

# **IBR PROCESS ASSESSMENT FOR TREATING SEWAGE SLUDGE**

**December 22, 1998**

## **1. TRIAL REQUESTS AND CONCLUSIONS**

On behalf of a client in Boston, MA, IBR conducted a witnessed and documented trial to digest municipal sludge.

Using the normal IBR process, amended only to compensate for the characteristics of the raw material, municipal sludge from the Greater Vancouver Regional District's Iona sewage treatment plant was successfully treated and converted into a useful granular product. During the trial the IBR process accomplished the following:

- eliminated the Fecal Coliforms and Fecal Streptococci from the final product.
- conserved the nutrients of the original sewage material.
- eliminated the sewage odor from the final product.

## **2. PROCEDURE**

### **A. Process**

On December 14, 1998 several truck loads of primary sewage sludge from the Iona Sewage treatment facility were received at International BioRecovery (IBR). The tanker trucks were driven into the plant on to the tipping floor, and the receiving door shut before the pumping process took place. The sewage was pumped directly into the macerator, and transferred to digester#1. This process took about 20 minutes per truck. During the pumping, little odor was created inside the plant and due to the plant air collection and treatment system, none was detected outside the plant.

The sewage was heated to thermophilic range which took about 6 hours to complete. During this time the sewage was aerated with bubble diffusers. After the desired temperature was reached, the sewage was transferred from digester#1 to digester#5 and inoculated with slurry from a previous digestion. Digester#5 is equipped with six 6 blade Shearators™, each providing 27 cubic feet per minute (cfm) of air each, for a combined air supply of 162 cfm.

After completion of the digestion, the slurry was screened using a 1/4" mesh, and then sent to the press where it was separated into solid cake (45% w/w) and filtrate (1.5% w/w). The cake was then dried to approximately 95% solid content

### **B. Sampling and Measurement**

Representative grab samples were taken for analyses from the pulp feed; the primary digesters and the final products. Air flow rate in the Primary Digester from the Shearator™ was measured by an air flow meter. All samples were analyzed within 3-4 hours. Samples were also sent to an accredited outside laboratory, Cantest, for analysis and test results. The raw test results obtained from Cantest are attached as an appendix to this report.

### **C. Analysis**

The following analysis has been done using Standard procedures for water and wastewater and a modified procedure for slurry and solid product (The results of the modified procedure is within a maximum 2% deviation from the results of the accredited outside laboratory, Cantest):

- Total Solids
- Total Volatile Solids
- Total kjeldahl Nitrogen (TKN)
- Phosphorous
- Biochemical Oxygen Demand
- Pathogen removal (assessed using two laboratory media: Eosin Methylene Blue Agar and MacConkeys Agar)

## **3. RESULTS AND DISCUSSION**

### **A. Substrate Characteristics (Raw Sewage)**

Total Kjeldahl Nitrogen (TKN): 3.15%

Phosphorous, P<sub>2</sub>O<sub>5</sub>: 0.77 %

Potassium, K<sub>2</sub>O: 0.2%

pH: 5.5

Gram Negative Enteric bacilli:  $3.53 \times 10^9$  cfu/g dry sewage

### **B. Digestion Process**

The Digestion process proceeded as expected. As shown in Figure 1, the pH and temperature profile were typical for an IBR digestion of other organic waste. There was an initial decrease in pH, followed by an increase and stabilization at pH 7.3. However, the initial pH drop was shorter and less substantial than what normally occurs. This suggests the waste was in a more easily digestible form compared to vegetables, fruit or other wastes. The first temperature rise was evident after 13 hours (67.6<sup>0</sup>C) and continued to rise reaching a maximum of 75.0<sup>0</sup>C at 49 hours. After 63 hours of digestion, the temperature was definitely on a slight downward trend indicating a decrease in the metabolic activity. This is an indication that the digestion has completed. At this point, the digested product was screened, pressed and dried.

As shown in Figure 1 by Point A, the process time could have been reduced by 14 hours to coincide with the initial temperature fall. As well, it should be noted that the inoculum used in the sewage digestion came from a previous digestion which has been conditioned over time to be very efficient in the digestion of vegetable waste. If one was

to continually digest sewage sludge, the inoculum would be improved over time by natural selection. This could further reduce the process time.

The increase in pH and temperature indicates a successful digestion occurred. During the digestion, a BOD reduction of 37% occurred along with a 16% reduction in volatile solids<sup>1</sup>. The total solids did not change during the digestion, and the total kjeldahl nitrogen increased slightly (see Appendix 1).

### C. Pathogen Analysis

As shown in Table 1, the level of gram negative enteric bacilli pathogens in the sewage was reduced from 3,530,000,000 colony forming units per gram dry sewage to zero detectable colonies after digestion.

**Table 1** IBR Results: Gram Negative Enteric Bacilli (Includes Fecal Coliforms)

Time (hours)	Eosin Methylene Blue Agar		MacConkeys Agar	
	Total (cfu/g dry)	Possible E.coli (cfu/g dry)	Total (cfu/g dry)	Possible Salmonella (cfu/g dry)
<b>0</b>	3,530,000,000	192,000,000	484,000,000	235,000,000
<b>14</b>	688	0	0	0
<b>63</b>	0	0	0	0

cfu = colony forming units

Eosin Methylene Blue Agar = Bacterial growing media for isolating and differentiating gram-negative enteric bacilli.

MacConkeys Agar = Bacterial growing media for isolating and differentiating lactose fermenting from lactose non fermenting gram-negative enteric bacilli.

Tests performed by CanTest laboratories found no detectable Fecal Coliforms or Fecal Streptococci in IBR's final product (Table 2).

**Table 2** CanTest Results

CanTest Results	Fecal Coliforms (MPN/100g)	Fecal Streptococci (MPN/100g)
<b>IBR Final Product</b>	below detectable limits	below detectable limits
Detection limits	20	20

MPN = Most Probable Number

### D. Heavy Metal Analysis

<sup>1</sup> Calculated assuming the weight of the fixed solids in the digested sludge equals the weight of fixed solids in the untreated sludge and the volatile solids are the only constituent of the untreated sludge lost during digestion.

Table 2 shows the metal analysis performed by CanTest laboratories on the sewage at different stages of the digestion. The only drastic change in concentration that occurs is due to the dilution effect of the inoculum. Otherwise, the metal concentration present in the slurry at the start of digestion, on a dry weight basis, will be very similar to the concentration of heavy metals in the final product. Therefore, one can control the concentration of heavy metals in the final product by using different mixtures of raw sewage (which characteristically contain a high concentration of heavy metals) and vegetable/food matter (which contain a low concentration of heavy metals).

**Table 2**

<b>Metal</b>	<b>Raw Sewage (mg/kg)</b>	<b>Inoculum (mg/kg)</b>	<b>Raw Sewage + Inoculum (mg/kg)</b>	<b>Solid Fertilizer Product (mg/kg)</b>	<b>United States Pollutant Concentration limits for EQ and PC biosolids (mg/kg)</b>
<b>Antimony</b>	<	<	<	<	-
<b>Arsenic</b>	<	<	<	<	41
<b>Barium</b>	90	<	50	35.1	-
<b>Beryllium</b>	<	<	<	<	-
<b>Cadmium</b>	<	<	<	<	39
<b>Chromium</b>	31	3.57	19	18	1200
<b>Cobalt</b>	<	<	<	<	-
<b>Copper</b>	288	2.79	161	102	1500
<b>Lead</b>	130	<	72	25	300
<b>Mercury</b>	0.95	<	0.53	0.19	17
<b>Molybdenum</b>	<	<	<	<	-
<b>Nickel</b>	<	11	4.95	10	420
<b>Selenium</b>	1.1	<	<	<	36
<b>Silver</b>	<	<	<	<	-
<b>Tin</b>	<	<	<	<	-
<b>Vanadium</b>	12	2.1	8	5	-
<b>Zinc</b>	173	26.82	108	86	2800
<b>Aluminum</b>	4790	123	2713	1620	-
<b>Boron</b>	10	23	16	19	-
<b>Calcium</b>	8550	100000	49189	84700	-
<b>Iron</b>	7330	922	4478	3390	-
<b>Manganese</b>	124	15.35	76	79.5	-

Results expressed as micrograms per gram, on a dry weight basis

< = Less than detection limit

- = No metal concentration standard

## **E. End Product Characteristics**

The digested slurry was screened and sent to the press. The cake was dried to 96.8% solid content and the filtrate has been collected for further use. The analysis on the N-P-K of the solid and liquid product is as follows:

**Table 3**

<b>Fertilizer</b>	<b>Total Solid (%)</b>	<b>Total Kjeldahl Nitrogen (%TKN)</b>	<b>Phosphorous (%P<sub>2</sub>O<sub>5</sub>)</b>	<b>Potassium (%K<sub>2</sub>O)</b>
<b>Solid Fertilizer</b>	96.8	3.26*	1.25*	0.72*
<b>Liquid Fertilizer</b>	2.84	2.6*	0.5*	4.6*

\* Based on dry weight

The higher concentration of nitrogen and phosphorous in the solid fertilizer compared to the liquid fertilizer, show these nutrients to be in a predominantly insoluble form. Their release from the fertilizer will be slow which will significantly reduce the problems of nitrogen contamination of the ground water, and poor utilization of the nutrients. The soluble potassium in IBR fertilizers can be used immediately by the plant, or can be held and made available through the presence of humic substances ( which can act as chelating agents) found in IBR fertilizers.

#### **4. CONCLUSIONS**

According to the data available during the process and on the final product, it is concluded that sewage can successfully be processed using IBR technology.

Basically the digestion process has accomplished several things:

- eliminated the Fecal Coliforms and Fecal Streptococci from the final product.
- conserved the nutrients of the original sewage material.
- eliminated the sewage odor from the final product.

#### **Appendix 2**

CanTest Laboratories Results:

Sample 1: Sample of Raw Sewage

Sample F: Liquid Fertilizer

Fertilizer S: Solid Fertilizer