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Report Number: 29110403

E-Compost Motherson Joint Venture Compost Testing Trial Report

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Prepared for: ECompost/Motherson Joint Venture

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E-Compost Motherson Joint Venture Compost Testing Trial Report

1. Executive Summary

The GEM Aerobin, using the outlined composting and operating parameters, is the best performed bin, followed by the ECompost Wheelie Bin. These bins removed three times the dry weight carbon than the Norseman Earthmachine and the Thermobin. The latter two bins operated more as drying technologies than as compost bins. None of the bins produced mature compost in the thirteen week duration of the trial, although this was not really expected in this type of static compost bin trial. Whilst the performance of the Aerobin was clearly the best, it is expected that a mixed waste trial would further demonstrate an enhanced performance improvement. The Norseman Earthmachine and the Thermobin cannot be used for kitchen waste without creating significant environmental problems related to odour, vermin, insects and leachate.

Overall the Aerobin is the best performed bin using the ranking system as outlined. If the ranking system was weighted toward composting performance (Section 4) then the Aerobin would be ranked even higher as it performed best on all of these key composting parameters.

2. Objective of the Trial

To conduct a comparative performance trial of the ECompost Wheelie Bin and Aerobin compost bins against two potential competitor bins for the WRAP Tender in the UK (the Norseman Earthmachine and the Thermobin). The bins were monitored for a range of composting parameters and these are reported on here. In addition a number of features were observed and commented upon with regard to operation of the compost bins. All composting parameters and features were ranked between all four bins and an overall comparative score tabulated.

3. Materials and Methods

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3.1 Material Identification – the Compost Bins

Four types bins were tested (each type in triplicate) in the trial. These were the:

- GEM Aerobin
- Norseman Earthmachine
- Thermobin
- ECompost Wheelie Bin

Figure One – Two sets of the tested compost bins.

3.1.a GEM Aerobin

The bin is a prototype compost bin with an internal aerator, a leachate chamber and insulated walls.

Figure Two – The Aerobin with two images of the aeration technology.

3.1.b Norseman Earthmachine

Figure Three - The bin is a commercially-available, cone-style compost bin that relies on external airflow through slots in the wall for aeration.

3.1.c Thermobin

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Figure Four - The bin is a commercially-available, box-style compost bin that relies on external airflow through holes in the wall for aeration.

3.1.d ECompost Wheelie Bin

Figure Five - The bin is a prototype compost bin with an internal aerator, a leachate chamber and is mobile.

3.2 Material Identification – the Material Added to the Bins

19.5 Kg of material was added to each of the twelve bins on the first day (d = 0) Four subsequent additions of compost material were added on days 9, 17, 26 & 63. An addition of 3 litres of water was made on day 54. The total compostable material added to the bins weighed 41.5 kg with a C:N of approximately 20:1.

Table One – Analysis of the material added to the compost bins

Material	Moisture (%)	Carbon (%)	Nitrogen (%)	Ash (%)
Dynamic Lifter	17.9	30.7	4.9	33.1
Eucalyptus Mulch	51.2	45.5	2.0	4.4
Grass	65.6	42.9	3.1	11.5
Grass Straw	11.7	41.6	3.4	9.0
Mushroom Compost	58.3	43.9	0.9	14.5
Pine Chips	49.2	54.3	0.3	1.2
Pine Mulch	53.1	48.6	2.5	3.7
Water	100.0	0	0	0

4. Results & Discussion - Compost Performance Parameters

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4.1 Explanation of Parameters and Rankings

A number of composting-related parameters were reviewed under two headings:

1. Composting performance parameters
2. Bin operating parameters.

The "compost performance parameters" are indicators related to the performance of a composting system and relate to good composting performance. The "bin operating parameters" are related to design characteristics of compost bins in the WRAP tender process. The only parameter not commented on is "aesthetics" as this is an area of design expertise and beyond the scope of this trial.

Each of the bins was given a ranking of 1 – 4 for each parameter with 1 being the best score and 4 the worst score for each parameter. All parameters were given equal ranking although more weighting could have been given for compost performance parameters. The rankings were then tabulated with the lowest overall score indicating best overall performance.

The composting performance parameters examined were:

- weight loss
- moisture control
- C/N stabilisation
- temperature profile
- compost quality.

The bin operating parameters examined were:

- ease of assembly
- stability of compost bin
- access to top of bin
- vermin control
- insect control
- odour management
- access to compost
- leachate management.

4.1 Weight Loss

41.5 Kg of material was added to each of the twelve bins. At the completion of the 13 week trial the material was removed from the bins, mixed thoroughly and analysed.

	Wet weight (kg)	Moisture (%)	Dry weight (kg)	Dry weight loss (%)	St. dev (%)
Aerobin	24.9	56.8	10.8	36.6	4.0
Earth Machine	21.4	29.2	15.2	11.1	7.4
Thermobin	20.3	26.9	14.8	12.6	3.5
Wheelie Bin	29.9	61.3	11.6	31.9	4.7

Table Two - Weight loss data for the compost bins.

Initially the material added to the Thermobin and the Earthmachine appear to have lost more weight (Column Two, Table Two). However, after taking into account moisture loss (Column

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Three, Table Two) it is clear that dry weight loss (Column Four, Table Two) is much greater in the Aerobin and Wheelie Bin. When expressed as a percentage dry weight loss (Column Five, Table Two) the two ECompost bins give significantly greater biomass loss – almost 3 times the Thermobin and Earthmachine. Each measurement tabulated in Table Two represents six individual measurements. The standard deviations indicate the final measurements are reasonable for a biological experiment of this nature. The moisture loss is discussed further in the next section.

4.1.a Weight Loss Rankings

Aerobin	**1**
Earthmachine	**3**
Thermobin	**4**
Wheelie Bin	**2**

4.2 Moisture

The moisture levels were initially 60% in all bins. Significant moisture loss is occurring in both the Earthmachine and the Thermobin with more than half the initial moisture being lost by the end of the experiment. Some moisture loss occurred in the Aerobin and the Wheelie Bin although the addition of 3.0 litres on Day 54 has meant final moisture is similar to starting levels. It should be noted that in the Aerobin moisture had migrated to the sides and the core was drier. The material in the Wheelie Bin was in two phases with the bottom half of the bin being moist and the top half was dry.

	Wet weight (kg)	Moisture (%)	Dry weight (kg)	Weight loss (%)	St. dev (%)
Aerobin	24.9	56.8	10.8	36.6	4.0
Earth Machine	21.4	29.2	15.2	11.1	7.4
Thermobin	20.3	26.9	14.8	12.6	3.5
Wheelie Bin	29.9	61.3	11.6	31.9	4.7

Table Three (repeat of Table Two) – Moisture loss from the compost bins.

The Earthmachine and the Thermobin gave very poor moisture control with significant drying occurring. This excessive drying is a potential Occupational Health & Safety problem as large levels of dry spores were evident in the dried out compost.

Figure Six – Moisture in bins. Clockwise from top left – Aerobin, Earthmachine, Wheelie Bin & Thermobin

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4.2.a Moisture Control Rankings

Aerobin	**1**
Earthmachine	**3**
Thermobin	**4**
Wheelie Bin	**2**

4.3 Carbon:Nitrogen (C:N) Stabilisation

All bins have reduced the C:N ratios from a starting ratio of 20:1 but none have reached the ideal 10/1. Although the C:N ratios indicate better carbon stabilisation in the Aerobin and ECompost bins. Producing mature compost in all bins would require more than 13 weeks and better moisture control.

	C:N ratio	St. dev
Aerobin	12.1	0.7
Earth Machine	16.7	0.5
Thermobin	15.7	1.6
Wheelie Bin	14.0	1.7

Table Four – Final C:N ratios in the compost bins.

4.3.a C:N Ratio Rankings

Aerobin	**1**
Earthmachine	**4**
Thermobin	**3**
Wheelie Bin	**2**

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4.4 Temperature Profile

The temperature profile, as measured in the centre of the bins and 15 cm below the surface, indicates that all the bins give elevated temperature profiles over ambient temperatures. As the readily biodegradable material decreases so does the temperature profile. The addition of fresh material spikes temperatures upwards.

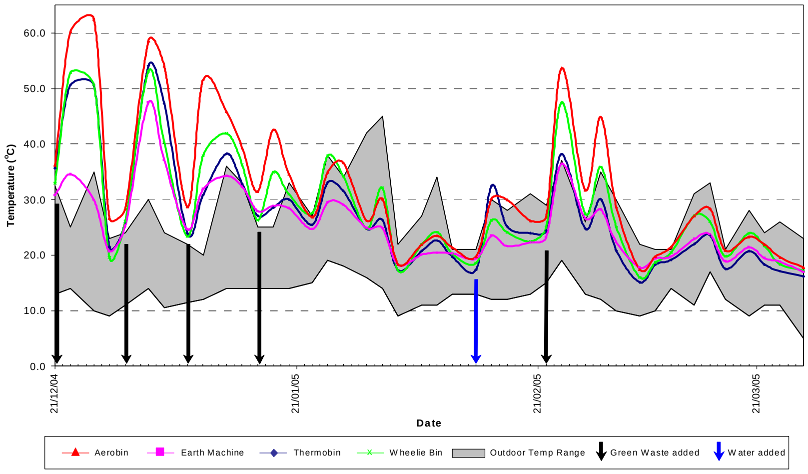

Figure Seven – The temperature profiles of the compost bins.

Overall temperature is higher in the Aerobin giving improved composting performance, pathogen control and an extended composting season. Adding fresh material clearly affects the temperature as does the ambient temperature. Notably the addition of moisture after 54 days spiked the temperatures. Clearly availability of moisture as well as aeration is a parameter that requires optimising in these styles of compost bins.

4.4.a Temperature Profile Rankings

Aerobin	**1**
Earthmachine	**4**
Thermobin	**3**
Wheelie Bin	**2**

4.5 Compost Quality

The appearance of the compost is not that of a mature compost that can be achieved in twelve to thirteen weeks in a commercial-sized, turned windrow system. The compost quality was not assessed according to Australian Standard 4454 as the compost was not considered mature. This means making a judgment of compost quality is difficult but an assessment was conducted using the “old” 5 tier Rottegrad scale rather than the “new” 3 tier Rottegrad scale. This test gives an indication of compost maturity rather than compost quality. It should be noted that it was not expected that mature compost would be formed in any of the bins in this time frame.

Aerobin	Rottegrad 4 (temperature rise 18ºC) (actively maturing)
Wheelie Bin	Rottegrad 3 (temperature rise 30ºC) (moderately active)
Thermobin	Rottegrad 3 (temperature rise 28ºC) (moderately active)
Earthmachine	Rottegrad 3 (temperature rise 25ºC) (moderately active)

Even though the Earthmachine, Thermobin and Wheelie Bin had the same Rottegrad rankings the relative temperature increases above ambient enabled a ranking. The smaller the temperature increase the more mature the compost.

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4.5.a Compost Quality – Rottegrad Rankings

Aerobin	**1**
Earthmachine	**4**
Thermobin	**3**
Wheelie Bin	**2**

5. Results & Discussion – Bin Operating Parameters

5.1 Ease of Assembly

Aerobin

The Aerobin is very easy to assemble. The sections slide together. The only difficult part is bending over and sighting the aeration tube.

Earthmachine

The Earthmachine is difficult to assemble as the bottom and top sections do not easily fit together, requiring significant force to be applied.

Thermobin

The Thermobin is relatively easy to assemble. The difficulty being lining up all the sides and pushing the locking pins in.

Wheelie Bin

The Wheelie Bin is very easy to assemble. The only difficult part being bending over and sighting the aeration tube.

5.1.a Ease of Assembly Rankings

Aerobin	**2**
Earthmachine	**4**
Thermobin	**3**
Wheelie Bin	**1**

5.2 Stability of Compost Bin

Aerobin

The Aerobin is stable but if bumped hard can be pushed off the leachate chamber. Relatively easy to put back into position.

Earthmachine

The Earthmachine is very stable and not easy to knock over.

Thermobin

The Thermobin if bumped can be easily knocked out of shape, especially when holding low levels of compost. Relatively easy to put back into position.

Wheelie Bin

The Wheelie bin is very stable and difficult to knock over as would be expected for a bin designed primarily to hold garbage.

5.2.a Stability of Compost Bin Rankings

Aerobin	**3**
Earthmachine	**1**
Thermobin	**4**
Wheelie Bin	**2**

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5.3 Access to Top of Bin

Aerobin

The lid of the Aerobin is easy to get on and off but needs a hinge. The lid fits reasonably well.

Earthmachine

The lid of the Earthmachine can be secured by turning and locking in place. However it is not easy to use on a daily basis and is difficult to get off.

Thermobin

The lid of the Thermobin is relatively easy to use with a hinge. The lid fits reasonably well.

Wheelie Bin

The lid of the Wheelie Bin is very easy to use with a hinge and a well designed lid.

5.3.a Access to Top of Bin Rankings

Aerobin	**3**
Earthmachine	**4**
Thermobin	**2**
Wheelie Bin	**1**

5.4 Vermin Control

Aerobin

Good above ground control with stable footprint and good lid.
Good below ground control with no access route.

Earthmachine

Good above ground control with locking lid and lockable door.
Poor below ground control unless on solid base. Vermin able to easily tunnel into the bin from below.

Thermobin

Good above ground control with relatively stable footprint and good lid.
Poor below ground control unless on solid base. Vermin able to easily tunnel into the bin from below.

Wheelie Bin

Good above ground control with stable footprint and good lid.
Good below ground control with no access route.

5.4.a Vermin Control Rankings

Aerobin	**2**
Earthmachine	**3**
Thermobin	**4**
Wheelie Bin	**1**

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5.5 Insect Control

Aerobin

Good insect control with no access to bin.
It was necessary to put mesh on air inlet to prevent mosquitoes breeding.

Earthmachine

Poor insect control with easy access through ventilation holes for most insects. A problem if adding wet lawn clippings, spoilt fruit and similar materials that may be attractive to flies and fruit flies.

Thermobin

Poor insect control with easy access through ventilation holes for most insects. A problem if adding wet lawn clippings, spoilt fruit and similar materials that may be attractive to flies and fruit flies. Large number of spiders colonised the inside walls.

Wheelie Bin

Good insect control although fruit flies accessed the lid. It was necessary to put mesh on air inlet to prevent mosquitoes breeding.

5.5.a Insect Control Rankings

Aerobin	**1**
Earthmachine	**3**
Thermobin	**4**
Wheelie Bin	**2**

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5.6 Odour Management

Aerobin

Good odour management although on warm days some odour escapes through the bottom lip on the bin.

Earthmachine

Almost no odour management as the bin relies on large ventilation holes for aeration. On warm days the odour was evident.

Thermobin

Almost no odour management as the bin relies on a large number of ventilation holes for aeration. On warm days the odour was evident.

Wheelie Bin

Good odour management as the bin was originally designed to hold rubbish. Minimal odour can be detected on warm days.

5.6.a Odour Management Rankings

Aerobin	**2**
Earthmachine	**3**
Thermobin	**4**
Wheelie Bin	**1**

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5.7 Access to Compost

Aerobin

Access is via lid or by lifting sections off the bin. 400L version has four drawers of moderate practical use.

Earthmachine

Access is via lid or by using door on the front of the bin. Not really a practical door.

Thermobin

There is excellent access to the compost by lifting the wall locking pins and opening the sides.

Wheelie Bin

Access is via the lid. Ability to wheel the bin, either to a garbage truck or to put compost on the garden is useful.

5.7.a Access to Compost Rankings

Aerobin	**3**
Earthmachine	**2**
Thermobin	**1**
Wheelie Bin	**4**

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5.8 Leachate Management

Aerobin

Excellent leachate management as leachate is captured in a drainable leachate chamber. Bin can be operated without the leachate chamber if drainage is not an issue.

Earthmachine

No leachate management. This is not an issue when using uncontaminated garden waste. Diseased garden waste and fruit & vegetable waste may present a problem. The technology cannot be used for kitchen waste.

Thermobin

No leachate management. This is not an issue when using uncontaminated garden waste. Diseased garden waste and fruit & vegetable waste may present a problem. The technology cannot be used for kitchen waste.

Wheelie Bin

Good leachate management. The leachate chamber may not be big enough if a large amount of high moisture waste is used. The leachate chamber must be used.

5.8.a Leachate Management Rankings

Aerobin	**1**
Earthmachine	**3**
Thermobin	**4**
Wheelie Bin	**2**

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Overall Rankings – lowest score is best

	Aerobin	Earthmachine	Thermobin	Wheelie Bin
Parameters				
4.1 Weight loss	1	3	4	2
4.2 Moisture control	1	4	3	2
4.3 C:N stabilisation	1	4	3	2
4.4 Temperature profile	1	4	3	2
4.5 Compost quality	1	4	3	2
5.1 Ease of assembly	2	4	3	1
5.2 Stability of compost bin	3	1	4	2
5.3 Access to top of bin	3	4	2	1
5.4 Vermin control	2	3	4	1
5.5 Insect control	1	3	4	2
5.6 Odour management	2	3	4	1
5.7 Access to compost	3	2	1	4
5.8 Leachate management	1	4	3	2
Total	**22**	**43**	**41**	**24**

6.1 Final Rankings & Summary

1. **Aerobin (22)**
2. **Wheelie Bin (24)**
3. **Thermobin (41)**
4. **Earthmachine (43)**

Overall the Aerobin is the best performed bin using the ranking system as outlined. If the ranking system was weighted toward composting performance (Section 4) then the Aerobin would be ranked even higher as it performed best on all of these key composting parameters. The performance of the Aerobin could be improved further and these recommendations are listed in the next Section. It is understood that all of these design changes are already being addressed in the commercial design.

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6. Recommendations for Improving the Performance of the Aerobin

- Improve the aerator design
- Improve the stability of bin on leachate chamber.
- Add a hinged lid.
- Provide a larger access door.
- Provide insect screening on air inlet and drainage tap.
- Remove the bottom lip to prevent odour.
- Provide a bigger bin for garden waste.

7. Additional Comments

- The data from the ongoing kitchen waste trial will provide additional information that will strengthen the scientific evidence regarding the Aerobin's performance
- Moisture management is a controllable parameter and is worthy of further fundamental research to improve the Aerobin's performance
- Compost maturation can be accelerated by the addition of compost worms.
- A mixed kitchen and garden waste trial in a "commercially available" large bin (400litres or larger) would be very valuable in improving success rates with tenders like WRAP and in the market generally, especially if the trial includes greenhouse gas data.

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Global Environmental Management (GEM) Kitchen Waste Trial Report

Report Number: 29110404

Prepared for: Global Environmental Management (GEM)

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GEM Kitchen Waste Trial Report

1. Executive Summary

The trial was designed to measure the biodegradation of kitchen waste in three different compost bins. The GEM Aerobins, the Ecompost Wheelie Bins and Viscount/Linpac Cone Bins (a bin often used for kitchen waste in Australia). The GEM Aerobins, when measuring Kg dry weight remaining, were the best performed compost bins (15.69 Kg), followed by the Viscount/Linpac Cone Bins (29.92 Kg) and then the Ecompost Wheelie Bin (34.82 Kg). It is important to note that the Aerobins achieved this result in approximately six months whilst the other bins were run for approximately nine months. Additionally, due to improved aeration, significantly less methane was produced in the GEM Aerobins and Ecompost Wheelie Bins when compared with the Viscount/Linpac Cone Bins. This result was so marked that a more detailed and accurate scientific quantification is justified as there is likely to be a very significant environmental impact. This may also be of importance from a marketing perspective. The higher temperatures achieved by the Aerobin when compared with the other bins contributed to the increased breakdown rates and should extend the composting season in cooler climates.

In summary the GEM Aerobin with its novel aeration technology, insulation and leachate control is the best performed technology we have tested in this area of static, non-turned, home composting bins.

2. Objective of the Trial

To conduct a comparative performance trial of the GEM Aerobins and Ecompost Wheelie Bins against the Viscount/Linpac Cone Bins. The feedstock added to the bins was kitchen waste and no attempt has been made to optimise the C:N ratios or any other composting parameters. The trial was designed to monitor the bin performance with “randomly-added” kitchen waste alone. The most significant parameter is the measurement of the comparative biodegradation rates although other indicators were also assessed and commented upon. These parameters being moisture, temperature, odour, aeration (O_2 along with the greenhouse gases (CO_2 and CH_4)), biodegradation profile, compost quality, vermin control and leachate management.

3. Materials and Methods

3.1 Material Identification – the Compost Bins

Three types of bins were tested (each type in duplicate) in the trial. These were the:

GEM Aerobin
Viscount/Linpac Cone Bin
Ecompost Wheelie Bin

Figure One – The tested compost bins.

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3.1.a GEM Aerobin

The bin is a prototype compost bin with an internal aerator, a leachate chamber and insulated walls as significant features.

Figure Two – The Aerobin with two images of the initial aeration technology.

3.1.b Viscount/Linpac Cone Bin

The bin is a commercially available bin that is frequently used in Australia for kitchen waste. It has no significant design features.

Figure Three – The Viscount/Linpac Cone Bin as used in the trial.

3.1.c Ecompost Wheelie Bin

The bin is a prototype compost bin with an internal aerator and a leachate chamber.

Figure Four - The bin is a prototype compost bin with an internal aerator, a leachate chamber and is mobile.

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3.2 Material Identification – the Material Added to the Bins

A total of 212.50 Kg of material was added to each of the six bins over the duration of the trial (see Table One below).

N.B. The trial was started with two Ecompost Wheelie Bins and two control bins (Viscount/Linpac Cone Bins) on 19 November 2004. The two GEM Aerobins were not available and the trial commenced without them. On 22 February 2005 the two Aerobins were added into the trial. Since that date the same amount of material has been added to all six bins. Additionally all the material previously added to the first four bins has also been added to the two Aerobins. Effectively requiring the Aerobins to handle the same amount of material in three months less time.

Table One - The foodstuffs added (total) to each compost bin (kg). The material was added at the rate of 3 -5 kg per week.

almonds	0.15	margarine	0.50
apple	2.60	meat	0.30
apricot	0.60	milk	5.10
avocado	2.60	mint	1.60
baby beets	0.45	muesli bars	0.40
bacon	0.30	mushroom	0.90
baked beans	0.42	noodles (2 mins)	0.30
banana	4.30	nutrigrain	0.50
beetroot	0.20	nuts	0.20
bran	3.50	olive oil	0.50
bread	6.50	olives	0.70
breadcrumbs	0.75	omega3 bread	2.30
broad beans	0.40	onion	0.40
broccoli	2.20	orange gatorade	1.00
cabbage	17.70	orange juice	4.00
canary mix	1.50	oranges	0.30
canola oil	1.50	Pal dog food	0.70
capsicum	0.60	paper towel	0.20
carrot	7.70	peach	0.30
cat food	0.40	peanuts	0.15
cauliflower	2.00	pear	0.70
celery	2.40	pet food	1.00
cheese	0.50	porkchops	0.50
chicken	2.00	porridge	1.00
Chinese cabbage	2.00	potato	19.00
chips	0.15	potatoes mini	2.00
coffee	1.20	pumpkin	4.60
Coke	1.40	QC oats	4.70
corn	0.50	red grapefruit	0.50
cran/black juice	0.50	rice	22.50
cranberry juice	0.50	rice cream	0.50
crushed toms	1.23	rockmelon	2.70
cucumber	2.80	rolled oats	0.75
dry cat food	3.40	sashimi	0.50
eggs	1.70	sausage	0.90
feijoa	1.00	sausage (pork)	0.50
figs	0.50	soup	0.65

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four bean mix	0.85	soup mix	1.00
Friskies	1.00	soya milk	3.90
garlic	0.15	spaghetti	2.00
Gatorade	0.60	spinach	2.20
ginger beer	2.05	SR flour	1.00
grape juice	0.20	steak (p/house)	1.00
grapefruit	0.20	steak (t-bone)	0.75
grapefruit juice	0.20	sugar	2.00
grapes	1.20	tea	0.20
honey	0.15	tea bags	0.95
icecream sticks	0.30	tissue	0.50
icecreams	0.15	tomatoes	2.50
lamb	0.30	tonic water	0.30
lemon	0.50	watermelon	8.00
lemon juice	0.20	Weetbix	11.30
lemonade	2.25	wine	0.60
lentils	0.75	yeast	0.25
lite margarine	0.30	yoghurt	0.40
mandarin	0.40	zucchini	0.40
		Total weight added:	212.50

4. Results & Discussion

4.1 Weight Loss and Moisture Control

A total of 212.50 kg of material was added to each of the six bins. At the termination of the trial (approximately nine months), the material was removed from the bins, mixed and weighed.

Table Two – The weights of material taken from each bin. Calculated by averaging wet weights of bins (duplicates); averaging moistures of bins (4 readings).

	Wet weight (kg)	% moisture	Dry weight (kg)
Aerobin	49.98	68.6	15.69
Cone Bin	89.59	66.6	29.92
Wheelie Bin	76.87	54.7	34.82

Even though the Aerobin has had three months less to biodegrade the material in the bin, there has been a significantly greater level of biodegradation when compared with the Wheelie Bin and the Cone Bin. The wet weight analysis indicates less than 24% of the added material remains in the Aerobin whereas slightly over 42% remains in the Cone Bin. The dry weight moisture data indicates an even greater level of breakdown in the Aerobin compared with the other two bins. However, the moisture readings, although consistent, are probably not as reliable as the material was very difficult to homogenise and there was a surprising level of moisture stratification within each of the bins. As with previous trials, moisture distribution is an area for design improvement.

4.2 Temperature Profile

The temperature profile, as measured in the centre of the bins and 15 cm below the surface, indicates that all the bins give elevated temperature profiles over average ambient temperatures. As the readily biodegradable material decreases so does the temperature profile. The regular addition of fresh material (see Figure Five) spikes temperatures upwards and thus has a major effect on the composting process.

All three bin types had differing operating temperature profiles. The Cone Bin temperatures tended to follow reasonably closely with the upper ambient temperatures with an average

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temperature of approximately 21°C (see Figure Five). The Wheelie Bin operated continuously above ambient temperature with an average temperature of approximately 29°C. The Aerobin maintained a temperature significantly higher than the upper ambient temperature with an average temperature of approximately 40°C. This elevated temperature is most likely due to two factors. Increased aeration with a concomitant rise in microbial activity giving rise to a temperature increase and the heat produced by this activity being trapped in the bin by the insulation. The net effect of the elevated temperature is increased enzyme activity and a greater level of biodegradation.

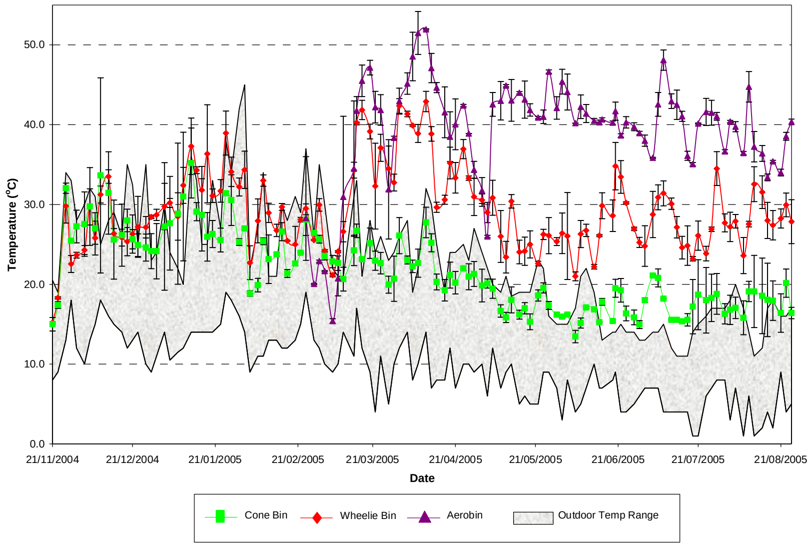

Figure Five – The temperature profiles of the compost bins (high probe).

In summary the operating temperature is significantly higher in the Aerobin over both the Wheelie Bin and the Cone Bin. The level of aeration and related biodegradation patterns linked to the presence of insulation is clearly having a dramatic impact on the temperature. Two major benefits include an improved composting performance and an extended composting season.

It should be noted that the elevated temperatures are likely to have an impact on both weed seed kill and pathogen control. Whether this impact is negative or positive is not possible to determine with the truncated trial. It is information that would be useful to measure at some time in the future.

4.3 Odour

When the bins were just standing in normal operation, odour was not a significant issue with the Aerobin or the Wheelie Bin although odour was detectable from the Cone Bin from January onwards. This odour is possibly due to greater levels of anaerobic activity in the bin. All of the bins smelt when the lids were opened to add new material but the smell rapidly dissipates when the lid is closed. The Aerobin had a slight issue with odorous leachate escaping under the bottom lip of the bin until the lip was sealed. This problem has been addressed in the newer design. It is surprising that the elevated temperatures in the Aerobin did not appear to give rise odour problems. Possibly the increased aeration is resulting in greater levels of aerobic breakdown and thus reduced production of odorous breakdown products common in anaerobic systems.

4.4 Aeration Control Profile

Accurately measuring the amount of air available and the gas composition within the compost bins was difficult. Initially the measurements were made by pushing the measuring probe to a constant depth in the composting material. Data collected in this manner tended to fluctuate wildly as insufficient gas was being drawn into the probe to give a consistent reading. After

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the 13 March 2005 data on gas trends has been collected by inserting a tube into each compost bin and routinely measuring the gas composition (O_2, CO_2 and CH_4) (see Figures Six, Seven & Eight) as it collected in each tube. The capped tubes were placed in each bin with slots cut in the tube to allow the gases to permeate the tubes. The slots were only made below the level of the composting material to prevent atmospheric gases from contaminating the samples. A number of trends were observed and are likely to be reasonably accurate. Less regard should be paid to the absolute measurements as these are less likely to be accurate. Comments are restricted to the time period after 13 March 2005.

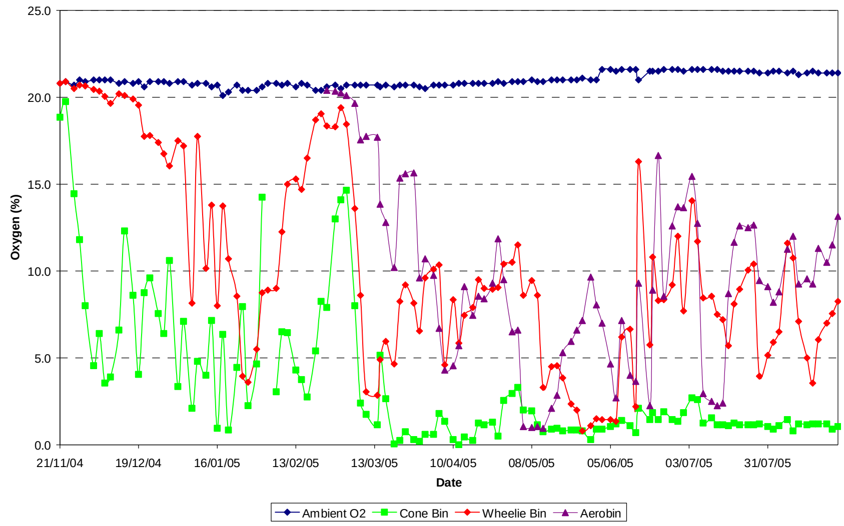

Figure Six – The aeration (O_2) profiles of the compost bins as measured in the gas insert tubes.

There is a clear difference in the pattern of oxygen consumption between the Cone Bins and the Aerobins and Wheelie Bins. The O_2 levels in the Cone Bins are low and do not really fluctuate, indicating poor O_2 transfer and a largely anaerobic environment. The Aerobins and Wheelie Bins indicate generally higher levels of O_2 although significant fluctuations are occurring. These swings in the concentration of O_2 most likely due to increased loading of easily metabolisable feedstocks to the bins, leading to increased O_2 demand for short periods. It is notable that at no stage do the O_2 levels reach the observed atmospheric levels. This indicates that with kitchen waste the bin's aeration system cannot supply all of the O_2 demand.

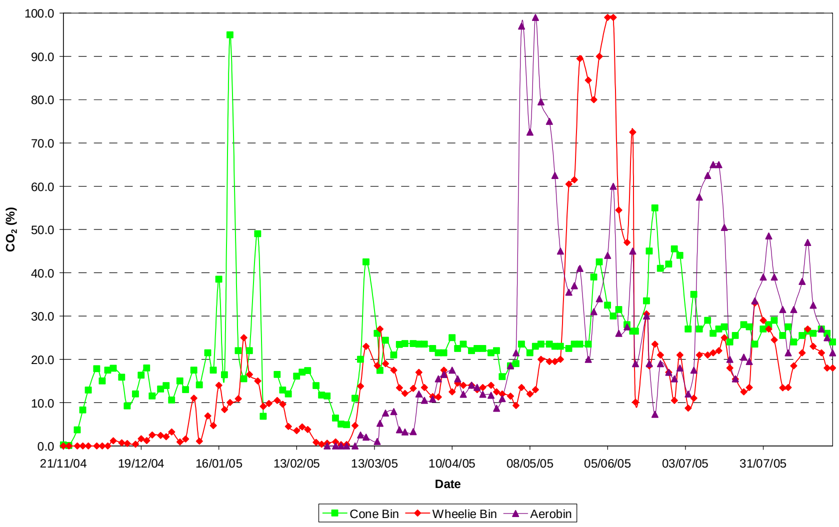

Figure Seven – The CO_2 profiles of the compost bins as measured in the gas insert tubes.

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The measured levels of CO_2 production in the Cone Bins were reasonably constant, consistent with a steadily metabolising, largely anaerobic environment. The CO_2 levels in the Aerobins and Wheelie Bins fluctuated considerably, as would be expected with varying levels of aerobic and anaerobic metabolism. These fluctuations are occurring as feedstocks are loaded into the bins. Initially high levels of CO_2 are produced as a result of aerobic metabolism but as the O_2 temporarily exhausts CO_2 is also produced as a result of anaerobic breakdown. A better understanding of this process would be advantageous in increasing the performance of the Aerobin, especially in the reducing the levels of greenhouse gas reduction.

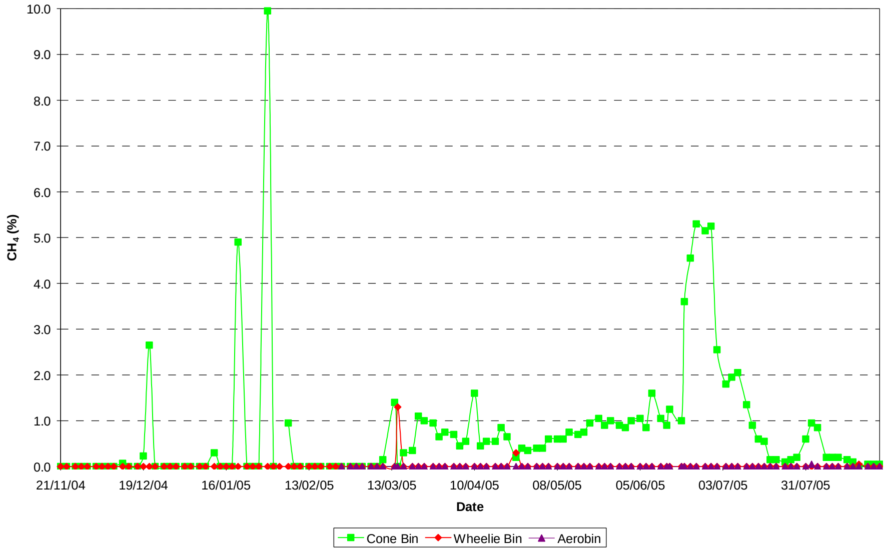

Figure Eight – The CH_4 profiles of the compost bins as measured in the gas insert tubes.

Methane (CH_4) production was consistently detected in the Cone Bins (0.1 – 5.0% v/v) whilst only occasional levels of methane were detected in both the Aerobins and the Wheelie Bins (<0.01% v/v). The Aerobin and Wheelie Bin methane levels are not evident in Figure Eight but very low levels were occasionally detected. The previous comment indicating anaerobic CO_2 production is linked to the consistent detection of methane production in the Cone Bins.

The lowered levels of methane production in the Aerobins and Wheelie Bins over that detected in the Cone Bins is very significant as methane is 21 times more potent as a greenhouse gas than CO_2. A strong recommendation from this report is to follow up with a more detailed examination of this finding. Demonstrating this level of greenhouse gas reduction is of major environmental importance. Additionally, it may also have commercial marketing significance.

4.5 Biodegradation Profile

The biodegradation profile is not a parameter that would normally be measured in a compost trial. The observed results were significant enough to be worth commenting on as there are clear and discernable differences between the self-aerating technologies and the Cone Bins. The aerated bins have large numbers of invertebrates living in and around the surfaces of the kitchen waste. These invertebrates include beetles and mites (see Figure Nine). In contrast the Cone Bin kitchen waste surfaces are covered with fungal species that appear to be either *Penicillium* or *Trichoderma* species (see Figure Ten).

Figure Nine. Invertebrate activity on the surface of the material in the Aerobins

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Figure Ten. Fungal growth in the Cone Bins.

This difference is likely to be related to the level of aeration and pH. It is possible the reduced oxygen tensions in the Cone Bins preventing the small invertebrates from colonising them. Interestingly the elevated temperatures in the Aerobin and, to a lesser extent, the Wheelie Bins do not appear to be affecting the growth of these small invertebrates. Additionally lowered pHs will favour the growth of certain fungal species.

4.6 Compost Quality

Adding kitchen waste at high levels without the addition of bulking materials (such as garden waste) is not conducive to producing good compost without an extended maturation process. With experiment being terminated early it was not possible to allow a maturation phase. Clearly the rate of breakdown is much greater in the Aerobin than any other static compost bin we have tested to date. It would be reasonable to assume a shortened maturation phase for the Aerobin.

4.7 Vermin Control

Vermin control is an important operating parameter for bins containing kitchen waste and thus the following observations were included.

Aerobin

Good above ground control with stable footprint and good lid.
Good below ground control with no access route for vermin.

Cone Bin

Moderate to good above ground control with lid but no locking mechanism.
Poor below ground control unless on solid base. Vermin able to easily tunnel into the bin from below.

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Wheelie Bin

Good above ground control with stable footprint and good lid.
Good below ground control with no access route for vermin.

4.8 Leachate Management

Leachate management from bins containing kitchen waste is important. If the bin is sitting on a well draining, microbially-active soil then the best option is to probably allow free drainage of the leachate to the soil below the bin. However, if the soil is not free draining or is on a solid base then leachate control is important. Allowing the capture of the leachate and then controlled release to the garden or drainage systems via a hose. At no stage should leachate be allowed to aerosol due to the presence of significant numbers of microorganisms. Ideally the leachate chamber should be removable without affecting the bin operation.

Aerobin

Excellent leachate management as leachate is captured in a drainable leachate chamber. Bin can be operated without the leachate chamber if drainage is not an issue.

Cone Bin

No leachate management. This is a serious issue if using possible pathogen containing kitchen waste. The technology is not really suitable for kitchen waste although often used for this purpose.

Wheelie Bin

Good leachate management. The leachate chamber may not be big enough if a large amount of high moisture waste is used. The leachate chamber must be used.

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5. Overall Comments and Recommendations

The trial was designed to measure the biodegradation of kitchen waste in three different compost bins. The GEM Aerobins, the Ecompost Wheelie Bins and Viscount/Linpac Cone Bins (a bin often used for kitchen waste in Australia). The biodegradation in the Aerobin was significantly greater than that achieved in both the other bins. This outcome was reached in two thirds of the time the other bins were run for due to the initial unavailability of the Aerobins. This result is a strong endorsement of the Aerobin's ability to achieve biodegradation rates substantially greater than I have observed before in static, passively aerated compost bins. In addition, significantly less methane production was observed in the GEM Aerobins and the Ecompost Wheelie Bins with only trace levels being detected in comparison with the high levels detected in the Viscount/Linpac Cone Bins. It is reasonable to assume this result is due to improved aeration in the GEM Aerobins and Wheelie Bins. It would be my recommendation that the Viscount/Linpac Cone Bins should not be used for kitchen waste. The Aerobin is a substantially better technology with some clear environmental impacts such as greater biodegradation rates, reduced green house gas and better leachate control.

The following recommendations could be considered for further enhancing the technology:

1. Carry out a detailed scientific analysis of the greenhouse production from the Aerobin against competitors. There is likely to be very significant environmental and marketing impacts from having this information.

2. Conduct a mixed waste trial against "newer" competitors such as the Green Johanna. It likely that the best composting performance will be observed when using mixed wastes in a "commercially available" large bin (400 litres or larger).

3. Moisture management is a controllable parameter and is worthy of further fundamental research to improve the Aerobin's performance.

4. Compost maturation can be accelerated by the addition of compost worms. For this reason a leachate chamber should be removable or allow for some access of worms.

In summary the GEM Aerobin with its novel aeration technology, insulation and leachate control is the best performed technology we have tested in this area of static, non-turned, home composting bins.