On-Site Composting for Bio-Containment and Safe Disposal of Infectious Animal Carcasses and Manure in the Event of a Bio-Terrorism Attack

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Introduction

This project was sponsored by the Canadian Food Inspection Agency (CFIA) and the Canadian Research and Technology Initiative (CRTI–Canada's equivalent of US Homeland Security Agency). The purpose was to evaluate the design and performance of a bio-secure swine mortality composting system. The original 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. Specific objectives include studies of moisture distribution and loss within the composting matrix; the function and optimal spacing of passive aeration devices; effects of envelope material type on temperature, O_2, and decomposition rates; 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

The first full year for this project was 2006 and will continue through March 2009. Work conducted from March through September included construction and performance testing of a prototype test platform and instrumentation system, followed by construction of nine identical platforms and instrumentation sets for use in future replicated field trials. From October through January, the first replicated trial was completed.

Composting trials were conducted in 2m × 2m × 1.2m plywood test units that were wrapped in plastic. The units were designed to be weighed periodically to monitor mass loss, and are instrumented to monitor temperature, O_2, CO_2, and VOCs at 27 locations. Samples of composting materials were collected from nine locations in each unit on a monthly basis and were tested for moisture and volatile solids.

Each platform was loaded with approximately 225 kg of 45–65 kg swine carcasses enveloped within one of three different plant materials. Ground cornstalks, ground oat straw, and corn silage were used as envelope materials during the first replicated trial. Nine test platforms were monitored during each trial, thereby permitting triple replications of each envelope material. Three additional envelope materials will be tested later in the study. Since external temperatures can markedly affect microbial activity and rate of decomposition, the performance of all six envelope materials will be tested during both warm and cool seasons. Vaccine strains of avian encephalomyelitis and Newcastle Disease Virus were inserted into each test unit to obtain data on viral pathogen inactivation.

Results and Discussion

Preliminary results from the first replicated trial revealed interesting trends in temperature, O_2, and moisture distribution. Unseasonably cold and windy weather in October and early November, made it difficult for the test units to retain heat. Temperatures in test units using corn silage peaked in the 50–60ºC range immediately after construction and slowly dropped into the 20–40ºC range by early January. Temperatures within cornstalk and oat straw test units were much lower, peaking in the 20–30ºC range during the early weeks of the trial, and then quickly dropping to temperatures that were nearly the same as the ambient air.

Average O_2 concentrations within cornstalk and oat straw test units were spatially uniform and typically above 20%. Those within silage units were often less than 10% and varied considerably with location. These differences in O_2 seem to have been caused in part by differences in natural settling and compaction rates. On completion of the trial, cornstalks and oat straw exhibited air-filled porosities of 84–93% at all depths. Values of less than 20% were found in silage layers surrounding the pig carcasses. It is believed that this compaction is an important factor contributing to low O_2 concentrations and to lower carcass degradation in silage. Despite much higher temperatures in silage test units, mass loss data indicate average carcass decomposition of only about 58%, while decomposition of 70–76% was estimated for carcasses in cornstalks and oat straw test units.

Routine livestock mortality composting operations that are not enclosed in plastic typically exhibit the highest moisture content near the base of the pile. In bio-secure composting units constructed with cornstalks or oat straw, however, moisture was highest at the top. The mechanism for this redistribution appears to be upward migration of air and water vapor through the highly permeable envelope materials, followed by condensation of the water on the underside of the plastic membrane and subsequent transfer to the top layers of envelope material. In several of the test units this process led to abnormal drying of base layers and partial mummification of external carcasses surfaces.

Analysis of emitted VOCs collected following completion of the first field trial found that dimethy disulfide (DMDS) was not emitted by any of the plant-based envelope materials, but it was consistently present in samples containing un-decomposed animal tissues or a mixture of plant and animal tissues. These preliminary results suggest that DMDS is a good indicator of decaying animal tissue, and that it may be feasible to use it to assess the extent of carcass decomposition without the need to disrupt the biosecurity membrane. This finding also is consistent with results of previous laboratory studies where dimethyl disulfide was reported as an indicator of decaying animal tissue. Other VOCs identified in the lab that may be indicative of animal tissue decomposition include sulfur-containing compounds, such as methyl mercaptan, carbon disulfide, dimethyl trisulfide, and 1,4-dimethyl tetra sulfide, and nitrogen-containing VOCs such as 1-H-indole and 3-methyl-1H-indole.

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