ODOR REDUCTION BY ANAEROBIC DIGESTION: EFFECT OF ORGANIC WASTES

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Abstract

Storage of livestock manure is an important source of odor and odorants which causes considerable odor nuisance to the surrounding neighborhood. Odor mainly is caused by a large number of chemical components present in manure. Anaerobic digestion of slurry changes the composition and physical properties of slurry and may therefore lessen the odor pollution during subsequent storage. An experiment was set up to study the effects of anaerobic co-digestion of slurry with different organic wastes on the emission of odor and odorants. Odor concentrations (OC) above anaerobically treated (degassed) and untreated (raw) slurries with and without added organic wastes were compared during storage. Concentrations of odorants were measured using TD-GC/MS and OC was determined using dynamic dilution olfactometry. Concentrations of hydrogen sulfide (H2S) and ammonia (NH3), by means of precision gas detector tubes (Kitagawa, Japan), and physicochemical characteristics of the slurry (i.e. pH, temperature and chemical composition) were also measured.

Preliminary results showed that OC in air sampled above stored slurry seemed to be lower in anaerobic digested slurry than in untreated slurry. In addition, OC was reduced in the slurries with added organic wastes when compared with slurries with no additives. Further results are required for a final conclusion.

Key-words: additive, emission, odorant.

Introduction

Livestock production is a source of airborne contaminants including gases, odors, dust, microbes and insects. Odor is mainly caused by a large number of chemical components present in manure. Many of these odorants have been identified by Hobbs et al. (1995), and the major odor components in pig slurry are sulfides, volatile fatty acids (VFA), and phenolic and indolic groups. The emission of
odorous gases and odors from manure storages depend on the concentration of odorants in the manure. The production of odorants in the slurry is caused by an incomplete anaerobic decomposition of organic substrates, mainly proteins and fermentable carbohydrates, which may occur during collection, handling, storage and spreading of the slurry (Le at al., 2005). The concentrations of odorants vary according to the type of slurry, but may also depend on how the slurry has been treated prior to storage. Anaerobic digestion is a biological process which reduces the dry matter content of the slurry and ensures degradation of some important organic odorants such as VFA, thereby reducing the odor releasing potential of slurry during subsequent storage. In many anaerobic digestion processes different types of organic wastes are added to boost methane production. This factor is expected to have a major impact on odor emissions from anaerobically digested slurry. Furthermore, the process of anaerobic digestion for the production of biogas has also been shown to reduce odour by the oxidative decomposition of 99% of volatile compounds when the biogas is combusted (Smet et al., 1999).

The objectives of this study were to determine the odor reduction effects of anaerobic digestion, and to study how addition of different types of organic waste during digestion influences odor emissions during subsequent storage.

**Material and Methods**

The experiment consisted of sixteen plastic barrels (dynamic flux chambers, 63 l) in which slurries (43 kg/chamber) were incubated during a period of eight weeks. Samples of untreated (U) and anaerobically treated (D) slurry were previously taken from four different commercial anaerobic digesters with different added materials.

The evaluation involved the following eight treatments (slurries): T1- Degassed (Maize + glycerol), T2- Untreated (Maize + glycerol), T3- Degassed (Maize + slaughterhouse waste), T4- Untreated (Maize + slaughterhouse waste), T5- Degassed (No additive), T6- Untreated (No additive), T7- Degassed (no additive, swine + cattle slurry), T8- Untreated (no additive, swine + cattle slurry). Each treatment was conducted in duplicate, resulting in 16 chambers.

The following measurements were included: Odor concentration (OC) in air samples determined by means of a dilution-to-threshold olfactometry technique (European standard EN13725), concentrations of odorous volatile organic compounds (VOC’s) measured by Thermal Desorption Gas Chromatography-Mass Spectrometry (TD-GC/MS), concentrations of hydrogen sulfide (H₂S) and ammonia (NH₃) measured by means of precision gas detector tubes (Kitagawa, Japan), and physicochemical characteristics of the slurry (i.e. pH, temperature and chemical composition).

In order to sample odors and odorants above the slurry surface, a lid was fastened on top of each barrel with a steel tension belt to make the lid/barrel interface airtight. Each lid was supplied with four ports which were used for air inflow and outflow, and for sampling the headspace air. Air drawn from outside the laboratory was filtered through an activated charcoal filter and continuously pulled through the barrels at a constant airflow rate of 1.85 l/ min, which was secured by critical orifices inserted inside the outflow tube of each barrel.
The measurements were carried out three times: at the beginning of the experiment (week 0); after four weeks (week 4); and at the end of the experiment (week 8).

In parallel with the laboratory scale experiment, a similar field experiment was carried out in eight tanks with capacity to 5 tonnes (pilot scale). However, in this case it was not possible to measure concentrations in the headspace air due to the higher air exchange rates of these tanks. Instead an air circulation system was used when air sampling was carried out. Any statistical analysis has yet to be realized.

**Results and Discussion**

The partial results from this experiment are presented as follows. Average slurry temperatures in weeks 0, 4 and 8 were 16, 14 and 20°C, respectively (in laboratory experiment) and 5, 6 and 13°C (in pilot scale experiment). In both laboratory and pilot scale experiments, the pH in T4 (untreated, maize + slaughterhouse waste) and T8 (untreated, no additive, swine + cattle slurry) was 6.5±0.5, while in the other treatments it was between 7.5±0.5 and 8.0±0.5. At the surface of T3, T4, T7 and T8 a natural crust of 5, 24, 3 and 11cm, respectively, developed. OC in the headspace air at week 0, week 4 and week 8 are shown in Figures 1 (laboratory) and 2 (pilot scale). OC above anaerobically digested swine slurries was found to be lower compared with untreated slurries. OC above untreated swine slurries was higher at the end (week 8) than at the beginning (week 0) of the experiment. However, mixed slurries (cattle + swine), showed a lower OC at the end (week 8) of the experiment.

A higher temperature at week 8, can explain higher OC in this period, as temperature promotes the formation and release of odorants. Besides, pH also affects the emission of odorants. In this respect, the lower pH in T4 and T8 and consequent lower OC can be related to the presence of a natural crust formed over time in these treatments (Xue et al., 1999). OC increased with storage time, mainly in swine raw slurries. The highest OC was found in the air sampled above untreated slurry without additive (12000 and 3400 OU/m³, laboratory and pilot scale, respectively) at week 8, and the lowest odor concentration was found in the air sampled above T3 (180 and 110 OU/m³, laboratory and pilot scale respectively) at week 4. Volatile fatty acid (VFA) is an important group of odorants, which have often been used for qualification of odor strength in slurry. In general terms, the concentrations of VFA were lower in anaerobically digested slurry (80%) due to the fact that VFA are easily degradable and serve as the main carbon source for methanogenic microorganisms during anaerobic digestion of slurry. Similar results have been reported by Powers et al. (1999). The pilot scale experiment showed similar results, according to Figure 2.

**Conclusions**

Quantified by dynamic dilution olfactometry, odor concentration measured in headspace air sampled above undisturbed stored slurry showed to be reduced by anaerobic digestion. OC seems to be reduced in slurries with additives, due a natural crust formed in this case, acting as a physical barrier. OC was lower at the beginning of the storage period (week 0) and after 4 weeks (week 4) of the experiment, while
OC was found to be higher in headspace air sampled after 8 weeks storage (week 8), due to a higher temperature in this period. A final conclusion of this experiment is expected after further results analysis.

References


Figure 1. Concentration of odor (OC/m³ – odor units per m³ of air) in the laboratory scale experiment.
* OC at week 0 was below detection limit.

**Figure 2.** Concentration of odor (OC/m³ – odor units per m³ of air) in the headspace of the pilot scale.