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Survey of Causes and Control of Anaerobic Digester Foaming- A WERF Study

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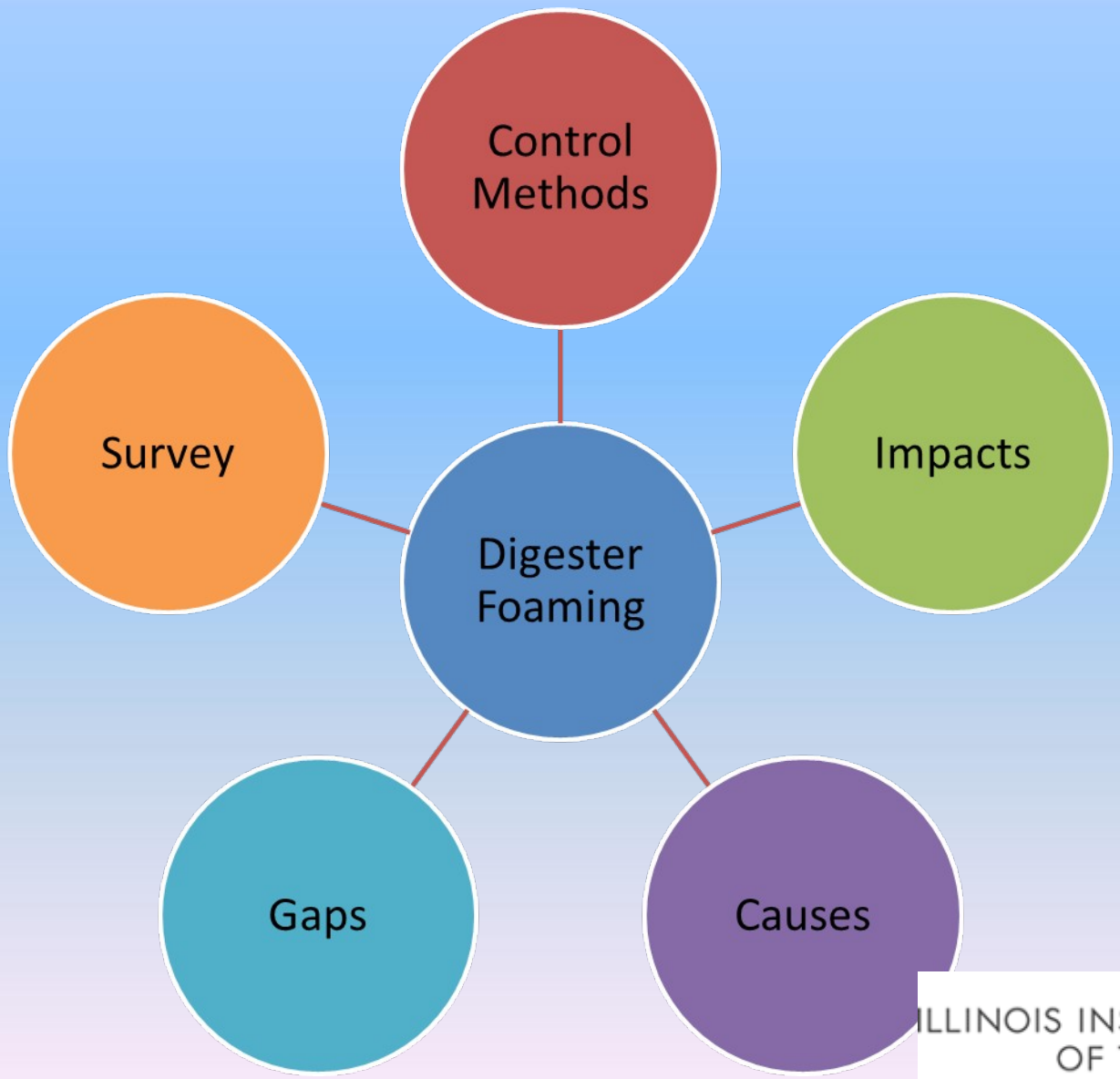
Presentation Outline



Approach

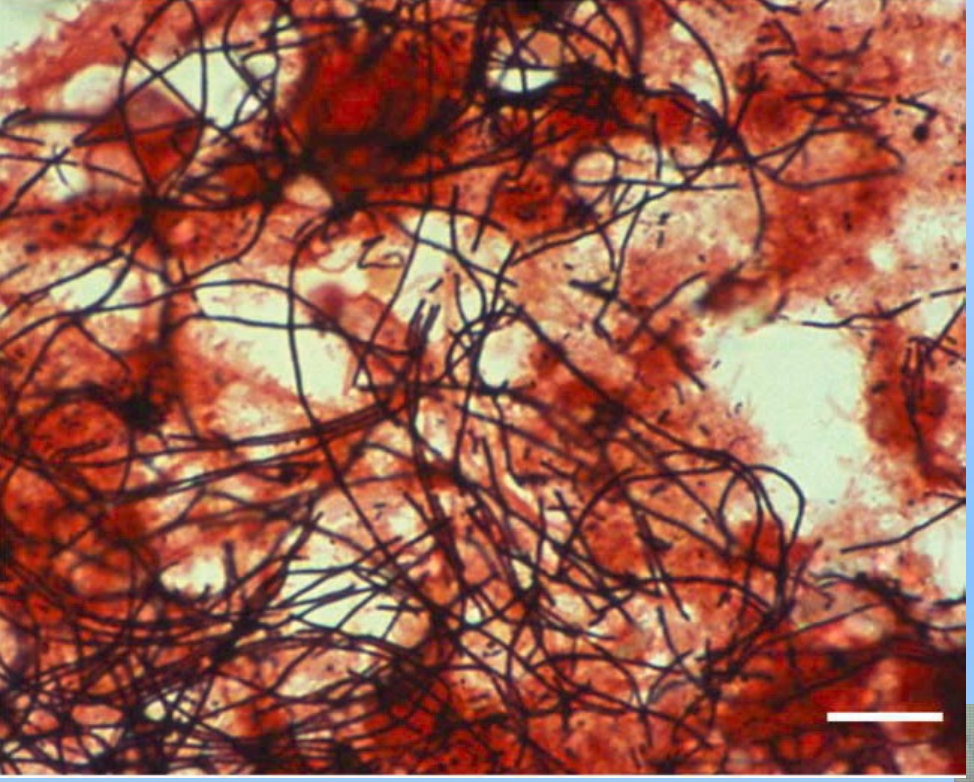
1. Literature Study to Identify State-of-the-Art and Gaps/Needs in Knowledge
2. Plant Survey – Reconcile Literature Gaps with Survey Responses

Foaming Causes & Contributors

Classification	Causes
Sludge feed characteristics	Surface active agents in feed
	Foam causing filaments in feed sludge
Digestion process-related characteristics	Organic loading aspects – overload and inconsistent loading
	VFA production - Imbalances between the successive hydrolysis, acidogenesis and methanogenesis
	Gas production
Digester operating conditions	Temperature, pH, Alkalinity
	Mixing
Digester configuration, shape and physical features	Digester shape and configuration
	Sludge withdrawal and gas piping

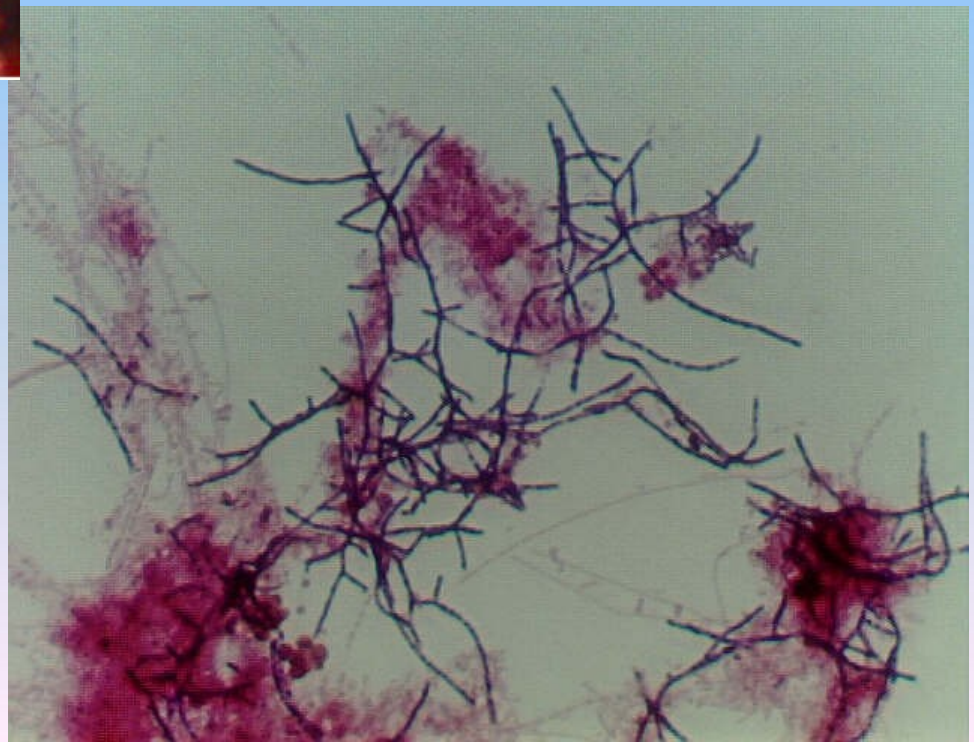
Feed-Based Characteristics

- Feed Quality - affect surface activity of digester contents
  - Proteins
  - Lipids (FOG)
  - Detergents
    - Degradation of the nonionic detergents was 27% and anionic was 7%.
    - Filaments - *Microthrix parvicella* and *Gordona amarae*
  - stabilize gas bubbles in the digester due to their surface active nature
  - produce EPS that add to the total surface active material in the digester.



M. parvicella – Gram Stained. Bar is 10µm.

Rossetti et al., 2004.

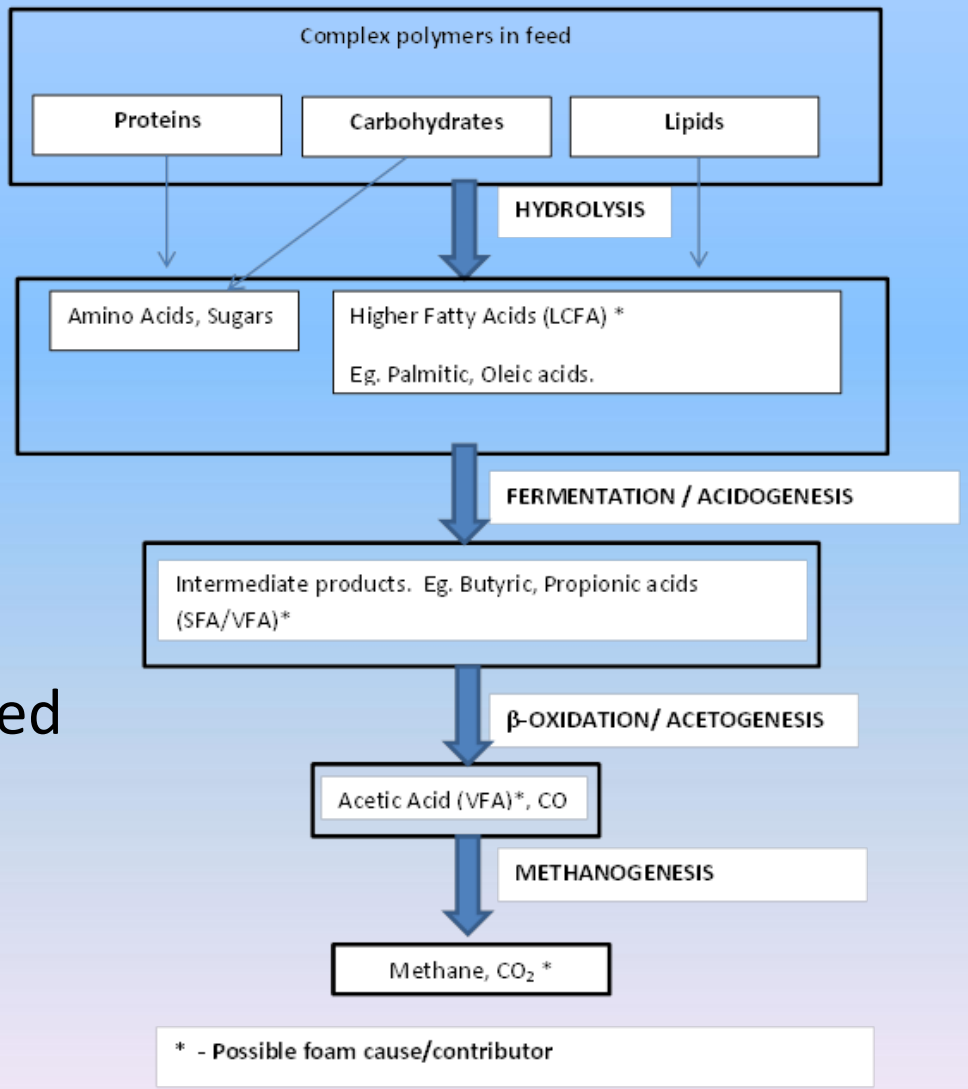


Nocardia or NALO - Gram stained - 1000x

Nielsen PH et al., 2002.

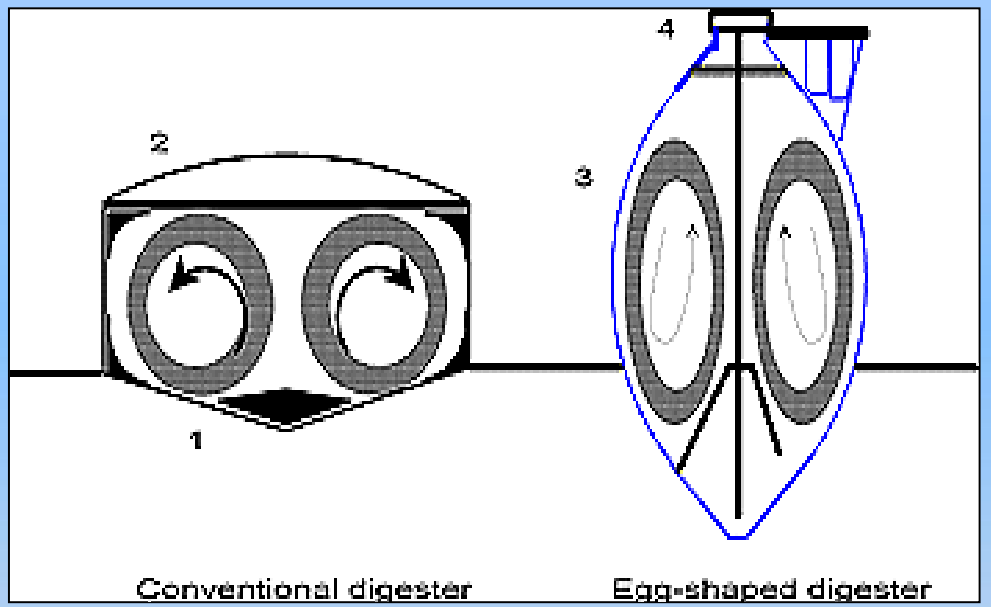
Digestion Process-Related Causes

- Formation of surface active agents in digester
  - EPS (biosurfactants)
  - VFA
  - Quantity of feed (OLR) & inconsistent feed
- PS:WAS solids in digester feed
- Gas production



Digester Physical Features and Operational Causes

- Physical Features
  - Digester Shape
    - ESD vs. cylindrical
    - Sludge withdrawal
    - Hydraulic vs. valve methods
    - Gas collection piping
  - Operational Causes
    - Temperature
    - Mixing (intended/unintended)
      - Type – gas or mechanical
      - Power and/or frequency



Currie, 2004; Wu, 2010.

PREVENTION AND CONTROL OF FOAMING

- Sludge Disintegration Methods
- Operational Modifications to Prevent/Control Foaming
  - Control of the secondary treatment process and associated WAS
  - Control of the feed sludge storage and feeding
  - Control of the digester physical features
- Chemical Antifoaming Agents for Foam Control
  - Antifoams/Defoamers (Eg. Tramfloc,Fibrochem)
  - Coagulating Salts and Polymers (Eg. PAX-14)
  - Chemical Oxidants (Eg. Chlorine, H_2O_2)

Impacts of Foaming

- Reduced active volume - lowered gas production and VS destruction.
- Tank mechanical and structure failure
- Cleaning piping and foam overflows
- Short-circuiting of pathogens

Classification of Impacts

- Qualitative Impacts
  - Performance Related Impacts
  - Operational Impacts
  - Regulatory Impacts
- Economic Impacts – Not available

Selected Identified Knowledge Gaps

- Surface active compound threshold concentrations
- Optimum ratio for PS to WAS in digester feed
- In the case of combined sludge,
  - (a) effect of holding tank residence time on foaming,
  - (b) effects of mixing primary sludge & WAS in storage - increased HRT and VFA production
- Feed microbiological thresholds and generation of surface active compounds by filaments

Identified Knowledge Gaps

- Effects of
  - feed rate on instantaneous gas production and withdrawal rate and foaming
  - defoamers/antifoams on foaming and digester performance
- Economic impacts due to AD foaming in full scale plants

SURVEY OF FULL SCALE PLANTS

Objectives :

- To determine the current status of full scale AD foaming in WWTPs.
- Obtain information beyond available in the published or grey literature.
- Reconcile gaps found in published literature with these full scale plants.

SURVEY - OVERVIEW

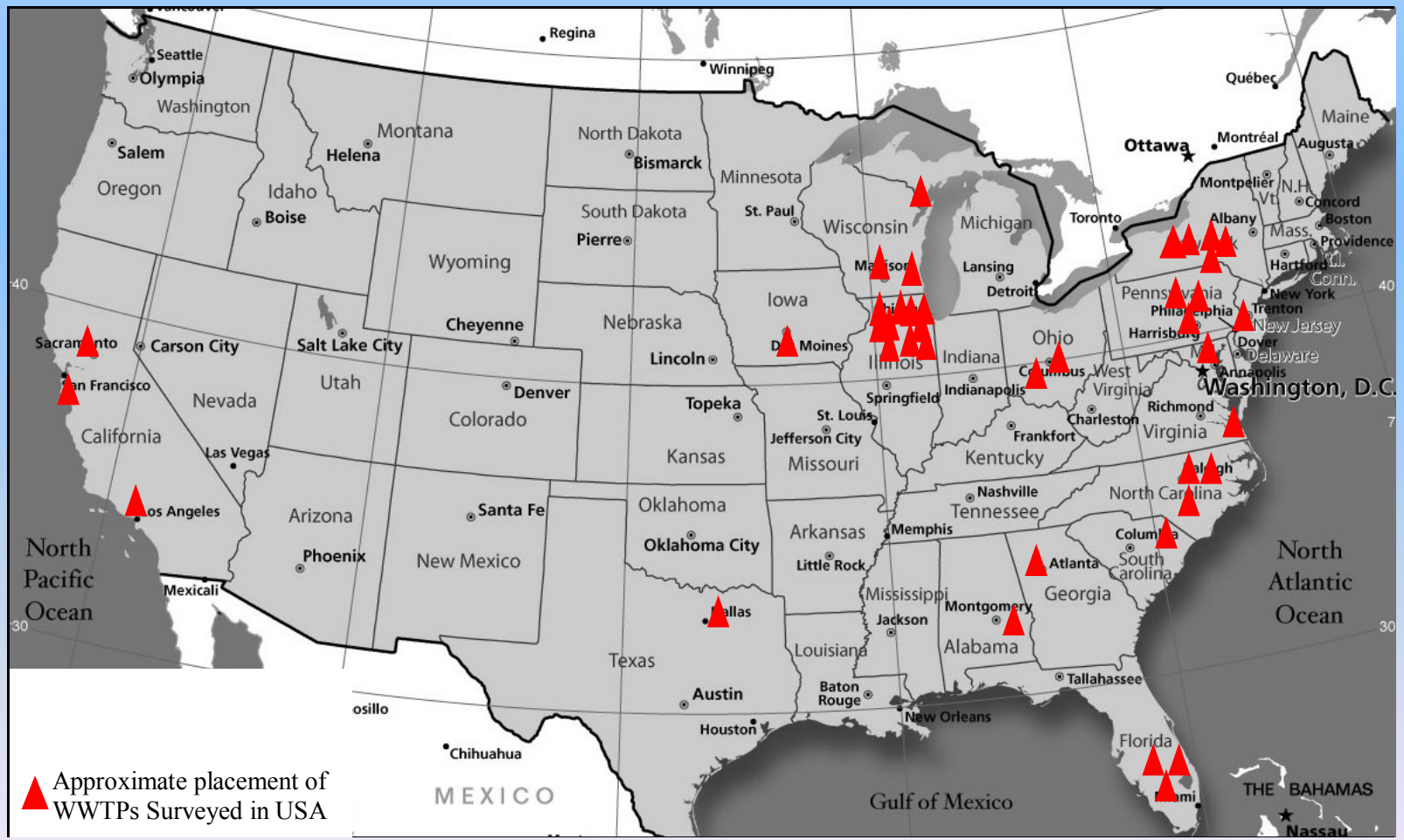
- Total 77 plants
  - 39 in the USA; 38 in Spain
  - Plants in USA - Envirofacs and prior foaming knowledge.
  - Plants in Spain - ACA (Catalan Water Agency) and the rest by DAM (Depuración de Aguas del Mediterráneo).
  - Number of plants foaming

    USA - 32

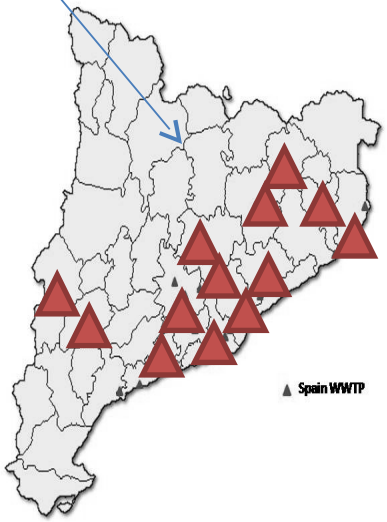
    Spain – 22

    - Questionnaire based on our literature review
    - Knowledge gaps reconciled with survey responses
  - Full scale study parameters

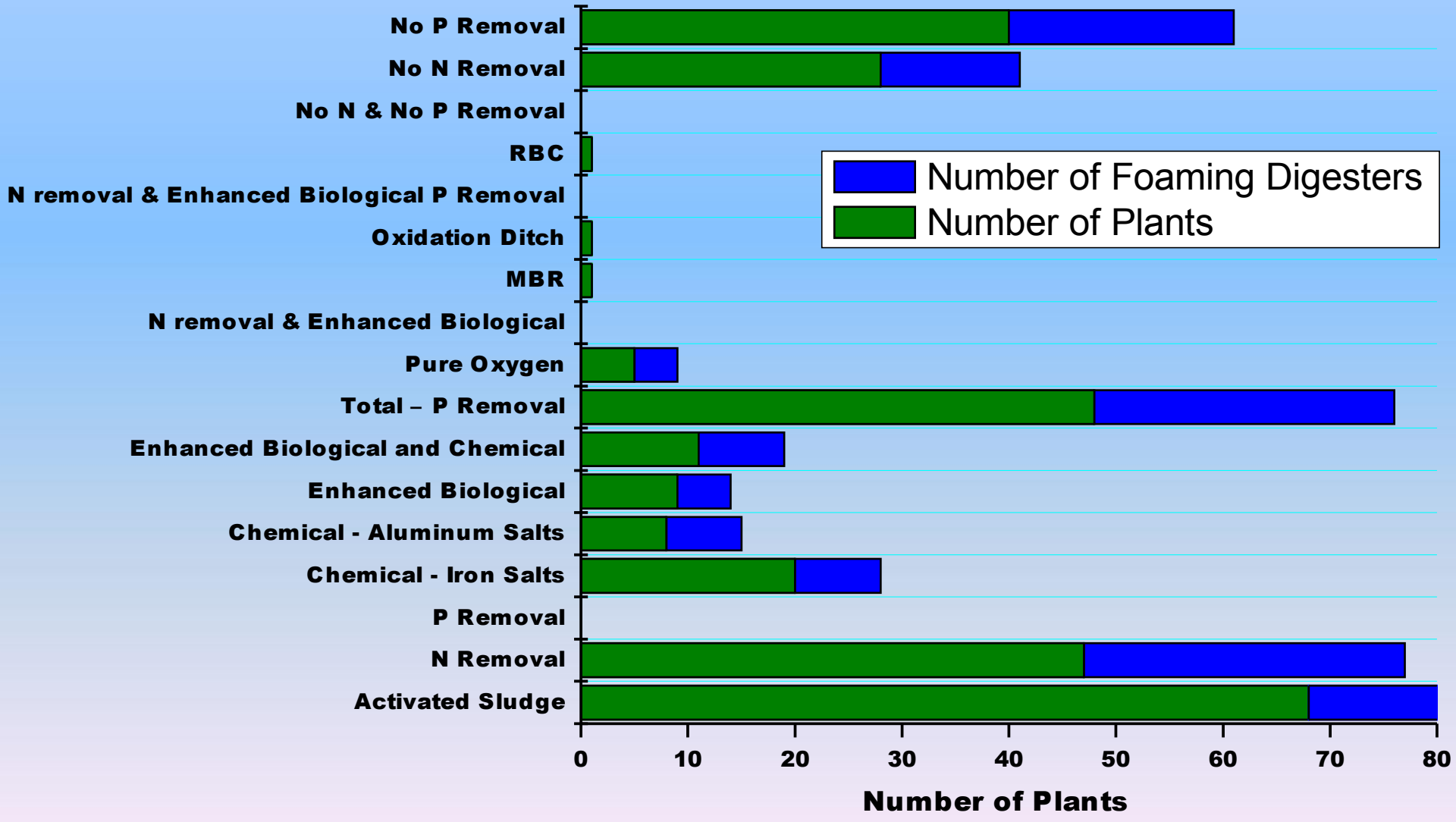
Map of US Utilities Surveyed



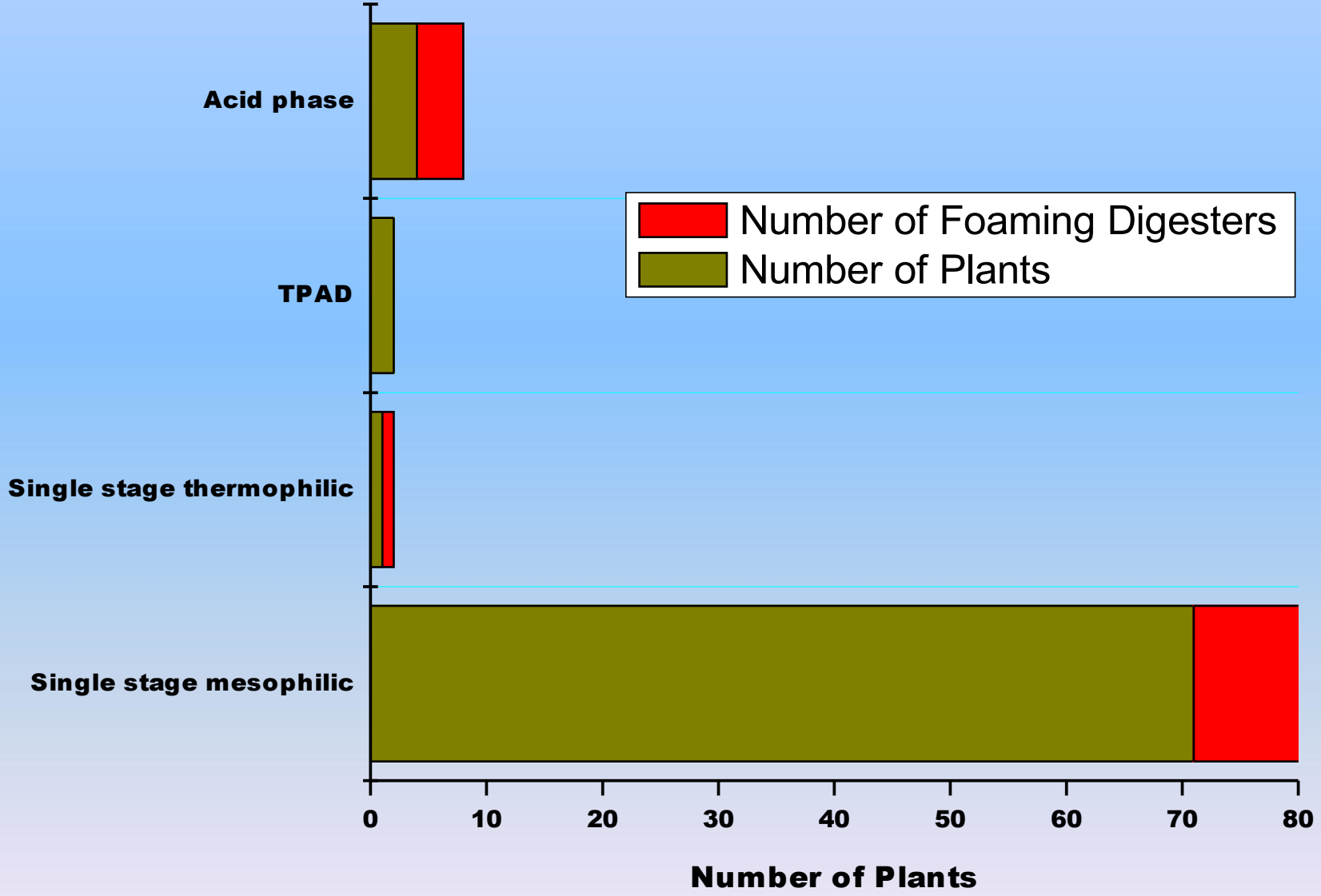
Map of Spanish Utilities Surveyed

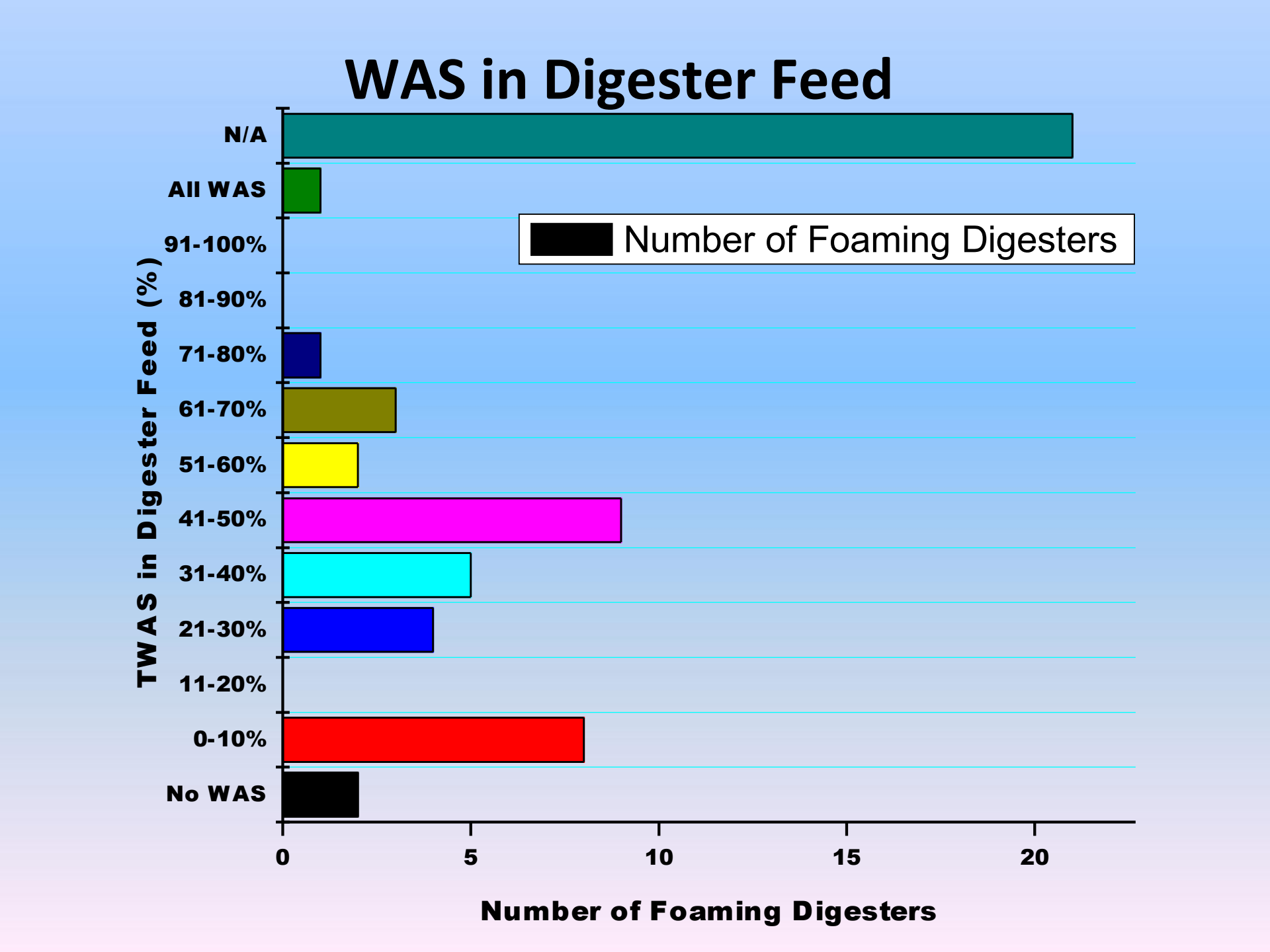


Type of Secondary Process & Foaming

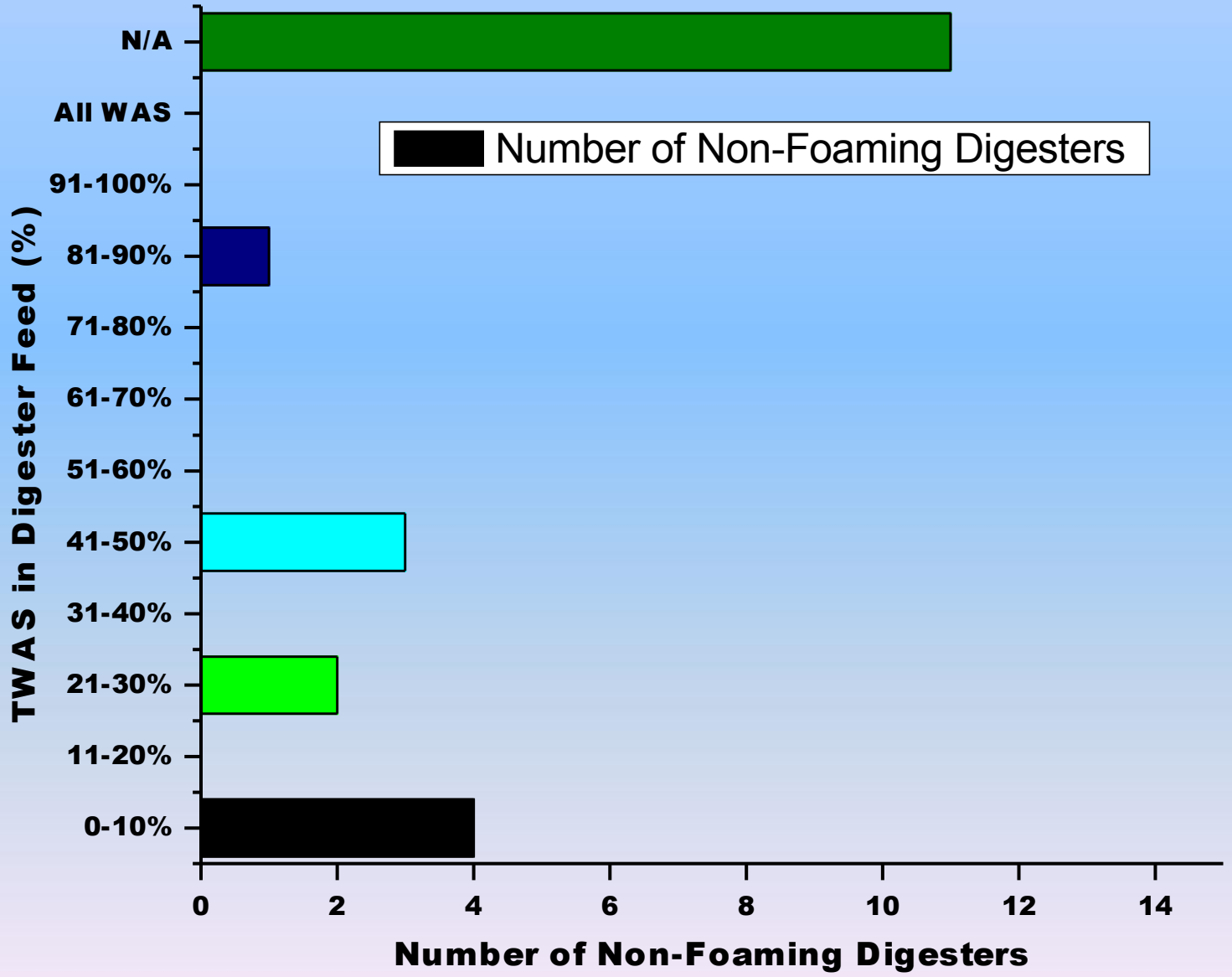


Digester Configuration

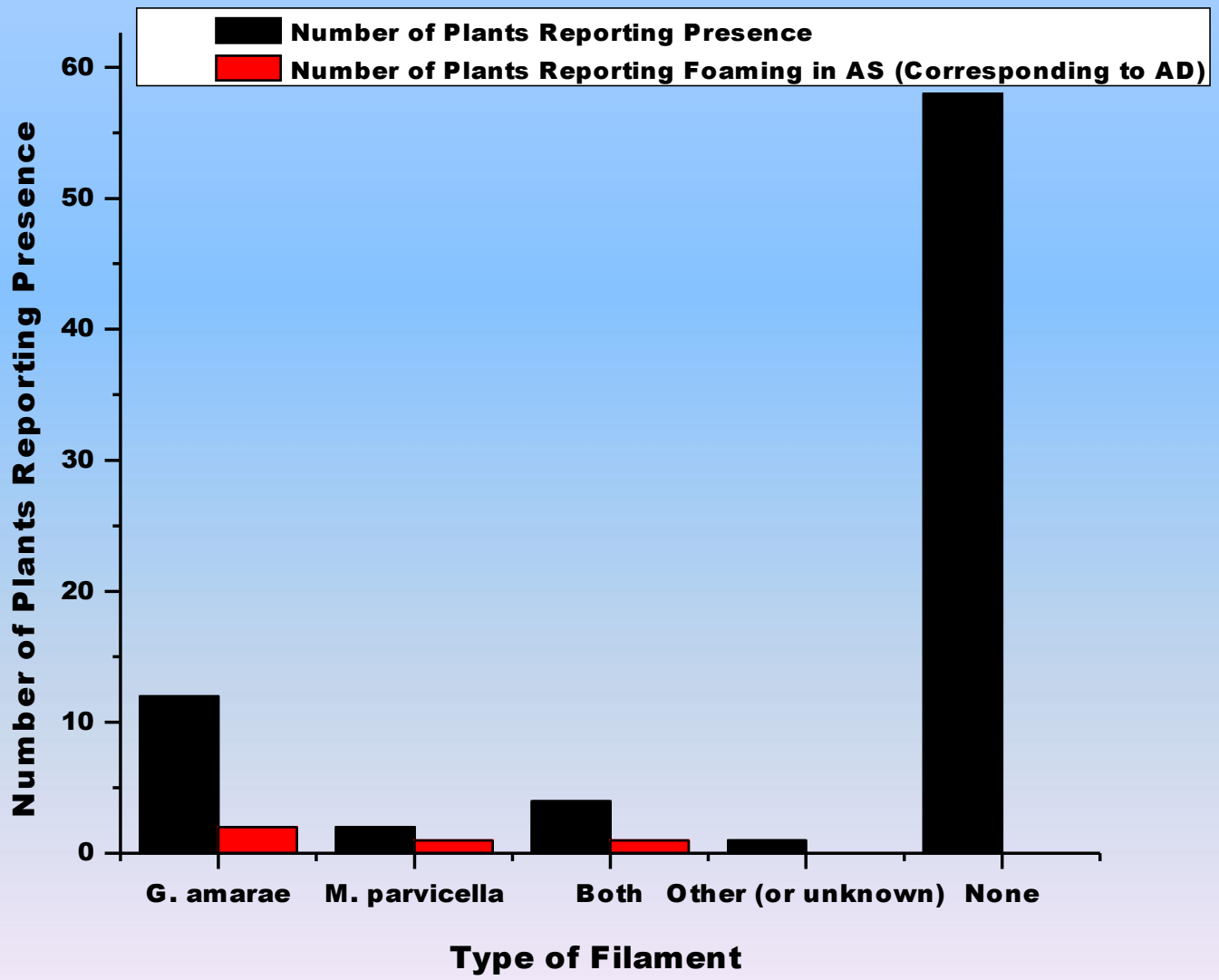



WAS in Digester Feed
N/A
All WAS
91-100%
81-90%
71-80%
61-70%
51-60%
41-50%
31-40%
21-30%
11-20%
0-10%
No WAS
TWAS in Digester Feed (%)
Number of Foaming Digesters
0
5
10
15
20
Number of Foaming Digesters

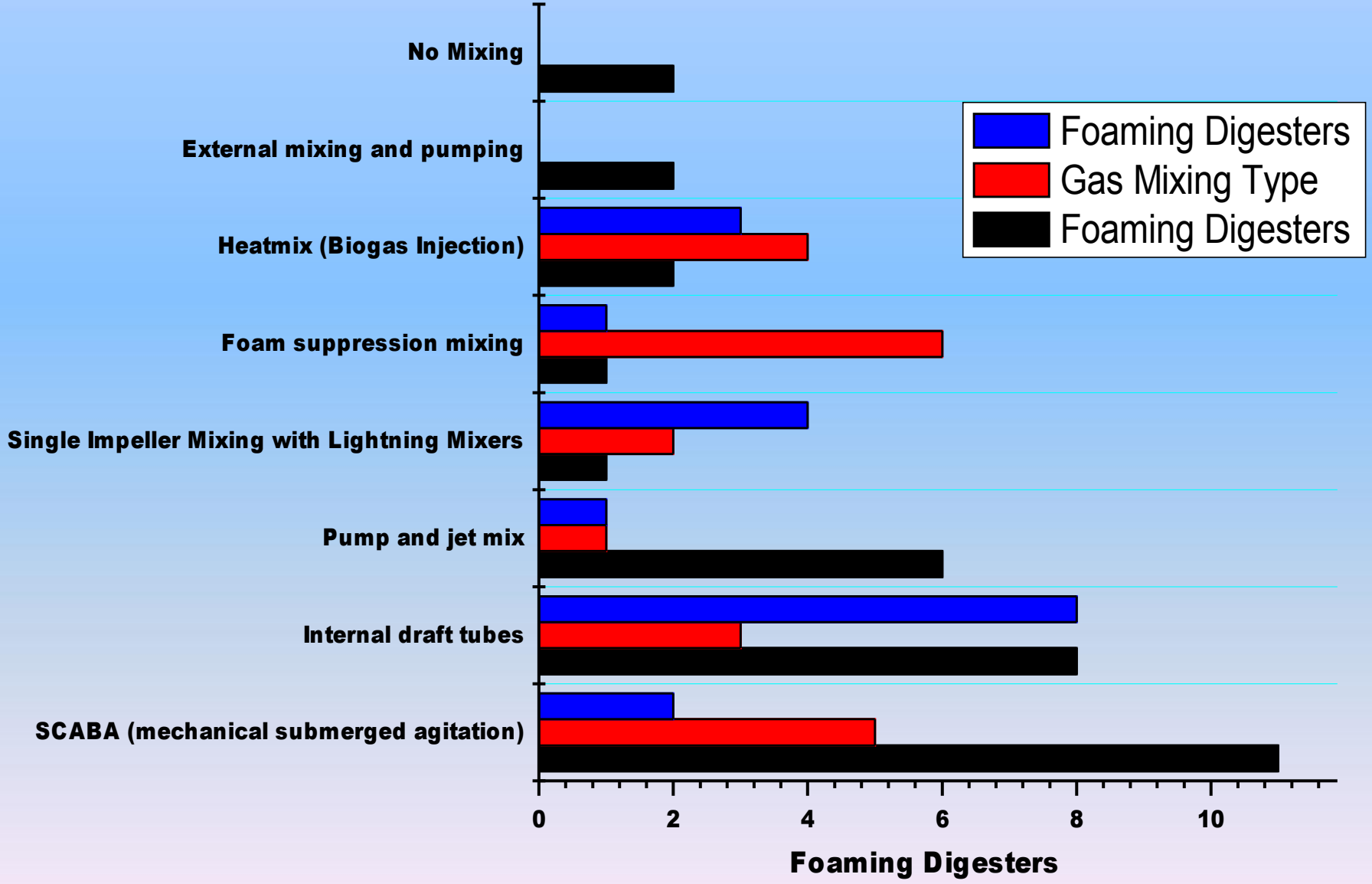
WAS in Digester Feed



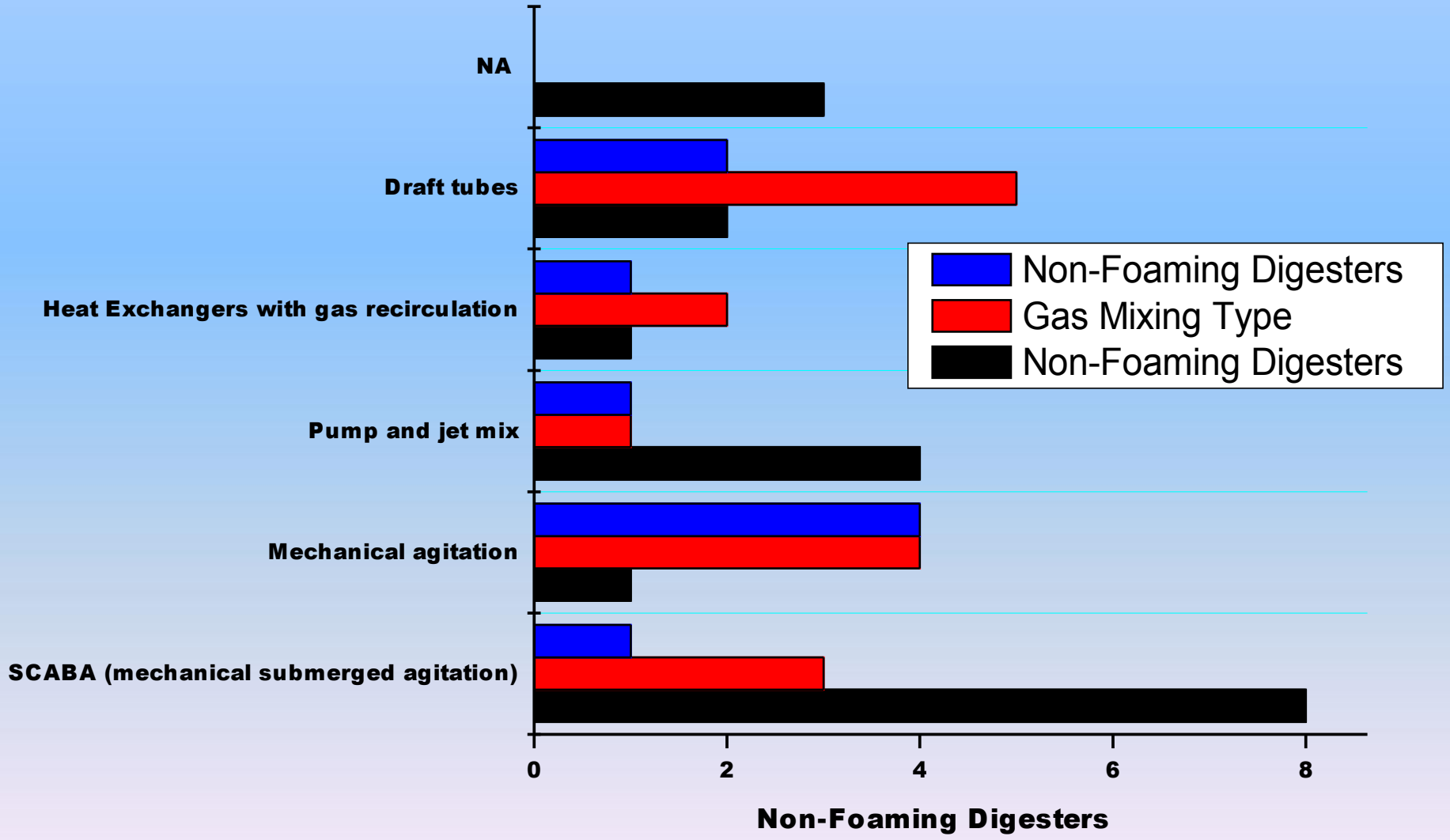
Presence of Filaments



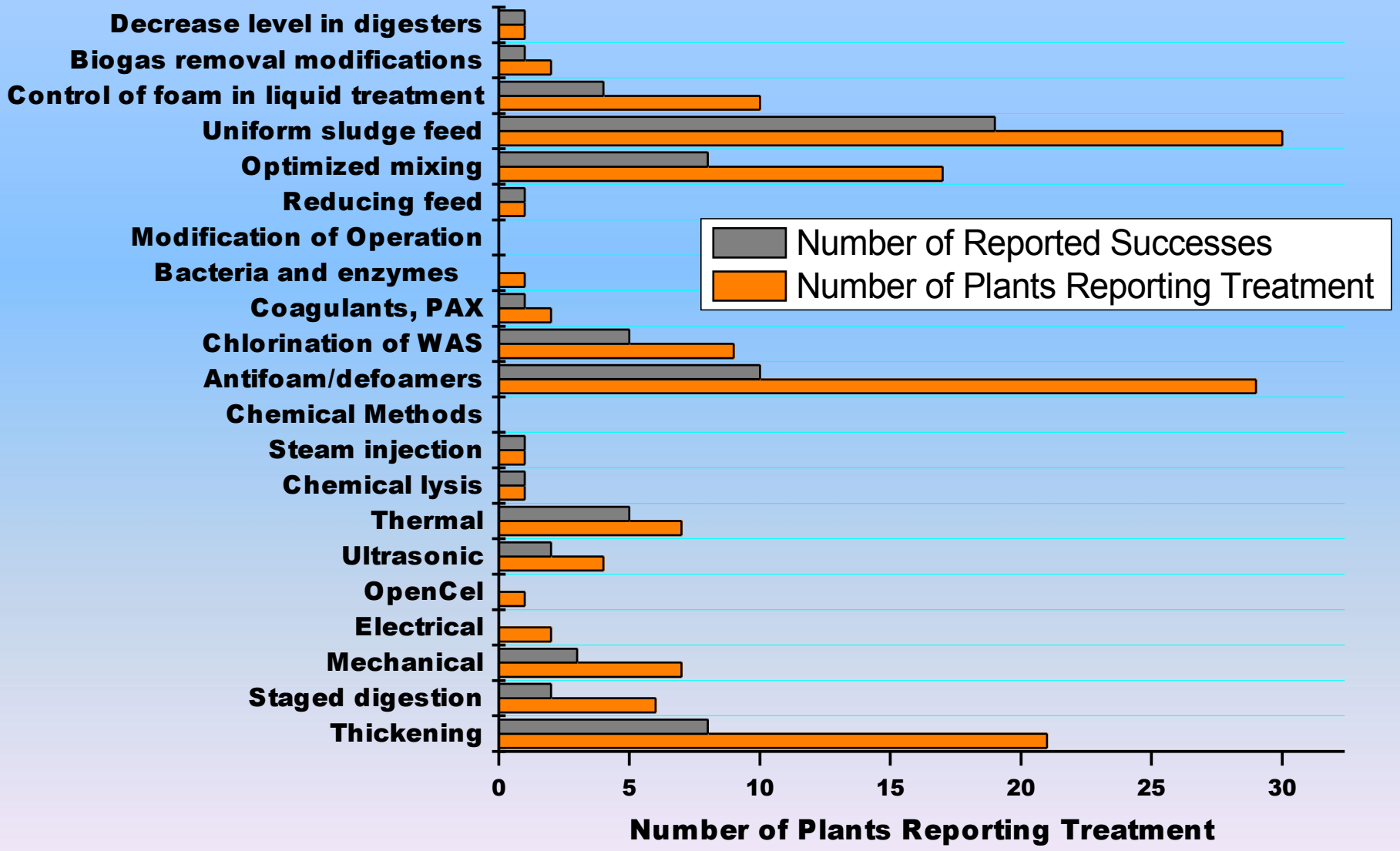
Types of Mixing



Non-Foaming Digesters



Control Methods



Interim Observations from Survey Responses

- Most common reported cause is the presence of filaments.
  - Foaming thresholds for the filaments is much lower in the anaerobic digesters than in activated sludge.
- The second most common reported cause of foaming was feed sludge quality and the presence of FOG and other surface active materials in the feed to the digester.
- Relationships between surface active material in feed sludge, point of introduction in the treatment stream and foaming – N/A.
- Differentiate between the causes and contributing factors to the foaming episodes in the plants surveyed – N/A
- No conclusive trend in %WAS in feed could be established.
- No conclusive trend established between mixing types.

Full Scale Study Parameters

- Modifying WAS in digester feed to determine the effect of PS:WAS ratio, particularly in the plants not experiencing filamentous foaming.
- Modifying different OLRs for full scale digesters in an attempt to determine threshold loading rates for each digester is necessary.
- Frequency of feed and mixing of digesters concurrently .
  - Areas of localized overloading near the feed inlets if fed only for a certain period of time in a day, not mixed during the feeding.
  - Survey reported utilities were successful in controlling foaming with antifoams, which will be tested in a full scale plant in this study.