The Canadian Society for Bioengineering
The Canadian society for engineering in agricultural, food, environmental, and biological systems.

La Société Canadienne de Génie Agroalimentaire et de Bioingénierie
La société canadienne de génie agroalimentaire, de la bioingénierie et de l'environnement

Paper No. 06-114

Dead animal composting; results on the Biovator^{TM} composter for the swine industry

Author #1

Yves Choinière, ing., agr., P. Eng
Les Consultants Yves Choinière Inc.
84, rue Roy, Ange-Gardien (Québec) J0E 1E0
Téléphone : (450) 293-8960 / Fax : (450) 293-8963 / consultants@yveschoiniere.com

Written for presentation at the
CSBE/SCGAB 2006 Annual Conference
Edmonton Alberta
July 16 - 19, 2006

Abstract

The Biovator^{TM} composter is basically a long rotating drum built to operate as an in-vessel composter. It operates on a continuous flow basis with daily addition of mortalities. This system is currently used across Canada on swine production units. The main objectives of the project were to optimize the composting process mix ratio and to validate the disinfection potential with regard to pathogens and bacteria.

The results demonstrate that the Biovator^{TM} composter operates effectively for the first high temperature composting period with internal temperatures ranging from 50 to 65° C. The pathogens and bacteria are non-present following the period of 7 to 10 days of residence. The produced compost has very high soil fertilizer values.

Key words: Compost, mortality, pig, swine, Biovator^{TM}, agronomic, microbiological parameters.

Résumé

Le Biovator^{MC} est vendu et fabriqué au Québec par la compagnie *Agri-Ventes Brome Ltée*, pour effectuer le compostage d'animaux morts de la ferme. Le premier rapport sur les conditions de température au-dessus de 0° C a été soumis le 6 janvier 2006, couvrant une période d'essais du 16 mars au 14 octobre 2005. Le site expérimental permet de composter un mélange d'animaux morts composé de truies, porcelets et porcs à l'engraissement (excluant les placentas). Le présent rapport contient les données du 17 octobre 2005 jusqu'au 7 février 2006 pour obtenir des résultats d'essais en période froide.

Résumé des résultats - Phase de compost en continu avec l'ajout de compost recyclé

Recette utilisée

	Période hivernale (T° < 0)	Période estivale (T° > 0)
Animaux morts	1 kg	1 kg
Copeaux de bois (TEE 10-12 %)	0.28 kg	0.32 kg
Compost recyclé	0.44 kg	0.45 kg

Analyses effectuées sur le compost produit (moyenne)

	Période hivernale	Période estivale
Azote total Kjeldahl	22.8 kg / t	26.9 kg / t
Phosphore	5.2 kg / t	3.3 kg / t
Potassium	6.0 kg / t	5.3 kg / t
Matière organique	96 %	94 %
Rapport C/N	23	19
Matière sèche	48 %	57 %

Bilan de masse du processus de compostage avec le Biovator^{MC} et l'entreposage

Intrants, animaux morts	Compost à entreposer cumulatif
1 kg	0.83 kg

Note : La masse volumique est non quantifiée car il y a une grande variabilité selon la teneur en eau. La masse volumique suggérée de conception est de 500 kg / m^3 pour une teneur en eau (TEE) de 40-60 % pour des amas non compactés de 3.6 m de haut.

Le tableau suivant présente les capacités estimées du Biovator^{MC} selon la recette suggérée.

Intrants du Biovator^{MC}	Masse suggérée (kg / jour)	
	Période estivale	Période hivernale
Mélange d'animaux morts	70 à 80	75 à 85
Copeaux de bois	17 à 20	21 à 24
Compost produit à entreposer, valeur moyenne pour un rapport de 0.83	58 à 66	62 à 71

Les analyses microbiologiques et parasitologiques du compost démontrent que l'atteinte de 130° F (55° C) et plus à l'intérieur du Biovator^{MC}, permet d'obtenir un compost d'une qualité satisfaisante pour l'utiliser comme fertilisant sur les terres agricoles.

Résumé des résultats d'analyses microbiologiques et parasitologiques

Date	*Salmonella Spp.*	*Escherichia Coli*	*Enterococcus*	*Clostridium perfringens*	*Yersinia enterocolitica*	*Cryptosporidium*
16 septembre 2005 au 11 octobre 2005 Nb = 9 échantillons	--	--	✓	--	--	--
7 décembre 2005 au 18 janvier 2006 Nb = 12 échantillons	--	--	✓	--	--	--

✓ = Présent

-- = Négatif

Le compost d'animaux morts pourrait être utilisé pour épandage sur les terres agricoles selon le « Règlement sur les Exploitations Agricoles » (REA).

En conclusion, le Biovator™ permet de produire un compost de qualité, tout au long de l'année selon des conditions climatiques similaires à la Montérégie.

INTRODUCTION AND REVIEW

In the province of Quebec, the mortality disposal is regulated by the act named "Loi sur les produits alimentaires, L.R.Q.c.P-29" and by the regulation named "Règlement sur les aliments r.1". According to this regulation, there are 3 authorized methods for mortality disposal. They are 1) incineration, 2) burial and 3) recuperation. For a number of years, recuperation was almost the generalized way. However, important cost increases with the transport of carcasses and the concerns of disease transmission have added pressure to develop reliable on-farm composting techniques.

Across Canada, dead animal composting has been accepted and recommended. Numerous fact-sheets and guidelines are published. However the in-vessel composting technique had not been investigated for swine mortalities.

The in-vessel composting technique presents numerous advantages with regard to 1) short period for the first 10 to 14 days of composting with controlled hot temperatures, 2) automatic mixing of the compost mass, 3) frequent aeration associated with the 6 to 10 drum rotations per day and 4) non-access to rodents and pest.

OBJECTIVES

The goal of the project is to validate the composting capabilities and efficiency of the Biovator™ composter. More specifically, the objectives of the project were to:

1. Develop the compost recipes and mix ratio of ingredients
2. Optimize the composting process with regard to
    - 2.1 Operating temperatures
    - 2.2 Compost moisture levels
    - 2.3 Optimize the drum rotation frequencies and speeds
3. Validate the operation during the summer period and the winter period
4. Monitor the levels of specific bacteria and pathogens at the end of the composting period
5. Present results to comply with the Quebec law and regulation for the disposal of swine mortalities.

PROJECT COLLABORATORS

Experimental site

Ferme Gaudreau Inc. – Farnham, Quebec

Owner: Réal Gaudreau

1250 sows farrowing site, nursery site, finishing site

Laboratories

Agronomic compost analysis

Agridirect Inc. laboratories – Longueuil, Quebec

Metals and specific contaminants

Bodycotte Essais de Matériaux Canada Inc. – Quebec, Quebec

Bacteria and pathogens

Laboratories of the « École de médecine vétérinaire de l'Université de Montréal »

St-Hyacinthe, Quebec

Inspection division, dead animals disposal

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) – Quebec, Quebec

Direction de la normalisation et de l'appui à l'inspection des aliments

Mr. Guy Boucher, agr.

Quebec Federation of Pork Producers – Longueuil, Quebec

Mr. Claude Miville, agr., program coordinator, R&D

Financial support

Brome Agri-Sale Ltd. – Dunham, Quebec

Mr. Denis Martin

Mr. Alain Senay

The Puratone Corporation – Winkler, Manitoba

Mr. Shawn Compton

Conseil de Développement en Agriculture du Québec (CDAQ) – Longueuil, Quebec

PROCEDURES AND METHODS

Project phases

There were 4 phases to the project. Table 1 summarizes the major aspects of each phase.

Table 1: Summary of the experimental phases

Phases	Description of the activities
1 – March 9 to June 1st , 2005	Composter start-up • Initial start recipes • Supplemental heating • Recycling of the first-age compost • Re-introduction of the visible bones and parts
2 – June 1st to September 30, 2005	Warm and hot temperature test period • Measurements of temperatures, relative humidity • Sampling for laboratory analysis
3 – November 2005 to January 2006	Cool and cold temperature test period • Measurements of temperatures, relative humidity • Sampling for laboratory analysis
4 – January 9 to February 1st , 2006	Composter test closing • Stop of addition of mortalities

<u>Equipment and installation</u>

Photo 1 and figure 1 illustrate the experimental Biovator™ installed at *Gaudreau Farm* during February 2005. The Biovator™ used is the midsize model with 9.1 m (30') long by 1.2 m (4') of diameter. The drum is entirely made with stainless steel (inner and outer covers). It is insulated with an injected product. There are 3 basic openings. The first set of doors (2 doors) allows introducing mortalities, wood shavings and the recycled compost. The second set of doors is located downstream near the 4/5 of the cylinder. It allows measuring the temperatures and sampling the compost mass before the end of the process. Lastly, an effluent door is showed on photo 2 next to the recuperation basin. Photo 3 illustrates the long-term storage for the compost prior to final land spreading.

The following procedure was followed with regard to the mass balance aspects.

Photo 1: Biovator™ composter, installation of February 25, 2005

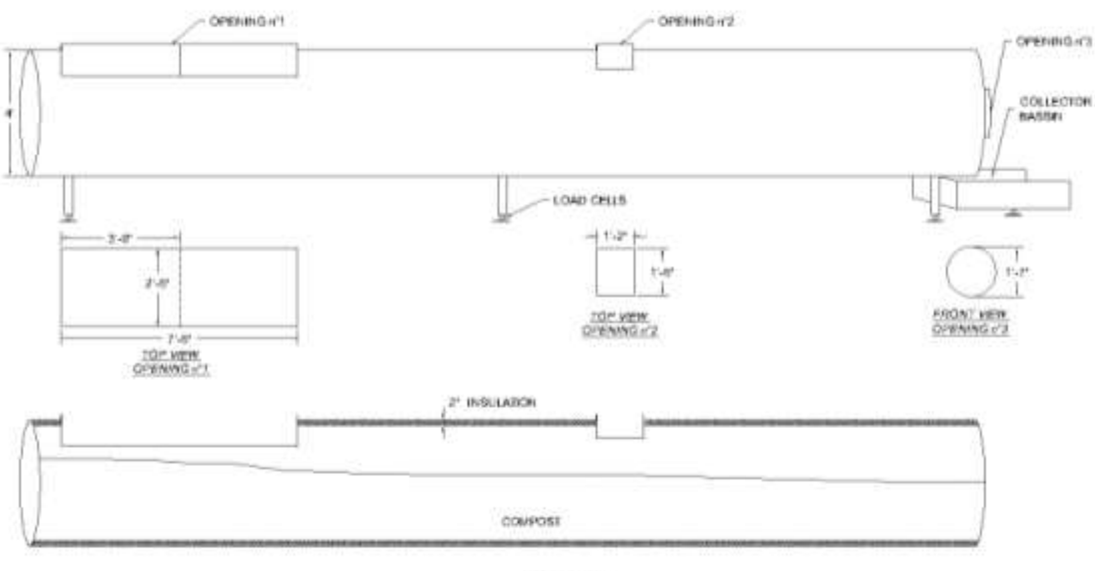

Figure 1: Biovator™ schematic

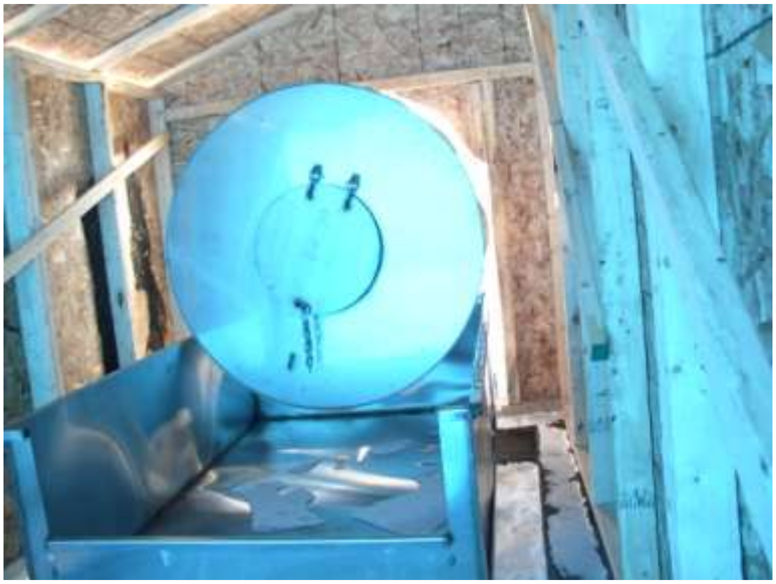

Photo 2: Biovator^{TM} effluent opening and collector basin

Photo 3: Long term storage of the composted mortalities

Table 2: Summary of the procedure to obtain a mass balance

Ingredient	Type of weighing equipment	Procedure
Mortalities	• Load cell on the tractor front end-loader • 5 days per week. Weekend mortalities are added on Monday • Biovator load cell system	• Suspend the animal with the tractor bucket • Introduction in the Biovator™ opening # 1 • Verification of the added weight with the Biovator™ load cell
Wood shavings	• Floor scale drums	• Measure the weight of wood shavings • Introduction in the Biovator™ to cover the mortalities with 150 mm of wood • Verification with the Biovator™ load cell
Recycled compost and bones	• Floor scale drums	• Measure the weight of the compost to recycle with the bones • Introduce in the Biovator™ opening # 1 • Verification with the Biovator™ load cell

MONITORING PROGRAM

Table 3 summarizes the monitoring program followed during the summer and winter test periods.

Table 3: Monitoring program

Item	Description	Frequency
Temperature	• Compost mass, openings #1, #2 and #3, every week day • Exterior temperature • Thermocouple instrument and insert sensors	• 5 days / week
Relative humidity	• Thermo hygrometer	• 5 days / week
Compost sampling	• In the collector basin	
	• Following the removal of the bones to recycle	
	• Before the long term storage	
	• Agronomic sampling	• Every 14 days, June 2005 to January 2006
	• Pathogen sampling	• Every 14 days, specific period

Photo 4 shows a compost sample with the monitoring equipment.

Photo 4: Composted material, collector basin

RECIPES AND MIXES FOR THE COMPOSTING PROCESS

Two basic recipes were tested during the first test phase. For the starting period, a bed of 150 to 200 mm of wood shavings was laid on the bottom part of the Biovator^{TM}. The mortalities were introduced and covered with wood shavings according to the following mix ratio.

- 1 kg of mortality
- 0.7 kg of dry wood shavings (12 % DM)
- No addition of water

The goal is to obtain temperatures above 38° C to initiate the composting process. For cool weather (below 0° C), the initial addition of heat with a 60 000 Btu / hr propane heater was necessary to rapidly obtain a temperature rise. When the composting process is activated, the same mix ratio was used for a period of 14 days.

When composted material appeared in the collector basin, the operator recycled the compost in the opening # 1 with mortalities and new wood shavings with the following proportion.

- 1 kg of mortality
- 0.25 kg of wood shavings (12 % DM)
- 0.44 kg of recycled compost including bones

RESULTS AND DISCUSSION

Phase 1: Composting process initiation.

The first mortalities were introduced on March 16, 2005. The initiation period from March 16 to April 30 allowed to validate the mix ratio of 1 kg of mortality / 0.7 kg of dry wood shavings. During this period, there should be no addition of water. For temperature below 0° C, supplemental heat is necessary to reach an interior Biovator^{TM} temperature of 60° to 65 ° C. Wet wood shavings is not recommended for the initial period.

During this phase, piglets and small pigs should be disposed. Large sows or finishing pigs present some difficulties to rapidly compost and produce non-degraded bones.

Phase 2: Recycling compost

If the start-up recipe is followed, the duration of the initiation phase 1 should vary between 14 to 28 days.

Compost exits by the horizontal door at the end of the Biovator^{TM}. For the current test, the intent was to reach a compost without the presence of visible bones or residual meat parts prior to the transfer in the long-term storage. Consequently, the overall capacity of the Biovator^{TM} to treat mortality may be enhanced if the user decides not to recycle bones and immediately store the compost. The bones would degrade in the static pile similar to other pile or windrow composter facilities.

RESULTS ON THE BIOVATOR^{TM} INTERNAL TEMPERATURE

Figure 2 presents the temperature measured at 3 locations in the Biovator^{TM} for the period of September 1st to 30, 2005. The figure shows the temperatures at the openings # 1, # 2 and # 3. Basically, the temperatures were in the range of:

Table 4: Temperatures range, September 1st to 30, 2005

Opening	T° range	Average
1	48° to 61° C	55° C
2	54° to 62° C	60° C
3	36° to 60° C	51° C

The temperature varies according to the addition of large sows or mass of pigs. The addition of a 230 to 270 kg sow creates a drop of temperatures for about 4 days. On September 9 and 14, the automatic system of the Biovator^{TM} did not function and the drum rotated for 3 or 4 consecutive hours. This created an over mixing and rapid cooling of the compost mass.

Generally, the addition of piglets, finishing pigs and occasional sows allows the composting process to be fairly uniform.

During July and August 2005, different bone recuperator units were tried. They were built with a wire grid or an inclined reversed cone to sort the bones from the composted material.

These separation grids were not successful due to door plugging problems. Small bones are long and narrow and they fitted in between the grids. After 1 day, the operator had to clean the grid. Consequently, bone separation was done with a simple fork with long narrow spaced hairs. It took only minutes to comb the compost.

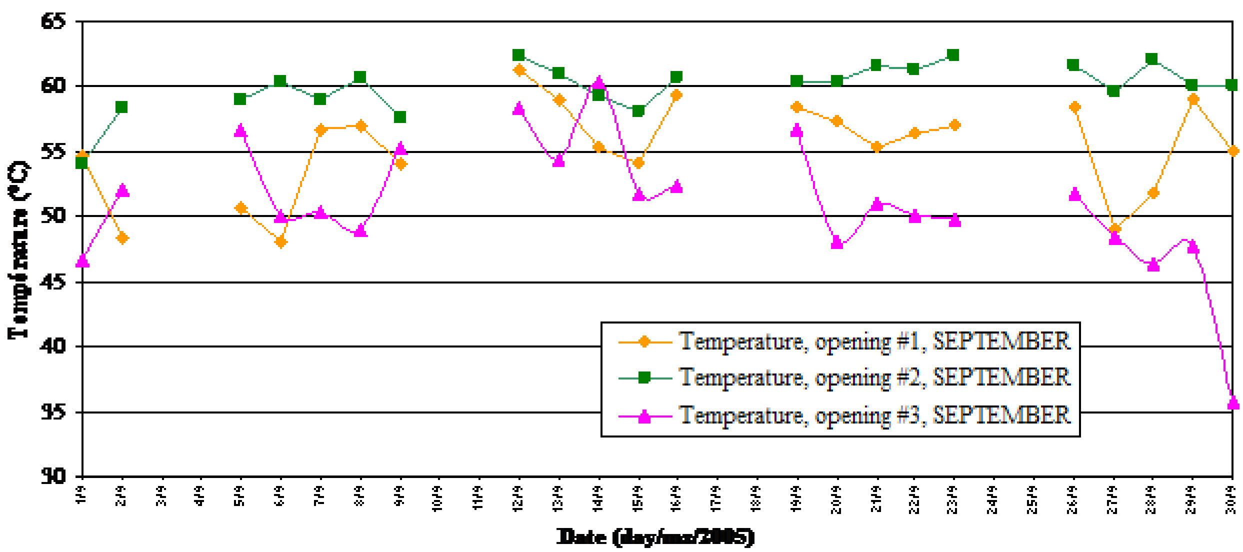

Figure 2: Internal temperatures, Biovator™ September 1st to 30, 2005

The summer tests were concluded in mid September with a stable composting process.

WINTER TEST PERIOD

The second part of the research program was to study the composting process during cool and cold weather. From October 1st, 2005 until January 16, 2006, the same protocol for site visits, temperature sampling and collection of samples for laboratory tests was followed.

Period of November 1st to 30, 2005

Figures 3, 4 and 5 summarize the data obtained from November 1st to 30, 2005. Figure 3 presents the composition of the types of mortality being: sows, weaners or finishers. Figure 4 illustrates the average and minimum daily temperatures from the Farnham airport weather station. Figure 5 shows the measured temperatures at the three locations in the Biovator™.

For exterior temperatures within –10° to +10° C, internal temperatures were fairly stable.

Table 5: Temperatures range, November 1st to 30, 2005

Opening	T° range	Average
1	44° to 57° C	51° C
2	54° to 64° C	61° C
3	48° to 64° C	57° C

These temperatures are ideal for rapid composting of the mortalities, the only temperature drop has coincided with the addition of a 240 kg sow during the week of November 7 to 14, 2005. However, it had negligible effects on the temperatures at opening #2 and #3.

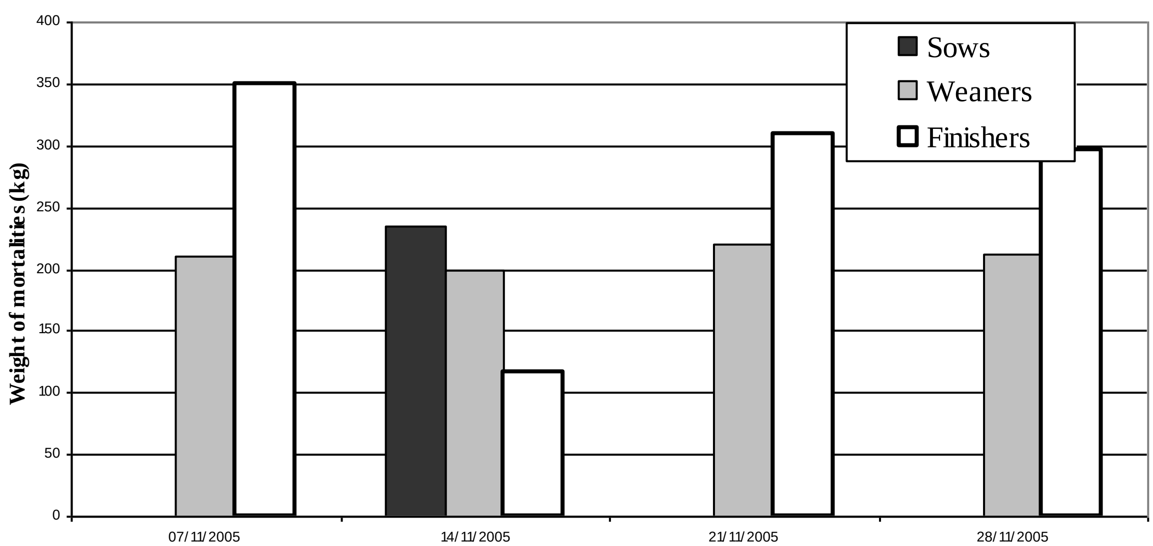

Figure 3: November 2005, composted mortalities

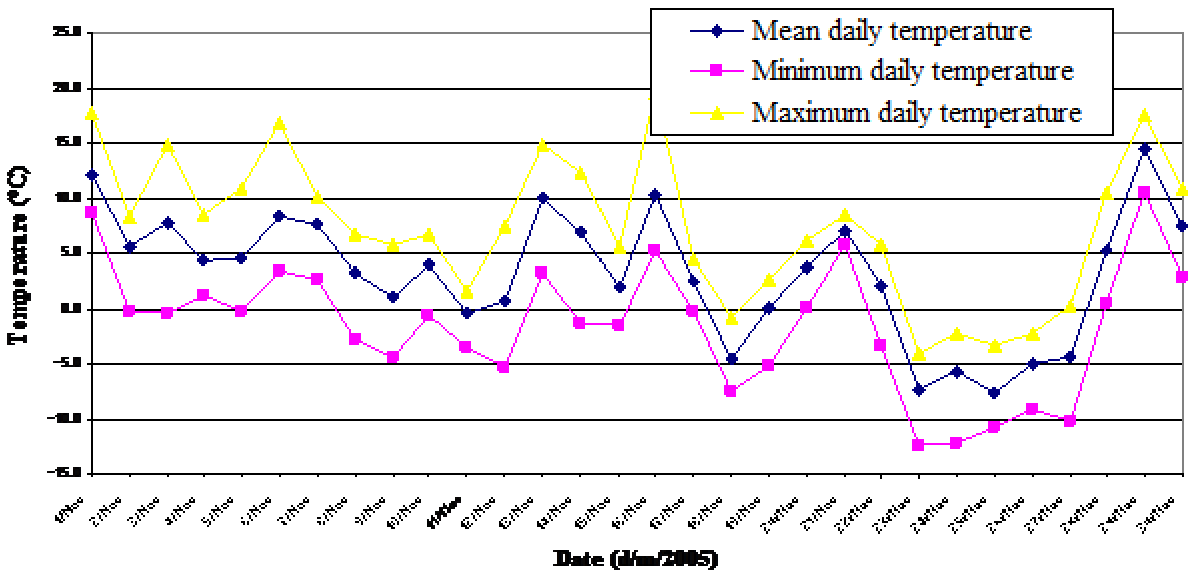

Figure 4: Exterior temperatures, November 2005

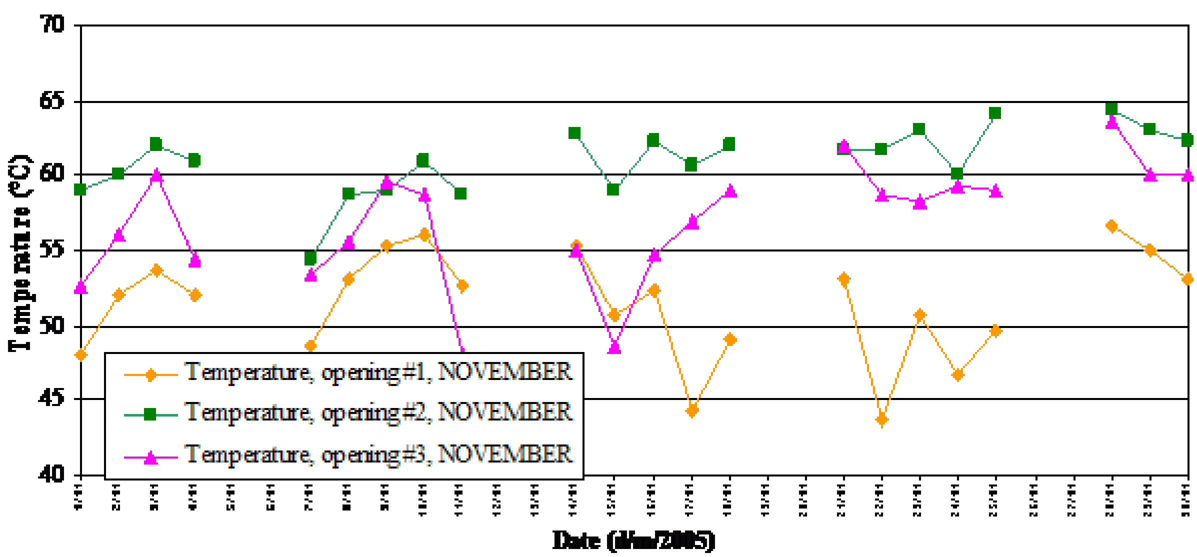

Figure 5: Average temperatures, openings #1, #2 or #3, Biovator™, November 2005

<u>Period of December 1st to 31, 2005</u>

For this period, the exterior temperatures dropped from –20° C down to –25° C. The rapid temperature drops of December 9 to 14 and December 18 to 22 created a gentle temperature decrease at the opening # 3 of the Biovator™. However, the internal temperatures remained above 55° C in average. The quality of the produced compost was not impaired. Surprisingly, the temperature drops of December 9 to 14 from –2° to –20° C created a overheating in the Biovator™. The highest internal temperatures were reached during this period.

Table 6: Temperature range, December 1st to 31, 2005

Opening	T° range	Average
1	49° to 71° C	57° C
2	59° to 76° C	66° C
3	47° to 69° C	57° C

Generally, the composting process is capable to perform between temperatures from –25° C to +30° C. During the 2005-2006 winter, there was no long period of cold weather below –10° C. Winter tests were then terminated.

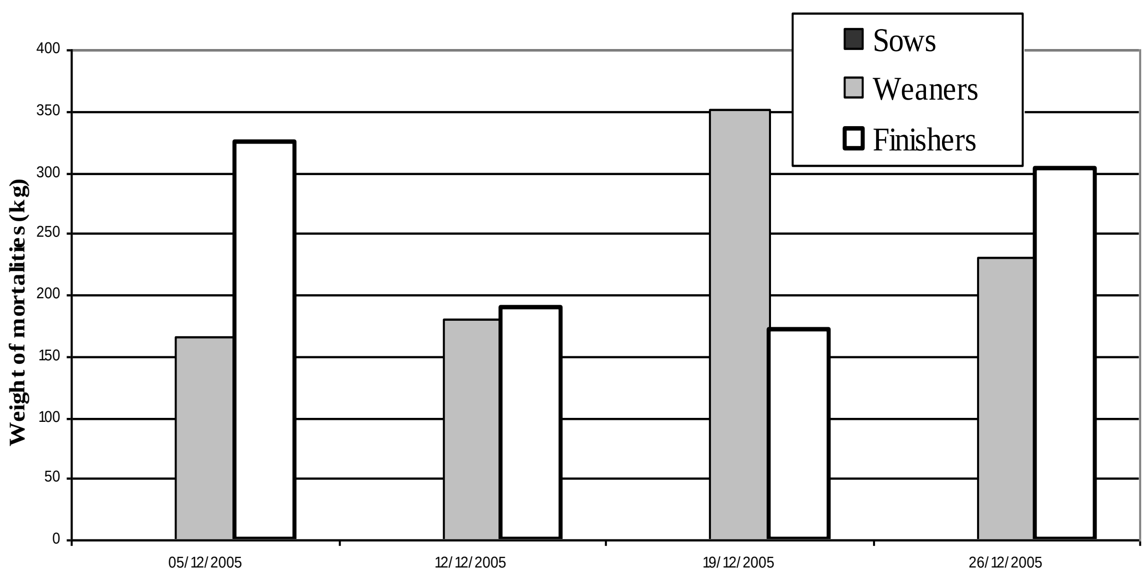

Figure 6: Composted mortalities, December 2005

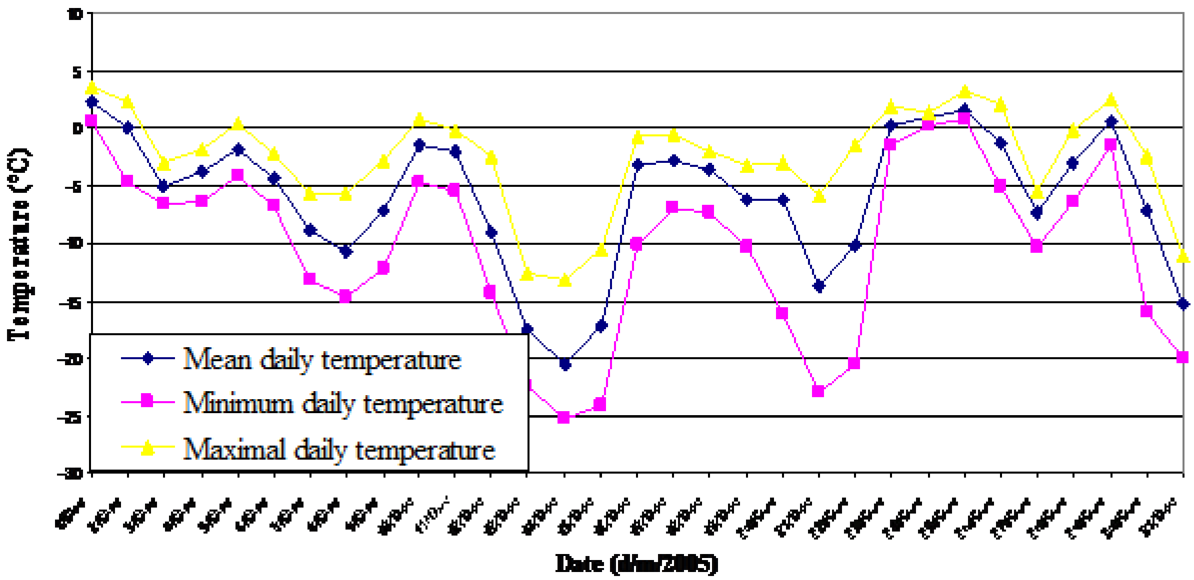

Figure 7: Exterior temperatures, December 2005

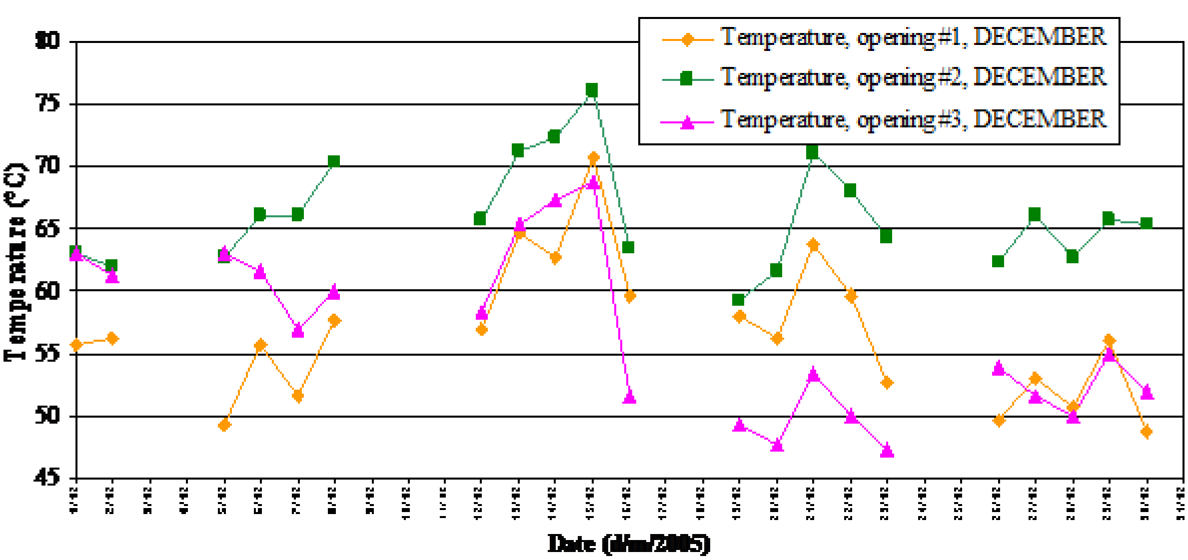

Figure 8: Average temperatures, openings #1, #2 and #3, Biovator^{TM}, December 2005

MOISTURE CONTENT OF THE COMPOST MASS IN THE BIOVATOR^{TM}

Samples were regularly collected and sent to the laboratory to measure the moisture content of the compost and the processed material. Samples of material were collected at each opening once a week. A total of 4 samples per week were sent to the laboratory to obtain agronomic data.

Table 7 summarizes the results for the period of October 17, 2005 to January 27, 2006.

Table 7: Moisture content

Openings	Moisture content (%)
1	47.6 – 71.3
2	45.5 – 66.3
3	30.8 – 56.5
4*	31.8 – 61.1

* Collector basin, to be transferred in the long-term storage.

PHYSICAL AND CHEMICAL PARAMETERS

The Quebec Ministry of Agriculture required results for a list of physical and chemical parameters. Table 8 summarizes the results from 15 samples submitted to the laboratory during the period of June to October 2005.

Table 8: Summary of the compost physical and chemical parameters, summer period

Parameters		Average	Minimum	Maximum
Aluminium	mg/kg	--	< 20	140
Boron	mg/kg	--	< 2	3
Calcium	mg/kg	5 213	2 300	16 000
C/N ratio		19	12	30
Total organic carbon	%	46	37	48
Copper	mg/kg	9	2	14
Moisture content	%	43	37	50
Iron	mg/kg	386	200	640
Potassium	mg/kg	5 327	4 600	6 200
Magnesium	mg/kg	523	410	690
Manganese	mg/kg	41	29	54
Sodium	mg/kg	2 967	2 700	3 500
Ammoniacal nitrogen (N)	mg/kg	10 420	6 500	13 000
Total Kjeldahl nitrogen (N)	mg/kg	26 933	16 000	39 000
Organic matter	%	94	90	96
pH		8.3	8.1	8.6
Total phosphorus	mg/kg	3 340	2 700	3 700
Dry matter	%	57	50	63
Zinc	mg/kg	4 513	2 500	8 200

Table 9 summarizes the results from 12 samples submitted to the laboratory during the period of November 2005 to January 2006.

Table 9 : Summary of the compost physical and chemical parameters, winter period

Parameters		Average	Minimum	Maximum
Aluminium	mg/kg	--	< 20	370
Boron	mg/kg	4	3	5
Calcium	mg/kg	9 283	3 200	25 000
C/N ratio		23	14	34
Total organic carbon	%	48	47	52
Copper	mg/kg	8	6	11
Moisture content	%	52	50	54
Iron	mg/kg	443	350	900
Potassium	mg/kg	5 958	5 500	6 500
Magnesium	mg/kg	629	340	960
Manganese	mg/kg	48	37	68
Sodium	mg/kg	3 342	2 300	4 200
Ammoniacal nitrogen (N)	mg/kg	9 608	8 100	12 000
Total Kjeldahl nitrogen (N)	mg/kg	22 833	14 000	35 000
Organic matter	%	96	95	96
pH		8.4	8.1	9.0
Total phosphorus	mg/kg	5 258	3 300	7 700
Dry matter	%	48	39	57
Zinc	mg/kg	3 242	2 300	4 600

As noticed with any manure sampling procedure for compost, there is a wide variability for different chemical and physical parameters. Only long-term averages of the product could be used as reliable data for estimation of the fertilizer values of the compost.

The produced compost from mortalities and wood shavings presents high total organic matter contents and high levels of nitrogen, phosphorus and potassium.

MICROBIOLOGICAL AND PATHOGENIC PARAMETERS

In order to fulfill the requirements of the Quebec Ministry of Agriculture, tables 10 and 11 present the chemical parameters and results from the laboratory test for the summer and the winter periods. Analysis were carried for the following bacteria:

- *Salmonella Spp.*
- *Escherichia Coli*
- *Enterococcus*
- *Clostridium perfringens*
- *Yersinia enterocolitica*
- *Cryptosporidium*

Table 10 : Microbiological and pathogenic parameters, August to October 2005

Date (D/M/Yr)	*Salmonella Spp.*	*Escherichia Coli*	*Enterococcus*	*Clostridium perfringens*	*Yersinia enterocolitica*	*Cryptosporidium*
16/08/2005 compost # 1	--	--	✓	✓	--	--
16/08/2005 compost # 2	--	--	✓	--	--	--
16/08/2005 compost # 3	✓	--	✓	--	--	--
31/08/2005 compost # 1	--	--	✓	✓	--	--
31/08/2005 compost # 2	--	--	✓	✓	--	--
31/08/2005 compost # 3	--	--	✓	✓	--	--
15/09/2005 compost # 1	--	--	✓	--	--	--
15/09/2005 compost # 2	--	--	✓	--	--	--
15/09/2005 compost # 3	--	--	✓	--	--	--
30/09/2005 compost # 1	--	--	✓	--	--	--
30/09/2005 compost # 2	--	--	✓	--	--	--
30/09/2005 compost # 3	--	--	✓	--	--	--
12/10/2005 compost # 1	--	--	✓	--	--	--
12/10/2005 compost # 2	--	--	✓	--	--	--
12/10/2005 compost # 3	--	--	✓	--	--	--

✓ = Present

-- = Negative

Table 11 : Microbiological and pathogenic parameters, December 2005 - January 19, 2006

Date (D/M/Yr)	*Salmonella Spp.*	*Escherichia Coli*	*Enterococcus*	*Clostridium perfringens*	*Yersinia enterocolitica*	*Cryptosporidium*
08/12/2005 compost # 1	--	--	✓	--	--	--
08/12/2005 compost # 2	--	--	✓	--	--	--
08/12/2005 compost # 3	--	--	✓	--	--	--
22/12/2005 compost # 1	--	--	✓	--	--	--
22/12/2005 compost # 2	--	--	✓	--	--	--
22/12/2005 compost # 3	--	--	✓	--	--	--
04/01/2006 compost # 1	--	--	✓	--	--	--
04/01/2006 compost # 2	--	--	✓	--	--	--
04/01/2006 compost # 3	--	--	✓	--	--	--
19/01/2006 compost # 1	--	--	✓	--	--	--
19/01/2006 compost # 2	--	--	✓	--	--	--
19/01/2006 compost # 3	--	--	✓	--	--	--

✓ = Present

-- = Negative

From the results, it could be concluded that the composting process is efficient to disinfect the mortality compost in order to have negative results for *Salmonella spp*, *Escherichia Coli*, *Clostridium Perfringens*, *Yersinia Enterocolitica* and *Cryptosporidium*. However, the composting process did not eliminate the *Enterococcus*.

MASS BALANCE FROM INGREDIENTS TO MORTALITY COMPOST

Table 12 presents the summary of the ingredients in comparison with the mortality compost transferred to a long-term storage. These data present the Biovator^{TM} performances only. There were no data collected on further mass, nor volume reduction occurring in the long-term storage.

Month	Weight of mortalities (kg)		Weight of wood shavings (kg)		Total weight mortality + wood shavings (kg)		Compost weight to storage (kg)		Compost / mortality ratio
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Monthly
March 2005	278	278	356	356	634	634	0	0	0.00
April 2005	546	824	330	686	876	1 510	0	0	0.00
May 2005	1 050	1 874	160	846	1 210	2 720	297	297	0.28
June 2005	1 690	3 564	280	1 126	1 970	4 690	620	917	0.37
July 2005	2 472	6 036	735	1 861	3 207	7 897	2 677	3 594	1.08
August 2005	2 041	8 077	476	2 337	2 517	10 414	1 257	4 851	0.62
September 2005	1 883	9 960	543	2 880	2 426	12 840	1 577	6 428	0.84
October 2005	1 854	11 814	583	3 463	2 437	15 277	1 376	7 804	0.74
November 2005	2 456	14 270	803	4 266	3 259	18 536	1 547	9 351	0.63
December 2005	2 059	16 329	659	4 925	2 718	21 254	1 875	11 226	0.91
January 2006	1 031	17 360	421	5 346	1 452	22 706	2 268	13 494	1.21[1]
February 2006	0	17 360	0	5 346	0	22 706	917	14 411	-- (end of experiment)
								Mean ratio	***0.80***
								Minimum ratio	***0.37***
								Maximum ratio	***1.21***

(Shaded rows:) Continuous operation

[1] This value is obtained for the period from January 1st to 18, 2006. After January 18, no mortality was added. This compost/mortality ratio is calculated with 2 268 kg of mortality / month x 18 days / 31 days, equivalent to 1 316 kg of compost per month.

Figure 9 illustrates the cumulative weights of ingredients and compost.

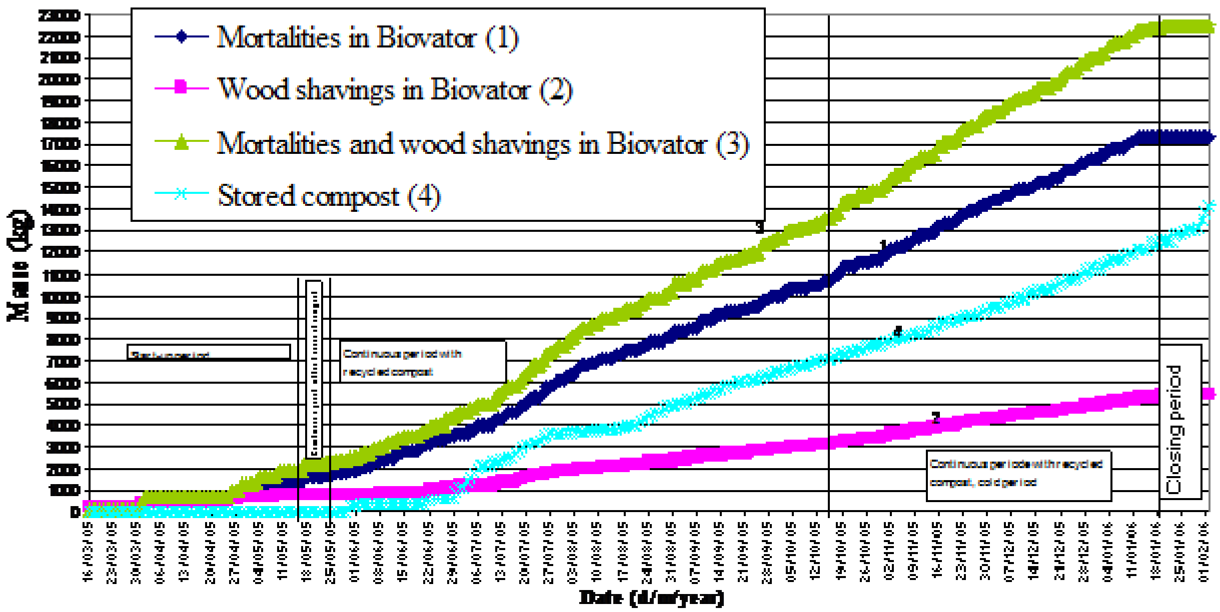

Figure 9: Cumulative weight of ingredients and compost

Following the starting phase, the rate of loading of mortalities was currently stable and uniform for the summer and winter period.

WEIGHT – COMPOST RATIO

Considering the long term tests results, the Biovator^{TM} composted according to the following ratio:

Compost / mortality weights = 14 411 kg ÷ 17 360 kg = 0.83

Consequently, when the ingredient recipe is followed with the mix of mortalities, wood shavings and recycled compost (including bones), the composting process of 1 kg of mortality produces an average of 0.83 kg of compost after a 10 to 14 days process.

The volumetric data are widely variable. The moisture content and the compaction levels of the compost to store have impacts on the final volume of compost. The volume of compost was measured before each transfer from the Biovator™ to the long-term storage.

For practical design purposes, compost moisture contents ranging from 40 to 50 % is assumed and a pile height of 2.4 to 3.6 m is hypothesized. These are some suggestions:

- No compacted mortality compost : 450 to 600 kg / m³
    - Design value : 500 kg / m³

OR

- Compacted compost (pile height above 2.4 m) : 500 to 700 kg
    - Design value : 600 kg / m³

SUMMARY AND PRACTICAL IMPLICATION

The Biovator™ composter has been tested to treat mortalities from a swine farrow to finish operation from March 2005 until February 2006.

The following presents practical data.

Phase 1: Composting facility start-up

Recipe

- 1 kg of mortality (preferably piglets, weaners, light finishers)
- 0.7 kg of wood shaving (12 % DM)

For exterior temperatures below 0° C, use a heating source to rise the Biovator™ temperature up to 60 to 70° C.

Duration

- 14 to 28 days

Phase 2 : Continuous operation with recycled compost (including bones)

Recipe	Winter (T° < 0° C)	Summer (T° > 0° C)
Mortalities	1 kg	1 kg
Wood shavings (12 % DM)	0.28	0.32 kg
Recycled compost	0.44 kg	0.45 kg

PHYSICAL AND CHEMICAL PARAMETERS OF THE 14 DAYS COMPOST

Recipe	Winter (T° < 0° C)	Summer (T° > 0° C)
Total Kjeldahl nitrogen	22.8 kg / t	26.9 kg / t
Phosphorus	5.2 kg / t	3.3 kg / t
Potassium	6.0 kg / t	5.3 kg / t
Organic matter	96 %	94 %
C/N ratio	23	19
Dry matter	48 %	57 %

MASS BALANCE OF THE COMPOSTING PROCESS

Weight of mortality	Weight of compost to store
1 kg	0.83 kg

- Non compacted volumetry : 500 kg / m^3
- Compacted volumetry : 600 kg / m^3 (for pile height above 2.4 m)

ESTIMATED CAPACITY OF THE TESTED BIOVATOR^{TM} (9 M LONG, 4' DIAMETER)

Ingredients	Suggested weight (kg / day)	
	Summer	Winter
Mortality	70 – 80	75 – 85
Wood shavings	17 – 20	21 – 24
Produced compost (weight ratio of 0.83)	58 –66	62 – 71

MICROBIOLOGICAL AND PATHOGENIC PARAMETERS

The Biovator™ composter achieves temperatures above 55° C for about 10 days of composting process. During composting, the mass is subjected to a sterilization process, the microbiological and pathogenic tests present the following results.

Date	*Salmonella Spp.*	*Escherichia Coli*	*Enterococcus*	*Clostridium perfringens*	*Yersinia enterocolitica*	*Cryptosporidium*
September 16 to October 11, 2005 Nb = 9 samples	--	--	✓	--	--	--
December 7, 2005 to January 18, 2006 Nb = 12 samples	--	--	✓	--	--	--

✓ = Present

-- = Negative

The Biovator™ composter produces a product with high agronomic values and almost sterilized. Compost produced by the Biovator™ complies with the regulations of the Quebec Ministry of Environment.

Annex 1

Photos of the experimental site

Photo 1, May 6, 2005: Opening # 1, entrance of the mortalities with wood shavings and recycled compost.

Photo 2, June 28, 2005: Interior view, desired level of the composter with 2/3 of the total capacity.

Photo 3, June 10, 2005: Exit door.

Photo 4, December 16, 2005: Exterior installation.

Photo 5, December 14, 2005: Interior view from the exit opening, exterior temperature of –25° C.

Photo 6, February 7, 2006: Long term storage of the mortality compost. Prior to farmland spreading.