Characterization of Livestock Odors Using Steel Plates, Solid Phase Microextraction, and Multidimensional-Gas Chromatography-Mass Spectrometry-Olfactometry

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Summary and Implications

Livestock odor characterization is one of the most challenging analytical tasks. This is because odor-causing gases are often present at very low concentrations in a complex matrix of less important or irrelevant gases. The objective of this project was to develop a set of characteristic reference odors from a swine barn in Iowa, and in the process identify compounds causing characteristic swine odor. Odor samples were collected using a novel sampling methodology consisting of clean steel plates exposed inside and around the swine barn for up to one week. Steel plates were then transported to the laboratory and stored in clean jars. Headspace solid phase microextraction (SPME) was used to extract characteristic odorants collected on the plates. All analyses were conducted on a Gas Chromatography-Mass Spectrometry (GC-MS)-Olfactometry system where the human nose is used as a detector simultaneously with chemical analysis via MS. The effects of sampling time, distance from a source, and the presence of particulate matter (PM) on the abundance of specific gases, odor intensity, and odor character were tested. Steel plates were effectively able to collect key volatile compounds and odorants. The abundance of specific gases and odor was amplified when plates collected PM. The results of this research indicate that PM is major carrier of odor and several key swine odorants. Three odor panelists were consistent in identifying *p*-cresol as closely resembling characteristic swine odor as well as attributing the largest odor response out of the samples to p-cresol. Further research is warranted to determine how the control of PM emissions from swine housing could affect odor emissions.

Introduction

Odor emissions from confined animal feeding operations affect air quality in surrounding communities. The chemical makeup of odor emitted from swine manure has been a focus of several previous studies. To date, relatively little is known about swine odor, odor-causing chemicals, odor-particulate matter interactions, and persistence of swine odor.

Our goal for this project was to develop a novel method for sampling the ambient air in livestock facilities capable of long-term sampling. We attempted to create a sampling method that would be inexpensive and easy to deploy in field conditions and to allow for efficient long-term storage of samples with characteristic odor in the laboratory, multiple sampling, and analysis of odor with a SPME and GC-MS-O system. In this research, we also further investigated the effects of exposure time, distance, and dust of odor and odorants. In addition, further use of such a system will allow for the identification of key compounds causing characteristic swine odor. This was accomplished using the multidimensional capability of the GC-MS-olfactometry system. Chromatographic retention times associated with characteristic odors were identified and then used to determine optimum 'heart-cut regions'. During heart-cutting, compounds with retention times coinciding with characteristic compounds only were passed into a second column for improved separation and odor characterization.

Materials and Methods

Carbon steel plates approximately 6 cm $\times$ 3 cm $\times$ 0.25 cm were deployed and collected at the Iowa State University swine research farm. The selection of sampling locations was driven by the need to represent air inside a barn immediately before exhaust, outside of a barn and very close to the same air exhaust location, and a distant location where the effects of air dilution and pollutant/odor dispersion were likely to occur. After sampling, plates were brought back into the lab and were placed into previously prepared jars. The jars were then stored for 2-3 months at room temperature (~22 °C) to allow the headspace within the jar to become saturated with the compounds adsorbed to the steel plates.

Headspaces of jars with plates were sampled using solid phase microextraction (SPME). An Agilent Technologies GC-MS system (Agilent 6890N GC / 5973 MS, Agilent Inc., Wilmington, DE) modified with MDGC-Olfactometry system and Aromatrax software (Microanalytics, Round Rock, TX) for recording odor events was used to analyze all samples. This system allows for the simultaneous identification and analysis of chemicals and corresponding odors. Dual column MDGC systems with heart-cutting capability enable isolation of critical trace level odorants from complex background matrices.

Results and Discussion

Steel plates are capable of collecting volatile organic compounds (VOCs) and odorants from long term sampling of livestock operations and were best used for analysis and qualitative comparison, not quantification. However, steel plates carried significantly more VOCs and odor when left not rinsed, as rinsing produced greater variability in results.

PM and other particulates have great potential significance in odor contribution. Butyric acid, isovaleric acid, p-cresol, and skatole play a large role in the odor from PM in ambient air at swine facilities. Dimethyl trisulfide plays a significant role in the odor in ambient air at swine facilities regardless of the presence of PM.

SPME-MDGC-MS-O analyses are very useful for the sampling, isolation, separation, and identification of important odorants in swine environments. All three panelists identified p-cresol as one of the key odorants causing the characteristic swine odor.

P-cresol was present on all plates even at the distant location without PM present. This underscores the potential for this compound to remain in environments exposed to air from livestock facilities for extended periods of time after exposure.
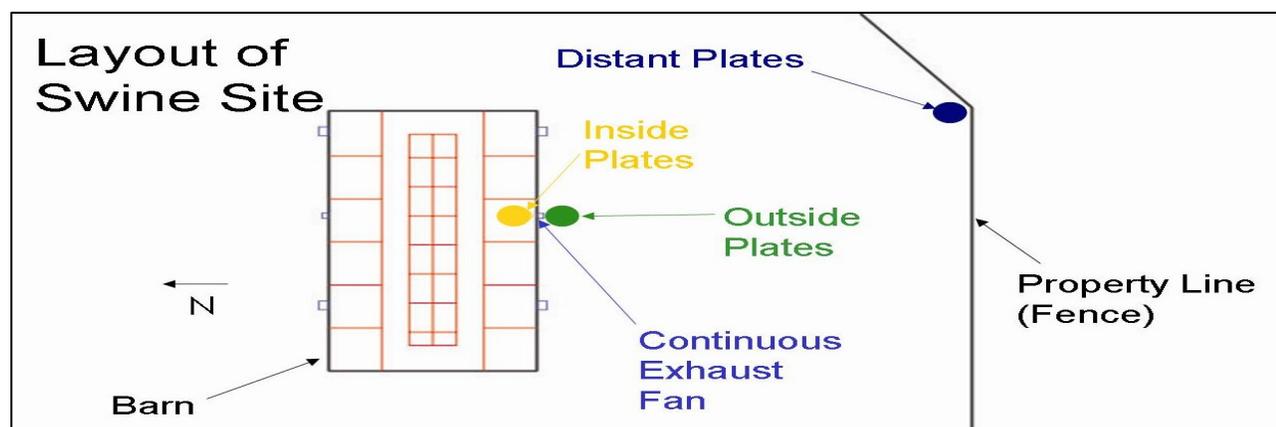
Figure 1. Layout of sampling locations.

Figure 2. Headspace sampling of odors emitted from steel plates exposed in swine farm.

Figure 3. **Panelist evaluate swine odor with multidimensional gas chromatography-mass spectrometer-olfactometry.**