Lesson 18. Water Quality

Water Pollution

June 1, 2006

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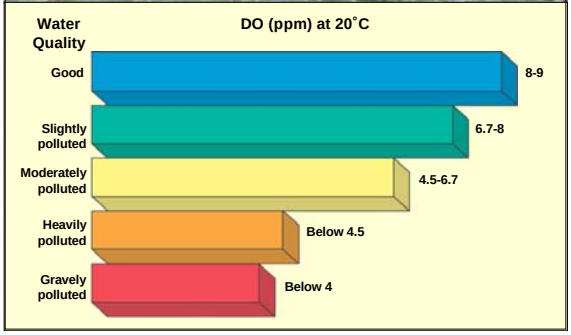
What is water pollution?

- Any chemical, biological, or physical change in water quality that has a harmful effect on living organisms and/or makes water unsuitable for desired uses.

How is water quality measured?

1. Biological Oxygen Demand (BOD)
   - The amount of dissolved oxygen required to destroy the organic materials in aquatic ecosystems.

Dissolved Oxygen



How is water quality measured?

2. Fecal Coliform Bacteria

- **Any of the many types that live in the colon or intestines of humans and other animals.**
- *Eschericia coli (E. coli)*

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Bacterial Indicators

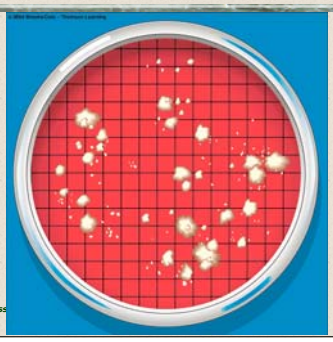

Figure 19-2
Page 485

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Bacterial Indicators

Testing for *E. coli*

Point Source Pollution

- Discharge pollutants at specific locations through pipes, ditches, or sewers into bodies of surface water.
- Examples????

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Non-Point Source Pollution

- Sources that cannot be traced to any single site of discharge.
- Large land areas that pollute water by runoff
- Examples???

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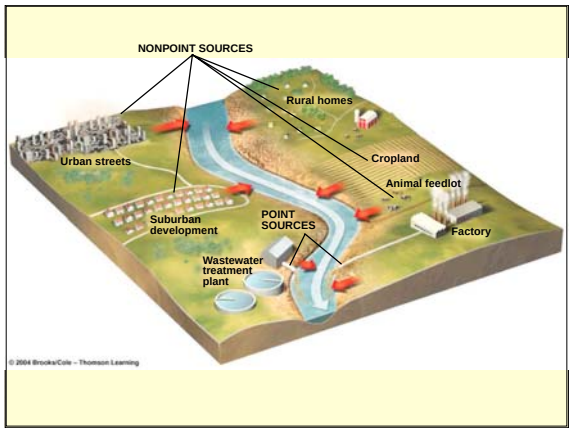

Major Categories of Water Pollution

Types of Water Pollution

- Infectious agents
- Oxygen-demanding wastes
- Inorganic Chemicals
- Organic Chemicals
- Heat (Thermal)
- Radioactive Material
- Sediment
- Genetic Pollution

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Infectious Agents

Table 9-1 Major Categories of Water Pollutants

INFECTIOUS AGENTS

Examples: Bacteria, viruses, protozoa, and parasitic worms

Major Human Sources: Human and animal wastes

Harmful Effects: Disease

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Oxygen Depletion

Table 9-1 Major Categories of Water Pollutants

OXYGEN-DEMANDING WASTES

Examples: Organic waste such as animal manure and plant debris that can be decomposed by aerobic (oxygen-requiring) bacteria

Major Human Sources: Sewage, animal feedlots, paper mills, and food processing facilities

Harmful Effects: Large populations of bacteria decomposing these wastes can degrade water quality by depleting water of dissolved oxygen. This causes fish and other forms of oxygen-consuming aquatic life to die.

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Inorganic Chemicals

Table 9-1 Major Categories of Water Pollutants

INORGANIC CHEMICALS

Examples: Water-soluble 1) acids, (2) compounds of toxic metals such as lead (Pb), arsenic (As), and selenium Se), and (3) salts such as sodium chloride (NaCl) in ocean water and fluorides (F–) found in some soils

Major Human Sources: Surface runoff, industrial effluents, and household cleansers

Harmful Effects: Can (1) make fresh water unusable for drinking or irrigation, (2) cause skin cancers and crippling spinal and neck damage (F–), (3) damage the nervous system, liver, and kidneys (Pb and As), (4) harm fish and other aquatic life, (5) lower crop yields, and (6) accelerate corrosion of metals exposed to such water.

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Organic Chemicals

Table 9-1 Major Categories of Water Pollutants

ORGANIC CHEMICALS

Examples: Oil, gasoline, plastics, pesticides, cleaning solvents, detergents

Major Human Sources: Industrial effluents, household cleansers, surface runoff from farms and yards

Harmful Effects: Can (1) threaten human health by causing nervous system damage (some pesticides), reproductive disorders (some solvents), and some cancers (gasoline, oil, and some solvents) and (2) harm fish and wildlife.

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Nutrients

Table 9-1 Major Categories of Water Pollutants

PLANT NUTRIENTS

Examples: Water-soluble compounds containing nitrate (NO_3^-), phosphate (PO_4^{3-}), and ammonium (NH_4^+) ions

Major Human Sources: Sewage, manure, and runoff of agricultural and urban fertilizers

Harmful Effects: Can cause excessive growth of algae and other aquatic plants, which die, decay, deplete water of dissolved oxygen, and kill fish. Drinking water with excessive levels of nitrates lowers the oxygen-carrying capacity of the blood and can kill unborn children and infants ("bluebaby syndrome").

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Sediment

Table 9-1 Major Categories of Water Pollutants

SEDIMENT

Examples: Soil, silt

Major Human Sources: Land erosion

Harmful Effects: Can (1) cloud water and reduce photosynthesis, (2) disrupt aquatic food webs, (3) carry pesticides, bacteria, and other harmful substances, (4) settle out and destroy feeding and spawning grounds of fish, and (5) clog and fill lakes, artificial reservoirs, stream channels, and harbors.

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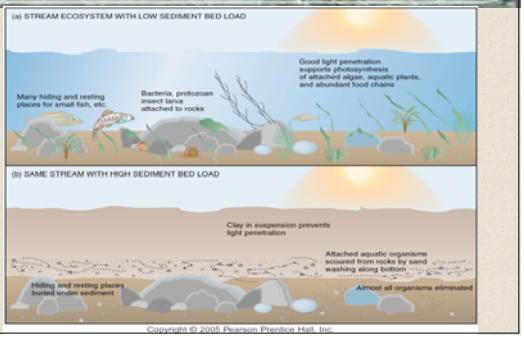
Sediment Pollution



Radioactive Materials

Table 9-1 Major Categories of Water Pollutants

RADIOACTIVE MATERIALS

Examples: Radioactive isotopes of iodine, radon, uranium, cesium, and thorium

Major Human Sources: Nuclear and coal-burning power plants, mining and processing of uranium and other ores, nuclear weapons production, natural sources

Harmful Effects: Genetic mutations, miscarriages, birth defects, and certain cancers

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Thermal Pollution

Table 9-1 Major Categories of Water Pollutants

HEAT (THERMAL POLLUTION)

Examples: Excessive heat

Major Human Sources: Water cooling of electric power plants and some types of industrial plants. Almost half of all water withdrawn in the United States each year is for cooling electric power plants.

Harmful Effects: Lowers dissolved oxygen levels and makes aquatic organisms more vulnerable to disease, parasites, and toxic chemicals. When a power plant first opens or shuts down for repair, fish and other organisms adapted to a particular temperature range can be killed by the abrupt change in water temperature—known as *thermal shock.*

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Surface Water Pollution

Rivers & Lakes

Oxygen Sag Curve

- The breakdown of degradable wastes by bacteria depletes dissolved oxygen.

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Oxygen Sag Curve

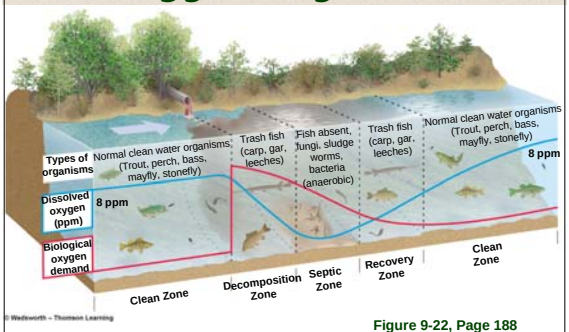

Figure 9-22, Page 188

Cuyahoga River

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Acid Mine Drainage

Contains Sulfides and iron which oxidizes with air

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Lake Pollution

Eutrophication

Eutrophication

- "well nourished" by nitrates and phosphates (both natural and cultural)
- Process that eventually depletes dissolved oxygen, killing off aquatic organisms

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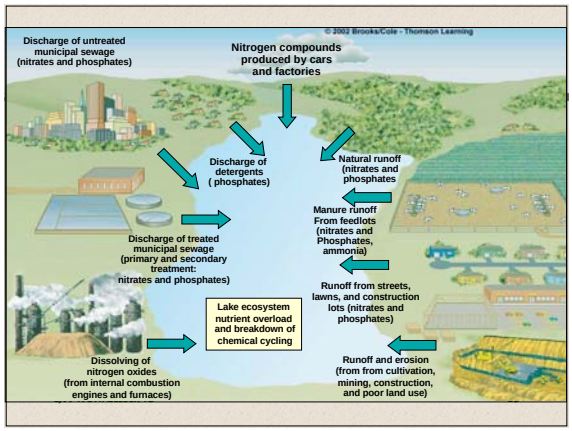
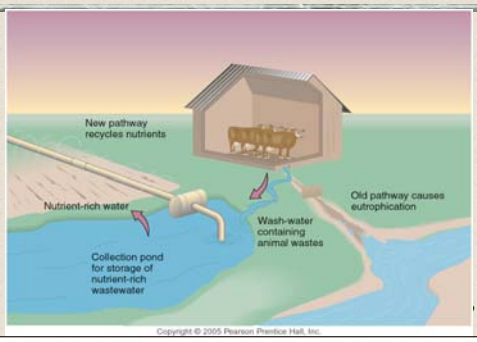
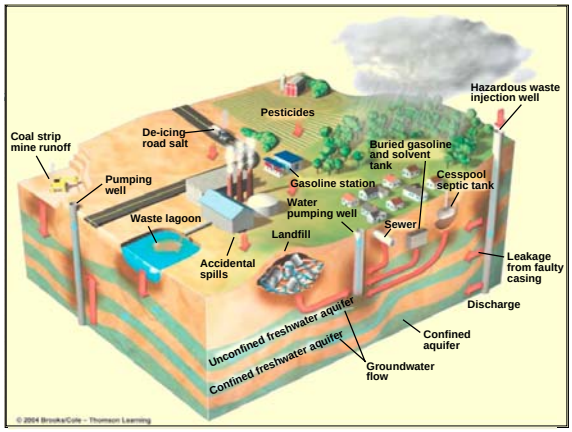


Collection Pond for Dairy Washings



Sources of Groundwater Pollutants



A TOUR THROUGH A WATER RESTORATION PLANT

Oregon & Washington

Municipal Treatment Plants

What is Wastewater?

- Wastewater is water which is:
  - contaminated by human use
  - and discarded

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Definition (Continued)

- Or, said another way, wastewater is:
  - Water
  - +
  - whatever we add to it?

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Influent Waste Water

- What goes to a WWTP?
  - Toilet flush & Sink (bathroom and kitchen)
  - Industrial waste (if permitted)
  - Septic Sludge
  - Storm Water
  - Combined Sewers (Storm Drains & Sanitary Sewers)
  - Inflow / Infiltration

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Domestic Sewage

Composition:

BOD	200 - 290 mg/L
TSS	200 - 290 mg/L
Nitrogen	35 -100 mg/L
Phosphorus	18 - 29 mg/L
Coliforms	10^{10} - 10^{12} / ml
Fecal Coliforms	10^{8} - 10^{10} / ml

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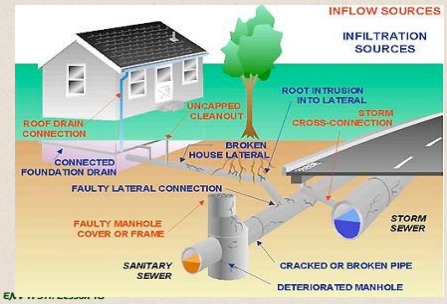
I / I Sources



39

Influent Waste Water

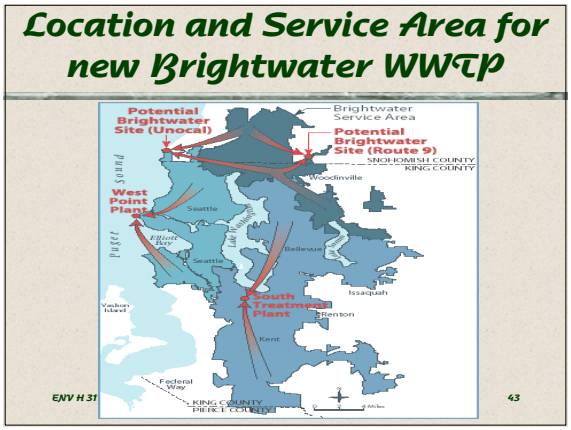
- How much water goes to a WWTP?
- Grants Pass, Oregon
  - Average: 5.5 Million Gallons / Day
- West Point (Seattle, WA)
  - Average: 140 Million Gallons / Day

West Point WWTP

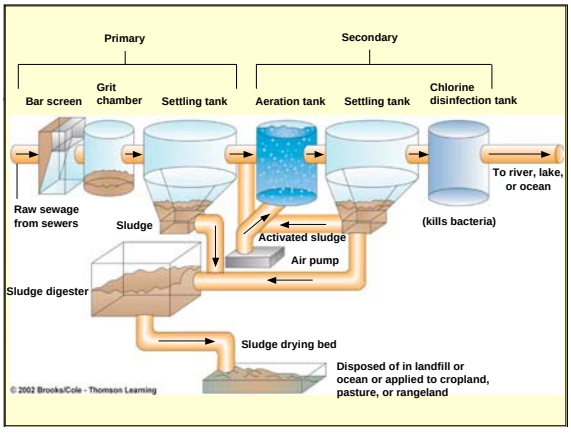
- The West Point Treatment Plant is located in Seattle's 534-acre Discovery Park.
- Can treat up to 215 MGD of wastewater.
- Discharges into Puget Sound
  - 3,600 ft offshore, 240 ft deep

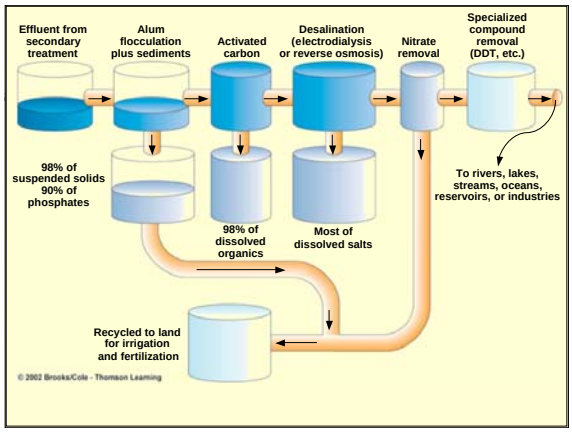
West Point WWTP

Location and Service Area for new Brightwater WWTP



Typical Flow Diagram for (most) WWTP





Let's take a tour of Grants Pass WRP

Liquid Treatment Train

Primary Treatment

- **Mechanical Process**
- **Purpose: to remove any small and large debris.**

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Primary Treatment

- Bar Screens – remove debris (rags, plastic bags, sticks, shoes, tennis balls, etc). This material than collected and taken to the landfill for disposal.

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Primary Treatment

- Grit Cyclones
  - Gravitational forces minimize the release of particles with densities greater than water.
  - Grit settles by gravity to the bottom of the unit and goes to a collection hopper. This is taken to the landfill for disposal.
  - Organics exit with the effluent to the next process.

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Primary Treatment

- Primary Settling Tanks (Primary Clarifiers)
- Can either be rectangle or circular. Grants Pass has one of each.
- Purpose: To remove floating material with skimmers (fats, oils, and greases) and allow other solids to fall slowly to the bottom where they are removed (leaves, algae, coffee grounds, silt, etc).

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Secondary Treatment

- Biological Process
- Use natural decomposers to feed on organic material to break it down to carbon dioxide & water.
- Must add oxygen to water for this process to occur.

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Secondary Treatment

- Activated Sludge Tanks
- Water from Primary Clarifiers enters Activated Sludge Tanks with remaining organics.
- Oxygen added so microbes can feed on organic material.

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Secondary Treatment

- From the Activated Sludge Tanks, the water goes to a SECONDARY CLARIFIER
- Circular basin
- Water is slowed down so the bacteria can settle to the bottom. Some of the bacteria is returned to the Activated Sludge Tanks for reuse, while the rest of it is sent to the solids treatment train.

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Disinfection

- Purpose: to kill any remaining pathogens.
- Can use:
  - Chlorine gas – used at Westpoint
  - UV Radiation – used at Grants Pass
  - Ozone gas

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Pipe Gallery

- Just a shot of the underground pipes hard at work.

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Outfall

- From disinfection the water meets Oregon Department of Environmental Quality (ODEQ).
- It is now permitted to be discharged to the Rogue River.

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Solids Treatment Train

Dealing with the yucky stuff

Solids Treatment

- From the primary & secondary clarifiers and the activated sludge tank, "sludge" is blended and sent to the gravity thickener belt to remove some of the water and thicken the solids.

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Solids Treatment

- From the gravity thickener belt, the sludge is heated by heat exchangers to 95 degrees and then pumped to the digesters to thicken.
- Digesters create the right environment for bacteria to break down the pathogens and organic material. Methane gas is produced as a result. The mass of solids is reduced.

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Solids Treatment

- Digesters
  - Process occurs anaerobically (without oxygen).
  - Remains in digester for about 3 to 4 weeks.

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Solids Treatment

- From the digester, sludge goes to belt filter press to remove the remaining water out.

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Then where?

- Sludge or "biosolids" is then taken to a composting site outside of Grants Pass.

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What are Biosolids?

- Biosolids are the nutrient-rich organic material produced by treating wastewater solids.
- After processing and treatment, they can be beneficially recycled as a fertilizer and soil amendment.

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Questions

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On-site Sewage Disposal

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What is it?

- System designed to provide long-term treatment & disposal of sewage / wastewater
- System designed to deal primarily with residential sewage

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What is it?

- System designed to treats and dispose of sewage on / near the generation site
- System where final disposal / dispersal is below the surface of the soil
  - INTO the soil

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Where is it used?

- Where sewers are not available
  - Suburban areas with larger lots
  - Rural areas
- Where sewers are not desirable
  - Sewer is too expensive
  - Sewer may create too high a density
  - Sewer may cause environmental concerns
- Where limited ground water is available

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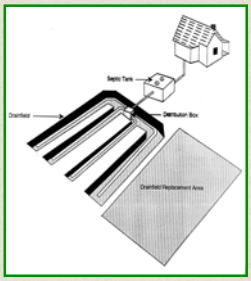
On-site Systems

- Major Components
  - House Drain
  - Septic Tank
  - Distribution Box
  - Drain Field



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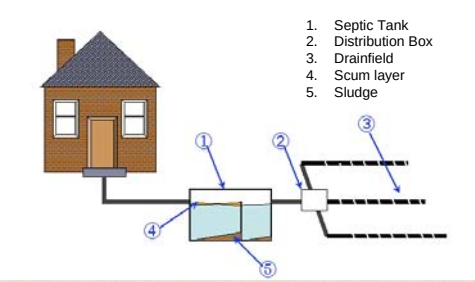
Example

On-site System



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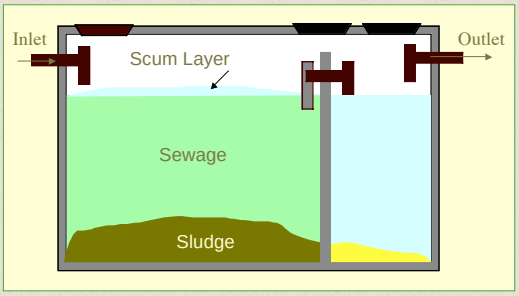
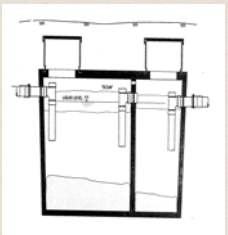
Septic Tank



Septic Tank

- Functions
- Remove solids
- Anaerobic digestion
- Vent back to home



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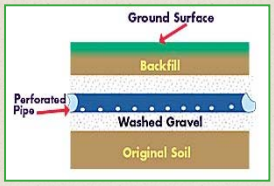
Septic Tanks

Drainfields

- Provide majority of treatment
- Trench network to discharge liquid into soil
- Provide aerobic environment
- Remove pathogens in suitable soil below trench



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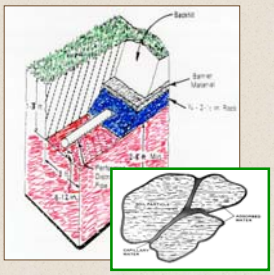
Drainfield

Treatment Process

- Physical
  - Filtration
  - Adsorption to particle surfaces
  - UV disinfection – stops cell reproduction



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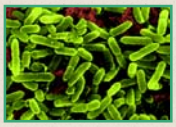
Treatment Process

- Microbiological – bacteria, fungi, yeasts
  - Aerobic, anaerobic & facultative
  - Cause chemical transformations – e.g. N



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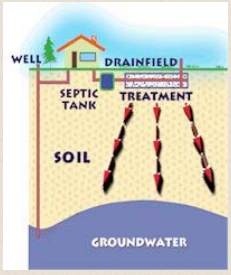
Treatment Process

- Chemical
  - Ion exchange e.g. NH_4
  - Chemical adsorption e.g. PO_4^-
  - Oxidation - Chlorination



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Issues & Concerns

- On-site systems used by:
  - 25% households in US (~26 million)
  - 30% households in WA (~600,000)
- 500,000 installed annually in US
- 25,000+ installed annually in Washington
- BUT, only 32% of area in US is suitable

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Issues & Concerns

- Bad historical reputation
  - Short-term: Until sewers come
  - "Out-of-site / Out-of-mind" philosophy
  - Placed where they didn't belong
  - Many failures
  - Systems are "second rate"
- Not as convenient as sewer:
  - Can't "flush & forget,"
  - "What do you mean: I've got to be involved with my sewage"

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Issues & Concerns

- Most of the good land is gone
  - Much of remaining land is being saved for other priority uses
- Many people moving from urban to rural
- There has been little or no federal assistance
  - Research
  - Grants/loans - most $$$ have been for sewers
- Lack of understanding on part of public, decision-makers, others

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Issues & Concerns

- Land Use Issues
  - Land use & wastewater management planning done with poor assumptions
  - Sewers bring high density
  - On-site systems can't support high density
  - Industrial wastewater not suitable for on-site systems

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Issues & Concerns

- Health concerns
  - Pathogens – bacteria, virus, protozoans
  - Chemicals – nitrogen, some organics, etc.
  - Organic material

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Issues & Concerns

- Environmental concerns
  - Nutrients – nitrogen, phosphorus
  - Organic material
- Nuisances

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Solutions

- Put systems where they belong
- Use systems that provide known & predictable levels of acceptable treatment
- Use systems that have long-term life expectancy
- Match site conditions & sensitivity with appropriate technology

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Solutions Continued

- Practice high levels of quality control throughout system's life
- Fix problems in a timely fashion
- Educate the owners/users & others

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Legislative Milestones Protecting Our Nations Waters

1899

- Rivers & Harbors Act
- First federal legislation
- prohibits the construction of any bridge, dam, etc without gov't approval

1948

- Water Pollution Control Act
- Federal gov't to provide technical assistance & funds to states & local gov't
- Assist states in constructing of WWTP's

1972

- The Federal Water Pollution Control Act
- Aka "Clean Water Act" (CWA)
- Protect & restore the physical, chemical, and biological integrity of the nation's waters.

CWA

- National Pollution Discharge Elimination System (NPDES) - requires permits for any discharge of pollution
- Strengthens water quality standards

CWA

- Provided $57 billion dollars for construction and upgrades of WWTP through the Construction Grant Program
- Encourages use of best achievable pollution control technology

1972

- Marine Protection, Research, and Sanctuaries Act
- Prevents unacceptable dumping in oceans

1974

- Safe Drinking Water Act (SDWA)
- EPA established drinking water standards
- Amended in 1986 – stricter regulations

1977 – Clean Water Act Amendments

- Amendment to 1972 CWA
- Strengthens controls on toxic pollutants
- Allows states to assume responsibility for federal programs

1987 - Water Quality Act

- Major amendments to CWA
- Address regional pollution within watersheds
- Requires states to develop and implement plans dealing with non-point source pollution
- Phase out of the Construction Grant Program by 1994 and replace it with a State Revolving Fund which provided low interest loans to support WWTP construction

Questions

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Next Lesson

Solid & Hazardous Waste

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Plan & Implement Plan