

# Anaerobic Digestion 101 – Do's and Don'ts

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**AECOM**

## Topics

- Biology
- Feeding
- Mixing
- Temperature
- Monitoring
- What If?
  
- Conclusions and Recommendations



# Biology and Processes

# Anaerobic Digestion – Biochemistry Process

## Process Occurs in Several Basic Steps

### 1) HYDROLYSIS

Conversion: complex organic matter + water  
=> simple soluble organic molecules  
(simple sugars, fatty acids, amino acids and peptides)

### 2) ACIDOGENESIS or FERMENTATION

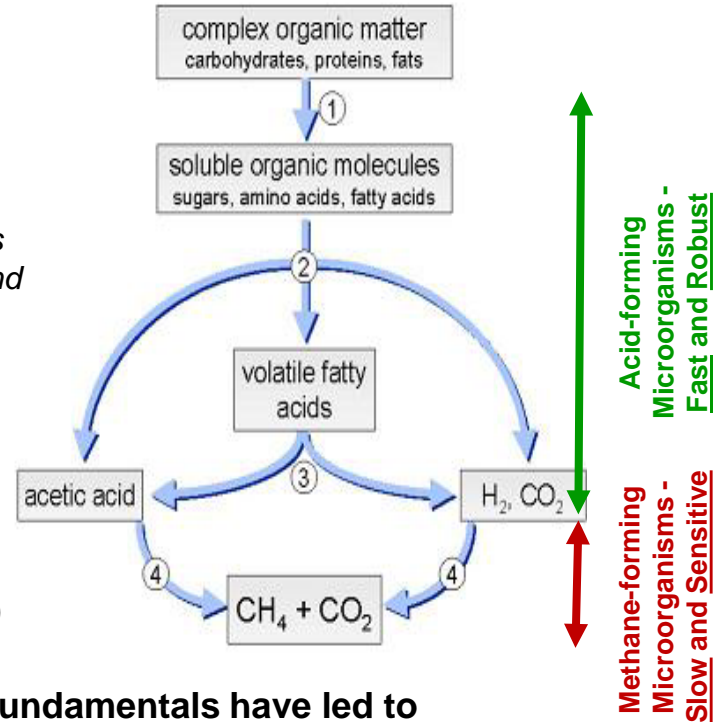
Conversion: simple soluble organic molecules  
=> organic acids, alcohols, carbon dioxide, and hydrogen

### 3) ACETOGENESIS

Conversion: fermentation products  
=> acetate, hydrogen and carbon dioxide

### 4) METHANOGENESIS

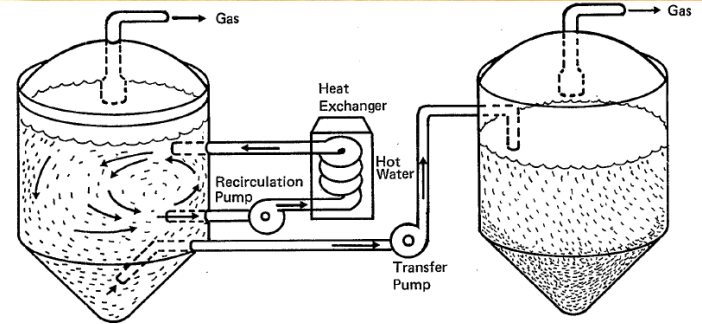
Conversion: acetate, hydrogen, and carbon dioxide  
=> methane, carbon dioxide, water (= biogas)



**Better understanding of the process fundamentals have led to innovative designs and process improvements.**

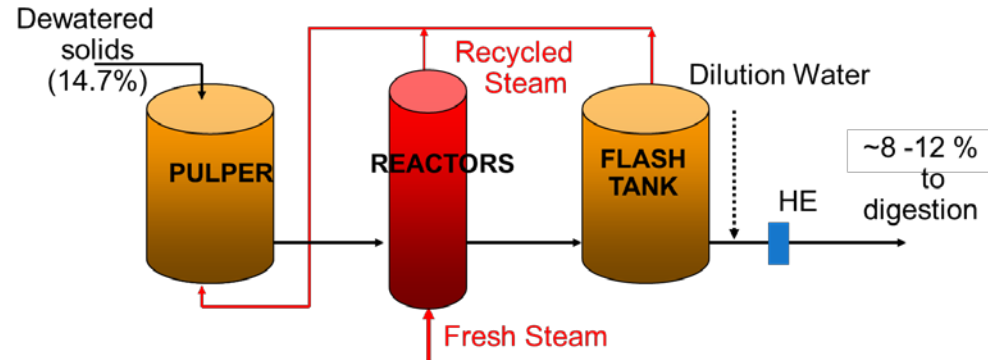
# Classic Two Stage Digestion

- First Stage
  - Receives Feed Solids
  - All Biology in One Reactor
- Second Stage
  - Typically Not Mixed
  - Typically Not Heated
  - Acts as Storage for Downstream Processes
  - Still Some Biological Activity
  - Becoming Less Common – Supernatant?



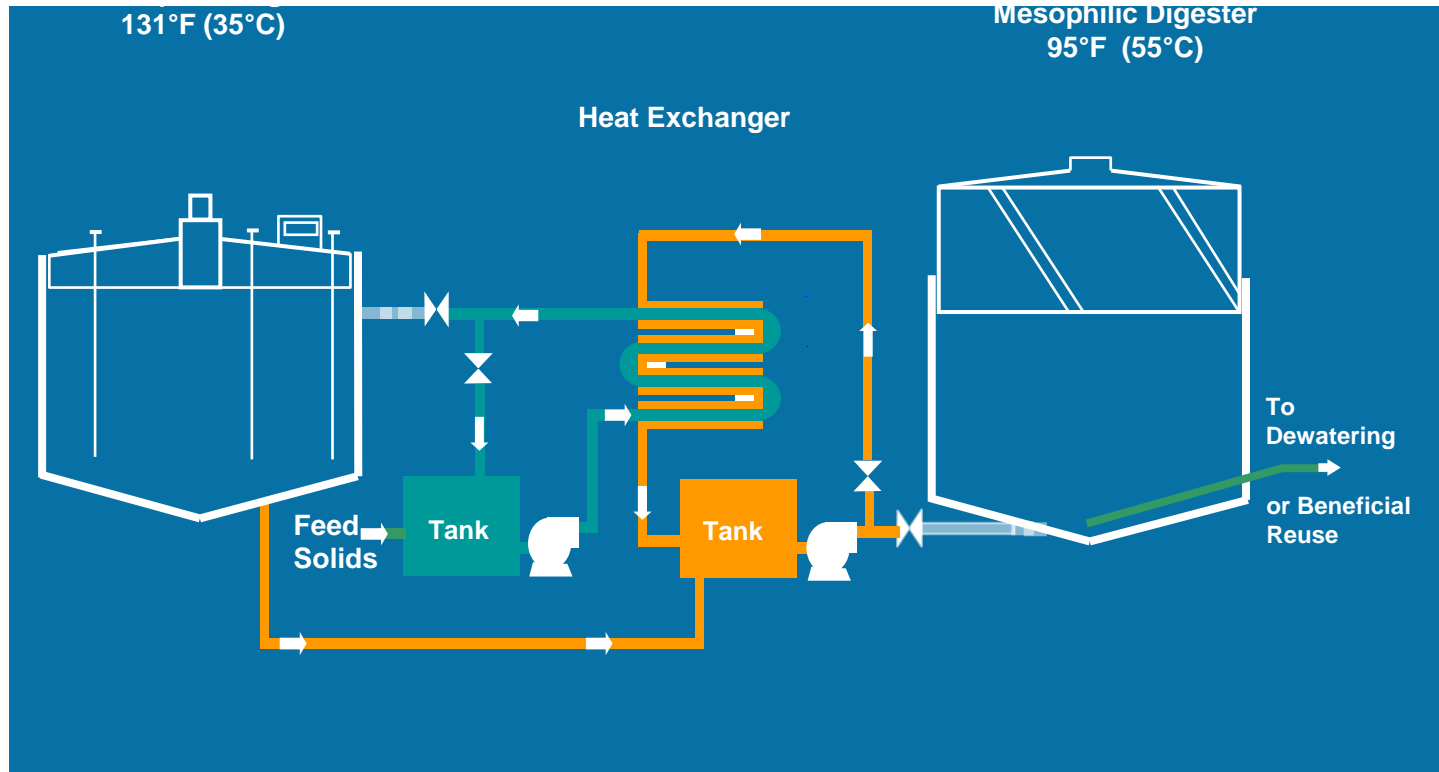
# Advanced Anaerobic Digestion Processes

- Recuperative Thickening
- Thermophilic Digestion
- Staged Thermophilic
- Temperature Phased Anaerobic Digestion (TPAD)
- Acid Gas Anaerobic Digestion
- 2PAD IDI Process
- Pre-Digestion Pasteurization
- Thermal Hydrolysis pretreatment
- Thermal Chemical hydrolysis



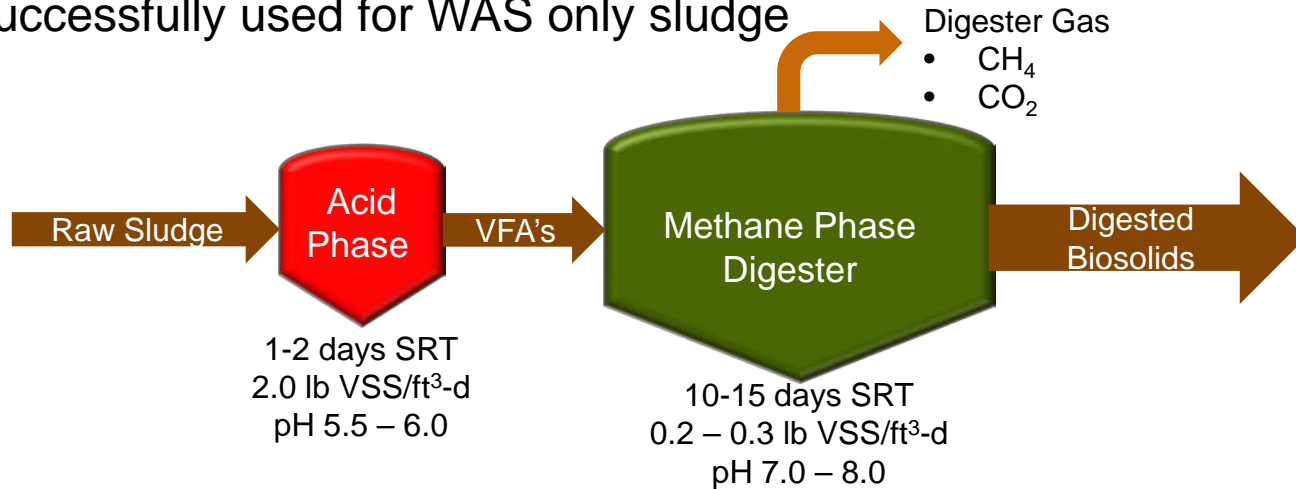
# Temperature Phased Anaerobic Digestion (TPAD)

## Typical TPAD Configuration



# Acid Gas (AG) Digestion

- Digestion Process separated into two phases
  - Acid Phase → Hydrolysis, Acidogenesis, Acetogenesis (Highly Loaded)
  - Methane Phase → Methanogenesis (Low Loading)
- Potential to increase VSR and reduce required volume
  - **Down to 10 day SRT in methane phase possible**
  - Successfully used for WAS only sludge





# Feeding

## Feed Sludge Concerns

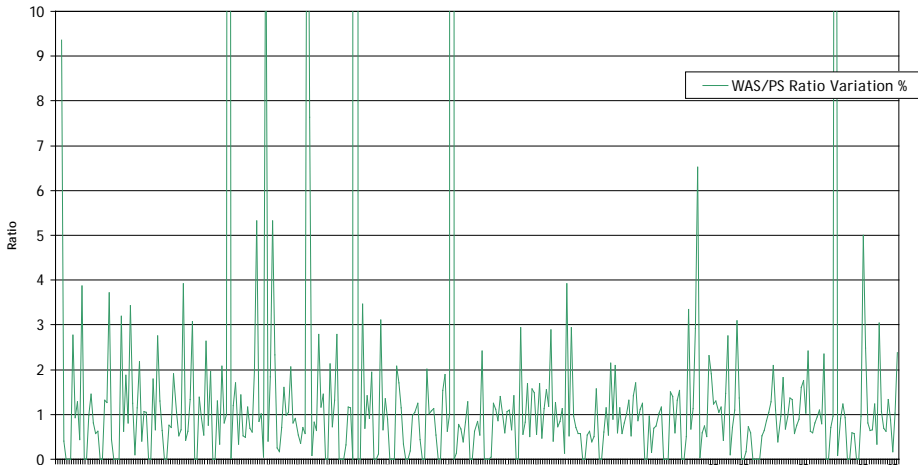
- Mixture of Primary and Waste Activated
- Scum
- Aeration Tank Foam (*Nocardia*?)
- High Strength Waste
- Uniform, Regularly Mixed the Best
- Current Research on Genome and Feed Impacts



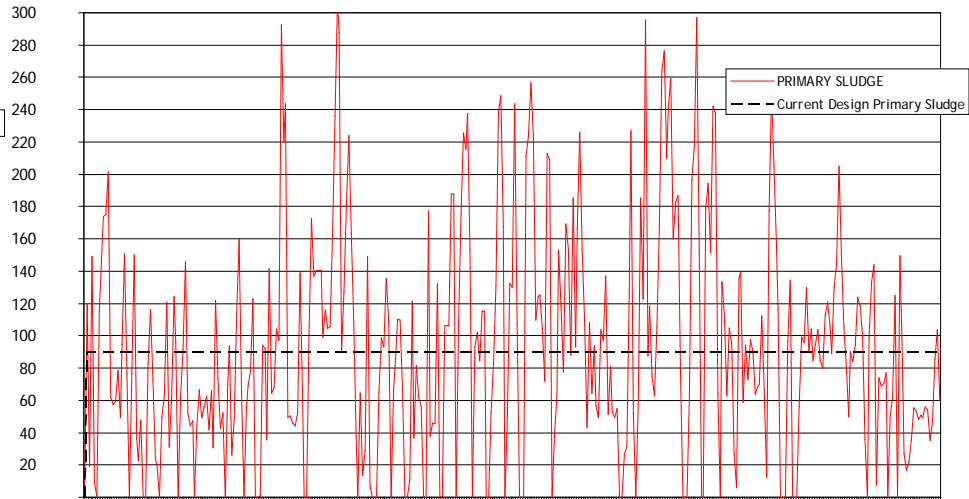
# Digester Feeding Considerations

- Consistent, Intermittent Feeding is Best
- No Slug Loading
- Co-Digestion?

Daily Change in Ratio of WAS to Primary Sludge



Primary Sludge



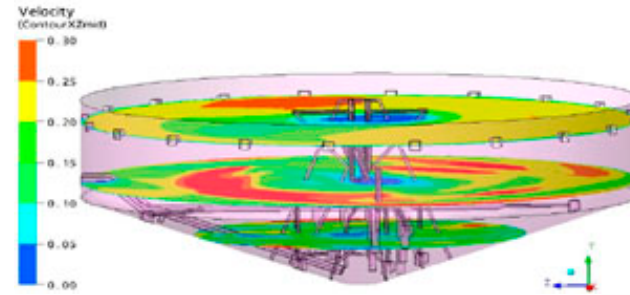
## Digester Feeding Considerations

- Consistent, Intermittent Feeding is Best
- No Slug Loading
- Co-Digestion?
- **Consistent, Intermittent Feeding is Best**

# Mixing

## Many Types of Mixing Systems

- Gas Mixing – Older Technology
- Pumped Mixing
  - Exterior and in a Tube
  - Exterior with Induced Flow
- Linear Motion Mixing – Newer
- Too Much or Too Little May Not Be Good
- Caution – High Solids Concentrations
- Check for Accumulation of Grit, Debris, Heavy Solids



# Foaming

- “Foaming” Happens – Numerous Studies and Papers
- Three Workshops by Central States WEA (2010, 2011, 2012)
- See <http://cswea.org/resources/papers-presentations>
- Rapid Rise
- Causes and Cures Often a Mystery
  - *Nocardia*?
  - Mixing Energy?
  - BNR Solids?
  - Surfactants



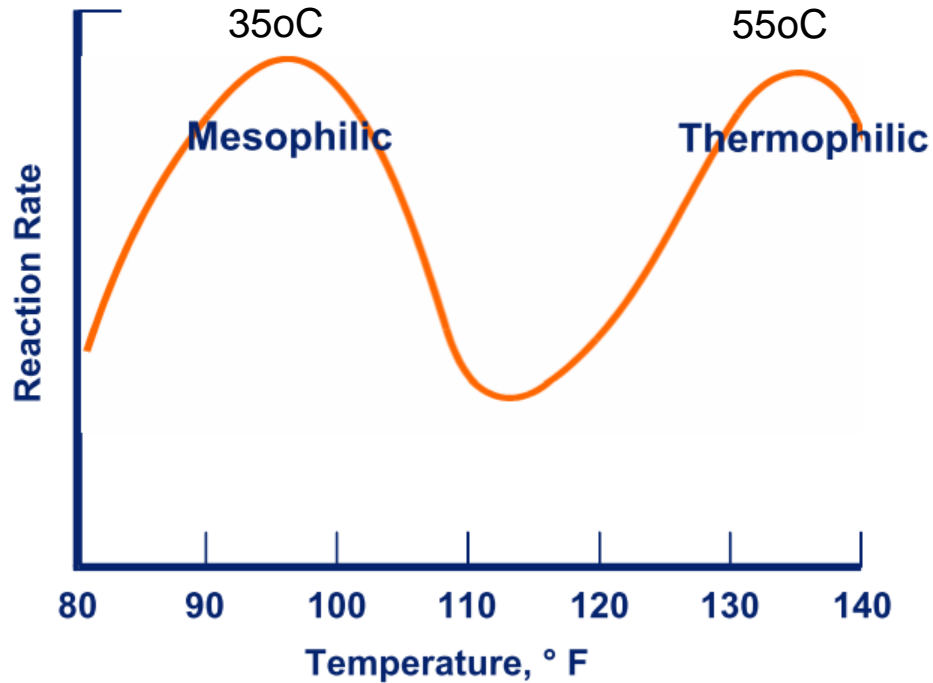
# Temperature



## Maintaining Constant Temperature Critical

- Psychrophilic – 50-68°F (10-20°C) – Not Commonly Used
- Mesophilic – 85-100°F (29-38°C) – Most Common – Typically 95°F
- Thermophilic – 120-135°F (49-57°F) – Most Common at 130-135°F
- Biological Activity Significantly Impacted by Operating Temperature

# Methanogen's reaction rates as a function of temperature

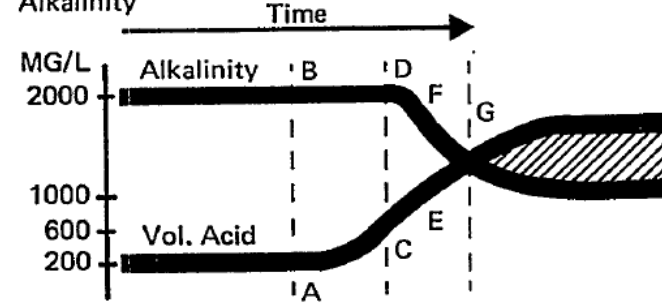


# Monitoring

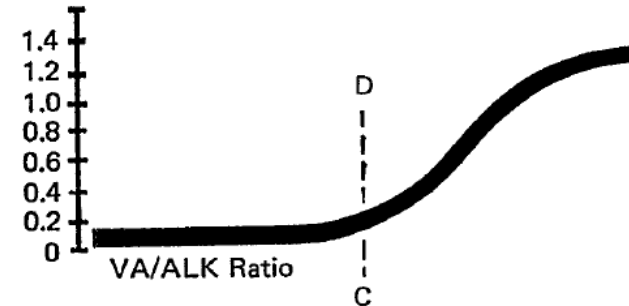
# Common Parameters to Monitor

- Feed Sludge Characteristics
- Volatile Solids Destruction
- Temperature (Trend Data)
- Solids Concentration
- Volatile Acids to Alkalinity Ratio
  - Target V/A Less Than 0.10
  - Trend Data
  - pH? (Too Late)
- Digested Sludge Characteristics

I Relationship Of Volatile Acids To Alkalinity



II Volatile Acids/ Alkalinity Ratio



# USEPA Publication

United States  
Environmental Protection  
Agency

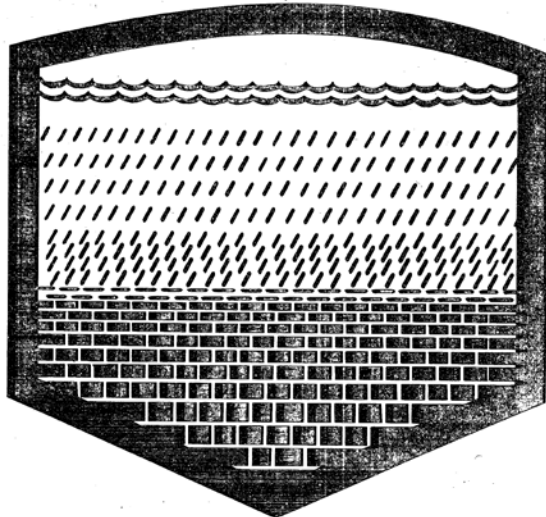
Office of Water  
Program Operations (WH-647)  
Washington DC 20460

EPA 430/9-76-001  
February 1976

Water

## Anaerobic Sludge Digestion

## Operations Manual



MO-11

- Available On-Line
- Enter Full Name – EPA 430-9/9-76-001
- Very Old Publication (1976)
- Excellent Troubleshooting Guide
- Recommendations for Startup
- Good Recommendations on Data
- Many Other Good References Available

# What If?

## What to Do If.....

### – Foaming

- Control or Limit Feeding
- Check Mixing and Heating
- Remove the Foam
- Add Defoamant Chemical

### – Digester Goes “Sour”

- Control or Limit Feeding
- Reduce Sludge Inventory
- Check Mixing and Heating
- Add Chemical – Sodium Bicarbonate, Sodium Carbonate, Lime

## Conclusions and Recommendations

- Consistent and Intermittent Feeding is Best
- Plan for Operating Problems
  - Foam
  - Sour Digester
  - Digester Cleaning
  - Chemical Supply
- Regular Monitoring Important – Trend the Data
- Regular Testing Important



# Thank You

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