Evaluation of Zeolite for Control of Odorants Emissions from Simulated Poultry Manure Storage

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Summary and Implications

Poultry operations are associated with emissions of aerial ammonia (NH_3), volatile organic compounds (VOCs), and odor, and the magnitude of emissions is influenced by manure management practices. As a manure treatment additive, zeolites have been shown to have the potential to control NH_3. Because of their properties it is also expected that zeolites could effectively adsorb VOCs and odor. The effectiveness of zeolite in controlling odor and VOCs was qualitatively evaluated in this controlled laboratory study involving simulated poultry manure storage. In the first two trials, zeolite was topically applied on nearly fresh laying hen manure at rates of 0, 2.5%, 5%, and 10% (by weight). In the third trial, zeolite was topically applied at 5% with each addition of fresh manure into the storage vessel. Headspace samples from the emission vessels were collected with solid phase microextraction (SPME) and analyzed on a multidimensional-gas chromatograph-mass spectrometry-olfactometry (MDGC-MS-O) system for identification and prioritization of poultry manure odorants. Acetic acid, butanoic acid, isovaleric acid, indole, and skatole were consistently controlled in the headspace, with the reduction rate being proportional to the zeolite application rate. Dimethyl trisulfide and phenol were consistently generated, and with a few exceptions, the rate of generation was proportional to the application rate. Average reduction of the odor caused by all odorants evaluated with SPME-GC-O was 67% (±12%) and 51% (±26%) for the two topical applications, respectively, while no significant reduction of VOCs and odor was detected for the layered application.

Introduction

Emissions of aerial pollutants from high-density poultry and livestock facilities are of increasing public concern. The anaerobic nature of manure stabilization can cause offensive odors and release of NH_3, and H_2S along with various VOCs during collection, transfer, storage, treatment, and subsequent land application. Environmental problems associated with poultry manure could be mitigated through application of treatment additives. Numerous types of additives have been used to reduce NH_3 and odor emissions from livestock wastes. Zeolites are one of such additives and have high surface area and cationic exchange properties. The physicochemical properties that make zeolite so attractive for NH_3 abatement are also expected to enhance adsorption of VOCs and odor emitted from poultry and livestock wastes.

The objective of this research was to qualitatively evaluate the effectiveness of natural zeolite as a manure additive to control odor and VOCs during simulated laying hen manure storage. The zeolite was topically applied to fresh laying hen manure at a rate of 0, 2.5%, 5%, or 10% (by weight). Headspace samples from the storage/emission vessels were collected with SPME 85 µm Carboxen/PDMS and analyzed on a MDGC-MS-O for the identification and prioritization of poultry manure odorants.

Materials and Methods

About 2.5 kg of fresh manure was loaded into a 3.8 L container with 0.02 m^2 surface area. Different amounts of zeolite (grade 14×40, Bear River Zeolite Company, Thompson Falls, MT) of 0 g, 62.5 g, 125 g or 250 g, i.e., 0%, 2.5%, 5%, and 10% by weight, respectively, were surface-applied on top of the manure, corresponding to an application rate of 0, 3.125, 6.25, or 12.5 $kg \cdot m^{-2}$ manure surface. Each container was placed inside a 19-L emission vessel. Two trials (A and B) were conducted to achieve four replicates of each treatment. In Trial C, fresh manure (5 cm thickness and 2.5 kg per layer) was loaded to 19-L vessels (as opposed to the smaller 3.8 L container, then placed inside the vessel) every other day for four layers to simulate periodic manure addition and zeolite application to manure storage. Zeolite (125 g, 5% by weight) was surface-applied on top of each layer in four of the eight vessels while the others served as controls.

Carboxen/PDMS 85 µm SPME fiber (Supelco, Bellefonte, PA) was used for sampling headspace above the poultry manure in the emission vessels. The headspace SPME sampling was carried out at room temperature and was immediately followed by sample analyses on a MDGC-MS-O system (Microanalytics, Round Rock, TX).

Results and Discussion

Sampling with SPME and analysis with GC-MS-O is a useful qualitative approach for testing of treatment effectiveness of zeolite applications to control VOCs and specific odorants from simulated poultry manure storage.

Topical application of zeolite to laying hen manure showed the potential for reducing emissions of acetic acid, butanoic acid, isovaleric acid, dimethyl sulfone, phenol, indole, and skatole from the manure storage, with the effectiveness of treatment being proportional to the zeolite application rate. Sulfide compounds including DMS, DMDS, DMTS, MM, and 1-propanethiol were generated

with the rate of generation being generally proportional to the application rate. Specific odors caused by VFAs, skatole and indole, i.e. fatty acid/body odor (butanoic acid), body odor (isovaleric acid), barnyard (indole), and naphthalenic (skatole) were controlled by 10% topical zeolite treatment.

The 10% zeolite application rate was the most effective in controlling specific odorants emitted from poultry manure among the tested application rates. Average reduction of the total odor measured with the GC-O approach was 67% (±12%) and 51% (±26%) for Trials A and B, respectively.

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Figure 1. Laboratory set up for testing of the effects of zeolite treatments on odor and VOCs emissions from poultry manure.

Figure 2. Simultaneous chemical and olfactory analysis of odor and VOCs emitted from poultry manure using GC-MS-O.