Digester technologies

3/27/2017

MUNICIPAL ENERGY ELECTRONICS

Worldwide Experts in Water Treatment

Digester topics that will be covered

1. Basics of digester operation 101
2. Types of digester vessels
3. Digester processes
4. Digester solids pre-treatment technologies
5. Digestivore PAD (post anaerobic digestion) system

Digester stages of operation

Step 1: Hydrolysis- Complex organic matter converted to Lipids, Carbs, and Proteins. Readily available COD

Step 2: Acidogenesis- Fermentation and Anaerobic oxidation converting long chain amino acids with oxidation and simple sugars/aminos with fermentation to Acids (Butyric, propionic, and valeric)

Step 3; Acetogenesis- conversion of acids to Acetate and Hydrogen

Step 4: Methanogenesis- conversion of Acetate and hydrogen to Methane

Digester operational kinetics

Methanogens- increase metabolism twice as fast as acetogens with temperature increases.

Biological respiration- doubles with every 10 degrees C increase of process temperature increase

Toxicity- can be inhibitory to organisms. Possible causes: Low PH/alkalinity, high ammonia loads, metals, and chemical (industrial/domestic).

Other important parameters- feeding (batch/constant), heating, overloading, and mixing.

Primary sludge is more degradable than secondary sludge which is partially stabilized during aeration.

Biogas yield- 13 cubic ft per /lb VSD

PH- is to slow of indicator, use VFA/ALK ratio for indicator of digester biology health

Ammonia (NH_3)- 800-1000 mg normal, 1500-3000 is inhibitory, greater than 3000 mg/L is toxic

Loading rates- for a 20-30 HRT digester should be around .1-.3 lb VS/CF/day

Types of digesters

Aerobic digesters- Typically used on smaller plants (1 MGD or below). Cheapest options to achieve Class B. Negatives are higher HRT requirements, foaming, no way to recover methane gas for beneficial use.

Cylindrical cone bottom- Pros: low profile, pressure, and relatively low construction costs. Cons: Dead spots, inefficient configuration for mixing.

Egg shaped digesters- Pros: most efficient mixing and steep side prevent grit accumulation. Cons: special construction, tall profile, and high construction costs.

Tall cylindrical- Pros: replicate egg shape mixing efficiencies, avoids pockets of grit accumulation, and requires least area per volume. Cons: Tall profile, high pressure for mixing, and substantial foundation work.

Waffle bottom- Pros: low mixing pressure, low profile, high mixing efficiencies like egg shape. Cons: Largest footprint area per volume, costly construction, and awkward to clean.

Single-Stage Mesophilic (typical 93-98F) Digestion (SSM)

Before digesters were used, anaerobic treatment of residuals occurred to some extent in sludge storage tanks at wastewater facilities.   History is inconclusive whether German or UK municipal wastewater works were the first to build anaerobic digesters for the express purpose of residuals treatment in the 1930’s

Thermophilic Digestion

- **Thermophilic Temperatures 115-150 deg F(125-140F normal)**
- **-Class A capable depending on operation**
- **-High operational upsets from VFA's and foaming potential**
- - negatives include odors, and poor dewatering characteristics.

ACID/GAS TPAD phased Digestion

Acid/Gas digestion (A/G), often called acid phase digestion or two-phase digestion, is a staged digestion process. The purpose of A/G is to provide separate environments for the different groups of microorganisms involved in anaerobic digestion. The first stage of an A/G system is the acid phase, which is characterized by low (1-2 HRT) hydraulic retention time (HRT), acidic pH, and high volatile acids concentration. Volatile acid producing organisms (acidogenic and acetogenic bacteria), sulfate reducing bacteria, and hydrogen-consuming methanogens are capable of thriving under the conditions prevalent in the acid phase (PH 4-6.5). This phase can be operated at thermophilic to achieve Class A if used in batch configuration. The second stage is the gas phase, which is similar to a conventional anaerobic digester with near neutral pH (6.8-7.2) and low volatile acid concentrations. The environmental conditions in the gas phase favor the growth of volatile fatty acid consuming bacteria and methane producing organisms. In theory, the low pH in the acid phase of the A/G process results in accelerated hydrolysis. The HRT in the gas phase is substantially less (approximately 10 days) than the 15 to 25 days needed for conventional digesters because the A/G process can operate at higher loading rates. The level of volatile solids reduction and biogas production achieved in an A/G system is comparable to that of a conventional digestion system operated with a considerably larger HRT.

Negatives- double the tankage requirements, high foaming events, odors, and poor dewatering characteristics.

Digestivore PAD process

Post anaerobic digestion

Anaerobic Digestion

The Good

Energy efficient means of stabilizing sludge

Produces a renewable fuel source

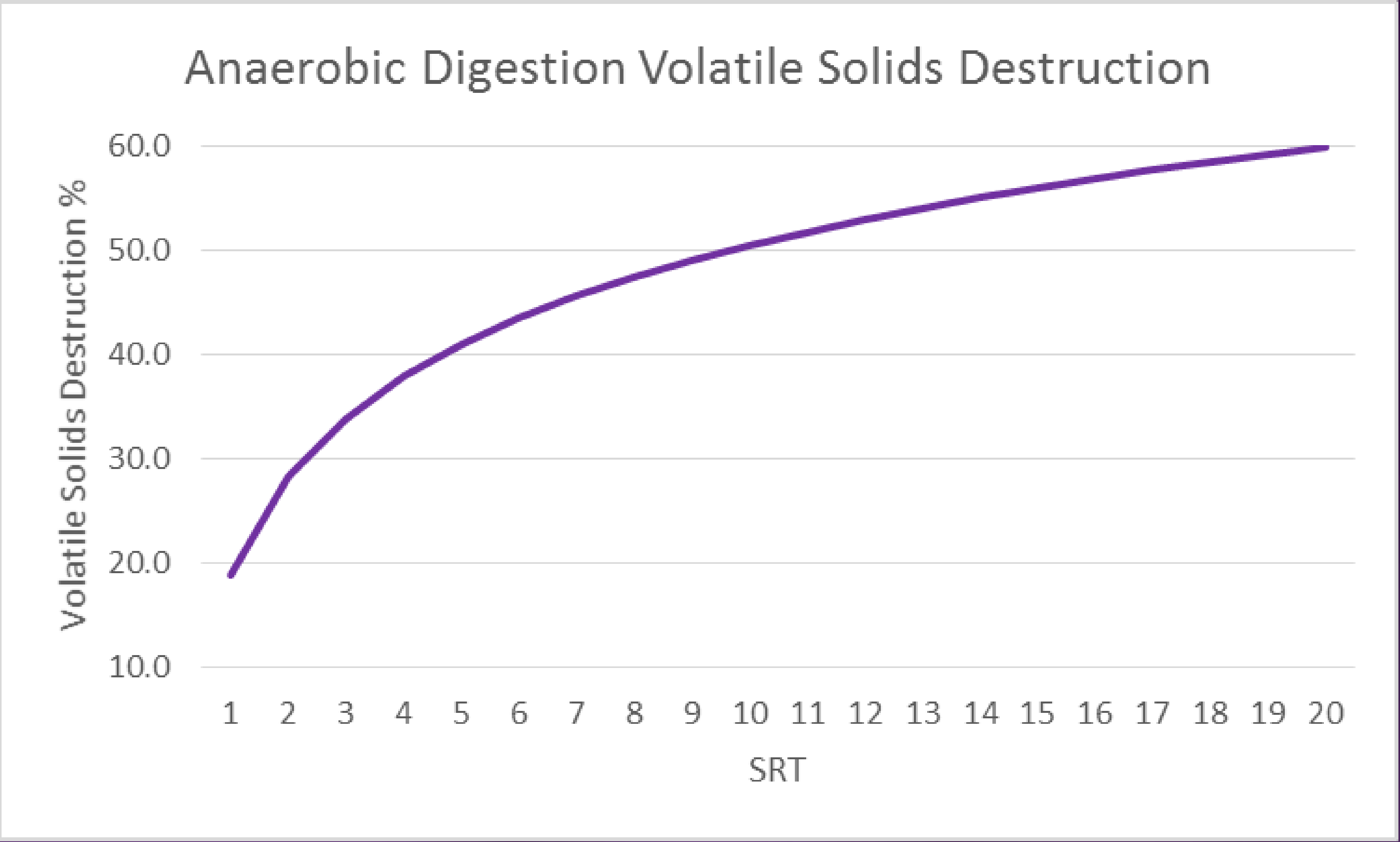
Ability to treat a variety of feedstocks

The Bad

Produces a sidestream containing pollutants we are trying to remove on the liquid side

Equipment intensive

Law of diminishing returns

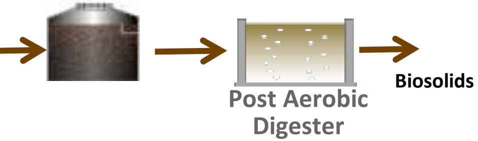

Anaerobic Digestion Volatile Solids Destruction
Volatile Solids Destruction %
60.0
50.0
40.0
30.0
20.0
10.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SRT

Pre-Treatment Advancements:

- Cell Lysis (Sonolyzer/MicroSludge)
- Algae Treatment (BioAlgaNyx)
- THP (LysoTherm and Haarsleve)

Process Advancements:

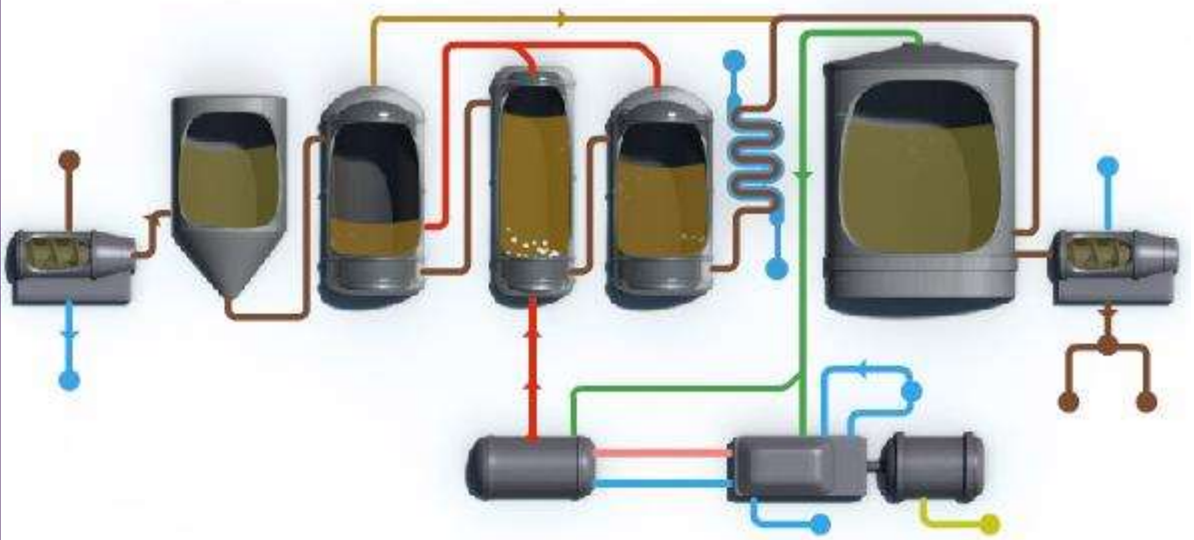
- Post Aerobic Digestion (Digestivor™ PAD), Temperature Phased, and Acid/Gas phased digestion.



New Equipment

- Digestion Mixing (LM™ Mixer)
- Gas Storage (Ultrastore™ Gasholders)

THP



The Ugly

Odor

Struvite

DigestivorePAD™: Not quite a silver bullet but close

DigestivorePAD™

- Origins
- How it works
- How it performs
- How it provides value
- Equipment components

Origins

RESIDUALS AND BIOSOLIDS MANAGEMENT CONFERENCE 2006

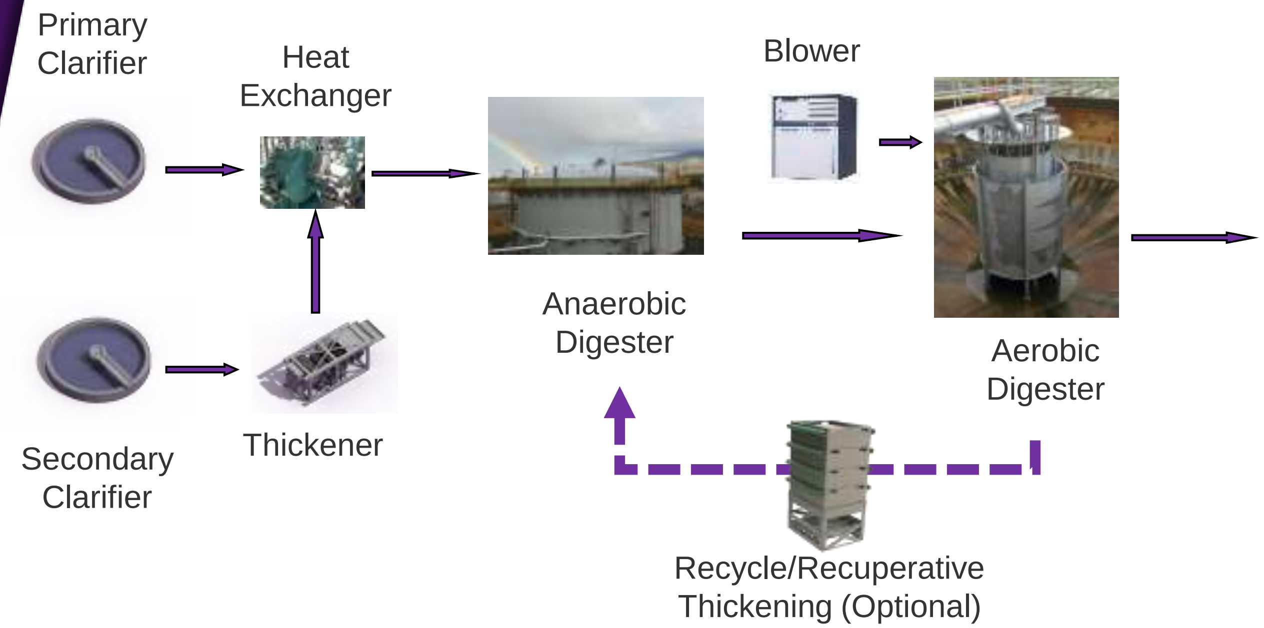
Bridging to the Future

SEQUENTIAL ANAEROBIC-AEROBIC DIGESTION FOR ENHANCED VOLATILE SOLIDS REDUCTION AND NITROGEN REMOVAL

Nitin Kumar, CH2M-HILL,
John T. Novak*, Virginia Tech
Sudhir Murthy, D.C. Water and Sewer Authority
Department of Civil and Environmental Engineering
Virginia Tech, Blacksburg, VA 24061

How it works

- Process flow diagram



DigestivorePAD™

Benefits for Utilities

- 10-30% VSR ↑
- Side stream N & P ↓
- Struvite Scaling ↓
- Dewaterability ↑
- Odor ↓
- EASY RETROFIT

DigestivorePAD™

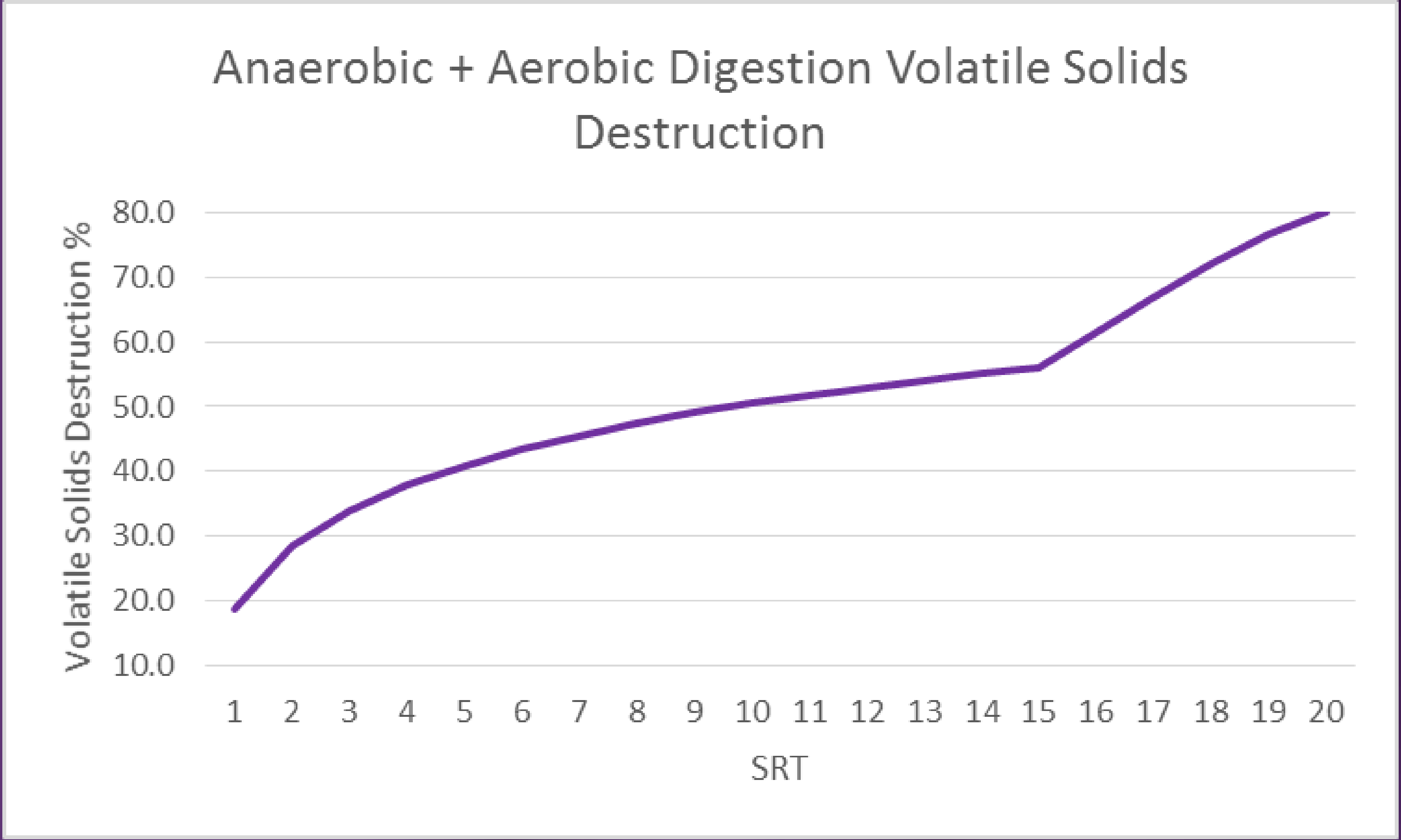
Benefits for Utilities

- Improved VSR

Certain organic components during sludge digestion are degraded only during anaerobic digestion OR only during aerobic digestion.

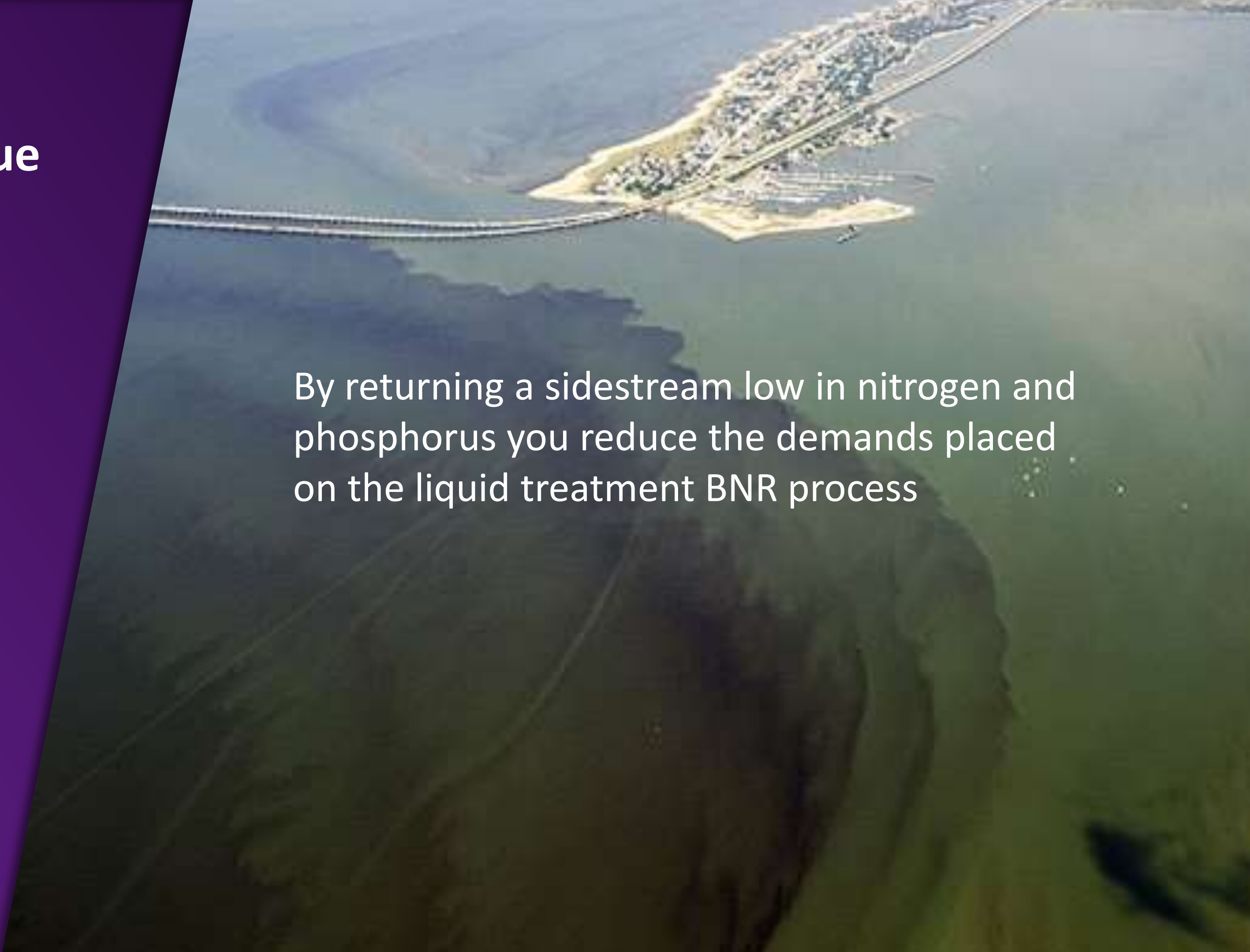
Therefore, dual digestion (anaerobic/aerobic) is expected and proven to provide volatile solids reduction beyond that achieved by either anaerobic or aerobic digestion alone.

DigestivorePAD provides a mechanism to achieve approximately 15% to 30% additional VSR


Anaerobic + Aerobic Digestion Volatile Solids Destruction
Volatile Solids Destruction %
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SRT

How it provides value

- Improved BNR



By returning a sidestream low in nitrogen and phosphorus you reduce the demands placed on the liquid treatment BNR process

How it works

- Aeration

Aeration Strategy will vary on the desired level of nitrogen removal:

Moderate: Cyclical aeration based on timers. Produces sidestream with TIN < 50 mg/L.

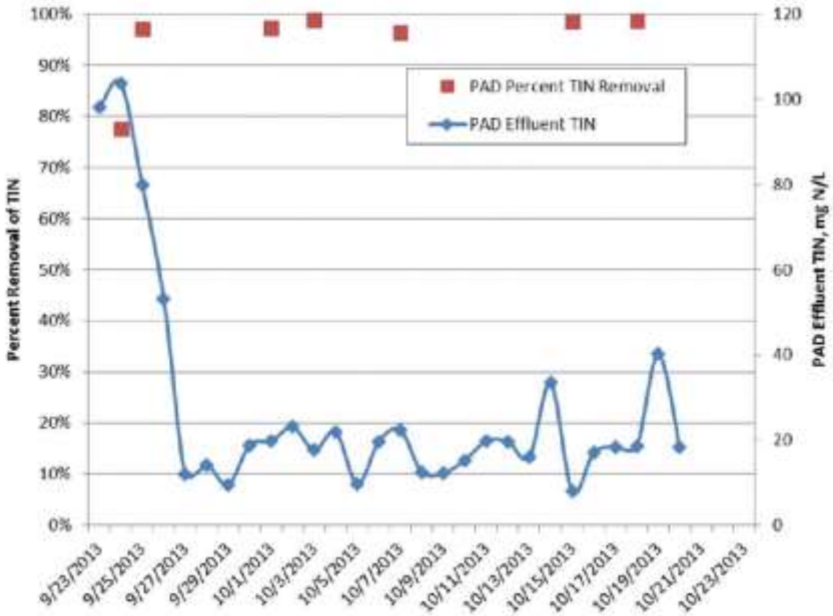
Advanced: Blower VFDs tied to pH, DO, online NH3 monitoring. Produces sidestream with lowest level of TIN.

SPOKANE COUNTY REGIONAL WRF DigestivorePAD™ (BASED ON DATA PROVIDED BY CH2M)

VSR Results

Parameter	Acceptance Test
Anaerobic Digester Influent Volatile Solids, *kg/d (lb/d)*	11,600 (25,500)
Anaerobic Digester Effluent Volatile Solids, *kg/d (lb/d)*	3,920 (8,650)
PAD Effluent Volatile Solids, *kg/d (lb/d)*	2,330 (5,140)
Anaerobic Digester VSR	66.2%
Post-Aerobic Digester VSR	40.6%
DigestivorePAD VSR	79.9%

Nitrogen Removal Results

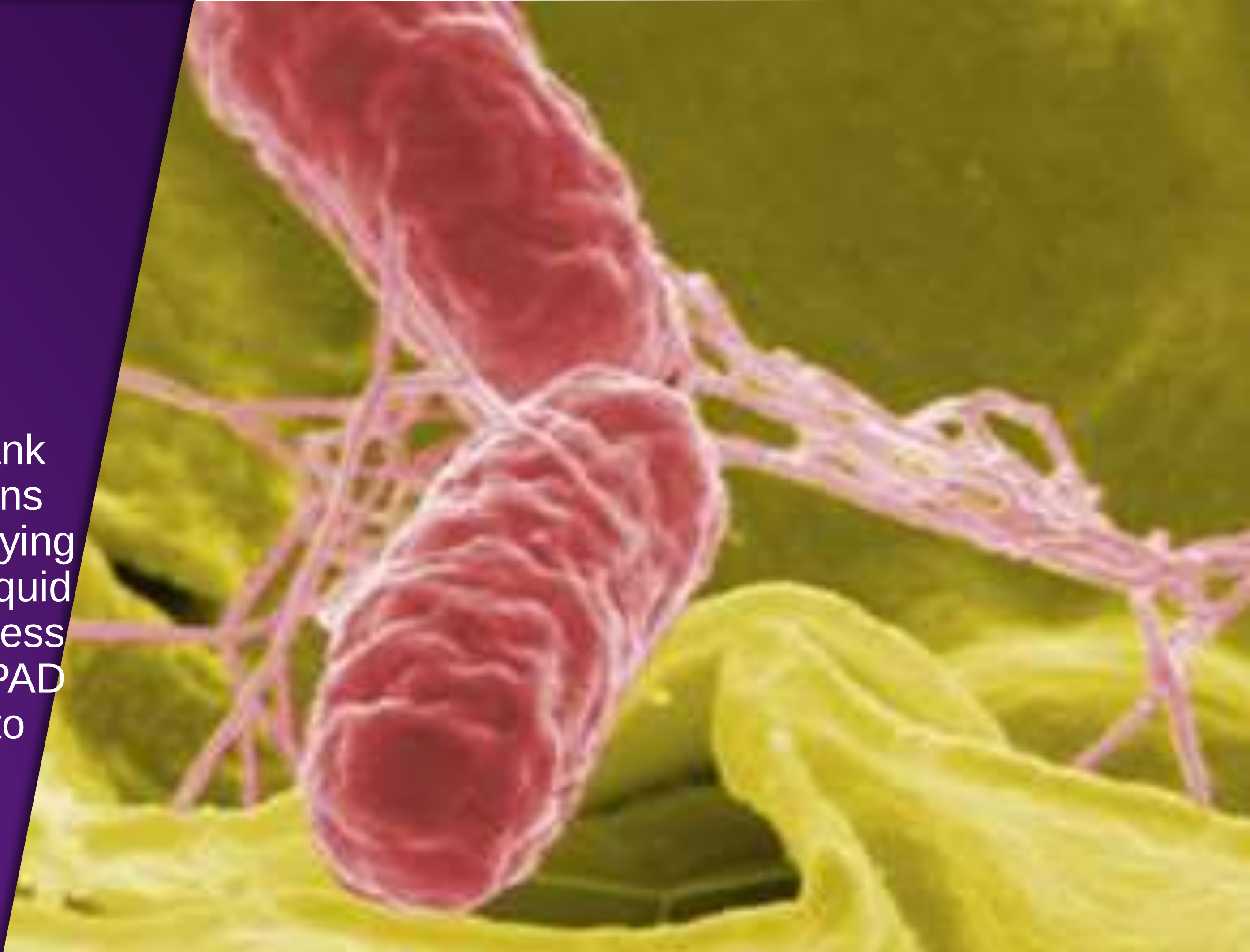


**Results achieved without chemical addition*

How it provides value

- Bioaugmentation

The DigestivorePAD tank will be rich in populations of nitrifying and denitrifying bacteria. Should the liquid side experience a process upset, the DigestivorePAD can act as a reservoir to reseed or increase the performance of the existing system



How it provides value

- Struvite

By driving off the CO2 present in the anaerobic sludge the DigestivorePAD adjusts the pH of the sludge to the point where struvite crystals form within the DigestivorePAD sludge. These crystals are then removed with the dewatered cake

How it provides value

- Odor

By eliminating up to 95% of the ammonia present in the sludge the DigestivorePAD removes one of the major drivers for odor control at dewatering buildings. The odor of the sludge itself is improved allowing for less concern for land applied sludges.

How it provides value

- Dewaterability

By lowering the amount of volatile solids in the sludge as well as the presence of ortho-phosphate the performance of dewatering equipment is improved by 2-5% overall.

How it provides value

- Simplicity

Retrofits- using existing tanks for conversion to D-PAD process.

Ease of operation- well proven digestion technologies that have been established for hundreds of years

Robust operation-not dependent on specialized bacteria not normally present in your WW stream.

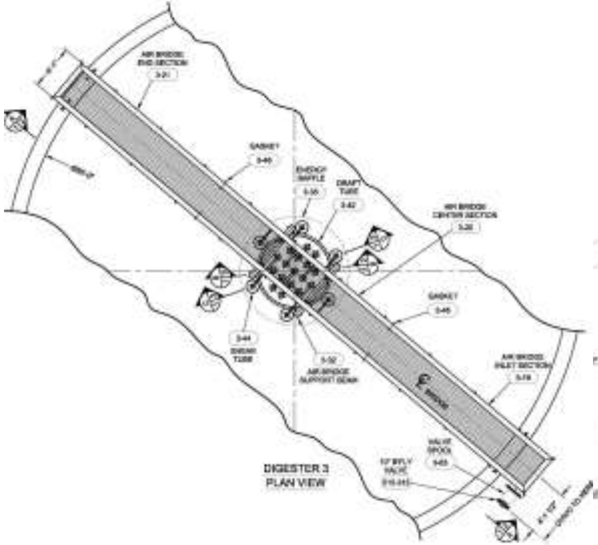
Equipment Components

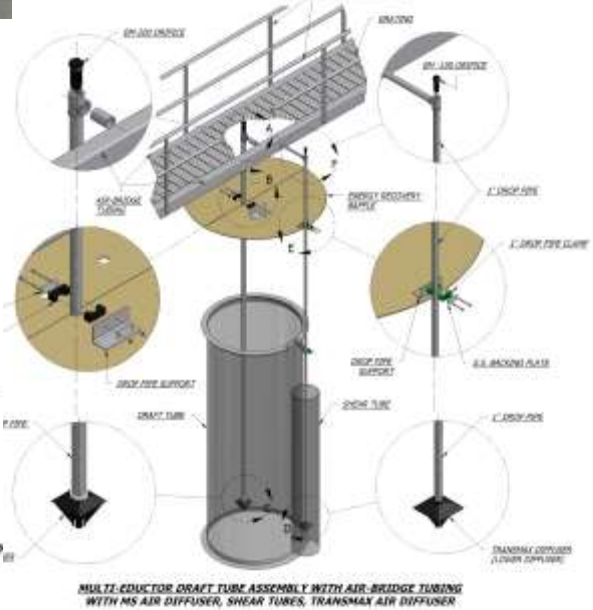
Equipment Components

- Anaerobic Equipment
  - LM Mixers
  - Covers
  - Gas Holders
  - Draft Tube Mixers

Equipment Components

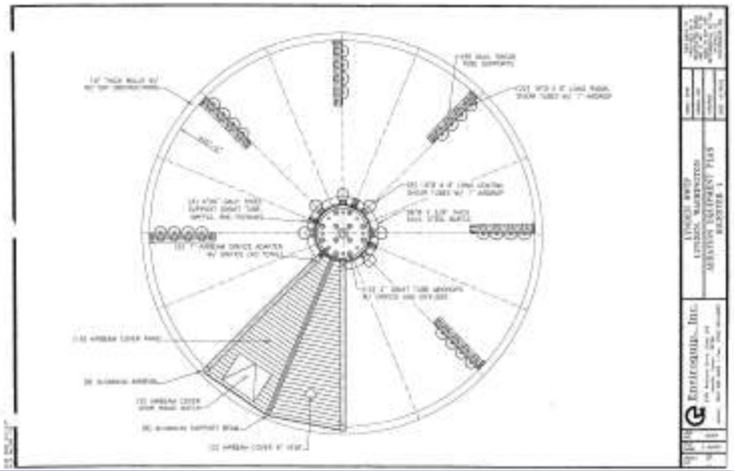
- Multi-Eductor Draft Tube

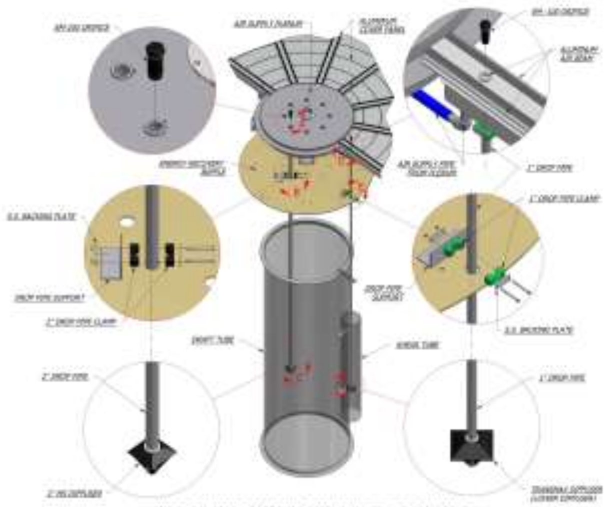




Equipment Components

- AirBeam Covers



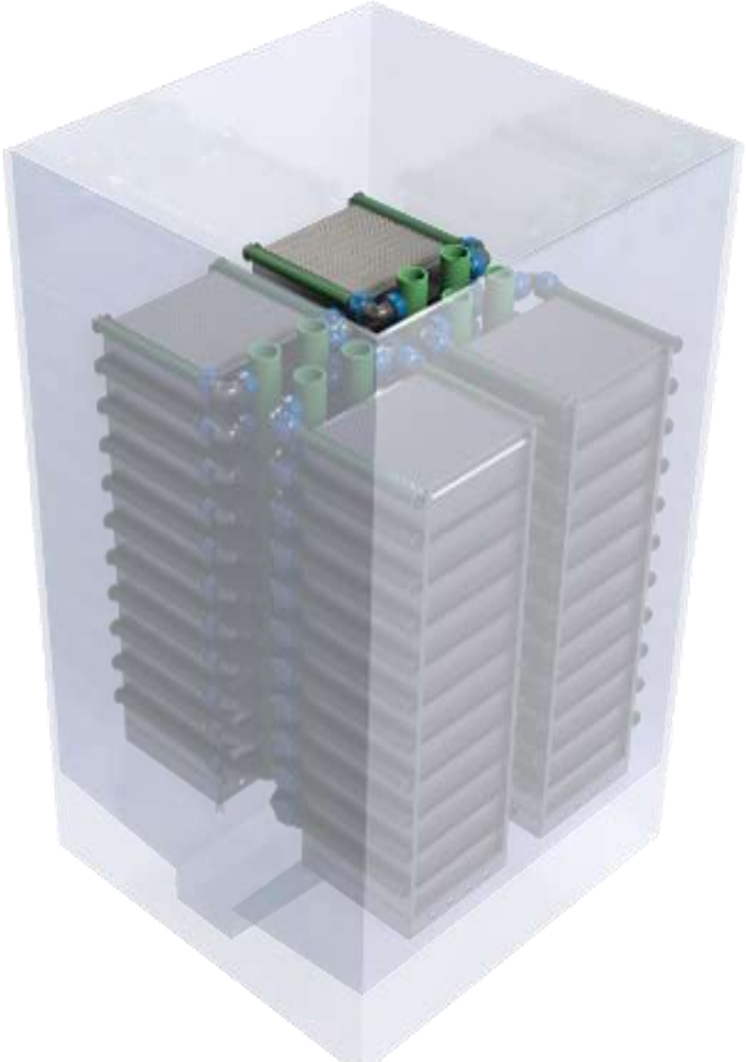


Equipment Components

- Blowers

Equipment Components

- Ceramic Membranes



Ceramic Data

Questions?

Thank You!

Chris McCalib

Chris@tec-nw.com

206-909-1546

TREATMENT EQUIPMENT COMPANY

Water and wastewater treated better