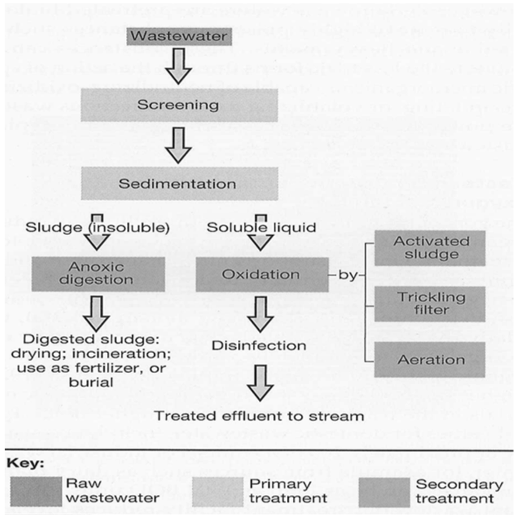
Sludge Treatment

Primary Treatment or Primary Sedimentation

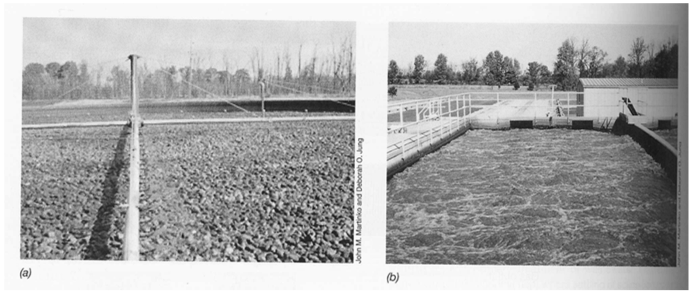
- Settle solids for 2-3 hours in a static, unmixed tank or basin.
- ~75-90% of particles and 50-75% of organics settle out as "primary sludge"
- **enteric** microbe levels in primary sludge are ~10X higher than in raw sewage
- Little removal of enteric microbes: typically ~50%

rod-shaped Gram-negative *bacteria*; most occur normally or pathogenically in intestines of humans and other animals



Simmons 3

Trickling Filter and Aeration Basin for Wastewater Treatment



Simmons 4

Secondary or Biological Treatment

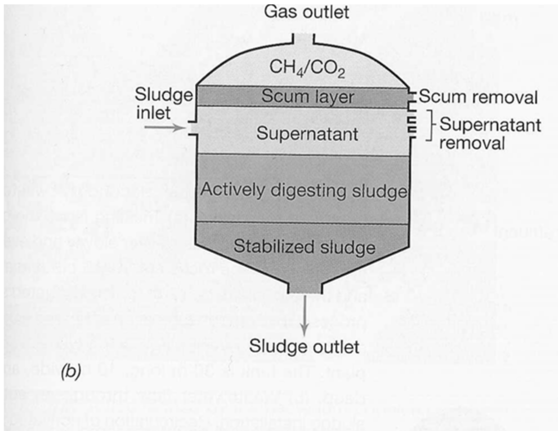
- **aerobic biological treatment**
  - activated sludge or trickling filtration
- **Settle out** the biological solids produced (secondary sludge)

  ~**90-99% enteric** microbe/pathogen **reductions** from the liquid phase

  enteric microbe **retention** by the **biologically active solids**
- **Biodegradation** of enteric microbes

  - proteolytic enzymes and other degradative enzymes/chemical

  - Predation by treatment microbes/plankton (amoeba, ciliates, rotifers, etc.)



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Waste Solids (Sludge) Treatment

- Treatment of the settled solids from sewage treatment
- Biological "digestion" to biologically stabilize the sludge solids
  - Anaerobic digestion (anaerobic biodegradation)
  - Aerobic digestion (aerobic biodegradation)
  - Mesophilic digestion: ambient temp. to ~40ºC; 3-6 weeks
  - Thermophilic digestion: 40-60ºC; 2-3 weeks

Simmons 7

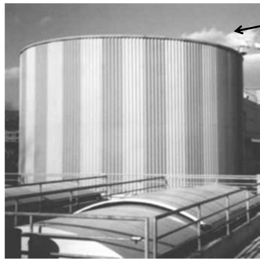
Anaerobic digestion

The goal is to reduce the amount of sludge that needs to be disposed.
The most widely employed method for sludge treatment is **anaerobic digestion.**

In this process, a large fraction of the organic matter (cells) is broken down into **carbon dioxide (CO2)** and **methane (CH4),** and this is accomplished in the absence of oxygen.

About half of the amount is then converted into gases, while the remainder is dried and becomes a residual soil-like material.

- Produce digested (biologically stabilized) sludge solids for further treatment and/or disposal
  - Waste liquids from sludge treatment are recycled through the sewage treatment plant
  - Waste gases from sludge treatment are released or burned if from anaerobic digestion: methane, hydrogen, etc.



What the equipment looks like:
The tank is capped
- to prevent oxygen from coming in, and to capture the methane produced.
This methane, a fuel, can be used to meet some of the energy requirements of the wastewater treatment facility (co-generation).

What the sludge looks like after anaerobic digestion and subsequent drying.

It is rich in nitrates and performs well as a fertilizer.

2-stage Anaerobic Sludge Digester

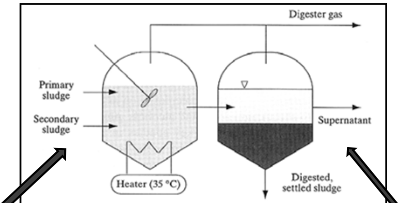


Figure 6.E.7 Schematic of a two-stage, high-rate anaerobic sludge digester (Metcalf & Eddy, 1991).

- all incoming flows of sludge are combined,
- heated to a mild temp (about body temperature) to accelerate biological conversion.
- residence time ranges from 10 to 20 days

- the mixture is allowed to undergo further digestion.
- There is no longer active mixing in order to promote separation,
- there is no need of heating as the process generates its own heat.

Processes to Further Reduce Pathogens (PFRP) Class A Sludge

- **Class A sludge:**
  - <1 virus per 4 grams dried sludge solids
  - <1 viable helminth ovum per 4 grams dried sludge solids
  - <3 *Salmonella* per 4 grams of dried sludge solids
  - <1,000 fecal coliforms per gram dry sludge solids

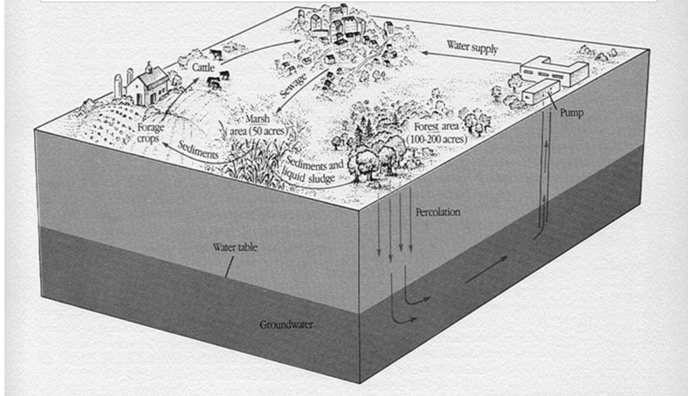
Class A sludge or “biosolids” can be disposed by a variety of options

- marketed and distributed as soil conditioner for use on non-edible plants)

Processes for producing Class A sludge

- thermal (high temperature) processes (incl. thermophilic digestion); hold sludge at 50^{o}C or more for specified times
- lime (alkaline) stabilization; raise pH 12 for 2 or more hours
- composting: additional aerobic treatment at elevated temperature

Land Application of Treated Wastewater:
Alternative Disposal Option



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Dewatering Systems

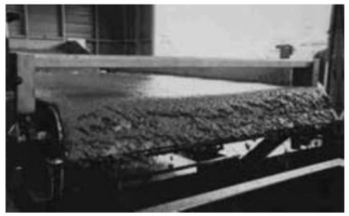
The purpose of thickening the sludge is to reduce its volume, which can be several fold.

Typical sludge comes at 1% solid fraction. Thickening it to 2% halves the volume, to 10% reduces the volume by a factor 10. [1% solid fraction ≈ 10,000 mg/L]

The various existing methods are:

- Gravity thickening (can achieve up to 10% solid fraction)
- Dissolved air flotation (can achieve up to 6% solid fraction)
- Thickening centrifuge (can achieve up to 8% solid fraction).

- - Gravity belt thickening (can achieve up to 6% solid fraction)
- (uses a polymer to coagulate the solids, from which follows a rejection of water)



Modular Wastewater Treatment Systems

electrochemical metals removal process, pH adjustment, coagulation, clarification, multi-media filtration, air stripping, activated carbon adsorption, final pH adjustment, sludge dewatering

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Wastewater Reuse and Tertiary Treatment

Wastewater Reuse

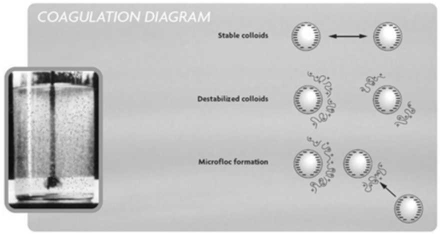
- Wastewater is sometimes reused for beneficial, non-potable purposes in arid and other water-short regions
- Often use advanced or additional treatment processes, sometimes referred to as "reclamation"
- Biological treatment in "polishing" ponds and constructed wetlands

Physical-chemical treatment processes as used for drinking water:

- Coagulation-flocculation and sedimentation
- Filtration: granular medium filters; membrane filters
- Granular Activated Carbon
- Disinfection

Coagulation-Flocculation-Clarification

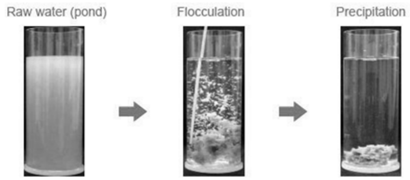
Coagulation *is a chemical reaction which occurs when a chemical, or coagulant, is added to the water. The coagulant encourages colloidal material in the water to join together into small aggregates or " flocs ". Further suspended matter in the water is then attracted to the flocs. Rapid mixing of the water and coagulant is important to ensure thorough and even distribution of the coagulant.*

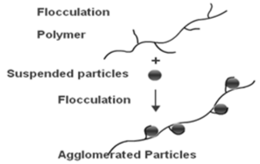


Coagulants neutralize the negative electrical charge on particles, which destabilizes the forces keeping colloids apart.

Examples:
aluminum salts, iron salts, and polyelectrolytes.

Flocculation *is a slow gentle mixing of the water to encourage the flocs to form and grow to a size which will easily settle out. This mixing is often done in a chamber or a series of chambers.*





Flocculants:
low, medium, and high molecular weight polymers

Clarification *is the final part of the process and allows the large flocs containing much of the suspended matter to sink to the bottom of a tank or basin, while the clear water overflows and is then further treated.*

Disinfection

- Disinfection is any process to destroy or prevent the growth of microbes
- Many disinfection processes are intended to inactivate microbes by physical, chemical or biological processes
- Inactivation is achieved by altering or destroying essential structures or functions within the microbe
- Inactivation processes include denaturation of proteins, nucleic acids, and lipids

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When Wastewater Disinfection is Recommended or Required

- Discharge to surface waters:
  - near water supply intakes
  - used for primary contact recreation
  - used for shellfish harvesting
  - used for irrigation of crops and greenspace
  - other direct and indirect reuse and reclamation purposes
- Discharge to groundwaters:

- used as a water supply source
- used for irrigation of crops and greenspace
- other direct and indirect reuse and reclamation purposes

Disinfection of Wastewater

- Intended to reduce microbes in treated effluent
  - Typically chlorination
  - **Alternatives:** UV radiation, ozone, and chlorine dioxide
- Good enteric bacterial reductions: typically, 99.99+%
  - Meet fecal coliform limits for effluent discharge
- Less effective for viruses and parasites: typically, 90% reduction

Toxicity of chlorine and its by-products to aquatic life now limits wastewater chlorination.

Dechlorination

- Alternative less toxic chemical disinfectants
- Alternative treatment processes to reduce enteric microbes
- granular medium filtration or membrane filtration

Estimated Pathogen Reductions by Sewage Treatment Processes: An Example

	% reduction	Cumulative reduction	Organisms/L
None	0	0	10000
Primary settling	50	50	5000
2º biological treatment	99	99.5	50
Granular med. filtration	90	99.5	5
Disinfection	99	**99.9995**	0.05

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Common Disinfectants in Water and Wastewater Treatment

- Free Chlorine
- Monochloramine
- Ozone
- Chlorine Dioxide
- UV Light
  - Low pressure mercury lamp (monochromatic)
  - Medium pressure mercury lamp (polychromatic)
  - Pulsed broadband radiation

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Properties of an Ideal Disinfectant

- Broad spectrum: active against all microbes
- Fast acting: produces rapid inactivation
- Effective in the presence of organic matter, suspended solids and other matrix or sample constituents
- Nontoxic; soluble; non-flammable; non-explosive
- Compatible with various materials/surfaces
- Stable or persistent for the intended exposure period
- Provides a residual (sometimes this is undesirable)
- Easy to generate and apply
- Economical

THE END