

**Development of Environmentally Responsible
Techniques
and
Practices for Freshwater Aquaculture
in Ontario**

Part 2:
Chemical Analyses of Composted Fish Waste

Final Report submitted to:

Ontario Sustainable Aquaculture Working Group

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1. Introduction

Increased restrictions and costs of rendering animal products, a partial response to outbreaks of bovine spongiform encephalopathy (BSE) in North America, have resulted in changes to the, 'Dead Animal Disposal Act' and stimulated the review of composting techniques for carcass disposal. Furthermore, there is the opportunity to produce a value-added product from waste products that incur ever increasing costs for disposal. Although composting carcasses is widely practiced for many farm animals, e.g. swine, chickens etc., composting fish waste (carcasses and processing waste) has received considerably less attention (Gill 2000).

A private fish farmer in Northern Ontario has developed a composting system for fish waste. The system utilizes waste products from fish processing plants as well as dead stock, along with locally available waste saw dust in an aerobic digester to produce compost. Further refinement of the production processes, sampling procedures and analytical requirements have been finalized, and the operation could produce over 2,000 tonnes of compost per year.

The Ontario Ministry of the Environment has regulatory guidelines for the production and use of aerobic compost in Ontario (MOE 2004). These guidelines include site construction, operational methods and ingredient and final product quality analysis. To comply with MOE guidelines for the sale of commercial compost, selected metals and organic chemicals must not exceed stated levels, and minimum concentrations of certain plant nutrients (e.g. N,P, K), organic matter, carbon: nitrogen ratio etc. are deemed

desirable. The required chemical analysis and compilation of the ensuing results were the focus of this 'Phase 2' component of this project.

While the chemical analyses were supported in part by Environment Canada, this does not necessarily signify that the contents reflect the views and policies of Environment Canada. Mention of trade names or commercial products does not constitute recommendation or endorsement for use. This document does not purport to address all of the safety aspects associated with its use. Anyone using this document has the responsibility to consult the appropriate authorities and to establish health and safety practices in conjunction with any regulatory requirements prior to its use.

Certain aspects of this project were supported by the Fisheries and Oceans Canada, Aquaculture Collaborative Research and Development Program in collaboration with the Northern Ontario Aquaculture Association.

2. Method of Analyses

During the development of the composting operation, a series of samples of compost and their respective ingredients were collected by the operator. Samples were sent by courier to the Aquaculture Centre for submission to the University of Guelph Laboratory Services, Soil & Nutrient Laboratory for chemical analysis¹. The analysis performed included; plant primary and secondary nutrients, organic and inorganic carbon and total PCB concentration as required by the Ontario Ministry of Environment “*Interim Guidelines for the Production and Use of Aerobic Compost in Ontario (MOE 2004)*”.

A summary of the analytical procedures used is as follows:

Nitrogen and Phosphorus: modified kjeldahl digestion and digestions solutions measured by Technicon Auto Analyzer.

Potassium, Calcium and Magnesium: modified kjeldahl digestion and digestions solutions measured by Varian Atomic Absorption Spectrophotometer.

Carbon: total carbon measured using LECO SC444. inorganic carbon from ashed samples and LECO SC444. Inorganic carbon from difference.

Trace metals: hot acid extraction and analysis by emission spectrometer .

Arsenic and Selenium: hydride-flameless atomic absorption spectrophotometry.

Mercury: samples microwave digested with nitric acid and absorption measured with a Cetac M6000A Mercury Analyzer.

¹ The Soil & Nutrient Laboratory is accredited by the Canadian Association for Environmental Laboratories (CAEL) to ISO/IEC 17025 for Environmental Metals Analysis and is part of the North American Proficiency testing Program (NAPT) and the OMAFRA Agronomic Laboratory Accreditation Program.

3. Results and Discussion

A total of 11 sample batches of compost and their ingredients were collected and submitted to our UG lab, for a total of 88 chemical analyses over the course of the project. These included: 54 compost samples and 34 ingredient samples (8 fish mortalities, 21 fish processing offal, 3 sawdust samples and 2 feed fines samples).

A summary of the primary and secondary nutrients of the compost are given in Tables 1a and Table 1b, and for the compost ingredients in Tables 2a and Table 2b, respectively. The individual sample values are given in Appendices I through IV. The results are grouped into three chronological time frames representing samples taken during the “preliminary production” stages and two full production years. The 2007 production year is the most recent and represents a stable production cycle in terms of product supply.

The finished compost product (from the 2007 cycle) exceeded the target levels for the macro nutrients nitrogen (N), phosphorus (P) and potassium (K), with average values of 1.70% dry, 0.42% dry and 0.3% dry, respectively. Only a single sample showed lower than target levels of P. The finished compost product (2007 cycle) had levels of calcium (Ca) and magnesium (Mg) that were lower than the target values, with average values of 1.0% dry and 0.1% dry, respectively. Moisture content and carbon:nitrogen ratios were generally higher than target levels, with average values of 58% and 30%, respectively.

The trace metals content of the finished compost samples were below the MOE maxima for all samples taken from the preliminary and 2007 production cycles. There were two

samples in the 2006 production cycle that showed elevated levels of arsenic (As) and copper (Cu). The metals content of the samples taken from the various raw ingredients were all below the MOE maxima.

Seven compost samples were submitted for analysis of total PCB concentration (Table 3). All seven compost samples were below the analytical limits of detection. All samples from the 2007 production cycle were below the MOE maxima of 0.5 mg/kg dry weight.

Concluding remarks:

The chemical analyses of the finished compost and its various raw ingredients were within the levels required by the MOE guidelines for the production and use of aerobic compost in Ontario. This product may have good potential in the market place with regards to its final quality and compositional characteristics.

Table 1a: Summary of Primary Nutrients of Compost from Three Production Cycles. Data measured on a dry-weight basis.

(Note: ‘<’ indicates laboratory method detection limit).

Prod. Cycle	N % dry	P % dry	K² % dry	Ca % dry	Mg % dry	Inorg. C % dry	Org. C % dry	Total C % dry	Moisture %	C:N ratio
Prelim.										
ave	2.68	0.34	0.39	1.98	0.45	0.62	37.1	37.7	57.5	29
min	0.17	0.06	<0.30	0.71	0.09	0.06	11.5	14.0	0.6	5
max	9.44	0.66	0.70	6.50	1.47	2.48	47.7	47.8	76.9	82
sd	3.01	0.18	0.14	1.83	0.47	0.83	11.3	10.5	22.6	21
2006										
ave	2.17	0.38	0.31	1.05	0.10	0.07	51.9	52.0	64.3	26
min	1.33	0.17	<0.30	0.57	0.04	0.00	44.8	44.9	57.5	17
max	3.13	0.85	0.42	1.83	0.31	0.36	58.9	58.9	74.5	41
sd	0.57	0.17	0.03	0.37	0.07	0.09	4.5	4.5	5.4	7
2007										
ave	1.70	0.42	0.30	1.03	0.09	0.08	48.5	48.6	57.7	30
min	0.85	0.18	<0.30	0.63	0.06	0.00	41.7	41.8	35.2	21
max	2.38	0.73	0.34	1.64	0.14	0.53	54.2	54.2	74.1	49
sd	0.36	0.14	0.01	0.27	0.02	0.11	3.1	3.1	11.4	7
MOE										
target	0.6	0.25	0.2	3.0	0.3	NA	NA	NA	30-55	22

² Summary statistics calculated assuming method detection limit for some values.

Table 1b: Summary of Secondary Nutrients and Other Measurements of Compost from Three Production Cycles. Data measured on a dry-weight basis. (Note: ‘<’ indicates laboratory method detection limit).

Prod. Cycle	As³ mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Mn³ mg/kg	Hg³ mg/kg	Mo mg/kg	Ni³ mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg
Prelim.													
ave	<1.0	<1.0	<1.5	21.1	8.8	2,012	166	0.14	<2.5	15.3	<5.0	<1.0	53
min	<1.0	<1.0	<1.5	6.6	5.2	625	31	<0.05	<2.5	<4.0	<5.0	<1.0	40
max	<1.0	<1.0	<1.5	43.0	13.0	4,501	694	0.34	<2.5	35.0	<5.0	<1.0	75
sd	0.0	0.0	0.0	15.9	3.5	1,545	219	0.14	0.0	11.7	0.0	0.0	16
2006													
ave	3.1	<1.0	<1.5	8.6	19.2	673	21	<0.05	<2.5	6.2	<5.0	<1.0	83
min	<1.0	<1.0	<1.5	1.6	5.2	184	<10	<0.05	<2.5	4.0	<5.0	<1.0	36
max	25.0	<1.0	<1.5	30.0	180.0	1,506	63	<0.05	<2.5	15.0	5.1	<1.0	130
sd	6.3	0.0	0.0	8.8	41.6	324	15	0.0	0.0	3.2	0.0	0.0	30
2007													
ave	<1.0	<1.0	<1.5	2.6	7.2	430	23	<0.05	<2.5	<4.0	<5.0	<1.0	72
min	<1.0	<1.0	<1.5	1.3	5.0	191	14	<0.05	<2.5	<4.0	<5.0	<1.0	47
max	<1.0	<1.0	<1.5	5.9	12.0	924	40	<0.05	<2.5	<4.0	<5.0	<1.0	120
sd	0.0	0.0	0.0	1.1	1.9	223	6	0.0	0.0	0.0	0.0	0.0	18
MOE													
maxima	13	3	34	210	100	NA	NA	0.8	5	62	150	2	500

³ Summary statistics calculated assuming method detection limit for some values.

Table 2a: Summary of Primary Nutrients from Samples of Compost Ingredients. Data measured on a dry weight basis.
(Note: ‘<’ indicates laboratory method detection limit).

Compost Ingredient	N % dry	P % dry	K % dry	Ca % dry	Mg % dry	Inorg. C % dry	Org. C % dry	Total C % dry	Moisture %	C:N ratio
Mortality										
ave	7.37	0.98	0.80	1.84	0.10	0.07	58.5	58.6	67.3	8
min	5.33	0.47	<0.30	0.93	0.07	0.00	52.5	52.6	59.9	5
max	9.75	1.77	1.04	3.48	0.12	0.18	64.4	64.4	80.6	12
sd	1.26	0.44	0.27	0.84	0.02	0.05	3.6	3.6	6.2	2
Offal										
ave	3.73	1.05	0.46	2.04	0.07	0.01	60.7	60.7	58.3	23
min	1.05	<0.05	<0.30	0.05	<0.04	0.00	50.0	50.0	42.9	6
max	7.78	2.41	1.07	5.07	0.12	0.06	74.5	74.5	76.2	55
sd	1.87	0.65	0.18	1.24	0.03	0.02	5.7	5.7	6.9	16
Sawdust										
ave	0.15	<0.025	<0.30	0.30	0.06	0.10	48.7	48.8	60.9	404
min	0.08	0.00	0.00	0.27	0.04	0.05	48.7	48.8	43.3	195
max	0.25	0.00	0.00	0.36	0.09	0.15	48.8	48.8	72.0	610
Feed Fines										
ave	10.26	2.79	1.38	4.31	0.39	0.12	42.9	43.1	60.5	4
min	9.93	2.63	1.36	3.49	0.37	0.10	42.1	42.2	58.2	4
max	10.59	2.95	1.39	5.13	0.41	0.13	43.8	43.9	62.7	4

Table 2b: Summary of Secondary Nutrients from Samples of Compost Ingredients. Data measured on a dry weight basis.
(Note: ‘<’ indicates laboratory method detection limit).

Compost Ingredient	As mg/kg	Cd mg/kg	Co mg/kg	Cr⁴ mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg
Mortality													
ave	<1.0	<1.0	<1.5	2.7	2.7	28	<10	<0.05	<2.5	<3.0	<5.0	<1.0	39
min	<1.0	<1.0	<1.5	<1.0	1.2	<20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	21
max	<1.0	<1.0	<1.5	5.9	4.4	47	11	<0.05	<2.5	<4.0	<5.0	<1.0	61
sd	0.0	0.0	0.0	1.9	1.3	10	0	0.0	0.0	0.0	0.0	0.0	14
Offal													
ave	<1.0	<1.0	<1.5	2.6	3.5	32	<10	<0.05	<2.5	<3.0	<5.0	<1.0	59
min	<1.0	<1.0	<1.5	<1.0	1.0	<20	10	<0.05	<2.5	<3.0	<5.0	<1.0	8
max	<1.0	<1.0	<1.5	6.4	15.0	56	<10	<0.05	<2.5	<4.0	<5.0	<1.0	180
sd	0.0	0.0	0.0	1.6	4.6	14	0	0.0	0.0	0.0	0.0	0.0	51
Sawdust													
ave	1.3	<1.0	<1.5	3.1	2.3	121	18	<0.05	<2.5	<4.0	<5.0	<1.0	5
min	<1.0	<1.0	<1.5	2.0	1.6	20	10.0	<0.05	<2.5	<4.0	<5.0	<1.0	3
max	<1.0	<1.0	<1.5	4.1	3.1	199	31.0	<0.05	<2.5	<4.0	<5.0	<1.0	7
Feed Fines													
ave	<1.0	<1.0	<1.5	2.4	59	756	355	<0.05	<2.5	<3.0	<5.0	1.4	355
min	<1.0	<1.0	<1.5	2.3	56	695	314	<0.05	<2.5	<3.0	<5.0	1.3	350
max	<1.0	<1.0	<1.5	2.5	62	816	395	<0.05	<2.5	<3.0	<5.0	1.4	360
MOE													
maxima	13	3	34	210	100	NA	NA	0.8	5	62	150	2	500

⁴ Summary statistics calculated assuming method detection limit for some values

Table 3: Compost Analysis for Total PCB⁵.

Sample	Production Year	Total PCB (mg/kg)	Moisture (%)
1	2006	< 2	58.2
2	2006	< 2	60.5
3	2006	< 2	59.7
4	2007	< 0.2	53.8
5	2007	< 0.2	51.9
6	2007	< 0.2	53.1
7	2007	< 0.05	70.6
MOE maxima		0.5	

⁵ Total PCB analysis performed by ALS Laboratory Group, Waterloo, Ontario. Analytical method used reference EPA 8082. All samples were below laboratory detection limits at time of analysis.

4. References

Gill, T.A. (2000). Waste from processing aquatic animals and animal products: implications on aquatic animal pathogen transfer. FAO Fisheries Circular. No. 956. Rome, FAO. 2000. 26p.

MOE 2004. Interim guidelines for the production and use of aerobic compost in Ontario. Reprinted November 2004. 27 pages.

Support document for compost quality criteria. National Standard of Canada (CAN/BNQ 0413-200), The Canadian Council of Ministers of the Environment (CCME) Guidelines and Agriculture and Agri-food Canada (AAFC) Criteria. 43 pages.

5. Appendix I: Compost Primary Nutrients and Other Measurements. Data measured on a dry-weight basis.
 (Note: '<' indicates laboratory method detection limit).

Production Cycle	N % dry	P % dry	K % dry	Ca % dry	Mg % dry	Inorg. C % dry	Org. C % dry	Total C % dry	Dry Matter %	Moisture %	C:N
Preliminary	1.21	0.25	<0.30	0.71	0.09	0.06	40.2	40.3	31.0	69.0	33
Preliminary	1.22	0.34	<0.30	0.79	0.09	0.06	42.4	42.5	28.4	71.6	35
Preliminary	1.51	0.66	0.57	3.48	0.53	0.59	34.5	35.1	29.7	70.3	23
Preliminary	1.25	0.16	0.47	2.23	1.47	1.76	29.4	31.2	39.8	60.2	25
Preliminary	0.87	0.06	<0.30	2.33	0.43	0.64	29.2	29.8	39.2	60.8	34
Preliminary	0.17	0.40	0.70	6.50	1.11	2.48	11.5	14.0	99.4	0.6	82
Preliminary	2.12	0.24	<0.30	0.90	0.23	0.17	45.7	45.9	53.2	46.8	22
Preliminary	2.08	0.27	<0.30	0.94	0.24	0.18	45.1	45.3	53.7	46.3	22
Preliminary	6.90	0.54	0.36	0.99	0.10	0.15	45.4	45.5	27.6	72.4	7
Preliminary	9.44	0.44	0.34	0.97	0.24	0.15	47.7	47.8	23.1	76.9	5
2006	3.13	0.26	0.42	0.94	0.12	0.09	51.5	51.6	37.6	62.4	17
2006	2.88	0.32	0.30	0.65	0.06	0.06	52.0	52.0	40.3	59.7	18
2006	2.01	0.20	<0.30	0.57	0.04	0.00	58.9	58.9	38.7	61.3	29
2006	1.93	0.25	<0.30	0.80	0.05	0.05	54.2	54.2	40.3	59.7	28
2006	2.99	0.38	0.33	0.89	0.10	0.11	54.7	54.8	37.6	62.4	18
2006	1.38	0.26	<0.30	0.85	0.05	0.06	56.0	56.1	42.5	57.5	41
2006	1.89	0.28	<0.30	0.73	0.05	0.06	58.2	58.3	39.3	60.7	31
2006	2.16	0.34	<0.30	1.12	0.06	0.00	55.5	55.5	38.5	61.5	26
2006	2.03	0.17	<0.30	0.72	0.05	0.00	56.8	56.8	40.6	59.4	28
2006	2.87	0.42	<0.30	1.36	0.31	0.36	49.7	50.1	33.3	66.7	18
2006	2.71	0.34	<0.30	0.72	0.06	0.06	53.0	53.1	36.2	63.8	20
2006	1.33	0.49	<0.30	1.14	0.11	0.10	51.2	51.3	39.8	60.2	39
2006	2.17	0.43	0.34	1.16	0.11	0.05	47.2	47.2	29.6	70.4	22
2006	1.63	0.38	<0.30	1.32	0.12	0.00	47.1	47.1	26.8	73.2	29
2006	1.77	0.55	<0.30	1.60	0.19	0.14	45.3	45.4	32.7	67.3	26
2006	2.40	0.61	0.33	1.51	0.15	0.10	44.8	44.9	27.6	72.4	19
2006	1.55	0.85	<0.30	1.83	0.10	0.00	46.6	46.6	25.5	74.5	30

Production Cycle	N % dry	P % dry	K % dry	Ca % dry	Mg % dry	Inorg. C % dry	Org. C % dry	Total C % dry	Dry Matter %	Moisture %	C:N
2007	2.07	0.36	<0.30	0.99	0.08	0.05	46.3	46.3	32.8	67.2	22
2007	1.95	0.48	<0.30	1.08	0.08	0.06	46.1	46.2	52.4	47.6	24
2007	1.42	0.58	<0.30	1.37	0.09	0.06	45.7	45.8	34.8	65.2	32
2007	1.55	0.32	<0.30	0.76	0.07	0.07	47.2	47.3	43.5	56.5	31
2007	1.80	0.36	<0.30	1.09	0.14	0.09	47.5	47.6	45.6	54.4	26
2007	2.38	0.36	0.34	1.03	0.10	0.10	49.4	49.5	48.5	51.5	21
2007	1.73	0.57	0.31	1.21	0.09	0.07	48.2	48.3	50.6	49.4	28
2007	1.68	0.44	<0.30	0.95	0.07	0.00	51.5	51.5	48.2	51.8	31
2007	1.19	0.42	<0.30	0.80	0.06	0.06	52.1	52.2	64.8	35.2	44
2007	1.78	0.46	<0.30	0.93	0.07	0.09	52.0	52.1	53.1	46.9	29
2007	1.36	0.73	<0.30	1.62	0.08	0.00	51.7	51.7	55.9	44.1	38
2007	1.50	0.46	<0.30	0.95	0.07	0.05	50.8	50.8	50.6	49.4	34
2007	1.80	0.28	<0.30	0.63	0.07	0.05	54.2	54.2	42.6	57.4	30
2007	1.76	0.69	0.32	1.64	0.09	0.53	49.2	49.7	47.2	52.8	28
2007	2.01	0.41	<0.30	1.04	0.10	0.10	51.1	51.2	40.2	59.8	26
2007	1.74	0.35	<0.30	0.88	0.11	0.00	48.2	48.2	27.4	72.6	28
2007	1.64	0.42	<0.30	1.18	0.11	0.09	45.7	45.8	27.1	72.9	28
2007	2.30	0.34	<0.30	0.92	0.12	0.00	47.7	47.7	29.2	70.8	21
2007	1.45	0.27	<0.30	0.79	0.13	0.09	44.2	44.3	25.9	74.1	31
2007	0.85	0.18	<0.30	0.68	0.12	0.08	41.7	41.8	26.3	73.7	49

Appendix II: Compost Secondary Nutrients. Data measured on a dry-weight basis.
 (Note: ‘<’ indicates laboratory method detection limit).

Production Cycle	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg
Preliminary	<1.0	<1.0	<1.5	8.1	5.5	1,324	39	0.3	<2.5	12.0	<5.0	<1.0	46
Preliminary	<1.0	<1.0	<1.5	43.0	5.2	691	31	0.3	<2.5	35.0	<5.0	<1.0	41
Preliminary	NA	NA	NA	NA	NA	3,972	388	NA	NA	NA	NA	NA	NA
Preliminary	NA	NA	NA	NA	NA	2,342	139	NA	NA	NA	NA	NA	NA
Preliminary	NA	NA	NA	NA	NA	3,907	219	NA	NA	NA	NA	NA	NA
Preliminary	NA	NA	NA	NA	NA	4,501	694	NA	NA	NA	NA	NA	NA
Preliminary	<1.0	<1.0	<1.5	6.8	8.1	625	33	<0.05	<2.5	<4.0	<5.0	<1.0	40
Preliminary	<1.0	<1.0	<1.5	6.6	8.0	836	39	<0.05	<2.5	<4.0	<5.0	<1.0	43
Preliminary	<1.0	<1.0	<1.5	32.0	13.0	1,022	42	<0.05	<2.5	20.0	<5.0	<1.0	75
Preliminary	<1.0	<1.0	<1.5	30.0	13.0	904	39	<0.05	<2.5	17.0	<5.0	<1.0	70
2006	<1.0	<1.0	<1.5	3.2	13.0	600	36	<0.05	<2.5	4.5	<5.0	<1.0	120
2006	<1.0	<1.0	<1.5	4.7	6.0	431	12	<0.05	<2.5	4.6	<5.0	<1.0	89
2006	<1.0	<1.0	<1.5	3.6	7.8	306	<10	<0.05	<2.5	6.1	<5.0	<1.0	85
2006	<1.0	<1.0	<1.5	2.9	7.6	491	<10	<0.05	<2.5	7.0	<5.0	<1.0	87
2006	<1.0	<1.0	<1.5	3.2	13.0	738	27	<0.05	<2.5	<4.0	<5.0	<1.0	110
2006	13.0	<1.0	<1.5	20.0	12.0	691	10	<0.05	<2.5	<4.0	<5.0	<1.0	81
2006	<1.0	<1.0	<1.5	3.0	7.4	1,021	10	<0.05	<2.5	5.6	<5.0	<1.0	130
2006	<1.0	<1.0	<1.5	1.6	180.0	184	<10	<0.05	<2.5	<4.0	5.1	<1.0	130
2006	25.0	<1.0	<1.5	30.0	19.0	516	<10	<0.05	<2.5	5.7	<5.0	<1.0	89
2006	<1.0	<1.0	<1.5	19.0	7.0	477	11	<0.05	<2.5	15.0	<5.0	<1.0	57
2006	<1.0	<1.0	<1.5	21.0	9.1	700	18	<0.05	<2.5	11.0	<5.0	<1.0	57
2006	<1.0	<1.0	<1.5	5.4	7.7	667	14	<0.05	<2.5	11.0	<5.0	<1.0	110
2006	<1.0	<1.0	<1.5	3.1	5.6	556	23	<0.05	<2.5	<4.0	<5.0	<1.0	36
2006	<1.0	<1.0	<1.5	5.1	8.5	1,229	39	<0.05	<2.5	<4.0	<5.0	<1.0	55
2006	<1.0	<1.0	<1.5	16.0	11.0	1,506	63	<0.05	<2.5	6.4	<5.0	<1.0	73
2006	<1.0	<1.0	<1.5	2.8	6.5	619	29	<0.05	<2.5	<4.0	<5.0	<1.0	44
2006	<1.0	<1.0	<1.5	2.4	5.2	715	24	<0.05	<2.5	<4.0	<5.0	<1.0	51

Production Cycle	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg
2007	<1.0	<1.0	<1.5	2.0	9.4	459	29	<0.05	<2.5	<4.0	<5.0	<1.0	96
2007	<1.0	<1.0	<1.5	1.6	6.7	279	27	<0.05	<2.5	<4.0	<5.0	<1.0	78
2007	<1.0	<1.0	<1.5	1.3	9.1	273	24	<0.05	<2.5	<4.0	<5.0	<1.0	67
2007	<1.0	<1.0	<1.5	2.2	6.8	379	14	<0.05	<2.5	<4.0	<5.0	<1.0	69
2007	<1.0	<1.0	<1.5	3.1	12.0	723	33	<0.05	<2.5	<4.0	<5.0	<1.0	120
2007	<1.0	<1.0	<1.5	2.2	11.0	448	40	<0.05	<2.5	<4.0	<5.0	<1.0	100
2007	<1.0	<1.0	<1.5	3.1	6.0	339	26	<0.05	<2.5	<4.0	<5.0	<1.0	84
2007	<1.0	<1.0	<1.5	1.3	5.7	195	22	<0.05	<2.5	<4.0	<5.0	<1.0	62
2007	<1.0	<1.0	<1.5	2.9	5.8	196	24	<0.05	<2.5	<4.0	<5.0	<1.0	72
2007	<1.0	<1.0	<1.5	1.5	5.6	245	20	<0.05	<2.5	<4.0	<5.0	<1.0	71
2007	<1.0	<1.0	<1.5	2.1	5.0	191	22	<0.05	<2.5	<4.0	<5.0	<1.0	56
2007	<1.0	<1.0	<1.5	1.6	5.6	338	22	<0.05	<2.5	<4.0	<5.0	<1.0	64
2007	<1.0	<1.0	<1.5	1.7	6.1	276	14	<0.05	<2.5	<4.0	<5.0	<1.0	80
2007	<1.0	<1.0	<1.5	4.1	5.6	311	17	<0.05	<2.5	<4.0	<5.0	<1.0	60
2007	<1.0	<1.0	<1.5	2.2	9.2	302	27	<0.05	<2.5	<4.0	<5.0	<1.0	86
2007	<1.0	<1.0	<1.5	3.4	8.2	521	23	<0.05	<2.5	<4.0	<5.0	<1.0	55
2007	<1.0	<1.0	<1.5	3.9	6.7	924	21	<0.05	<2.5	<4.0	<5.0	<1.0	62
2007	<1.0	<1.0	<1.5	5.9	6.8	701	26	<0.05	<2.5	<4.0	<5.0	<1.0	47
2007	<1.0	<1.0	<1.5	2.6	6.8	745	16	<0.05	<2.5	<4.0	<5.0	<1.0	61
2007	<1.0	<1.0	<1.5	3.3	6.6	764	18	<0.05	<2.5	<4.0	<5.0	<1.0	50

Appendix III. Compost Ingredients Primary Nutrients and Other Measurements. Data measured on a dry weight basis.
 (Note: ‘<’ indicates laboratory method detection limit).

Sample Description	N % dry	P % dry	K % dry	Ca % dry	Mm % dry	Inorg. C % dry	Org. C % dry	Total C % dry	Dry Matter %	Moisture %	C:N
Mortality	7.54	1.37	1.04	2.40	0.11	0.06	56.0	56.1	32.5	67.5	7
Mortality	9.75	0.98	0.86	1.75	0.12	0.08	52.5	52.6	19.4	80.6	5
Mortality	7.17	0.99	0.87	1.86	0.10	0.06	57.2	57.3	37.1	62.9	8
Mortality	6.44	0.57	0.87	0.93	0.07	0.07	58.5	58.6	36.9	63.1	9
Mortality	7.69	0.63	0.88	1.23	0.11	0.05	62.4	62.4	32.6	67.4	8
Mortality	7.78	1.77	<0.30	3.48	0.11	0.18	58.5	58.7	31.6	68.4	8
Mortality	5.33	0.47	0.79	1.00	0.07	0.00	64.4	64.4	40.1	59.9	12
Mortality	7.29	1.09	0.90	2.04	0.10	0.09	58.7	58.8	31.1	68.9	8
Offal	1.82	0.08	<0.30	0.09	<0.04	0.00	63.3	63.3	57.1	42.9	35
Offal	2.23	<0.05	0.32	<0.05	<0.04	0.00	74.5	74.5	47.7	52.3	33
Offal	3.45	0.29	0.37	0.71	0.04	0.00	67.7	67.7	39.1	60.9	20
Offal	5.07	1.55	0.44	2.73	0.08	0.00	57.0	57.0	39.2	60.8	11
Offal	3.89	0.46	0.49	0.78	0.05	0.00	64.9	64.9	39.3	60.7	17
Offal	2.91	0.63	0.47	1.25	0.06	0.00	60.9	60.9	44.5	55.5	21
Offal	3.92	1.08	0.39	2.05	0.06	0.00	63.0	63.0	43.8	56.2	16
Offal	7.78	1.63	1.07	3.28	0.12	0.00	50.1	50.1	23.8	76.2	6
Offal	1.94	0.83	0.35	1.58	0.07	0.00	62.0	62.0	42.1	57.9	32
Offal	5.84	1.84	0.54	3.91	0.10	0.00	57.8	57.8	37.7	62.3	10
Offal	1.12	1.05	0.47	2.16	0.07	0.00	61.7	61.7	46.9	53.1	55
Offal	5.50	0.64	0.66	1.34	0.06	0.06	58.2	58.3	35.8	64.2	11
Offal	5.49	0.64	0.53	1.27	0.07	0.00	60.1	60.1	39.4	60.6	11
Offal	1.05	1.30	0.31	2.74	0.07	0.00	57.2	57.2	48.3	51.7	55
Offal	3.94	1.18	0.60	2.43	0.08	0.00	58.3	58.3	38.6	61.4	15
Offal	1.38	0.59	<0.30	1.56	0.07	0.06	67.1	67.2	45.4	54.6	49
Offal	1.55	0.95	0.39	1.84	0.06	0.00	61.7	61.7	50.9	49.1	40
Offal	5.91	1.71	0.51	3.07	0.11	0.00	50.0	50.0	32.6	67.4	9
Offal	4.81	2.15	0.40	3.03	0.12	0.00	54.7	54.7	37.4	62.6	11
Offal	4.31	1.02	0.49	1.81	0.08	0.00	64.8	64.8	42.6	57.4	15
Offal	4.34	2.41	<0.30	5.07	0.12	0.06	59.8	59.9	43.3	56.7	14

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Sample	N	P	K	Ca	Mg	Inorg. C	Org. C	Total C	Dry Matter	Moisture	C:N
Description	% dry	% dry	% dry	% dry	% dry	% dry	% dry	% dry	%	%	
Sawdust	0.25	<0.025	<0.30	0.36	0.09	0.15	48.7	48.8	28.0	72.0	195
Sawdust	0.08	<0.025	<0.30	0.28	0.05	0.09	48.7	48.8	32.5	67.5	610
Sawdust	0.12	<0.025	<0.30	0.27	<0.04	0.05	48.8	48.8	56.7	43.3	407
Feed fines	9.93	2.95	1.36	3.49	0.41	0.10	43.8	43.9	37.3	62.7	4
Feed fines	10.59	2.63	1.39	5.13	0.37	0.13	42.1	42.2	41.8	58.2	4

APPENDIX IV. Compost Ingredients Secondary Nutrients. (Note: ‘<’ indicates laboratory method detection limit).

Sample Description	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg
Mortality	<1.0	<1.0	<1.5	<1.0	1.3	<20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	43
Mortality	<1.0	<1.0	<1.5	2.7	4.2	30	<10	<0.05	<2.5	<3.0	<5.0	<1.0	61
Mortality	<1.0	<1.0	<1.5	5.9	4.4	<20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	41
Mortality	<1.0	<1.0	<1.5	4.4	<1.0	<20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	46
Mortality	<1.0	<1.0	<1.5	3.7	1.2	<20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	21
Mortality	<1.0	<1.0	<1.5	1	1.8	26	11	<0.05	<2.5	<3.0	<5.0	<1.0	26
Mortality	<1.0	<1.0	<1.5	1.5	2.6	47	<10	<0.05	<2.5	<4.0	<5.0	<1.0	25
Mortality	<1.0	<1.0	<1.5	<1.0	3.1	38	<10	<0.05	<2.5	<4.0	<5.0	<1.0	46
Offal	<1.0	<1.0	<1.5	<1.0	1.4	24	<10	<0.05	<2.5	<4.0	<5.0	<1.0	55
Offal	<1.0	<1.0	<1.5	5.1	14.0	46	<10	<0.05	<2.5	<4.0	<5.0	<1.0	180
Offal	<1.0	<1.0	<1.5	1	3.7	38	<10	<0.05	<2.5	<4.0	<5.0	<1.0	160
Offal	<1.0	<1.0	<1.5	<1.0	1.1	20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	34
Offal	<1.0	<1.0	<1.5	2.1	3.1	27	<10	<0.05	<2.5	<3.0	<5.0	<1.0	22
Offal	<1.0	<1.0	<1.5	2.5	14.0	55	<10	<0.05	<2.5	<3.0	<5.0	<1.0	39
Offal	<1.0	<1.0	<1.5	1.7	3.4	31	<10	<0.05	<2.5	<3.0	<5.0	<1.0	48
Offal	<1.0	<1.0	<1.5	1.4	3.3	55	<10	<0.05	<2.5	<3.0	<5.0	<1.0	53
Offal	<1.0	<1.0	<1.5	4.1	15.0	56	<10	<0.05	<2.5	<3.0	<5.0	<1.0	180
Offal	<1.0	<1.0	<1.5	3.3	<1.0	22	<10	<0.05	<2.5	<3.0	<5.0	<1.0	40
Offal	<1.0	<1.0	<1.5	3.4	<1.0	<20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	16
Offal	<1.0	<1.0	<1.5	3.1	<1.0	21	<10	<0.05	<2.5	<3.0	<5.0	<1.0	30
Offal	<1.0	<1.0	<1.5	4.8	1.6	35	<10	<0.05	<2.5	<3.0	<5.0	<1.0	54
Offal	<1.0	<1.0	<1.5	3.4	<1.0	<20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	56
Offal	<1.0	<1.0	<1.5	6.4	1.1	20	<10	<0.05	<2.5	<3.0	<5.0	<1.0	34
Offal	<1.0	<1.0	<1.5	3.3	1.4	56	10	<0.05	<2.5	<3.0	<5.0	<1.0	28
Offal	<1.0	<1.0	<1.5	<1.0	1.8	<20	<10	<0.05	<2.5	<4.0	<5.0	<1.0	8.2
Offal	<1.0	<1.0	<1.5	3	<1.0	49	<10	<0.05	<2.5	<3.0	<5.0	<1.0	91
Offal	<1.0	<1.0	<1.5	<1.0	<1.0	22	<10	<0.05	<2.5	<4.0	<5.0	<1.0	21
Offal	<1.0	<1.0	<1.5	<1.0	<1.0	23	<10	<0.05	<2.5	<4.0	<5.0	<1.0	28
Offal	<1.0	<1.0	<1.5	<1.0	1.0	22	<10	<0.05	<2.5	<4.0	<5.0	<1.0	64

Sample Description	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg
Sawdust	<1.0	<1.0	<1.5	4.1	2.1	199.0	12.0	<0.05	<2.5	<4.0	<5.0	<1.0	6.8
Sawdust	<1.0	<1.0	<1.5	2.0	1.6	144.0	<10	<0.05	<2.5	<4.0	<5.0	<1.0	5.4
Sawdust	1.3	<1.0	<1.5	<1.0	3.1	20.0	31.0	<0.05	<2.5	<4.0	<5.0	<1.0	2.9
Feed fines	<1.0	<1.0	<1.5	2.5	56.0	816.0	395.0	<0.05	<2.5	<3.0	<5.0	1.3	350
Feed fines	<1.0	<1.0	<1.5	2.3	62.0	695.0	314.0	<0.05	<2.5	<3.0	<5.0	1.4	360

End of Report