LABORATORY COMPARISON OF ODOUR CONTROL TECHNIQUES FOR SEPARATED RESIDENTIAL FOOD WASTE

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Abstract

With a moisture content of 75-85% and organic matter content over 80%, food residues can be a major source of odour during storage. A series of laboratory tests were conducted to compare odour control techniques for separated residential food waste under controlled conditions. A subjective odour intensity scale was used to monitor performance. The results indicate the importance of moisture absorption to control odours from food waste storage containers. Of the four additives considered, newspaper seemed to be the most effective because of its high moisture absorptive capacity and its ability to wrap the food wastes. Additives that would be expected to absorb or neutralise volatile, odour-causing compounds-- baking soda, EM Bokashi, and cat litter-- were not as effective, and neither was an additive that was expected to change the decomposition process and so change the odour production (EM Bokashi). Baking soda and EM Bokashi did not enhance water absorption when added to the waste. On the other hand, water absorption capability of cat litter varied depending on the placement method used and the form/size of the material.

Keywords: food waste, odour, baking soda, newspaper, EM Bokashi, cat litter

1. Introduction

Residential kitchen waste kerbside collection programs are increasingly in use because of their ability to provide alternative treatment for organics. Nonetheless, the storage, collection and transportation of the material have the risk of decay, odour and leachate, because mixed food residues have a high moisture content and a high organic matter content.

In pilot collection studies in Seattle (Bagby and Tarnecki, 2001) and Vermont (Farrell, 2001) odour was a concern throughout the collection period. In particular, warmer temperatures seemed to intensify smells. The use of odour control materials-- such as cat litter, baking soda, EM (effective microorganisms) Bokashi, newspaper, and biodegradable bags-- along with recommendations on their use, have the potential to provide householders with simple and cost effective means to control smell from food wastes.

Odour control materials rely on a mix of two processes to reduce odorous compounds-- direct adsorption, and a reduction in production rate. One known way to limit odour production is through moisture absorption. In a review of odour nuisance from livestock buildings, O'Neill and Phillips (1991) note how bedding materials such as straw, wood-shavings, and shredded paper, will limit odour because of their high moisture absorption, and they highlight that moisture absorption can inhibit the onset of anaerobic conditions.

Bokashi is a Japanese term that means "fermented organic matter." It is a bran-based material that has been fermented with EM liquid concentrate and dried for storage. The liquid is composed of several microbial groups such as lactic acid bacteria, filamentous fungi, yeasts, *streptomycetes*, and

photosynthetic bacteria (Higa, 1997). Experience has shown that odour and fly problems were less prevalent when EM Bokashi was added to the waste pile.

It has been observed that newspaper absorbs moisture from food residues when placed in the same container thus limiting odour production in an economical way (Cascadia Consulting Group, 2001). Newspaper is readily available in most households and is currently kerbside collected in some countries for recycling. The material, which originates from wood pulp, can absorb moisture and is compostable.

There are wide-ranging reports of the application of baking soda as a deodoriser, whether spread in the cat litter tray, sprinkled in the dishwasher or stored in the refrigerator to eliminate odour. Baking soda helps regulate pH and its anhydrous form absorbs moisture and odours.

Cat litter's micro-porous structure, most commonly of an absorbent clay base, provides a large surface area to effectively trap and absorb ammonia and urine stench. With cat litter, odour control is a major reason why a person buys the product.

This research was directed to investigate the effectiveness and suitability of newspaper, baking soda, EM Bokashi and cat litter at reducing or controlling food waste odour emission.

2. Methodology

All experimentation was conducted in the Environmental Laboratory of the Civil Engineering Department, University of Canterbury. Two kilograms of food waste were dumped into dry, 18 L plastic buckets, and kept inside a temperature controlled room set at 20°C with a relative humidity of 50% for up to two weeks. Since a large number of treatments were involved, the experiment was conducted in two stages. Sixteen treatments were tested in four batches initially, and then eight of the most promising odour-control treatments identified were tested in a comparative experiment.

2.1 Controlled Food Waste

To better isolate the effect of storage conditions, a standard food waste was used based on reported food waste collections (Farrell, 2001; Gies, 1996; Shin et. al., 2000; Steuteville and May, 1996; and Viana and Schulz, 2003). The composition of the food waste used is shown in Table 1. The food was prepared in five batches, four for the initial experiments, and a fifth batch for the comparative experiment. For each batch the food materials were placed into the buckets in the order as listed in Table 1 to ensure the layering and mixture of each bucket was similar. Cooked food was allowed to cool to ambient temperature before being placed in the buckets.

2.2 Odour-control test conditions

All materials were from local sources typically available to residents. For newspaper treatments, twelve sheets were laid onto an empty bucket's base. After wastes were added, the extended flaps of paper were folded to completely cover the food waste.

With the remaining odour-control additives, two application methods were used: a teabag-like pouch and sprinkling. A pouch was used to investigate whether the odour-control additives would be more or less effective on volatilised odour. To construct the pouch, two hundred grams of the appropriate material were weighed and placed within a single, two-ply kitchen towel with all sides secured with masking tape. A muslin cloth was placed over the teabag and then stuck to the lid to help position it.

The sprinkling method was also tested with crushed and uncrushed cat litter, and EM Bokashi. The cat litter was crushed using a mortar and pestle to a size between the almost powder-like baking soda, and the granular EM Bokashi. When material was added to the bottom of the buckets, a handful (approximately 200g) of the material was sprinkled into buckets. When material was added after placing all wastes in the bucket, another layer of the exact amount of material was sprinkled.

2.3 Data Collection

At 9 am on days 1,3,7,10 and 14, after weighing, lids were taken off and buckets were left opened for about 10 minutes prior to odour evaluation by the researcher and a member of staff unfamiliar with the treatment of each bucket. Odour intensity was recorded based on an intensity scale of 0 to 5 as described in Table 2. Photos were taken to document the condition of bucket contents and treatments before they were returned to the control room.

2.4 Odour evaluation procedure

The most reliable method of odour assessment involves the use of an instrument to dilute an odour source and blind testing of air samples to a panel of assessors (Burton et. al, 1998; Otto et. al., 2003; and Powers et. al, 1999). Although it is a highly sensitive method as panelists respond to an odour present in low concentration, a proper sampling procedure, controlled laboratory settings and a rather large panel are required for reliable and reproducible results.

Alternatively, for odour determination at source or when instrumental and olfactometric measurements are lacking, the method of 'sniffing team observations' has proven to be successful. Nicolas et. al. (2006) when assessing landfill odour emissions, found that the 'sniffing team' approach gave estimated emission fluxes coherent to other reported methods.

For this study, it was decided to conduct a rough screening of odour similar to the 'sniffing team' approach. It was recognized that the use of a simpler procedure would sacrifice accuracy and introduce the potential for bias; however, it was believed crucial to increase the number of odour treatments and to evaluate buckets over a number of days. Because of this simplification, the tests are termed odour evaluations rather than odour measurements.

The buckets were first arranged by the researcher according to the decreasing order of smell. Next, the other assessor evaluated this arrangement and changed the order according to his perception, again in decreasing order of smell. In most sets of measurements the researcher's and the other assessor's odour evaluation did not match and re-smelling was conducted to resolve this disagreement. This time both evaluators smelt the same bucket that caused the confusion simultaneously and then compared it to the smell of the following bucket. This procedure was repeated until all buckets were lined to the satisfaction of both evaluators. There was never an occasion that a consensus could not be reached.

For the odour testing the evaluators' head were completely inside the buckets and inhaled to smell the odour emission. The lids of the buckets were attached back on directly after smelling, to avoid odour escaping to the surroundings which may influence testing of the other buckets. Additionally,

the other assessor did not know the odour treatment assigned to each bucket anytime before or during the odour evaluation. This was crucial to minimise potential for bias based on expectation.

3. Results

3.1 Initial experiments

Table 3 shows the food waste odour evaluations for 16 buckets tested in four batches. The control buckets showed a similar, distinctive pattern across the different batches. All control buckets reached the highest level of odour intensity after 14 days' storage, and two of the four had reached this level by day 10. Although in numerous cases the odour-control conditions were given an equal score as the control bucket for that batch, in no case did the control bucket have a lower odour intensity than the test buckets from the same batch.

The results from the first batch of initial experiments indicated that newspaper-lining had decreased odour intensity; still, the odour intensity was moderate after seven days.

The second batch explored the use of cat litter in odour control. With cat litter, although the smell was moderate in the first week, odour increased to a stronger level and emitted an objectionable and unpleasant stench in the second week. Both crushing of the cat litter and its placement on top of the wastes, rather than at the bottom, seemed to reduce odour.

The third batch explored the use of baking soda in odour control. Food waste that had baking soda hanging over it had a strong smell on the final day. The smell was reduced to a moderate level when newspaper as a liner was combined with the use of baking soda. A similar odour reduction was not observed when cat litter as a liner was combined with the use of baking soda.

The fourth batch focused on the use of EM Bokashi by sprinkling it on top of food wastes. The results show very little difference in the odour resulting from sprinkling of the three additives (EM Bokashi, crushed cat litter and baking soda) tested. In fact, the sprinkling method seemed to give stronger odour than the use of the same materials in pouches stuck to the lid of the bucket. The benefit of newspaper in odour control was also confirmed in batch four.

3.2 Comparative experiment

Because of the difficulty in comparing results between batches, a comparative experiment was conducted using the more promising treatments identified in the initial experiments. Table 4 shows the relative odour intensity results. The control bucket for this batch gave similar odour intensities to those in the initial experiments.

When additives were combined with a newspaper liner, the smell from rotting food was detectable only after a week's storage. With hanging cat litter, the odour intensity was kept at a moderate level until the last days of storage. No strong or offensive odour was recorded for any of the three buckets with a newspaper lining after nine days.

Baking soda, either sprinkled on food wastes or enclosed in a pouch, and EM Bokashi were identified as materials that did not effectively manage odour intensity.

3.3 General observations

Food wastes in all buckets decomposed notably from day seven onwards (Figure 1). Mould began to form in all buckets after the first week, and in many cases by the third day, although their intensity varied greatly. Mould growth seemed closely linked to high moisture. A mouldy-like odour was

apparent when mould was present. In addition, build up of moisture was observed to be in line with the increasing storage period, particularly after the third day.

The newspaper liners retained their mechanical stability throughout the investigation period. The newspaper liners led to a fairly dry inner bucket surface, suggesting the material's ability to absorb moisture. The wrapping of food wastes was found to be very effective at preventing fungi, moisture, and wastes from being visible.

Cat litter was also another effective moisture absorber, evidenced by its ability to absorb both leachate at the bottom of bucket or condensate on the bucket's lid. However, the cat litter applied at the base of the bucket tended to clump as it absorbed moisture, which made it difficult to remove when emptying the bucket.

4. Discussion

These preliminary odour screening results showed newspaper as an effective odour control method. The crushed cat litter in a teabag-like pouch was also identified as a reliable additive to reduce food waste odour. Even though it was in a pouch, the cat litter's location on top of the bucket seemed to have effectively captured condensing vapour, while its crushed form may have encouraged moisture absorption because of a larger surface area. These experiments cannot indicate the mechanism by which the cat litter pouch reduced odour, but the correspondence between moisture absorption (for both newspaper and top-fitted cat litter) and low odour intensities indicates that moisture volatilization is a key part of odour development.

The comparative study found that EM Bokashi and baking soda were not able to reduce or manage odour emission as effectively as the other treatments and even smelt as bad as the control bucket

most of the time. The malodour observed during the experiment seems to have been a direct result of insufficient removal of water (in vapour or liquid form) from the bucket.

The practicality of the odour control methods will depend not only on their ability to control food waste odour but also on their cost, the cleanliness of the bucket after emptying, the health implications for householders of microbial degradation (eg, mold spores), the ease of use, and the impact on the succeeding waste treatment system.

The use of newspaper in a food waste collection bucket is a cheap and readily available material. A newspaper liner was very easy to apply and buckets were clean after contents were tipped out. The use of newspaper in food waste collections could have implications to an anaerobic digestion or composting system because unshredded newspaper mats together, resisting rotting down. Thus, sample pre-treatment maybe necessary.

These preliminary results indicate that, by absorbing condensate and leachate, the newspaper limited the availability of moisture to the microorganisms. From composting it is well known that the accumulation of water rapidly leads to anaerobic zones, and under anaerobic conditions bacteria form smelling compounds (Haug, 1993). Klammer and Insam (2002) observed a reduced odour emission when food waste dried partly during storage.

The impact of moisture on odour intensity could be tied with mould production. Klammer and Insam (2002) found that the storage method had a significant influence on the number of airborne microorganisms near the household biowaste pre-collection systems. Mean numbers of airborne

fungi measured in colony forming units (cfu) were lower when a permeable biodegradable bag was used to keep kitchen waste for fourteen days.

The large number of samples required for these screening experiments meant that more repeatable methods of odour measurement, such as olfactometry (European Community, 2003) were not practical. The use of cruder methodologies leads to issues that merit discussion.

There were difficulties associated with categorising odour intensity based on the scaling technique. First, the numbering of the scale was cut short at 5, which was not high enough to accommodate very intense odour. Second, the scale was not graded enough to represent very slight differences in odour. A ten-point scale would have enabled better representation of the odour differences.

5. Conclusions

A series of laboratory tests were conducted to compare odour control techniques for separated residential food waste under controlled conditions. The similarity of control and experimental results over the various experiments demonstrates an ability to reproduce qualitative odour evaluations under controlled conditions.

The results indicate the importance of moisture absorption to control odours from food waste storage containers. Of the four additives considered, newspaper seemed to be the most effective because of its high moisture absorptive capacity, its ability to wrap the food wastes, and its ability to ensure a dry bottom to the container.

In tests of containers without newspaper as a liner, the best results were obtained with a container using a pouch of crushed cat litter attached to the container's lid. It is unclear how much of the benefit is due to the moisture absorbing character of the material and how much is due to its ability to neutralise odours. Though the teabag pouch was more effective at reducing odour it was not as practical to use as sprinkling of an odour control product on the food waste. The use of the other odour neutralising compounds without newspaper provided little benefit in odour control over a control container.

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References

Bagby, J., and T. Tarnecki, 2001. Testing feasibility of household food residuals diversion. Biocycle, 42: 43-45.

Blackford, C., Greer, G., and J. Young, 1998. Guidelines for Community Odour Assessment. Dept. of Resource Management/Lincoln Environmental, Lincoln University, Lincoln, NZ.

Burton, C. H., Sneath, R. W., Misselbrook, T. H., and Pain, B. F., 1998. The effect of farm scale aerobic treatment of piggery slurry on odour concentration, intensity and offensiveness. J. Agric. Engng. Res., 71: 203-211.

Cascadia Consulting Group, Inc., 2001. Seattle Food Waste Collection Pilot Project: Final Report. Cascadia Consulting Group, Seattle.

European Community, 2003, Determination of odour concentration by dynamic olfactometry, Standard EN 13725.

Farrell, M., 2001. Evaluating residential organics collection pilot. Biocycle, 42: 34-37.

Gies, G., 1996. Residential organics diversion strategies. Biocycle, 37: 90-93.

Haug, R. T., 1993. The Practical Handbook of Compost Engineering. Lewis Publishers, Boca Raton, FL.

Higa, T., 1997. Composition and Process for Deodorising an Odour. US Patent No. 5 683 664. Available From: <http://www.uspto.gov> accessed August 2006.

Klammer, M. S., and H. Insam, 2002. Are There Weight Reductions and Hygienic Benefits Through The Ventilated Biomat-Combi-System And Mater-Bi Biobags? University Of Innsbruck, Innsbruck. Available from: <http://www.biobags.co.uk/technical/ventilated_systems.pdf> accessed August 2006

Nicolas, J., Craffe, F., and Romain, A. C., 2006. Estimation of odor emission rate from landfill areas using the sniffing team method. Waste Management, 26: 1259-1269

O'Neill, D. H., and Phillips, V. R., 1991. A review of the control of odour nuisance from livestock buildings: Part 1, Influence of the techniques for managing waste within the building. J. Agric. Engng Res., 50: 1-10.

Otto, E. R., Yokoyama, M., Hengemuehle, S., Bermuth, R. D. V, Kempen, T. V., and Trottier, N. L., 2003. Ammonia, volatile fatty acids, phenolics, and odor offensiveness in manure from growing pigs fed diets reduced in protein concentration. J. Anim. Sci., 81: 1754-1763.

Shin, H.S., Han, S.K., Song, Y.C. and E. J. Hwan, 2000. Biogasification of food residuals. Biocycle, 41: 82-86.

Steuteville, R., and K. May, 1996. Examining residential organics diversion. Biocycle, 37: 30-33.

Viana, E., and H. E. Schulz, 2003. Collection, processing and characterization of food residues from residential waste for use in broiler chicken feed. J. Solid Waste Technol. Manag., 29: 24-30.

Table 1. Composition of food waste (and wet weight percentages) used for all tests.

Item	**Percentage (%)**
Cooked rice	7.0
Teabags (total of 5 bags)	2.6
Spaghetti leftover (made of pasta, tomato puree, mixed vegetable, minced beef, oregano, salt)	5.0
Mashed potato (contains potato, butter, milk, salt)	5.0
Potato skin	4.0
Mixed vegetable (stir fry asparagus, cauliflower, peas, carrots, onions and corn)	4.0
Carrot skin	0.5
Apple skin	1.5
Apple core	1.5
Bread	3.0
Orange peel	7.0
Chicken bone (raw)	8.0
Chicken skin (raw)	4.0
Broccoli stalk (raw)	6.6
Pumpkin skin	3.5
Pumpkin seed	2.0
Salad (cut lettuce, carrot, tomato; boiled potato and mayonnaise)	12.5
Eggshells (total of 10 eggs)	4.0
Coffee ground and filter (one filtered coffee only)	4.5
Banana skin	8.5
Boiled pumpkin	5.4
Total	100.0

Table 2. Scale odour intensity description *(source: Blackford et. al., 1998)*.

Score	General classification	Possible descriptors
0	No odour	Odour not detectable; no noticeable/distinguishable odours; undetectable; none.
1	Very light odour	Activates the sense of smell; characteristics may not be distinguishable; slight, occasional wafts; faint, intermittent odour; odour recognisable to those who know its source; trace or hint of odour; odour caught momentarily; odour disappears when attention focused on it; odour at the detection threshold.
2	Light odour	Distinguishable and definite; not necessarily objectionable for short durations; recognition threshold; slight but constant odour; aware of odour occasionally during day; noticeable odour; distinct odour--one can deliberately sniff and detect at will.
3	Moderate odour	Easily activates the sense of smell; very distinct and clearly distinguishable; odour may tend to be objectionable and/or irriating; moderate but frequent odour; frequently noticeable; very noticeable.
4	Strong odour	Objectionable; odour would cause a person to avoid it completely; odour could possibly produce physiological effects during prolonged exposure; unpleasant odours; frequently strong; continuously noticeable; focuses itself on one's attention.
5	Very strong odour	Odour so strong it is overpowering and intolerable for any length of time; odour could easily produce some physiological effects; putrid; offensive; overwhelming; overpowering; intolerable to the point

		that one is physically sickened or forced to seek relief.

Table 3. Relative odour intensities recorded for 16 buckets tested in four batches with two kilograms each of controlled food waste.

		Odour Intensity				
Batch	Description of Test Conditions	Day 1	Day 3	Day 7	Day 10	Day 14
1	Newspaper-lined bucket cleared on day one	0				
1	Newspaper-lined bucket cleared on day three		0			
1	Newspaper-lined bucket cleared on day seven			3		
1	Newspaper-lined bucket cleared on day ten				3	
1	Newspaper-lined bucket cleared on day fourteen					4
1	Control	0	1	3	5	5
2	Uncrushed cat litter at the bottom of the bucket	2	3	3	4	4
2	Uncrushed cat litter both at the bottom and on top of the bucket	1	2	3	4	4
2*	Uncrushed cat litter on top of the bucket	0	1	2	3	4
2*	Crushed cat litter on top of the bucket	0	1	1	3	3
2	Control	1	3	4	5	5
3	Baking soda stuck on the lid and cat litter at the bottom of bucket	1	1	2	3	4
3	Baking soda stuck on the lid and the bucket lined with newspaper	1	1	1	2	3
3*	Baking soda stuck on the lid	1	2	3	3	4
3	Control	1	3	3	4	5
4*	EM Bokashi sprinkled on food wastes	1	2	3	4	4
4*	EM Bokashi sprinkled on food wastes and wrapped with newspaper	0	1	2	3	3
4	Crushed cat litter sprinkled on food wastes	1	2	4	4	4
4*	Baking soda sprinkled on food wastes	1	2	4	4	4
4	Control	1	3	4	4	5

* The test conditions chosen for further investigations with additional results in Table 4.

Table 4. Relative odour intensities recorded for 9 buckets under various test conditions tested as one batch with two kilograms each of controlled food waste.

	Odour Intensity			
Description of Test Conditions	Day 1	Day 3	Day 7	Day 9
Bucket lined with newspaper and sprinkled with EM Bokashi	0	0	0	2
Bucket lined with newspaper and crushed cat litter stuck on the lid	0	0	0	1
Bucket lined with newspaper and sprinkled with baking soda	0	0	0	2
Crushed cat litter stuck on the lid	1	2	3	3
Baking soda stuck on the lid	1	3	3	4
Baking soda sprinkled on food wastes	1	3	4	5
Uncrushed cat litter stuck on the lid	1	2	3	4
EM Bokashi sprinkled on food wastes	1	3	4	4
Control	1	3	4	5

Figure 1. Visual observation of food waste subjected to various treatments during the comparative experiment. All treatments with same wastes placed in buckets in same order. Odour intensities given in Table 4.

Description	Day 1	Day 9
Bucket lined with newspaper and sprinkled with EM Bokashi		
Bucket lined with newspaper and crushed cat litter on the lid		
Bucket lined with newspaper and sprinkled with baking soda		
Crushed cat litter stuck on the lid		
Baking soda stuck on the lid	n/a	
Baking soda sprinkled on food wastes		
Uncrushed cat litter stuck on the lid		
EM Bokashi sprinkled on food wastes		
Control