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Potential for composting of SRM materials in a drum composter

Ron Fleming and Malcolm MacAlpine

University of Guelph Ridgetown Campus, Ridgetown, ON, N0P 2C0

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Abstract

Composting trials were carried out in late 2007 and early 2008 in an effort to assess the feasibility of composting Specified Risk Materials (SRM). This study represents a portion of a larger study which will eventually look into the feasibility of pelletizing and burning the materials. The composting study used 2 small rotary drum composters and the inputs consisted of abattoir wastes intended to simulate SRM materials. Different substrates were evaluated, including corm silage, wood chips and tree leaves. The study ran into a few logistical problems (related to cold weather operation and mechanical problems) but the various recipes yielded useful information.

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Background

Following the discovery of BSE in a beef cow in Canada in May of 2003, strategies have been adopted to remove any risk of BSE entering the food chain. The elimination of rendered cattle products from cattle feed had been in place for several years. Cattle products continued to be rendered and used in other areas, such as pet food. On July 12, 2007, the Canadian Food Inspection Agency required the exclusion of Specified Risk Materials (SRM) from rendering. This forced the industry to develop other options for using or disposing of these materials. Advanced Compost Corporation, a company marketing drum composters, decided to look at the merits of composting the SRM and then incinerating the compost to recover the heat.

Composting is an effective way to convert organic materials into a stable organic fertilizer and soil amendment. There are several options for composting, including static piles, windrows with mechanical turning, in-channel systems with aeration and mechanical turning, rotating horizontal drums and others. Many farmers associate composting with livestock manure. However, there have been a range of studies showing its merits in the processing of livestock mortalities. Morris et al (1996) composted feeder pig mortalities in small static piles, using straw and sawdust as substrates. The process took about nine months. Fleming and MacAlpine (2006) reported on a farm trial where cattle carcasses were composted in static piles. Substrate materials included corn silage, sawdust, straw and solid manure. The compost process was complete in about 12 months. Fleming and MacAlpine (2005) composted blood (mixed with straw) and paunch manure from a beef slaughter house, in an in-channel compost system. The same facility was used to successfully compost hatchery waste (Fleming and MacAlpine, 2007). The key in these and other studies has been to achieve an appropriate ratio of carbon to nitrogen in the inputs (i.e. the C:N ratio), maintain aerobic conditions, maintain a proper moisture level and allow enough time.

The horizontal drum composter seems ideally suited for the treatment of materials such as livestock mortalities or SRM. It is an enclosed system, which should help reduce the release of any odours. The turning maintains aerobic conditions, to optimize the performance of the bacteria. Choiniere (2006) measured the performance of such a unit in composting swine mortalities. The initial high temperature phase of composting (i.e. temperature range of 55°C to 70°C) was completed in 10 to 14 days. Wood shavings were added at a ratio of 1.0 kg mortality to 0.7 kg wood shavings. A second recipe incorporated a portion of recycled compost. When outside air temperatures dropped below freezing, heat was added using a propane heater. This system was operated continuously – additions were made several times per week.

Composting typically achieves temperatures as high as 70°C, at least for part of the process. While this destroys most pathogens, much higher temperatures are needed to destroy the prions responsible for the spread of BSE. Composting SRM can produce a stable organic product (and reduce the overall mass). If this resulting compost can then be transformed into fuel for a biomass furnace, it has the potential to provide a source of biomass heat from a material that has been treated as a hazardous waste, while ensuring that any BSE organisms are destroyed in the heat of the furnace (over 800°C).

Objective

The objective of the project was to determine the feasibility of composting SRM and other materials by developing the most appropriate compost recipe for the SRM. This determination would include documenting the logistical considerations for each recipe tested and for the operation of the drums. The appropriateness of using the resulting compost as a biomass fuel was considered to be a separate “follow-up” issue – not within the scope of this study.

Project Setup

Drum Composters

The two composters (from Advanced Compost Corporation) were trailer-mounted drum systems. Each consisted of a metal drum, 1.2 m in diameter by 2.4 m long, with foam insulation sprayed on the exterior (see Figure 1). While the company manufacturers much larger “production” models, these were demonstration units, designed for smaller-scale on-site feasibility testing of materials. They were electrically powered, with about seven rotations of the drum per hour.

Figure 1: One of the drum composters used for study.

The drum was designed to be loaded using a tractor equipped with a front-end loader. Input material was dumped into a hopper. An auger in the bottom of this hopper fed the material into the drum. A typical horizontal drum composter is designed to operate in a continuous mode, as opposed to the batch mode used in this study. Batch operation was chosen, for a few reasons: a) it was not possible to get a steady daily supply of the raw materials since the nearby abattoirs only slaughtered animals once or twice per week; b) batch operation gave a better picture of the temperature profile for each recipe; and c) the compost units were only 2.4 m long and it was deemed impossible to ensure the material exiting the unit would have had adequate composting time (i.e. some lengthwise mixing would likely occur).

Selection of Inputs

While the study was designed to evaluate the composting of SRM, it was not practical or even necessary to use actual SRM. Two local abattoirs supplied the necessary materials. These materials consisted of abattoir wastes that would have been called SRM if the slaughtered animal had been over 30 months of age – i.e. the same parts of the animal were used, but since the animal was younger than 30 months, these parts were not labeled as SRM. This made acquisition and transport of the inputs, and disposal of the compost much easier. These materials will be referred to as SRM for this report, even though, technically, they were not.

The substrates for the study were spoiled corn silage, fresh corn silage, wood chips (containing some miscellaneous yard wastes) and tree leaves.

Preparation of Inputs

The SRM and substrate materials were placed into a PENTA 2410 tub feed mixer/grinder (PENTA One Ltd.), shown in Figure 2. For the initial batch, the substrate was added first, then the SRM. This was reversed for subsequent batches. The mixer shredded the SRM (Figure 3), breaking up any bones into small pieces. It then mixed the materials together into a homogeneous blend. The mixer ran for 30 minutes for the initial batch. The tub grinder was equipped with a scale, so accurate measurements of the weights of all inputs were possible. The mixed inputs were added to the composter's intake hopper using a tractor and front-end loader.

Figure 2: PENTA 2410 tub feed mixer/grinder – for breaking up any bones and for mixing the materials

The batches were initially sized to fill approximately 75% of the composter capacity. For the size of the compost units, this was considered to be a good compromise, allowing ample contact with air (during turning), yet maintaining a “critical mass” of material, for generating heat.

Figure 3: SRM in tub mixer/grinder prior to shredding.

Composter Operation and Sampling

The project was set up as a series of batches using the two drum composters (one white and one yellow). The first batch was added to the yellow drum on November 7, 2007.

The following steps were followed:

- Compost drum operation: The composting materials were weighed and added to the drums. They were typically left in the drums for two weeks and then removed and weighed. The compost was then placed in static piles inside an adjacent un-heated building.
- Temperatures were measured using an analog compost probe during the study period. Temperature loggers (Spectrum Technologies Watchdog) were also placed in one batch.
- Odour Measurement: Subjective odour assessments were made by Ridgetown campus staff.
- Ammonia Levels: Ammonia was measured as an indicator of composting performance (i.e. mainly of a low C:N ratio). Ammonia levels were measured daily outside and inside the drums - using a Drager PAC III Monitor with an Ammonia Sensor installed.
- Sampling: Samples were collected from all substrate materials before mixing. The mix was then sampled when placed into the composter. From the compost drum, samples were collected twice weekly, then when the compost was removed from the drums.

- Sample analysis: All samples were analyzed for levels of TKN, Ammonium, P, K, pH, total C, Organic C and inorganic C, Conductivity (EC), Dry Matter and Ash (LOI). This lab analysis was carried out at Laboratory Services, University of Guelph. Samples were refrigerated from the time they were collected until delivery to the Guelph lab.

Compost Recipes

The target for the various recipes was a C:N ratio of approximately 20 and a moisture level of approximately 60% (i.e. DM = 40%). Initially, assumptions of materials properties were made based on test results from previous studies. A summary of the test recipes and start dates is shown in Table 1.

Table 1 – Compost recipes tested

Batch	Substrate	Ratio (by weight) of Substrate to SRM	Start Date
1	Spoiled corn silage	10:1	November 7, 2007
2	Spoiled corn silage	5:1	November 8, 2007
3	Fresh corn silage	5:1	November 27, 2007
4	Fresh corn silage	4:1	December 7, 2007
5	Wood chips, yard waste	5:1	January 15, 2008
6	Tree leaves	5:1	January 29, 2008
7	Tree leaves	5:1	February 15, 2008
8	Corn silage	5:1	June 3, 2008
9	Tree leaves	5:1	June 3, 2008

Results and Discussion

General

The intention of the study was to test a number of recipes using SRM with various substrate materials. There were some challenges in achieving the goals, mainly related to mechanical issues. The drum composters had been stored outside for some time before delivery to Ridgetown. They had not been in recent use and some of the electrical components were in poor repair. The yellow drum needed extensive electrical repairs and the white drum had mechanical problems. There is no reason to believe that there would be any problems with the commercial scale compost units – the problems seemed to be related to machinery that had been neglected for a period of time and some poor design choices in developing a small demonstration-sized unit.

A further complication was that the study was started in the winter. Temperatures dipped to as low as -20^{o}C for an extended period of time. Even though the drums were insulated, they were not completely insulated. And, there simply wasn't the mass of material to maintain temperatures in the drums. As a result, some batches froze. Unlike the equipment used by Choiniere (2006), mentioned earlier, these demonstration units had no capability to easily add supplemental heat. The ventilation ports froze and compost froze to the side of the drums. This caused several batches to fail, as discussed later. For Batch 7, when the drum failed to work, the compost was placed into a static pile. In spite of the cold temperatures it maintained temperatures in the 40°C range and continued to compost.

Two batches were run in June 2008, to ensure that the system performed satisfactorily in warm weather.

Individual batches

Batch 1 used the yellow drum composter. The recipe consisted of a 10:1 mix (by weight) of spoiled silage to SRM. Spoiled silage was used because it was deemed to be the lowest cost substrate. While perhaps not available in large quantities from any one farm, it seemed to be a good starting point for the study. See Table 2 for a summary of the masses of all inputs and the mass at Day 14 (measured as material was being removed from the drum). Batch 1 was started on November 7, 2007 and finished on November 26, 2007. The projected C:N was 24.8, based on a C:N of approximately 40 for the silage. The actual C:N ratio of the spoiled silage used in Batches 1 and 2 was 11.3 and the moisture content was 70% (see Table 3). Unfortunately, the test results were not known until after the batch was finished. When mixed with SRM, the resulting recipe had a C:N ratio of about 11:1 to 13:1 (lower than desired) and a moisture level of 66% to 68% (slightly higher than desired).

Table 2 – Mass of compost inputs and outputs (i.e. at 14 days)

Batch	Substrate	Ratio	SRM (Kg)	Substrate (Kg)	Total (Kg)	Mass at 14 days (Kg)	Mass Reduction (%)
1	Spoiled silage	10:1	50	500	550	520	5.4
2	Spoiled silage	5:1	86	431	517	670	NA*
3	Fresh Silage	5:1	163	817	980	540	45
4	Fresh Silage	4:1	154	617	771	730	5.2
5	Wood Chips	5:1	136	680	816	580	29
6	Tree Leaves	5:1	145	725	870	540	38
7	Tree Leaves	5:1	127	635	762	NA	NA
8	Corn Silage	5:1	150	748	898	450	50
9	Tree Leaves	5:1	136	680	816	500	39

* Unfortunately, some composted material remained in the drum when it arrived on site

Batch 1 did compost, although the temperatures remained below 55°C. This mix did not result in any odours and it released no ammonia. When it was removed in two weeks it was black in colour. There were still bone fragments and some hide remaining, but it appeared all soft tissue had broken down. This mix appeared to break down fairly well, despite the lower temperatures and C:N ratio. The compost was left to cure in a static pile but did not progress very much further – it appeared the total mass was too small for effective composting.

Batch 2 used the white drum composter. It was intended to be similar to Batch 1, except with twice as much SRM for the same amount of spoiled silage. This was a 5:1 mix, by weight, of spoiled silage to SRM. The batch was started on November 8, 2007 and material was removed from the drum on November 26. Unfortunately, this batch was not considered a success, due to mechanical problems. The drum failed to rotate.

As in Batch 1, the C:N ratio of Batch 2 was lower than desired. The process resulted in heat generation, though the temperatures remained below 55°C. Similar to Batch 1, this mix produced no odours and released no measurable ammonia. It was black in colour when removed in two weeks. There were still bone fragments and some hide remaining although it appeared all soft tissue had broken down. The compost was left to cure in a static pile but did not progress much further, similar to Batch 1. An accurate mass balance could not be carried out for this batch. It appeared that a small amount of previously composted material remained in the drum when delivered to the site. While it is unlikely this had any impact on the compost process, it prevented a calculation of the quantity of mass lost during the process.

Batch 3 used the yellow drum. It was basically a re-run of Batch 2, but with fresh (high-quality) corn silage. The 5:1mix (by weight) of fresh silage and SRM was started on November 27 and finished on December 14, 2007. In this case, the silage C:N was 44, which was in the expected range. This mix quickly reached 40°C and reached a maximum temperature of 52.7°C, still lower than the desired range of 55 to 70°C. At two weeks, the soft tissue was broken down but bones remained. There was no hide in the SRM this time. The compost generated a small amount of additional heat as it cured in a static pile.

Batch 4 was a mix of fresh corn silage at a 4:1 ratio by weight with SRM. This was placed into the white drum composter on December 7, 2007. On December 10, the composter stopped turning. At the end of two weeks the compost was removed and placed into the yellow drum to finish it off, where it remained until January 10, 2008. At this point, the compost was wet and gave off a slightly offensive odour. It appeared to have composted well, despite the fact that the vents had frozen closed (and moisture could not escape). Everything except bone fragments had been effectively broken down. This compost was placed into a static pile for further curing.

Batch 5 was a 5:1 mixture of wood chips (from shredded tree limbs) to SRM. It was carried out in the yellow drum, from January 15 to January 28, 2008. This batch did not heat properly, with maximum temperatures around 3°C. The cold air temperatures appeared to chill the drum enough that composting could not begin. This batch was removed and placed in a pile with previous drum compost batches.

Batch 6 was a mix of tree leaves and SRM at a 5:1 ratio. It used the yellow drum and ran from January 29 to February 15, 2008. The drum experienced some mechanical problems at the start of the batch. In two days, repairs were completed and the drum was turning again. The mix heated, but the temperatures were quite variable, ranging from 4°C to 60°C while the drum was not rotating. Once the repairs were complete and the drum began rotating, the temperature dropped from 15°C to below freezing in just a few days. The compost could not generate enough heat and it cooled off and became inactive.

Batch 7 was a mix of tree leaves and SRM mixed in a 5:1 ratio. This batch was started February 15, 2008. It was intended for the yellow drum, but because of an electrical failure in the composter, was simply placed into a static pile alongside the curing piles from previous batches. This batch heated up in the static pile without aeration or turning. The temperatures reached the low 50°C range and the mix appeared to compost well. The success of this batch seemed to indicate that the recipe was appropriate.

Batch 8 was a 5:1 mix of corn silage and SRM, in the white drum composter. The start date was May 29, 2008 and the batch was removed two weeks later, on June 12. Outside air temperatures for Batches 8 and 9 were considerably higher than for the previous batches. However, the batch temperature in the drum stayed in the rather low range of 25 to 35 ^{o}C during the study period. The drum composter operated smoothly during the test and the material had the appearance of compost on removal from the drum.

Batch 9 was a 5:1 mix of tree leaves and SRM, in the yellow composter. The composter was loaded on May 29 and emptied on June 12. The tree leaves were from a pile that had been collected the previous fall. They had already begun the composting process – as evidenced by the analysis results discussed in the next section. Temperatures in this batch (side by side with Batch 8) ranged from 29 to 52 ^{o}C.

Sample Analysis

Samples were collected from input substrates as well as from the mix of SRM and substrates in the drums. Results (averaged) are shown in Table 3. No initial samples of only SRM materials were collected, due to the non-homogeneous nature of this material. Samples were then collected bi-weekly and, finally, when the compost was removed from the drums. These averaged results are shown in Table 4.

Table 3 – Average nutrient content of substrate materials (Batch numbers in brackets) - dry matter basis

Material	NH_4N (mg/kg)	N (%)	P (%)	K (%)	Dry Matter (%)	Ash (%)	pH	C (%)	C:N Ratio
Spoiled silage (Batch 1,2)	474.2	3.48	0.65	1.25	31.8	22.4	7.35	38.9	11.3
Fresh Silage (Batch 3, 4)	359.7	1.09	0.20	0.93	32.4	3.41	8.3	45.0	44.0
Wood Chips (Batch 5)	50.9	0.69	0.08	0.27	56.1	1.12	5.9	48.6	71.3
Tree Leaves (Batch 6)	48.7	1.62	0.15	0.72	32.4	12.5	6.35	46.6	38.0
Corn Silage (Batch 8)	868.9	1.50	0.34	1.31	38.4	5.48	7.05	43.3	29.9
Tree Leaves (Batch 9)	7.78	0.64	0.09	0.54	56.3	58.0	7.7	22.1	33.3

The values in Table 3 show the range of properties of the input materials. Table 3 also shows the variation that is possible in the same type of materials sampled at different times of the year, and subject to different storage conditions. For example, the tree leaves for Batch 9 had undergone considerable organic matter breakdown prior to the start of the testing, compared to the leaves used for Batch 6 - reflected in the very high ash content of the leaves used in Batch 9.

Table 4 – Average nutrient content of composting materials for each batch of SRM during the study - dry matter basis

Batch	NH_4N (mg/kg)	N (%)	P (%)	K (%)	Dry Matter (%)	Ash (%)	pH	C (%)	C:N Ratio
1- Spoiled silage 10:1	526.8	3.05	0.83	1.11	44.0	28.8	7.1	39.8	13.1
2- Spoiled silage 5:1	1579	3.35	0.76	0.99	42.6	27.9	6.88	36.5	10.9
3-Fresh Silage 5:1	499.3	1.60	0.47	1.00	38.6	7.7	6.09	47.7	30.5
4-Fresh silage 4:1	1214	1.96	0.40	0.89	31.6	26.3	6.2	34.8	17.5
5-Wood chips 5:1	24.9	1.15	0.14	0.34	43.5	5.98	5.84	47.7	45.3
6-Tree Leaves 5:1	15.41	0.95	0.15	0.40	36.7	23.21	6.24	43.0	45.7
8 – Corn silage 5:1	723.7	1.73	0.39	1.12	44.5	14.5	5.93	45.0	26.1
9 – Tree leaves 5:1	1346	1.14	0.18	0.67	70.8	43.5	6.50	31.7	28.7

For any given Batch, the concentrations of the measured chemical properties were fairly consistent from one sample to the next. The greatest variability was in the concentrations of NH_4-N. The C:N ratios were in the expected ranges, except for the spoiled silage, which was lower than expected. This material had already undergone considerable organic breakdown before it arrived at the test site. It had a high ash content (i.e. 22.4%), confirming that considerable breakdown had occurred.

The values in Table 4 have been averaged over time. This normally would not be appropriate for compost samples, where the results would be constantly changing as composting progresses. For simplicity, this format has been adopted here, with the following further justification:

- the time frame was relatively short – the process only covered two weeks,
- there was a certain amount of variability between samples (the sample size was chosen to give representative values) – it would be hard to separate the changes due to composting from this normal variability, and
- some of the batches did not reach a stage of active composting, so large changes in properties would not be expected.

Batches 1 (six samples) and 2 (four samples) showed very little variation in properties over the two-week period. The properties of the 10 samples from Batch 3 displayed more variability, especially in NH_4-N. However the ash content did not increase appreciably, nor did the moisture content drop as expected. Batch 4 faced equipment problems and only two samples were collected, as material was removed from the drum. These both had surprisingly high ash contents (for this material). The ash content is a critical factor in the decision to use this compost as a biomass fuel.

Composting of organic materials results in a loss of carbon (as CO_2) and water (as vapour). The ash content (inorganic matter), therefore, increases as composting progresses. Ash represents materials that will not burn and so the lower the number, the better, for a biomass fuel. There is no explanation why the ash content of Batch 3 compost was 7.7% and that of Batch 4 was 26.3% (the initial silage had an ash content of 3.41%).

There was very little change over time in the measured properties of the compost in Batch 5 (eight samples) or Batch 6 (11 samples). No samples were collected from Batch 7. The C:N ratios shown in Table 4 suggest that the recipes for Batches 5 and 6 could be adjusted to use less wood chips and tree leaves, respectively. The composting would likely proceed at a faster pace if the C:N ratio were closer to 20 (as opposed to the values of over 40 that were measured).

Batch 8 did not achieve the expected high temperatures in the drum, and there was no obvious reason for this. The data in Tables 3 and 4 suggest conditions were ideal for composting. Also, this batch experienced the highest loss of mass (see Table 2), suggesting that composting certainly did take place (and the material that came out appeared to be composted).

The compost in Batch 9 had the highest ash content of all the batches (the content was high in the initial tree leaves). This material did appear to compost as expect, however, despite the high ash content and the high dry matter content.

Odours

Odours were assessed subjectively several times per week, monitoring odour intensity and character. At no time during the study could odours be detected outside of the drums, even though a few of the batches, at times, developed objectionable odours inside the drum (detected when the hatch was opened).

Ammonia

Ammonia was monitored during the study period. At no time was ammonia detected outside or in the drums during composting. By keeping the C:N ratio above 20 in most cases, no ammonia emissions were expected. Even at the lowest C:N ratios, ammonia emissions did not occur in measurable amounts.

Drum turning and aeration

The intent of the study was to have all batches turned constantly during composting. Due to the technical problems with the drums, already discussed, it was not always possible to turn the drums. With Batches 2 and 4, the white drum failed to turn properly. The compost in Batch 2 was left in the drum for two weeks and then removed, without having been turned. This batch appeared to compost quite well in spite of the lack of turning. Batch 4, which was more moist than desired, did not compost well without turning. No forced aeration was used in the drums. The tumbling action caused by the constant turning of the drum appeared to provide adequate mixing and aeration.

Compost Temperatures

Temperatures were measured using a standard compost thermometer. This was inserted into the compost after halting the drum rotation and opening a hatch. In addition, for Batch 6, two Spectrum Watchdog temperature loggers were placed into the drum for the duration of the composting process.

Normally, composting generates high temperatures, but this was not evident for most batches. The expectation in this study was that temperatures would reach 55^{o}C within two or three days, then would stay in the thermophilic range (i.e. approximately 55 to 70^{o}C) for most of the two-week period. This simply did not happen, but it appears to be mainly due to higher than expected heat loss from the drums. This includes heat loss through the insulated portions of the bins, but mainly though the un-insulated steel and the ventilation ports. For most of the period when Batches 1 through 7 were running, the daily minimum ambient temperatures dropped below freezing. During nearly all of January and February, the average daily temperature was below freezing.

It is also possible that the heat that was generated was dissipated much more rapidly with this type of composter, especially with the smaller batch sizes used in this study. In a static pile, the material on the outer portion insulates the pile, slowing heat loss from the composting material.

Economics

The abattoirs that helped in this study were paying in the order of $175 per tonne for SRM disposal. This study was not able to generate enough information to assess the economic feasibility of composting, pelletizing and incinerating SRM. However, it identified several factors that must be considered in making this assessment:

- Abattoirs or slaughter plants that handle large numbers of animals over 30 months of age will have much more SRM to deal with.
- Smaller abattoirs will likely incur costs associated with storage of the SRM.
- This study did not look into the cost to pelletize the compost. Nor did it establish the heating value of burned compost.
- It may be feasible to remove compost from the drums at an earlier date (e.g. one week), in order to maximize the combustion value.
- A screening system would likely be needed to remove any remaining bones or hide prior to pelletizing.
- It may be possible to get quantities of substrate material at little or no cost (e.g. tree leaves or wood chips). Currently in southwestern Ontario, corn silage has a value in the order of $40 to $45 per wet tonne, based on 35% DM (Wand, 2008).
- Electricity costs were not calculated, though this type of composter has relatively low electricity inputs. If supplemental heat is needed, the cost could be significant.

Summary

The main findings from the study are:

- Composting using spoiled corn silage did not perform as well as composting using fresh corn silage. The C:N ratio was lower than desired in the spoiled material. Wood chips and tree leaves also appeared to be suitable substrates. In each case, however, there was room for a more complete study.
- The drum composters were effective at preventing the creation and/or release of offensive odours during the composting process.
- The rotation of the drums appeared to be adequate to maintain aerobic conditions in the compost.
- The drums did not have a large enough capacity to have the critical mass needed to maintain temperatures during the cold periods experienced in this study. This resulted in several batches freezing instead of composting. A larger capacity system may have solved this problem. It is possible that an external heat source may be needed for cold weather operation, at least for the smaller units that might be considered for slaughterhouse waste. Operating the system as a continuous flow process would not likely change this.
- Ammonia was not detected during any of the batches tested.
- The two drums (small demonstration units) arrived with, or developed, a number of mechanical/electrical problems that prevented testing to the extent desired.
- Temperatures of the compost never reached the expected 55^{o}C or more. There was no evidence to suggest there was a problem with the compost recipes, other than the batches that used spoiled silage as the substrate.
- The fact that Batch 7 composted in a static pile suggested that the recipe was acceptable and that, had the drum been operational at the time, composting should have proceeded similar to the previous batches.
- Reductions of total mass did occur in most batches, reaching a high of 50% in two weeks for the final corn silage test. The measured results should not be relied upon for design purposes, however, without running further tests.

Further Study

While this study showed the potential for composting SRM using drum composters, it fell short of expectations, for two reasons: a) running most of the tests during the winter resulted in too much heat loss; and b) the equipment was not fully serviced and tested upon arrival on site (i.e. before the start of the study) and developed several problems. A heating system should be incorporated if cold-weather composting trials will continue with the two demonstration units used for this study. Recipes need to be tested that result in lower C:N ratios, as this will almost certainly affect the economics of the system. Testing of other possible substrates or mixtures of substrates could be done. Finally, combustion testing needs to be carried out for the composts that appear to be most practical – establishing the best compromise of product stability and heating value.

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