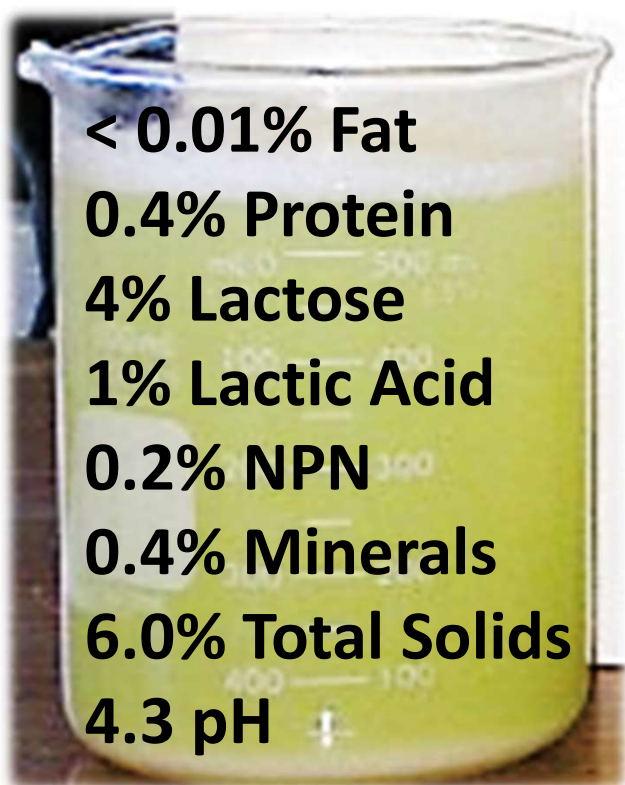


Anaerobic Digestion for the Treatment of Acid Whey and Other Dairy Manufacturing Waste

Brandon Nelson
Daisy Brand
Director-Innovation & Technical Services

Acid Whey





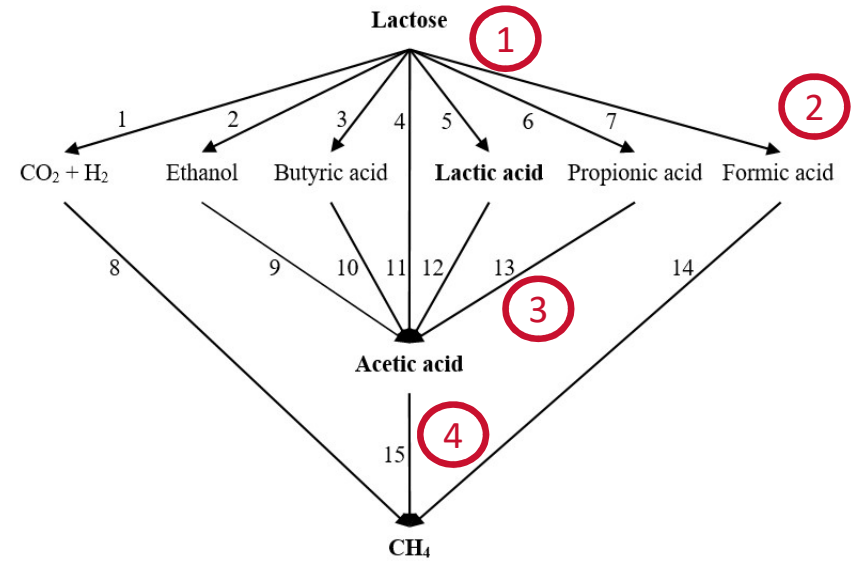
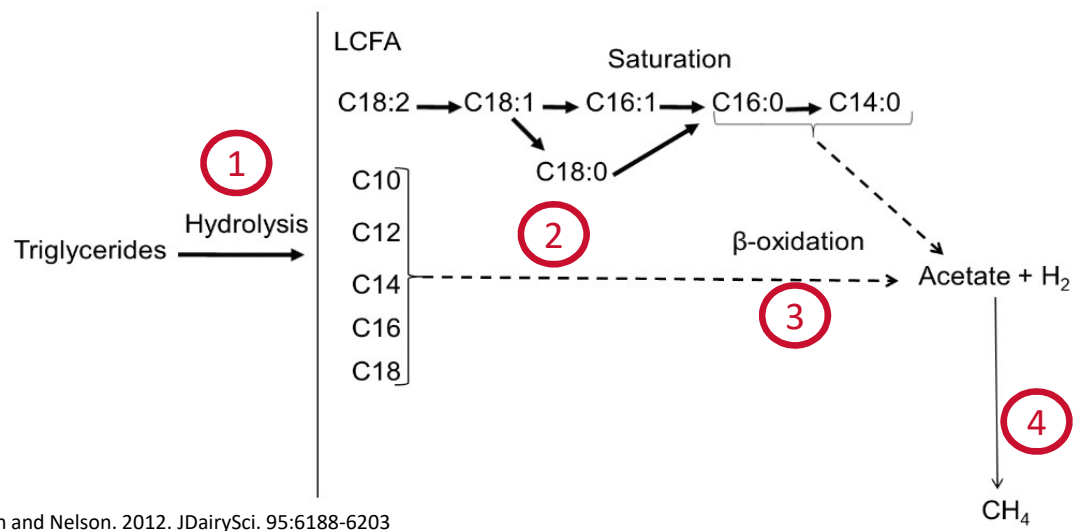
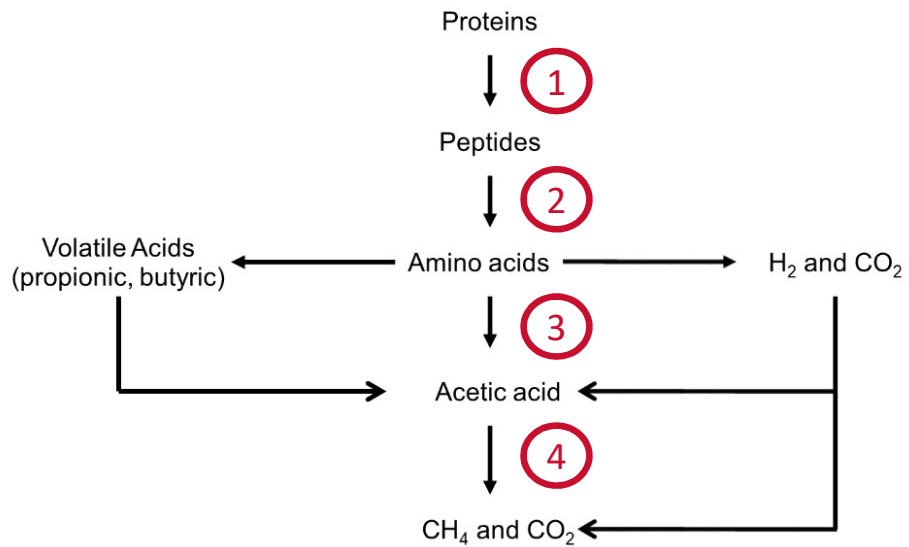
Aerobic Treatment

- Effluent BOD is lower
- Fast organism growth
- Energy intense
- Much higher biomass

Anaerobic Treatment

- Odor can be an issue
- Economical
- Smaller space requirement
- CH₄ can be used to generate electricity or replace natural gas
- Higher alkalinity requirement
- Complicated
- Temperature control is more critical

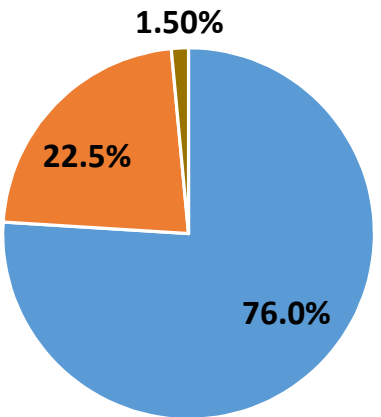
Dairy Food Waste to CH₄



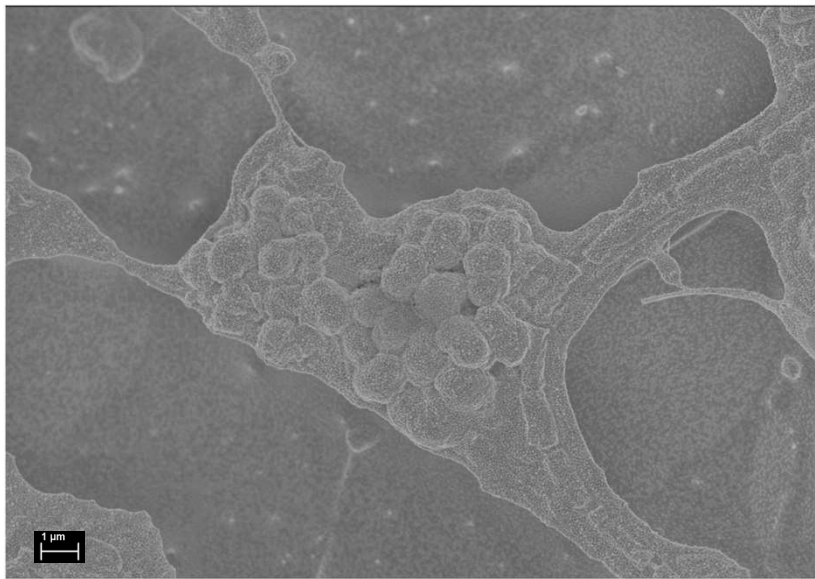
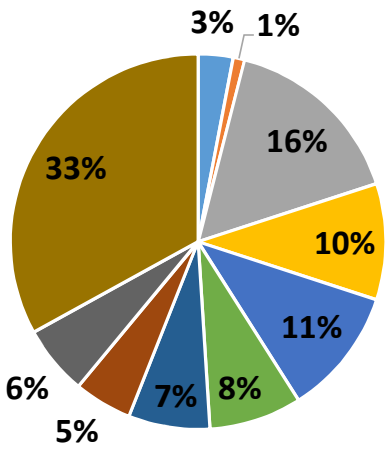
Hassan and Nelson. 2012. JDairySci. 95:6188-6203

Organisms

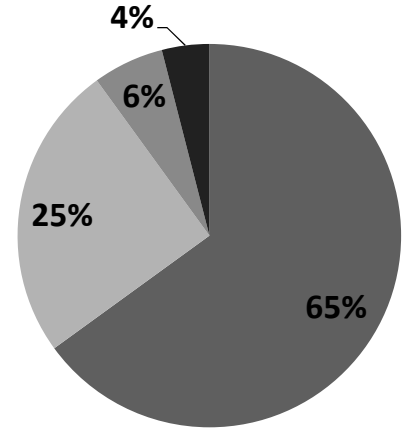
Acid Whey/Plant Dairy Waste



Sludge



Sludge (Archaea)



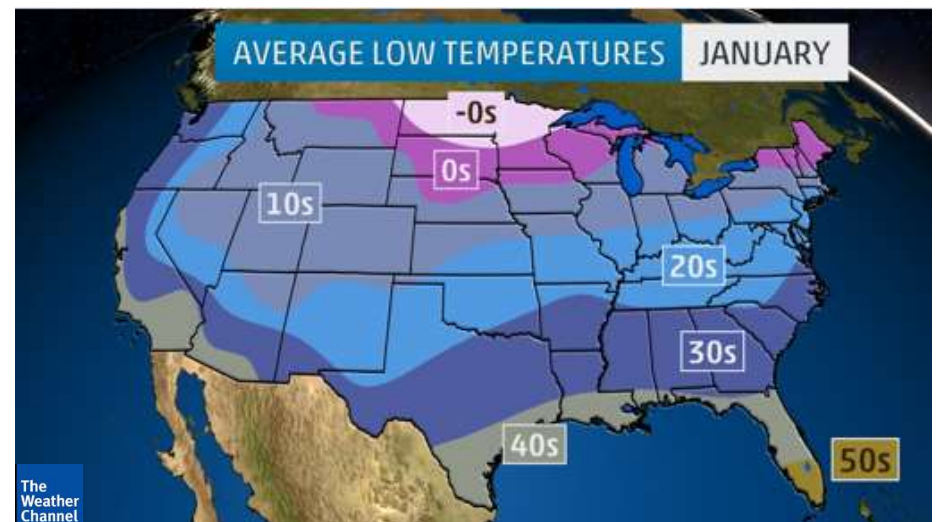
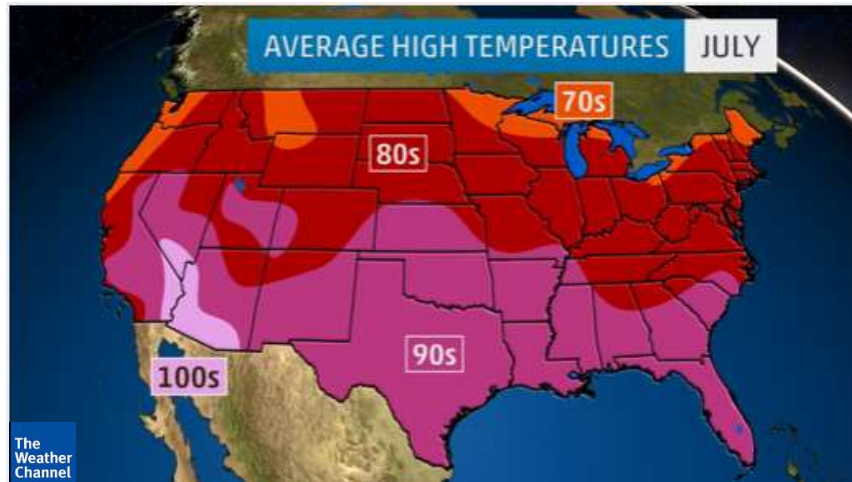
- Methanosaeta
- Methanobacterium
- Methanobacteriales WSA2
- Other

- Lactobacillus
- Lactococcus
- Thermodesulfobivriaceae
- Actinomycetaceae
- Kosmotoga
- Anaerolineae
- Geobacter
- Anaerolinaceae
- Bacteroidales
- Other

pH



Temperature



Retention Time



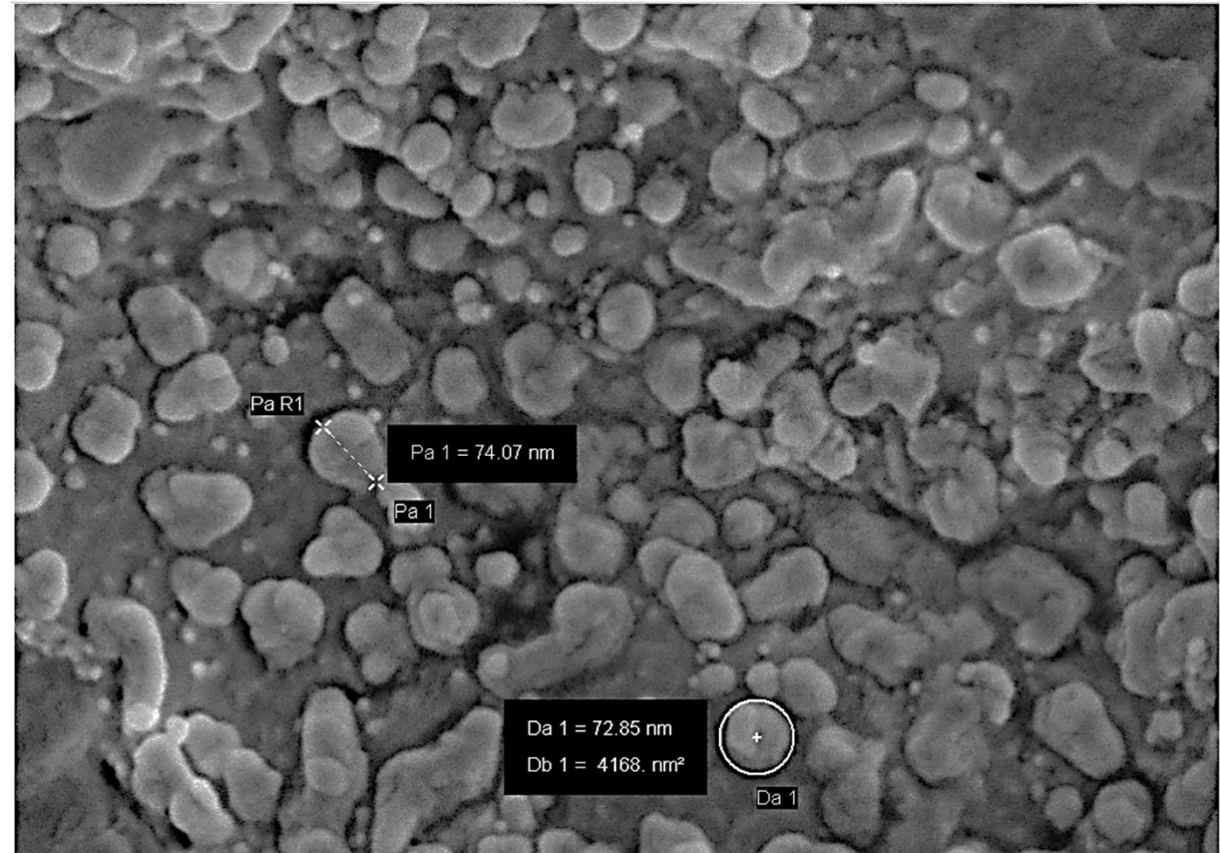


Minerals Needed

- Ni, Co, Fe, Zn, Mo

Problems

- $\text{Ca}_5(\text{PO}_4)_3\text{OH}$
- CaCO_3
- $\text{NH}_4\text{MgPO}_4 \cdot 6\text{H}_2\text{O}$





Requirements for Success

- Maintain temperature
- Prevent air incorporation
- Handle continuous and variable feed rates
- Retain organisms
- Support acidogenesis
- Support methanogenesis
- Capacity for HRT
- Continuous gas removal without disrupting operation

Anaerobic Attached Fixed Film Expanded Bed

Anaerobic Rotating Biological Contact Reactor

Anaerobic Moving-Bed Biofilm Reactor

Continuously Stirred Tank Reactor

Downflow Stationary Fixed-Film Reactor

Downflow-Upflow Hybrid Reactor

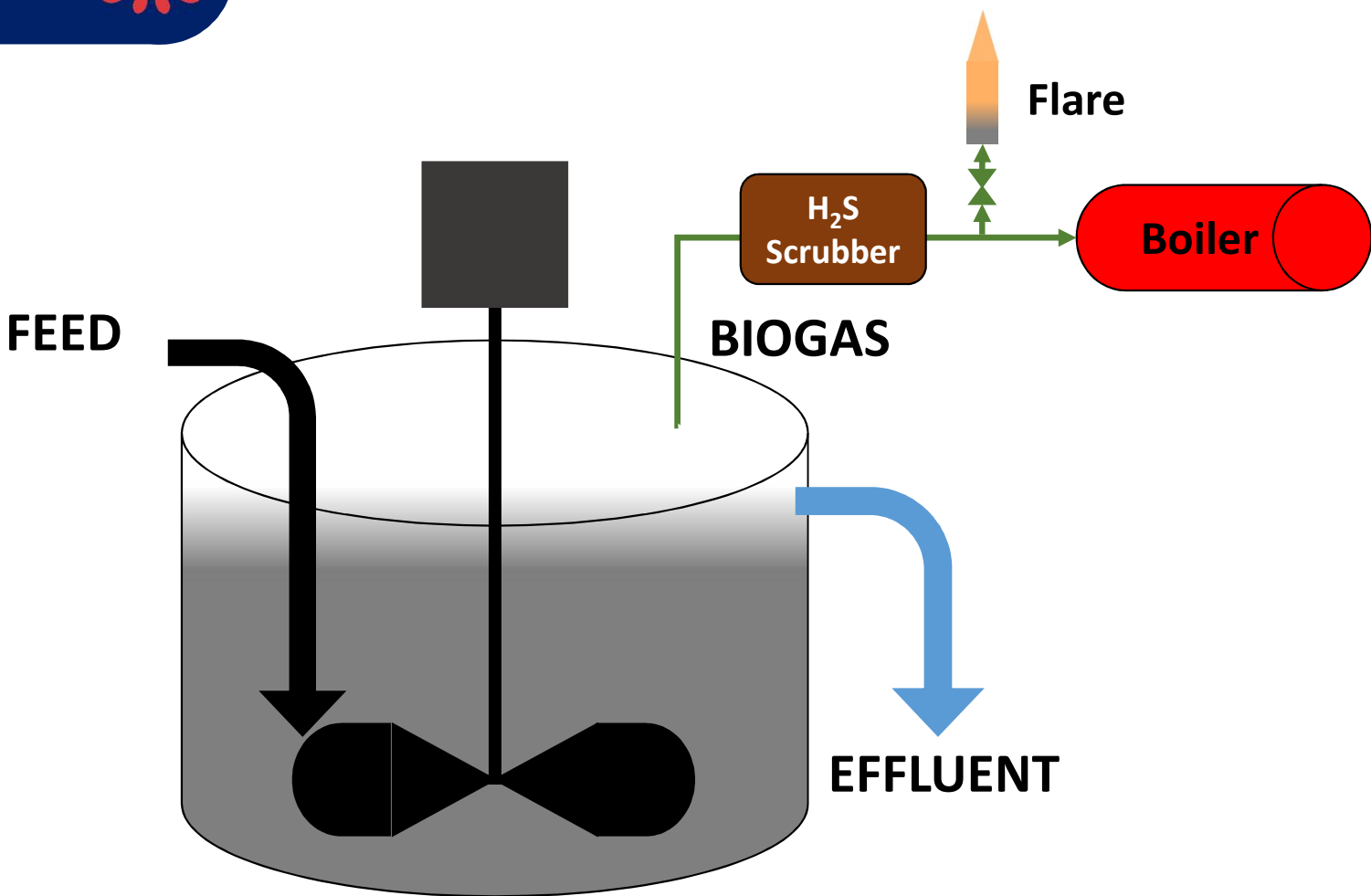
Membrane Coupled Anaerobic Bioreactor

Packed-Bed Immobilized Cell Bioreactor

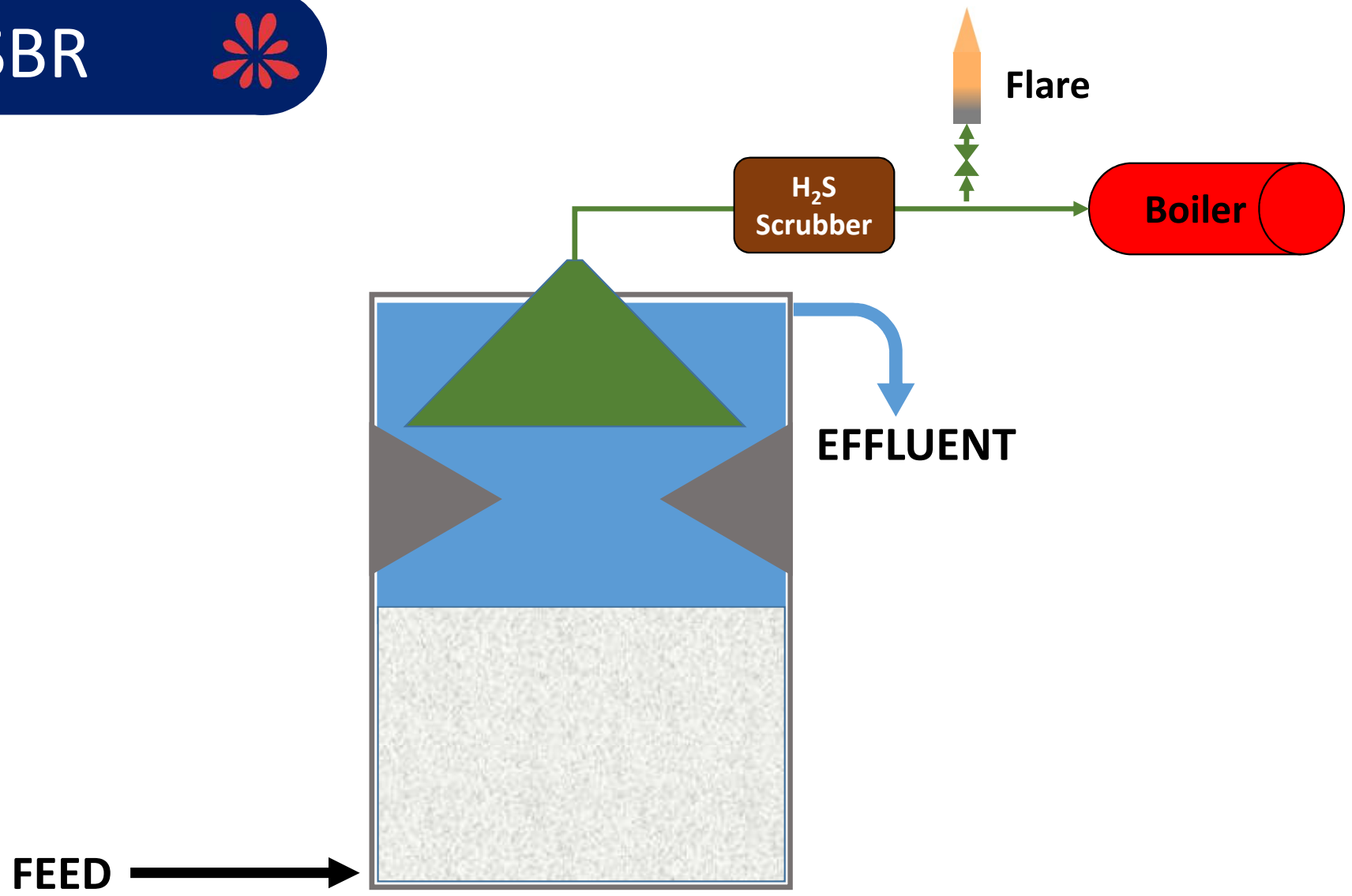
Upflow Anaerobic Sludge Blanket Reactor

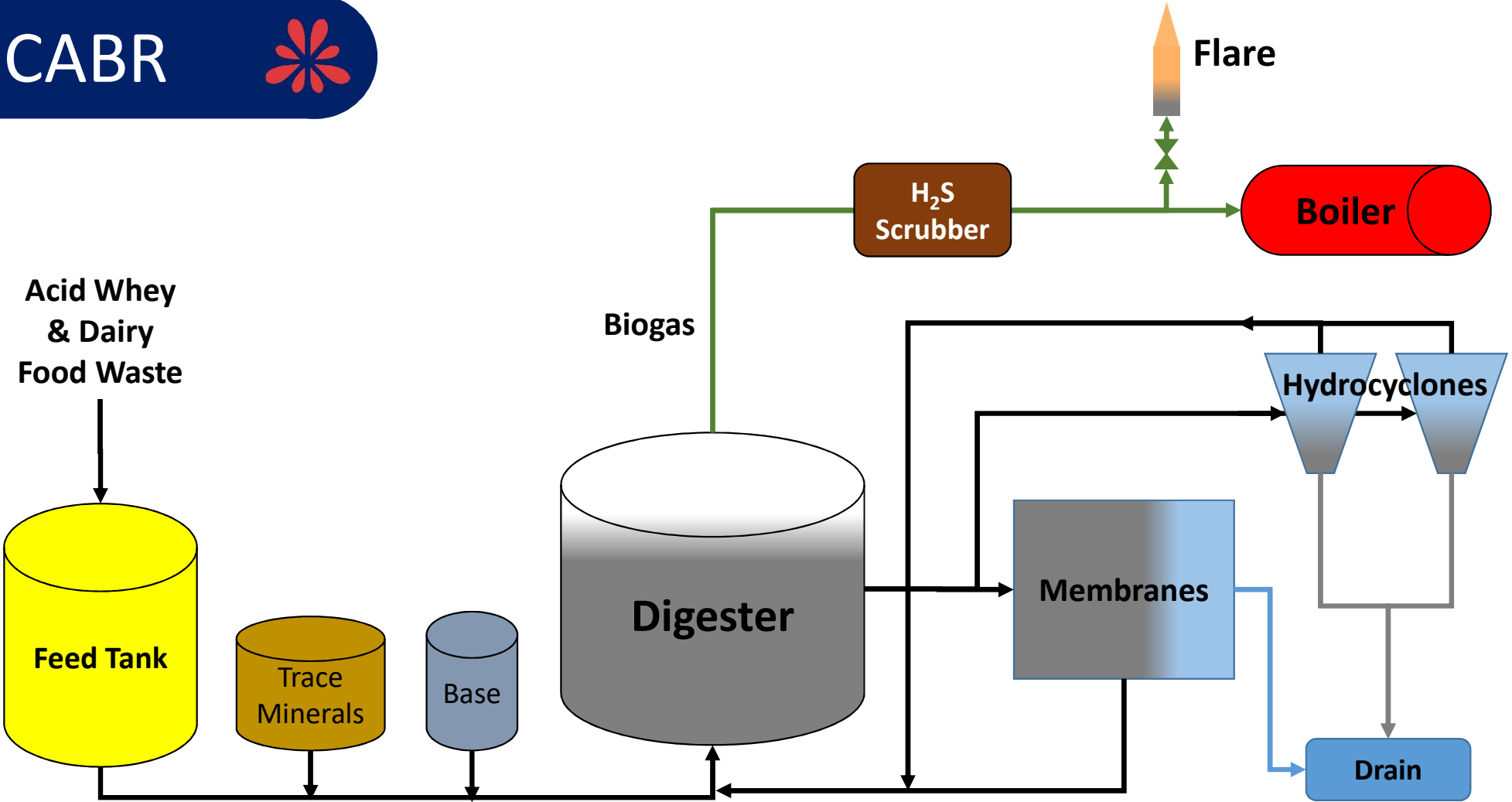
Upflow Fixed-Film Loop Reactor

CSTR

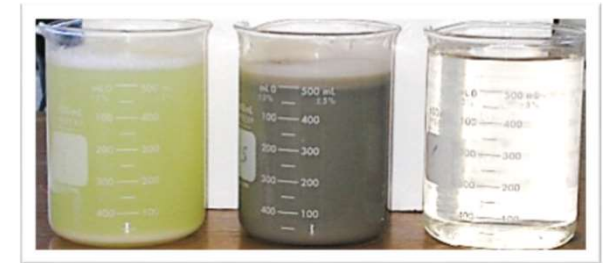


UASBR





Daisy



THANK YOU