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Stability Evaluation of Mixed Food Waste Composts

Teresa L. Matteson and Dan M. Sullivan
Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon

As interest in food waste composting grows, so does the need for proven composting methods. Stability testing has been proposed as a compost quality assurance tool. We conducted this study to: (i) to evaluate the efficacy of simple outdoor composting methods in producing a compost with a low, stable decomposition rate, and (ii) to determine the reliability of simple, 4-h compost stability evaluation methods. Composting was conducted outdoors in winter and spring in Eugene, Oregon without moisture addition. Mixed food waste was combined with screened dairy solids and ground yard trimmings. Sawdust was used to cover windrows for the first 27 d of composting. Compost windrow temperatures remained above 55°C for 30+ d. Carbon dioxide evolved with several 4-h test methods was strongly correlated ($r^2 > 0.7$) with CO_2 evolved using a 48-h test. A limited-turn windrow (LTW) composting system produced compost with slightly greater stability than a passively aerated windrow (PAW) composting system. Food waste compost samples had a low CO_2 evolution rate after 71 to 99 d using either composting system. Compost CO_2 evolution rate at 25°C decreased with composting time, reaching approximately 1 to 4 mg CO_2-C g compost C^{-1} d^{-1} for the PAW method and 0.5 to 2 mg CO_2-C g compost C^{-1} d^{-1} for the LTW method. Putrescible organic matter in food waste was effectively decomposed in outdoor windrows using composting methods that did not employ forced aeration, self-propelled windrow turners, or manufactured composting vessels. Several 4-h stability tests showed promise for implementation as quality assurance tools.

Introduction

Mixed food waste (MFW) is a major fraction of organic waste disposed in landfills. Local legislation (Crocket 2001) and worldwide research (Laos *et al.* 1998; Namkoong *et al.* 1999; Itävaara *et al.* 2002) have begun to form an infrastructure supportive of MFW composting. However, narrow economic margins coupled with stringent composting regulations continue to limit the adoption of food waste composting in Oregon (Oregon DEQ 1997). Practical, standardized procedures for monitoring of the composting process and for assessment of finished compost quality are needed to promote increased utilization of MFW by composters.

Turned windrow (TW) and passively aerated windrow (PAW) are two low-technology methods used by composters for a wide variety of feedstocks (Diaz *et al.* 1993; Rynk 1992; Haug 1993). We define low technology composting methods as those that do not employ forced aeration, self-propelled windrow turners, or manufactured composting vessels. For the TW method, windrows of blended feedstocks are periodically mixed with a tractor-mounted turner or a front-end loader. Turning blends feedstocks, moves material from the outside of the windrow into the hotter center of the windrow, and allows water addition or mixing of wet and dry portions of a windrow. Passively aerated composting is a less labor intensive alternative, where mixed feedstocks are covered with a layer of finished compost or other insulation, and air movement into the windrow is facilitated by perforated pipes placed within the windrow. Large passively aerated windrows typically retain moisture more effectively than do turned windrows (Rynk 1992). Composting using the turned windrow is an approved method for composting septage or biosolids; windrow temperatures and turning frequency must meet USEPA requirements for a Process to Further Reduce Pathogens (USEPA 2003). Composting using passively aerated windrows is not a USEPA-approved method to meet pathogen reduction standards.

Compost stability describes the resistance of organic substrates in compost to microbial decomposition. As composting proceeds, labile organic matter is decomposed and the remaining organic substrate becomes increasingly resistant to decomposition by microbes, or more stable (Rynk 1992; Haug 1993). Stability can be determined by measuring O_2 consumed or CO_2 produced when moist compost samples are incubated under specified conditions (Sullivan and Miller 2001). Carbon stability assays that measure CO_2 evo-

lution in sealed vessels are simple to conduct and have been reported for use for composts derived from yard trimmings (Brewer and Sullivan 2003), manures (Changa *et al.* 2003; Cooperband *et al.* 2003), biosolids (Wu and Ma 2001) and other many other feedstocks.

The standard stability test described in *Test Methods for the Examination of Composting and Compost* (TMECC Method 5.08-B; Thompson *et al.*, 2001) requires a 72-h incubation time at 37°C, so it is usually performed at a commercial laboratory. Simpler, more rapid stability assessment procedures also have been advocated for on-site testing of composting. The most common of the rapid tests, the Solvita Maturity Index, uses a 4-h incubation period at room temperature, so that compost can be tested and results provided on the same day (Woods End Research Laboratory, Inc. 2000).

To meet the need for more data on low-technology alternatives for mixed food waste composting, the Oregon Dept of Environmental Quality (DEQ) initiated a collaborative study in 2001 involving regulators, composters, consultants and academia. The DEQ study evaluated outdoor composting of mixed food waste (MFW) using two low technology processing treatments, the limited turn windrow (LTW) and passive aerated windrow (PAW) under western Oregon climatic conditions. The LTW windrow method followed a similar turning regime to that routinely employed for commercial yard trimmings composting in Oregon. The PAW method was chosen for study by DEQ project managers as a compromise between forced aeration systems and static windrows. Previous studies had demonstrated that static windrows were generally not capable of achieving pathogen reduction temperatures for food waste composting, while aerated static windrows usually achieved temperatures above the desired threshold (55°C). The addition of aeration pipe in the PAW method improves air movement into the windrow and moisture removal from the windrow. Thus, the PAW has a greater potential of achieving temperatures above 55°C than does a static windrow.

A complete report on the pilot Oregon DEQ food waste composting project has been published (Tetra Tech 2002). Research reported here is focused on narrower objectives, to (i) evaluate the efficacy of simple outdoor composting methods in producing a compost with a low, stable decomposition rate; and (ii) determine the reliability of simple, rapid 4-h compost stability evaluation methods.

Materials and Methods

Composting Process

Our study evaluated composting during winter and spring climatic conditions. The median daily temperature during the winter trial was 6°C, compared to 11°C for the spring trial. Compost windrows were not covered. Cumulative precipitation, 52.5 cm during the winter trial and 13.2 cm during the spring trial, was the only moisture added to the windrows during composting.

Compost feedstocks included MFW, separated dairy solids, and ground yard trimmings (Table 1). The mixed food waste used in the study came from both pre and postconsumer sources generated by restaurants, grocery stores, institutional kitchens, and meat markets. The winter trial MFW was collected from 21

TABLE 1.
Amounts and analyses of the feedstocks used in winter and spring composting trials[a].

Feedstock	Wet weight Mg	Volume m^3	Total Solids g kg^{-1}	Dry weight Mg	Total C g kg^{-1}	Total N g kg^{-1}	C:N
			Winter trial - Nov 28, 2001 to Mar 7, 2002				
Mixed food waste	12.0	16.8	250	3.0	498	11.6	43
Chicken offal	7.0	7.6	466	3.3	470	50.0	9
Screened dairy solids	3.6	7.6	229	0.8	443	15.6	28
Ground yard trimmings	41.7	84.1	293	12.2	408	9.2	45
Sawdust	24.5	72.6	490	12.0	492	0.8	656
			Spring trial - March 14 to June 20, 2002				
Mixed food waste	12.9	19.9	395	5.1	433	19.6	22
Chicken offal	8.4	9.2	460	3.9	470	50.0	9
Sheep heads and feet	0.3	0.4	550	0.1	ND[b]	ND	ND
Screened dairy solids	6.8	7.6	480	3.3	ND	ND	ND
Ground yard trimmings	29.2	41.3	315	9.2	386	7.8	49
Sawdust	29.0	72.6	340	9.9	497	0.8	662

[a]Feedstock data from Tetra Tech (2002). For each trial, feedstocks were mixed, then divided to make two windrows: a limited turn windrow (LTW) and a passively aerated windrow (PAW). Initial windrow volume for the LTW and PAW was half of the amount listed above. Sawdust was not mixed with other feedstocks until the first windrow turning on Day 27. [b]Not determined

sources, while spring trial MFW came from 14 sources (Tetra Tech 2002). Mixed food waste included by-products from chicken and sheep processing plants, in order to provide a "worst case" scenario for DEQ's monitoring of composting effects on human pathogen indicator organisms. Screened dairy solids consisted of bedding plus coarse manure fiber recovered by screening effluent from a flush manure handling system at a local dairy. Ground yard trimmings were a mixture of ground woody prunings, grass clippings, and leafy material from conifers, broadleaf evergreen shrubs and deciduous trees from the local area.

Feedstock mixing and composting was performed by Rexius Forest By-Products, Inc. at a facility in Eugene, Oregon. On Day 0, feedstocks were mixed by front-end loaders, then divided into equal parts for building one LTW and one PAW. Each PAW and LTW contained approximately 50 m^3 of the MFW, separated dairy solids, and ground yard trimmings mixture. Each windrow was enclosed in approximately 35 m^3 of sawdust in order to have comparable feedstock mixtures. Windrows were built on a 20 cm depth of insulation, and a 30 cm insulation layer was added over the entire windrow after it was in place. The LTW was turned on Day 6, 13, 20, 27, 34, 41, 48 and 55 with a front-end loader. For the PAW, perforated drain field pipes (10 cm diam. Schedule 40 PVC) were placed on the insulation layer, and the feedstock mixture was then placed on top of the aeration pipes. The perforated pipes were 90 cm apart and ran perpendicular to the long axis of the windrow. The PAW was turned once on Day 27 during each trial with a front-end loader.

Windrow Monitoring and Sampling

Temperature and oxygen concentration in both windrows (1 m from the windrow base and 1 m into the windrow) were monitored throughout winter and spring trials. After windrow building on Day 0, thermocouples mounted on 1 m rods were inserted into the actively composting feedstocks below the insulation layer. Temperature data were collected by attaching thermocouples to Fluke 51 and 52 Series II Thermometers (Fluke Corporation, Everett, Washington). Oxygen levels were monitored using a Demista Model OT-21 Oxygen/Temperature monitor (Demista, Arlington Heights, Illinois). Additional temperature and oxygen monitoring was done at 0.5 and 2 m from the windrow base, and is reported elsewhere (Tetra Tech 2002). Thermocouples were removed prior to turning the windrows and then replaced in approximately the same locations after the windrows were reformed.

Compost samples were collected on Day 29, 43, 57, 71, 85, and 99 during winter and spring trials. For Day 29, 43, and 57, the LTW samples were collected 2 d after windrow turning, as were Day 29 PAW samples. Four composite samples were collected from each windrow at each sampling date. Each composite sample (approx. 10 L) was a mixture of 30 grab samples collected from sample access holes 0.5, 1, and 2 m above the windrow base. To collect grab samples, we used a shovel to dig a 40-cm diameter hole into the windrow and collected grab samples from the bottom of each hole. The grab sample access holes extended 50 cm beyond the insulation cover into the composting feedstock mixture. Each 10 L composite sample was dumped on a tarp, then repeatedly mixed and quartered to obtain a representative 4 L composite sample for laboratory analysis (TMECC procedure 12.3.3.1; Thompson *et al.* 2001).

Sample Processing and Analyses

After arrival at the laboratory, samples were moistened (if necessary) to reach target total solids concentration of 350 g kg^{-1}, then allowed to sit overnight at 25°C (at least 12 h) in plastic bags with open tops. After moisture adjustment, all samples had total solids of 300 to 400 g kg^{-1}. Moisture adjustment of compost samples to an optimum moisture content for microbial activity is a recommended in several stability test protocols (Thompson 2001; Woods End Research Laboratory 2000). Total solids for both as-received and moisture-adjusted samples was determined gravimetrically by oven-drying at 55°C for 3 d. Compost total C analyses were used in calculating compost respiration rates. Total C in oven-dried samples was determined by a combustion analyzer equipped with an infrared detector (LECO Instruments Model CNS 2000, LECO Instruments, St. Joseph, Michigan).

Carbon Dioxide Evolution Tests

Carbon dioxide evolution was measured using four methods: a 48-h method and three 4-h methods. All tests were performed at a temperature of 25°C in sealed incubation vessels. The standard method was a 48-h alkaline trap procedure with a compost sample size (25 g), incubation vessel volume (3.8 L), and trap changing interval (every 24 h) as described in TMECC procedure 05.08-B (Thompson *et al.* 2001). For CO_2 determination, the carbonate trapped by NaOH was precipitated with excess $BaCl_2$, and the remaining NaOH was back-titrated with standardized 0.1 M HCl, using phenolphthalein as the indicator (Anderson 1982). We chose a 25°C incubation temperature for the 48-h alka-

line trap test in order to facilitate comparison with the 4-h quick tests. The standard TMECC 5.08-B (Thompson *et al.* 2001) procedure uses an incubation temperature of 37°C, although other researchers routinely use compost sample incubation temperatures of approximately 25°C (Grebus *et al.* 1994, Changa *et al.* 2003).

Two of the 4-h methods were designed to evaluate CO_2 determination method with the same incubation conditions (125 g compost sample in a 0.95 L Mason jar). Carbon dioxide was determined by the alkaline trap method or by a colorimetric tube method (Dräger CO_2 Detection Tubes, Drägerwerk, Lübeck, Germany; 0.1 to 6.0% CO_2 or 1 to 20.0% CO_2 scale). These tests used a greater amount of compost per incubation vessel volume than employed for the standard test (TMECC procedure 05.08-B; Thompson *et al.* 2001) in an effort to improve method sensitivity and reproducibility. For the Dräger tube method, we used a veterinary supply syringe (140 cm^3 volume) to withdraw 100 cm^3 of headspace air using a needle inserted into a rubber septa in the vessel lid. The air was then passed through a Dräger tube over a 15 second interval and percent CO_2 read from the tube's calibrated scale. For calculation of compost sample respiration rate, we assumed that the volume of headspace in the incubation vessel was 825 cm^3 (125 g of wet compost occupied approximately 125 cm^3 within the jar). For the 4-h Dräger test only, we also evaluated the effect of compost sample holding time. We conducted CO_2 evolution tests on samples that were i) held for 12 h after sampling at 25°C, or ii) refrigerated at 72 h at 4°C, then held for 12 h at 25°C prior to incubation.

For the third 4-h method, we used the Solvita test kit (with CO_2 determination by a colorimetric gel affixed to a paddle; Woods End Research Laboratory 2000). Compost was added to the incubation vessel (0.25 L) to the fill line (approximately 40 to 60 g wet compost). Immediately upon opening the incubation vessels, a 1 to 8 rating for CO_2 evolution was assigned by visual comparison of paddle gel color to a standard Solvita color chart. We also placed the Solvita paddles for colorimetric NH_3 detection in the incubation vessels. All Solvita NH_3 tests were negative (no NH_3 detected; rating = 5) so the Solvita CO_2 ratings reported here are equivalent to the Solvita maturity index (1 – fresh, raw compost; 8 – very stable compost), which incorporates both CO_2 and NH_3 measurements for a combined rating.

Results and Discussion

On-Site Monitoring of the Composting Process

The PAW and LTW reached temperatures in excess of 55°C after 14 d of composting in both winter and spring trials (Tetra Tech 2002), and temperatures remained above the 55°C regulatory threshold for > 30 days (Figure 1a). Therefore, windrow temperatures met time and temperature requirements for a Process to Further Reduce Pathogens (USEPA 2003). Monitoring of windrow temperature and O_2 concentration during the winter trial (Figure 1a and 1 b) showed that more than 57 days was required to attain windrow monitoring measurements indicative of partially-cured compost (windrow temperatures less than 55 ^oC, O_2 concentration above 10%). In comparing the winter and spring trials, the biggest difference was moisture (Figure 1c). Water was not added during composting. All water addition was via precipitation (52.5 cm in the winter trial, 13.2 cm in the spring trial). The winter trial had consistent windrow moisture from Day 27 to 99 (300 to 350 g total solids kg^{-1}). During the spring trial, windrows dried steadily with sampling date, becoming very dry (550 g total solids kg^{-1}) at Day 99.

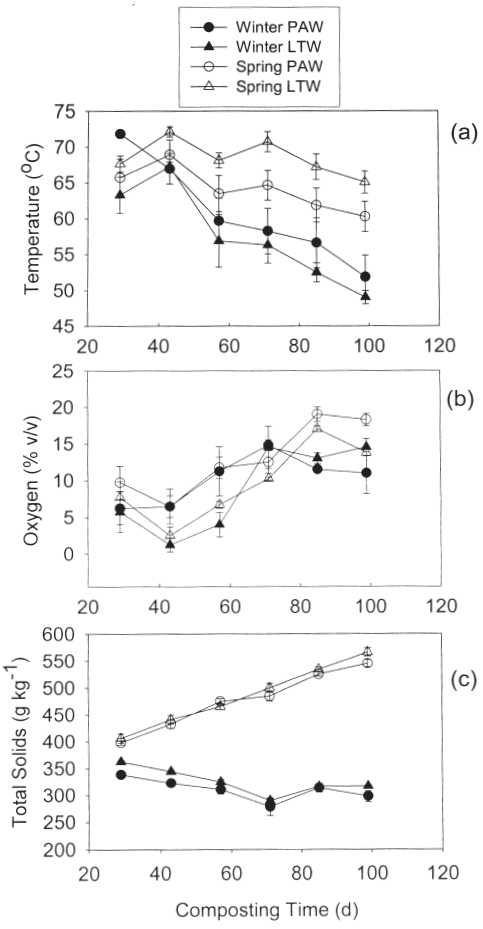

FIGURE 1. Internal windrow temperature (a), internal windrow interstitial oxygen concentration (b), and compost sample total solids (c) for PAW (passive aerated windrow) and LTW (limited turn windrow). Error bar is + SE of the mean (n = 4) for independent composite measurements collected within a single windrow.

Reliability of 4-Hour Compost Stability Evaluation Methods

We evaluated several variables in this study which could affect the reliability of our 4-h Dräger tube quick test method. First we compared results from the 4-h Dräger tube method to those obtained with a conventional 4-h CO_2 determination, using an alkaline trap (Table 2). For all of the 22 compost samples included in this comparison, the Dräger tube values were within 1 mg CO_2-C g compost C^{-1} d^{-1} of the alkaline trap values (Table 2). The 4-h Dräger tube method had acceptable accuracy and precision for food waste compost samples with respiration rates ranging from approximately 0.5 to 8 mg CO_2-C g compost C^{-1} d^{-1}. We also demonstrated that refrigeration of compost samples for 72-h had minimal impact on compost respiration as determined by the 4-h Dräger method (Figure 2). Compost sample refrigeration is often necessary when samples are shipped to a laboratory, or when samples arrive at a laboratory and cannot be processed immediately.

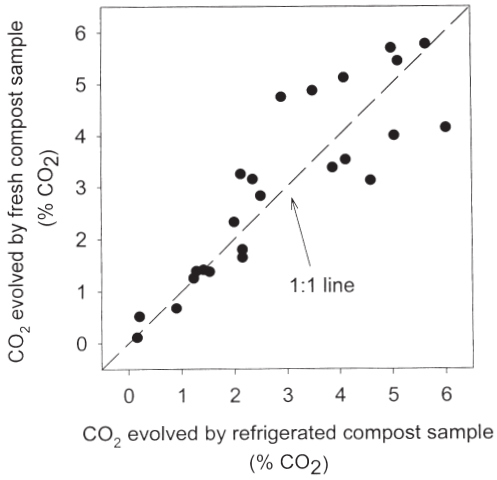

FIGURE 2. Effect of 72 h sample refrigeration (4°C) on compost sample CO_2 evolution, as determined by 4-h Dräger tube method. CO_2 measurement is percent CO_2 in headspace of incubation vessel, read directly from the Dräger tube. Combined data from winter and spring trials. Each data point represents one windrow-date mean (n = 4) for independent composite samples collected within a single windrow.

TABLE 2.
Carbon dioxide evolution from mixed food waste compost samples during winter and spring composting trials. Standard error (n=4) for independent composite samples collected within a single windrow in parenthesis.

Windrow[a]	Day	48-h Alkaline Trap[b]	4-h Alkaline	4-h Dräger Tube	4-h Dräger Tube	Solvita
		mg CO_2-C g compost-C^{-1} d^{-1}			% CO_2	1 - 8 scale
			Winter Trial - Nov 28, 2001 - Mar 7, 2002			
PAW	29	4.7 (1.14)	8.0 (2.34)	8.3 (1.43)	5.5 (0.81)	1.9 (0.13)
	43	3.1 (0.42)	6.8 (0.51)	7.5 (0.69)	4.9 (0.40)	3.0 (0.00)
	57	2.4 (0.33)	4.0 (0.97)	5.0 (0.89)	3.2 (0.61)	3.9 (0.55)
	71	1.4 (0.26)	1.4 (0.58)	2.3 (0.67)	1.3 (0.39)	6.1 (0.72)
	85	1.3 (0.23)	1.2 (0.38)	2.1 (0.58)	1.4 (0.38)	5.9 (0.24)
	99	1.5 (0.34)	2.0 (1.05)	2.4 (1.12)	1.4 (0.66)	5.8 (0.25)
LTW	29	4.6 (1.14)	5.3 (0.92)	5.4 (0.85)	4.0 (0.65)	2.1 (0.13)
	43	2.6 (0.24)	4.2 (0.78)	4.7 (0.49)	3.4 (0.35)	3.1 (0.13)
	57	1.5 (0.07)	1.4 (0.13)	2.1 (0.17)	1.4 (0.13)	5.9 (0.24)
	71	0.9 (0.14)	0.5 (0.15)	1.1 (0.22)	0.7 (0.12)	6.8 (0.32)
	85	0.3 (0.03)	0.1 (0.01)	0.2 (0.01)	0.1 (0.01)	8.0 (0.00)
	99	0.5 (0.04)	0.2 (0.02)	0.8 (0.50)	0.5 (0.33)	7.8 (0.25)
			Spring Trial - Mar 14 - Jun 20, 2002			
PAW	29	8.9 (1.42)	NA[c]	9.6 (2.58)	5.8 (1.53)	3.8 (0.25)
	43	6.2 (0.99)	7.7 (2.49)	8.0 (2.41)	5.1 (1.48)	4.3 (0.63)
	57	4.3 (0.52)	8.8 (1.06)	8.5 (1.10)	5.7 (0.62)	3.5 (0.29)
	71	3.0 (0.28)	5.5 (0.63)	5.6 (0.37)	3.5 (0.26)	3.5 (0.29)
	85	3.0 (0.45)	3.5 (0.28)	4.5 (0.15)	3.1 (0.13)	4.5 (0.29)
	99	4.2 (0.63)	5.9 (1.87)	6.4 (1.69)	4.2 (1.07)	3.8 (0.48)
LTW	29	6.0 (1.40)	NA[c]	8.0 (1.69)	4.8 (0.99)	3.8 (0.25)
	43	2.8 (0.94)	3.3 (1.86)	3.4 (1.97)	2.3 (1.32	6.0 (0.91)
	57	3.0 (0.39)	5.8 (0.22)	5.2 (0.69)	3.3 (0.50)	4.0 (0.00)
	71	2.1 (0.24)	3.7 (0.64)	4.2 (0.65)	2.8 (0.37)	4.8 (0.48)
	85	1.5 (0.10)	1.7 (0.28)	2.5 (0.34)	1.8 (0.29)	5.5 (0.29)
	99	1.4 (0.14)	1.7 (0.45)	2.4 (0.38)	1.7 (0.22)	5.3 (0.48)

[a]PAW = passive aerated windrow; LTW = limited turn windrow. [b]48 h alkaline trap values are average values for two 24-h intervals: 0 to 24 h and 24 to 48 h.
[c]no analytical values because samples held beyond prescribed holding time.

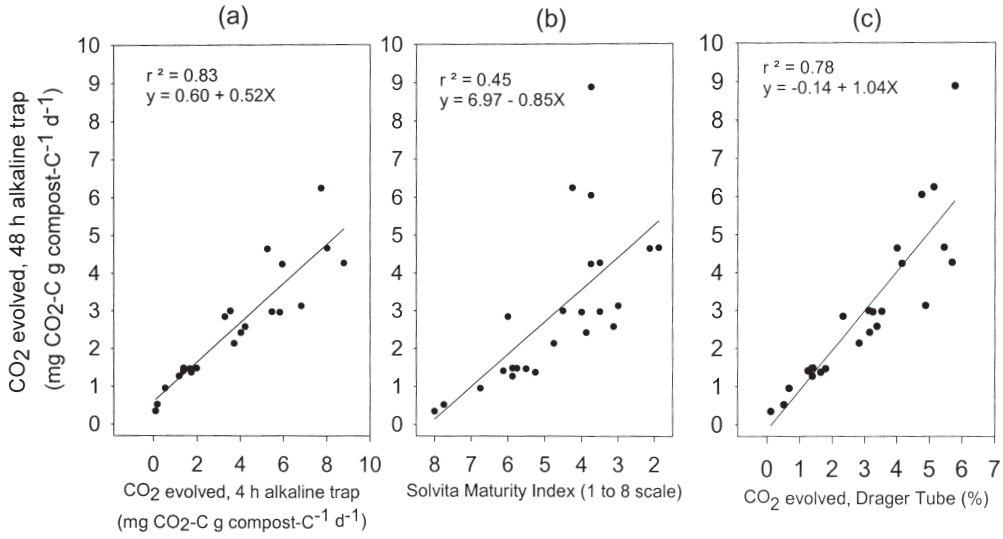

FIGURE 3. Relationships between CO_2 evolved using 4 h methods vs. CO_2 evolved using 48 h alkaline trap method. Four hour methods: alkaline trap (a), Solvita (b), Dräger, percent CO_2 as read from tube (c). Combined data from winter and spring trials. Each data point represents one windrow-date mean (n = 4) for independent composite samples collected within a single windrow.

Respiration rates obtained with the 48-h alkaline trap method were strongly linearly related to respiration rates for several 4-h tests: the alkaline trap test (r^2 = 0.83; Figure 3a), the Dräger test expressed in respiration rate units (g CO_2-C per g compost-C per d; (r^2 = 0.82; graph not shown) and the Dräger test in percent CO_2 units read directly from the tube (r^2 = 0.78; Figure 3c). Respiration rates for the 48-h alkaline trap were not as strongly related to Solvita test results (r^2 = 0.45; Figure 3b). When a single outlier data point was removed from the 4-h Dräger test data (Figure 3c), r^2 for the linear regression equation increased to 0.82. When a single outlier data point was removed from the Solvita data (Figure 3b), r^2 for the linear regression equation increased to 0.58. For the standard 48 h alkaline trap test, respiration rates were comparable for 0 to 24 h and 24 to 48 h intervals (data not shown). The median difference in respiration rate for the first day (0- 24 h) vs. the second day (24-48 h) was 0.3 mg CO_2-C g compost C^{-1} d^{-1} (n = 24).

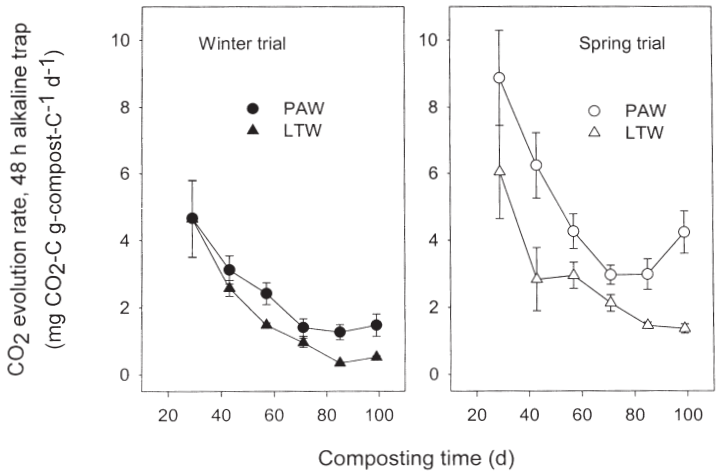

FIGURE 4. Carbon dioxide evolution as determined using 48-h alkaline trap method for compost samples collected from passively aerated windrow (PAW) and limited turn windrow (LTW). Winter and spring trials. Error bar is + SE of the mean (n = 4) for independent composite samples collected within a single windrow.

Efficacy of Food Waste Composting Methods

For all stability test methods, compost produced by the LTW method was more stable than compost produced by the PAW method (Table 2; Figure 4). Compost respiration rate decreased with time in both winter and spring trials for both PAW and LTW composting methods. Generally, respiration rate decreased until Day 71, then remained low and relatively consistent on Day 71, Day 85 and Day 99. Lower respiration rates for the LTW than for the PAW persisted until the end of both winter and spring trials. Across all sampling dates, the LTW respiration rates were 73% of PAW respiration rates for winter samples and 57% of PAW respiration rates for spring compost samples (48-h alkaline trap method; Table 2).

Lower compost sample respiration rates were observed in the laboratory for the winter trial than for the spring trial (Table 2; Figure 4). Lack of moisture

probably limited microbial decomposition in compost windrows in the spring trial (Figure 1c). Prior to laboratory respiration rate determination, all compost samples were moistened to near-optimum moisture, so that moisture did not limit respiration rates measured in the laboratory.

Compost Stability Interpretation

This study was one of many recent studies demonstrating that compost sample respiration rates decrease with composting time and stabilize at low respiration rates of approximately 1 to 4 mg CO_2-C g compost C^{-1} d^{-1}. Composting time required to reach "stable" compost respiration rates varies depending upon a host of environmental and management variables, but final values are remarkably consistent across compost feedstocks, including yard trimmings (Brewer and Sullivan 2003), hog and dairy manure (Changa *et al.* 2003), cannery waste, heifer manure, duck manure, and potato culls (Cooperband *et al.* 2003), pruning waste compost (Benito *et al.* 2003).

Composts produced in our study would likely meet the definition of "stable" compost in *Test Methods for Composts and Composting* (TMECC; Thompson *et al.* 2001). The TMECC interpretive table describes stable compost as having a respiration rate of 2 to 4 mg CO_2-C g organic $matter^{-1}$ d^{-1} when the test is conducted at 37 °C. The respiration rates reported for Day 71 to Day 99 in this study (48-h alkaline trap at 25 °C) were approximately 1 to 4 mg CO_2-C g compost C^{-1} d^{-1} for PAW and 0.5 to 2 mg CO_2-C g compost C^{-1} d^{-1} for LTW. Food waste compost stability values that prevent human pathogen regrowth are not defined in current TMECC guidance.

Summary and Conclusions

Stability Testing as a Quality Assurance Tool

This study demonstrated that compost CO_2 evolution tests provided additional information about the effectiveness of the composting process that was not reflected in measurements of compost windrow temperature, moisture and O_2 concentration. Carbon dioxide evolved from a compost sample in a 4-h incubation was strongly correlated with CO_2 evolved in a 48-h incubation. The 4-h methods offer advantages over the widely used CO_2 evolution test procedure (TMECC 5.08-B; Thompson *et al.* 2001) in providing same day results with simpler test procedures. We found that 4-h CO_2 evolution test results were not substantially changed by storing compost samples for 72-h under refrigeration.

Efficacy of PAW and LTW Composting Methods

We used four adaptations of CO_2 evolution stability tests to evaluate the efficacy of two composting methods in stabilizing food waste. Lower respiration rates for the LTW method than for the PAW method were observed throughout both winter and spring composting trials. After 71 to 99 d of composting, CO_2 evolution (48-h alkaline trap test) was low for PAW compost (1 to 4 mg CO_2-C g compost C^{-1} d^{-1}), and was very low (0.5 to 2 mg CO_2-C g compost C^{-1} d^{-1}) for LTW compost. Food waste compost produced by low technology methods in our study had acceptable stability for product use in horticultural and agricultural markets.

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