WASTEWATER TREATMENT




DOMESTIC WASTEWATER

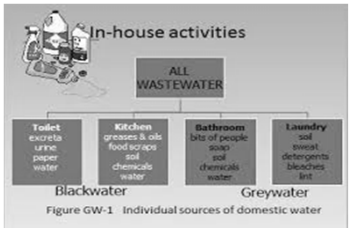
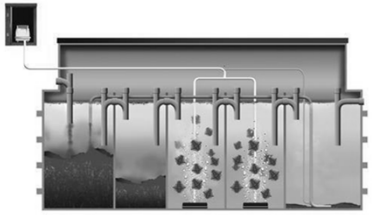


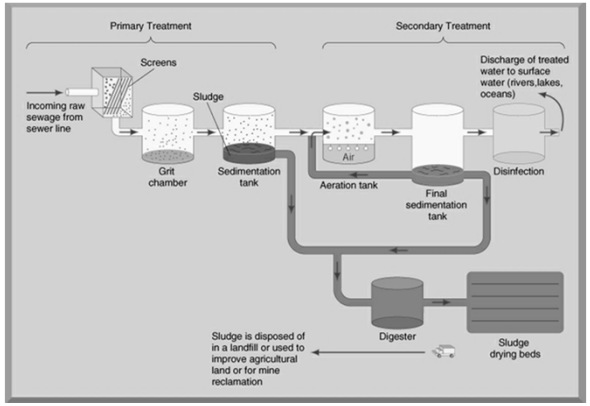
Figure GW-1 Individual sources of domestic water


Industry plants





Conventional Treatment Process



STAGES

- Pre-treatment
- Preliminary treatment
- Primary treatment
- Secondary treatment
- Sludge (biosolids) disposal

PRE-TREATMENT

❖ Pre-treatment

❖ - Occurs in business or industry prior to discharge

- Prevention of toxic chemicals or excess nutrients being discharged in wastewater

❖ Water discharged from homes, businesses, and industry enters **sanitary sewers**

❖ Water from rainwater on streets enters **storm water** sewers

❖ **Combined sewers** carry both sanitary wastes and storm water

❖ Water moves toward the wastewater plant primarily by **gravity flow**

❖ Lift stations pump water from low lying areas over hills

Preliminary Treatment

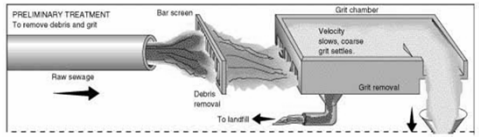
- removes large objects and non-degradable materials
- protects pumps and equipment from damage
- bar screen and grit chamber

❖ **Bar Screen**

- catches large objects that have gotten into sewer system such as bricks, bottles, pieces of wood, etc.

❖ **Grit Chamber**

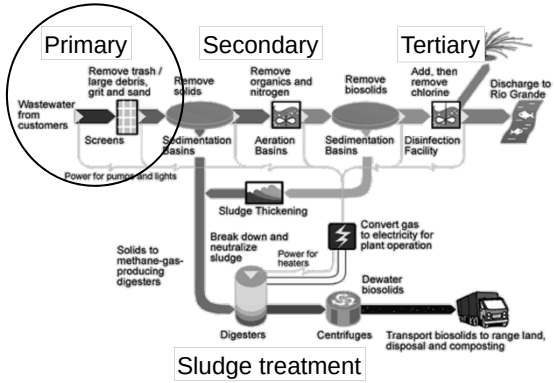
- removes rocks, gravel, broken glass, etc.



❖ **Mesh Screen**

- removes diapers, combs, towels, plastic bags, syringes, etc.

Wastewater Treatment – Processes

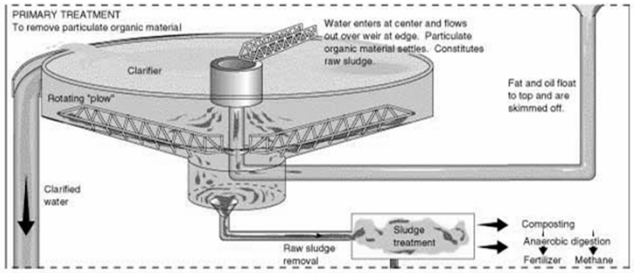


PRIMARY TREATMENT

-- a physical process

-- wastewater flow is slowed down and suspended solids settle to the bottom by gravity

-- the material that settles is called sludge or biosolids



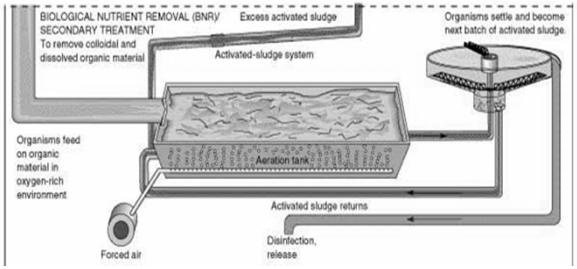
❖Sludge from the primary sedimentation tanks is pumped to the sludge thickener.

- more settling occurs to concentrate the sludge prior to disposal

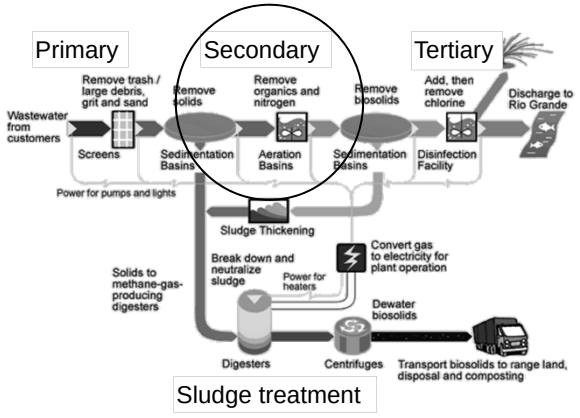
❖Primary treatment reduces the suspended solids and the B.O.D. of the wastewater.

❖From the primary treatment tanks water is pumped to the trickling filter for secondary treatment.

❖Secondary treatment will further reduce the suspended solids and B.O.D. of the wastewater.



SECONDARY TREATMENT



❖Secondary treatment is a biological process

❖Utilizes bacteria and algae to metabolize organic matter in the wastewater

Some examples are:
- aerobic processes - presence of dissolved oxygen
  - Biofilters
  - Trickling filters
  - Activated sludge

❖Measurement and sampling at the inlet structure
- a **flow meter** continuously records the volume of water entering the treatment plant
- water samples are taken for determination of **suspended solids** and **B.O.D.**

❖Suspended Solids
– the quantity of solid materials floating in the water column

❖B.O.D. = Biochemical Oxygen Demand
- a measure of the amount of oxygen required to aerobically decompose organic matter in the water

❖Measurements of Suspended Solids and BOD/COD indicate the effectiveness of treatment processes

❖Both Suspended Solids and B.O.D. decrease as water moves through the wastewater treatment processes

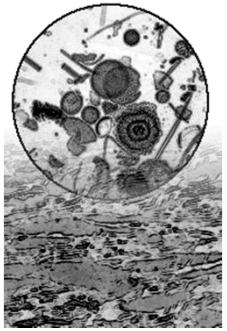
BIOLOGICAL TREATMENT

Composition of Wastewater

- Inorganics
  - Ammonia
  - Nitrate
  - Phosphate
  - Carbonate
  - Minerals
    - Calcium
    - Magnesium
    - Iron
    - Etc.
- Organics
  - Biodegradable (BOD)
    - Carbohydrates
    - Proteins (TKN)
    - FOG
  - Non-Biodegradable (COD-BOD)
    - Large particles
    - Complex polymers (plastics, lignin)
    - Surfactants (some)
    - Pesticides (some)
    - Pharmaceuticals (some)

Requirements for Growth of Microbes

- Temperature
- pH
- Water activity
- Energy source
- Nutrients
  - Carbon
  - Nitrogen
  - Phosphorus
  - Minerals
  - Vitamins/growth factors



Temperature and Growth

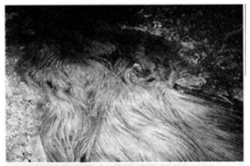
- Growth rates increase with increasing temperature (0 to 55 ºC)
- Growth rates approximately double for a 10 ºC rise in temperature
- Temperature extremes may interfere with metabolic processes or harm the organisms
  - ❖ Psychrophilic organisms prefer <5°C - 35°C
  - ❖ **Mesophilic** organisms prefer 20-45 °C
  - ❖ **Thermophilic** organisms prefer 45-60 °C

Yellowstone's Grand Prismatic Spring

- Named by Hayden Expedition in 1871
- Centre – hottest (87◦C)
- Very clear

- water spreads out and cools, creates concentric circles of varying temperatures
- very different environment inhabited by different types of bacteria → **PRISMATIC COLOURS**

pH


Massive growth of the extreme acidophile *Ferroplasma* in a california mine.

- Acidophiles
  - pH 0-6
- Alkaliphiles
  - pH 8-13
- Most bacteria prefer pH 6-8
- Most fungi prefer pH 4-7

Importance of Biological treatment

- Largely responsible for reduction of **organic material** in wastewater
- Use organic matter as a **food supply** to support the growth of biomass
- Also use organic material to provide energy for growth resulting in **production of CO_2** and other metabolic byproducts thereby reducing total BOD

26

Types of Microbial Communities

- **Aerobic**
  – utilize oxygen
- **Anaerobic**
  - grow in absence of oxygen
- **Facultative**
  can grow either with or without oxygen; metabolism changes as environment changes from aerobic to anaerobic

27

Aerobic Organisms

- Perform best when waters are **well aerated** and contain relatively high concentrations of **dissolved molecular oxygen**
- Require high rates of oxygen supply for wastewater treatment processes

28

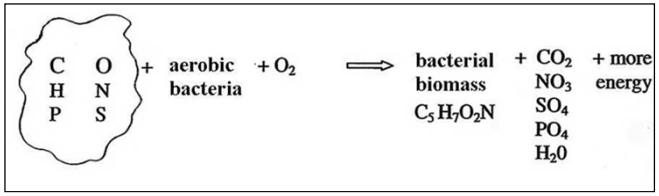
Diffused Aeration

Nutrients Required for Growth

- Carbon
  - Usually from food source or CO_2
- Nitrogen
  - Usually from ammonia, nitrate or simple organics (amino acids)
- Phosphorus
  - Inorganic phosphate
- Sulfur
  - Inorganic sulfate or simple organics
- Minerals (Ca, Mg, K, Na, Fe)
- Trace elements (Ni, Co, Cu, Mo, Zn)
- Growth factors/vitamins

Aerobic Processes

- presence of oxygen
- rapid conversion
- release lots of energy



31

Energy Sources

- Oxygen (aerobes) $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
  - Autotrophs
    - $NH_4^+ + 2\ O_2 \rightarrow NO_3^- + H_2O + 2\ H^+$ (Nitrifiers)
    - $H_2S + 2\ O_2 \rightarrow SO_4^{--} + 2\ H^+$ (sulfur oxidizers)
    - $H_2S + 0.5\ O_2 \rightarrow S^0 + H_2O$ (sulfur oxidizers)

- Nitrate (facultative) $C_6H_{12}O_6 + 6\ H_2O \rightarrow 6\ CO_2 + 12\ H_2$ / $5\ H_2 + 2\ NO_3^- + 2\ H^+ \rightarrow N_2 + 6\ H_2O$ (denitrifiers)

Anaerobic Organisms

- Perform best in conditions with little or no molecular oxygen
- Obtain needed oxygen from molecules that contain oxygen

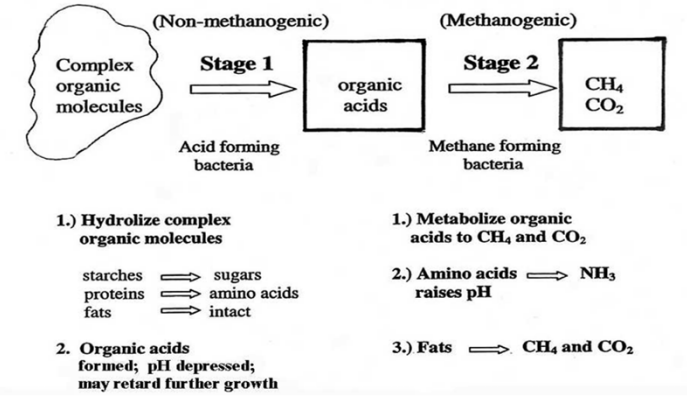
33

- Complex two stage process that takes place in the absence of oxygen:

acid-forming phase
acid forming bacteria hydrolyze the complex organic molecules and convert them into organic acids, lowering the pH

methanogenic phase
methane forming bacteria metabolize the acids to **CH_4 and CO_2**
amino acids are broken down, forming ammonia which tends to raise the pH

Anaerobic Processes



35

Energy Sources

■Sulfate (anaerobes) $C_2H_4O_2 \rightarrow CO_2$ / $SO_4^{--} \rightarrow H_2S$ (sulfate reducers)

Reduction of organic matter generates H_2S and other foul smelling compounds

■Carbon dioxide (anaerobes) $CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$ (methanogens)

■Fermentation $C_6H_{12}O_6 \rightarrow 2\ CO_2 + 2\ C_2H_5OH$

Facultative Organisms

- Prefer aerobic conditions but easily adapt to low oxygen circumstances
- Produce alcohols, organic acids and other organic chemicals when growing anaerobically

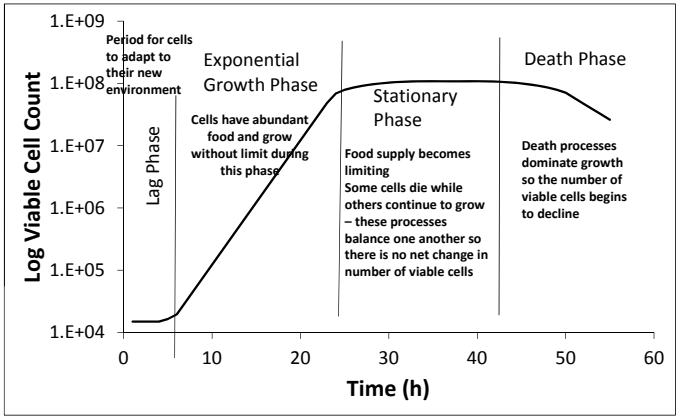
Toxicity

Many microbial organisms are able to adapt to changes in their environment – if changes are gradual

Sudden changes or introduction of toxic materials may be harmful or lethal to the biological community

37

Microbial Growth Phases



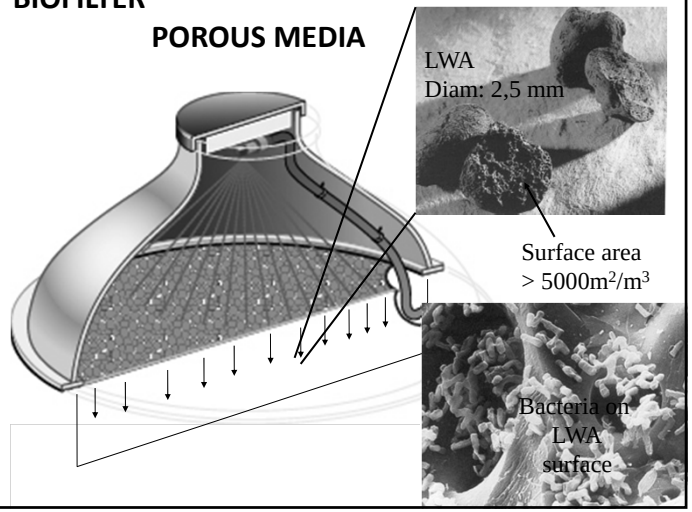
38

Typical Upsets

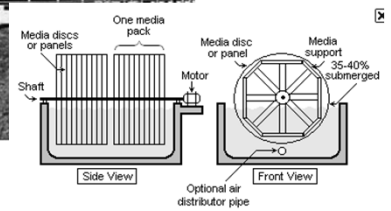
Heavy Organic Load
↓
Increased Growth/Respiration
→ Reduced Dissolved Oxygen
→ More Sludge to Clarifier
Reduced Growth/Respiration
→ Inadequate Removal
→ Deflocculation of the Biomass
Poor Settling
↓
Worse Effluent
→ Elevated BOD/COD
→ High Effluent Suspended Solids

BIOFILTER

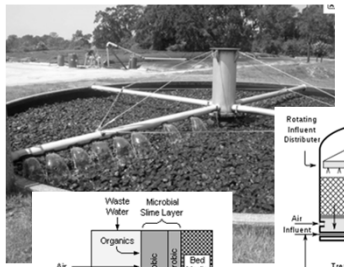
POROUS MEDIA



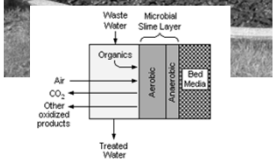
BIOFILTER: ROTATING BIOLOGICAL CONTACTOR - RBC (FIXED BIOFILM)

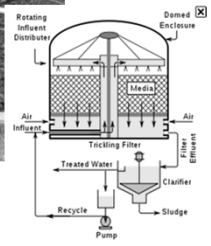


BIOFILTER



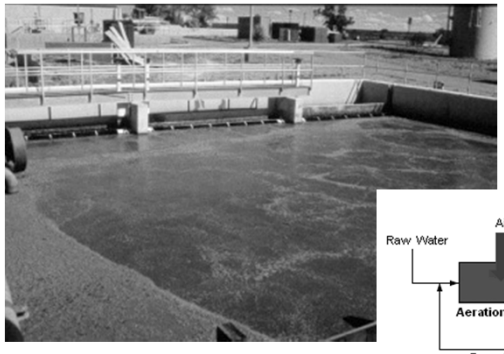
TRICKLING FILTER

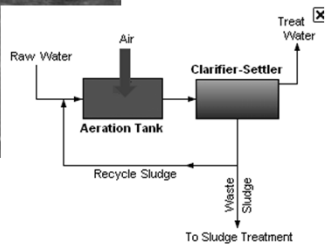




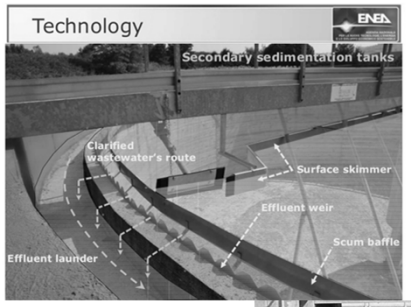
- the trickling filter does not "filter" the water
- water runs over a plastic media and organisms clinging to the media remove organic matter from the water

BIOLOGICAL TREATMENT: ACTIVATED SLUDGE (BIOFILM IN SUSPENSION)





- From secondary treatment on the trickling filter water flows to the final clarifiers for further removal of sludge.
- The final clarifiers are another set of primary sedimentation tanks.



❖ The final clarifiers remove additional sludge and further reduce suspended solids and B.O.D.

To be continued…..

Sludge treatment