Biosolids production at the Centre.

The possibility of adding a pelletizer unit at the end of the process should also be considered.

A further set of spike testing should also be arranged to provide additional assurances of the capabilities of the Micronex™ system.

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