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Effectiveness of Drum Composter Treating Food Processing Wastes

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Summary:
An insulated drum composter which featured continuous addition of 95% oxygen, semi-continuous controlled loading and intermittent rotation to mix the contents was used to treat green waste from a salad manufacturer. The results of analyses performed on the system including C:N ratio, respiration rate, color and odor, selected heavy metal content (Al, As, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, S, Se, Si, Sr and Zn), and moisture are reported. Performance was evaluated and stability determined by comparing beginning and ending C:N ratios, respiration rate, and color and odor of final product.

Keywords:

drum composter, food waste, compost

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INTRODUCTION

Environmental Products and Technologies Corp. contracted with Utah State University to evaluate a new design of drum composter featuring computer controlled mixing, feeding, emptying and aeration with 95% oxygen. The composter was 6 ft (1.83 M) in diameter by 18 ft (5.5 M) long and insulated with approximately 2 inches of spray-on polyurethane. It was controlled with an IBM compatible computer running at 90 MHz and programmed to run through continuous cycles of load, rotate drum, and unload. The length of each part of the cycle was variable. Oxygen was distributed throughout the drum by means of a header which ran along the center of the rotating drum. Gases were removed from the drum and treated for odor in a biofilter before release to the atmosphere. Other details of the unit are not yet available for publication.

Composting

Composting is a controlled aerobic biological decomposition process that converts organic matter to a stable, humus-like material (Collins, 1996). It converts material with offensive odor and other potential nuisance problems into a stabilized product. Heat generated during the process can volatilize and thus remove more than 1 kg moisture/kg VS day (Richard, 1998). Allowing the temperature to rise, may destroy pathogenic organisms and weed seeds. However, Mote et. Al, (1988) reported when dairy waste solids were composted in static piles with or without forced aeration, coliform bacteria numbers did not decrease in the composted waste.

Moisture content will largely determine whether the process will be "anaerobic" (without oxygen) or "aerobic" (with oxygen). A good moisture content for aerobic composting is about 60 percent. At a 70 percent moisture content, the process tends towards anaerobic. A moisture content of 50 percent or below will slow the composting process. Addition of a bulking agent such as straw or wood chips reduces the percentage of moisture compared to solids. Low moisture content is increased by adding water.

The carbon:nitrogen ratio (C:N) also affects the rate of biological activity. C:N ratios of 15:1 to 35:1 are acceptable. If the C:N ratio is less than 25:1, organisms cannot utilize all of the nitrogen available, and nitrogen will be converted to ammonia which can cause odor problems and overall loss of N for fertilizer. When the C:N ratio exceeds 30:1, there is not sufficient N and the rate of composting decreases. Inorganic nitrogen such as urea or ammonium nitrate can be added to lower the C:N ratio.

Temperature is a good indicator of biological activity in compost. Thermophilic microbes which prefer a temperature of 38- 66°C (100 - 150°F) should dominate. The temperature will drop when metabolizable substrate has been used up or conditions become less than favorable for the microbial population.

Composting Food Wastes

Composting food wastes is often a challenge. Food waste is highly variable in composition, often high in moisture, putrescible, and may have a low pH. To save costs, it is often desirable to compost on site, which infers that odors must be controlled. The drum composter can contain odors by treating off gases, usually in a biofilter. C:N ratio is unpredictable if the waste is a mixture of various foods. One needs to know the C:N ratios and the moisture contents of the food waste and the amendment(s) that are usually required in order to maintain proper conditions for composting. Despite the challenge, there is increasing interest in composting food residues on site (Rynk, 2000). Composting on or near site can result in significant savings for producers of food waste by avoiding waste transport and soaring disposal costs (Marion, 2000).

Drum Composters

Drum composters are vessels which contain and mix compost mechanically. O_2, mixing rate, moisture and other parameters may be controlled. In-vessel composting offers potential advantages including the following (partially taken from Cawthon, 1999):

1. Waste is retained on-farm, and composted in a relatively small area, eliminating the need to transport raw waste on highways to a centralized composting yard.
2. Composting can be completed rapidly, resulting in product stabilization/sanitation in 2 - 4 days.
3. While in the composter, raw wastes are isolated from the environment until the composting process is complete.
4. It is possible to maintain precise control of moisture, temperature and aeration during the composting process.
5. Excellent odor control.
6. In-vessel composting can maintain a rapid decomposition process year-round regardless of external ambient conditions.
7. There are no significant cold spots, thus pathogen destruction is complete.

MATERIALS AND METHODS

Food Waste

The drum composter used in this research was tested in northern Utah at the Caine Dairy Farm, Utah State University, from Spring of 1999 to the present. Food waste was provided by a fresh-cut vegetable processor which processed mostly lettuce and onions during the time the trials were conducted (waste was delivered during June, 2000). The annual US production of this type of waste is estimated at 359 kt and most is placed in local land fills (McGuckin et al., 1999). Material used in these trials varied from mostly onions (estimated to be about 65% by volume) shown in Figure 1 to mostly lettuce (90% by volume) shown in Figure 2. The composition depended on the day of the week it was collected. The remainder of the waste on any day was tomatoes, cucumbers, cabbage and

Figure 1. Onion waste used in this study.

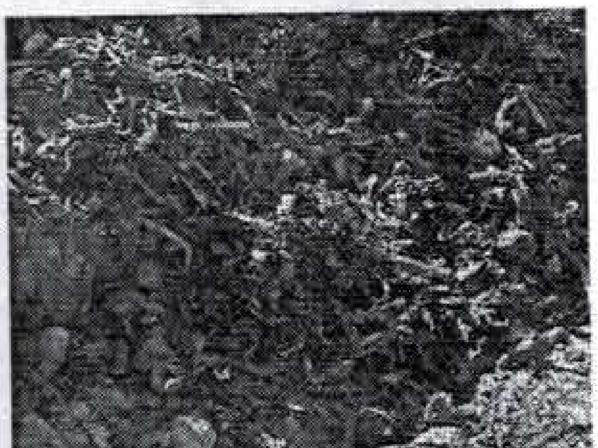

Figure 2. Lettuce waste used in this study.

carrots. Tests that were run on the food waste and/or compost are listed in Table 1. Results of moisture, pH, and C:N ratios of the food waste is given in Table 2. Table 3 shows results of inductively coupled plasma (ICP) spectroscopy analysis of the food waste. In order to compost this material which had a very high moisture content, it was mixed with a straw/manure mix (estimated at about 70% straw and 30% dried manure). The target moisture content for influent material to the drum composter was 60% and proved difficult to achieve.

Composter & Ingress Tank

The composter was a 6 ft (diameter) x 18 ft (1.83 x 5.5 M) drum (Figure 3) with approximately 300 ft^3 (8.5 m^3) usable capacity which rotated at about 18 rev/hr intermittently as set with the computer which controlled it. Influent was fed into the digester with an 8 in (203 mm) diameter, 15 ft (4.6 m) long feed auger, manufactured by EP&T, which conveyed the waste up into the 18 x 24 x 36 in (457 x 610 x 914 mm) inlet of the composter (Figure 4). A similar sized auger, the unload auger, was located at the far end of the drum to carry compost far enough from the composter to pick up with a front end loader. A 6' wide x 18' long x 2' deep ingress, balance tank was installed to store at least one days influent waste load and meter it into the composter semi-continuously. The ingress tank automated loading of the system and made it possible for workers to tend the composter in only about 30 minutes/day. The ingress tank feed mechanism was turned on at the same time as the feed auger and thus influent moved from the ingress to the feed augur as fast as the augur could handle

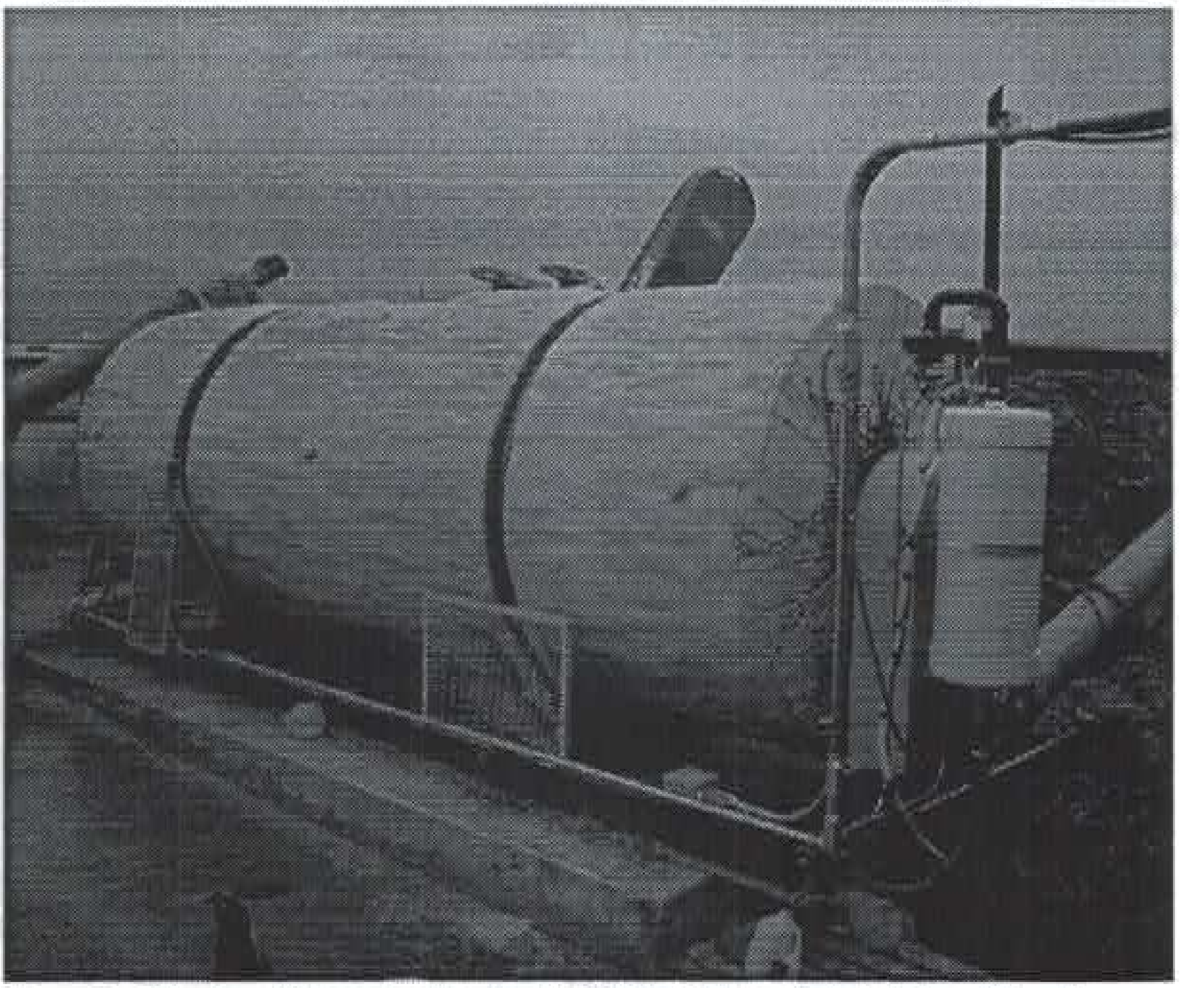

Figure 3. Side view of bioreactor showing the biofilter (white cylinder) at the outlet end.

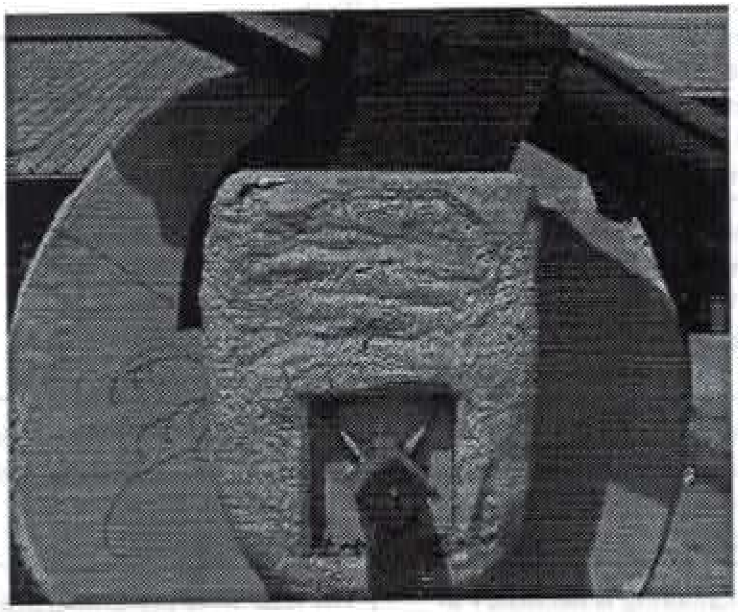

Figure 4. Composter inlet for the drum. An auger is located inside the inlet which moves influent dropped from the auger into the drum.

it. Other details of the ingress have not been disclosed at this time. A 19.5 in (495 mm) auger in the composter inlet was connected to the drum and thus rotated with the drum, forcing material from the inlet, thence through a 21 in (533 mm) opening into the drum. Generally, the system was set to load (rotate ingress auger) for 90 s, thence rotate the drum for 240 s, thence unload for 30 seconds, thence back to load, repeated continuously. Finished compost was emptied as the drum turned. It dropped onto another 8 in (203 mm) diameter auger which was 8 ft (2.4 M) long. It operated while the drum turned to stack the finished compost far enough away to pick up with a front end loader. Oxygen was added with two oxygen generators (Air Sep, AS-12, Buffalo, N.Y.). The oxygen generators were serviced by a ½ HP (500 W) air compressor. The bioreactor was operated under slight negative pressure by means of an 1/25 HP exhaust fan (Model 5C087, Dayton Electric Manufacturing, Niles, IL) which exhausted bioreactor gases though a biofilter. The biofilter design was proprietary. Vapor condensed in the biofilter and was called condensate. The entire process was controlled with a 90 MHz, IBM compatible computer using proprietary software. Temperature was monitored inside the drum with RTD temperature sensors and data was stored on the computer.

Analytical Methods

A LECO, model CHN-1000 (St. Joseph, MI) was used to determine concentration of carbon and nitrogen. Minerals analysis was done with ICP spectroscopy (Thermo Jarrell Ash, Franklin, MA). The Solvita test (Solvita, 1995) provided rapid, and reliable on-site monitoring of decomposition rate. The test results revealed respiration rate and thus enabled us to make inferences about the progress of composting and maturity of the end products. The Solvita test is based on colorimetric analysis.

Table 1. Tests for determining the degree of stability and safety of the finished compost.

Test for stability	**Purpose**	**Technique**
Carbon to Nitrogen[a]	Monitor the breakdown of solids to organic matter and carbon dioxide and to measure the degradation of nitrogen based toxins.	Tests was preformed by the USU Soil Testing Laboratory using the LECO.
Solvita Test[b]	The test results reveal respiration rate and thus enables anyone to make inferences to the progress of composting and maturity of the end products.	Test was preformed on site using the Solvita test kit distributed by Woods End Laboratory.
Color and Odor	Color of compost indicates the chemical composition of the compost. Biological compost is usually dark brown/black.	The test was preformed on site using the Test methods for the Examination of Composting and Compost, USCC.
Total Solids, Moisture	Constant monitoring is necessary to prevent improper decomposition. When the compost is above 60% moisture, water fills the free air-space and causes anaerobic conditions. In contrast if the moisture level is too low the bacteria cease to have a proper growth environment and decomposition will slow or stop.	The tests were preformed in a Nutrition and Food Sciences Dept., USU, lab using the Test methods for the Examination of Composting and Compost, USCC and standard methods for wastewater testing (APHA-AWWA-WEF. 1992).
Al, As, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, S, Se, Si, Sr and Zn	Heavy Metal status is necessary to measure to toxicity of the compost. The nutrient content and other elements are monitored and regulated by the EPA.	The test was preformed in the USU Soil Testing Lab using inductively coupled plasma spectroscopy (ICP).

Source: [a]The US Composting Council, *Test Methods for the Examination of Composting and Compost*, First Edition, 1997. [b]*Guide to Testing Compost Maturity*, Woods End Laboratory, Woods End, MA, 1995. and *Standard Methods for the Examination of Water and Wastewater*. 18th Ed., American Public Health Association. Washington, DC, 1992.

Table 2. Moisture, pH, and C:N ratio of influent waste streams.

Type of waste	Average Moisture	pH	Average C:N Ratio
Fresh cut food waste (mostly onion & lettuce)	91%	4.6 -5.5	26.5
Manure/straw mixture available for composting at Caine Dairy	59- 63%	8.5-9.5	22.9

Table 3. Results of inductively coupled plasma spectroscopy analysis of vegetable processing waste.

Al	As	B	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Se	Sr	Zn
------mg/kg------				%	---------mg/kg---------					----%----		------mg/kg-----				%	mg/kg	%	-mg/kg--		mg/kg
136	<	27.3	7.8	0.72	<	<	4.96	6.7	185	2.17	0.32	25.2	<	1129	<	0.28	<	0.28	<	66.6	41.2

RESULTS AND DISCUSSIONS

This paper reports the results of preliminary trials of composting food processing waste in the EPTC drum composter during the months of May and June, 2000. The goal was to feed as much food waste as possible and gather data including that listed in Table 1. The major limitation was maintaining an acceptable moisture content. As shown in Table 2, the moisture content of the food waste was too high for composting in a drum composter. No solid/liquid separator was available, thus it was necessary to mix the food wastes with a drier component to bring influent moisture content down. The only material available at the Caine Dairy was a straw/manure mix. Unfortunately, the moisture content of this mixture was often near 60% during the time of these trials. Therefore, it was often not possible to bring moisture concentration down to the levels needed for effective composting. During the month of June the average moisture content in the effluent from the bioreactor was near 70%. This explains the relatively low temperatures in the bioreactor (Table 4) compared to previous trials composting a manure/straw mixture in the same bioreactor. Because temperatures in the bioreactor were so low until the end of June, analysis for viable weed seeds and pathogens was not conducted. This will be done in the future when a separator is installed or a consistent source of dry amendment is procured and temperature in the drum consistently remains above an average of 135°F. The drum composter has been very effective at destroying pathogens and weed seeds when temperatures are uniformly high in the drum (Hansen and Maxfield, 1999). Temperature had risen in July because the straw/manure mixture used to adjust moisture in the influent was dry enough to consistently bring moisture in the influent to 60% or less. However, in order to do this, the amount of food waste was only 10-25% of the total organic material added to the composter. Tests will proceed with higher food waste percentages when we can either dry the food waste or use a solid/liquid separator. There are plans to add a separator to the system later this summer.

Table 4. Representative temperatures in the drum composter treating food wastes.

Date	15 June	20 June	25 June	30 June	4 July
Temperature	Ambient	125	113	100	140

The loading rate for all runs was set at about 2.5 days. Solvita tests (respiration rate) were taken on June 19, 21 and July 2. The results of these tests are shown in Table 5.

Table 5. Solvita test results

Date	19 June	21 June	2 July
Solvita number	2	3-4	8

The first Solvita test results indicated the compost process was incomplete. The moisture in the effluent on 19 and 21 June was near 70%, which likely caused the failure of the process. The final test result on 2 July indicated a mature compost even with the 2-3 day HRT. This is consistent with previous trials with dairy waste (Hansen and Maxfield, 1999). The color and odor of the finished compost (Solvita number greater than 7)was very acceptable.

In summary, preliminary results for treating fresh cut vegetable processing waste in the EPTC drum composter were encouraging. The moisture content of the waste was a serious problem. The C:N ratios and pH for the waste used in this study did not seem to be an impediment. However, we were unable to demonstrate digestion of unmixed food processing waste because we did not have a way to remove moisture from the waste. There are plans to install a solid/liquid separator such as a screw press later this summer. Without liquid separation, it will be necessary to add large quantities of dryer organic waste such as a relatively dry manure/straw mixture to bring the influent moisture content to acceptable limits. Simply adding straw would likely upset the C:N ratio and inhibit ideal composting. There does not seem to be any other serious impediment to composting this material in the EPTC drum composter.

ACKNOWLEDGMENTS

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