

**The Islamic University of Gaza
Faculty of Engineering
Civil Engineering Department**

**Environmental Engineering
(ECIV 4324)**

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Waste Water Treatment

Introduction

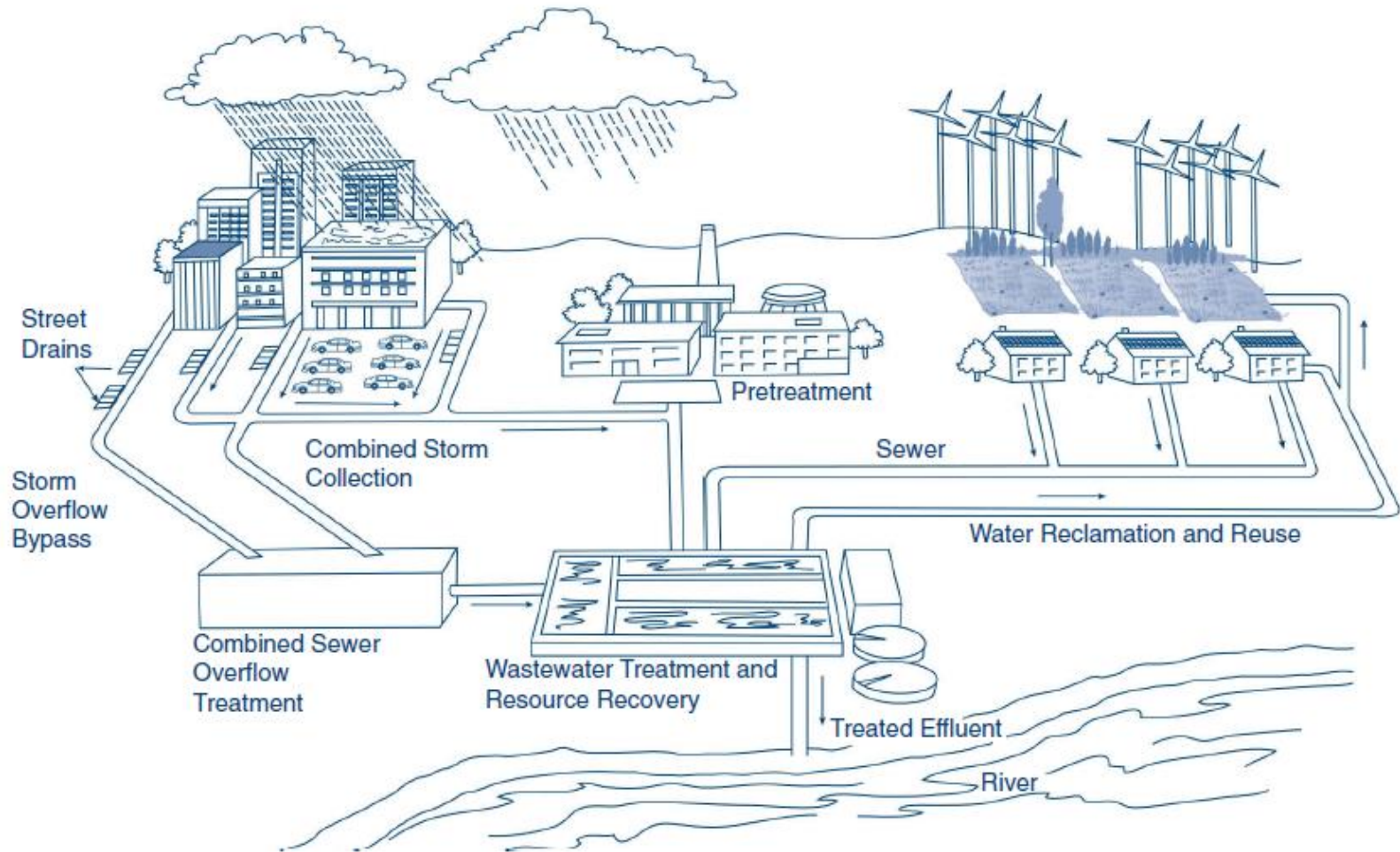
Municipal wastewater treatment plants, also referred to as publicly owned treatment works (POTWs), receive inputs from many domestic and industrial sources as well as from combined stormwater sewer systems

Introduction

There are four components of domestic wastewater:

- (1) wastewater from domestic, commercial, and industrial users;**
- (2) stormwater runoff;**
- (3) infiltration; and**
- (4) inflow**

Introduction



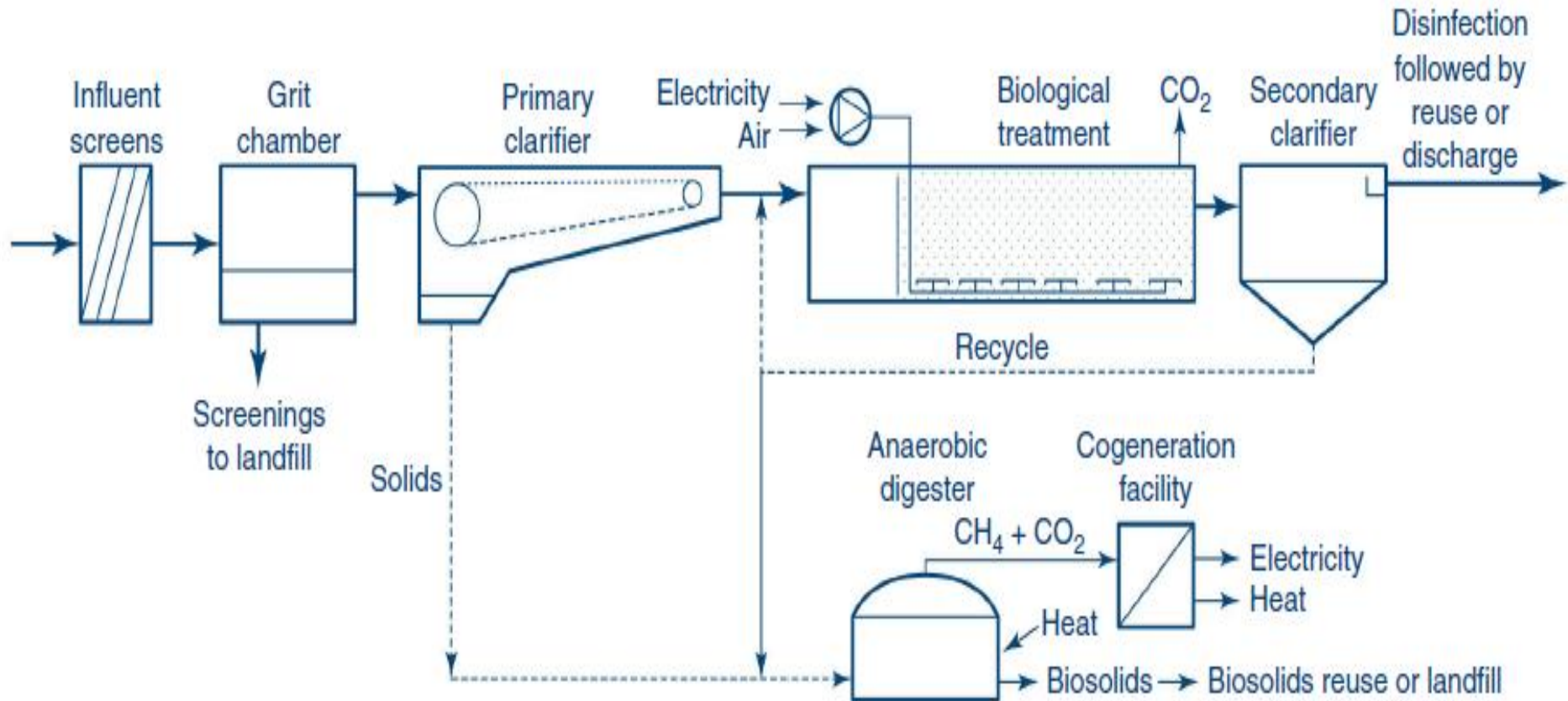
Characteristics of Domestic Wastewater

Table / 9.2

Concentration of Major Constituents Found in Average-Strength Wastewater

Constituent	Discussed Previously in	Average Concentration	Comments
Biochemical oxygen demand (BOD)	Chapters 2 and 5	200 mg/L	Oxygen-demanding materials can deplete the oxygen content of receiving waters.
Suspended solids	Chapters 2 and 8	240 mg/L (total solids typically 800 mg/L)	Cause water to be turbid; may contain organic matter and thus contribute to BOD; may contain other pollutants or pathogens. Organic solids can be anaerobically digested to produce energy.
Pathogens	Chapters 5 and 8	3 million coliforms per 100 mL	Disease-causing microorganisms usually associated with fecal matter.
Nutrients such as nitrogen and phosphorus	Chapters 2, 3, and 5	Total nitrogen: 35 mg N/L Inorganic nitrogen: 15 mg N/L Total phosphorus: 10 mg P/L	Can accelerate growth of aquatic plants, contribute to eutrophication; ammonia is toxic to aquatic life, can contribute to NBOD. Value as crop fertilizer during water reuse.
Toxic chemicals	Chapters 3, 5, 6, and 8	Variable	Heavy metals such as mercury, cadmium, and chromium; organic chemicals such as pesticides, solvents, fuel products.
Emerging chemicals of concern	Chapters 6 and 8	Unknown or variable	Pharmaceuticals, caffeine, surfactants, fragrances, perfumes, other endocrine-disrupting chemicals.

Overview of Treatment Processes



Overview of Treatment Processes

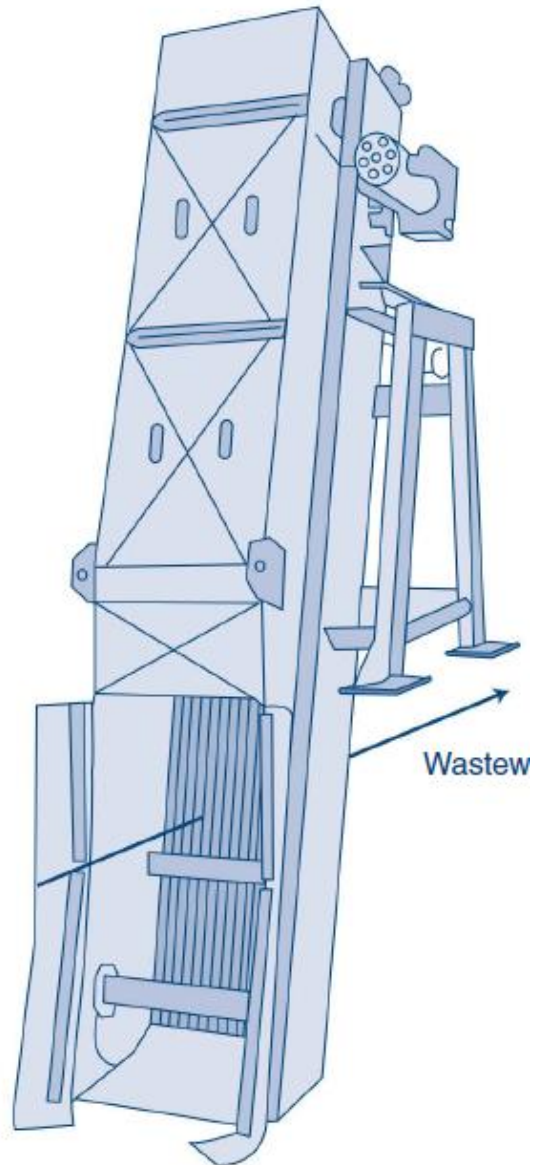
Different processes occur for the treatment of liquid and solid-waste streams. The steps involved in conventional wastewater treatment are:

(1) pretreatment, (2) primary treatment, (3) secondary treatment, (4) tertiary treatment to remove nutrients (N, P), and (5) disinfection.

Preliminary Treatment

Preliminary treatment prepares the wastewater for further treatment. It is used to remove oily scum, floating debris, and grit, which may inhibit biological processes and/or damage mechanical equipment

Preliminary Treatment- SCREENING



Preliminary Treatment- GRIT CHAMBERS

Grit consists of particulate materials in wastewater that have specific gravities of approximately 2.65 and a temperature of 15.5C. Particles with specific gravities between 1.3 and 2.7 have also been removed, based on field data. Grit can consist of inorganic sand or gravel (about 1 mm in diameter), eggshells, bone fragments, fruit and vegetable pieces and seeds, and coffee grounds.

Preliminary Treatment- GRIT CHAMBERS

Grit is primarily removed to prevent abrasion of piping and mechanical equipment. During grit removal, some organic materials are removed along with the grit. Sometimes grit-washing equipment is added to remove organic materials and return them to the wastewater.

Preliminary Treatment- GRIT CHAMBERS

Table / 9.4

Design Information Used to Size Aerated Grit Chambers

Parameter	Range
Peak flow detention time (min)	2–5
Depth (m)	2–5
Length (m)	7.5–20
Width (m)	2.5–7
Width-to-depth ratio	1:1 to 5:1
Length-to-width ratio	3:1 to 5:1
Air requirement per length of tank ($\text{m}^3/\text{m-min}$)	0.2–0.5
Quantity of grit ($\text{m}^3/10^3 \text{ m}^3$)	0.004–0.20

example/ 9.1 Design of an Aerated Grit Chamber

Design an aerated grit chamber system to treat a 1 day sustained peak hourly flow of $1.5 \text{ m}^3/\text{s}$ with an average flow of $0.6 \text{ m}^3/\text{s}$. Determine: (a) the grit chamber volume (assuming two chambers will be used); (b) the dimensions of the two grit chambers; (c) the average hydraulic retention time in each grit chamber; (d) air requirements, assuming $0.35 \text{ m}^3/\text{m-min}$ of air; and (e) the quantity of grit removed at peak flow, assuming a typical value of $0.015 \text{ m}^3/10^3 \text{ m}^3$ of grit in the untreated wastewater.

solution

Much of this problem can be solved by using the design guidance provided in Table 9.4.

The volume of the grit chambers is determined assuming a detention time of 3 min:

$$\begin{aligned}\text{total grit chamber volume} &= 1.5 \text{ m}^3/\text{s} \times 3 \text{ min} \times 60 \text{ s/min} = 270 \text{ m}^3 \\ \text{volume of each grit chamber} &= \frac{1}{2} \times 270 \text{ m}^3 = 135 \text{ m}^3\end{aligned}$$

Assuming a width-to-depth ratio of 1.5:1 and a depth of 3 m, the dimensions of the two grit chambers are

$$\begin{aligned}\text{grit chamber width} &= 1.5 \times 3 \text{ m} = 4.5 \text{ m} \\ \text{grit chamber length} &= \frac{\text{volume}}{\text{width} \times \text{depth}} = \frac{135 \text{ m}^3}{4.5 \text{ m} \times 3 \text{ m}} = 10 \text{ m}\end{aligned}$$

The average hydraulic detention time in each grit chamber is based on the average flow rate:

$$\text{detention time} = \frac{\text{volume}}{\text{flow}} = \frac{135 \text{ m}^3}{(0.6 \text{ m}^3/\text{s})/(2 \text{ tanks})} \times \frac{1 \text{ min}}{60 \text{ s}} = 7.5 \text{ min}$$

The air requirements, assuming $0.35 \text{ m}^3/\text{m-min}$ of air, are

$$\text{total air requirement} = (2 \text{ tanks}) \times (10 \text{ m length}) \times (0.35 \text{ m}^3 \text{ air}/\text{m-min}) = 7.0 \text{ m}^3/\text{min}$$

Finally, solve for the amount of grit to be disposed of, assuming peak flow conditions:

$$\text{grit volume} = (1.5 \text{ m}^3/\text{s}) \times (0.015 \text{ m}^3/10^3 \text{ m}^3) \times (86,400 \text{ s/day}) = 1.94 \text{ m}^3/\text{day}$$

Similar design methods are employed to size horizontal-flow and vortex grit removal devices.

Primary Treatment

The goal of primary treatment is to remove solids through quiescent, gravity settling. Typically, domestic wastewater is held for a period of approximately 2 h. Settling tanks, also referred to as sedimentation tanks or clarifiers, can be either rectangular or circular. During sedimentation, solids settle to the bottom of the tank, where they are collected as a liquid–solid sludge

Primary Treatment



example/ 9.3 Sizing a Primary Settling Tank

A municipal wastewater treatment plant treats an average flow of 12,000 m³/day and a peak hourly flow of 30,000 m³/day. Two circular clarifiers are to be designed, using a depth of 4 m and overflow rate of 40 m³/m²-day. Calculate the area, diameter, volume, and detention time required for each clarifier.

solution

To calculate the surface area required for clarification, divide the average flow rate (Q) by the overflow rate (OR):

$$\text{total clarifier area} = \frac{Q}{\text{OR}} = \frac{12,000 \text{ m}^3/\text{day}}{40 \text{ m}^3/\text{m}^2\text{-day}} = 300 \text{ m}^2$$

Since there are two clarifiers, the area for each clarifier would be

$$\text{clarifier area} = \frac{300 \text{ m}^2}{2 \text{ clarifiers}} = 150 \text{ m}^2$$

The tank diameter can be calculated from the area as follows:

$$\text{clarifier diameter} = \sqrt{\frac{\text{clarifier area}}{\frac{\pi}{4}}} = \sqrt{\frac{150 \text{ m}^2}{\frac{\pi}{4}}} = 13.8 \text{ m}$$

The diameter will be rounded up to 14 m for the final design.

The actual area for each clarifier is calculated as follows:

$$\text{clarifier area} = \frac{\pi}{4} (14 \text{ m})^2 = 154 \text{ m}^2$$

The volume of each clarifier is calculated as follows:

$$\text{clarifier volume} = \text{area} \times \text{depth} = \left(\frac{\pi}{4} (14 \text{ m})^2 \right) \times (4 \text{ m}) = 616 \text{ m}^3$$

The volume of each clarifier is calculated as follows:

$$\text{clarifier volume} = \text{area} \times \text{depth} = \left(\frac{\pi}{4} (14 \text{ m})^2 \right) \times (4 \text{ m}) = 616 \text{ m}^3$$

To determine the hydraulic detention time, divide the clarifier volume by the flow rate (Q) to each clarifier:

$$\text{detention time} = \frac{\text{volume}}{Q} = \frac{616 \text{ m}^3 \times 24 \text{ h/day}}{6,000 \text{ m}^3/\text{day}} = 2.46 \text{ h}$$

The observed overflow rate (OR) is calculated as follows:

$$\text{OR} = \frac{Q}{\text{area}} = \frac{6,000 \text{ m}^3/\text{day}}{154 \text{ m}^2} = 39 \text{ m}^3/\text{m}^2\text{-day}$$

Determine the detention time and overflow rate at peak flow:

$$\text{OR at peak flow} = \frac{(Q \text{ at peak flow})/2}{\text{area}} = \frac{15,000 \text{ m}^3/\text{day}}{154 \text{ m}^2} = 97.4 \text{ m}^3/\text{m}^2\text{-day}$$

$$[\text{detention time at peak flow}] = \frac{\text{clarifier volume}}{Q \text{ at peak flow}} = \frac{616 \text{ m}^3 \times 24 \text{ h/day}}{30,000 \text{ m}^3/\text{day}/2} = 0.99 \text{ h}$$

At the average flow, the calculated values of detention time and overflow rate are within the ranges we discussed in the previous chapter. At peak flow, the calculated value of detention time is fine, but the overflow rate is slightly lower than desired. The final clarifier design may need to have an increased surface area to provide enough detention time for sufficient solids to settle.