

CEE 370

Environmental Engineering Principles

Lecture #30

Wastewater Treatment I:

WW characteristics, 1° & 2° treatment

[Reading M&Z, Chapter 9](#)

[Reading: Davis & Cornwall, Chapt 6-1 to 6-8](#)

[Reading: Davis & Masten, Chapter 11-1 to 11-7](#)



WW Parameters

- Conventional
 - BOD
 - TSS
 - Oil & grease
 - pH
- Nutrients
 - Nitrogen
 - Ammonia
 - Nitrate
 - TKN
 - Phosphorus
- Toxics
 - Heavy metals
 - Chromium, etc.
 - Pesticides
 - Parathion, etc
 - Industrial
 - Phenol, etc.
- PPCPs
 - Pharmaceuticals
 - Personal care products
- Others
 - TOC, etc.

Wastewater Characteristics

■ Municipal/Domestic WW

TABLE 10-1

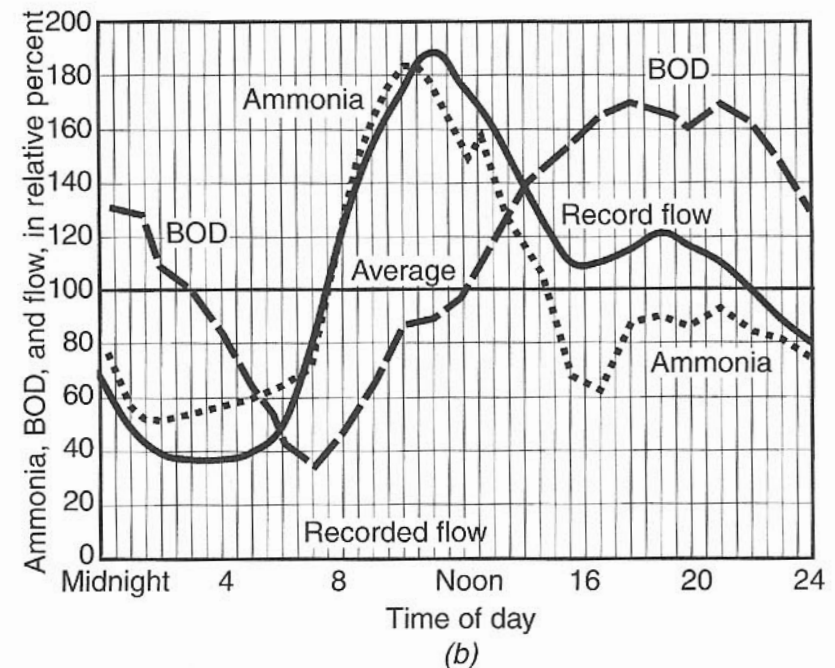
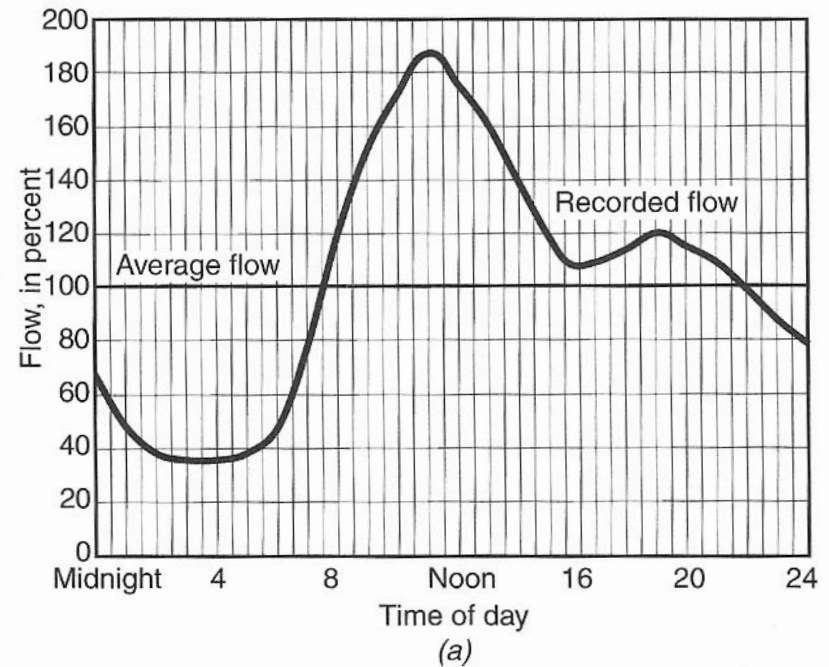
Typical Composition of Untreated Domestic Wastewater

| Constituent | Weak (all mg · L⁻¹ except settleable solids) | Medium | Strong |
|---|--|---------------|---------------|
| Alkalinity (as CaCO ₂) ^a | 50 | 100 | 200 |
| BOD ₅ (as O ₂) | 100 | 200 | 300 |
| Chloride | 30 | 50 | 100 |
| COD (as O ₂) | 250 | 500 | 1000 |
| Suspended solids (SS) | 100 | 200 | 350 |
| Settleable solids (in mL · L ⁻¹) | 5 | 10 | 20 |
| Total dissolved solids (TDS) | 200 | 500 | 1000 |
| Total Kjeldahl nitrogen (TKN) (as N) | 20 | 40 | 80 |
| Total organic carbon (TOC) (as C) | 75 | 50 | 300 |
| Total phosphorus (as P) | 5 | 10 | 20 |

^aThis amount of alkalinity is the contribution from the waste. It is to be added to the naturally occurring alkalinity in the water supply. Chloride is exclusive of contribution from water-softener backwash.

Municipal WW

- Temporal Patterns in flow and quality
 - Seasonal
 - Weekly
 - Daily



On-site disposal

- Septic Systems
 - Requires minor levels of maintenance

FIGURE 10-1

Schematic of a conventional septic system. (Source: R. Crites and G. Tchobanoglous, *Small Decentralized Wastewater Management Systems*, WCB/McGraw-Hill, Boston, MA, 1998. Reprinted by permission.)

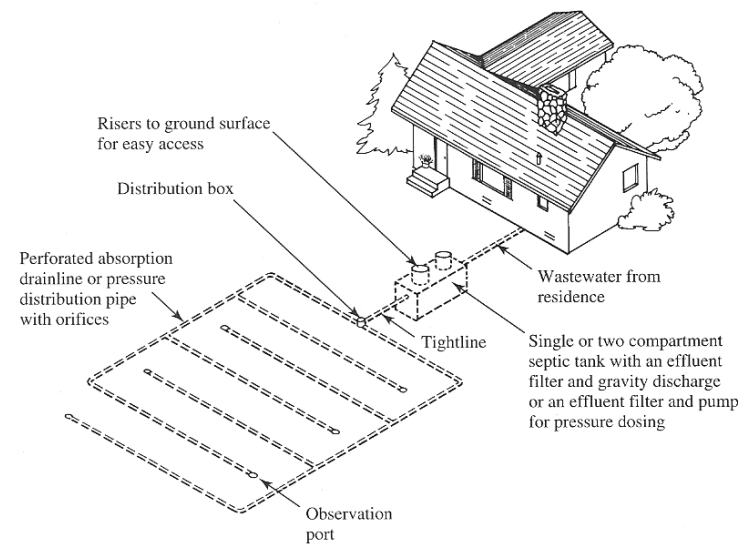


FIGURE 10-2

Definition sketch for the sludge, clear water, and scum zones that form in a septic tank. (Source: R. Crites and G. Tchobanoglous, *Small Decentralized Wastewater Management Systems*, WCB/McGraw-Hill, Boston, MA, 1998. Reprinted by permission.)

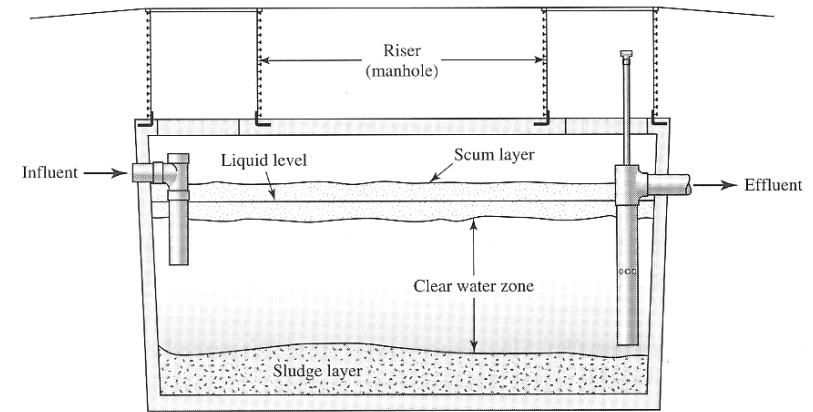
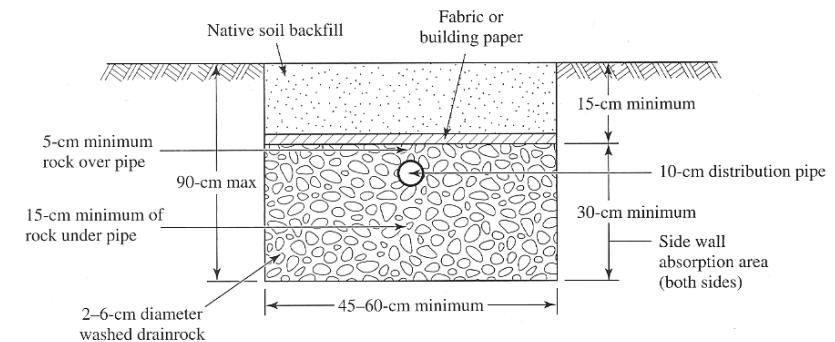


FIGURE 10-3

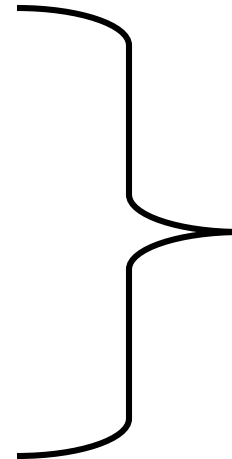
Typical cross section through conventional absorption trench. (Source: R. Crites and G. Tchobanoglous, *Small Decentralized Wastewater Management Systems*, WCB/McGraw-Hill, Boston, MA, 1998. Reprinted by permission.)





Municipal WW Treatment

- Primary
 - Solids removal
- Secondary
 - Biological treatment
 - BOD control
- Tertiary or Advanced
 - Biological or chemical
 - Nutrient control, etc

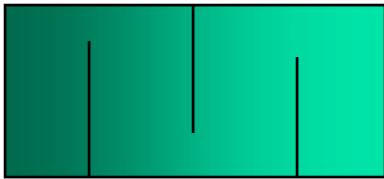


Conventional

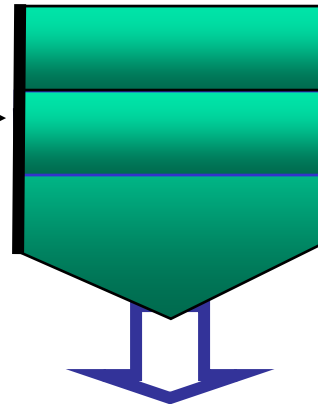
Also must treat residuals (e.g., sludge)

Conventional WW Treatment

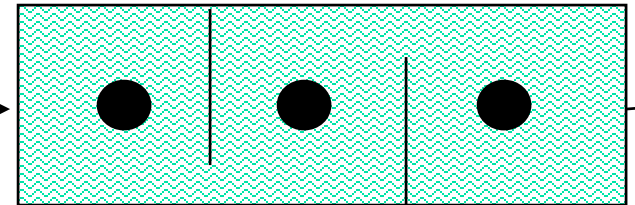
Preliminary Treatment



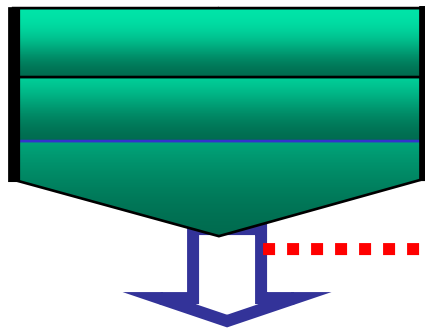
Primary Sedimentation



Biological Process



Secondary Sedimentation



Disinfection

Saskatoon WWTP



Chlorine Contact Chamber

Primary Settling Basins

Grit & Screen Facility

Control Room

Pump Station

Digester

Fermenters

DAF Thickener

Heating Building

Utility Building

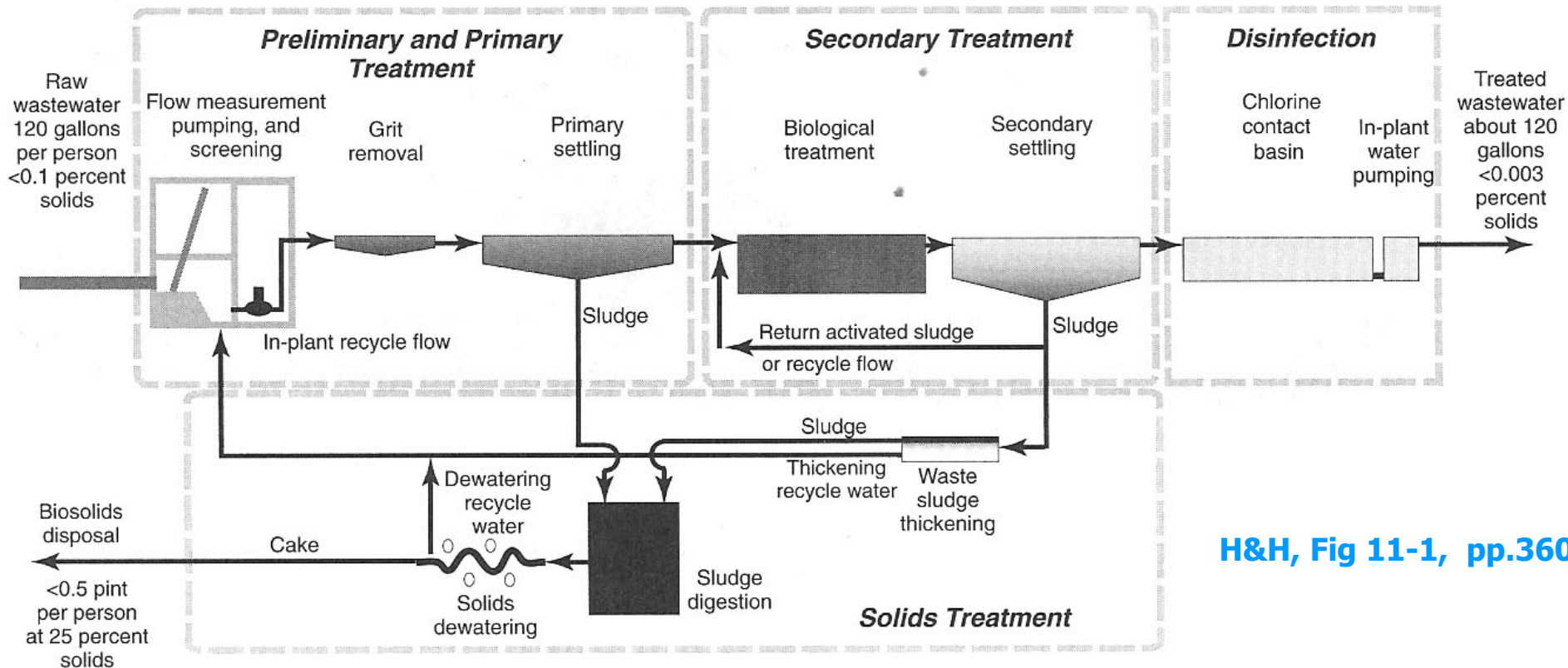
Secondary Clarifiers

Bioreactor

■ Activated Sludge

Intro to WWT

- Incorporating 1° and 2° treatment
 - May also need 3° treatment



H&H, Fig 11-1, pp.360

Small WWT Systems

- From a few hundred people to several thousand

H&H, Fig 11-2, pp.361

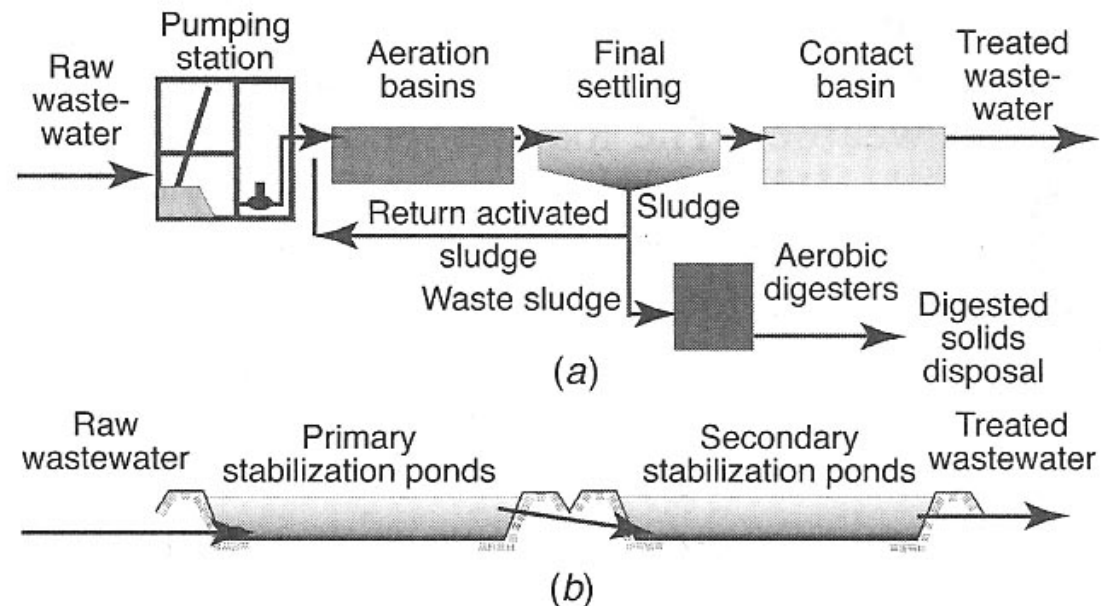


Figure 11-2

Processing diagrams of systems for treatment of small wastewater flows. (a) Biological processing without primary sedimentation. (b) Natural facultative stabilization ponds.



Design Loading & Parameters

- Peak hourly – often occurs during storm event

10 States Standards; 2004 Edition

TABLE II-1

H&H, Table 1-1, pp.363

Typical Design Criteria for the Treatment Processes Shown in Figure II-1

| PROCESS | LOADING |
|----------------------|---|
| Flow measurement | Peak hourly flow |
| Bar screen | Peak hourly flow |
| Pumps | Peak hourly flow Min. hourly flow |
| Grit chamber | Max. monthly flow Peak hourly flow |
| Primary settling | Max. monthly flow |
| Biological treatment | Max. monthly BOD loading Check peak hourly BOD loading |
| Final settling | Max. monthly flow |
| Disinfection | Peak hourly flow |
| Thickening | Max. daily sludge flow Check max. solids loading |
| Digestion | Max. monthly volatile solids load Check max. monthly sludge flow |
| Dewatering | Max. sludge flow Check max. solids loading |
| Land application | Max. nutrient loading (sludge) Max. hydraulic loading (water) |

Preliminary Treatment

- Chemical addition
 - Not common
- Flow measurement
 - Parshall flumes are most common
- Screening
- Pumping
- Grit Removal

H&H, Fig 11-4, pp.364

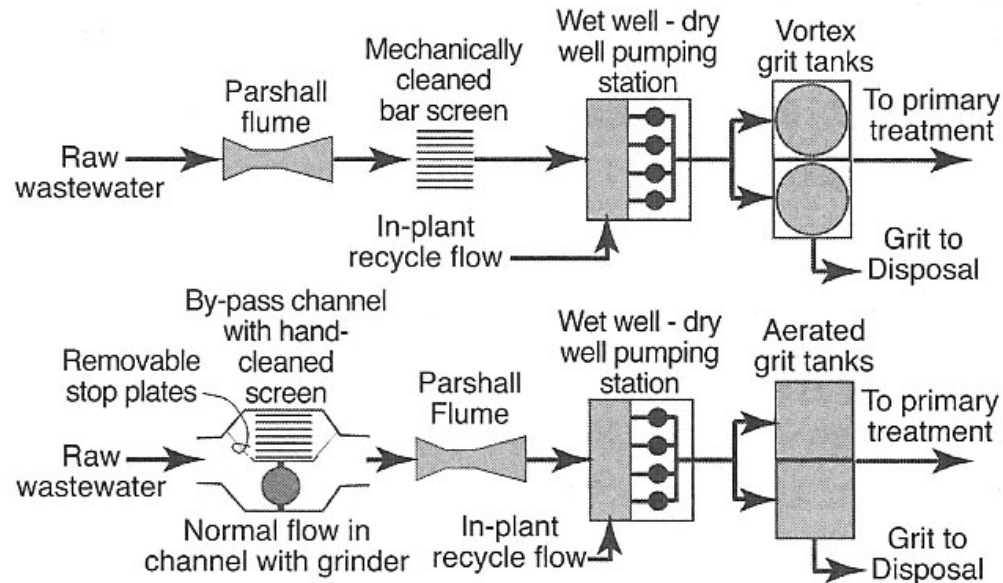


Figure 11-4

Typical arrangements of preliminary treatment units in municipal wastewater processing: flow measurement, screening, sewage pumping, and grit removal. The lower sequence is common for smaller plants.

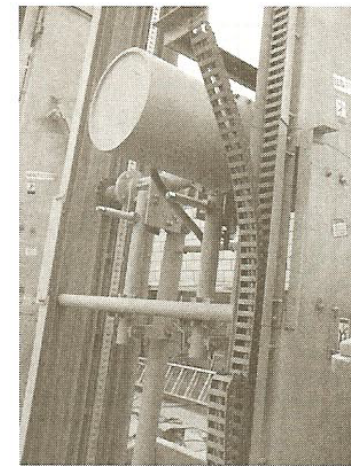
Screens

■ Bar Screens

- openings from 0.5-2.25 in
- Cleaned by mechanical travelling rake

■ Fabric Screens

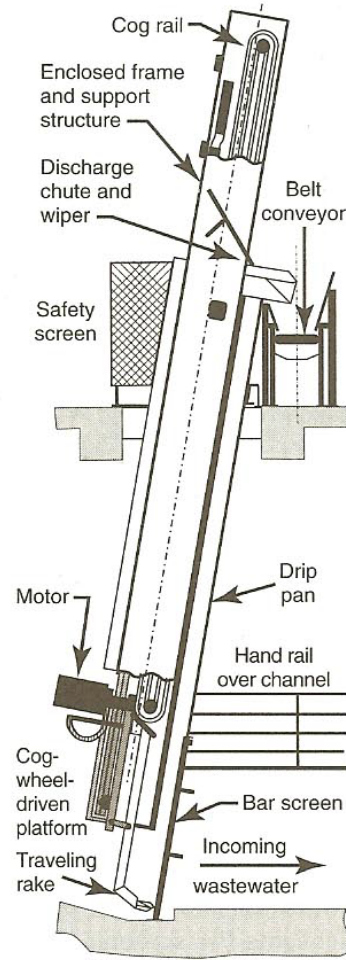
- Finer (0.125-0.25 in), more common in Europe



(a)



(b)



(c)

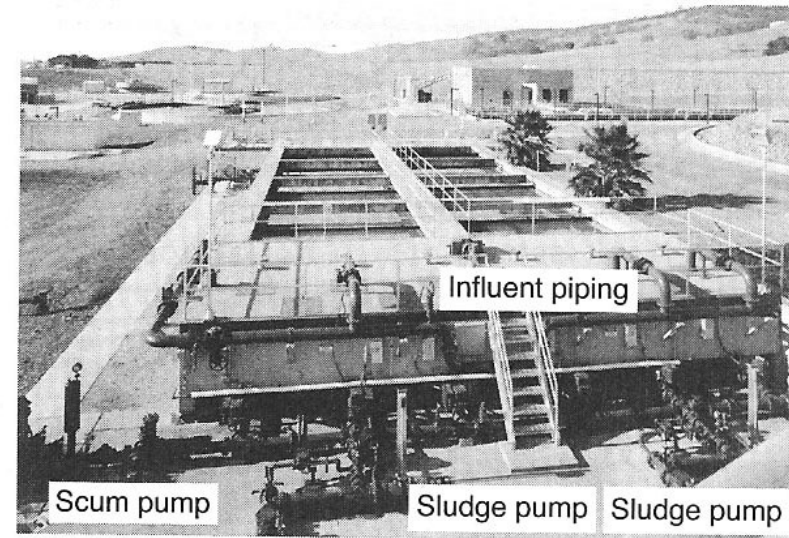
Figure 11-5

Climber-style mechanically cleaned bar screen. (a) Photo of drive at the top of the bar screen showing motor and cog wheels on the fixed plate between side rails. (b) Photo from behind the unit where screenings travel on a belt conveyor prior to compression dewatering and final disposal in a landfill. (c) Drawing of the bar screen. Screen openings are $\frac{3}{4}$ in. No moving parts are submerged in wastewater. The bottom portion of the bar screen is shown in Figure 11-11b.

1° Settling

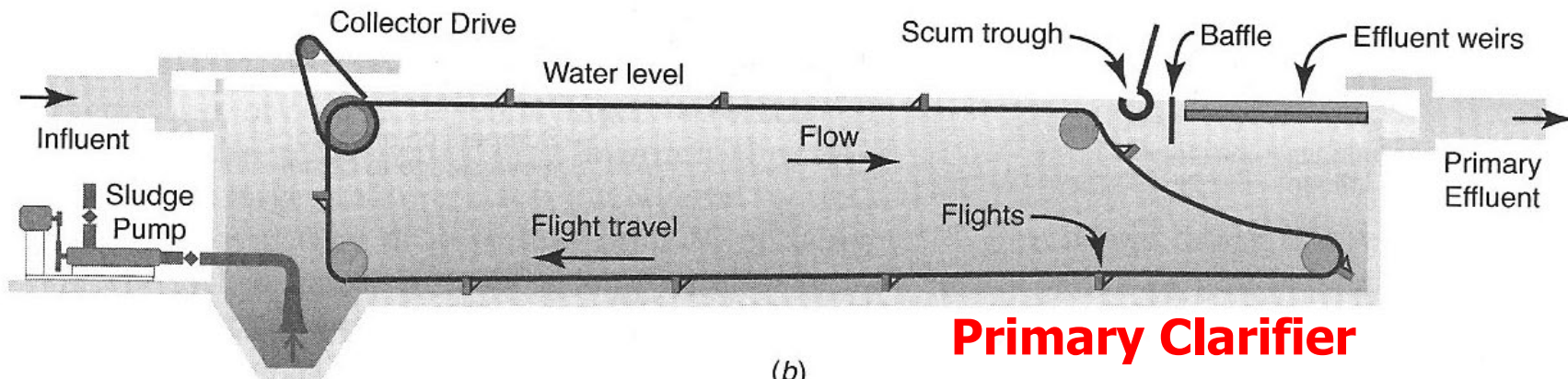
- Rectangular or circular tanks

- Similar to drinking water treatment
- Flow enters behind an inlet baffle
- Baffles placed in front of effluent weirs prevent loss of floating materials
 - Removed by a mechanical skimmer (dual purpose)



(a)

H&H, Fig 11-9, pp.368



Primary Clarifier



Biological Processes

- Secondary Treatment
 - Activated Sludge
 - Many variations
 - Ponds & lagoons
 - Many types
 - Tricking Filters
 - Rotating Biological Contactors
- } Suspended growth
- } Attached Growth
- Sludge
 - Aerobic digestion
 - Anaerobic digestion

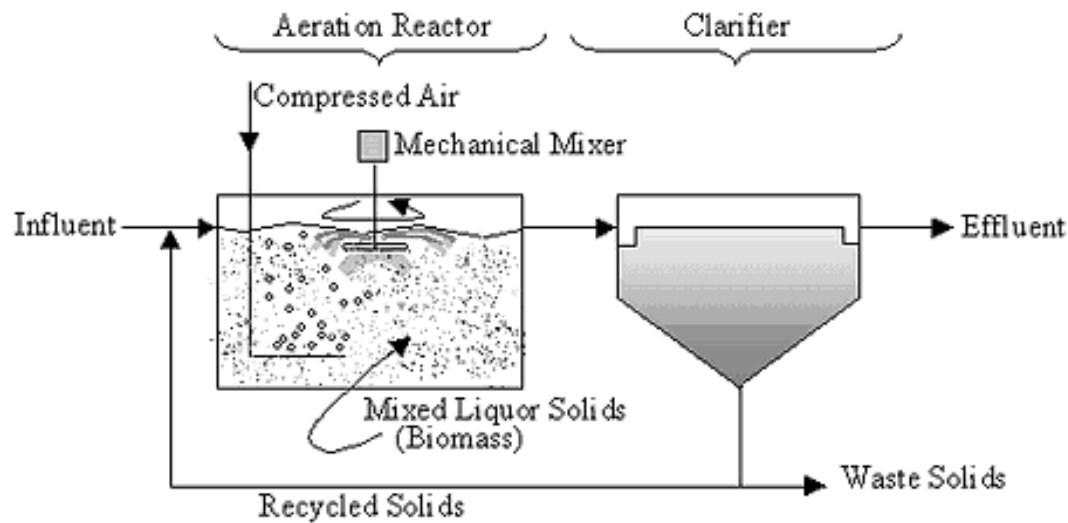


Microorganisms & treatment

- Stabilization of organic matter
 - Mostly oxidation to CO_2 in aerobic processes
 - Mostly to CH_4 & CO_2 in anaerobic processes
- Formation of cellular biomass
 - Requires management of population
 - Disposal of excess (biological sludge)
- May require intensive addition of electron acceptor
 - O_2 added in some aerobic processes

Activated Sludge

- Two components
 - Aeration basin
 - Clarifier & return sludge



From University of Birmingham

Activated Sludge

- Mixed liquor
- Return Activated sludge

Aeration!

1. Surface aerators 
2. Bubble diffusers



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- To next lecture