



# Water and Wastewater Treatment



CE421/521

Environmental Biotechnology

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# Wastewater Treatment

- Three objectives of wastewater treatment:

- reduce organic matter (includes xenobiotic & recalcitrant organics, e.g. pharmaceuticals, hormones, etc.)

- remove nutrients (N&P)

- reduce pathogens



# Categories of pollutants in wastewater

- Soluble and insoluble
- Organic and inorganic
- Natural and synthetic
- Toxic and non-toxic
- Volatile and non-volatile
- Xenobiotic and biogenic
- Anthropogenic and naturally occurring

$10,000 \text{ mg/L} = 170$

# Dilute nature of pollutants

- Large volume
- Concentrate & remove
- Sludge (biosolids) and liquid streams
- Use biochemical operations to treat both

200 mg/L TSS  
200 mg/L BOD

.02 % pollutant  
99.98 % H<sub>2</sub>O



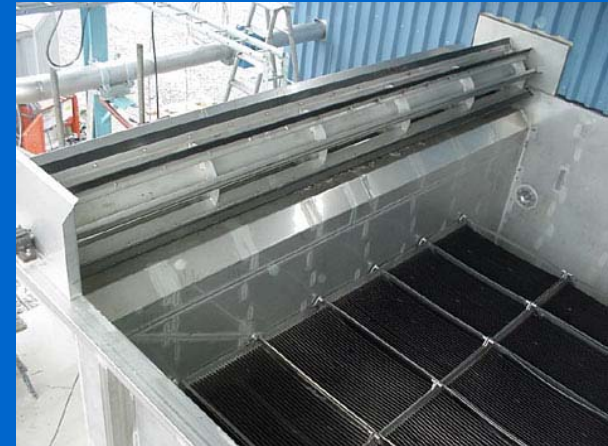
# Classification of biochemical operations

- Biochemical transformation
  - removal of soluble organic matter
    - aerobic treatment for soluble chemical oxygen demand (COD) in 50 - 40,000 mg/L range
    - anaerobic treatment for high CODs (4000 - 50,000 traditionally)
    - alternative processes for CODs < 50 mg/L (e.g., carbon adsorption, ion exchange) and >50,000 mg/L (e.g., evaporation and incineration)
  - stabilization of insoluble organic matter
    - biosolids (sludge) removed by sedimentation
    - colloidal matter not removed by sedimentation (entrapment in biomass)
  - conversion of soluble inorganic matter (N & P)
    - enhanced biological phosphorus removal (EBPR)
    - nitrification
    - denitrification



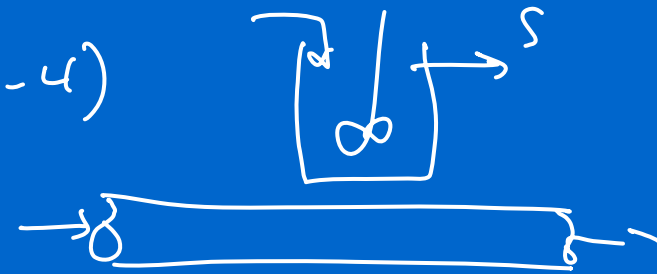
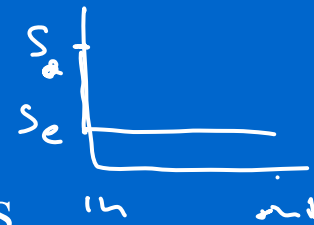
# Biochemical Environment

- terminal electron acceptor (TEA)
  - aerobic - oxygen
  - anaerobic - CO<sub>2</sub> or organics
  - anoxic - nitrate or sulfate
- ecology of microorganisms



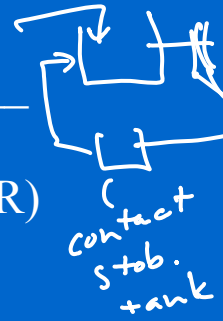
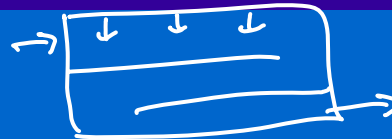
# Bioreactor Configuration

- suspended growth
  - continuously stirred tank reactors (CSTR)
  - CSTRs in series (2-4)
  - plug flow
- attached growth
  - packed tower - trickling filter
  - rotating discs - e.g., rotating biological contactor (RBC)
  - fluidized bed - e.g., anaerobic fluidized bed reactor



# Suspended Growth Bioreactors

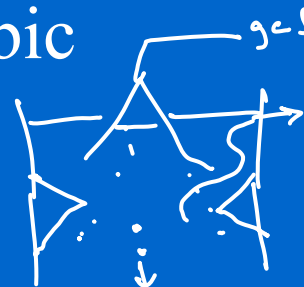
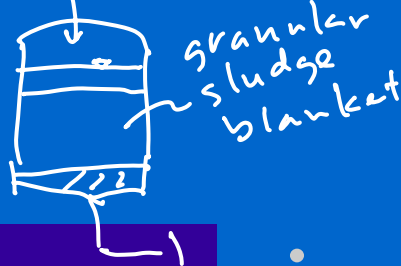
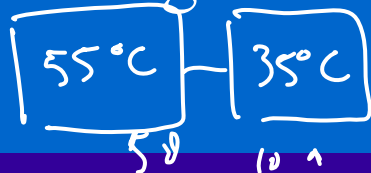
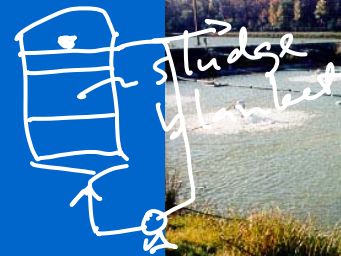
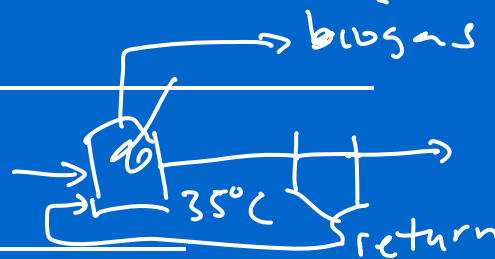
- Activated Sludge -
  - Completely mixed CMAAS
  - Conventional AS
  - High purity oxygen
  - Contact stabilization
  - Sequencing batch reactor (SBR)
  - Step feed
  - Extended aeration
- Biological Nutrient Removal
  - Biological phosphorus removal
  - Sequencing batch reactors
  - Separate stage denitrification
  - Single sludge systems
  - Separate stage nitrification





# Suspended Growth Systems

- Aerated Lagoons
- Aerobic Digesters
- Anaerobic Contact
- Upflow Anaerobic Sludge Blanket (UASB) Reactor
- Static Granular Bed Reactor
- Anaerobic Digestion
- Temperature Phased Anaerobic Digester

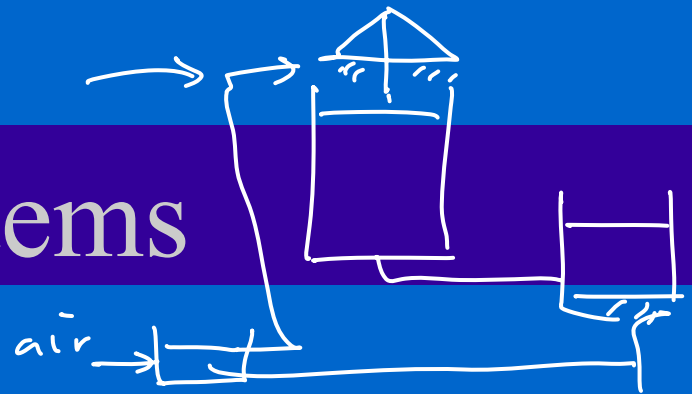


# Attached Growth Bioreactors

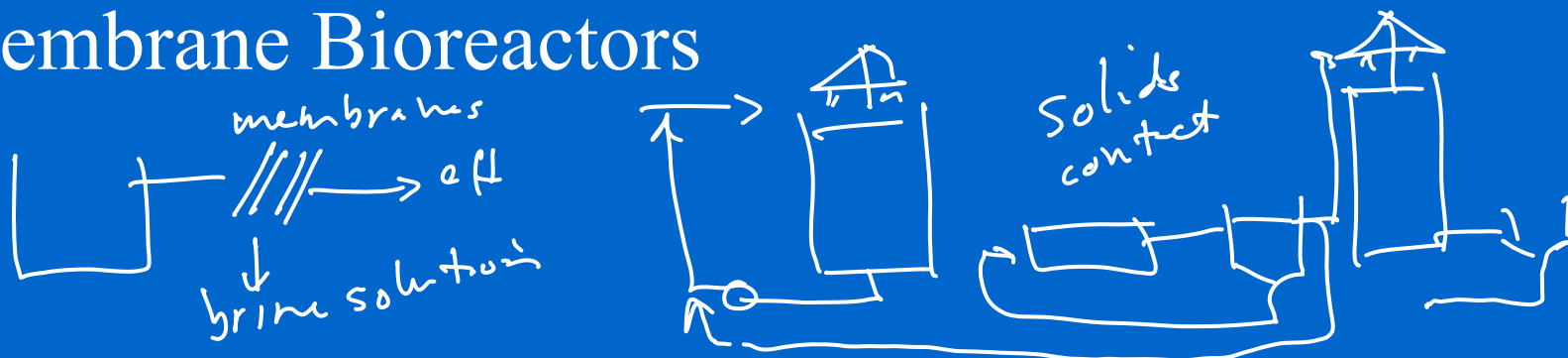
- Fluidized Bed Reactors
  - Aerobic
  - Anaerobic
  - Anoxic
- 2. Rotating Biological Contactors (RBCs)
- 3. Trickling Filter
- 4. Anaerobic Filter



# Hybrid Systems

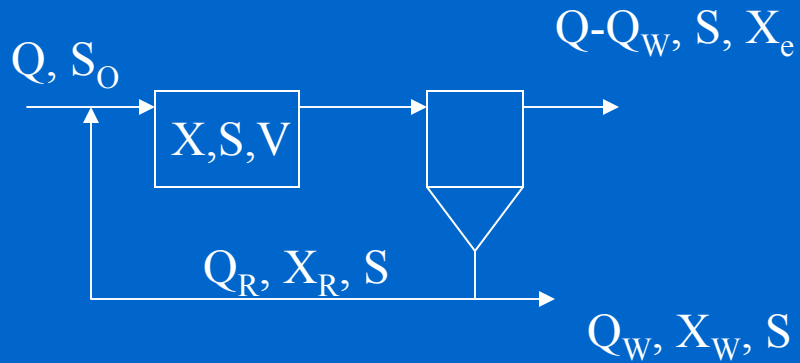


- Trickling Filter/Solids Contact Process
- Activated Sludge/Rotating Biological Contactor
- Integrated Fixed Film Activated Sludge (IFAS)
- Membrane Bioreactors



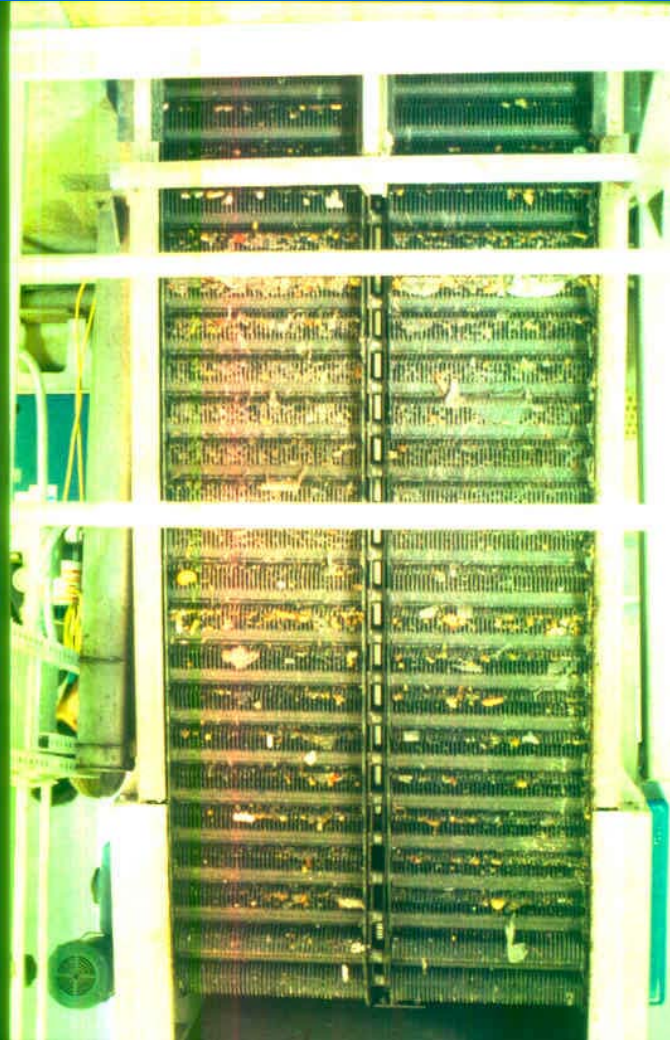
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# Completely Mixed A.S.





# Boone wastewater treatment plant





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# Wastewater treatment plants









# Wastewater treatment plants



# Wastewater treatment plants

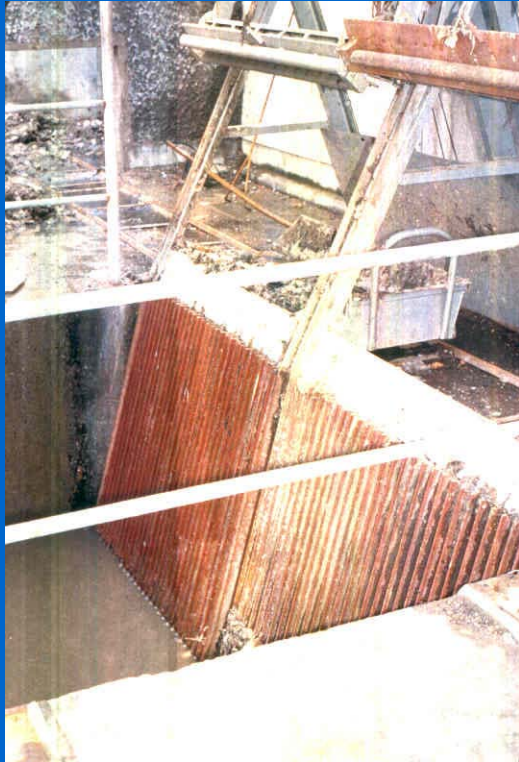




# Wastewater treatment plants



# Wastewater treatment plants





# Abu Dhabi WWTP



# Abu Dhabi WWTP

