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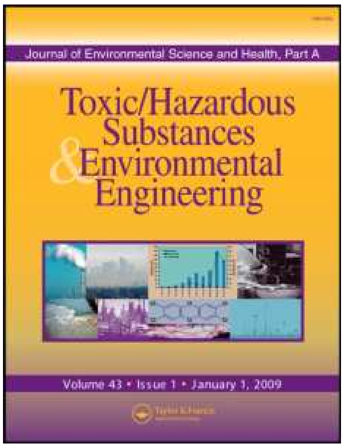


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# The role of feed composition on the composting process. II. Effect on the release of volatile organic compounds and odours

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# THE ROLE OF FEED COMPOSITION ON THE COMPOSTING PROCESS. II. EFFECT ON THE RELEASE OF VOLATILE ORGANIC COMPOUNDS AND ODOURS*

Key Words: Composting, organic material, volatile organic compounds (VOCs), odours, emissions

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## ABSTRACT

In this study the influence of four specific feed materials: grass clippings, leaves, cabbage and soya bean meal on odours and VOCs has been studied in a controlled and systematic manner using a commercial feed material in laboratory composters. The results of this study suggest that while some feeds can be composted with the minimum of problems, high levels of specific feeds could be problematic. Based upon the results obtained with the four feeds examined the following general observation can be made: Grass can be satisfactorily incorporated into compost feed at levels up to about 10% without adversely

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effecting odour emissions or VOC releases. At higher grass levels odours could start to become a problem. High levels of leaves, up to at least 30%, appear to have no detrimental impact on odours or VOC releases. While low levels of cabbage may be acceptable (less than 10%), higher levels can give rise to high emissions of sulphur compounds and result in serious odour problems. It appears that high nitrogen containing materials, when present in large amounts, can lead to serious odour problems associated with anaerobic activity. The presence of ammonia in the VOCs is a clear indication of excessive levels of nitrogen in the compost feed.

## INTRODUCTION

While composting is being widely embraced as an integral component of solid waste management [Glenn 1997, Antler 1997], several large composting facilities in North America have had to close due to odour problems. While the key parameters for good composting are well recognized by the majority of the commercial composting operators, feed variations can introduce challenges that need to be met. Over the years a wide range of organic waste materials have been subjected to the composting process including: lignin materials, agricultural wastes, grass, sludges, yard wastes, food wastes, paper products etc. Many of these feed materials bring their own challenges to the composting process and acceptable procedures need to be developed if they are to be successfully processed at a commercial operation. The composition of the starting material can influence not only the composting process and the quality of the compost produced, but also the volatiles released during the composting process.

In the first paper in this series (Shaw et al., 1998) the role of feed composition on the compostability of the organic fraction of municipal solid waste as well as the quality of the composted product was investigated. The four feed augmentations studied were: grass clippings, leaves, cabbage and soya bean meal. In this paper the effect of these feed amendments on the emissions of odour and volatile organic compounds (VOCs) is reported.

## EXPERIMENTAL

### Materials

The basic organic feed material used in this study was obtained from CORCAN's commercial composting facility located in Joyceville, Ontario. Details of the composting process were provided in an earlier paper (Day et al. 1998). Table I provides information regarding the composition and characteristics of the basic organic feed material used in this and the previous report (Shaw et al. 1998).

The actual tests conducted in this study involved taking this freshly mixed basic feed material and adding one of the following amendments: fresh grass clippings, leaves (principally sugar maple), fresh cabbage and soya bean meal at weight loadings of 0%, 10%, 20% and 30%. The chemical and physical characteristics of the feed augmentations and resulting feed mixtures were presented in detail in the previous paper (Shaw et al. 1998).

### The Laboratory Composting System

All the composting experiments were conducted using a laboratory composting system, which has been, described in detail elsewhere (Day et al.

**TABLE 1**
**Composition and Characteristics of Basic Compost Feed Composition**

| | |
|---|---|
| Composition (%wt) | |
| Food Waste | 32 |
| Manure | 25 |
| Recyclate | 20 |
| Wood Chips | 15 |
| Paper Products | 8 |
| Physical Properties | |
| Moisture (%) | 65.7 ± 1.5 |
| Bulk Density ($g/cm^3$) | 0.66 ± 0.08 |
| Air Voids (%) | 39.1 ± 8.6 |
| Chemical Composition | |
| C (%) | 42.3 ± 2.1 |
| N (%) | 1.99 ± 0.18 |
| C/N Ratio | 21.4 ± 2.2 |

1997). Essentially each unit is 5 litres in size and they are located in a room maintained at 35 ± 1°C to minimize heat loss. The temperatures of each unit along with the concentrations of $CO_2$ and $O_2$ in the exit gases are continually monitored with the data being logged on a PC data system operating under LABVIEW software control. Figure 1 provides a general overview of the system.

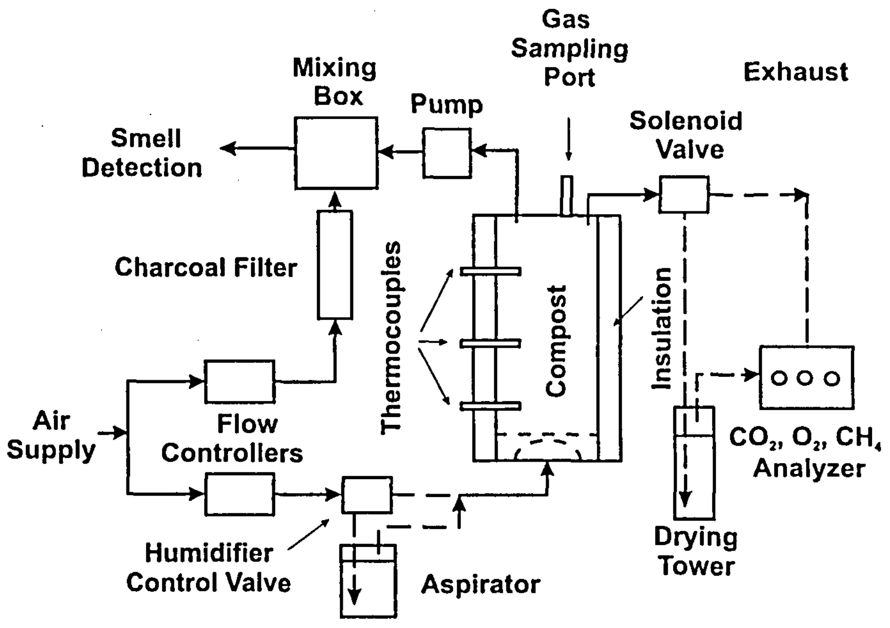


FIGURE 1
Schematic of the laboratory composting system

Odour Analysis

Odour emission levels from the laboratory composters were obtained by dilution to threshold measurements of the exhaust gas (Haug 1993). The approach that we took in this study involved supplying the exit gas from the laboratory composters at a constant flow rate of 30 ml/min. From this stream aliquots of 1-30 ml/min were directed into a continuous trace vapour source (Krzymien and Elias 1976) where it was diluted with a stream of pure air flowing at a rate of 5 to 20 l/min. An outline of this experimental set-up is presented in Figure 2. The resulting diluted gas was then presented to a panel of at least 6 subjects who were asked to discriminate between the diluted gas and a blank. By adjusting the flow rates the dilution to threshold (D/T) value was determined.

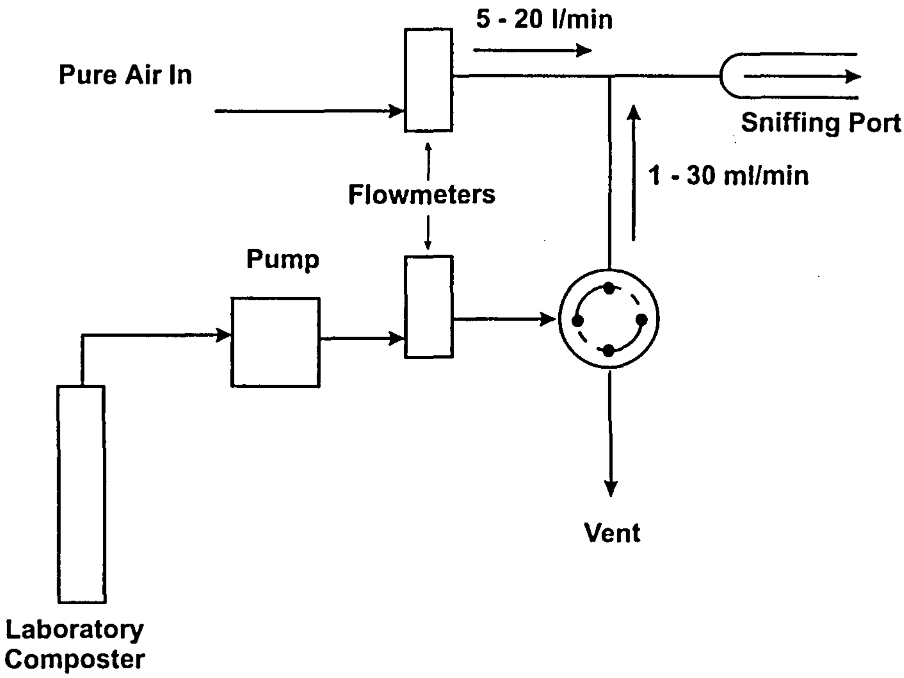


FIGURE 2
Schematic of the gas dilution system used in the odour evaluations

Chemical Composition

In addition to monitoring the exit gas for odours, samples were taken to determine the volatile organic compounds (VOCs) produced. These samples were collected using a special 76 mm x 6 mm I.D. Pyrex glass cartridges containing Carbotrap 20/40 (Supelco, Mississauga, Ontario). A sampling rate of 50 ml/min was employed for a 5-minute period. These tubes were then analyzed by thermal desorption GC/MS utilizing a modified injection port of a HP5790 gas chromatograph (Krzymien 1985) which thermally desorbs and cryogenically focuses the VOCs prior to analysis. A DB-1701 (J&W Scientific, Folsom, California) 30 m x 0.32 mm I.D., $d_f$ = 1 μm capillary column was used with helium as the carrier gas for the separation. The GC oven was temperature programmed from -20°C to 180°C at a rate of 5°C/min after a 3.5 min hold at -20°C. The separated compounds were detected by a HP 5970A Mass Selective Detector (MSD) operated in a scan mode at a mass range of 20-200 Daltons. The total ion chromatogram peaks were identified using a Probability Based Matching (PBM) search and retrieve algorithm and NBS REVF spectral library.

## RESULTS & DISCUSSION

The influence of the various feed augmentations on the compost process and the quality of the compost produced were presented in part I (Shaw et al. 1998). The conclusions reached can be summarized as follows: Grass augmentation levels up to 30% appear to have little effect upon the composting process or the characteristics of the final compost material. However, the high moisture content of the grass may cause aeration problems unless additional bulking agents are employed. The high nitrogen content of the grass can promote respiration rates. The compostability of leaves are not as great as those of the basic control feed material and hence some reduction in respiration rate can be expected as the concentration of leaves in the feed increases. The addition of high levels of cabbage to the feed resulted in high moisture levels, and low air porosity of the system. However, despite these problems compost activity as measured by respiration rates remained unaffected. Soya bean meal augmentation increased the nutrient level and enhanced composting activity. The 30% augmentation level was felt to be too high and resulted in anaerobic conditions.

Odour Measurements

Prior to reporting the results of the augmentation effects of the individual components on the odour measurements it is worthwhile to look at the results obtained with the basic control feed materials used in each study. This data is presented in Figure 3. These plots represent the odour D/T values measured for the four basic control feed materials used in each of the four augmentation studies. From this data it can be seen that the control samples showed similar odour characteristics. In all four cases the highest odour levels were measured in the first few days of the composting in the laboratory composters. The odour levels then, rapidly decreased to reach a relatively constant value. Although the odour profiles from the four basic control feed materials were very similar, it was noted however, that the initial (2 day) reading from the leaves study was lower than those observed in the other augmentation studies. Also the odour from the basic control feed material used in the soya bean experiments after 5 days was a little higher than those noted for the others. While these measurements suggest some variability in the basic control feed materials used in each study, it is not excessive considering that the samples were collected at one week intervals. Thus, while their compositions were very similar they were not identical.

The influence of grass on the measured odour levels is summarized in Figure 4. The augmentation of grass to the basic control feed material at a level of 10% appears to have a beneficial effect on reducing odour levels through the whole 12 day laboratory composting process. However, when the grass augmentation levels are raised to 20% and 30% levels, while some improvements

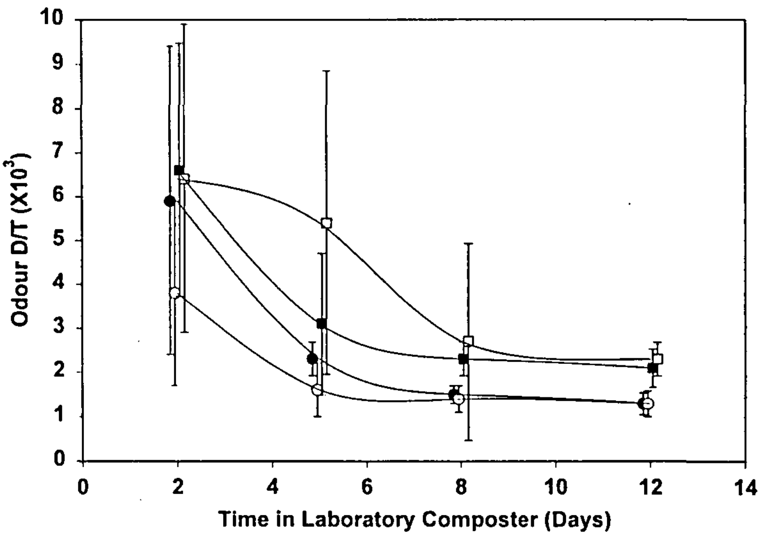


FIGURE 3
Odour values as a function of time in the laboratory composters for the basic feed control materials used in the augmentation studies with grass (●), leaves (○), cabbage (■) and soya bean (□)

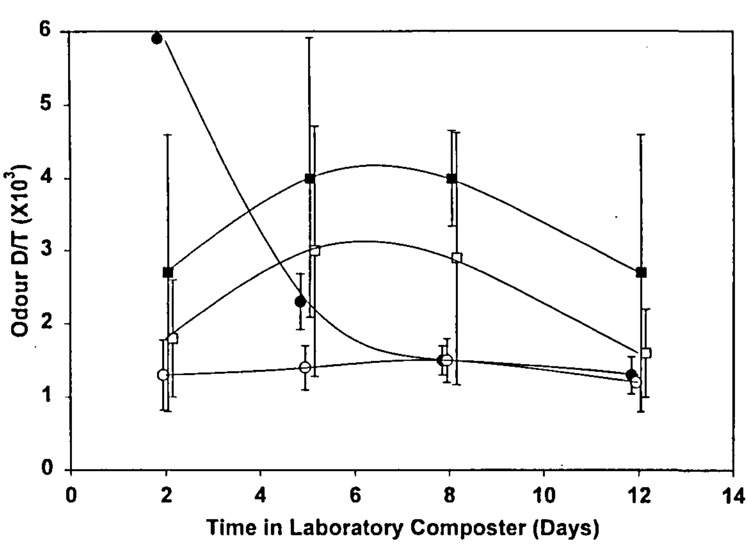


FIGURE 4
Odour values as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (○), 20% (■) and 30% (□) grass.

were noted during the first 2 days of composting, this beneficial effect disappears after 5 and 8 days composting. In effect it appears that grass augmentation at the 20% and 30% levels delays the release of the odours such that the maximum odour levels are now reached after about one week of composting rather than during the first few days. The apparent higher odours level with the 20% grass augmentation over the 30% augmentation appears to be related more to composting activity and higher compost temperatures (72°C at 20%, 67°C at 30%) (Shaw et al. 1998) rather than feed composition.

The role of leaf augmentation on the measured odour levels is presented in Figure 5. Based upon the data presented in this figure it would appear that the augmentation of the basic control feed material with leaves up to a level of 30% has no influence on the odour levels. In effect as was noted in the case of the grass study the presence of leaves in the feed may be responsible for a slight reduction in the initial odour levels based upon the 2 day readings.

Cabbage augmentation was included in this study especially to address odour concerns. Because cabbage is known to release sulphur compounds when it decomposes it is important for the operator of a commercial composting facility to be aware of any potential problems that can be expected if they were to receive a shipment of vegetable wastes containing large quantities of cabbage. The results of the cabbage augmentation study are presented in Figure 6. Once again it would appear that when the first samples were taken for analysis after 2 days the odour levels in all augmented samples were less than those noted with the basic control feed material. However, while the odour level obtained with the

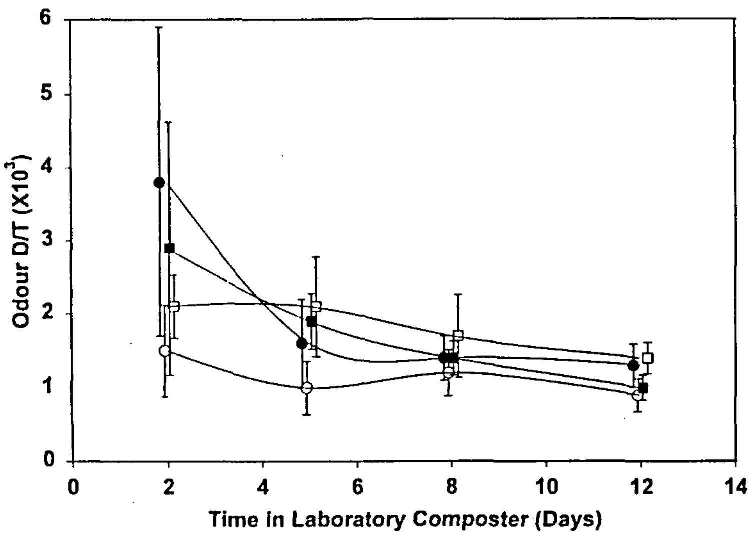


FIGURE 5
Odour values as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (○), 20% (■) and 30% (□) leaves.

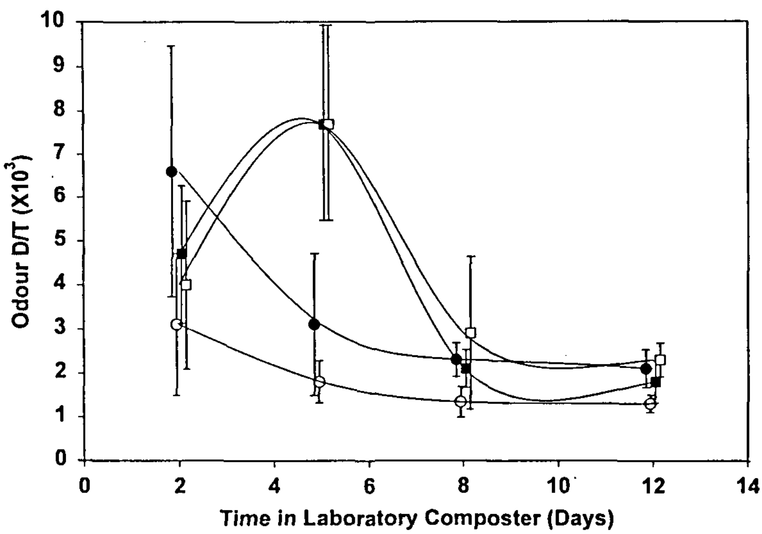


FIGURE 6
Odour values as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (○), 20% (■) and 30% (□) cabbage.

10% cabbage augmentation level remained below those of the control throughout the full 12 day composting period the odour levels measured in the case of the 20% and 30% augmentation samples showed a rapid increase in odour levels. Both the 20% and 30% cabbage augmentation samples reached maximum odour levels after 1 week which were substantially higher than those obtained with the control. However, after reaching high odour level within the first week the odour levels rapidly fell during the second week, such that by the end of the composting period (12 days) the odour levels were comparable to those measured for the control.

The soya bean augmentation study was undertaken, not as a representation of any practical composting situation, but more as a scientific investigation to determine the influence of a high nitrogen feed material on the composting process and odour formation potential. The results of the odour measurement are summarized in Figure 7. From this data it can be seen that the soya bean augmented composting material releases much higher detectable odour levels than materials augmented with grass, leaves or cabbage. However, once again, odour levels for the augmented samples were lower than that of the control after the first 2 days of composting. However, while the odour level for the basic control feed material fell during the remaining composting period, the odour levels for the three soya bean augmented samples increased rapidly over the first week of composting and retained high levels over the second week. There also appeared to be a direct correlation between the level of soya bean in the feed and the odour level as can be seen from the data presented in Figure 8. Although the odour

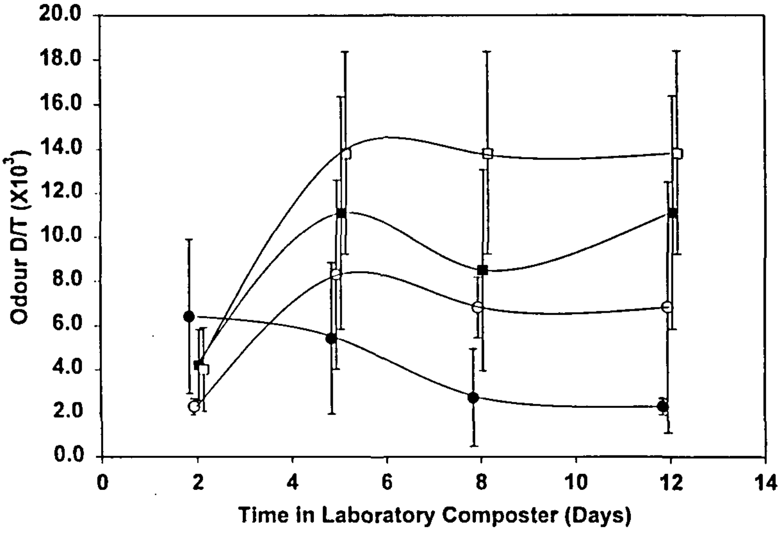


FIGURE 7
Odour values as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (○), 20% (■) and 30% (□) soya bean.

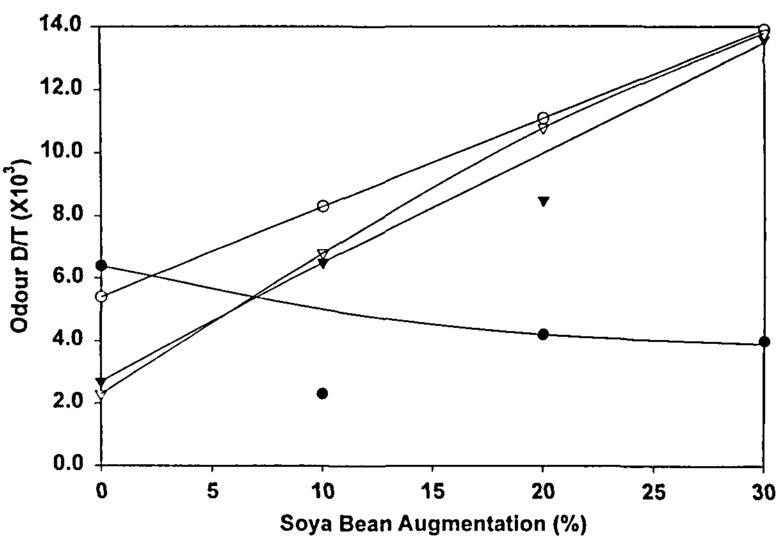


FIGURE 8
Odour values as a function soya bean augmentation for samples tested 2 days (●), 5 days (○), 8 days(■) and 12 days(□) in the laboratory composters.

levels in all tests after 2 days were not appreciable, after 5, 8 and 12 days composting significant odour level increases can be attributed to the increases in soya bean levels. Clearly these results have important consequences for commercial composting operator who could be dealing with feed materials that are high in available nitrogen.

Volatile Organics

In a previous study the types of volatile organic compounds (VOCs) measured in the volatiles released from a commercial composting operation were presented, along with data regarding the types of changes that can be anticipated during a typical composting operation (Krzymien et. al. 1998). Table 2 presents the average composition of the major VOCs detected from the four duplicate control experiments after 2 days of laboratory composting. This shows some interesting information in that the natural products limonene, pinene and camphene are present in relatively high concentrations along with low molecular weight ketones and alcohols. The basic control feed materials also appears to release relatively high levels of dimethyl disulphide.

The chemical compounds identified as components of the compost gas have been grouped according to chemical composition into essentially six types:

A oxygenated compounds (aldehydes, ketones, alcohols, acids, esters etc.)

B nitrogen compounds (amines, nitriles etc.)

C sulphur compounds (mecaptans, sulphides etc.)

D alkane hydrocarbons (pentane, hexane etc.)

E alicyclic hydrocarbons and natural products (terpenes, bicyclo compounds etc.)

**TABLE 2**
**VOCs Released from Control Samples**

| Ret. Time (min.) | Compound | Average Area % | Fit |
|---|---|---|---|
| 32.319 | Limonene | 12.05 | 81 |
| 17.514 | 2-Butanone | 11.93 | 48 |
| 18.547 | 1,2-Propanediol | 11.18 | 70 |
| 31.388 | .alpha.Pinene | 8.33 | 88 |
| 30.352 | .beta.-Pinene | 7.90 | 89 |
| 18.318 | 2-Butanol | 5.06 | 85 |
| 29.154 | Camphene | 4.03 | 87 |
| 22.569 | Disulfide, dimethyl | 3.04 | 94 |
| 11.630 | 3-Butadiene, 2-methyl- | 2.85 | 87 |
| 22.872 | Benzene, methyl- | 2.59 | 74 |
| 29.397 | 2-Hexanone, 4-methyl- | 2.47 | 79 |
| 21.142 | Butane, 2,3-dimethyl- | 2.04 | 56 |
| 21.409 | 3-Pentanone | 1.91 | 59 |
| 13.899 | Pentane, 3-methyl- | 1.52 | 32 |
| 19.843 | 2-Butanone, 3-methyl- | 1.23 | 67 |
| 10.090 | 1 ,3-Pentadiene | 1.14 | 88 |
| 18.679 | Butenol, methyl- | 1.06 | 58 |
| 25.412 | 2-Pentanone, 3-methyl- | 1.03 | 71 |
| 31.917 | 1,3-Cyclohexadiene, 1-methyl-4-(1-methylethyl)- | 0.94 | 94 |
| 30.801 | .beta.-Myrcene | 0.80 | 64 |
| 32.878 | Benzene, methyl(1-methylethyl)- | 0.68 | 89 |
| 34.413 | Cyclohexene, 1-methyl-4-(1-methylethylidene)- | 0.66 | 84 |
| 10.098 | Butane, 2-methyl- | 0.62 | 38 |
| 28.589 | Bicyclo[4.2.0]octa-1,3,5-trienne | 0.61 | 66 |
| 33.390 | Tricyclo[2.2.1.02,6]heptane, 1,7,7-trimethy-l- | 0.58 | 79 |
| 12.675 | Methane, thiobis- | 0.53 | 84 |
| 10.769 | Pentane | 0.41 | 93 |
| 16.305 | Furan, 2-methyl- | 0.40 | 93 |
| 22.137 | Hexane, 2,4-dimethyl- | 0.31 | 46 |
| 16.458 | Cyclohexane | 0.28 | 69 |
| 32.623 | Bicyclo[3.1.0]hex-2-ene, 4-methyl-1-(1-methylethyl)- | 0.27 | 77 |
| 19.936 | Furan, 2,5-dimethyl- | 0.24 | 60 |
| 19.642 | 1-Propanol, 2-methyl- | 0.23 | 89 |
| 16.365 | 2-Hexyne | 0.22 | 70 |
| 17.901 | Heptane | 0.22 | 89 |
| 13.442 | 2-Propanone | 0.21 | 71 |
| 30.162 | Disulfide, methyl propyl- | 0.20 | 89 |
| 20.422 | Propane, 1-(methylthio)- | 0.18 | 87 |

F aromatic compounds

Using this classification scheme the products listed in table 2, breakdown to: A = 38.26%; B = 0.34%; C = 3.39%; D = 9.49%; E = 41.89% and F = 6.63%.

Prior to the analysis of the influence of the individual augmentations, it appears worthwhile to investigate the variability in the total VOC emissions from the four basic control feed materials used in each augmentation study. The total VOC emissions from these control experiments as a function of composting time are presented in Figure 9. From this data it would appear that much larger quantities of VOCs are released from the soya bean control experiments than from the controls used in the grass, leaves and cabbage augmentation studies. This might, once again, be a result of changes in the composition of the basic control feed materials used in each study. Consequently comparisons between different experimental sets should be undertaken with care. The composition of VOCs from the basic control feed material is presented in Table 3. From this data it can be seen in this composition that there is a certain amount of variability between the measured VOCs species from the different control experiments. This once again suggests that while comparisons may be made within one experimental set, comparisons between experimental data sets should be made with care.

The total release of VOCs from the feed materials augmented with grass at 10%, 20% and 30% levels is presented in Figure 10. Analysis of this data suggests that the highest VOC levels are measured after 2 days in the composter, after which the levels rapidly fall off. It also appears that the VOC levels from the basic control feed material and the grass augmentation samples are very similar.

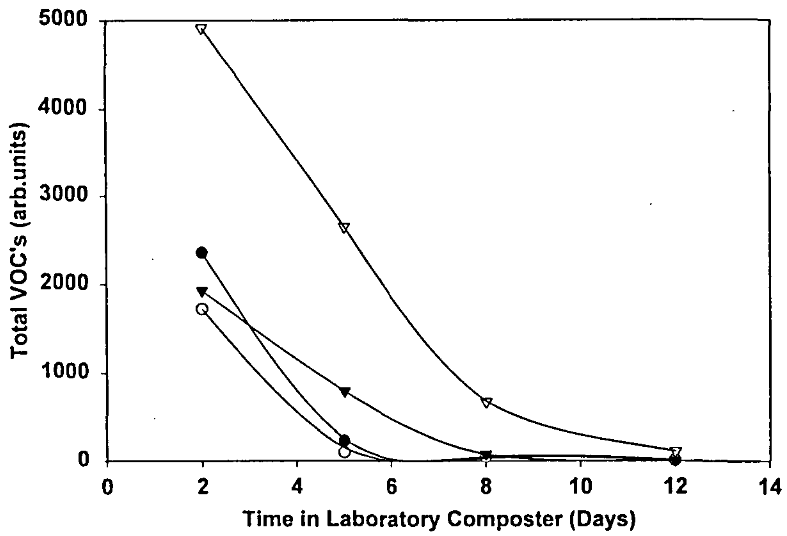


FIGURE 9
Total VOCs released as a function of time in the laboratory composters for the basic feed control materials used in the augmentation studies with grass (●), leaves (O), cabbage (■) and soya bean (□)

**TABLE 3**
**VOC Product Distribution for the Control Samples as measured after 2 Days of Composting in the Laboratory Composters**

| Aug. Study | O Comp. | N Comp. | S Comp. | Alkanes | Nat. Prods. | Aromatics | Total VOCs |
|---|---|---|---|---|---|---|---|
| Grass | 462 | 23 | 254 | 487 | 566 | 566 | 2358 |
| Leaves | 411 | 15 | 75 | 246 | 945 | 33 | 1725 |
| Cabbage | 1028 | 0 | 7 | 128 | 744 | 24 | 1931 |
| Soya Bean | 762 | 0 | 17 | 201 | 3916 | 19 | 4915 |
| Average | 666 | 10 | 88 | 266 | 1543 | 161 | 2732 |

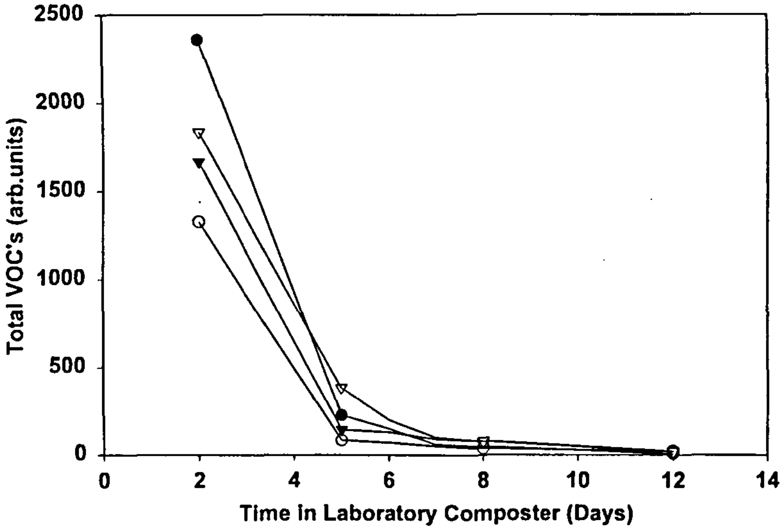


FIGURE 10
Total VOCs released as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (O), 20% (■) and 30% (□) grass.

Table 4 presents the distribution of the six types of compounds in the compost gas from these samples measured after 2 days in the laboratory composter.

This data shows a large amount of scatter, which makes it difficult to determine definitive trends that may be attributable to the role of the grass additions. However in a general sense it would appear that grass augmentation may be responsible for increases in the volatile oxygenated compounds and alkanes while the aromatics and sulphur compounds are reduced. In terms of a link between the VOCs and odours (Figures 10 and 4) it would appear that while the curves for the control are very similar, the curves for the odours and VOCs obtained with the 20% and 30% grass augmentations samples failed to show any correlations. However, a detailed analysis of the VOCs produced from the 20%

**TABLE 4**
**VOC Product Distribution for the Grass Augmented Samples as measured after 2 Days of Composting in the Laboratory Composters**

| % Grass | O Comp. | N Comp. | S Comp. | Alkanes | Nat Prods. | Aromatics | Total |
|---|---|---|---|---|---|---|---|
| 0 | 462 | 23 | 254 | 487 | 566 | 566 | 2358 |
| 10 | 993 | 0 | 23 | 291 | 9 | 11 | 1337 |
| 20 | 1228 | 0 | 83 | 327 | 0 | 9 | 1667 |
| 30 | 586 | 0 | 47 | 657 | 418 | 127 | 1738 |

and 30% grass augmented samples after 5 days of composting did reveal relatively high levels of dimethyl disulphide, which could be the cause of the higher odour levels associated with these two samples as noted in Figure 4.

The total VOCs released from the leaf augmented tests are presented in Figure 11. From this series of experiments it is quite clear that the addition of leaves to the basic control feed material causes significant reductions in the VOCs released. This data is very much in agreement with the composting activity associated with the addition of leaves to the control feed material as noted in part I (Shaw et. al. 1998). This VOC data would explain why the addition of leaves up to a level of 30% would have no influence on the odour levels as noted in Figure 5. The types of VOCs evolved are presented in Table 5. From this data it is difficult to establish distinctive changes in composition that can be attributed to the leaves augmentation.

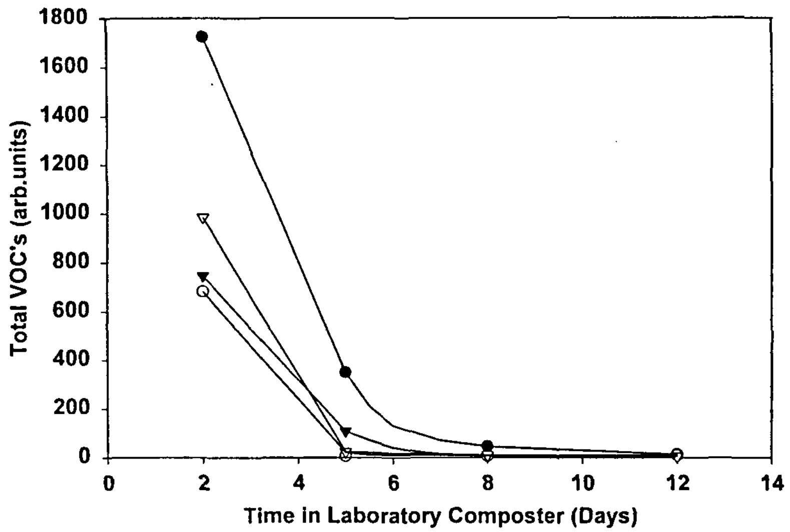


FIGURE 11
Total VOCs released as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (○), 20% (■) and 30% (□) leaves.

**TABLE 5**
**VOC Product Distribution for the Leaves Augmented Samples as measured after 2 Days of Composting in the Laboratory Composters**

| % Leaves | O Comp. | N Comp. | S Comp. | Alkanes | Nat Prods. | Aromatics | Total |
|---|---|---|---|---|---|---|---|
| 0 | 411 | 15 | 75 | 246 | 945 | 33 | 1725 |
| 10 | 567 | 0 | 0 | 57 | 58 | 0 | 692 |
| 20 | 250 | 37 | 8 | 159 | 262 | 30 | 766 |
| 30 | 238 | 10 | 8 | 271 | 435 | 22 | 1014 |

The cabbage augmentation series was, as already mentioned, conducted to investigate the role of a sulphurous material on odour formation. The odour data has already shown that the addition of cabbage to the control feed material results in higher odours levels when present at levels of 20% and 30% (Figure 6). These higher odour levels can be seen to be linked in part to the higher VOCs levels released when cabbage is added to the control feed material as is shown by the data in Figure 12. In terms of VOCs levels these are highest after 2 days in the composter rather than 5 days as indicated by the odour measurements (Figure 6). However, once again the composition of the VOCs needs to be taken into consideration and this data is presented in Table 6. This data suggests that in the case of cabbage augmented samples the increased levels of VOCs are principally due to the increased quantities of oxygenated compounds being produced as the weight of cabbage in the feed is increased. The quantities of the nitrogen and sulphurous compounds are also increasing with increased cabbage content. Meanwhile the alkanes, natural products and aromatics appear to be unaffected by the cabbage content. However, the important role that cabbage plays in the release of potentially offensive odours, can be appreciated by considering Figure 13. This graph presents the area for all measured sulphurous compounds in samples taken from the cabbage augmentation experiments. These emission values correspond to the maximum values obtained during the laboratory composting period. In the case of the 0% and 10% augmentation levels these values were recorded after 2 days of composting. The values for the 20% and 30% augmentation levels were recorded after 5 days of composting. Clearly there

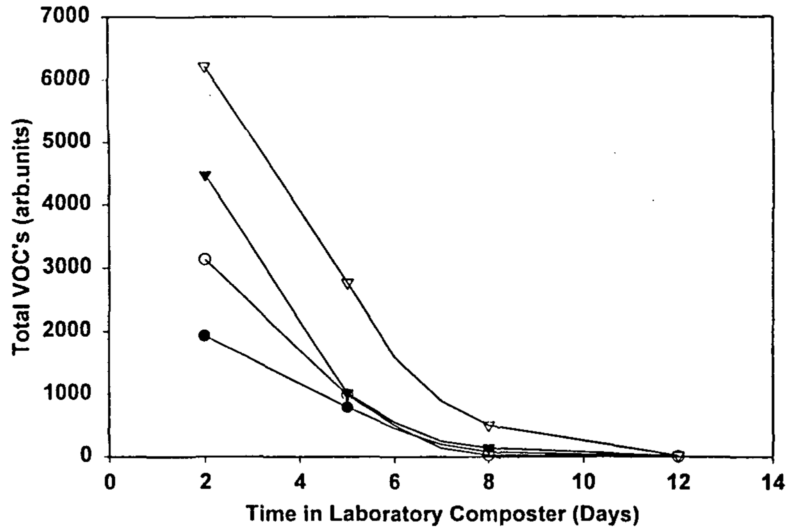


FIGURE 12
Total VOCs released as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (○), 20% (■) and 30% (□) cabbage.

**TABLE 6**
**VOC Product Distribution for the Cabbage Augmented Samples as measured after 2 Days of Composting in the Laboratory Composters**

| % Cabbage | O Comp. | N Comp. | S Comp. | Alkanes | Nat. Prods. | Aromatics | Total |
|---|---|---|---|---|---|---|---|
| 0 | 1028 | 0 | 7 | 128 | 744 | 24 | 1931 |
| 10 | 2796 | 0 | 18 | 28 | 280 | 10 | 3142 |
| 20 | 3721 | 157 | 78 | 33 | 472 | 14 | 4495 |
| 30 | 5150 | 64 | 153 | 278 | 561 | 7 | 6243 |

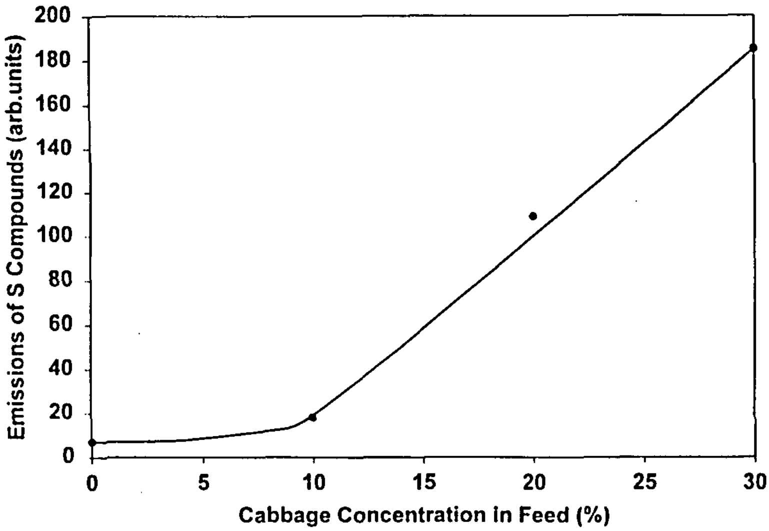


FIGURE 13
Maximum Emissions of sulphur compound during the laboratory composting period as a function of the concentration of cabbage in the feed.

is a link between the quantity of cabbage in the compost, the levels of sulphurous compounds released and the odours produced. While it would appear that a 10% cabbage augmentation level may be acceptable it appears evident that higher levels of cabbage could well be troublesome from an odour perspective.

The total yield of VOCs from the soya bean augmentation studies are presented in Figure 14. From this figure it is clear that once again the VOC yields are highest after 2 days of composting when the composting activity is close to its peak. Moreover, the addition of soya bean to the basic control feed material increases the total VOC yield at all time intervals for which measurements were taken. However, while the VOCs levels are highest after 2 days of composting (Figure 14), the odour levels, for the soya bean augmented samples are highest

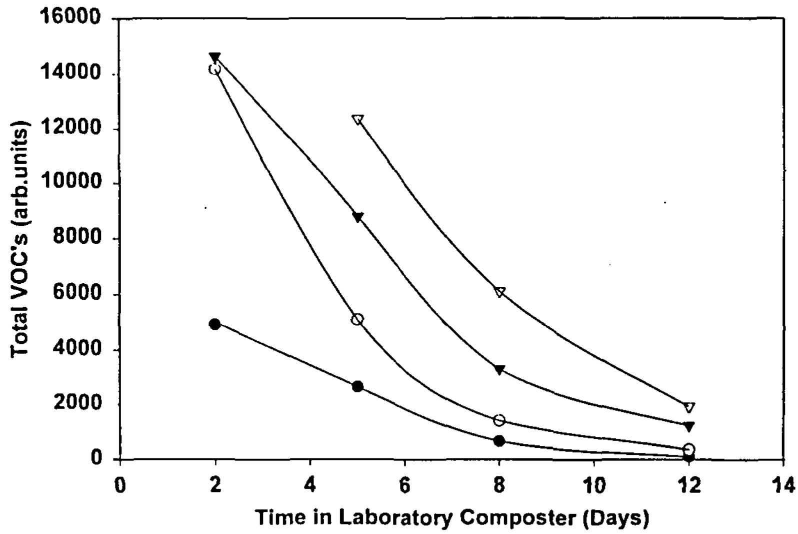


FIGURE 14
Total VOCs released as a function of time in the laboratory composters for test samples augmented with 0% (●), 10% (○), 20% (■) and 30% (□) soya bean.

after 5 days of composting (Figure 7) and appear to retain these high odour levels during the remaining composting period. To explain this apparent abnormality it is necessary to examine the composition of the VOCs which is shown in Table 7. From this data it would appear that the high odour levels are associated with the large increases in the oxygenated compounds and natural products which show significant increases with the level of soya bean in the compost. However, an additional explanation for the higher odour levels is the amount of ammonia in the exit gases. Figure 15 provides data on the ammonia concentrations in the exit gases as a function of composting time. Clearly high soya bean levels in the basic control feed material are responsible for high ammonia levels in the gases released, which increase with composting time. A combination of effects are

**TABLE 7**
**VOC Product Distribution for the Soya Bean Augmented Samples**
**As measured after 2 Days of Composting in the Laboratory Composters**

| % Soya Bean | O Comp. | N Comp. | S Comp. | Alkanes | Nat Prods. | Aromatics | Total |
|---|---|---|---|---|---|---|---|
| 0 | 762 | 0 | 17 | 201 | 3916 | 19 | 4915 |
| 10 | 4324 | 0 | 29 | 1360 | 8373 | 83 | 14169 |
| 20 | 12064 | 7 | 132 | 348 | 2039 | 43 | 14633 |
| 30 | | | | | | | |

**As measured after 5 Days of Composting in the Laboratory Composters**

| % Soya Bean | O Comp. | N Comp. | S Comp. | Alkanes | Nat Prods. | Aromatics | Total |
|---|---|---|---|---|---|---|---|
| 0 | 59 | 0 | 30 | 111 | 2440 | 4 | 2644 |
| 10 | 1193 | 0 | 38 | 721 | 3086 | 49 | 5087 |
| 20 | 3231 | 0 | 19 | 1605 | 3904 | 31 | 8790 |
| 30 | 7347 | 11 | 95 | 635 | 4241 | 39 | 12368 |

responsible for the formation of odours from nitrogen rich feeds, and while ammonia formation is one of the explanations, other factors could also be contributing.

## CONCLUSIONS

The evaluation of odours by the use of a panel of at least six people, and the measurement of VOCs by GC/MS are two approaches to identify the role of chemical feedstock on composting performance. In part one of this study the role

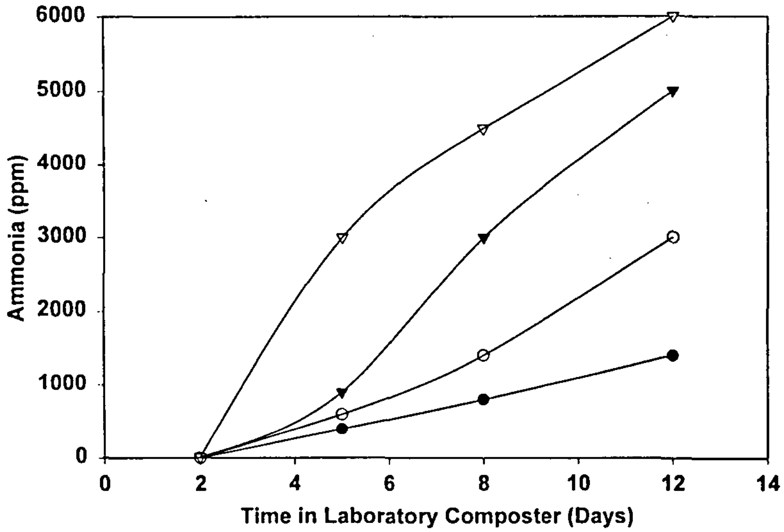


FIGURE 15
Measured concentrations of ammonia in the exit gases from the composters as a function of composting time for test samples augmented with 0% (●), 10% (O), 20% (■) and 30% (□) soya bean.

of four feed augmentation materials: grass, leaves, cabbage and soya bean on the composting process were evaluated. In this study the role of these materials on odours and VOCs have been evaluated. Based upon the results of the current study some additional conclusions can be drawn: The addition of grass to a commercial composting feed can be made up to a level of about 10%, without any adverse effect on odour emissions or VOCs released. When higher levels of grass are employed it is possible that higher odour levels may ensue which could persist for longer periods than would otherwise be anticipated. However, the actual peak odour levels may still be acceptable for most commercial operations, provided sufficient aeration is available to maintain aerobic conditions. The additions of leaves up to levels of 30% were found to have no negative impact on odours or

VOC generation. It would, in effect, appear that the measured quantities of VOCs are reduced by the presence of the leaves within the controlled feed material. Whether this is due to actual absorption of VOC by the leafy matter, reduced VOC releases, or a slight retardation in composting activity (slower respiration, reduced temperatures) is difficult to ascertain. The addition of large quantities of cabbage to a commercial compost feed materials is clearly an area that can cause problems in terms of odours and VOCs. While no major odour problems were noted at the 10% augmentation level, higher quantities clearly lead to serious odour problems due to the release of large quantities of organic sulphides. The quantities of these compounds released increase dramatically with increased cabbage concentrations. The addition of high nitrogen containing materials such as soya bean is also capable of enhancing odour formation and the production of VOCs. While some of the odour problems appear to be associated with the formation of ketones, aldehydes, alcohols and esters, the formation of ammonia is also a major concern. The amounts of ammonia produced are dependent on the level of soya bean augmentation as well as time within the laboratory composter. Based upon the results obtained with the soya bean material it would appear that a balanced C/N feed is essential to help alleviate problems associated with nitrogen rich organic feed materials.

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