Anaerobic Digester Foaming: occurrence and control in Spain

Ignasi Rodríguez-Roda[1,2], Maria Casellas[1], Elvira César[3], Laura Pastor[3], Eduard Moliné[3], August Bonmatí[4], Bhargavi Subramanian[5], Krishna Pagilla[5]

[1] ICRA, Catalan Institute for Water Research, Carrer Emili Grahit, 101, Parc Científic i Tecnològic de la Universitat de Girona, E-17002 Girona, Spain. (*E-mail:irodriguezroda@icra.cat; mcasellas@icra.cat*)
[2] LEQUiA, Laboratory of Chemical and Environmental Engineering, University of Girona, Campus Montilivi, E-17071 Girona, Spain. (*E-mail: ignasi.rodriguezroda@udg.edu*)
[3] DAM, Depuración de Aguas del Mediterráneo, Spain. (*E-mail:elvira.cesar@dam-aguas.es; laura.pastor@dam-aguas.es*; *eduard.moline@dam-aguas.es*)
[4] IRTA, GIRO Joint Research Unit IRTA-UPC, Torre Marimon, E-08140 Caldes de Montbui, Barcelona, Spain. (*E-mail: august.bonmati@irta.cat*)
[5] IIT, Illinois Institute of Technology, Chicago, USA. (*E-mail:bsubram3@IIT.edu; Pagilla@IIT.edu*)

Abstract
Anaerobic digestion (AD) has gained importance in Spain due to increased interest in biogas production and for reducing solids residuals quantities from wastewater treatment plants. The major bottleneck of AD due to biological foaming has been surveyed in AD plants in selected plants of Spain. A total of 44 plants were sent the surveys, 38 plants responded to the survey, and 23 plants reported incidence of AD foaming. The frequency of AD foaming ranged from seasonal (7 plants), intermittent (13 plants), and persistent (3 plants). The AD foaming causes included feed sludge characteristics and operating factors. The most common control technologies implemented include use of defoamers, uniform sludge feeding, and optimized mixing. The linking of the primary cause to a specific control technology or more than one could not be determined from this survey and could be useful for future work at full scale. Vilanova i la Geltrú WWTP full scale was studied more in detail. The main cause of AD foaming events is attributed to high levels of gas production with insufficient surface area for gas to escape the liquid volume. This was mitigated by controlling the percentage of PS and WAS, consequently reducing the %VS going to the digester. This plant has ultrasound WAS pretreatment process whose effect on AD foaming is being investigated.

Keywords
Anaerobic Digestion; Foaming; Causes; Control; Survey

INTRODUCTION

Anaerobic digestion (AD) in municipal wastewater treatment is of great importance for sludge management all over Europe, not only in Spain. The recent implementation of CHP (combined heat &power) engines for energy recovery has increased the interest in maximizing biogas production. AD is the energy production center of a wastewater treatment plant (WWTP) and has the potential to make WWTP energy self-sufficient. However, any bottlenecks to AD must be eliminated prior to the realization of this potential. For example, the incidence of foaming in AD is a major bottleneck. The implementation of longer sludge retention time (SRT) for biological nutrient removal (BNR) has increased the incidence of digester foaming due to Microthrix parvicella and nocardioforms. In spite of some work on AD foaming, both through research and full scale practices, definitive methods for foam prevention and mitigation have not been confirmed and foaming remains a ubiquitous operational problem in AD.

Due to the lack of data on AD foaming from Spanish municipal full scale facilities, ICRA and DAM joined the *Water Environment Research Foundation (WERF) – Wastewater Treatment Anaerobic Digester Foaming Prevention and Control Methods* project to further investigate AD foaming in Spanish WWTPs. The main objectives were i) to complement the US experience and compare the investigation of mechanisms of foaming in anaerobic digesters based on full scale experience, ii) synthesize current prevention methods and control practices to determine gaps in the knowledge base and to obtain best practice(s) for implementation, iii) investigate methods to overcome the gaps and the best practices at different full scale test facilities for their effectiveness, and iv) develop a systematic guidance document for WWTP industry use. Case studies in Spain can provide useful information based on different wastewater characteristics and specific operation and control practices.

ANALYSIS OF SURVEY RESPONSES AND DISCUSSION

Causes of Foaming

A survey was developed and administered to AD plants in Spain to determine the occurrence of AD foaming and methods used to determine causes, effects, and prevention/control. A total of 38 WWTPs responded to the survey in Spain when 44 plants were request to participate in the survey. The Spanish survey was similar in content to with respect to the requested information on identified causes of foaming, control methods, and impacts as in the USA survey. Table 1 below summarizes the causes of foaming reported by the survey respondents, where 23 out of the 38 plants reported incidence of AD foaming in their respective plants. Out of the 23 plants reporting AD foaming, 7 plants experienced seasonal incidents, 13 plants experienced intermittent foaming throughout the year, and 3 plants experienced persistent foaming. Only 2 out of the 7 plants reporting seasonal foaming identified it to occur in winter.

Table 1. Most Common Reported Causes of AD Foaming (Spain).

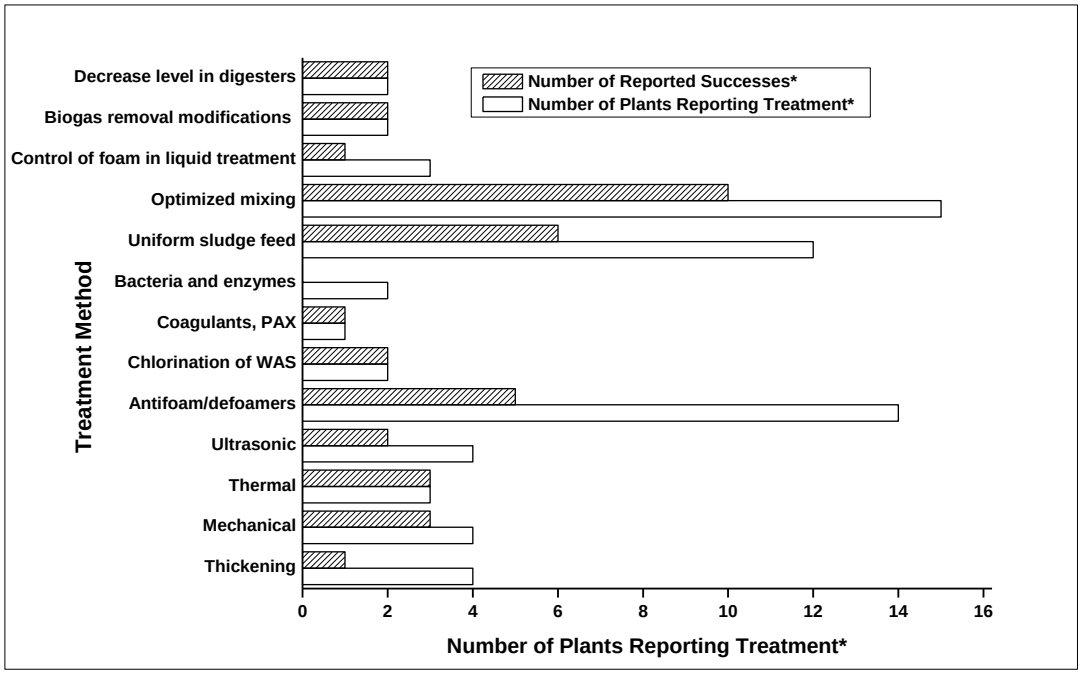
Cause of Foaming	Plants Reporting Foaming (% of 23)	Comments
Filaments	**26**	Nocardia &*Microthrix*, both filaments are present in one plant
Unknown	**26**	Cause was not identified
Overloading	**22**	Organic (VS) loading rate (OLR)
Sludge Feed Characteristics	**13**	Surface active agents in feed – two plants; FOG in feed – one plant
Digestion Process Related	**9**	Reported Cause: Gas production - one plant; high VFA in feed – one plant
Operational Causes	**4**	Foam due to BNR operation

As can be seen from Table 1, the causes of foaming cited were numerous, although it was not possible to determine from the survey whether it is a primary cause or a contributing factor to AD foaming. Hence, all the causes listed in foaming could be additive or synergistic in increasing foaming incidence in these plants. The plants which stated that the cause of AD foaming was unknown or due to BNR operation may have been due to a causative agent such as

foaming filaments in the feed sludge and/or surface active materials. This needs to be determined at selected AD WWTPs.

Foaming Control Methods

The control methods seen in literature as well as the survey responses can be divided into (a) Sludge Disintegration Methods, (b) Operational Modifications, and (c) Chemical Antifoaming Agents. The results from the survey regarding foam control/mitigation methods are reviewed in Figure 1.



***Note: plants were asked to list/select all methods they may have used. NA indicates results not known after the treatment method was implemented by the plants.**

Figure 1. Effectiveness of Reported Treatment Methods

VILANOVA I LA GELTRÚ CASE STUDY SUMMARY

The WWTP of Vilanova i la Geltrú treats an average of 3.7 MGD, where 80% comes from domestic and 20% from industrial flow, mostly lubricants from a metallic cast company using greases, oils and solvents, 24 hours/day and 365days/year. The plant also receives septage wastes, all introduced at the headworks. The biological process is an activated sludge system without nutrient (N and P) removal. Part of the waste activated sludge (WAS) flow from the secondary clarifier is treated in an ultrasound process. Then the primary sludge (PS) together with the WAS goes to a mixed PSWAS holding tank. The holding tank is mixed mechanically and has an average composition of 60% PS and 40% WAS. The first AD foaming event was attributed to start-up of the digester. The second event was in 2008, when very high biogas flows were observed. Similarly, one month before the third foam event, biogas production was almost double that of the baseline period in 2010, attributed to overloading of digester (53% no Ultrasound treated WAS, 22% of ultrasound pretreated WAS, and 25% primary sludge). Distribution of type of sludge to digestion (PS, WAS no ultrasound, WAS ultrasound), Volatile acids (VFA) concentration, OLR, biogas production/sludge and % of volatile solids (VS) before

and after foaming events will be presented in the conference and/or the extended version of this manuscript.

SUMMARY OF SURVEY RESULTS AND FUTURE STUDIES

The following results are the most common causes of AD foaming in this survey of Spanish WWTPs and they will be further evaluated in selected full scale plants in the future. Preliminary conclusions about Vilanova i la Geltrú WWTP case study is also listed:

1. The presence of foam causing filaments is the most common cause of foaming.
2. The second most common reported cause of foaming was an operating problem of organic overloading to the digesters.
3. Sludge feed characteristics, the presence of surface active materials or fats and an oils coming from industries in the feed to the digester produce foaming events.
4. It is significant to identify that there are still unknown causes of foaming reported (5 plants).
5. Most of the causes reported in Spain are similar to the ones in USA and could be classified into feed sludge and operational characteristics.
6. It is important to notice the relationship of cause and foaming effect identified in Spain when biological nutrient removal processes are added to the facility.
7. The control methods used in Spain are: i) sludge disintegration ii) chemical methods and iii) modification of operations to lessen AD foaming.
8. Impacts of foaming events are caused in many WWTPs, but are not well quantified yet.
9. The potential cause of foaming in Vilanova i la Geltrú WWTP is attributed to the amount of WAS solids that are digested and no further degradation occurs when fed into the anaerobic digesters. This inert VS in the feed could be a contributing factor in causing/maintaining the foaming in the AD.
10. In the three foaming events in Vilanova i la Geltrú WWTP, the OLR was very stable and within operating range. The VFAs were also stable and VA/Alkalinity ratio within acceptable levels, indicating overloading and fermentation leading to acid formation in the mixed tank were not possible causes of foaming.

REFERENCES

van Niekerk,A.; Kawahigashi, J.; Reichlin, D.; Malea, A.; Jenkins, D. 1987. Foaming in anaerobic digesters – Asurvey and laboratory investigation, *Journal of the Water Pollution Control Federation*. **59**, 249-253.

Ganidi, N. 2008.*Anaerobic digestion foaming causes.*Ph.DThesis.The University of Cranfield, UK.

Dalmau, J.;Comas, J.; Rodríguez-Roda, I.; Pagilla, K.; Steyer, J. 2010. Model development and simulation for predicting risk of foaming in anaerobic digestion systems. *Bioresour.Technol.* 101, 4306-4314.

Subramanian,B.; Wold, D.; O'Dell,S.; Poole, A.; Hunter, J.; Pitt, P.; Sharp, R. 2012 Survey of causes and prevention/control of anaerobic digester foaming – A WERF study. In: *Proc. of the annual water environment federation technical exhibition and conference,* New Orleans, USA, Oct. 1–3.