INSTRUCTIONS

WELCOME.

NEDR # 10 is SPONSORED BY:
Unmatched Reliability
Vaughan®

Rotamix®
Process Mixing
Hydraulic mixing system using fixed nozzles and an external Vaughan Chopper Pump
DUAL-ZONE MIXING

- **Zone 1:** Vortical flow pattern, and reduces settling in center of tank
- **Zone 2:** Uniform flow pattern, driving the tank contents.
- Ability to mix multiple tanks with one pump.

- The Vaughan Chopper Pump provides all motive force for distribution of flow while also *continuously breaking down solids*. 
WHY USE ROTAMIX?

- Low cost, effective means of mixing
- Easily maintained
- No moving parts in the tank
- Reliable operation using the Vaughan Chopper Pump
- Designs for all geometries
- Guaranteed mixing
- Computerized flow models optimize mixing
Applications

- Lime Stabilization
- Anoxic Zone Mixing
- FOG and High Strength (Food) Wastes
- Septage Receiving
- Skimmings Systems
- Influent Channels
- CSO Basins
FOG (Fats, Oils and Greases) & High Strength Wastes (HSW)
Rotamix®

Other Mixing Assemblies

- **Externally Mounted Assemblies**, available in several configurations with various features to suit the application.

- **Foambuster with**
  - 1” thick glass lined nozzle with 74C Rockwell Hardness
  - 3M™ Scotchkote™ 134 Fusion Bonded Epoxy Exterior Coating
  - 10 year full warranty includes wear
Vaughan Chopper Pumps

- Mixing flows to 13000 GPM
- Ability to physically break down solids increases VSR
- Multiple Seal Options
- Self Primer, Vertical Wet Well and submersible pumps offer design flexibility
- Chopping action enhances Volatile Solids Reduction
OPERATIONAL ADVANTAGES

✓ Flexibility if feedstocks change.
✓ Chopper Pump conditions sludge
✓ Reduced Energy Option Savings
✓ Dual function-mix or load out
✓ Not liquid level dependent
✓ Optional Foam Suppression
WERF ENER12R13:
Understanding Impacts of Co-Digestion:
Digestion Chemistry, Gas Production, Dewaterability, Solids Production, Cake Quality, and Economics

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What Happens When We Add Co-Wastes?

Possible Impacts:

1. Changes in Digester Chemistry
   a. Alkalinity, pH, N, P, VFAs, COD (digester stability and sidestream impacts)
   b. Gas Composition (CH\textsubscript{4}, CO\textsubscript{2} ratios)
   c. Gas Production (gas holdup and rapid rise)
   d. Cations: Na, K, Ca, Mg, NH\textsubscript{4}\textsuperscript{+} (dewatering impacts)
   e. C/N Ratios of solids (cake quality)

2. Changes in Viscosity and Surface Tension
   a. Mixing, gas holdup, rapid rise and foaming, dewatering
Goals of WE&RF Project

Central Goal: Develop Tools to Understand Impacts

1. Develop stoichiometric model
   a. central to predicting digester stability, gas production, chemistry, and side-streams...

2. Understand relationships between
   a. rheology and volume expansion/foaming
   b. cations, anions and dewaterability
   c. CHNO and cake quality (odors)
Phase I Approach: Field Studies

1. Evaluate Full Scale Sites
   - side-by-side control and co-digestion
   - baseline testing followed by co-digestion

2. Characterize
   1. feed in terms of elemental analysis
   2. digester chemistry (pH, Alkalinity, NH₄, etc)
   3. gas composition and production
   4. digester rheology, rapid rise potential
   5. dewaterability and return liquor characteristics
   6. cake quality
Phase II Approach: Lab Studies

Fill in our knowledge gaps with controlled laboratory digestion studies.

- 10 L active volume
- T = 37 °C
- High Torque, 100 rpm Motor
- Gas Volume and Rate by Respirometer
Stoichiometry of Anaerobic Digestion

Theoretical General Equation (Buswell, 1952)

\[
C_nH_{a-b}O_{c+b}N_c + H_2O \rightarrow xCH_4 + yCO_2 + zHCO_3^- + zNH_4^+
\]

x, y and z are a function of n, a, b, and c
### Stoichiometry of Anaerobic Digestion

<table>
<thead>
<tr>
<th>Parameters we can predict...</th>
<th>Importance</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digester pH</td>
<td>Master variable for digester operation</td>
<td>6.7-7.8</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>Helps maintain pH due to high loading</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>NH$_4^+$</td>
<td>Can lead to inhibition at high concentrations, dewaterability effects, side-stream composition</td>
<td>&lt;2800</td>
</tr>
<tr>
<td>CH$_4$ Production</td>
<td>Gas/Energy Production</td>
<td></td>
</tr>
<tr>
<td>Biogas Composition (CH$_4$/CO$_2$ Ratio)</td>
<td>Biogas Production and quality</td>
<td></td>
</tr>
</tbody>
</table>
## Stoichiometry of Anaerobic Digestion

<table>
<thead>
<tr>
<th>Type</th>
<th>Formula</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Sludges</td>
<td>$C_{17}H_{31}O_{7.2}N$</td>
<td>Bucknell Data (average of 5 plants)</td>
</tr>
<tr>
<td>Waste Activated</td>
<td>$C_{6.6}H_{12}O_{2.4}N$</td>
<td>Bucknell Data (average of 8 plants)</td>
</tr>
<tr>
<td>Food Waste</td>
<td>$C_{17}H_{30}O_{6}N$</td>
<td>Bucknell Data (average of 3 different FWs)</td>
</tr>
<tr>
<td>Fats</td>
<td>$C_{16}H_{32}O_{2}$</td>
<td>Rittman and McCarty</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>$C_{6}H_{10}O_{5}$</td>
<td>Rittman and McCarty</td>
</tr>
<tr>
<td>Protein</td>
<td>$C_{16}H_{24}O_{5}N_{4}$</td>
<td>Rittman and McCarty</td>
</tr>
</tbody>
</table>
Applications of Stoichiometry

1. Evaluate effects of different feed stocks on digester chemistry
   - pH
   - alkalinity
   - ammonia
   - gas production

2. Solve digester chemistry issues:
   - pH (too low or too high)
   - alkalinity (too low)
   - ammonia inhibition (too high)
Scenario 1: Low Loaded Digester

**Scenario 1 Inputs:**

**Sludges**
- 3% TS Inflow, 50/50 Mix of Primary and Secondary
- 20 d SRT
- VSR = 55%

**Co-Digestion Feedstocks:**
- Fats, Protein or Carbs
- 15% TS, VS/TS = 0.9 80% VSR
Scenario 1: Effect on Methane Production

![Graph showing the effect of co-waste addition on methane production. The x-axis represents co-waste addition (% by volume), and the y-axis represents increase in methane production relative to no HSW (%). Three types of waste are shown: FOG, Protein, and Carbohydrate. Each type has a linear trend line indicating an increase in methane production as the co-waste addition increases.]
Scenario 1: Effect of Co-Waste Addition on Digester pH

The chart illustrates the pH trends for different co-waste addition levels, categorized by FOG, carbohydrates, and protein. The pH danger zones are also indicated on the chart.
Scenario 1: Effect on Digester Bicarbonate Alkalinity

Co Waste Addition (% by Volume)

FOG
Carbohydrates
Protein
Scenario 1: Effect of Co-Waste Addition on Digester NH$_4^+$

![Graph showing the effect of co-waste addition on digester NH$_4^+$ levels.](image)

- **NH$_4^+$ Inhibition Zone**
- **COG**
- **Carbohydrates**
- **Protein**

**Legend:**
- FOG
- Carbohydrates
- Protein

**Axes:**
- **Y-axis:** Digester NH$_4^+$ (mg N/L)
- **X-axis:** Co-Waste Addition (% by Volume)

**Data Points:**
- 0%
- 5%
- 10%
- 15%
- 20%

*Graph shows the concentration of NH$_4^+$ in the digester for different levels of co-waste addition, indicating the inhibition zone where NH$_4^+$ levels are significantly affected.*

*Note: Only the graph is considered in the analysis, not the descriptive text.*
Scenario 1: Effect of Co-Waste Addition on Digester NH$_4^+$
We can use co-digestion to solve digester issues

Issues with *highly loaded digesters* such as thermal hydrolysis:

a. high ammonia concentrations > 3000 mg/L
b. high pH and alkalinity
c. inhibition of methanogens and possibly hydrolysis

Adding **low N co-wastes** can reduce inhibition by reducing pH and ammonia concentrations while also increasing gas production:

- FOG: $C_{16}H_{32}O_2$
- Carbs: $C_6H_{10}O_5$
Understanding Impacts

1. Rheology and rapid volume expansion

2. Solids production – net mass of wet cake leaving plant
   a. Dewatering – cake solids
   b. Volatile solids destruction

3. Polymer Demand

4. Effects on cake quality in terms of odors
Effect on Solids Mass Balance

Sludges -> Anaerobic Digestion

HSW -> Digester Effluent

Dewatering

Water -> Solids -> Wet Cake Mass
Effect on Solids Mass Balance

Orange County Project: Waste Management EBS Product (Food Waste)
1. Control – Sludges only
2. 25% additional VS from food waste
3. 45% additional VS from food waste
4. 65% additional VS from food waste
Effect on Dewaterability

![Bar graph showing cake solids (%) for different digesters: Control, 25%-FW, 45%-FW, and 65%-FW.]
Effect on Solids Production

![Bar chart showing wet mass solids produced (g wet solids/d) across different digesters.]

- Control: ~40 g wet solids/d
- 25%-FW: ~35 g wet solids/d
- 45%-FW: ~35 g wet solids/d
- 65%-FW: ~50 g wet solids/d
Net Wet Cake Mass Leaving the Plant

![Graph showing the relationship between VS Loading Relative to Control (%) and Wet Cake Leaving the Process Relative to Control (%). The graph includes data points for different plants and waste types, such as Millbrae Full Scale FOG, Plant 14 Lab Scale - Food Waste, Strass Full Scale - Food Waste, Plant 16 Lab Scale I - Food Waste, Plant 16 Lab Scale II - Food Waste, Plant 13 Full Scale - Food Waste, Plant 4 Full Scale - Cheese Waste, and Plant 15 Lab Scale - Pre-Consumer FW.]
Net Change in Polymer Demand

- Millbrae Full Scale - FOG
- Plant 14 Lab Scale - Food Waste
- Strass Full Scale - Food Waste
- Plant 16 Lab Scale I - Food Waste
- Plant 16 Lab Scale II - Food Waste
- Plant 13 Full Scale - Food Waste
- Plant 4 Full Scale - Cheese Waste
- Plant 15 Lab Scale - Pre-Consumer FW

Polymer Dose Relative to Control (%)

VS Loading Relative to Control (%)

0 10 20 30 40 50 60
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Questions?
Thank you for joining NEDR #10.

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