SPH 262
Principles of Environmental Health Sciences

Water and Wastewater

Part 2: General Concepts

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Major Concepts

- Sources and types of pollution that threaten water supplies
  - Point sources & nonpoint sources
- Clean Water Act
- Safe Drinking Water Act
- Wastewater treatment
  - Septic systems & wastewater treatment plants
  - Biological oxygen demand & sag curve

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Water Quality

- Characteristics of water
  - Taste, color, temperature, purity, toxicity
- Water quality requirements vary with intended use
  - High quality needed for drinking water and certain industrial uses
  - Lower quality may be acceptable for irrigation
    - Wastewater reuse

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Water Quality

- Types of pollutants that may pollute a water supply
  - Physical
  - Chemical
  - Biological
  - Radioactive

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Types of Pollution

- Inorganic chemicals
  - Of particular concern are metals
    - Lead, cadmium, mercury, arsenic, copper
  - Can cause serious acute and chronic health problems
  - Sources include
    - Mining and manufacturing
    - Agriculture
    - Households
    - Arial deposition from fossil fuel burning

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Types of Pollution

- Organic chemicals
  - Volatile organic compounds (VOCs)
    - Solvents, petroleum fuels, fuel additives
  - Synthetic organic compounds (SOCs)
    - Pesticides, dioxins, PCBs
  - Sources include
    - Industry
    - Agriculture
    - Households

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Types of Pollution

- Biological – waterborne disease
  - 1 million illnesses each year in U.S.
  - Bacteria
    - Typhoid fever, cholera, bacillic dysentery
  - Viruses
    - Viral hepatitis, acute gastroenteritis
  - Parasites
    - Amebic dysentery, giardiasis

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Types of Pollution

- Radioactive
  - Most common in water are
    - Radium, uranium, radon and man-made radionuclides
  - Naturally occurring radionuclides appear mainly in groundwater
  - Surface waters more likely to contain artificial radionuclides
    - Atmospheric fallout from nuclear testing

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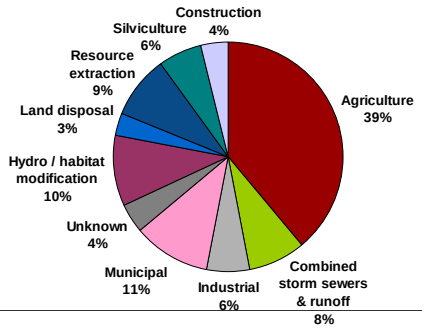
Sources of Pollution in U.S. Rivers



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Sources of Pollution

- Point sources
  - Industrial discharges and municipal wastewater treatment plants
    - Regulated under federal Clean Water Act
    - National Pollutant Discharge Elimination System (NPDES) permits
  - Underground injection wells

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Sources of Pollution

- Nonpoint sources
  - Agricultural runoff
    - Pesticides
    - Nutrients (fertilizers) – cause eutrophication
    - Sediment
  - Urban storm water
    - Pesticides
    - Nutrients (fertilizers)
    - Sediment
    - Petroleum

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Sources of Pollution

- Nonpoint sources (cont.)
  - Acid mine drainage
    - Expose ore and waste rock to atmosphere
    - Sulfide minerals oxidize → low pH (acidic)
    - Mobilizes metals and salts
  - Confined animal facilities
    - Nitrate
    - Organic matter
    - Pathogens
    - Hormones, antibiotics

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Drinking Water Treatment

- Municipal drinking water treatment in the United States
  - 170,000 public water supply systems supply most drinking water
    - 115,000 small scale suppliers
    - 55,000 community supply systems
  - Supply water to 250 million Americans

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Drinking Water Treatment

- Main treatment steps
  - Coagulation - flocculation
  - Sedimentation
  - Filtration
  - Disinfection

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Disinfection

- Most critical step in water treatment
- Goal: destroy all organisms in water supply
- Chlorine
  - Major disinfectant used in U.S. today
  - Form disinfection byproducts
- Alternatives
  - UV radiation
  - Ozone
  - Chloramines

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Drinking Water Regulation

- Safe Water Drinking Act
  - U.S. Environmental Protection Agency sets Maximum Contaminant Levels (MCLs)
    - Protect the public health and welfare from specific water pollutants
  - Delegated enforcement to individual states
    - Oversight provided by the USEPA

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Wastewater Treatment and Disposal

- Sewage
  - In many developing countries human waste pollutes land and water
  - Organic material can serve as food for disease-producing organisms living in the water

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Biological Oxygen Demand (BOD)

- As microorganisms decompose organic material in water, they use dissolved oxygen
- If water overloaded with biodegradable organic pollutants, decomposition can deplete dissolved oxygen supply
- Kills fish and other aquatic organisms that depend on dissolved oxygen for respiration
- Reaeration of water caused by
  - Turbulent flow
  - Aquatic plant photosynthesis

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Biological Oxygen Demand (BOD)

- Sag curve
  - Deoxygenation and reaeration of water presented graphically
  - Shows level of dissolved oxygen over time
  - Shows "critical point"
    - Minimum dissolved oxygen
    - Maximum aquatic life impact

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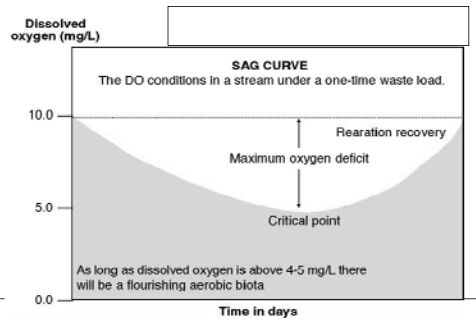
BOD and Sag Curve



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Types of Sewage Disposal

- Pit privies
- Individual septic systems
- Municipal sewage treatment plant

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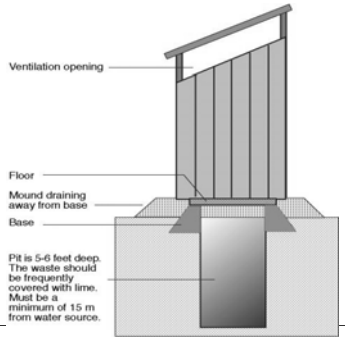
Pit Privy



- Separation from water
- Drainage
- Ventilation

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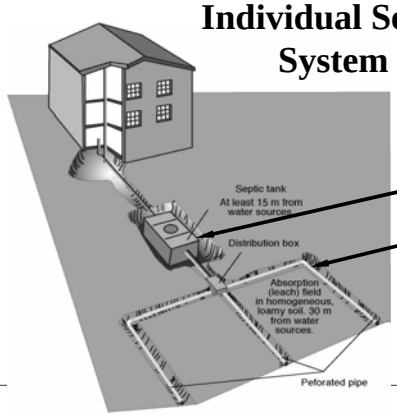
Individual Septic System



- Septic tank
- Leach field

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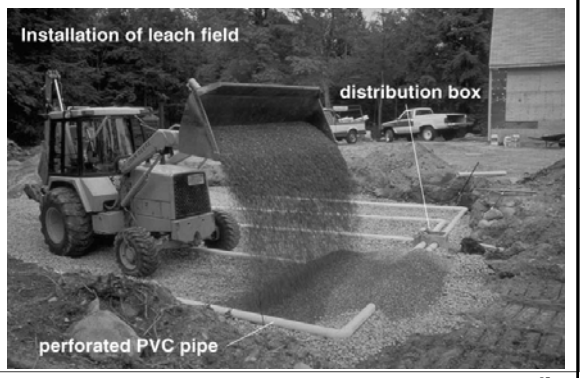

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Prevent Septic System Failure

- Proper installation
  - Separation from water sources
  - Soil properties - drainage
- Keep microorganisms healthy
  - Minimize toxins
- Don't overload with solids
  - Grease, fats, food wastes
  - Remove solids periodically

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Municipal Sewage Treatment

- Speeds up natural purification processes
  - Settling
  - Biooxidation
  - Filtration
- Stages of treatment
  - Primary
  - Secondary
  - Tertiary
  - Sludge disposal

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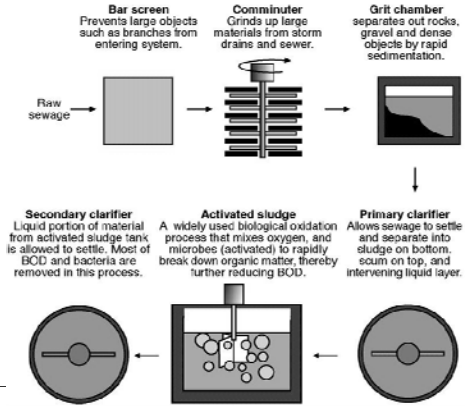
Primary and Secondary Wastewater Treatment



Municipal Sewage Treatment

- Primary treatment
  - Mechanical processes for removal of solids
  - Bar screen
  - Grinder or comminuter
  - Clarifier

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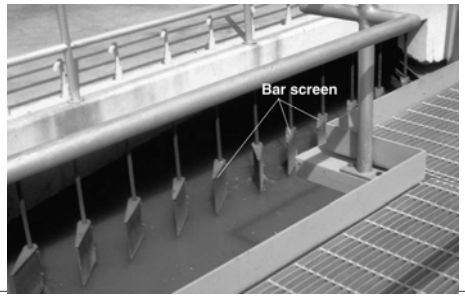
Bar Screen



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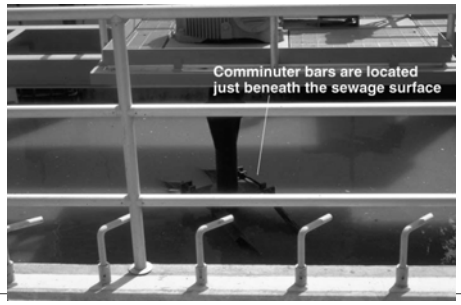
Comminuter



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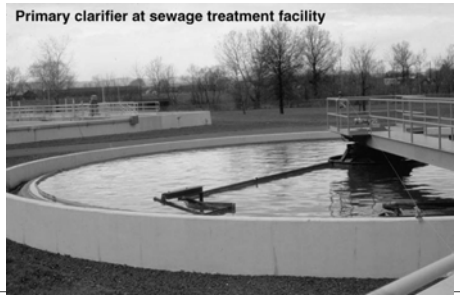
Clarifier



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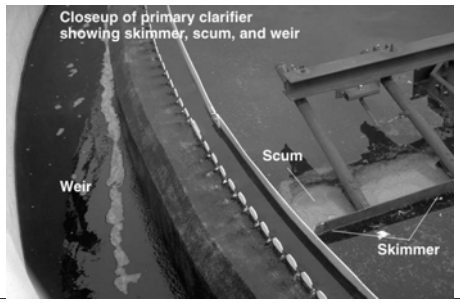
Clarifier



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Municipal Sewage Treatment

- **Secondary treatment**
  - **Trickling filters and activated sludge treatment**
    - **Bacteria break down and digest organic material in the sewage**
  - **Sludge from primary and secondary treatment**
    - **Dried**
    - **Disposed of in landfill or composted**

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Activated Sludge Tank

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Activated Sludge Tank (drained)

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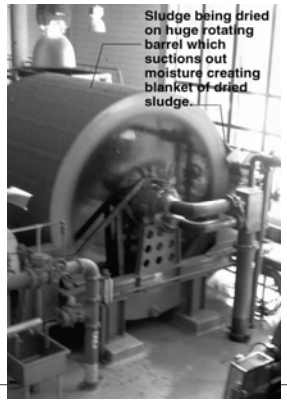

Sludge Drying Centrifuge

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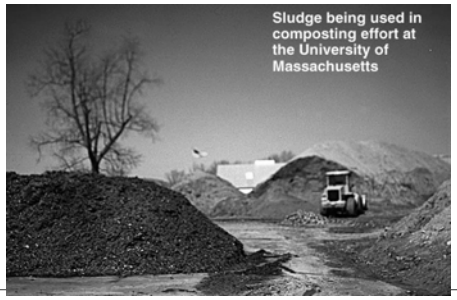
Sludge Composting



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Municipal Sewage Treatment

- Tertiary treatment
  - Advanced wastewater treatment methods, including
    - Air stripping of ammonia
    - Coagulation
    - Rapid granular filtration
    - Reverse osmosis – membrane filtration
  - Further reduce BOD, salts, pathogens and other pollutants

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Municipal Sewage Treatment

- Sludge treatment and disposal
  - Sludge or "biosolids"
    - Solids and associated liquids separated from wastewater during sewage treatment
  - Sludge disinfection
    - Destroys pathogens in the sludge to prevent the spread of disease
  - Digested sludge may be air dried
  - Disposal in landfill or reused as agricultural fertilizer

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Future Outlook

On a planet covered with water, yet plagued by waterborne disease, drought, and water mismanagement, we must promote conservation, efficiency, and frugality.

- Every drop counts!

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