environmental finance center network

SOUTHWEST ENVIRONMENTAL FINANCE CENTER

Solids Handling Part 2: Digesters and Land Application

11/9/2023

This program is made possible under a cooperative agreement with US EPA.

About Us

The Environmental Finance Center Network (EFCN) is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and environmental infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S, including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.

The Wastewater Treatment Works Program Team

- Southwest Environmental Finance Center at the University of New Mexico
- Environmental Finance Center at Wichita State University
- Syracuse University Environmental Finance Center
- Environmental Finance Center at The University of North Carolina at Chapel Hill
- Environmental Finance Center at the University of Maryland
- EFC West
- Moonshot Missions
- Mississippi State Water Resources Research Institute

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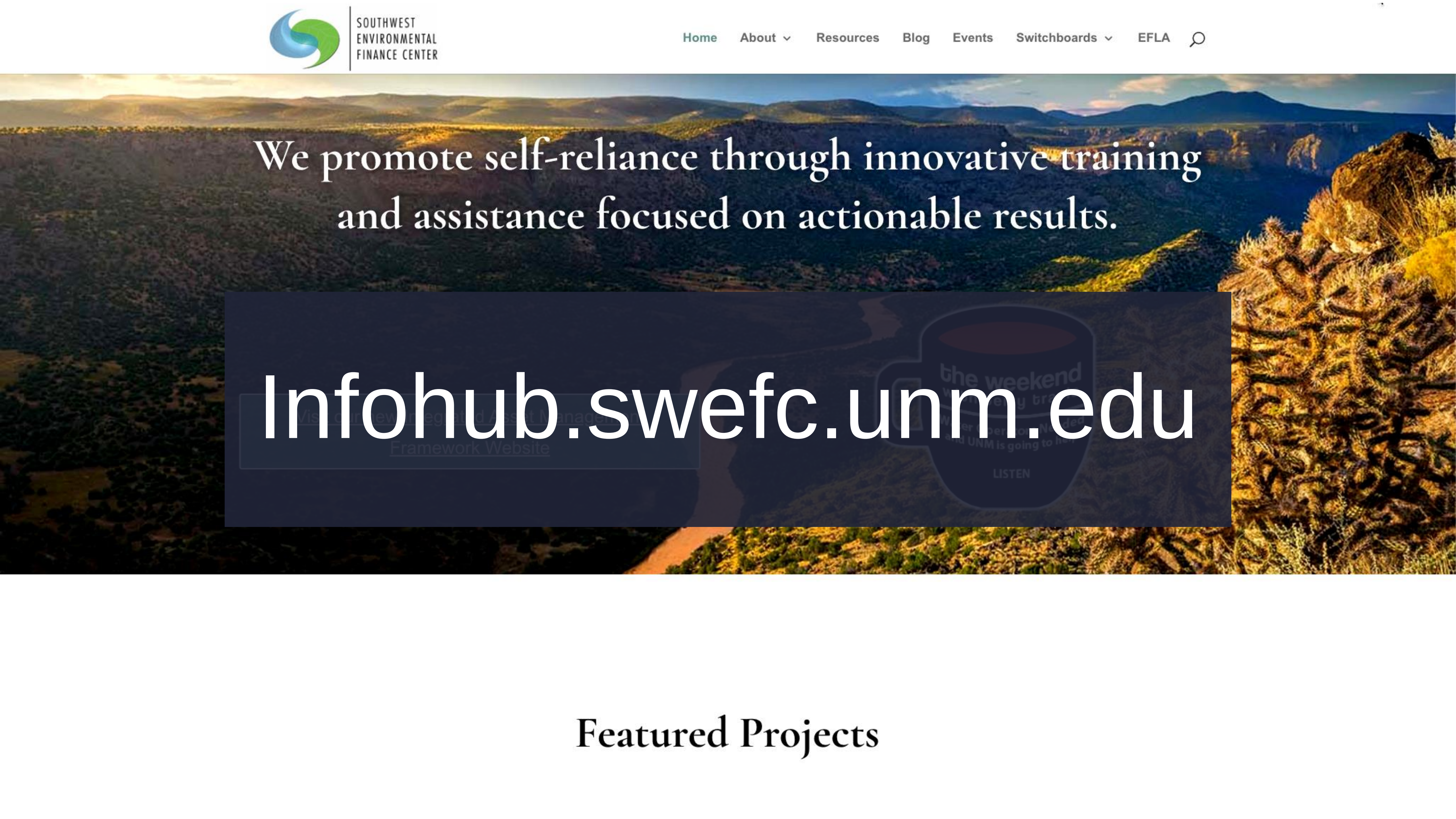
Areas of Expertise

- Asset Management
- Rate Setting and Fiscal Planning
- Leadership Through Decision-making and Communication
- Energy Management Planning
- Accessing Infrastructure Financing Programs
- Workforce Development
- Collaborating with Other Systems
- Resiliency Planning
- Mapping and Data Collection
- Wastewater Operator Certification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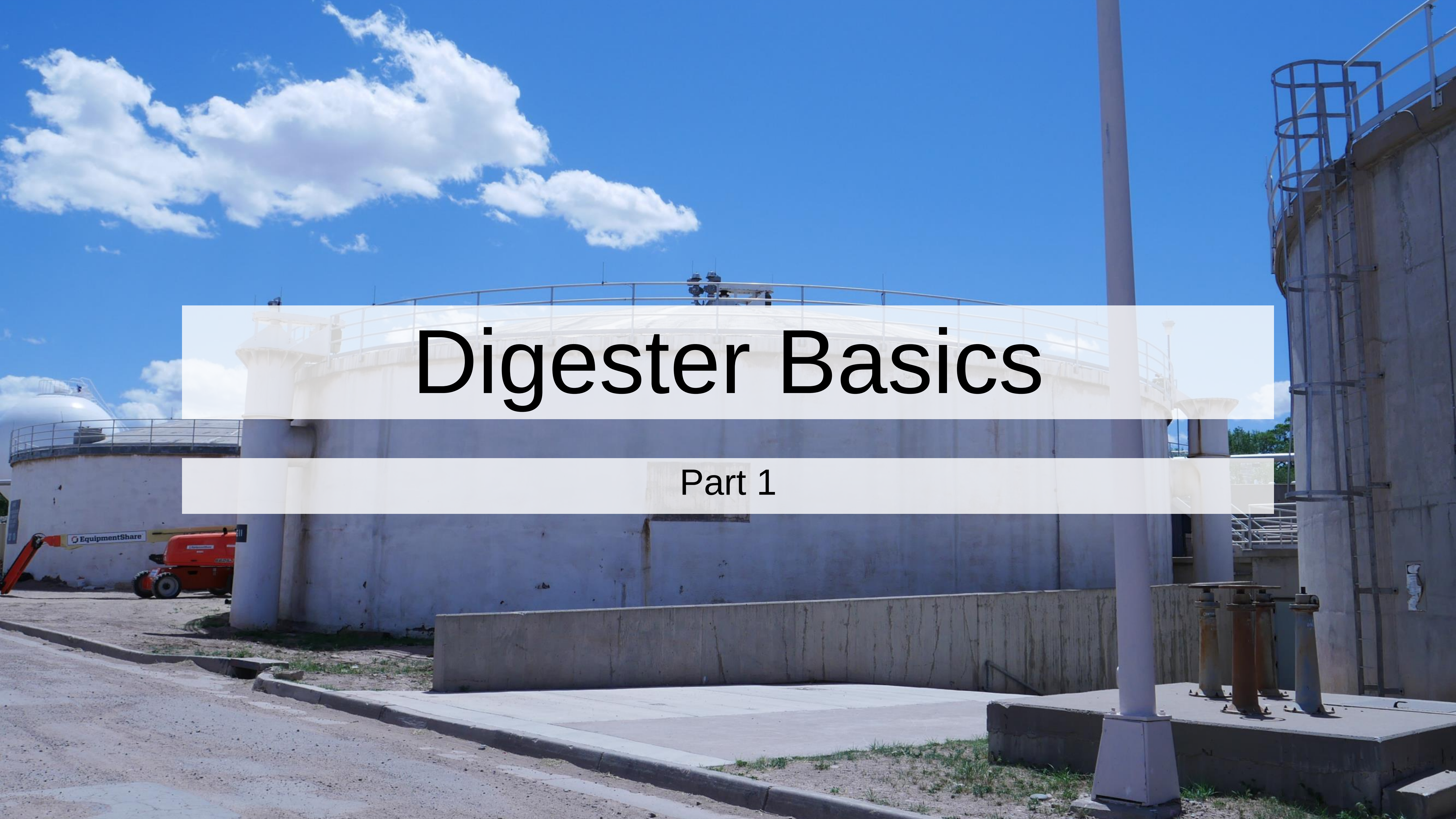
Agenda

- Digester Basics
- Aerobic Digestion
- Anaerobic Digestion
- Land Application

Digester Basics

Part 1



Digestion Overview

Biological digestion utilizes microorganisms to treat sludge.

Goals of biological digestion:

- Stabilization
  - Odor control
- Volume reduction
  - Reduction of organic matter to simpler components
- Pathogen removal
- Biogas production (Anaerobic digestion)
- Nutrient removal (Aerobic digestion)

Benefits of Digestion

- Improved Sludge Dewaterability
- Enhanced Biosolids Quality
- Minimized Environmental Impact

Types of Wastewater Sludge

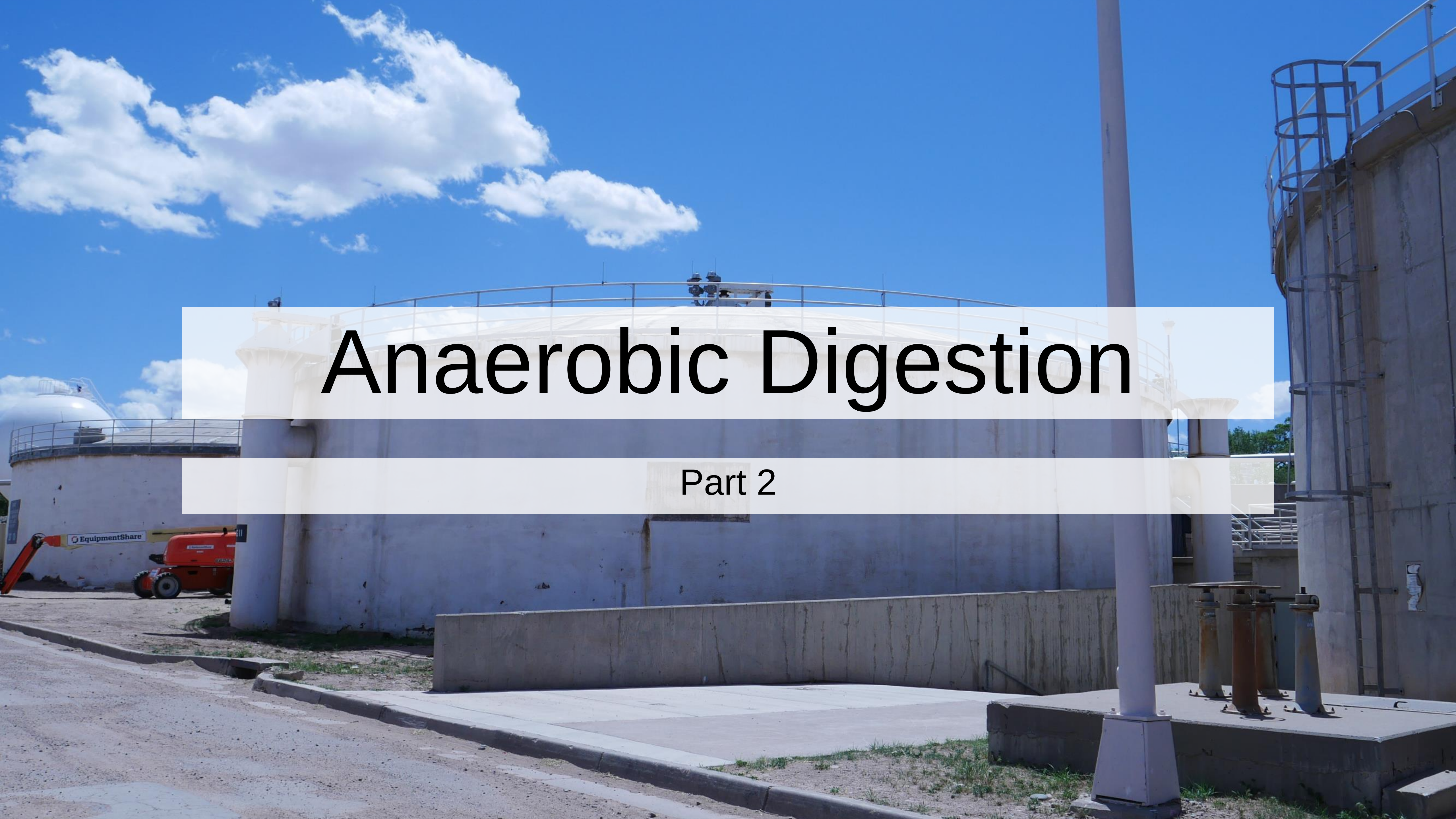
Primary sludge is produced during primary clarification and is unstable, odorous, and full of pathogenic bacteria.

- 4-5% total solids, with 70-90% volatile matter.

Secondary sludge is produced after secondary treatment through clarification and is partially stabilized.

- .2-6% total solids, with 65-75% volatile matter.

Tertiary sludge is similar to secondary sludge with additional chemical treatment.



Anaerobic Digestion

Part 2

Anaerobic Digestion Overview

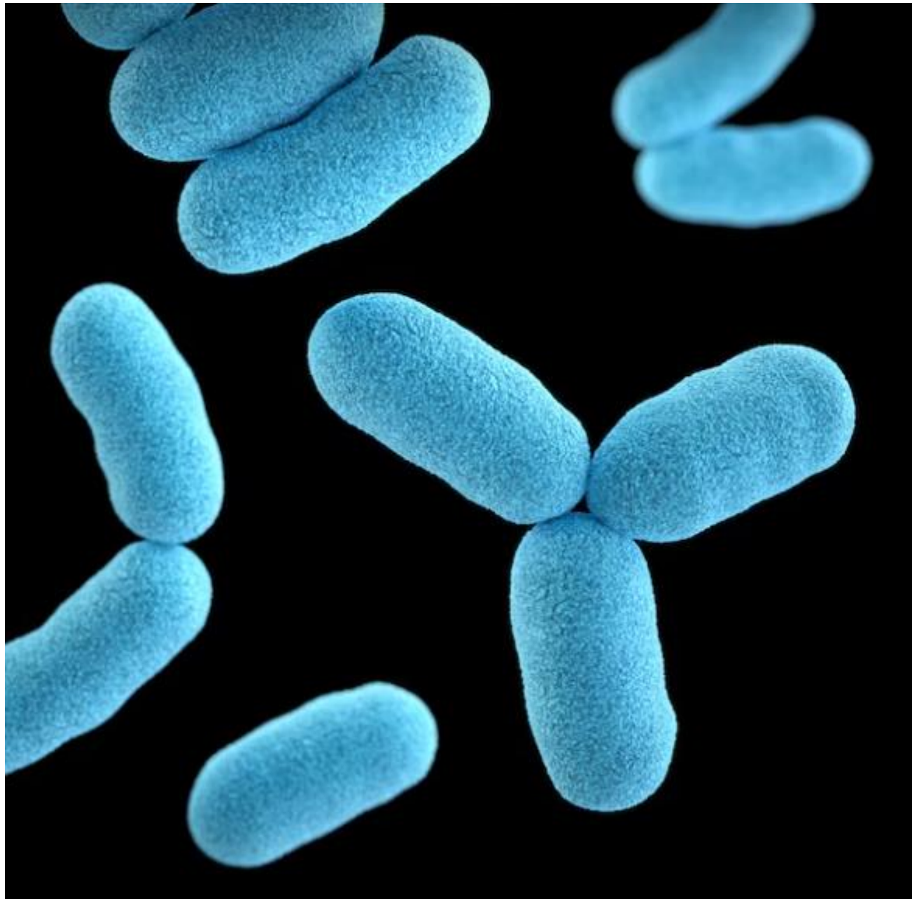
Takes place in the absence of oxygen

Relies on acid producers (saprophytic bacteria) and methanogens to breakdown organics to smaller components.

Produces methane, carbon dioxide, and water.

Anaerobic digestion occurs in multiple steps:

- Hydrolysis
- Acidogenesis
- Acetogenesis
- Methanogenesis



Anaerobic Digestion

Hydrolysis- Breakdown of large complex molecules such as proteins, carbohydrates, and lipids.

Acidogenesis- Hydrolyzed products are further metabolized, producing volatile fatty acids (VFA) and other intermediates.

Acetogenesis- Intermediate products are converted to acetate, which is another VFA.

Methanogenesis- Final step resulting in the conversion of intermediates into biogas, which is primarily methane and carbon dioxide

Digester Temperature Ranges

Psychrophilic = 50-68°F (10-20°C)

- Cold-loving bacteria, produces CO_2, H_2S, and a little bit of CH_4.

Mesophilic = 68-113°F (20-45°C)

- Medium-temperature-loving bacteria that produces high levels of CH_4. Ideal range is 95-98°F.

Thermophilic = 120-135°F (49-57°C)

- Hot-loving bacteria, which produces poor liquids/ solids separation. High temperatures are difficult to maintain.

Anaerobic Digestion Parameters

- Detention Time = 25-30 days
- pH = 6.6-7.6
- Ideal pH is 6.8-7.2
- Temperature = 95-98°F
- Volatile Acid/ Alkalinity Ratio = 1:10
- Alkalinity > 1,500 mg/L as $CaCO_3$

Anaerobic Digestion Components

Anaerobic Digester Tank- Primary vessel where anaerobic digestion takes place, constructed of concrete, steel, or fiberglass-reinforced plastic. At least 20 ft deep with a sloped floor.

Sludge Feed and Transfer Lines- Used to feed sludge to the top of the tank and to draw-off from the bottom. Draw-off lines are 6-inchs in diameter and equipped with plug valves.

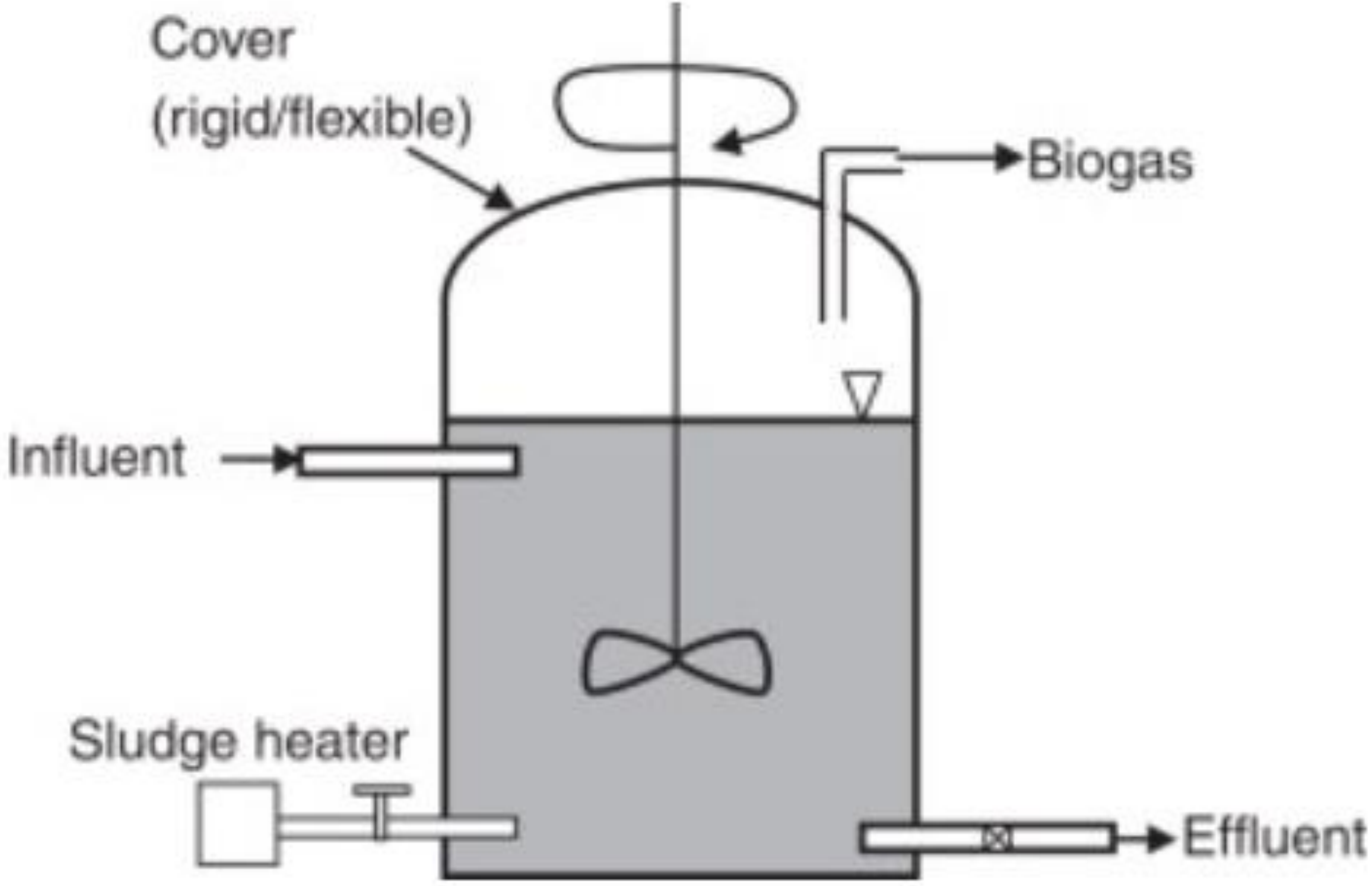
Heat Exchange System- Used to heat recirculated sludge and perform temperature control.

Mixers- Accomplished by mechanical mixers. Speeds up volatile solids breakdown and CH_4 production.

Floating Cover- Provides flexible space for sludge and gas storage.

Anaerobic Digestion Components Cont’d

- Digester Gas System- Provides management and collection method for biogas.
- Flame Arrestor- Used to burn off excess
- Supernatant Lines- Remove supernatant low in solids and transfers them to the headworks or clarifiers.
- Sample Port- Used to sample sludge at the top of the digester or from recirculation lines.
- Pressure Release Valves- Prevent overpressure situations and open when there is excessive biogas pressure.


Cover
(rigid/flexible)
Biogas
Influent
Sludge heater
Effluent

Anaerobic Digester Operations

Anaerobic digestion in the mesophilic range, occurs in 2 stages.

- Primary Stage- Heated and mechanically mixed, with up to 90% of gas production occurring here. Utilizes a floating cover.
- Secondary Stage- Utilized for storage and solid/liquid separation. Sometimes mechanically mixed and can be used as a reseeding source for primary digesters.

Operators should have a strong understanding of their pipe alignments

- Allows for proper manipulation of sludge flow

Anaerobic Digester Operations Cont'd

Anaerobic digester operation revolves around balancing the acid formation and methane fermentation processes by:

- Maintaining ideal temperature range (Never change more than 1° F/ day)
- Ensuring mixing to promote contact between microorganisms and sludge/ food sources, and consistent heating throughout.
- Maintaining proper feed and withdraw rates.
- Maintain acid/alkalinity rates.

Sludge Feeding

- Inlet and Mixing System- Raw and partially digested sludge are mixed and introduced into the anaerobic digesters.
- Best done several times a day to distribute heat throughout the day.
- Pumping multiple times a day is also beneficial to clarifiers.
- Sludge should be as thick as possible.

Operations and Analysis

- Temperature measurement is usually located in the sludge recirculation line.
- Volatile acid/ alkalinity acid is essential to maintain 0.1 VA/ALK ration.
- Biogas content
  - CH_4 = 65-70% CO_2 = 30-35%
  - Gas does not combust if CO_2 >= 45%
- pH
- Solids Content
  - 3-6% total solids ideal

Digester Trouble Shooting

Digester “Souring”- VA/Alkalinity ratio > 0.1 and pH = 7.0-7.2

- Usually caused by overfeeding.

Digester “Stuck”- VA/Alkalinity ratio > 0.5 and pH < 7.0

- Caused by not correcting a sour digester.

Foaming- Large amounts of foam in sample ports or in seal of floating cover.

- Caused by scum blanket breaking up, radical temperature change or overfeeding.

Low Methane Production- CO_2 > 40%

- Underfeeding or uneven temperature control.

High TSS in Supernatant- TSS > 1000 mg/L

- Caused by errors in supernatant management or excessive heat

Digester Gas

Gas system is composed of gas dome, pressure and vacuum relief valves, flame arresters, thermal valves, sediment traps, drip traps, gas meters, manometer, pressure regulators, and waste gas burner.

8-12 ft^3 of biogas produced for every pound (lb) of volatile matter added and 12-18 ft^3 for every lb of volatile matter destroyed.

Gas has a heat value of 500-600 BTU per ft^3.

Gas is used for heating digesters, driving generators for electricity and building heat.

Often used to heat water used for heat exchangers to 140-180°F.

Aerobic Digester

Part 3

Aerobic Digester Basics

- Takes place in an aerobic environment.
- Extension of secondary treatment processes.
- Digesters are provided dissolved air, but no additional heating.
- No external food source, and microorganisms are used as a food source.
- Volatile solids reduction is 20-40% and detention times are 20-30 days.

Aerobic Digester Components

Digester tank- At least 10 ft deep

Aeration system- Produces DO for the system

Sludge lines- Inlet located above water line and outlet at the digester floor. Minimum 3-inches.

Supernatant tubes- Remove decanted liquid from the top of the digester. Aeration must be shut off to remove decant. Supernatant can be source of filamentous bacteria.

Aerobic Digester Operations

- Operations are actually simpler than anaerobic digesters.
- Feed rates = wasting rates of secondary processes.
- Sludge removal based on level of the digester.
- DO = 1.0 mg/L min.
- Require regular cleaning every few years for inspection and to remove sediment.

Aerobic Digester Parameters

- pH >= 7.0
- Total Solids = 1.5-4%
- Volatile solids reduction = 20-40%
- DO = 1.0 mg/L min. is ideal and should NEVER drop below 0.5%

Land Application

Part 4

Drying Beds

- Limited to small to medium sized plants that handle less than 5 MGD
- Require a lot of land
- Warmer climates are better suited for drying beds
- 3 types: sand, asphalt or concrete, and vacuum filter beds

Sand drying beds

- Shallow lined concrete or earthen basins with perforated pipe installed under a 12-18 in layer of gravel with an 8-12 in layer of sand on top
- Decant tubes located on the corners to drain pooled water off the sludge
- Sludge is poured on to bed at a depth of 12 in
- Water evaporates from the sludge while also percolating down through the sand layer and collected and removed by the perforated pipe under drain system
- When the sludge has dried and cracked all the way through the sand it is removed by shovel or if skid loader is used care must be taken not to crush the under-drain system

Sand Drying Beds Cont’d

Climatic conditions: frozen beds can only be cleared when thawed

Depth of sludge: not to exceed 12 in or drying time will increase substantially; should not pour sludge on partially dry sludge known as “capping” because lower layer will get sealed off; this lower layer will turn into “green sludge” and will be odorous and will not dry

Condition of sand: sand must be level; older drying beds can become compacted and will not allow water to permeate and if this happens the top 2-3 in should be removed and replaced with fresh sand; some beds use expensive prewashed sand and others use “arroyo sand”; best sand has no dirt or clay and is free of excessive small particles called “fines”

If polymer is used, the drying time can be cut in half

Can produce greater than 95% Total Solids

Asphalt Drying Bed

- Similar to sand drying beds but instead of sand hard asphalt or concrete surface is used
- Hard surface allows mixing equipment to be used which speeds up drying time
- Decant tubes are especially important it takes too much time for water to evaporate off the surface
- Sludge can be poured deeper 18-30 in
- Mixing is accomplished by tractor, backhoe specially designed equipment

Vacuum Filter Beds

- Consist of shallow concrete basin with an under-drain system covered over with porous pumice bricks or stainless steel or plastic perforated panels
- Sludge is conditioned with polymer before being put into bed
- Vacuum pump is used to create a vacuum underneath the panels which rapidly draws water from the sludge
- Can produce sludge to 15-30% TS in a matter of hours or days
- Bed is cleaned out by a skid loader or small backhoe

Land Application of Biosolids

Involves applying biosolids to vegetated land

3 areas of concern:

- Pathogenic contamination
- Vector attraction reduction
- Toxins or potential toxins

Governed by Title 40 CFR part 503

2 classes of sludge

- Class A- Can be provided to the general public
- Class B- Cannot be provided to the public

Class A sludge

Class A has strict composting requirements.

Sludge is placed in a pile called a windrow along with wood chips or other mulched green waste.

Microorganisms digest the sludge and green waste.

Windrow is mechanically aerated or turned to provide oxygen.

Process creates heat with temperature > 131°F and must be maintained for 15 days with 5 complete pile turnings.

Requires a special compost facility license.

Surface Disposal

- Sludge can be injected as a liquid 1-3 ft below the surface
- Can be spread as solid over land and plowed to mix into soil
- Regulated by Title 40 CFR part 503 and requires a regulatory permit
- Not considered as environmentally friendly option as land application

Landfilling

Least desirable option

Takes up valuable landfill space

Should only be practiced due to economics or poor sludge quality

Requires a sludge disposal plan by the NMED Surface Water Bureau and haulers must be licensed with a “special waste” permit to transport the sludge


Questions?

CONTACT INFORMATION

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