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WATER

WATER POLLUTION:

"The alteration in physical, chemical and biological characteristics of water which may cause harmful effects on humans and aquatic life."

* Types, Effects and Sources:

1) Infectious Agents: Eg: Bacteria, virus, protozoa etc.
   (i) Human sources: ~~fish animal sources~~ Human & animal waste
   (ii) Effects: diseases: variety of diseases.

2) Oxygen Demanding Wastes: Eg: animal manure, plant debris
   (i) Human sources: Sewage, animal ~~decomposition~~ feedlots, paper/food waste.
   (ii) Effects: Degrade DO and kill aquatic life.

3) Inorganic Chemicals: Eg acids, metals (Pb, As, Se), NaCl, F^-.
   (i) Human sources: surface runoff, industrial effluents, household cleansers
   (ii) Effects
   > Makes fresh water unusable
   > causes skin cancer / neck damage
   > Harm aquatic life
   > Lower crop yield

4) Organic Chemicals: Eg oil, gasoline, plastic, detergent, pesticide
   (i) Human Sources: surface runoff, industrial effluents, household cleansers
   (ii) Effects
   > Harm fish & wild life
   > Cause nervous system damage / cancer

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5) Plant Nutrients: water soluble (NO_4^{3-}), (PO_4^{3-}), (NH_4^+)

(i) Humans sources: Sewage, manure, agriculture runoff, urban fertilizer.

(ii) Effects:

> Excess growth of algae that deplete O_2.

> Excess levels N levels lower O_2 carrying capacity of blood.

6) Sediment: Eg: soil, silt.

(i) Human sources: Land erosion

(ii) Effects:

> Reduce photosynthesis

> Disrupt aquatic life

7) Radioactive Eg: Isotopes of Uranium / Thorium

(i) Human sources: Nuclear power plants

(ii) Effects

> Birth defects

> cancer

8) Heat (Thermal Pollution): Eg: excessive heat

(i) Human sources: Electric power plants

(ii) Effects

> lowers DO

> Harms aquatic life

Point & Non-Point Sources

Point → known source

Eg: factories, treatment plants etc.

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Non-point sources Unknown sources
Eg surface water of croplands etc.

* Control Measures
  - > Laws, administration, awareness
  - > Plant trees
  - > Recycle using scientific methods

Dissolved Oxygen (DO) (Optimum 4-6mg/l)

- Absorption from air → Physical process
- Photosynthesis by vegetation → Biological process

Methods of determination of DO.

1. Electrode or oxygen meter method (quick & convenient)
2. Winkler's / iodometric method

*1.) Apparatus : (i) Oxygen meter with oxygen probe
(ii) Electric stirrer
(iii) 5% NaS sol^n

Procedure :

Dip the probe in NaS sol^n, then dip it in water to measure the scale.

*2) $MnSO_4(aq) + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4$

$Mn(OH)_2 + O_2(dissolved) \longrightarrow 2MnO(OH)_2$

$MnO(OH)_2 + 2H_2SO_4 \longrightarrow Mn(SO_4)_2 + 3H_2O$

$Mn(SO_4)_2 + 2KI \longrightarrow MnSO_4 + K_2SO_4 + I_2$

$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$ (titration)

Biochemical Oxygen Demand (BOD)

Amount of O_2 required by microbes in organic degradation

$$BOD\ (mg/l) = \frac{(D_1 - D_2) - (B_1 - B_2)f}{P}$$

D_1 = DO of diluted sample

D_2 = DO of diluted sample after incubation

B_1 & B_2 = DO of dilution water containing seed before and after incubation.

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Chemical Oxygen Demand (COD)

Amount of O_2 required for all organic matter oxidation

$6FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O + K_2Cr_2O_7 + 7H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 6(NH_4)_2SO_4 + 43H_2O$

$$COD(mg/L) = \frac{(V_1 - V_2) \times 1000 \times 8}{V_s\ (mL)}$$

V_1 = volume of FAS against blank

V_2 = volume of FAS against sample

V_s = volume of sample

8 = eq. wt. of O

TREATMENT OF WATER

SEWAGE :

* 1) Primary : (i) Sedimentation (ii) Mechanical flocculation (iii) Coagulation
* 2) Secondary : (i) Coagulation (ii) Oxidation of organic to O_2 (iii) Degradation of organic to NH_3 to NO_3^- (iv) Reduction of BOD, removal of oil etc.
* 3) Tertiary : (i) Removal of inorganic solids (ii) " trace of organics (iii) " of bacteria of faecal origin.

→ Processes : Coagulation, Precipitation, Adsorption, Chlorination, Nitrogen stripping, Phosphorus removal, oxidation, desalination, anaerobic digestion.

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INDUSTRIAL

*1) Primary : (i) Sedimentation (ii) Mechanical Flocculation
(iii) Equalization (iv) Neutralization

*2) Secondary (Biological) : aerobic anaerobic processes

*3) Tertiary : (i) Adsorption (ii) Ultra & Micro Filtration
(iii) Reverse Osmosis

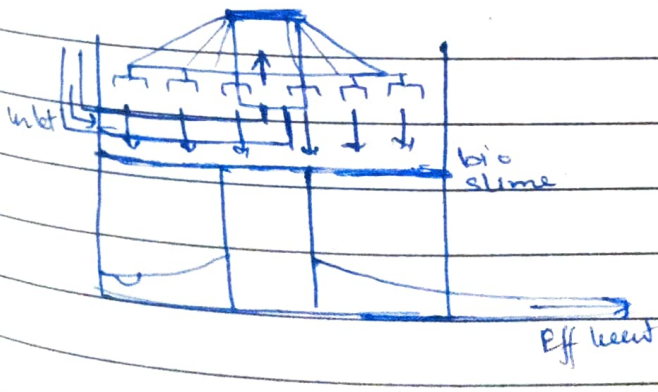
Commonly Used Processes

> Aerobic Processes

*1 > Lagooning Process : Natural / Artificial earth basins used to recieve sludge. (a) aerobic (b) anaerobic (c) both
> Waste water is collected in tank & aerated
> Healthy flocculant sludge produced for organic oxidation
> 90% BOD removed

Disad. > Bacterial contamination requires further purification.

*2 Trickling Filters:



As it oxidizes more & more organic matter the bio slime becomes so thick, the bed can't hold it so it gets detached this is known as sloughing

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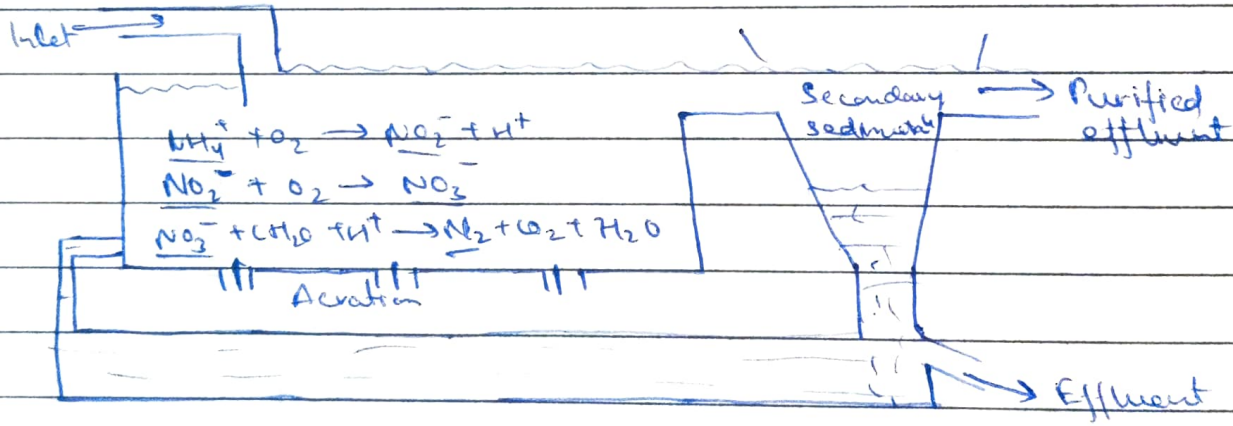
Adv:
> Safer (no explosion)
> 85% BOD removal
> No attention required
> Used in dairy, food, paper industry etc.

Disadv.
> Expensive
> Efficiency decreases with increased loading

*3) Activated Sludge Process (ASP)



Mass of req. O_2 = (Mass of ultimate BOD removed) − 1.42 (Active mass of organisms wasted)

Sludge Volume Index (SVI) = $\frac{\text{Sludg vol after 30 min.} \times 1000}{\text{MLSS conc.}}$

Adv
> Low retention time
> 95% BOD removal
> Food / sugar / textile / antibiotic industries

Disadv
> Only good for low strength waste
> High sludge production to dispose

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> Expensive operation / maintenance
> creates foam. Thus needs antifoams.

*4) Oxidation Ditch:
> Modification of ASP
> Mixed liquor is mechanically aerated

Adv:
> Simple
> Cheap
> Efficient / Flexible

Disadv.
> Only for low BOD wastes from fruit canning, beet-sugar, meat industry
> Longer retention time

*5) Autothermal Thermophilic Aerobic Digestion (ATAD)
> Sludge digestion @ 40-70°C
> Heat is released by volatile solid oxidation by microbes

$$C_5H_7O_2N + 5O_2 \longrightarrow 4CO_2 + H_2O + NH_4HCO_3 + \Delta$$

Adv:
> Low Retention time
> Low oxygen requirement
> May reduce pathogens

Disadv.
> Expensive capital / operation
> Odour produced

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> Anaerobic Process

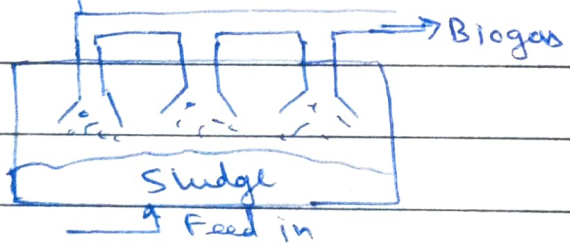
Adv.

> Reduction in volume (≈ 70%)
> Digested sludge safer than undigested as manure
> Biogas can be used internally
> Low cost

Disadv

> Microbes involved are sensitive to env. change
> Monitoring required
> High oxygen demand of supernatants

Upflow Anaerobic Sludge Bed (UASB)



Anaerobic over Aerobic (adv.)

> Energy instead of waste as by-product
> Cheaper
> Less space
> Less equipment cost