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Prediction of Foaming in Biogas Digesters

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ABSTRACT
Due to the ambiguity and complexity surrounding anaerobic digester foaming, several academics have made attempts to understand the process of anaerobic digester foaming to provide a solution that can be used globally rather than site-specific. All attempts, from experimental research to a comparative evaluation of other processes, have failed to adequately explain the circumstances and mechanism of foaming in an anaerobic digester. This piece of work gives a brief and increased understanding of foaming in anaerobic digesters as well as offers a simple way to identify the start of anaerobic digester foaming based on an examination of historical data from a field scale system.
Keywords : foaming, anaerobic digester.

I. INTRODUCTION

For more than a decade, foaming in anaerobic digesters has been recognized, with significant consequences for the whole digestion process(Hernandez and Jenkins 1994). Digester foams have been shown to overrun digester floating covers, foul gas collecting systems, and invert digester total solids (TS) profiles. In many cases, the presence of a significant foam layer can cause considerable operational issues and a drop in process efficiency. AD foaming is extremely unpleasant, as it can result in a loss of active digester volume, structural damage, leakage, damage to the gas-handling system, and a drop in biogas output. When foaming develops in AD, it tends to limit gas output by up to 40% (Moeller et al,2010). Several studies have researched AD foaming, however, their findings do not constitute a comprehensive analysis of foaming incidence. Some of these investigations relied on heuristic information from site operators or inferences from foaming reports in other biological systems. For example, a comparison of foam generation in biogas facilities and ruminant bloat was conducted. the broader understanding of a well-studied subject of biological foaming in the activated sludge process to give important information on understanding the foaming process in AD To analyze AD foaming, a study of mechanistic multidimensional information was employed, to build a better link between AD foam properties and process and operational parameters.

Foam

The majority of foam occurs as a medium of gas trapped in a thin fluid film with or without particles, and it may be represented as a three-dimensional solid with flat polygonal faces (films), straight edges (plateau), and sharp corners or vertices (Junctions). The most visible aspect of foam is the film, which separates the gas bubbles that are pressed together to create the foam. The plateau boundaries are a line or curve that connects the films. These are liquid-filled interstitial channels that link at junctions to form an interconnected network. Understanding this detailed foam structure is critical in understanding the reliance of changing characteristics of foam from creation to stability/collapse on microscale fluid flow and macroscale motion of foam bubbles that comprise the foam structure. Thus, the foam may be further categorized depending on how easy it is created and how long it can remain stable before collapsing to liquid. As a result, foam might be stable, metastable, or unstable.

Formation of Foam

Gaseous and liquid particle mixtures will foam only when surfactants are their which lowers the surface tension of the liquid and trap the gas bubbles as they blow up. Thus ,chemically pure liquids do not foam. Usually, the foam developed is made of about 80% gas.

Stability of Foam

The stability of foam and collapsing of foam is very crucial as it explains the extrinsic life of foam. It is difficult to explain stability of foam separately from foam collapsed as they are two inevitable conditions. It means when the foam is formed it will either collapse or stabilize. Mostly, the foams are unstable and will collapse in and turns into liquid.

Molecular weight and density of major gases present in biogas

Gas	Formula	Molecular weight	Density (kg/m^3)
Methane	CH_4	16.043	0.717
Carbon dioxide	CO_2	44.01	1.977
Ammonia	NH_3	17.031	0.769
Hydrogen	H_2	2.016	0.0899
Hydrogen Sulphide	H_2S	34.076	3.74
Nitrogen	N_2	28.02	1.165

During the anaerobic digestion, the enzymes produced by different microorganisms which acts as facilitators while, hydraulic retention time, alkalinity, absence of toxic substances, pH, play very significant role in ensuring the process efficiency.

Mechanism of Foam Formation in Anaerobic Digester

When gas bubbles through a liquid containing surfactants, whether or not there are some solid particles present, foaming will result. Gas bubbles, liquid, and surfactants are inherent characteristics of the system because of the Anaerobic Digestion process. As a result, biogas produced during anaerobic digestion will rise to the top due to a difference in density and become trapped in an aqueous solution made up of surfactant (detergents introduced into the process) and bio surfactants (produced by microorganisms during the digestion period), forming foam. Typically, Anaerobic Digestion foam comprises a lot of solid particles and has a specific gravity of 0.7 to 0.95 (Metcalf and Eddy,2014) However, whether a foaming nuisance will develop depends on the type of foam and the operational circumstances in the Anaerobic Digestion.

In anaerobic digestion sufficient amount of gas is released and there is a hydrodynamic interaction between the adjacent bubbles formed due to increase in pressure between the adjacent bubbles. Subsequently, the foamed bubbles break to release gas at top of the digester. On the contrary, when the digester is not functioning properly . There is insufficient production of gases , then the hydrodynamic interaction between neighbouring bubbles tends to reduce, resulting in more emulsified bubbles moving to the surface of digester forming a layer of foam.

At optimal anaerobic digestion operating conditions, the ratio of methane to carbon dioxide is higher. This shows that methane has lower density and smaller bubbles as compared to other gases that methane makeup the anaerobic digestion biogas. (Ginnis etal,2006) found that the solubility of methane in mesophilic condition in digesterto be one twentieth of that of carbon dioxide with the coefficient of diffusion of methane to be 5 times greater than that of carbondioxide. Consequently, coarsening effect makes it easier for methane gas bubbles which are smaller to be released faster from the foam trap than other gas components. However, when the digester is getting sour, the acid formers (CO_2 releasing) works much more quickly than the methane forming microorganisms resulting toan increase in carbon dioxide production which is bigger and not released easily from the foam which results in foam stability and convert into a foam nuisance.

Viscosity, which is the degree to which a fluid resists a desire to flow by another fluid, has an impact on the stability of foam. Given that foaming is likely to happen at the wet limit of 35% (Wearie et al,2003), AD should be operated at an optimal organic loading rate to make sure that the digester maintains an adequate viscosity while preventing the development of nuisance foaming. This will allow the flow of produced biogas to the headspace and down to the gas storage. This will make it possible for foamed bubbles to drain quickly and prevent an overabundance of sludge from building up in the digester and impeding the use of the available biomass. This reinforces the view held by the majority of researchers that organic overload brought on by irregular digester feeding, separate feeding, or insufficient nutrition is the main contributor to digester foaming mixing of WAS and primary sludge. When an AD is overloaded with organic material, the digester content becomes more viscous and more volatile fatty acids (VFAs) are produced than can be converted to methane. Under these conditions, the acid formers (which release carbon dioxide) function much more quickly than the microorganisms that form methane and produce more carbon dioxide.

Foam Prediction

We may infer from the description above that foaming occurs often in the aqueous phase of the Anaerobic Digestion and is influenced by the amount of biogas generated, the amount of surfactant in the liquid, and the concentration of the liquid. As seen in an ongoing experiment, it is difficult to determine the surfactant concentration in Anaerobic Digestion. However, since more surfactants found in Anaerobic Digestion are released as biosurfactants by biomass during the anaerobic digestion process' hydrolysis stage, the concentration of surfactants in Anaerobic Digestion can be related to the digester feed.

$$\text{Foaming prediction} = \frac{\text{volume of biogas produced}}{\text{volume of feed to the digester}}$$

The ratio was determined to be over 20 for non-foaming digesters and below 20 for foaming digesters after using this formula plus historical and analytical data from two full scale digesters, one with a foaming problem and the other without. This might be a simple approach for biogas operators to predict when the digester would probably foam. Additionally, effective system monitoring employing variables like temperature, VFA, alkalinity, pH, total solids, volatile solids, organic loading rate will help operators be made aware of potential foam incidents. Focus should be placed on accurate sampling and regular analysis.

II. CONCLUSION

By carefully monitoring the anaerobic digester process and utilising the data received from the monitoring process to evaluate foaming propensity, a unique approach to forecast the commencement of foam production has been developed, which has helped to better understand anaerobic digester foaming.

REFERENCES

[1]. Barber, W., 2014. Influence of wastewater treatment on sludge production and processing. Water and Environment Journal, 28(1), pp. 1-10. [3]

[2]. Barjenbruch, M., H., H., O., K. & J., T., 2000. Minimising of foaming in digesters by pretreatment of the surplus sludge. Water Science and technology, 42(9), pp. 235-241. [4]

[3]. Batstone, D. et al., 2002. Anaerobic Digestion Model No. 1, London: IWA publishing.

[4]. Moeller, L., Herbes, C., Müller, R. A. & Zehnsdorf, A., 2010. Formation and removal of foam in the process of Anaerobic Digester. Landtechnik 65, 3(Energy production), pp. 207-207.

[5]. McGinnis, D. et al., 2006. Fate of rising methane bubbles in stratified waters: How much methane reaches the atmosphere? Journal of Geophysical Research, 111(C9).

[6]. Metcalf and Eddy,2014, Wastewater Engineering – Treatment and Resource recovery. Fifth Ed. New York: McGraw-Hill International.

[7]. Rodriguez-Roda, I. et al., 2013. Anaerobic Digester Foaming: occurrence and control in Spain, s.l.: IWA; accessed on February, 10, 2014. URL: http://www.redbiogas.cl/wordpress/wp-content/uploads/ 2013/07/IWA-11509.pdf.

[8]. Subramanian, B. & Pagilla, K., 2015. Mechanisms of foam formation in anaerobic digesters. Colloids and Surfaces B: Biointerfaces, Volume 126, pp. 621-630.

[9]. Westlund, A., Hagland, E. & M., R., 1998. Operational aspects on foaming in digesters caused by Microthrix parvecilla. Water science and technology, 38(8-9), pp. 29-34.