

## **CH. 21 (+ 22): Water Pollution**

**Types of water pollution**

**Sources of water pollution**

**Clean Water Act**

**Treatment of waste water**

## **Possible Test Questions:**

1. List and discuss 6 categories of water pollutants.
2. Discuss how sewage is related to biological oxygen demand (BOD), dissolved oxygen, and eutrophication.
3. Discuss the problems associated with pesticide use. Use DDT as a specific example. (More in Ch 22)
4. Why were PCBs thought to be a 'miracle chemical'? Why is this organic chemical an 'environmental curse'.
5. Contrast point source pollution and non-point source pollution, giving examples of each.
6. Distinguish among primary, secondary, and tertiary treatments for wastewater.

**Water Pollution:** physical, chemical, biological changes in water quality that adversely affect living organisms.  
Degradation.

Types:

**Infectious Agents**

**Oxygen-Demanding Wastes**

**Inorganic Pollutants**

**Organic Chemicals**

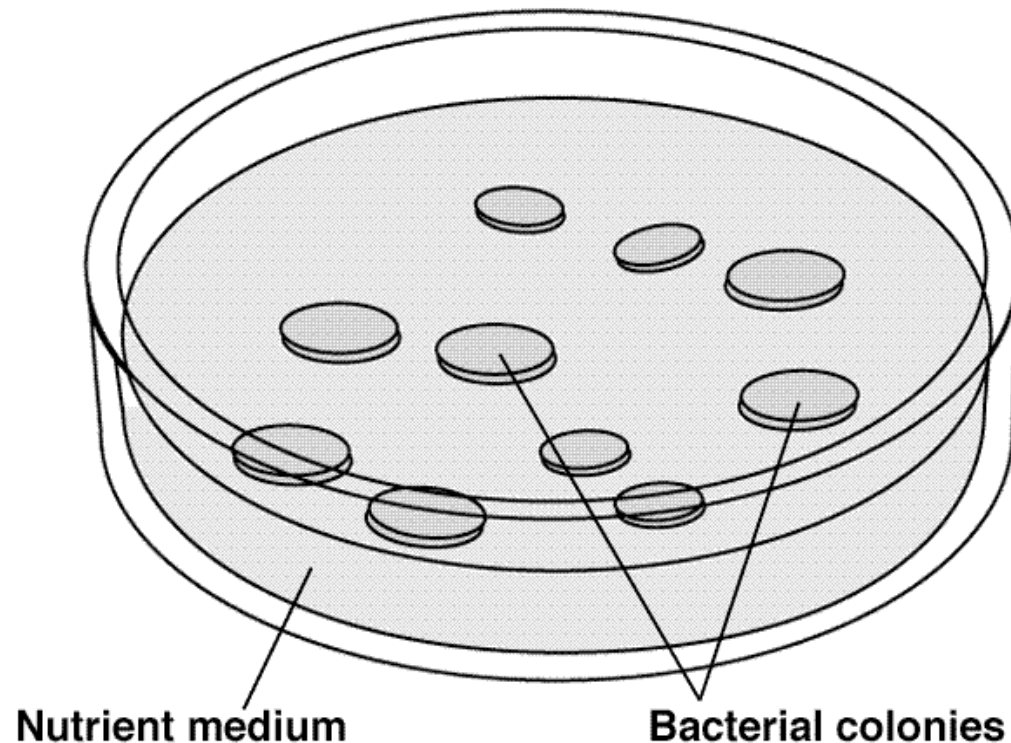
**Sediment (Particulates)**

**Thermal Pollution**

**Infectious Agents:** pathogenic organisms. Water-borne diseases include typhoid, cholera, bacterial and amoebic dysentery, polio, infectious hepatitis, guinea worm and schistosomiasis. **Due to lack of sanitation.**

**Analyze coliform bacteria (E. coli).** Presume if coliform bacteria are present, infectious pathogens are also present.

**Coliform Bacteria in a Petri Dish.**

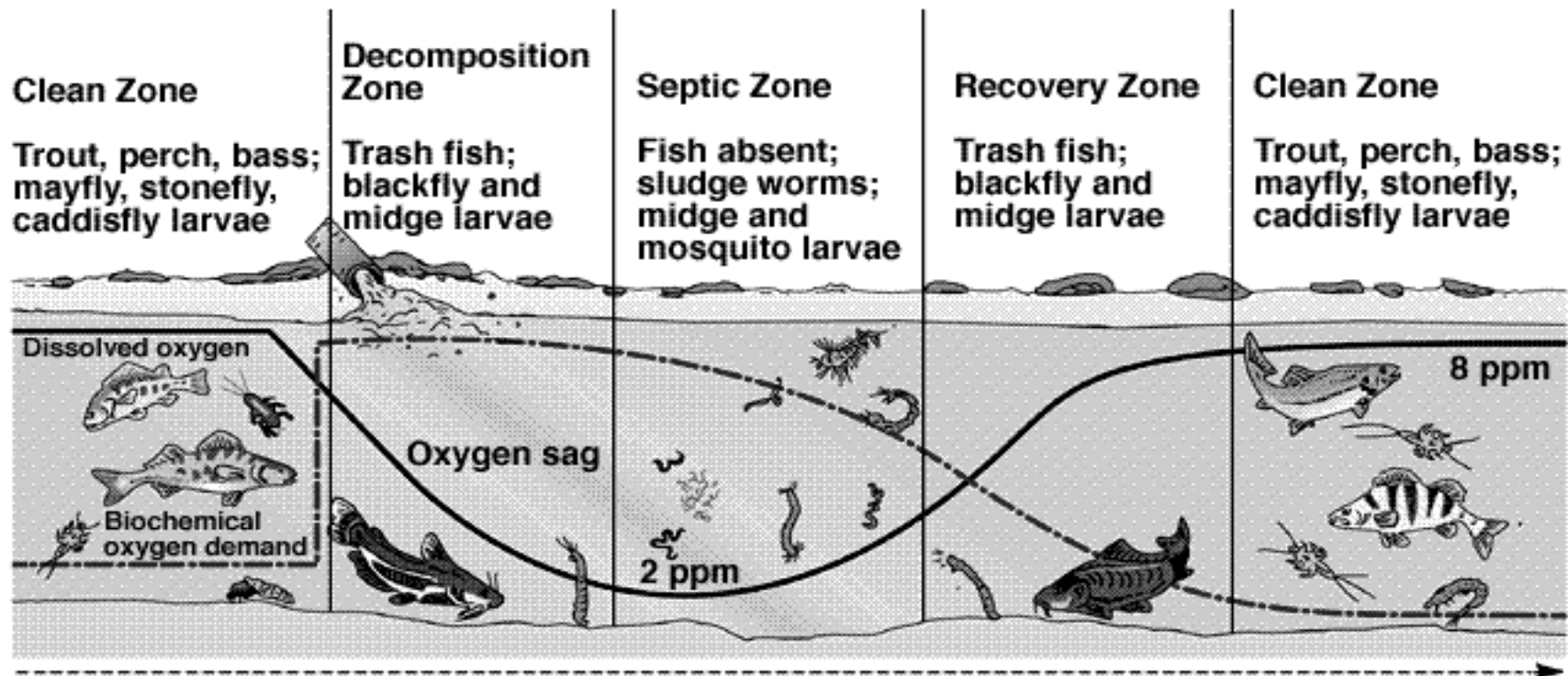


*Table 21-1* SOME HUMAN DISEASES TRANSMITTED BY POLLUTED WATER

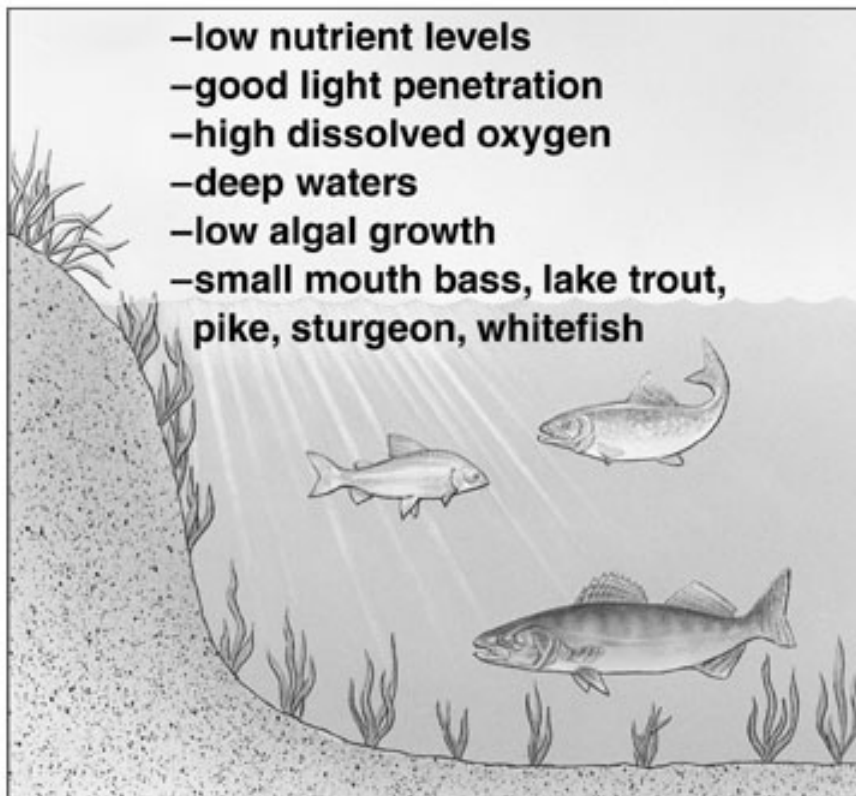
<b>Disease</b>	<b>Infectious Agent</b>	<b>Type of Organism</b>	<b>Symptoms</b>
Cholera	<i>Vibrio cholerae</i>	Bacterium	Severe diarrhea, vomiting; fluid loss of as much as 20 quarts per day causes cramps and collapse
Dysentery	<i>Shigella dysenteriae</i>	Bacterium	Infection of the colon causes painful diarrhea with mucus and blood in the stools; abdominal pain
Enteritis	<i>Clostridium perfringens</i> , other bacteria	Bacterium	Inflammation of the small intestine causes general discomfort, loss of appetite, abdominal cramps, and diarrhea
Typhoid	<i>Salmonella typhi</i>	Bacterium	Early symptoms include headache, loss of energy, fever; later, a pink rash appears along with (sometimes) hemorrhaging in the intestines
Infectious hepatitis	Hepatitis virus A	Virus	Inflammation of liver causes jaundice, fever, headache, nausea, vomiting, severe loss of appetite; aching in the muscle occurs
Poliomyelitis	Poliovirus	Virus	Early symptoms include sore throat, fever, diarrhea, and aching in limbs and back; when infection spreads to spinal cord, paralysis and atrophy of muscles
Cryptosporidiosis	<i>Cryptosporidium</i> sp.	Protozoon	Diarrhea and cramps that last up to 22 days
Amoebic dysentery	<i>Entamoeba histolytica</i>	Protozoon	Infection of the colon causes painful diarrhea with mucus and blood in the stools; abdominal pain
Schistosomiasis	<i>Schistosoma</i> sp.	Fluke	Tropical disorder of the liver and bladder causes blood in urine, diarrhea, weakness, lack of energy, repeated attacks of abdominal pain

**Oxygen-Demanding Wastes:** Oxygen dissolved in water is indicator of water quality. 6 ppm O<sub>2</sub> or more supports desirable aquatic life.

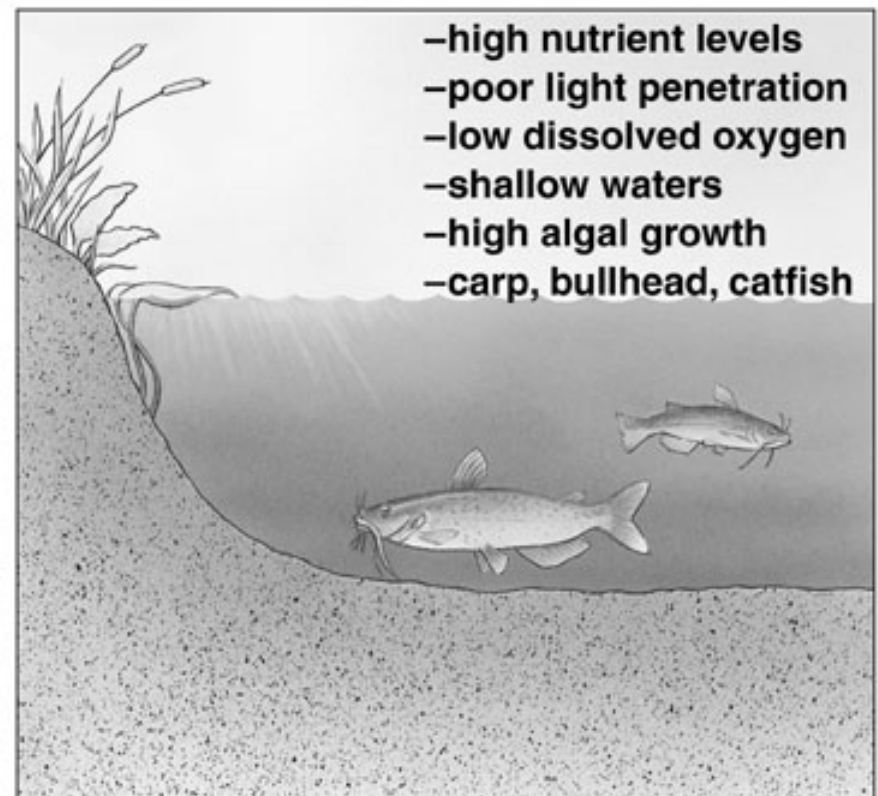
**BOD: Biochemical oxygen demand:** measures the amount of dissolved oxygen consumed by aquatic microorganisms. Sewage, paper pulp, or food wastes can cause an **Oxygen sag**, where few fish survive.



**BOD and Eutrophication:** rapid succession in a body of water because of an increase in biological productivity. (Oligotrophic lakes and rivers have clear water and low biological productivity).



(a) Oligotrophic lake



(b) Eutrophic lake

**Inorganic Pollutants:** Heavy metals, like mercury, lead, tin, cadmium, selenium, and arsenic are caused by human activities.

**Metals:**

**Mercury poisoning** from coal, incineration

- Causes:
- damage to the nervous system
  - metal retardation
  - cerebral palsy
  - development delays
  - kidney disorders

**Lead poisoning** from incineration, pipes, solder  
(previously in shot, gasoline)

- Causes:
- miscarriages
  - hearing loss
  - learning disabilities



# **Inorganic Pollutants**

## **Nonmetallic Salts:**

**Arsenic** from mining or drainage of desert soils

- Causes:
- anemia
  - cancer
  - death.

**Sodium Chloride:** Salinization

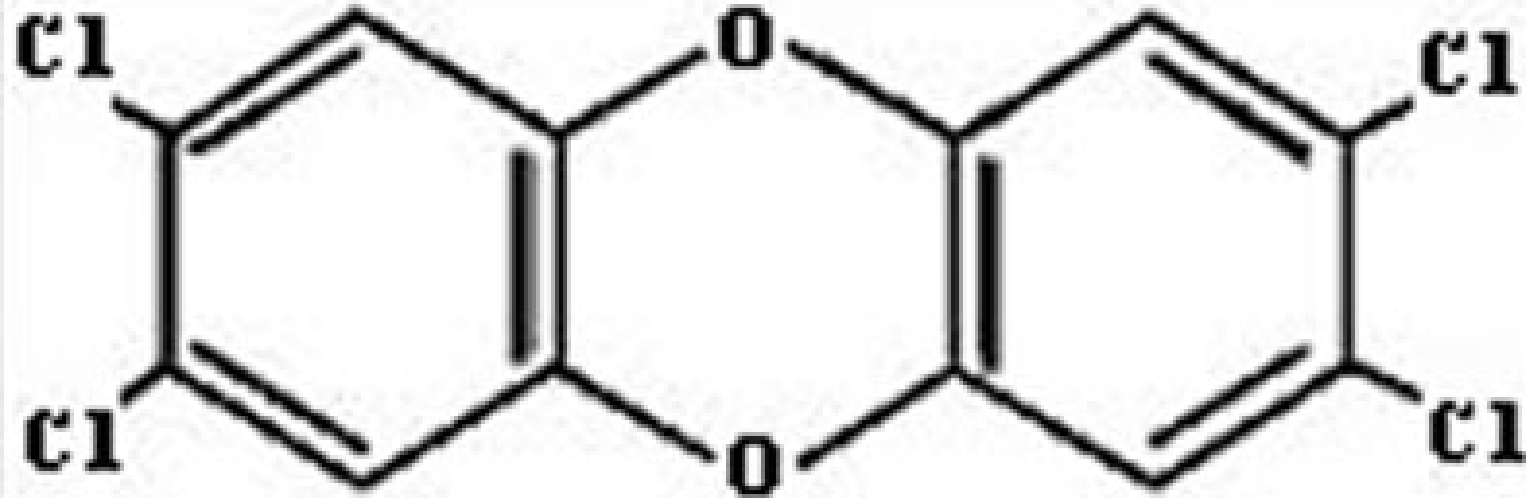
## **Acids:**

**Sulfur and nitrogen compounds** from coal.

- Causes:
- pH changes which affect species
  - leaches aluminum

## **Organic Pollutants: Dioxin, PCB, DDT (Chlorinated)**

**Dioxin:** stable; slow to degrade



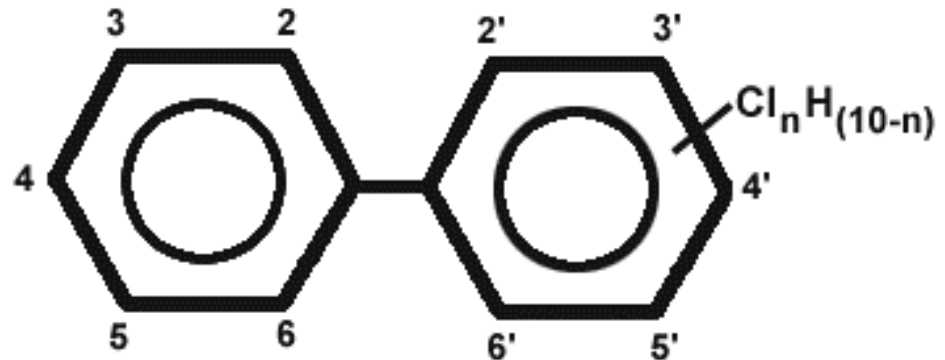
**Generated from:** Burning wood, coal, oil, household trash, and chlorine bleaching of pulp and paper

**Accumulates in fat of animals → biomagnification**

**Causes:**        **cancer**  
                     **weakened immune response**

## Organic Pollutants:

**PCBs:** non-flammable; not dissolved in water; high boiling points; does not conduct electricity well. So used for **transformers and capacitors.**



Polychlorinated Biphenyl (PCB)

More than one **billion pounds** of PCBs have been made.

**Accumulates in fat of animals → biomagnification**

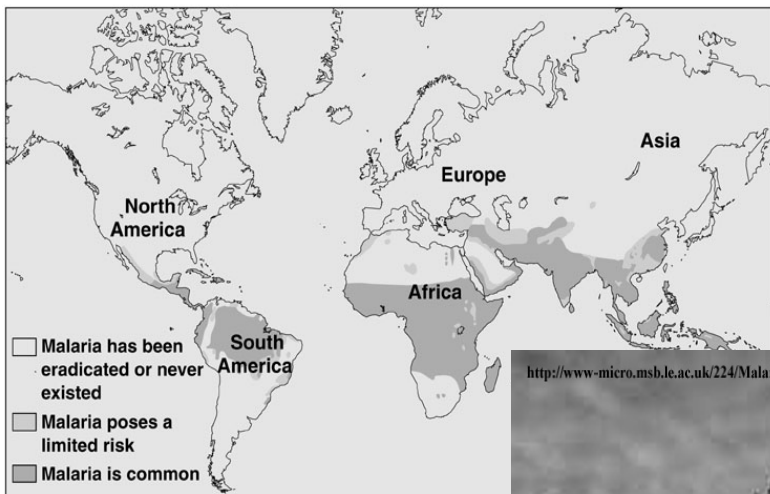
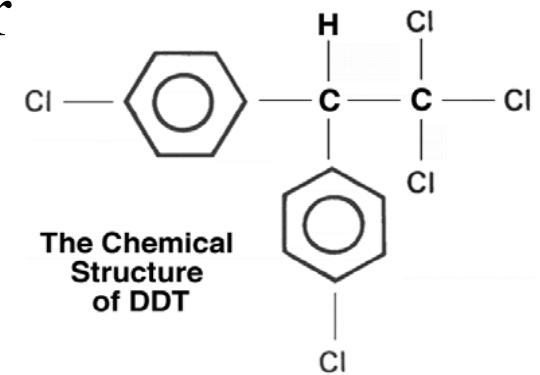
Causes: **cancer**  
**hormonal and reproductive disruptions**  
**decrease cognitive abilities (dopamine)**

# Organic Pollutants:

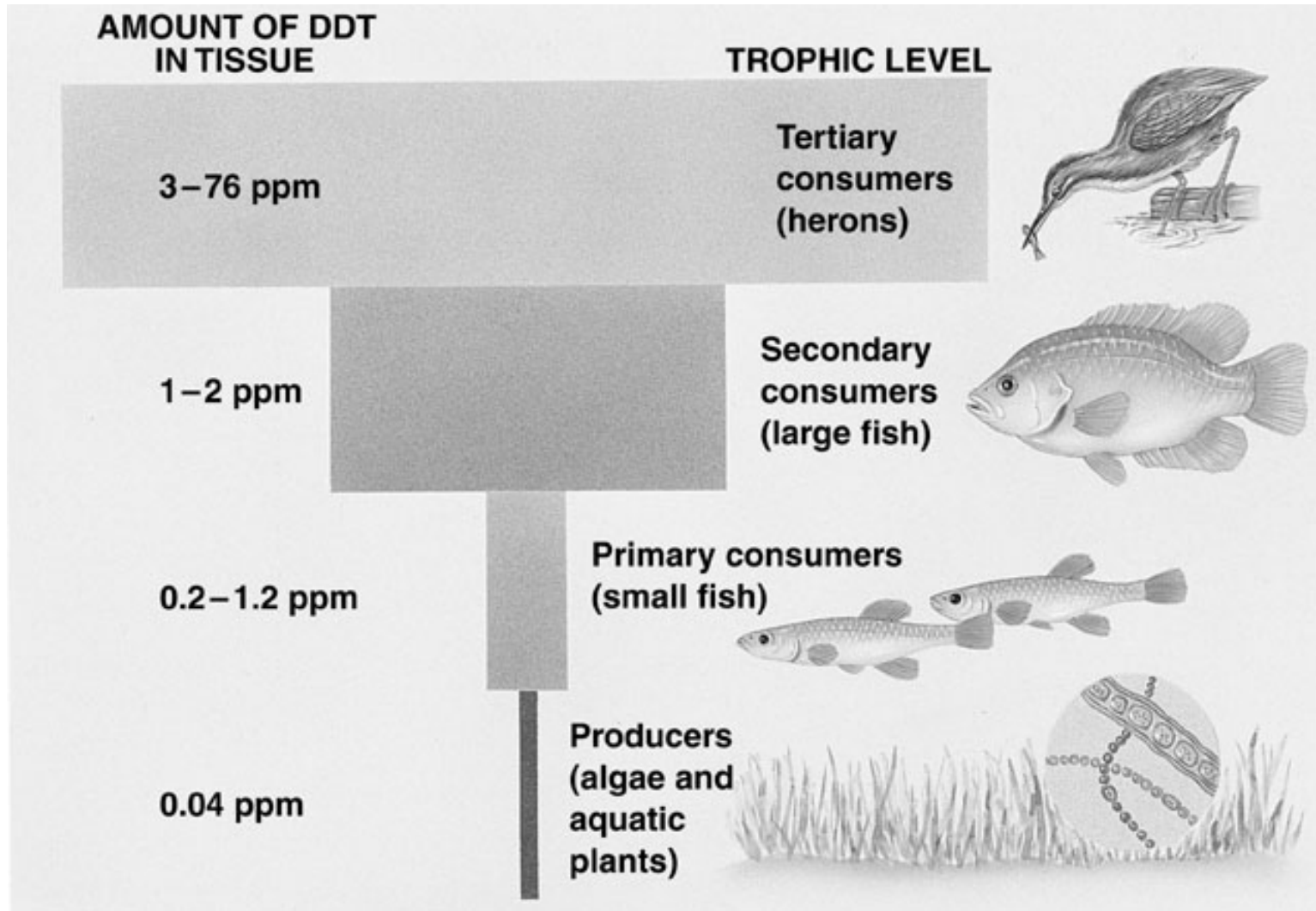
**DDT:** insecticide; stable and slow to degrade.

**Paul Muller** won the Nobel Prize in 1948 for developing it.

**Benefits: Controlled spread of malaria;  
Provided crop protection**

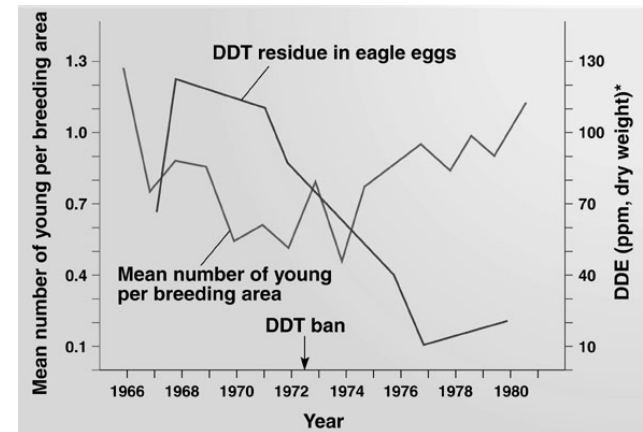


# Problems with DDT: DDT is not metabolized very rapidly by animals; instead, it is deposited and stored in the fatty tissues → biomagnification



# Problems with DDT: stable and slow to degrade

- Toxic to Fish
- Increased mortality in birds: calcium decreased in egg shells
- Estrogen mimic in Vertebrates: feminizes males - lower sperm count; alters behavior
- Human Health
  - decreased mental function
  - male infertility
  - cancer



*Table 22-3* SOME PESTICIDES THAT ARE KNOWN ENDOCRINE DISRUPTERS\*

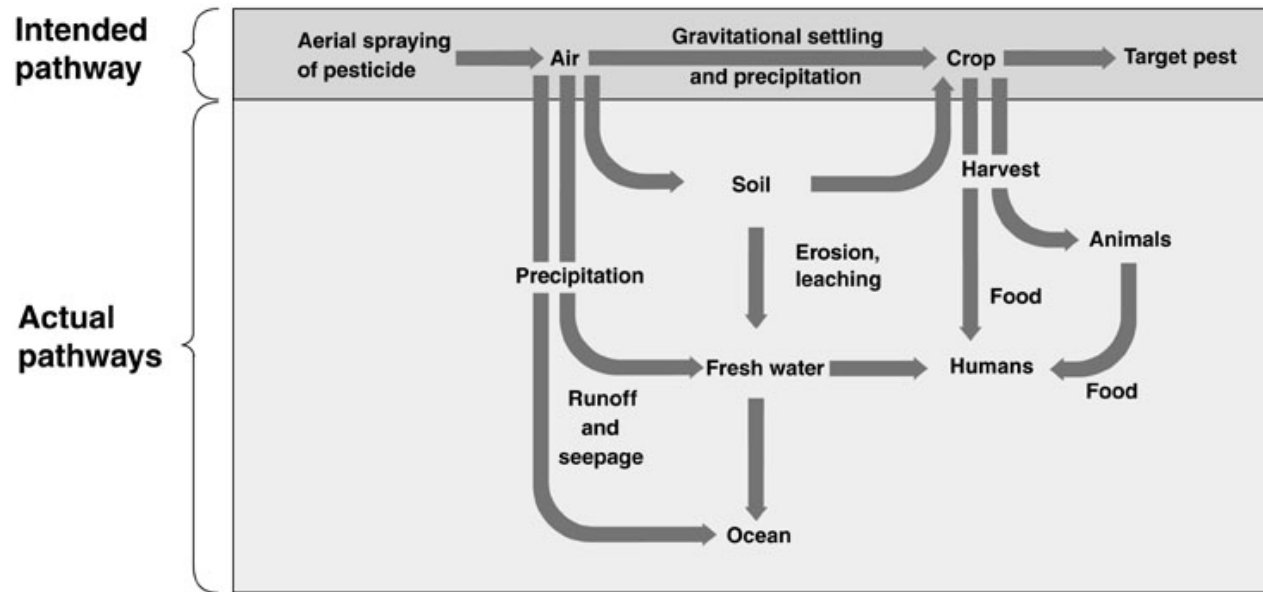
Pesticide	General Information
Atrazine	Herbicide; still used
Chlordane	Insecticide; banned in United States in 1988
DDT	Insecticide; banned in United States in 1972
Endosulfan	Insecticide; still used
Kepone	Insecticide; banned in United States in 1977
Methoxychlor	Insecticide; still used



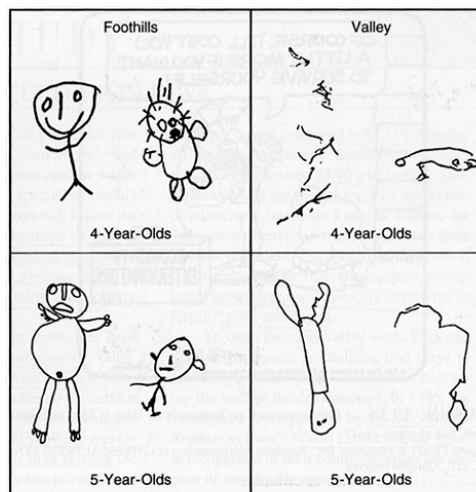
Cunningham & Saigo, Environmental Science, 2001 by McGraw Hill

# Problems with DDT and other pesticides:

## Unintentional Pathways:



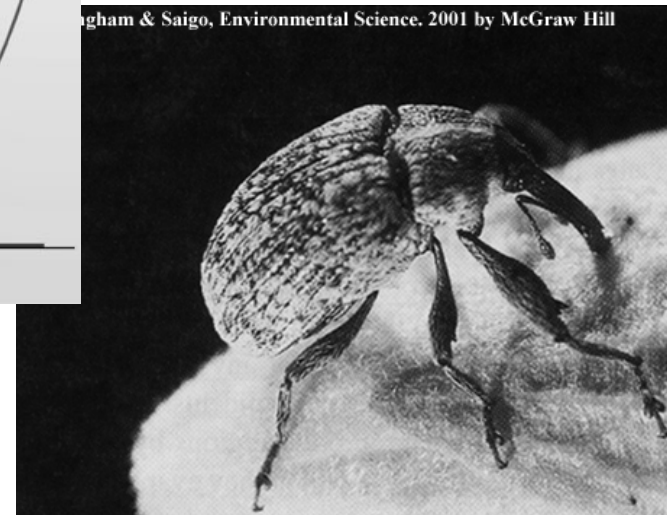
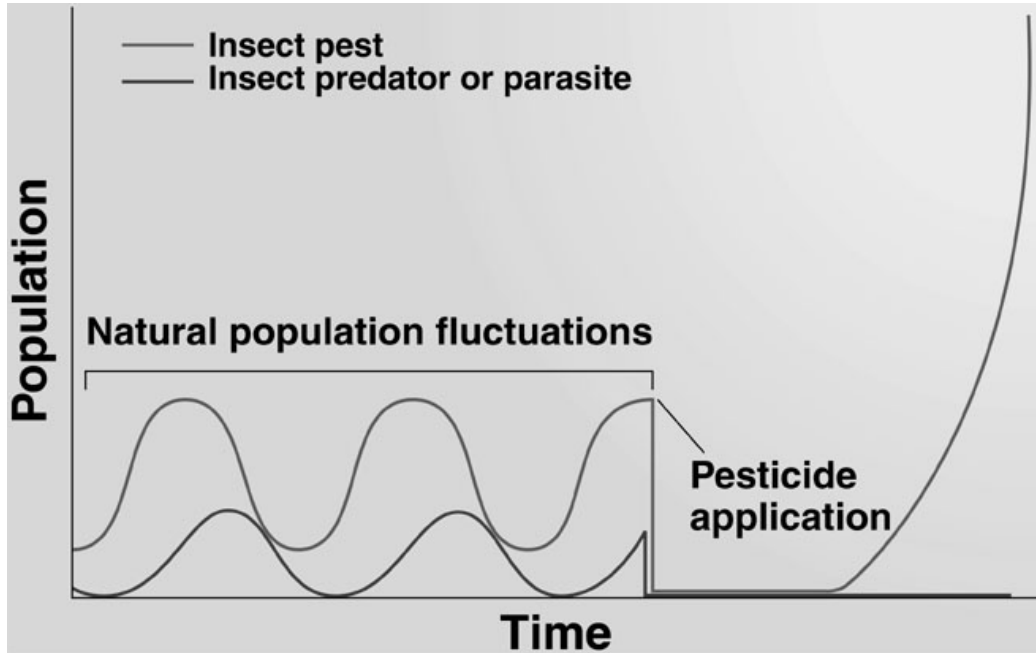
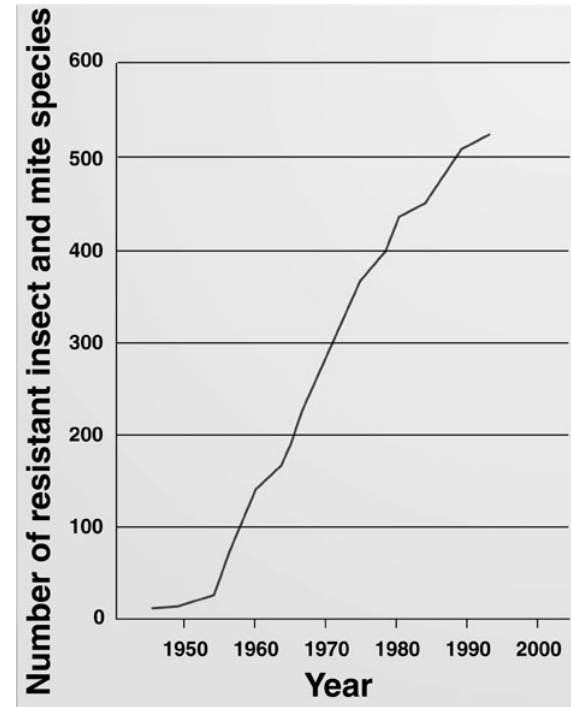
## Effects on people:



# Problems: DDT (and other pesticides)

## Evolution of Resistance

## Non-target Species and creation of new pests





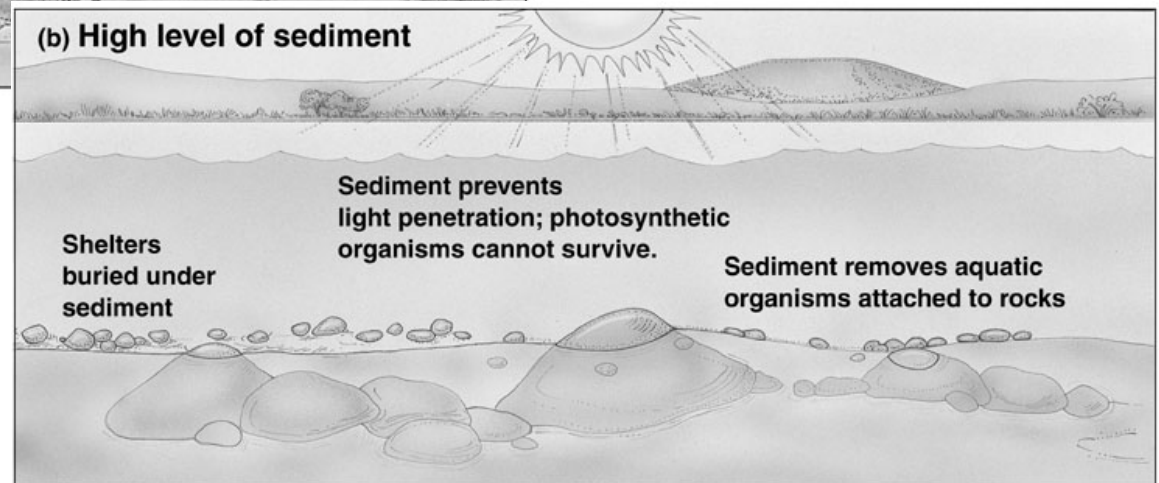
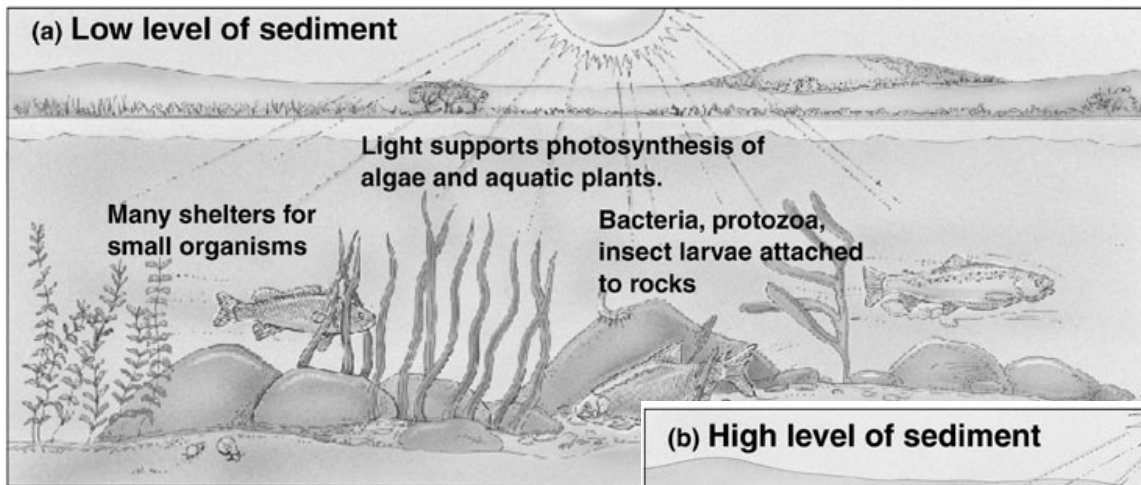
# **Sediment: Erosion and runoff.**

**fills lakes**

**obstructs shipping channels**

**clogs hydroelectric turbines**

**purification more costly**



# Thermal Pollution: an increase in temperature

Can cause: **thermal shock**  
**parasites and disease**  
**greater vulnerability to toxic pollutants**

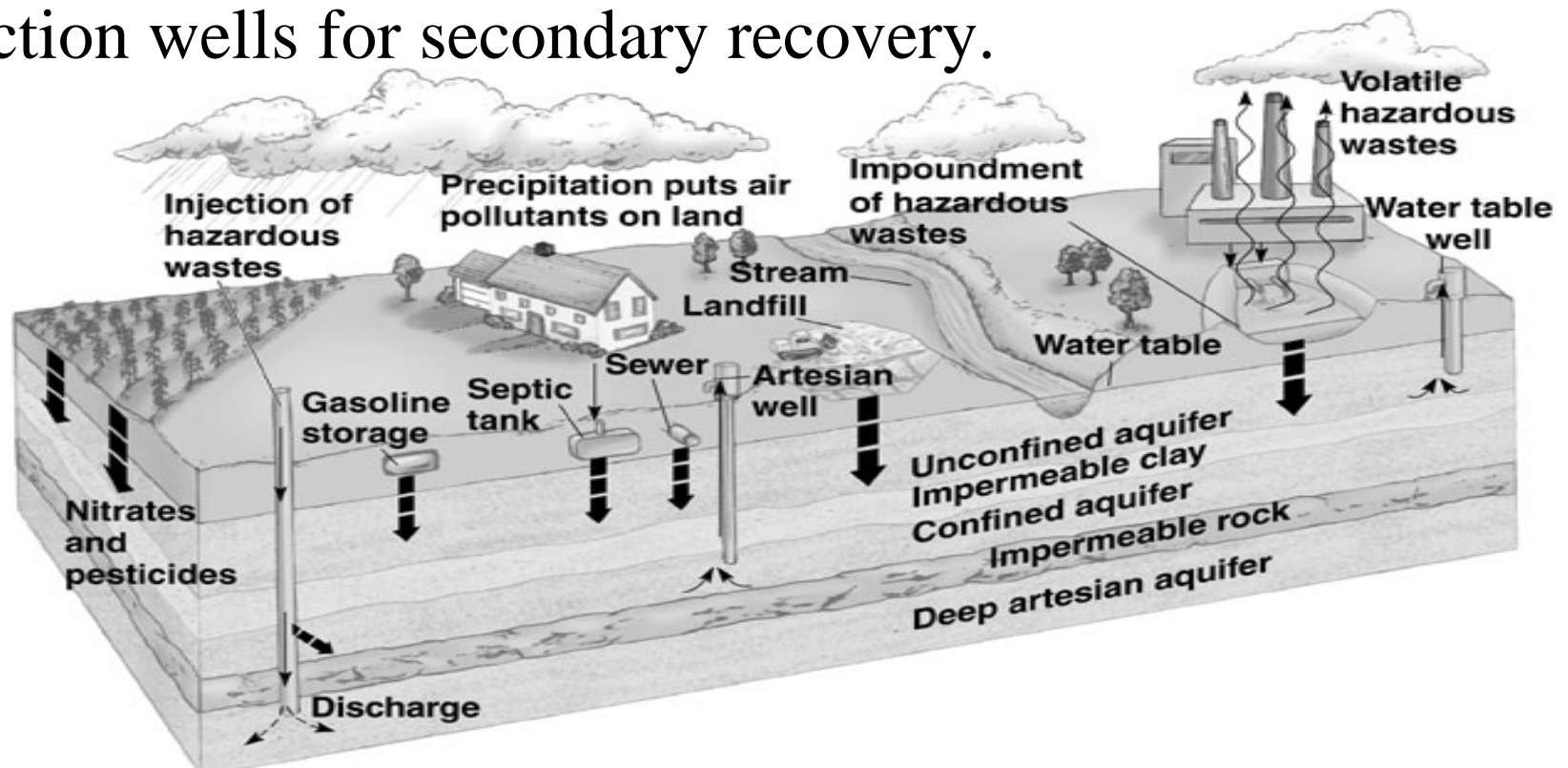
## Major categories of water pollutants

<u>Category</u>	<u>Examples</u>	<u>Sources</u>
<b>A. Causes health problems</b>		
1. Infectious agents	Bacteria, viruses, parasites	Human and animal excreta
2. Organic chemicals	Pesticides, plastics, oil, gas, detergents	Industrial, household, and farm use
3. Inorganic chemicals	Acids, caustics, salts, metals	Industrial effluents, household cleansers, surface runoff.
4. Radioactive materials	Uranium, thorium, cesium, iodine, radon	Mining/processing ores, power plants, weapons, natural sources
<b>B. Causes ecosystem disruption</b>		
1. Sediment	Soil, silt	Land erosion
2. O <sub>2</sub> -demanding wastes	Animal manure and plant residues	Sewage, agricultural runoff, paper mills, food processing
3. Thermal	Heat	Power plants, industrial cooling

# Specific Sources of Ground Water Pollution:

(rate of breakdown is extremely slow in ground water)

- Industrial waste into aquifer recharge zone
- Surface runoff into abandoned wells—Industry, agriculture, home
- Leaking underground storage tanks of gas stations
- Leaking septic tank into recharge area.
- Injection wells for secondary recovery.

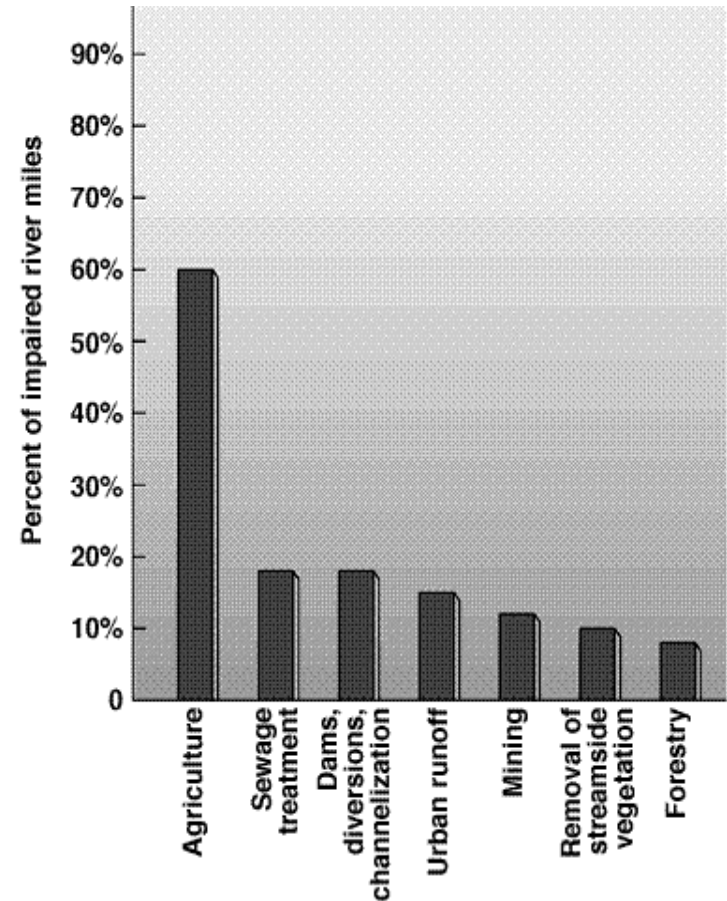


# Water Pollution Control: Reduce the sources of water pollution

**Point Source:** discharge of pollutants from single point. Factories, power plants, sewage treatment plants, oil wells.

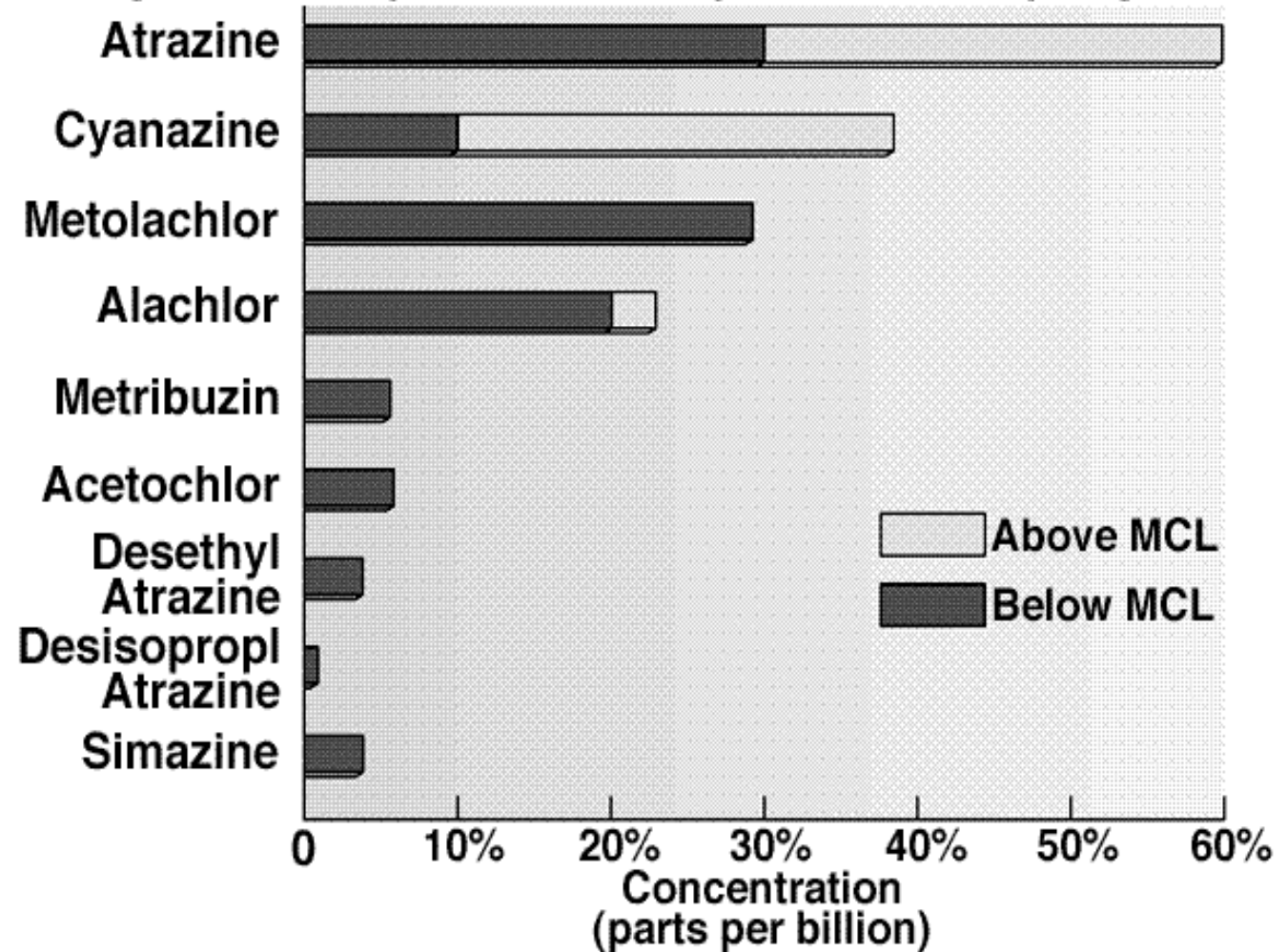
**Non-point Source:** sources of water pollution that are scattered or diffuse, not having a specific location.

Farm fields, golf courses, lawns, cities, roads, clearcut forests, mines



# Water Pollution Control: Agriculture is the biggest source of water pollution

Nine herbicide active ingredients and metabolites found in drinking water samples in Fort Wayne, Indiana, spring 1995.



Maximum Concentration Levels

## **Legislation enacted to improve our water:**

**Clean Water Act:** to restore and maintain the chemical, physical, and biological integrity of the nation's waters. (1972/77/81/87)

greatly decreased the amount of point source pollution.

PCB's, DDT, and Dioxin are no longer allowed as waste products into waters.

**Superfund Program:** remediation of toxic waste sites created in 1980/1984.

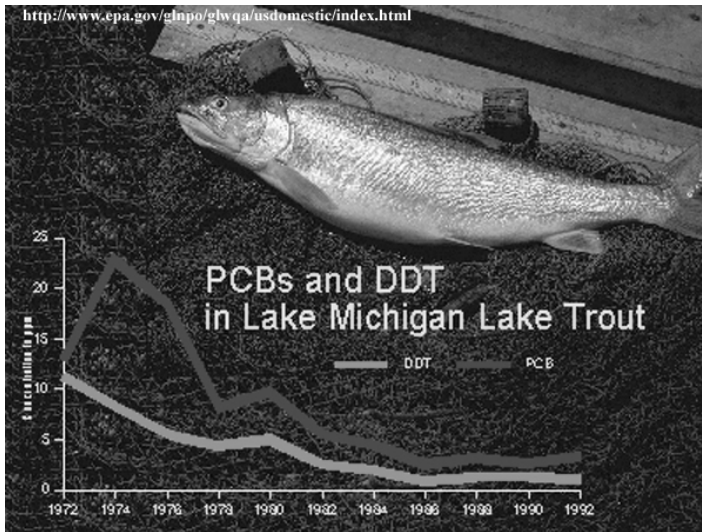
**Safe Drinking Water Act:** regulates water quality in commercial and municipal systems. (1974)

# U.S. EPA Index of Watershed Indicators (IWI) Percent of Impaired Waters in the U.S.

[http://www.epa.gov/iwi/1999aug/iv22\\_usmap.html](http://www.epa.gov/iwi/1999aug/iv22_usmap.html)



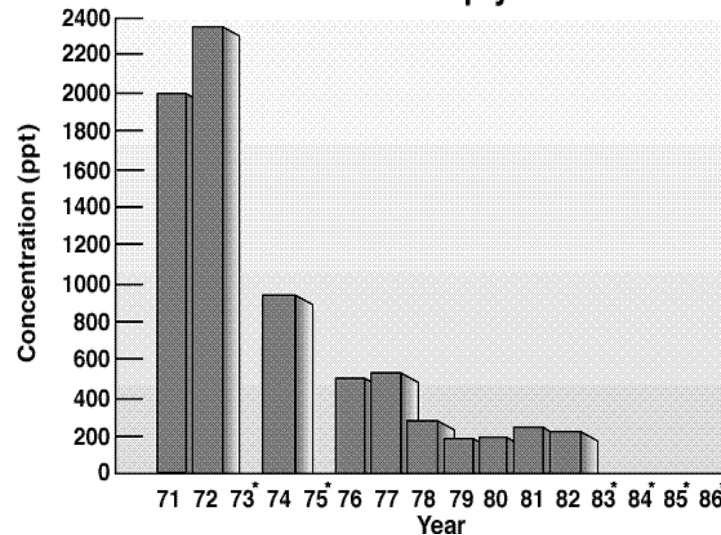
# Improved water quality has been one of the biggest success stories of the environmental movement.



## Oil Spills

Year	Number of tankers afloat	Accidental oil spills	Oil lost (metric tons)
1973	3750	36	84,485
1974	3928	48	67,115
1975	4140	45	188,042
1976	4237	29	204,235
1977	4229	49	213,080
1978	4137	35	260,488
1979	3945	65	723,533
1980	3898	32	135,635
1981	3937	33	45,285
1982	3950	9	1,716
1983	3582	17	387,773
1984	3424	15	24,184
1985	3285	9	15,000
1986	3139	8	5,035
1987	3132	12	8,700
1988	3100	14	10,700
1989	3170	10	9,200
1990	3090	7	4,700
1991	3010	6	6,200

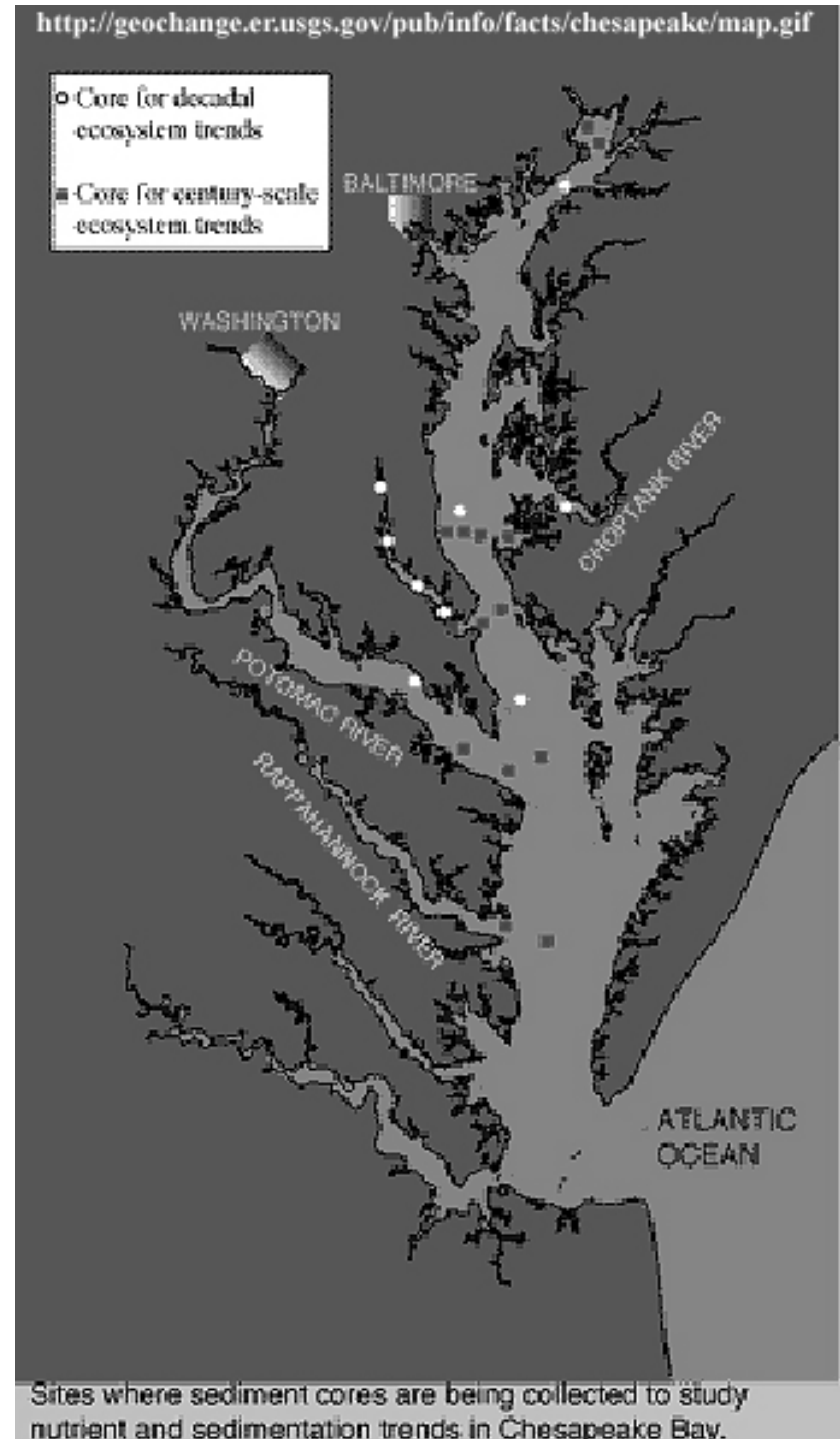
Dioxin concentrations in herring gull eggs on Scotch Bonnet Island in Lake Ontario have fallen sharply since 1971.





## Improved water quality: Chesapeake Bay—America's largest estuary.

- reducing nutrient loading
- banning phosphate detergents
- restoring seagrass and wetlands.
  
- upgrading wastewater treatment plants



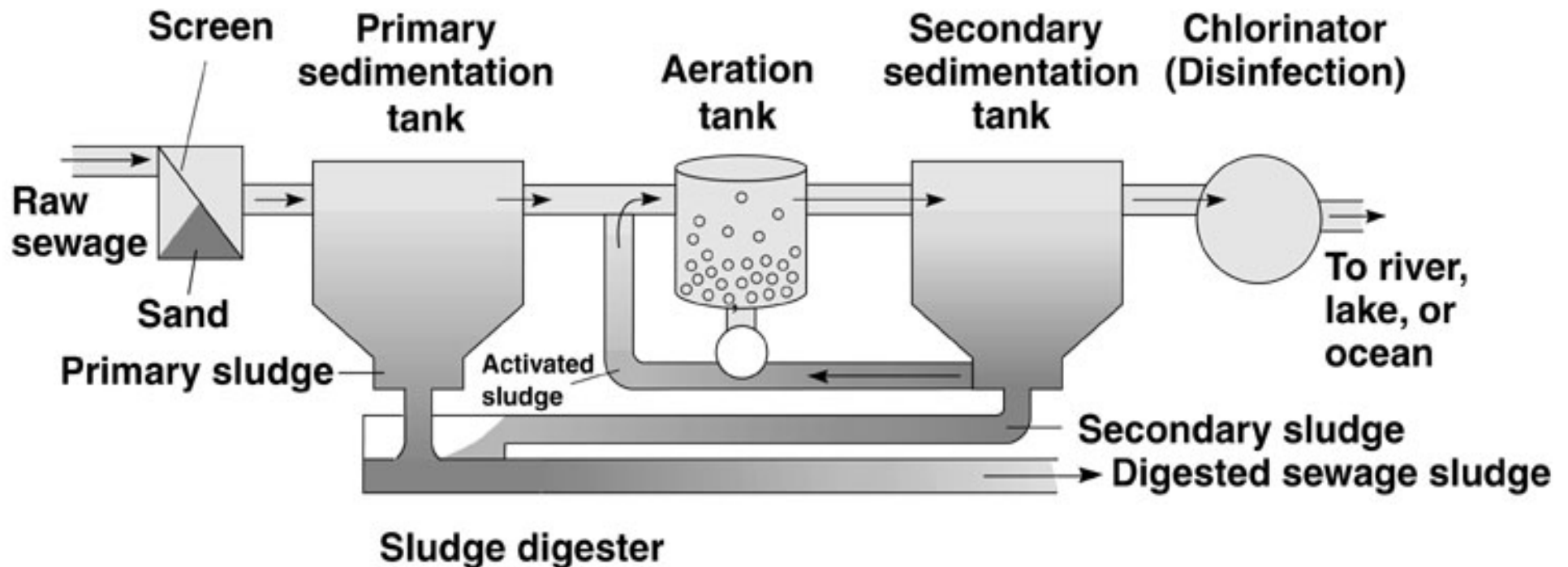
# Municipal Sewage treatment

**Primary treatment:** physical separation of solids

**Secondary treatment:** Aeration tank: biodegradation

**Tertiary treatment:** remove phosphates/nitrates  
lagoon/marsh or trickling filter.

**Bioremediation:** use of organisms to remove  
water pollutants

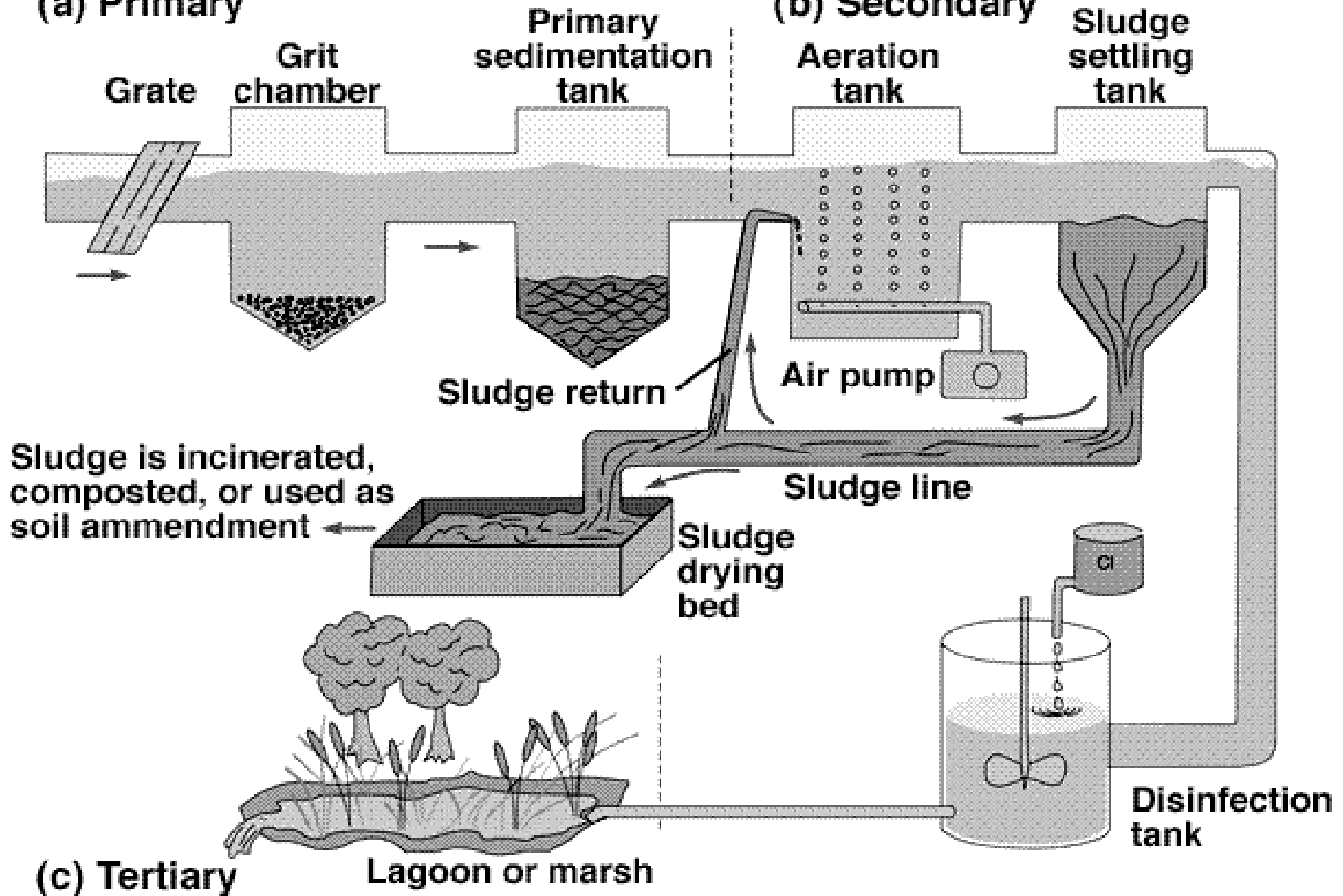


# Three types of sewage treatment.

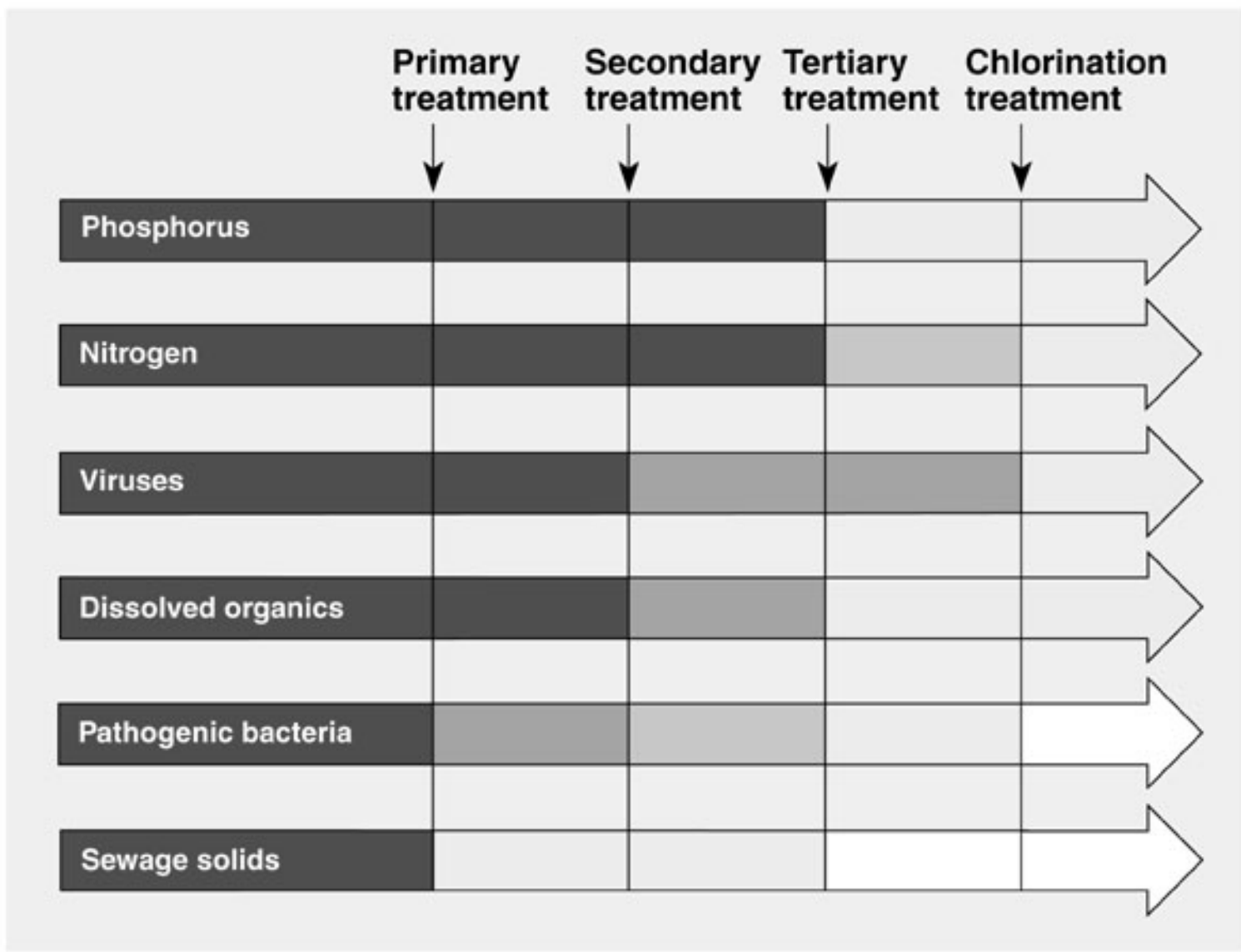
(a) Primary

(b) Secondary

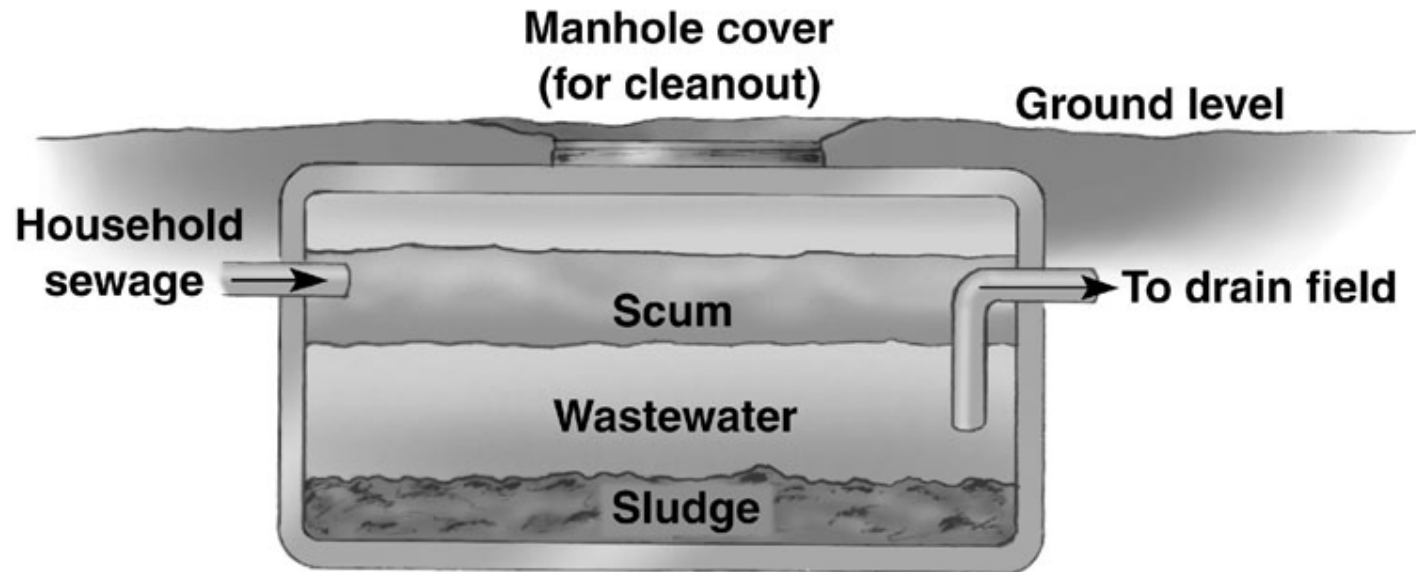
Sludge settling tank



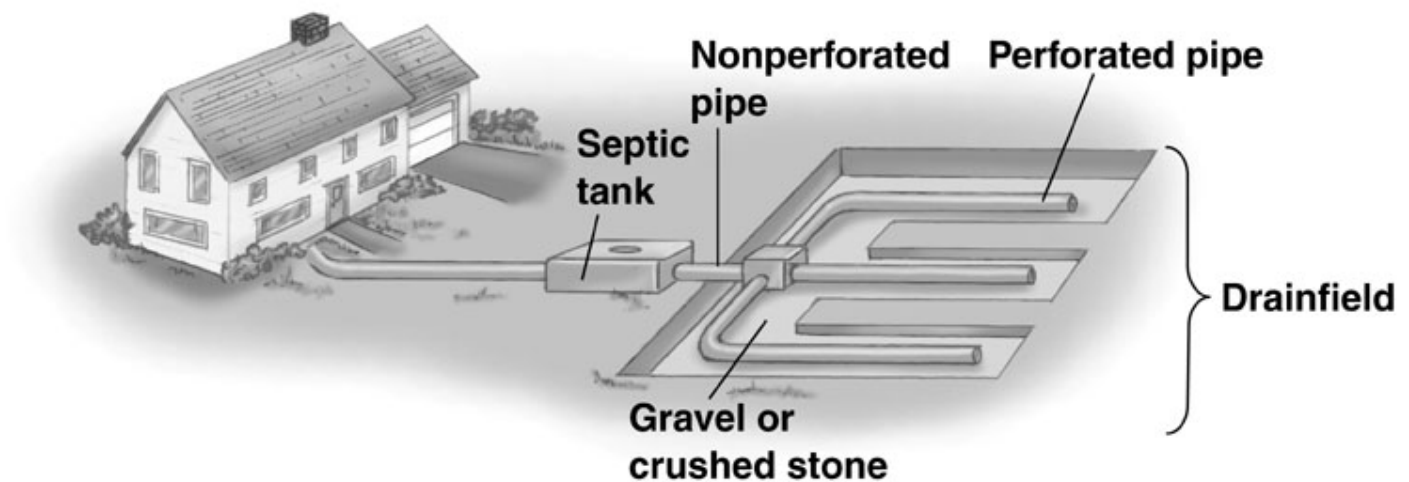
Raven/Berg, Environment, 3/e  
Figure 21.13



# Domestic sewage treatment: Septic tanks and drain fields.



(a)



(b)