Dairy Manure Odor Perception and Management Series

Part 5: Employing anaerobic digestion for manure-based odor control

Anaerobic digestion (AD) is a treatment strategy that retains manure in a heated vessel devoid of oxygen, to intentionally promote and expedite anaerobic decomposition. There are multiple benefits associated with this odor reduction strategy, but many considerations need to be evaluated before implementation.

Farms should have a clear understanding of the goals and objectives of an on-farm AD before implementing. Experience has shown that common goals and objectives that producers have include odor reduction, reduction of manure land-application costs (tangible and non-tangible), generation of renewable electricity, production of bedding material from separated manure solids, assistance in complying with nutrient management plans, exportation of nutrients off-farm, and reduction of greenhouse gas emissions. The proper viewpoint on AD is one that recognizes that it is a viable component of an overall manure treatment and handling system for many, but not all, dairy farms. A systems-based perspective of anaerobic digestion is one that not only looks at the advantages and disadvantages of anaerobic digestion itself but also how anaerobic digestion affects the farm from all pertinent perspectives. This approach is imperative in today's dairy industry and environmental regulatory climate as each are dynamic and change is driven by forces outside of the dairy producer's control.

How AD reduces odors: Total Volatile Acids

Treatment of manure and other feedstocks by way of *anaerobic* digestion, yields significant odor reductions due to the unique process whereby a specific set of bacteria that thrive in the absence of oxygen complete the task of breaking down organic compounds, converting organic matter to various volatile organic acids, and in the process, produce comparatively foul smelling odors. Total volatile acid (TVA) concentration is an indicator of the presence of odor, therefore, tracking the change in the concentration of TVAs, referred to as "waste stabilization", demonstrates the reduction in odor between raw and post-digested manure. Allowing the decomposition to progress to completion in a controlled, enclosed vessel (anaerobic digester), should result in less odor, since the intermediary volatile organic acids are transformed into the final products, which are methane, carbon dioxide and the mostly "odorless" liquid effluent. It is important that the process is allowed to progress to completion, since many intermediary steps produce highly offensive odorous compounds that are eventually transformed to inert products in the effluent.

The reduction in TVA was measured at 7 farms with operational ADs yielding the following percent change in TVA between the influent and effluent: 85.9, 83.9, 90.7, 84.8, 85.3, 75.1, and 48.7%, with an average value of 79.9% reduction in TVA attributed to the AD system[1]. This demonstrates just how effective anaerobic treatment of manure and other substrates can be at reducing TVA concentrations, and therefore the associated odors.

Different AD technologies

The two main AD technologies that are used on dairy farms in NYS are plug-flow and complete mix (CSTR – continuous stirred tank reactor), which each have pros and cons from the standpoint of reducing manure-based odors.

A plug-flow AD (Figure 1) is in theory, more efficient at producing a completely digested effluent product, since material travels through the system as "a plug", being subjected to microbial decomposition throughout theprocess until the effluent material exits the AD vessel.

NEW YORK STATE OF OPPORTUNITY. NYSERDA

This material is based upon work that is supported by the New York Energy Research & Development Authority (NYSERDA) under agreement #28264. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of NYSERDA.

Figure 1. Plug-flow anaerobic digester on New York farm

On the other hand, a CSTR (Figure 2) incorporates influent and immediately dilutes it with material that has been in the reactor for varying lengths of time. In theory, the effluent from this type of process will contain organic material at different stages of the process and therefore be more odorous than the effluent of a plug-flow system.

Figure 2. Synergy Farm CSTR anaerobic digester, New York

Using the waste stabilization data previously mentioned for 7 farm ADs, and accounting for AD type, the plug flow ADs in the study yielded an average waste stabilization for TVA of 75.7%, while the complete mixed ADs resulted in 88% reduction of TVAs. This increase in waste stabilization for CSTR systems could also be due to the fact that they accept off-farm substrates whereas the plug flow ADs in the study generally did not.

Thoughts on system design to ensure high-level odor control

Regardless of the type of AD reactor that is used, there are certain criteria that need to be met in order to maintain significant odor reduction for the manure treatment system. One is adequate retention time of organic material in the AD system. The difference in how material is handled for plug-flow and CSTR systems was discussed in the previous section. For most AD types, regularly scheduled influent feedings can help to avoid upsets when material is added at irregular intervals or quantities.

The state of the materials used in the system have a significant impact on the potential for leaks in the process. If pipes, fittings, and seals are not properly maintained they can lead to fugitive gas emissions. Every AD system must have gas pressure safety valves and flares, these and other components when not in good working order, can lead to gas leakages, and henceforth, increase odors on the farm. In order to achieve significant odor reductions, all biogas generated must be combusted (by way of an engine, a micro turbine, or a flare). Flare sizing is important to handle routine and emergency needs of the system.

Storage of AD effluent also needs to be considered, since it is likely that there will be at least some un-digested organic material, which will impart odor to the surrounding vicinity. Some farms decide that covering the effluent storage is best, which has other benefits, including the exclusion of precipitation. Anaerobic digestion was chosen to discuss in this series as an appropriate manure-odor management technology, as many farms find that the effective odor reduction along with the many additional benefits the technology offers the farm, makes it a worthwhile investment.

AUTHORS: ***Jennifer Pronto*** and ***Curt Gooch*** (cag26@cornell.edu)
REFERENCE: [1] Gooch, C.A. et al. *Biogas Distributed Generation Systems Evaluation and Technology Transfer*. NYSERDA project #6597. 2011