Wastewater Treatment

• Three objectives of wastewater treatment:
  – reduce o__________________ matter (includes xenobiotic & recalcitrant organics, e.g. pharmaceuticals, hormones, etc.)
  – remove n_________________ (N&P)
  – reduce p___________________
Categories of pollutants in wastewater

- S________________ and insoluble
- O________________ and inorganic
- N________________ and synthetic
- T________________ and non-toxic
- Volatile and non-volatile
- Xenobiotic and b____________
- Anthropogenic and n________ occurring
Dilute nature of pollutants

- Large v____________________
- C________________________ & remove
- S________________________ and liquid streams
- Use b____________________ operations to treat both
Classification of biochemical operations

• Biochemical transformation
  – removal of s________________
    o________________ m________________
  • a_________________ treatment for soluble chemical oxygen demand (COD) in 50 - 40,000 mg/L range
  • a_________________ treatment for high CODs (4000 - 50,000 traditionally)
  • a_________________ processes for CODs < 50 mg/L (e.g., carbon adsorption, ion exchange) and >50,000 mg/L (e.g., evaporation and incineration)
  – stabilization of i____________________________ organic matter
  • b_______________ (sludge) removed by sedimentation
  • c_________________ matter not removed by sedimentation (entrapment in biomass)
  – conversion of soluble i____________________________ matter
    • enhanced b____________ p________________________ removal (EBPR)
    • n____________________
    • d____________________
Biochemical Environment

- t__________________________
e__________________________
a__________________________ (TEA)
  - a__________________________ - oxygen
  - a__________________________ - CO₂ or organics
  - a__________________________ - nitrate or sulfate

- e___________________________ of microorganisms
Bioreactor Configuration

- **s** growth
  - **c** s tank reactors (CSTR)
  - CSTRs in **s**
  - p f

- **a** growth
  - p tower - trickling filter
  - rotating d - e.g., rotating biological contactor (RBC)
  - f bed - e.g., anaerobic fluidized bed reactor
Suspended Growth Bioreactors

• Activated Sludge
  – Completely m____________
  – C____________________
  – High p____________ o____________
  – Contact s____________________
  – Sequencing b_________ reactor (SBR)
  – S_________ feed
  – Extended a______________

• Biological N____________ Removal
  – Biological phosphorus removal
  – S_______________________ batch reactors
  – Separate s_________ denitrification
  – S_____________________ sludge systems
  – Separate stage n_______________
Suspended Growth Systems

- Aerated
- Aerobic
- Anaerobic
- U Anaerobic Sludge Blanket (UASB) Reactor
- Static Granular Bed Reactor
- A Digestion
- Temperature Phased Anaerobic Digester
Attached Growth Bioreactors

- Fluidized B___________ Reactors
  - A_________________
  - A_________________
  - A_________________
  - A_________________
- 2. Rotating Biological C_________________
- 3. T_______________ Filter
- 4. A_______________ Filter
Hybrid Systems

- Trickling Filter/S___________ Contact Process
- Activated Sludge/R___________ Biological Contactor
- Integrated Fixed Film Activated Sludge
- Membrane Bioreactors
Completely Mixed A.S. Design

Q - Q_w, S, X_e

Q, S_o

X, S, V

Q_r, X_r, S

Q_w, X_w, S
FIGURE 5-25
Boone wastewater treatment plant
Wastewater treatment plants
Wastewater treatment plants
Back River WWTP
Back River WWTP
Back River WWTP
Back River WWTP
Abu Dhabi WWTP
Abu Dhabi WWTP
Lake Balaton WWTP
Lake Balaton WWTP
Lake Balaton WWTP
Lake Balaton WWTP
Wastewater Treatment in Developing Countries

Community Biogas Plant in China