Engineering Evaluation of a Bio-Secure Composting Procedure for Disposal of Infectious Animal Carcasses

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Introduction

This project is sponsored by the Canadian Food Inspection Agency (CFIA) and the Canadian Research and Technology Initiative. Its purpose is to evaluate the design and performance of a bio-secure swine mortality composting system. The system design, which includes an external plastic biosecurity membrane, was first used during an avian influenza outbreak in British Columbia in 2004. In 2006, the Canadian government requested engineering assistance from ISU to improve the composting system and extend its use to disposal of larger species such as swine. Objectives include evaluation of moisture distribution and loss; the effectiveness of passive aeration devices; the effects of envelope material type on temperature, O_2, and decomposition; and identification of volatile organic compounds (VOCs) that might be used to safely assess completion of animal tissue decomposition without disrupting the biosecurity membrane.

Materials and Methods

2007 was the second full year for this project, which will be completed in the fall of 2008. Field research, which was conducted at the Livestock Environment and Building Research Center on the ISU Ag Engineering/Agronomy Research Farm included construction and monitoring of two eight-week replicated composting trials. The first trial started in June and the second trial in September.

Composting trials were conducted in 2m × 2m × 1.2m plywood test units that were wrapped in plastic as a biosecurity measure intended to reduce the potential for pathogen release. Fresh air supply, release of CO_2, water vapor, and other decomposition products takes place through 4-in. diameter slotted drain tubing installed in the layer of compost beneath the carcasses, and a vent duct through the plastic biosecurity barrier at the top of each test unit.

Each test platform was loaded with approximately 225 kg of 45–65 kg swine carcasses that were enveloped in one of three agricultural plant residues. Carcasses were loosely wrapped in coarse plastic netting to facilitate recovery of remains at the end of the trial. Ground cornstalks, ground oat straw, and corn silage were used to envelope the carcasses during the first replicated trial, and wood shavings, ground soybean straw, and ground alfalfa hay in the second trial. Nine test platforms were monitored during each trial, thereby facilitating triple replication of test units with each envelope material.

To quantify decomposition, the carcasses were weighed when placed in the test units, and the un-decomposed remains were weighed at the end of the trials. The complete test units also were weighed on a weekly basis to monitor the combined loss of plant and animal tissues, and water vapor. Test units also were instrumented to monitor temperature and O_2 and CO_2 concentrations at 27 locations in each test unit. Volatile organic compounds (VOCs) produced during plant and animal tissue decomposition were sampled on a weekly basis at three locations in each test unit. Samples of compost were collected from nine locations in each unit on a monthly basis and tested for moisture and volatile solids.

Vaccine strains of avian encephalomyelitis and Newcastle Disease Virus were inserted into the core of each test unit to obtain data on viral pathogen inactivation.

Results and Discussion

During Trial 1, mean temperatures in the layer beneath the carcasses during the initial 30 days of the trial were 57°C for cornstalks and silage, and 47°C for oat straw. Envelope materials used during Trial 2 had much lower moisture levels than those in Trial 1, and comparable mean temperatures were 43°C, 40°C, and 35°C, respectively, for wood shavings, alfalfa hay, and soy straw.

In the compost layer immediately beneath the carcasses, and at a distance of 0.5 m from the sidewalls of the test units, success rates in meeting USEPA Class A criteria for pathogen reduction (≥ 55°C for three or more consecutive days) during Trial 1 were 100% for cornstalks and silage and 52% for oat straw. During Trial 2 the comparable Class A success rates were 29%, 25%, and 4%, respectively, for wood shavings, soybean straw, and alfalfa hay.

During Trial 1, average O_2 concentrations in the bottom and mid-depth layers of compost were 21% (equivalent to ambient air) in oat straw, 16–19% in cornstalks, and 9–18% in silage. During the first two weeks of Trial 2, bottom and mid-depth layers within soybean test units exhibited oxygen concentrations to air (21%) while those in the wood shavings and alfalfa hay test units ranged from 16–18%, and 17–20%, respectively (Figure 2). As time progressed, oxygen concentrations of all three test units gradually increased to ambient air levels (21%). The high O_2 concentrations during Trial 2 are believed to be due mainly to the low moisture content of the envelope materials—resulting in low microbial activity and low oxygen demand—and to their high gas permeability, which facilitates movement of fresh air throughout the composting matrix.

Average decomposition of carcass soft tissue mass (total weight – estimated bone weight) during the 8-week period for Trial 1 ranged from 64% for corn silage, to 72% and 75% for oat straw and cornstalks. During Trial 2, both wood shavings and alfalfa hay produced average soft tissue decomposition of 64%, and decomposition in soybean straw averaged 71%. Failure to achieve complete decomposition was caused by significant drying of the envelope material surrounding the carcasses which led to desiccation and reduced microbial activity. Excessive air flow through the compost matrix, and significant periods when compost gases were vented from the base of the pile rather than at its top, are believed to be the main causes of drying and also of odor emission during the early phases of composting.

Analysis of VOCs emitted during composting show that dimethy disulfide, dimethyl trisulfide, and pyrimidine are reliable indicators of decaying animal tissue, and completion of their decomposition.

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