Wastewater Systems

Solids Handling Part 2

8/27/2026

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

Agenda

- Sludge Thickening – Covered last time
- Dewatering – Covered last time
- Digester Basics
- Aerobic Digestion
- Anaerobic Digestion
- Land Application

Biological Digestion

Part 1

Biological Digestion Overview

Biological digestion utilizes microorganisms to treat sludge

Goals of biological digestion:

- Reduce volume of organic matter to simpler components
- Stabilization for odor control
- 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.

- 0.2-6% total solids, with 65-75% volatile matter.

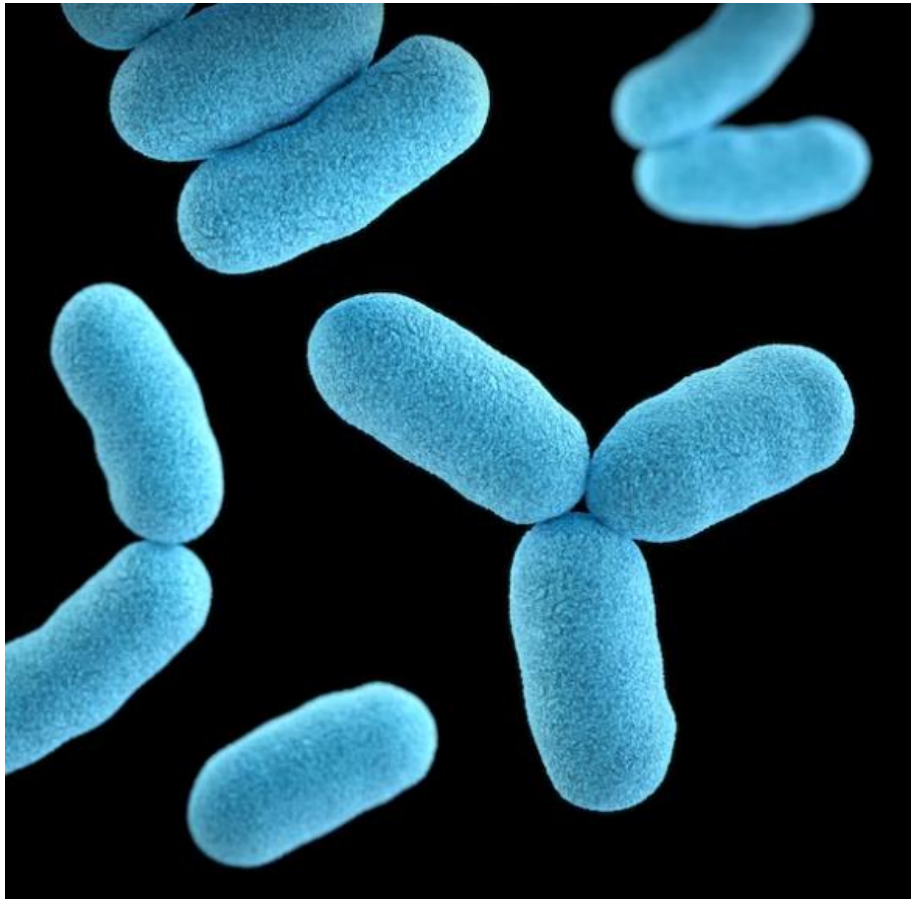
Tertiary sludge is similar to secondary sludge with additional chemical treatment.

Anaerobic Digestion

Part 2

Anaerobic Digestion Overview

- Takes place in the absence of oxygen
- Relies on **saprophytic bacteria** (acid producers) and **methanogens** to breakdown organics to smaller components
- Occurs in multiple steps
- Produces methane (CH_4), carbon dioxide (CO_2), and water (H_2O)



Anaerobic Digestion Steps

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, another VFA

Methanogenesis
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)

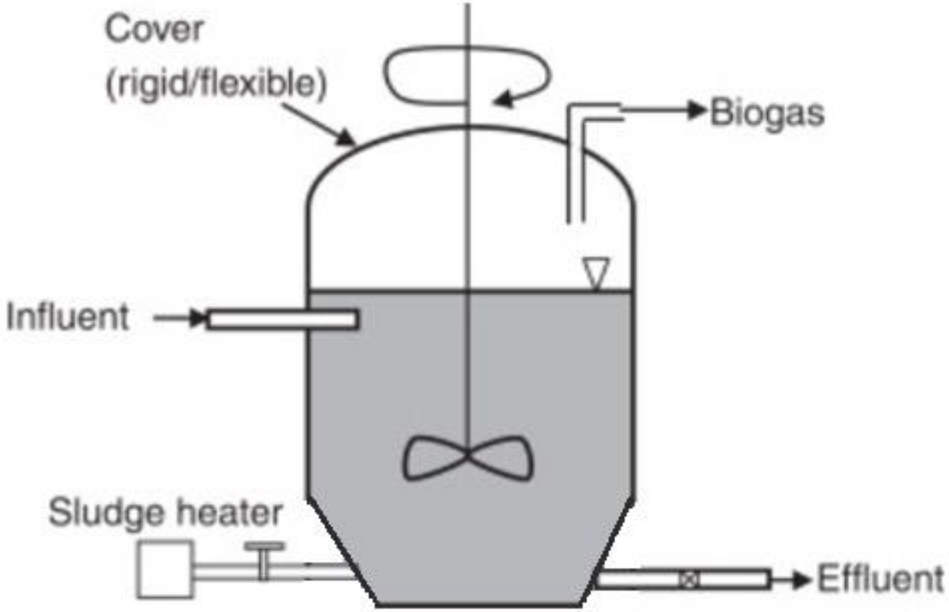
- Hot-loving bacteria, accelerated digestion and biogas production, but results in poor liquids/ solids separation, and high temperatures are difficult to maintain.

Anaerobic Digestion Conditions

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

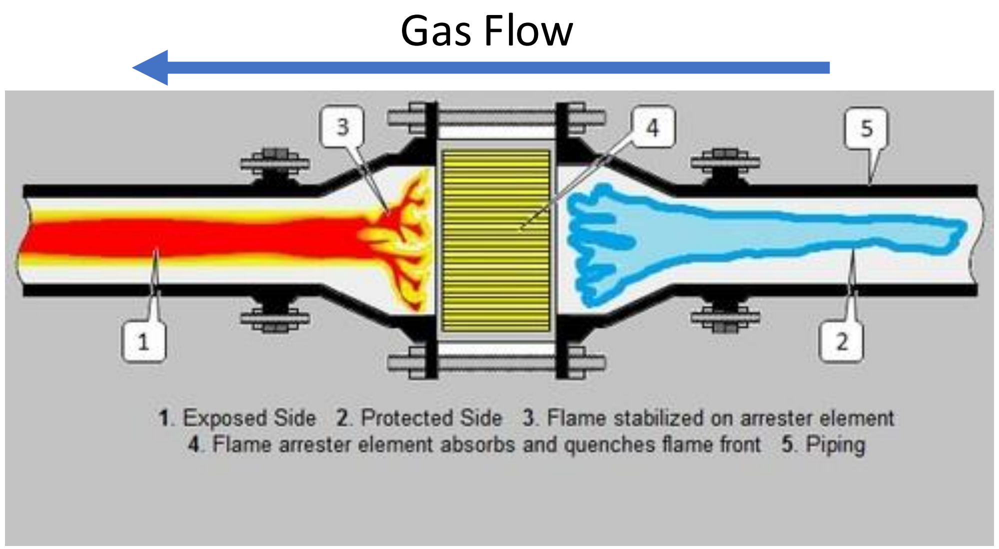
Anaerobic Digester Components

- Anaerobic Digester Tank
- Sludge Feed, Discharge, and Draw-off Lines
- Heat Exchange System
- Mixers
- Floating Cover



Anaerobic Digestion Components Continued

- Digester Gas System
- Flame Arrestor
- Supernatant Lines
- Sample Port
- Pressure Release Valves



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 fixed 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 to avoid issues with overfeeding
- Overfeeding can increase the volatile acid/alkalinity ratio

Sludge Feeding

Sludge should be a well mixed combination of raw sludge from primary clarification and partially digested secondary sludges

- Raw sludge = 4-5% solids that is 70-90% volatile matter
- Secondary sludge = 0.2-4% solids (3-6% with polymer) that is 65-75% volatile matter

Sludge Feeding

- Done several times a day to avoid
  - Lowering temperature and overfeeding
  - Holding sludge too long in the primaries
- Sludge should be as thick as possible
  - Takes up less space
  - Doesn’t dilute digester’s buffering capacity
- Sludge rate withdrawal should not exceed 5% of digester contents in 24h

Anaerobic Digester Operational Analysis

- Temperature
- Volatile acid and alkalinity multiple times/week (1:10 ratio)
- Biogas content
  - CH_4 = 65-70%
  - CO_2 = 30-35%
  - Gas does not combust if CO_2 >= 45%
  - H_2S <5%
- pH = 6.6-7.6
- Total Solids Content
  - 3-6% ideal

Anaerobic Digester Troubleshooting

Digester "Souring"

- VA/Alkalinity ratio >0.1 (1:10) 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.

Anaerobic Digester Troubleshooting

Low Methane Production

- CO_2 >40%
- During startup, underfeeding, or uneven temperature control

High TSS in Supernatant

- TSS >1000 mg/L
- Caused by errors in supernatant management or excessive heat

Anaerobic Digester Gas System

- System is composed of gas dome, pressure and vacuum relief valves, flame arresters, thermal valves, sediment traps, drip traps, gas meters, a manometer, pressure regulators, and a 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/ft^3
- Gas is used for heating digesters, driving generators for electricity and building heat.

Aerobic Digester

Part 3

Aerobic Digester Basics

- Takes place in an aerobic environment (O_2 present)
- 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% with detention times of 20-30 days

Aerobic Digester Components

- Digester Tank (~10 feet depth)
- Aeration system to maintain dissolved oxygen (DO)
- Sludge lines with inlet located above water line and outlet at the digester floor. Minimum 3-inches in diameter.
- Supernatant tubes to remove decanted liquid from the top of the digester and return to headworks. Aeration must be shut off to remove decant. Supernatant can be source of filamentous bacteria.

Aerobic Digester Operations

- Operations are simpler than anaerobic digesters
- Feed rates less critical and based on need to waste solids from secondary treatment
- Sludge removal based on level of the digester
- DO = 1.0 mg/L
- Require regular cleaning every few years for inspection and to remove sediment

Aerobic Digester Operational Analysis

- 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 0.5mg/L

Land Application

Part 4

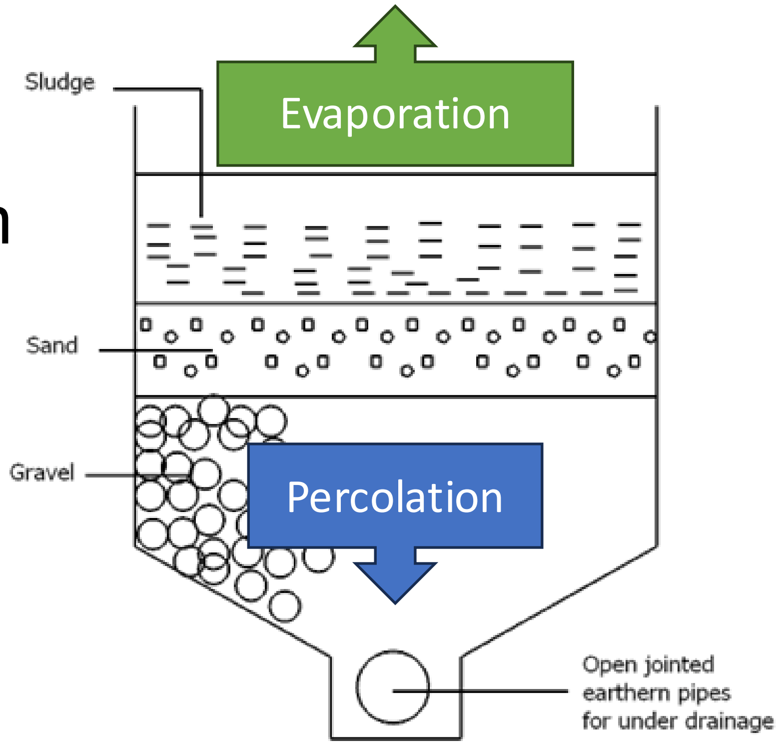
Drying Beds

- 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
  - Vacuum filter beds

Drying Beds

Sand Drying Beds

- Shallow lined concrete or earthen basin with a perforated pipe installed under a 12-18” layer of gravel with an 8-12” layer of sand on top
- Decant tubes at corners drain pooled water from the sludge
- Water evaporates from the sludge while also percolating down through the sand layer and collected and removed by the perforated pipe under drain system
- Sand must be level; older drying beds can become compacted and will not allow water to permeate; the best sand has no dirt or clay and is free of excessive small particles called “fines”



Sand Drying Bed Operation

- Frozen beds can only be cleared when thawed
- Depth of sludge should not be >12”
- New sludge should not be poured on partially dry sludge (capping)
- Polymer can cut the drying time in half
- When the sludge has dried and cracked all the way through to the sand it is removed by shovel or if a skid loader is used, care must be taken not to crush the under-drain system
- Can produce greater than 95% total solids

Asphalt/Concrete Drying Bed

- Asphalt or a concrete surface is used instead of sand
- Hard surface allows mixing with mechanical equipment to speed up drying time
- Sludge is poured to a depth of 18-30”
- Decant tubes are especially important to remove surface water

Vacuum Filter Beds

Shallow concrete basin with an under-drain system covered with porous pumice bricks, stainless steel, or plastic perforated panels

Sludge is conditioned with polymer before being put onto bed

A vacuum pump rapidly draws water from the sludge

Can quickly produce sludge with 15-30% total solids (TS)

Bed can be cleaned out by a skid loader or small backhoe

Land Application of Biosolids

- Involves applying biosolids to vegetated land to create compost that adds nutrients to the soil
- 3 areas of concern when doing land application
    1. Pathogenic contamination
    2. Vector attraction reduction (VAR)
    3. Toxins or potential toxins
- Governed by Title 40 CFR part 503
- Two classes of sludge
    1. Class A
    2. Class B

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 operator license.

Surface Disposal

- Regulated by Title 40 CFR part 503 and requires a regulatory permit
- Sludge can be injected as a liquid 1-3 ft below the surface
- Sludge can be spread as solid over land and plowed to mix into soil
- 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 solids quality
- Requires a sludge disposal plan approved by the appropriate regulating agency
- Sludge haulers must be licensed with a “special waste” permit to transport the sludge

Poll Question #1

Sludge digestion is designed to do what?

a. Break down debris removed from wastewater influent
b. Stabilize and reduce volume of solids
c. Disinfect wastewater effluent
d. Dewater solids

Poll Question #2

Aerobic digestion occurs in the presence of what?

a. Water
b. Anaerobes
c. Oxygen
d. Pathogens

Poll Question #3

Mesophilic bacteria prefer what type of temperature?

a. Cold (50-68°F)
b. Hot (120-135°F)
c. Medium (68-113°F)
d. Cold (10-20°C)

Poll Question #4

What is the ideal pH range for anaerobic digestion?

a. 6.8-7.2
b. 6.6-7.2
c. Greater than 100°F
d. Less than 6.6

Poll Question #5

Land application of solids is governed by which rule?

a. International Plumbing Code
b. 40 CFR Part 503
c. Clean Drinking Water Act
d. Forest Department Code 1235

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