CE2354 ENVIRONMENTAL ENGINEERING II

(FOR VI – SEMESTER)

UNIT – III

PRIMARY TREATMENT OF SEWAGE

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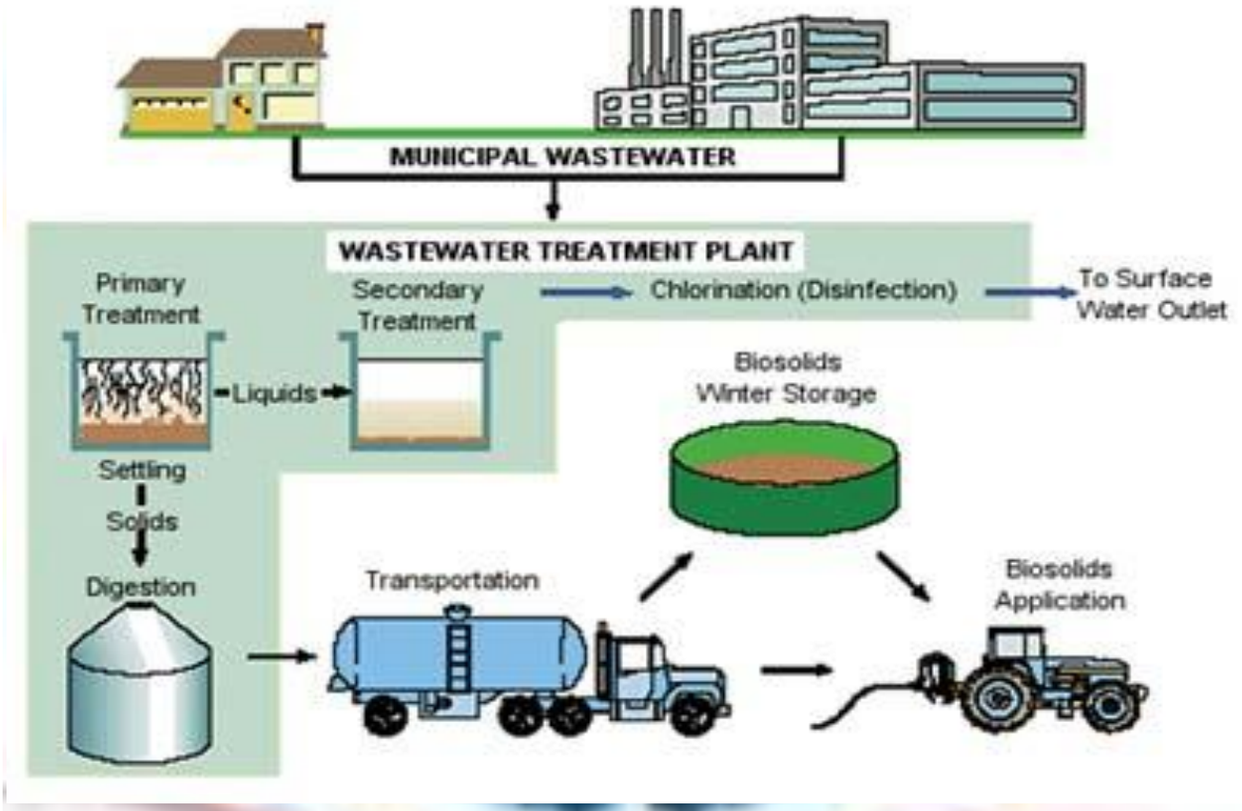
UNIT III

PRIMARY TREATMENT OF SEWAGE

UNIT OPERATIONS & PROCESS

- Unit operations are the physical operations to remove the impurities present in the water and waste water where as the unit processes are the chemical and biological conversion on the status of the impurities that they will be easily removed by chemical or biological processes, both are applied especially to make the fine colloidal particles to coalesce and grow in size to be removed from the water

SELECTION OF TREATMENT PROCESS



- Sewage received at the treatment works is normally greyish in colour with a slight ‘fruity' smell and an occasional tint of ‘bad eggs’.
- It is basically dirty water with less than 0.1% being waste that needs to be treated.
- There are four main stages in wastewater treatment; preliminary, primary, secondary (biological) and tertiary treatment.
- The number of stages applied depends on the quality of discharge required to protect the environment

ON-SITE SANITATION

Definition

- On-site sanitation is the whole of actions related to the treatment and disposal of domestic waste water that cannot be carried away by an off-site sanitation system because of low density of population (technical guidelines on sanitation).

Characteristics

- The autonomous part of on-site sanitation refers to the techniques used (purification of water), its design, as well as its financing, implementation and maintenance.

Types of onsite sanitation

- Individual on site sanitation

  Individual on-site sanitation, when a house (plot) makes use of the soil as a treatment medium (example of soak-away, latrines, etc),

- Grouped on site sanitation

  grouped on-site sanitation (or semi off-site sanitation), when many individual houses are linked to a network leading to a treatment system, or small communities: grouped sanitation doesn't always use the soil as treatment medium

GREY WATER HARVESTING

- Grey water is water that has been used in the household for purposes other than in the toilet. For example, water from the shower, washing machine, dishwasher, sink, can actually be collected and re-used

- Unless you have a grey water treatment system, it is recommended that your grey water be used for purposes like filling toilets; however, it can be used on your ornamental garden if you use low-impact, biodegradable soaps and alternate the grey water with several waterings of fresh water

PRIMARY TREATMENT

- Designed to remove settle able solids and reduce the organic load (BOD) on the secondary units.

  - Primary treatment includes

- Bar screen

- Comminutor

- Grit chamber

- Primary clarifier

- To achieve these goals, a variety of treatment operation and process are utilized, which exploit various physical and chemical phenomena to remove or reduce the undeliverable constituents from water.

- Those operation used in this treatment of water in which change is brought about by means of or through application of physical forces are known as *Unit operation (UO)*. Those process used for the treatment of water in which change is brought about by means of chemical reaction are known as *Unit Process (UP)*.
- After preliminary treatment the sewage flows into large round or rectangular tanks.
- In these the heavier organic material sinks to the tank floor and is swept by a scraper blade to a submerged outlet.
- From here it is pumped as slurry to a storage tank for subsequent treatment.
- Most of the solids in wastewater are removed in this process and concentrated into a thick slurry which has a volume less than 1% of the sewage received at the works.
- This slurry is known as sewage sludge and it is dealt with separately. The liquid element (settled sewage) flows over a weir to the next stage of treatment
- Water treatment involves removal of undesirable constituents from water and them disposal of them in easiest and safest manner.

PHYSICAL WATER TREATMENT OPERATIONS

1)Screening

2) Comminution

3) Flow equalization

4) Mixing

5) Flocculation

6) Sedimentation

7) Floatation

8) Elutriaition

9) micro screening

10) vacuum filtration

11) air drying

CHEMICAL UNIT PROCESSES

1) Chemical precipitation

2) Adsorption

3) Combustion

4) Electrodialysis

5) Gas transfer

6) Disinfection

7) Ion exchange

BIOLOGICAL WATER TREATMENT PROCESSES

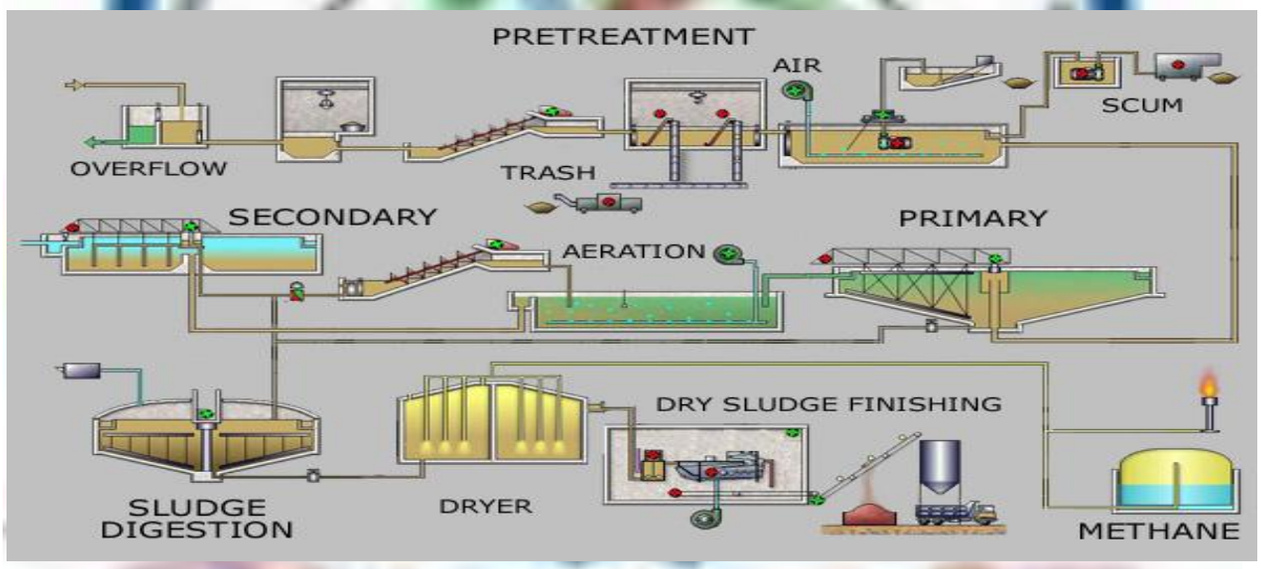
- In biological *water treatment processes* the removal or conversion of organic solids is brought about by the biological activities.
- They remove colloidal or dissolved bio-degradable organic substances in wastewater.
- Organic substances are converted into gases that can escape to the atmosphere and as biological cell tissues that can be removed by settling.

Types:

1) Aerobic process

2) Anaerobic

3) Aerobic- anaerobic process



SCREENING

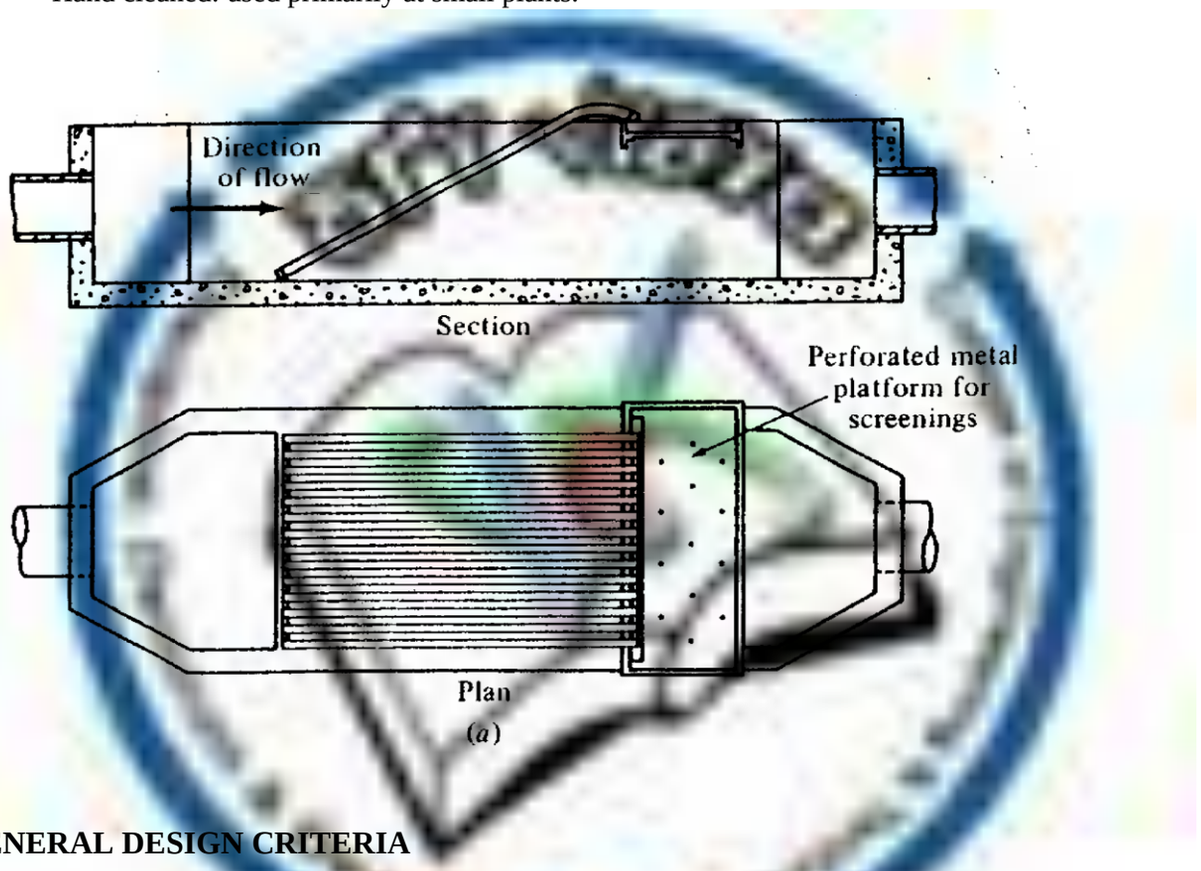
- On entering a sewage treatment works, dirtywater passes through screens to remove paper, wood and other large articles that could damage machinery or block pipe systems.
- Screens consist of vertical bars spaced close together or perforated plates that are cleaned by rakes or water jets.
- The cleared material (known as screenings) is washed and safely disposed of at a landfill site.
- The amount of screenings which can block sewers before the treatment works with unpleasant results.
- Only toilet paper should be flushed down the toilet. Water companies run ‘Bag It and Bin It’ campaign to encourage the public not to flush cotton buds or plastic and sanitary items.

- In some European countries the sewer pipes are so small that not even paper may be flushed.

BAR SCREEN

VENDOR-PROVIDED EQUIPMENT

- Purpose: to remove large objects (sticks, cans, etc) which may cause flow obstructions.
- Depending on the size of the plant, bar screens are either hand or mechanically cleaned.
- Hand cleaned: used primarily at small plants.



GENERAL DESIGN CRITERIA

- Bar Width: 1/4 to 5/8 in
- Spacing: 5/8 to 3 in
- Depth: 1 to 1.5 inches
- Slope: 30 – 45^{o} from the vertical
- Approach velocity – 1.25 fps @ minimum flow (as determined by the Manning Eqn.), the purpose in controlling the approach velocity is to prevent deposition of grit in the channel.
- Velocity through the screen - < 3 fps, to prevent excessive headloss and to prevent forcing of screenings through the openings.
- Quantities of screenings – 0.5-5 ft^3/ MG, average 2 ft^3/MG
- Disposal of screenings – landfill or incineration
- Density: 80% moisture (60 pcf) right off the screen, dry (12 pcf)

- h_L = 0.5 – 2.5 ft (max)
- $h_L=(V_s^2-v_c^2)/(2g * 0.7)$
    - V_s= velocity through the bars
    - v_c= approach velocity in the upstream channel

GRIT CHAMBERS

- Purpose: to remove inorganic material referred to as grit. Grit includes sand, eggshells, bone chips, coffee grounds, etc.
- Grit is removed to prevent abrasion of pumps and to reduce deposits in pipe lines, channels, and digesters.

GENERAL DESIGN CRITERIA

- Specific gravity of grit: 2.65
- Diameter of grit: 0.22 mm
- Settling velocity: 0.075 fps
- Equivalent overflow rate: 48,400 gpd/ft^2
- Quantity of girt: 1/3 to 24 ft^3/MG
    - Ave = 4 ft^3 /MG
- Disposal of grit: land fill or incineration (Grit must be washed before disposal)
- Grit chamber storage:
    - Small plant: provide storage below the design invert depending on the quantity and frequency of removal.
    - Large plant: continuous removal, the conveyor hopper is designed based on the size of the equipment.

CLARIFIER

Types:

- Square Clarifier (Detritus Tank)
- Aerated Tanks

Square Clarifier (Detritus Tank)

- Detritus tanks are designed so that the horizontal velocity is 1.0 fps at maximum flow. This means that at low flow, the velocity is less than 1.0 fps, and therefore, organic material will accumulate.
- Organics are removed by counter current washing as the grit moves up an incline for disposal.

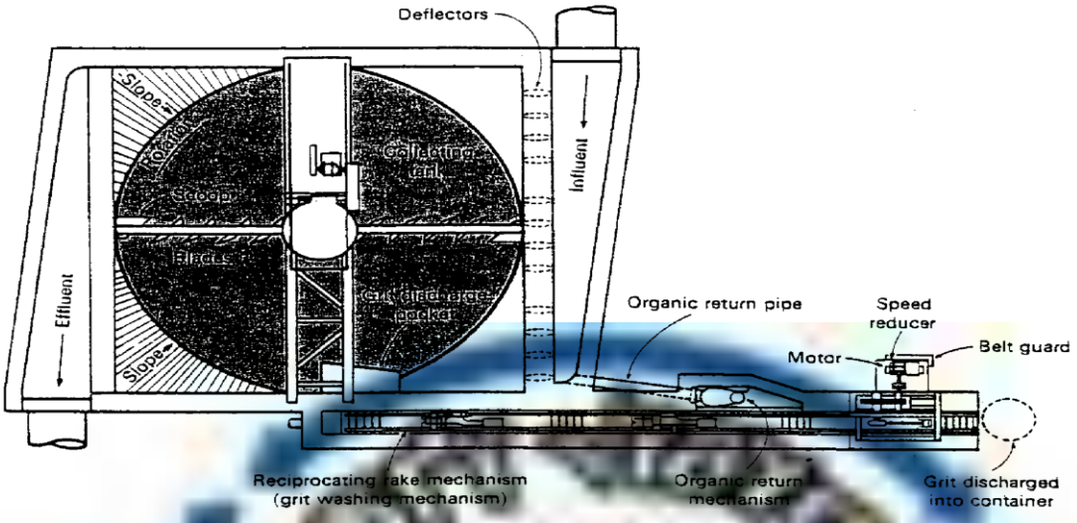


FIGURE 9-6
Typical square horizontal-flow grit chamber (from Dorr-Oliver).

- Basic Design Criteria
  - V_s = 0.075 fps @ Average Flow
  - td < 1 min
  - Overflow rate: 48,400 gpd/ft^2
  - V_h: 0.75-1.25 fps (keeps organics in suspension)

Aerated Tank

- Upon discovering that grit accumulated in the bottom of activated sludge aeration basins, it has became common practice to use aerated grit chambers.
- Aeration also provides pretreatment of the waste by removing odors and inducing flocculation of the organic material making primary clarification more effective

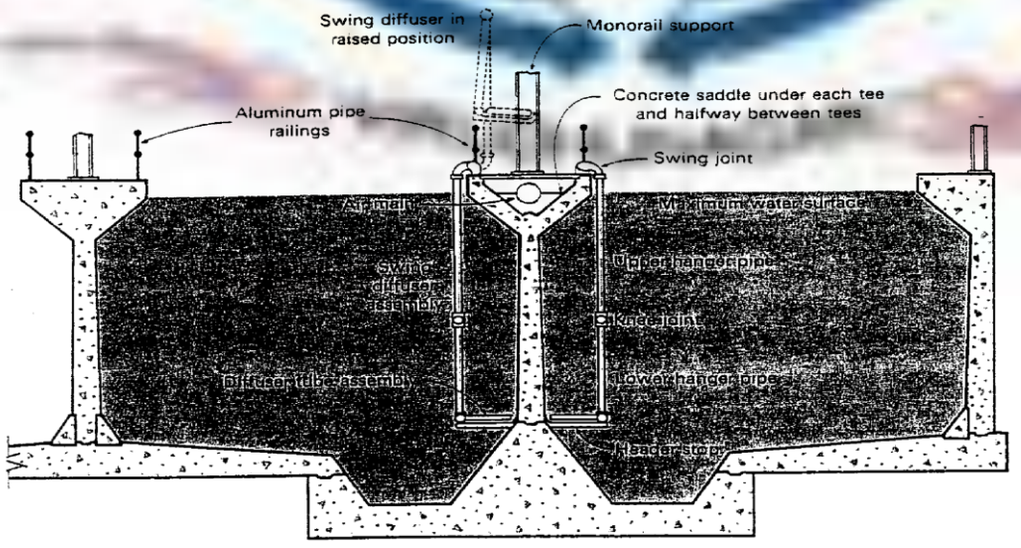


FIGURE 9-8
Typical section through an aerated grit chamber.

Benefits of Pre-aeration

- By providing preaeration, primary treatment is improved through:
  - Grit removal
  - Flocculation
  - Odor Control
  - Grease Separation
  - Design the detention time and aeration rate to control all four

GENERAL DESIGN CRITERIA

- Rate of aeration: 5 cfm/ft length (provide for variable rates of aeration which is adjusted according to the flow and efficiency of grit removal).
- Width to Depth Ratio: a critical factor in providing an effective spiral-rolling action in the grit chamber
  - W:D = 1 – 2.2 : 1
- Depth = 10 – 15 ft (starting point: set depth first)
- Length:Width Ratio = 3:1, final dimensions are adjusted so that the detention time is 3-10 minutes

Primary Clarifier

- Purpose: to remove settleable organics and floating scum (grease and oils).
- Efficiencies:
  - Suspended solids 50 – 65%
  - BOD 30 – 35%
- Primary clarifiers are either circular or rectangular. They are very similar to sedimentation basins used in water treatment except that scum removal is always provided in addition to sludge collection.
- Type II Settling Clarifier: during settling organic solids come in contact with each other and aggregate increasing the particle size and settling rate. Aggregation increases with time, therefore detention time is important.
- T_d: 90 – 150 min at average flow (Avg 2 hr)
- Overflow rate: 600 – 1,200 gpd/ft^2
- Weir loading rate: 10,000 – 15,000 gpd/ft.

CIRCULAR PRIMARY SEDIMENTATION TANK

A Circular Primary Sedimentation Tank