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An ASABE Meeting Presentation

Paper Number: 085047

Identification and evaluation of VOCs evolved from warm season swine mortality composts

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Written for presentation at the
2008 ASABE Annual International Meeting
Sponsored by ASABE
Rhode Island Convention Center
Providence, Rhode Island
June 29 – July 2, 2008

***Abstract*.** The intensive production of swine in Iowa (28.4 % of the U.S.A production) inevitably results in high amounts of piggery waste including animal carcasses. Composting is an environmentally sound and relatively inexpensive method to dispose swine mortalities especially when the carcasses are diseased. Measurement of VOC emissions is an alternative to test progress and completion of the process. In this study, diseased swine mortalities are composted in summer conditions of Central Iowa. Corn silage, oat straw and corn stalks are used as envelope materials. Once a week, air samples are collected from the center of test units and sampled with 85 μm Carboxen/ polydimethylsiloxane (CAR/PDMS) solid phase microextraction (SPME) fiber. Samples were analyzed using gas chromatography (GC) - mass spectrometry (MS). The objective of the study is to investigate the potential usage of VOCs as indicators of swine mortality degradation. It is found that nitrogen and sulfur containing compounds can be used as indicators of the composting process. Sulfur-containing compounds are detected from all test units. Nitrogen-containing compounds are detected from only corn silage test units. It is concluded that carcass degradation is incomplete in all of the test units. Carcass degradation in corn stalks and oat straw test units is better than corn silage test units. These results are supported with respiration rate results. Respiration rates of the remaining swine carcasses are found to be between 5-7 mg CO_2-C g $VS^{-1}d^{-1}$ and swine carcasses are categorized as moderately unstable composts.

Keywords. Compost, GC-MS, SPME, swine mortality, VOC

Introduction

Iowa has led the US in swine production and pig inventory for one hundred twenty years (Honeyman and Duffy, 2006). In 2005, Iowa produced 28.4% (8 billion pounds) of all the swine in the U.S (Iowa Agricultural Statistics Bulletin). This intensive production of swine in one area inevitably results in production of high amount of piggery waste including animal carcasses. Animal carcasses, like all animal waste, contain useful nutrients which can be recycled into agricultural land. However, this recycling must be done in an environmentally sound, economically feasible and socially acceptable manner especially when carcasses are capable of spreading diseases in soil, plants, animals and humans (Imbeah, 1998, Kalbasi et al., 2005). Methods for disposal of swine carcasses include burial, incineration, rendering and composting. Burial pits cause concerns including the decline in ground water quality where pigs are located and residue remaining in pits after years of use (Blake, J.P., 2004). Incineration uses forced air combustion, petroleum fuel and an insulated fire box to achieve the high temperatures needed to burn diseased carcasses without producing serious air pollution. In the event of widespread animal disease, the unavailability of these equipments and high costs of burning can limit use of this method (Glanville, 2006). Rendering carcasses into a protein by-product is an alternative in the U.S., but the spread of pathogenic microorganisms during pickup and transportation to a rendering facility threads human and environmental health. On the other hand, composting is environmentally sound and relatively inexpensive (Blake, 2004). Properly designed composting operation will operate in all seasons and handle daily management of mortalities on farms as well as carcass disposal in emergency animal disease outbreak (Glanville, 2006).

During an emergency outbreak of avian influenza in British Columbia, the Canadian Food Inspection Agency (CFIA) developed a new emergency composting system and successfully dispose of poultry carcasses. To reduce the risk of pathogens spread to the ambient, diseased carcasses are fully covered by plant (envelope) materials and compost piles were surrounded by plastic sheets (Spencer, Rennie, and Guan, 2004). (Ahn et al., 2007; Glanville et al., 2007). Studies have been conducted to investigate application of this bio-secure composting system to dispose diseased swine mortalities (Ahn, et al., 2007, Glanville et al., 2007). In this type of composting systems since carcasses are surrounded by plant materials and plastic sheets, visual inspection of the system is not possible. A new approach is needed to monitor progress and completion of the process. In this study, VOCs evolved by decaying swine carcasses are monitored and potential usage of VOCs as indicators of carcass degradation is investigated.

Methodology

Swine mortalities were composted in summer conditions of Central Iowa for 8 weeks. Corn silage, oat straw and corn stalks were used as envelope materials. Swine mortalities were covered by envelope (plant) materials and wooden 2 m x 2 m x1.5 m (height) wooden test units were wrapped by plastic sheets. The composting system and test units are described in Ahn et al. (2007) and Glanville et al. (2007). Polytetrafluoroethylene (PTFE) tubings (1/4 inch I.D., E&S Technologies, Chelmsford, MA) were used to draw air samples from the center location of test units. The air samples were captured inside glass sampling bulbs and immediately carried to Atmospheric Air Quality Laboratory for analysis (Figure 1).

Eighty five μm SPME fiber coating (Supelco, Bellefonte, PA) and 1 h sampling time were used to extract VOCs in air samples. VOCs are analyzed using 6890N GC and 5973 MS (Agilent Inc., Wilmington, DE). A polar capillary column (DB20, SGE, Austin, TX) was used to separate analytes. The initial temperature of the GC oven was 40 ºC and hold at this temperature for 3 minutes. GC oven temperature was increased by 7 ºC/min until 220 ºC and hold at this temperature for 12 minutes. MSD ChemStation (Agilent) and BenchTop/PBM™ V. 3.2.4 (Palisade Corporation, Ithaca, NY) were used to analyze chromatographic data.

Respiration rates of the composted swine carcasses were measured using titration method described by Sadaka et al (2006).

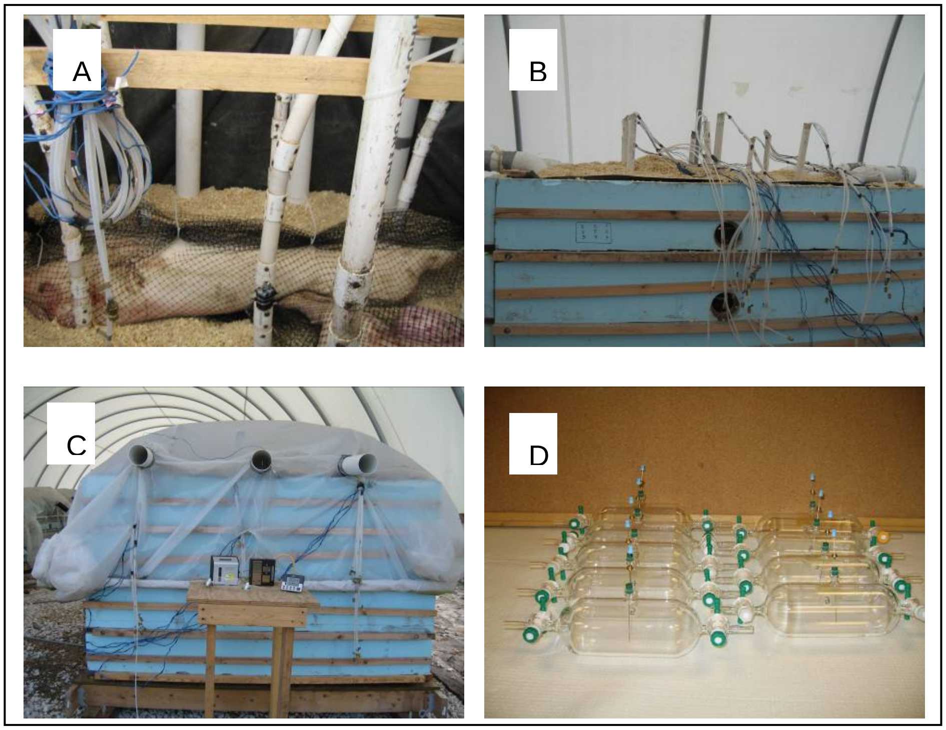

Figure 1. Swine carcasses (A), swine carcasses covered by plant materials (B), completed test units and air sampling (C), glass sampling bulbs and SPME (D)

Results and discussion

Sulfur containing compounds (e.g.,dimethyl disulfide, dimethyl trisulfide), VFAs (e.g., acetic acid, propanoic acid, isovaleric acid), alcohols (e.g.,1-octanol, 1-decanol), nitrogen-containing compounds (pyrimidine, piperidone), ketones (e.g.,acetone, 2-butanone, 2-heptanone), and aldehydes (e.g., butanal, hexanal) are detected from the air samples collected from corn silage, oat straw, and corn stalks test units. Average peak areas of compounds in the same group are added and average total peak areas are shown (Figures 2, 3, and 4). The highest concentrations of the compounds are measured in the first, second and the third weeks. This is the active phase of the process, where microbial activity is high (Haug, 1993). After the third week of the process, VOC concentrations started to decrease. Average total peak areas of the VOCs in the last week of the process (week 9) are presented in Figure 5. Akdeniz et al. (2007) reported sulfur and nitrogen containing compounds are indicators of decaying swine tissues and are not produced by decaying corn silage, oat straw and corn stalks. Thus, sulfur and nitrogen containing compounds are evaluated as indicators of decaying swine carcasses. It is seen that sulfur-containing compounds are detected from all three test units. However, nitrogen-containing compounds are detected from only corn silage test units. It is concluded that carcass degradation is incomplete in all of the test units. Carcass degradation in corn stalks and oat straw test units is better than corn silage test units. These results are supported with respiration rate results. Respiration rates are found to be between 5-7 mg CO_2-C g $VS^{-1}d^{-1}$ and categorized as moderately unstable composts based on Thompson classification. Average respiration rate of corn silage is found to be about 1.19 times bigger than the respiration rates of corn stalks and oat straw. High respiration rates indicate presence of degradable material and incomplete degradation.

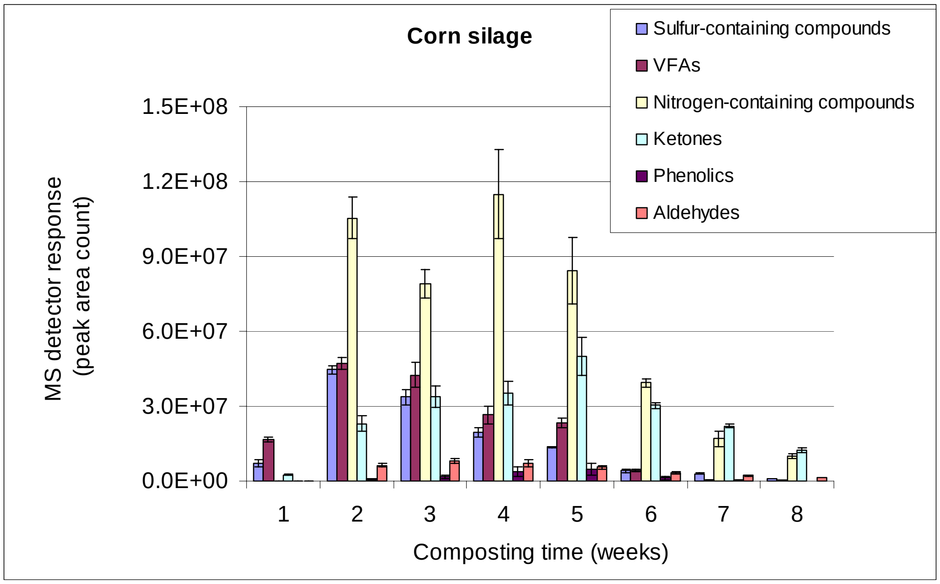

Figure 2. Average total VOCs detected from corn silage test units (N=3)

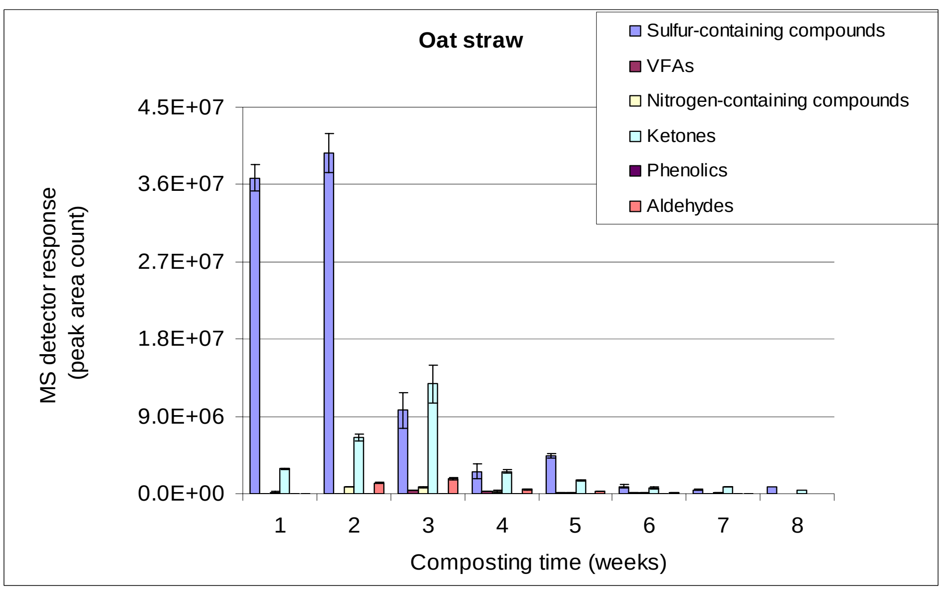

Figure 3. Average total VOCs detected from oat straw test units (N=3)

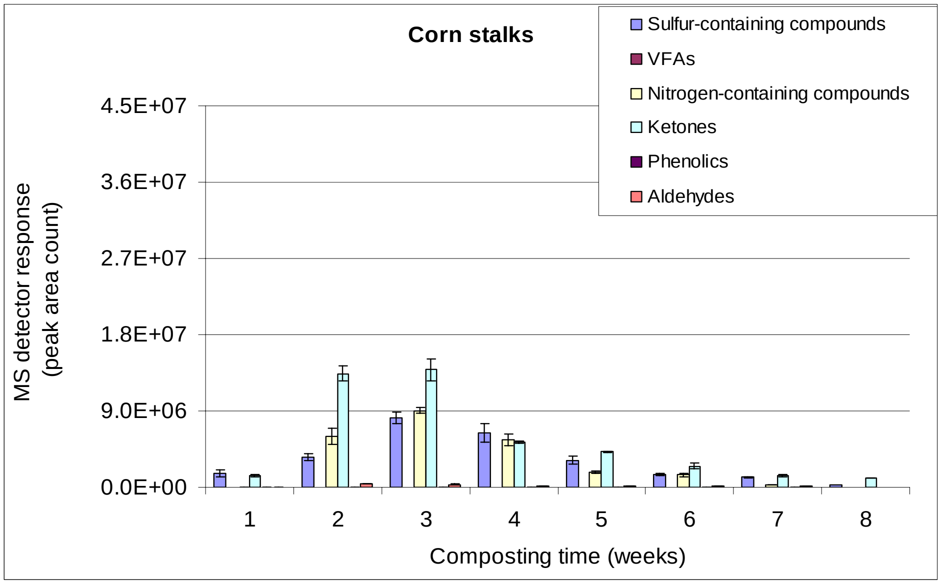

Figure 4. Average total VOCs detected from oat straw test units (N=3)

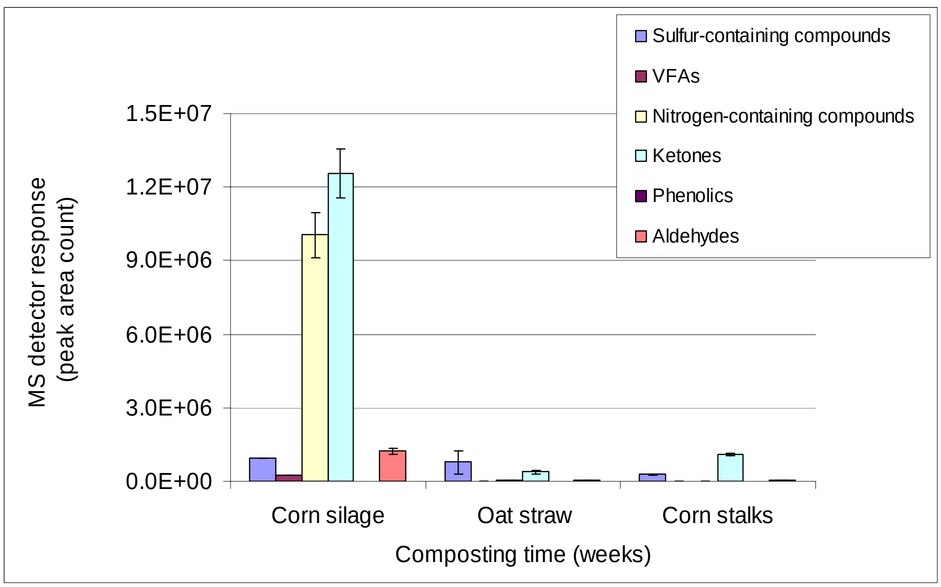

Figure 5. Average total VOCs detected from the test units in the last week (week 8) of the process (N=3)

Conclusions

Six group of chemicals were detected from full scale carcass composting test units wrapped by plastic sheets. 85 μm CAR/PDMS SPME fiber coating and 1 h sampling time were used to extract VOCs in air samples. Sulfur and nitrogen containing compounds are found to be good indicators of decaying swine carcasses. These VOCs have potential to be used as indicators of completion of swine carcass degradation when visual inspection is not possible.

Acknowledgements

The authors gratefully acknowledge Canadian Food Inspection Agency for the financial support through a grant from the Canadian Research and Technology Initiative (CRTI Project # 04 0052 RD).

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