

Environmental Science

A Study of interrelationships

Unit 7

Water Management

Useful Words and Expressions

- **Fresh Water** –淡水
- **Potable water** –自来水；饮用水（tap water； drinking water）
- **groundwater** –地下水
- **coolant** –冷却剂
- **metabolic activity** –新陈代谢活动
- **The Hydrologic Cycle** –水文循环过程
- **Precipitation** –降水
- **Transpiration** –蒸腾（作用）
- **Evaporation** –蒸发（作用）
- **Runoff** –径流
- **Infiltration** –渗透
- **Point source** –点源
- **Nonpoint source** –面源

- **impervious** – 不受影响的；不透水的
- **porous** – 多孔的
- **paved surface** – 铺设、硬化的路面
- **municipal wastewater** – 市政污水
- **water withdrawal** – 取（用）水量
- **non-consumptive use** – 非消耗性用水
- **consumptive use** – 消耗性用水
- **domestic use** – 生活用水
- **in-stream use** – 流域内（就地）用水
- **Water Works** – 给水处理厂 (**Drinking water treatment plant**)
- **purification** – (水的) 净化
- **distribution** – (水的) 输送、分配
- **coagulation** – 凝聚
- **flocculation** – 絮凝

- **sedimentation** – 沉淀
- **filtration** – 过滤
- **holding tank**– 中间（水）池
- **thickening unit**–（污泥）浓缩单元
- **sludge conditioning**– 污泥调理
- **tub bath**– 盆浴
- **shower**–淋浴
- **spray**– 喷灌
- **trickle**– 滴灌
- **destruction**–破坏
- **impounded water** – 被坝所围起来的水
- **arid region** – 干旱地区

The Water Issue

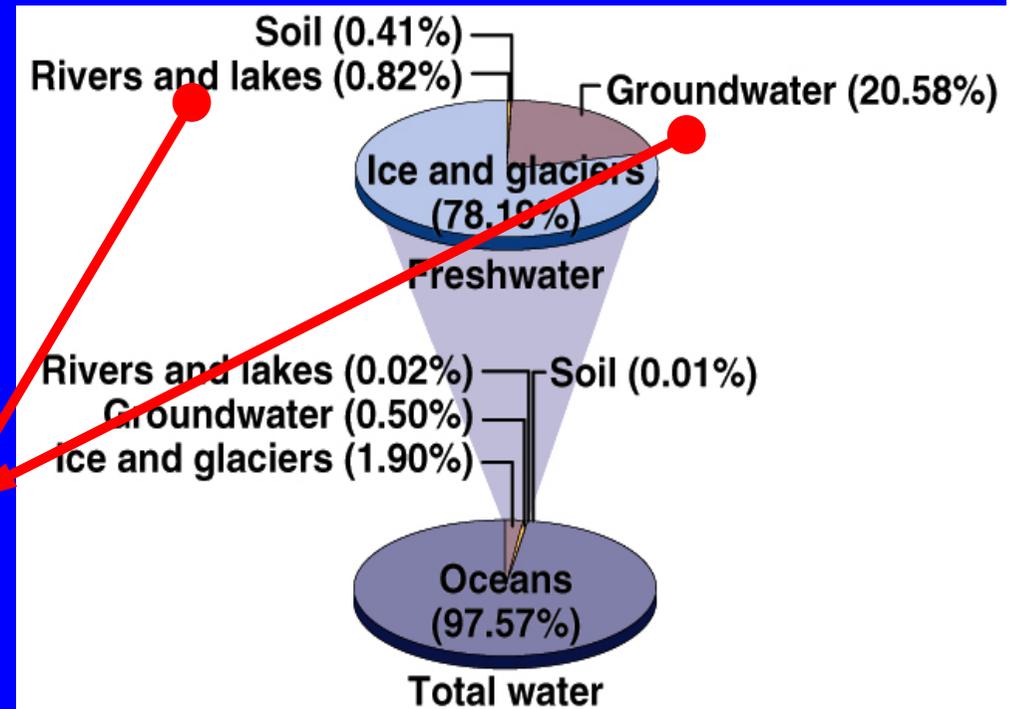
- Water in its liquid form is the material that makes life possible on Earth. All living organisms are composed of cells that contain at least 60 percent water. Furthermore, their metabolic activities take place in a water solution.
- **Physical Properties:**
 - **Polar:** One molecule is slightly positive, and the other is slightly negative.
 - ❖ Molecules tend to stick together.
 - ❖ Separate other molecules from each other (solvent).
 - ❖ Stores Heat-retains Heat
 - Industrial coolant
 - Modifies local climates

The Water Issue

- 70% of the Earth's surface is covered by oceans, which contain over 97% of the water on the Earth (saltwater).
 - Fresh Water is approximately 3%

Of the freshwater found on Earth, only a tiny fraction is available for use.

- **Potable water:** Unpolluted, fresh water, suitable for drinking.

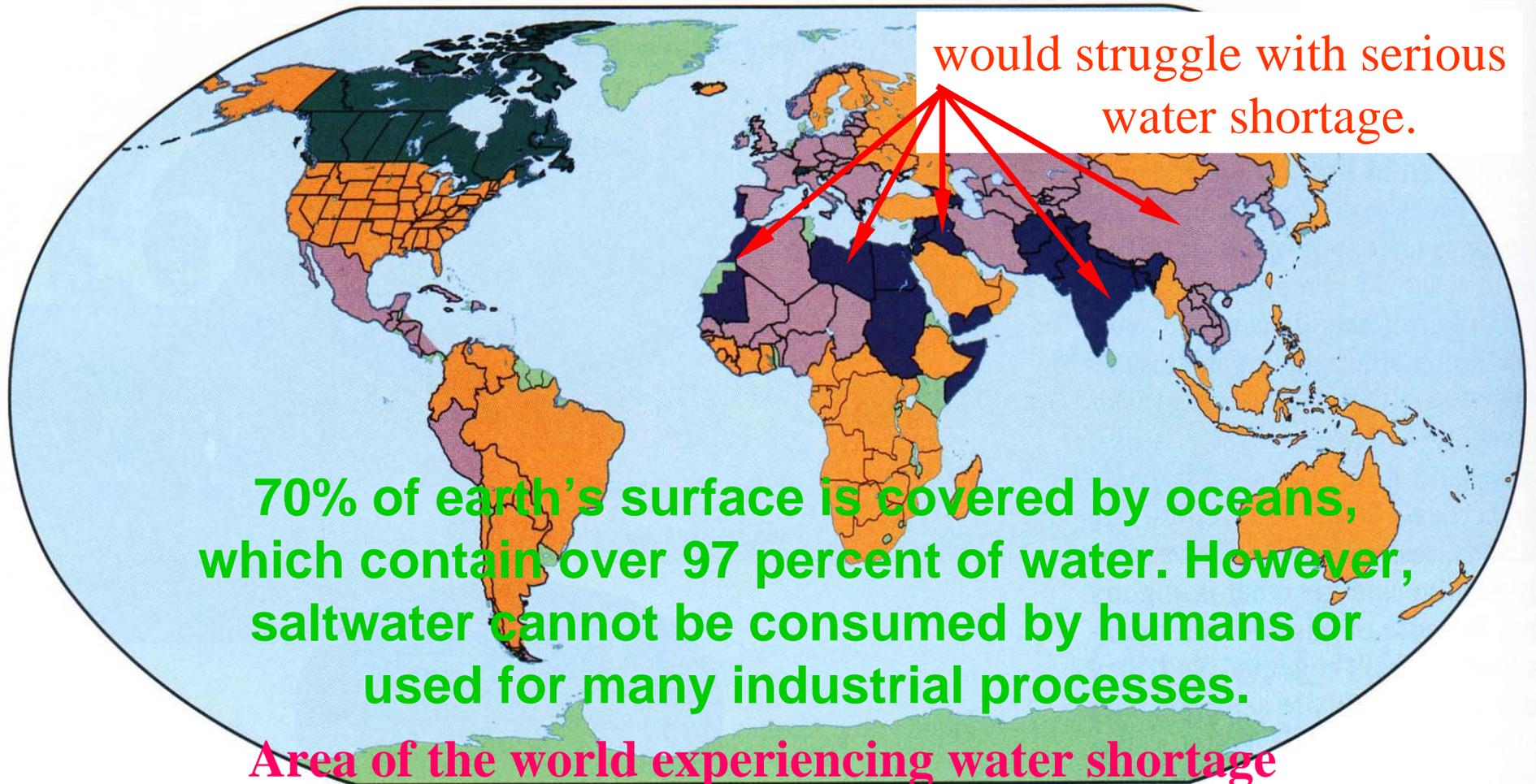


The Water Issue

- For most human as well as some commercial and industrial use, the quality of the water is as important as its quantity.
- The shortage of potable freshwater:
 - increases in human populations (demand is increasing for freshwater for industrial, agricultural, and personal needs) and limitations on the supply available;
 - can also be directly attributed to human abuse in the form of pollution. (Water dissolves and carries substances from nutrients to industrial and domestic wastes) . Water pollution has negatively affected water supplies throughout the world.

The Water Issue

- WHO estimates that about 25 percent of the world's people do not have access to safe drinking water.

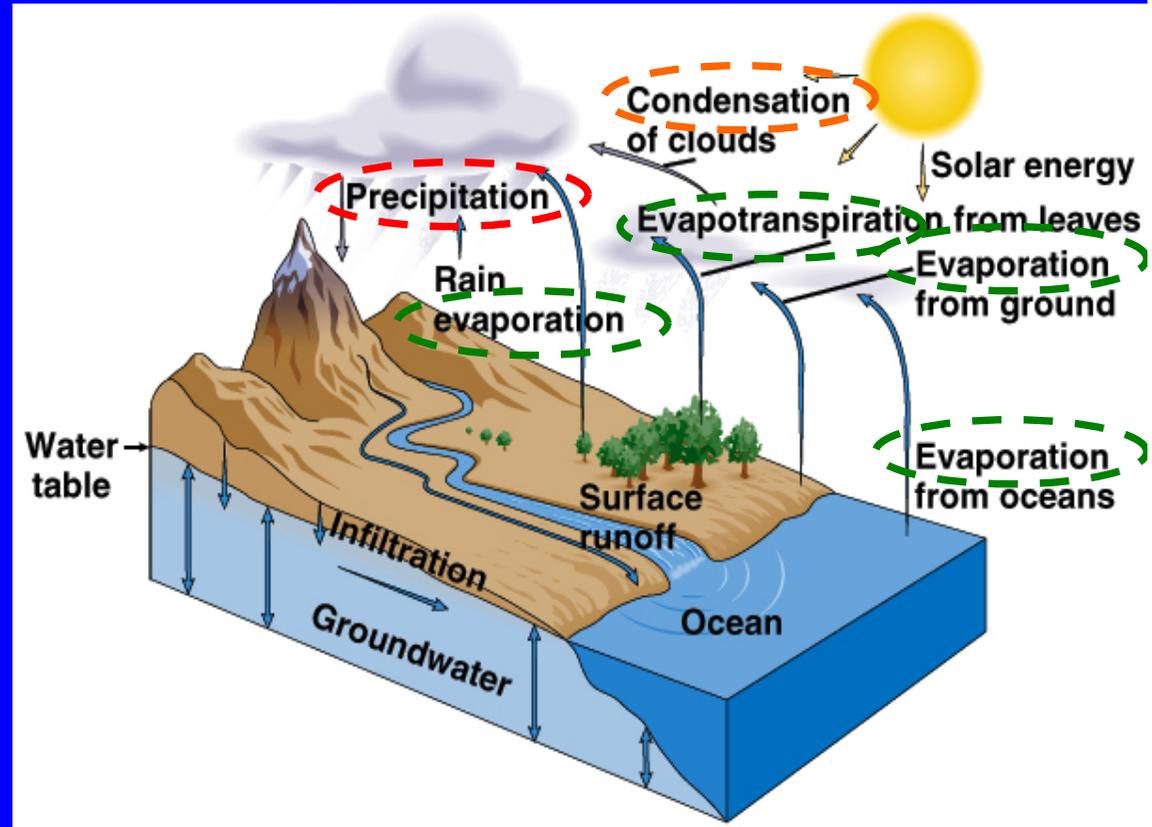


The Water Issue

- It was stated that water could become as a major source of world conflict.
- A study by the United Nations in 2002 said that by 2025, one in three people globally could be threatened by shortage of freshwater.
- **Quantity of water:** The availability of freshwater is highly depend on the amount of water that can be obtained from river, lake and the amount of groundwater.
- **Quality of water:** Water pollution control.

Hydrologic Cycle

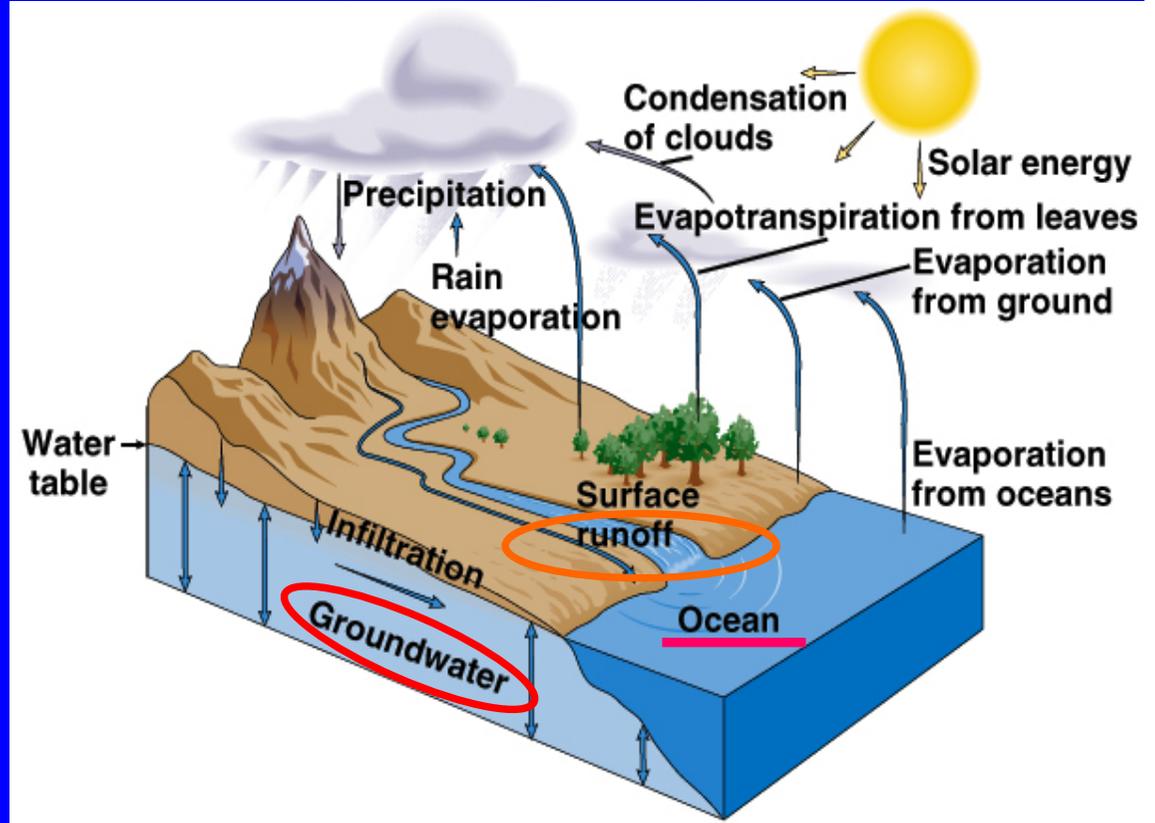
- All water is locked into a constant recycling process - **Hydrologic Cycle**.
- Solar energy **evaporates** water.
- **Transpiration** - Plants giving off water.
- Warm, moist air rises, cools, condenses, and falls as **precipitation**.
- Some precipitation remains on the surface and evaporates, while most sinks into the soil or returns to the oceans.



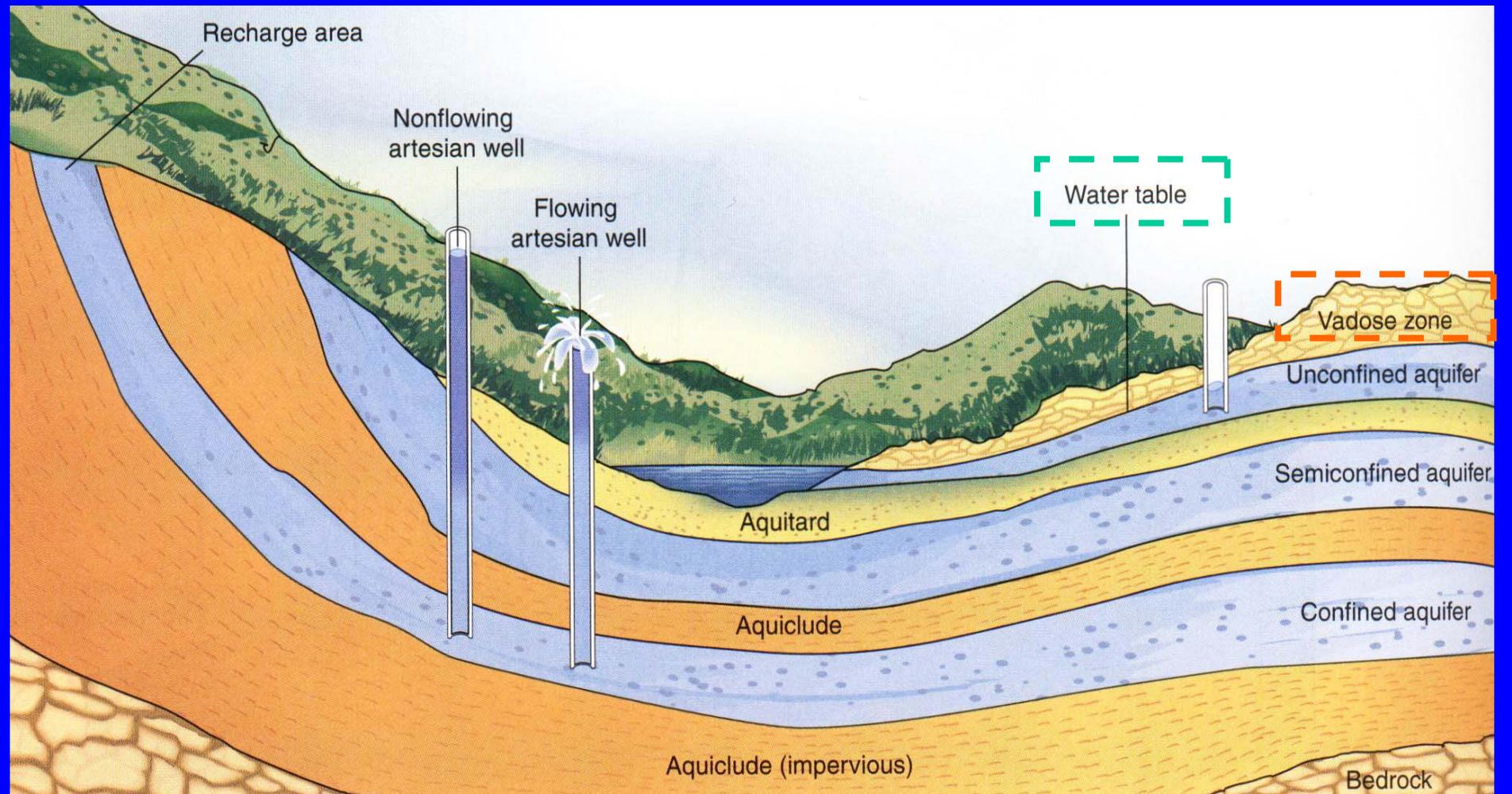
- **Runoff**- Surface water that moves across the surface of land and enters streams and rivers.

- **Groundwater** – The water that fills the space in the substrate is called groundwater.

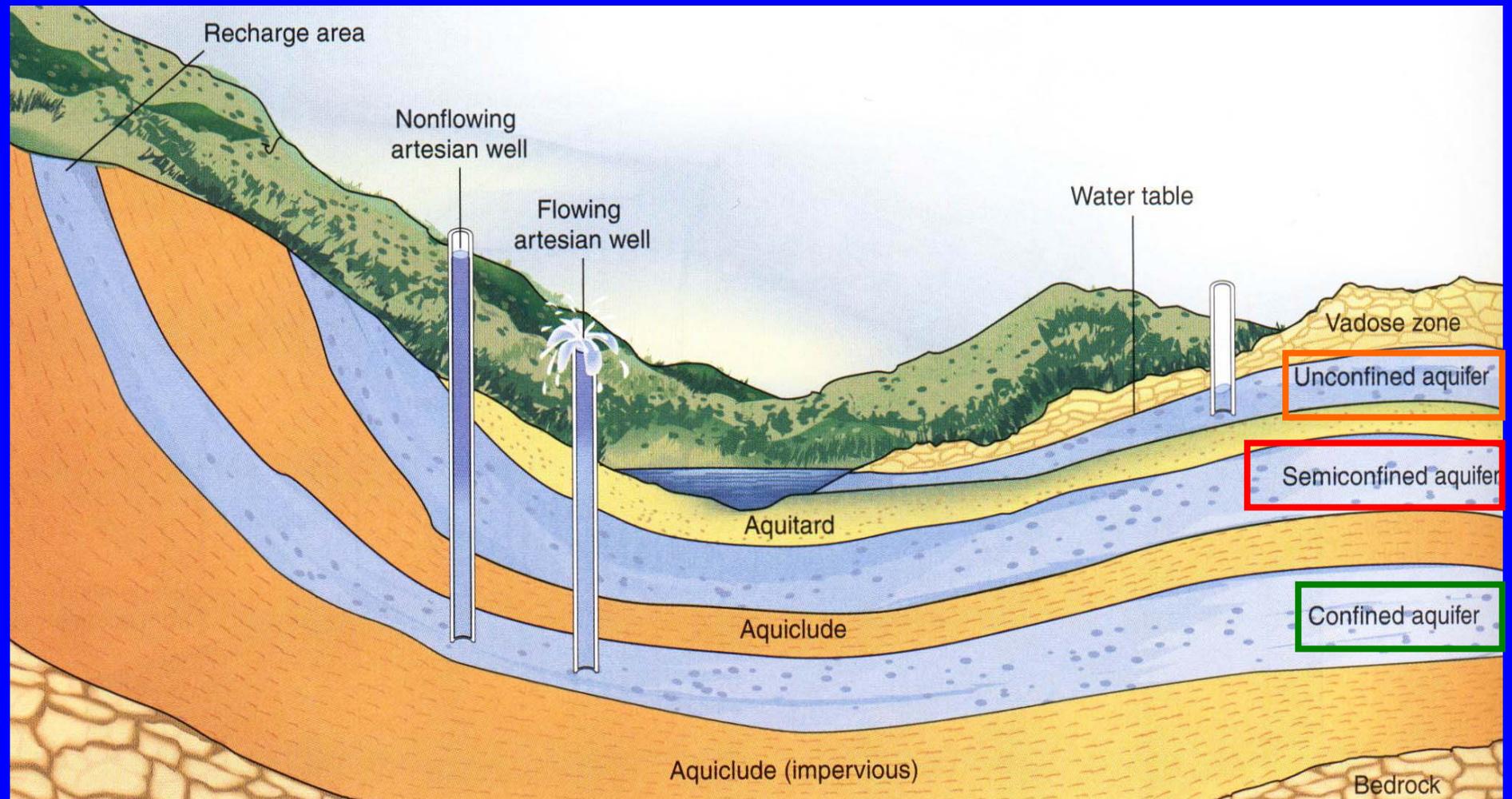
many cities depend on the ground water for their water supply.



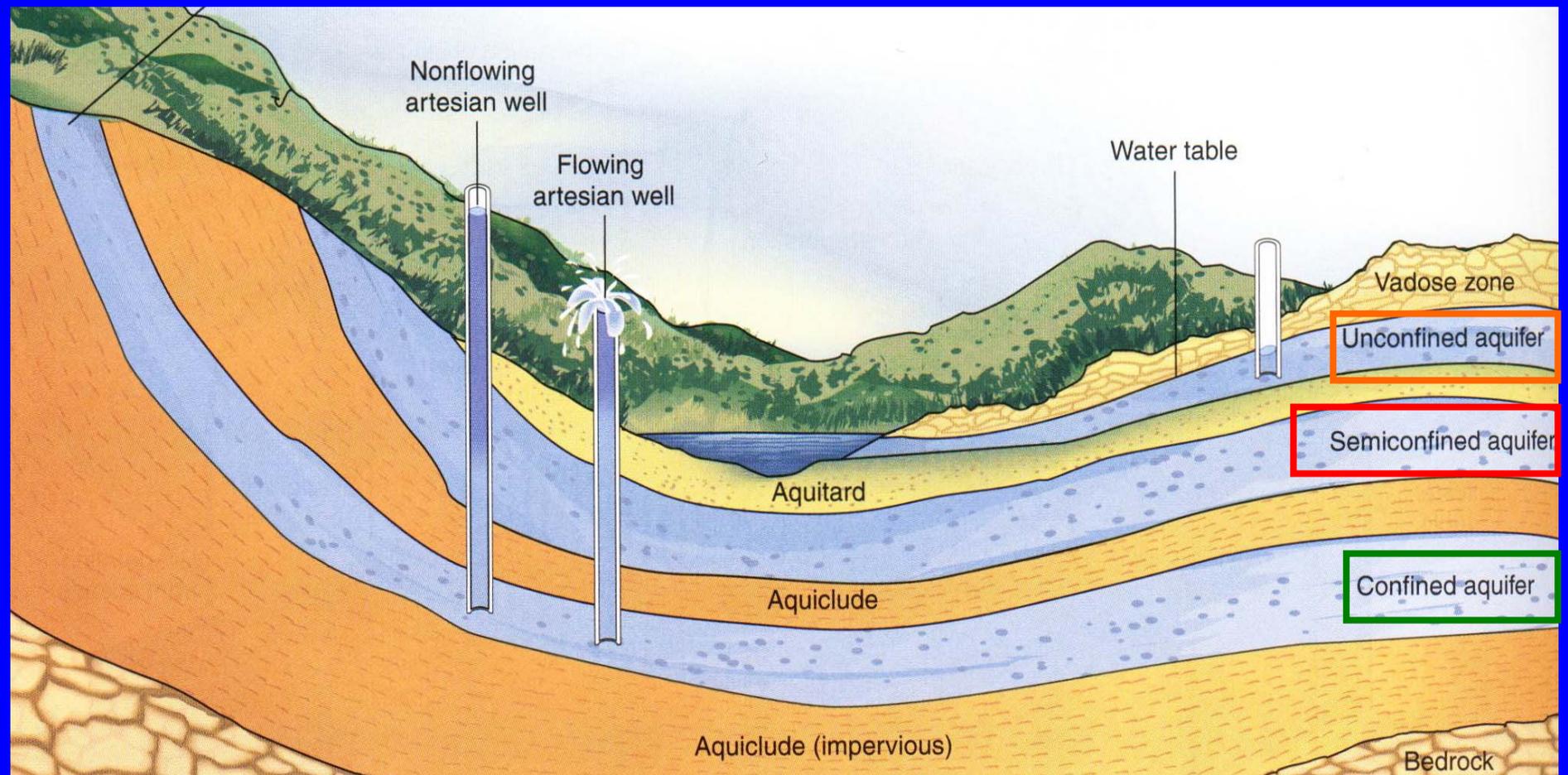
- **Water table** – the top of the layer saturated with water.
- **Vadose zone** – above the water table and below the land surface



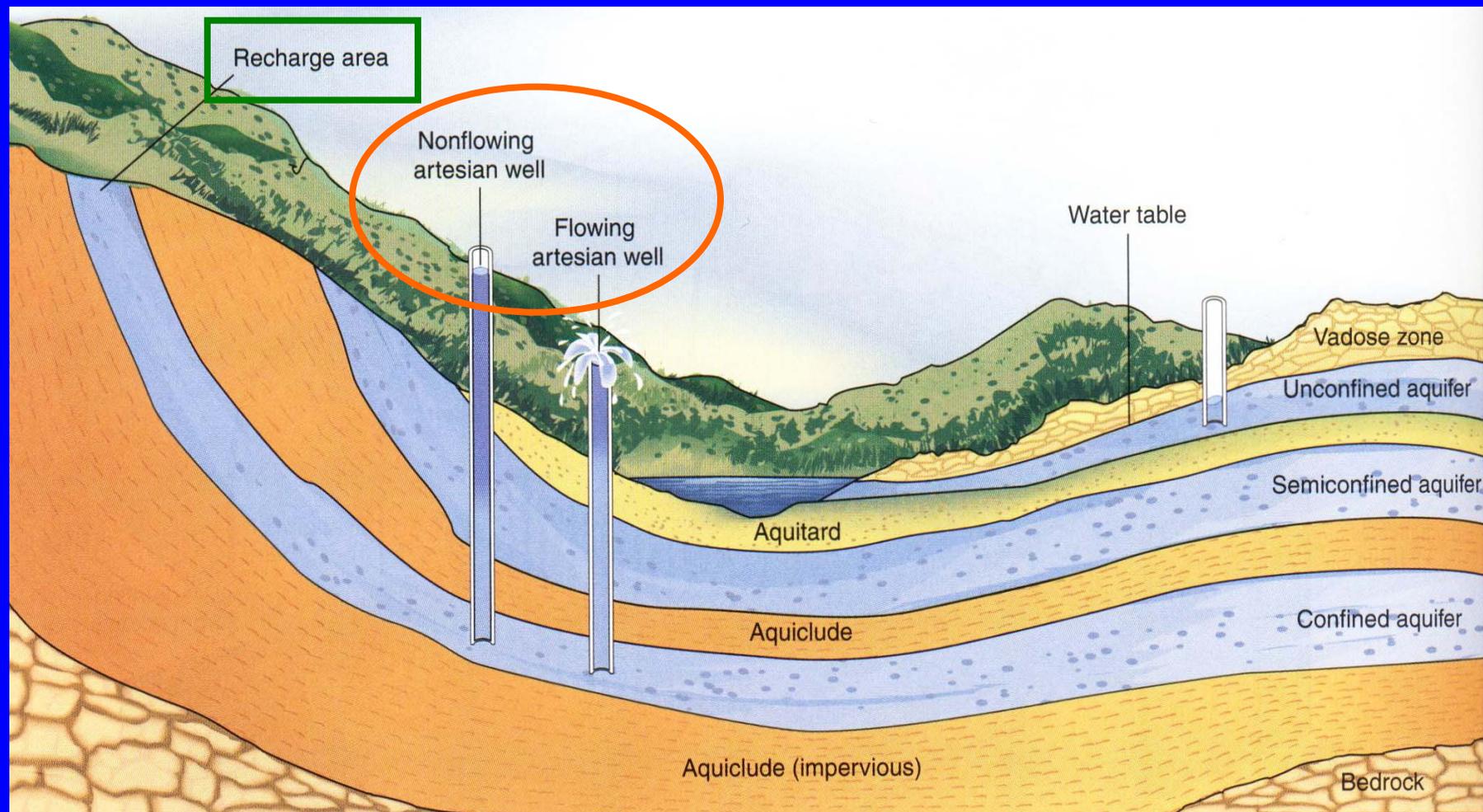
- **Aquifer** - Water entering the soil is either taken up by plants roots or moves downward until it reaches an impervious layer of rock, and accumulates in porous stratum called an aquifer, i.e., porous soil contains water.



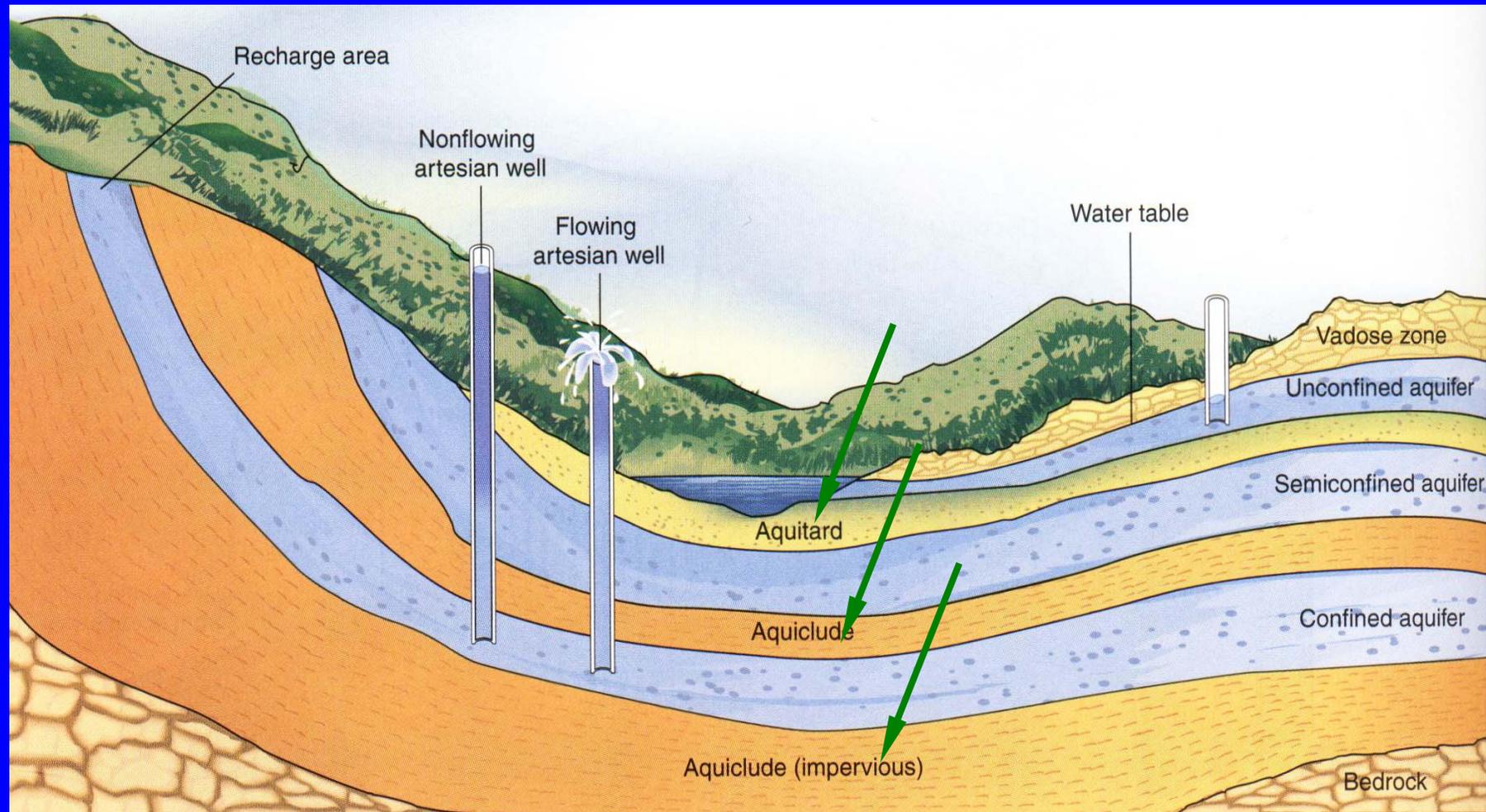
- **Unconfined Aquifer** – usually occurs near the land's surface where water enters the aquifer from the land above it.
- **Confined Aquifer** – is bounded on both the top and bottom by layers that are impervious to water and is saturated with water under greater-than-atmospheric pressure.



- **Recharge area** – the area where water is added to the aquifer.
- **Artesian well** – If the recharge area is at a higher elevation than the place where the aquifer is tapped, water will flow up the pipe until it reaches the same elevation as the recharge area. Such wells are called artesian well.



- **Aquiclude** – an impervious confining layer.
- **Aquitard** – the confining layer that water can pass in and out.



Human Influences On The Hydrologic Cycle

- Evaporation, runoff and infiltration rate are greatly influenced by human activity.
 - **Rapid evaporation** – water is used for cooling in the power plants or to irrigate crops, the rate of evaporation is increased. This can affect local atmospheric condition.
 - **Factors effects on runoff and infiltration rate** – removing the vegetation by logging or agriculture increase runoff and decrease infiltration rate; urban complexes with a high percentage of impervious, paved surfaces have increased runoff and reduced infiltration .

- Major concern in many urban areas is transportation of storm water.
 - **Reduce the flooding risk:** Designing and constructing surface waterways and storm sewer to carry storm water away rapidly to reduce the flooding risk.
 - **Cause water pollution:** Many cities combine their storm-sewer water with municipal wastewater at their treatment plant, which can cause serious pollution problems after heavy rains.

- Determining how much ground water or surface water can be used and what use should be is a major concern, especially in water-poor areas of the world:
 - **Water Withdrawal** – are measurements of the amount of water taken from surface and/or groundwater source.
 - ◇ used temporarily and returned to its original source and use again (**non-consumptive use**).
 - ◇ withdrawing water and incorporating it into a product, or otherwise moving it to another area, so it does not make it back to original source (**consumptive use**).

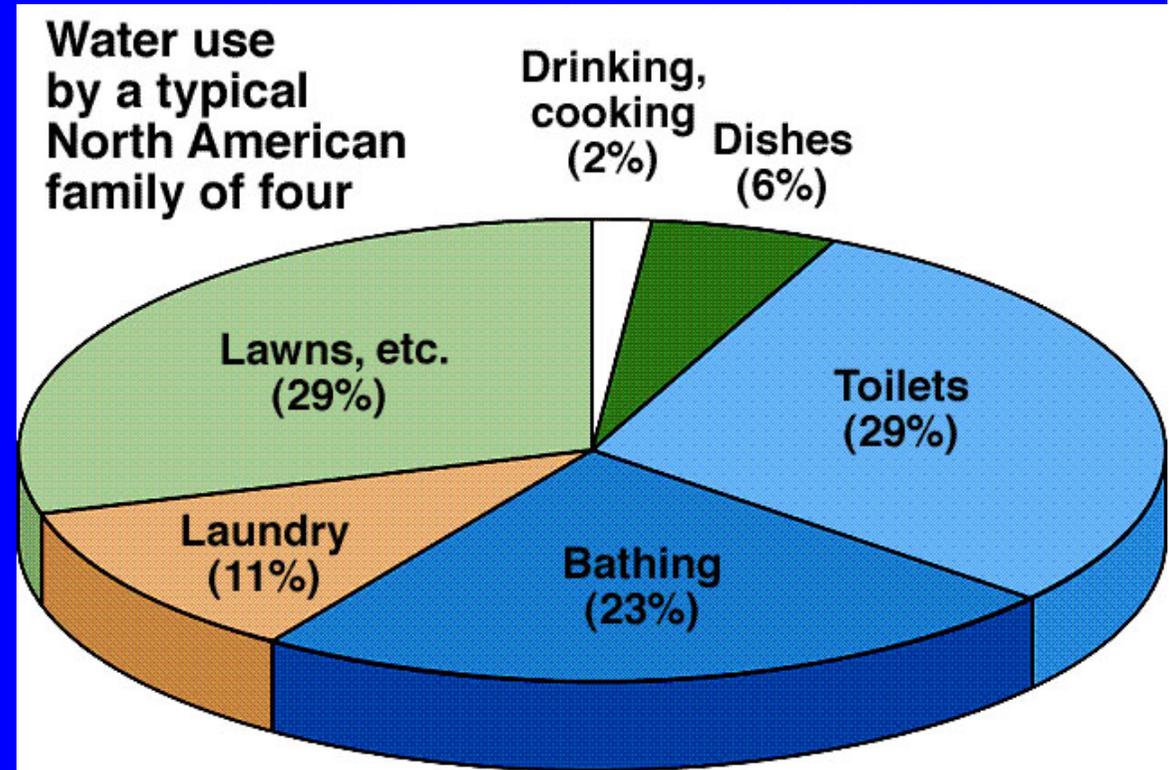
Kinds of Water Use

- Water use varies considerably around the world, depending on availability of water, and the degree of industrialization. However, use can be classified into four categories:
 - ◇ domestic use;
 - ◇ agricultural use;
 - ◇ industrial use;
 - ◇ in-stream use.

Domestic activities in highly developed nations require a great deal of water. This domestic use includes drinking, air conditioning, bathing, washing clothes, washing dishes, flushing toilets, and watering lawns and gardens.

Domestic Water Use

- Average person in NA home uses approximately 400 liters of water per day.
 - 70% used as solvent to carry wastes.
 - 30% used for lawn and garden.
 - Very small fraction used for drinking (actually only 2 percent).



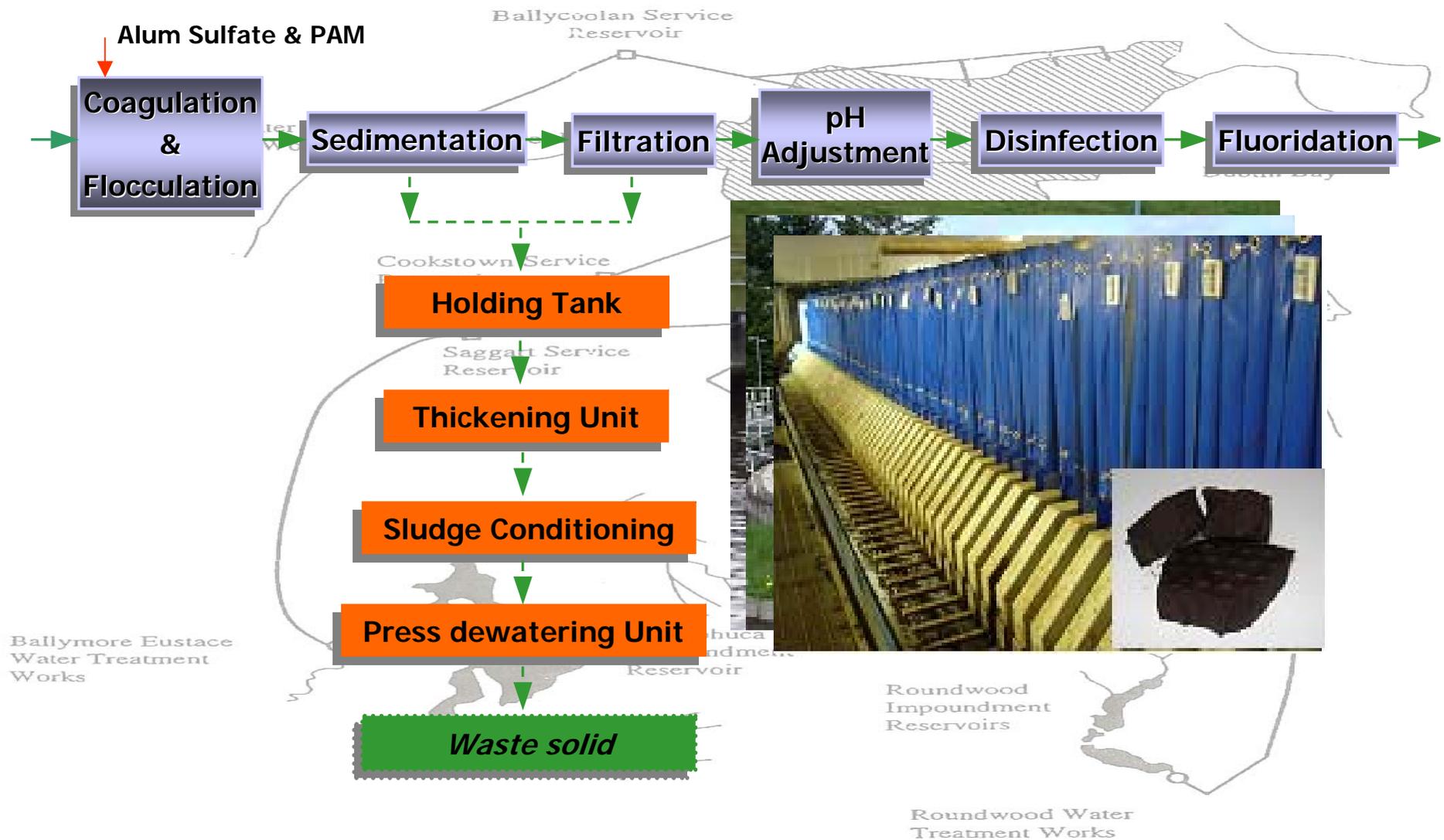
Regardless of the water source (surface or groundwater), water supplied to cities **is treated** to ensure its safety.

- Over 90 percent of water used for domestic purpose in NA is supplied by municipal water supply systems, which typically include **complex, costly** storage, purification, and distribution facilities.

Water Works



- Treatment of raw water before distribution usually involves some combination of the following processes: chemical aids; particle removal; disinfections.

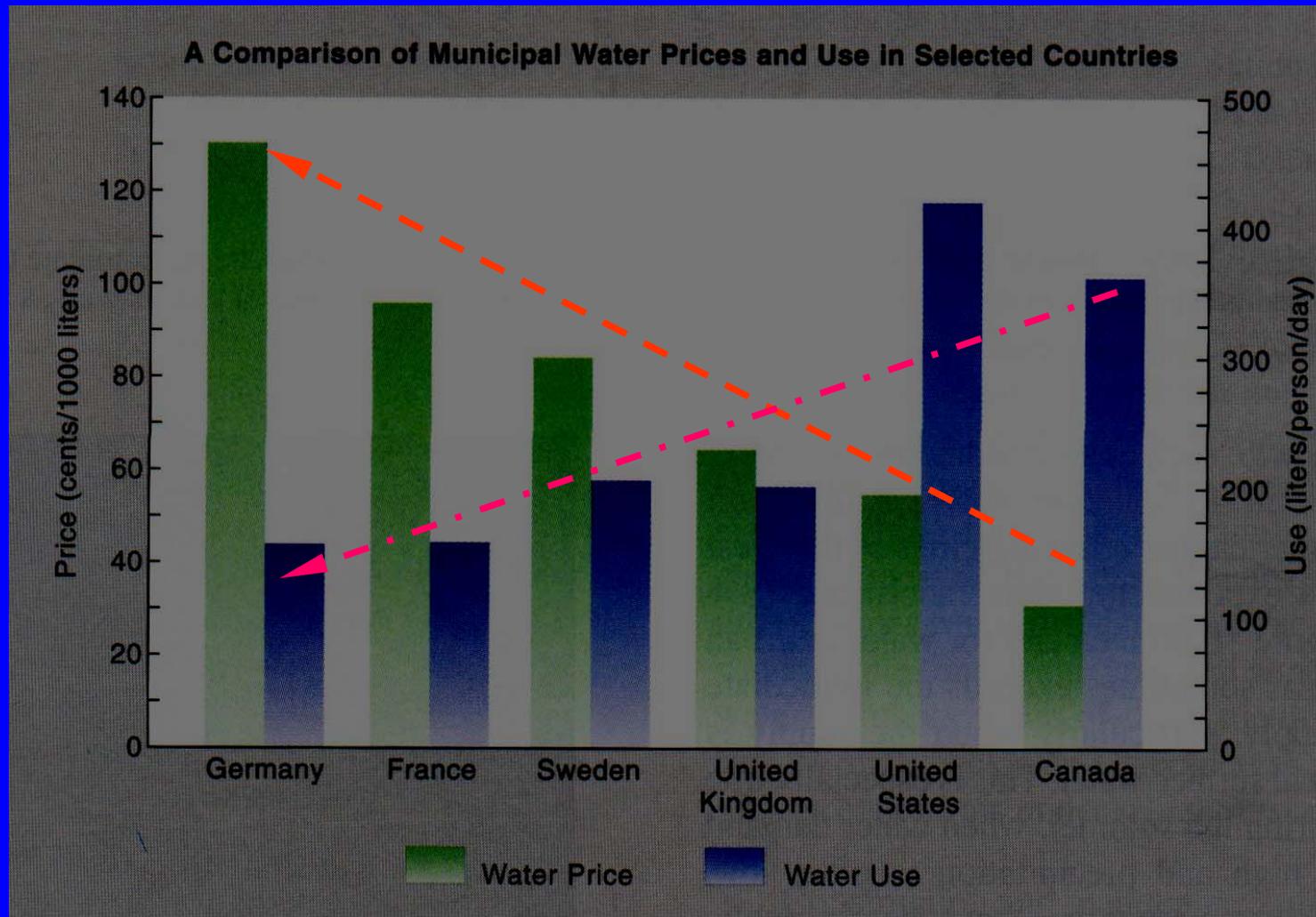


Domestic Water Use

- Natural processes cannot cope with highly concentrated urban wastes.
 - **Must be treated before release.**
- **Public attitude** has been major force working against water conservation.
 - As long as water is considered limitless, inexpensive resource, few conservation measures will be taken.
- **However**, shortages of water and increasing purification costs have raised the price of domestic water in many parts of the world.
 - It is becoming evident that increased costs do tend to reduce use.

Domestic Water Use

- Water prices and use in selected countries:

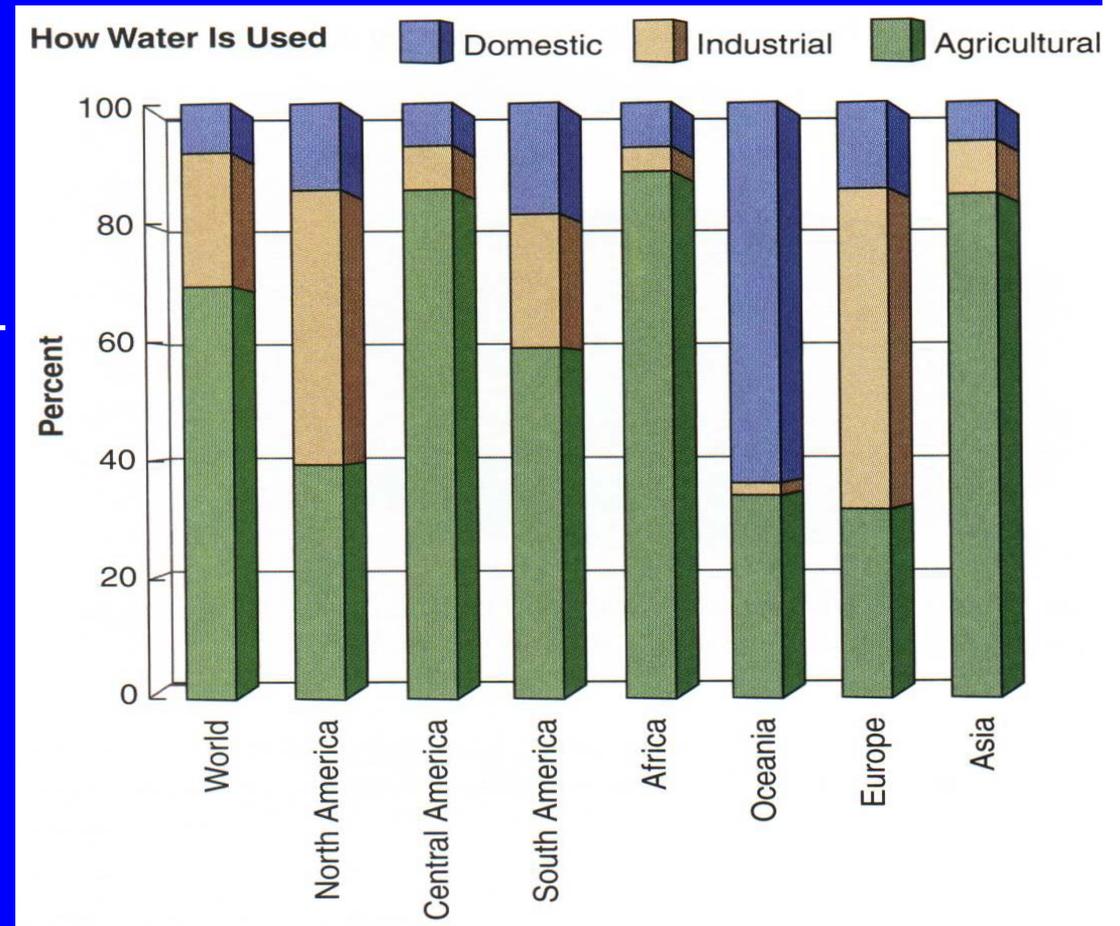


Kinds of Water Use

- World uses of water:

Although domestic use of water is a relatively small component of the total water-use picture, **urban growth** has created problems in water supplies.

Demand for water in urban areas sometimes exceeds the immediate supply.



Therefore, many communities have begun public education to help reduce water usage.

Water Saving Guide

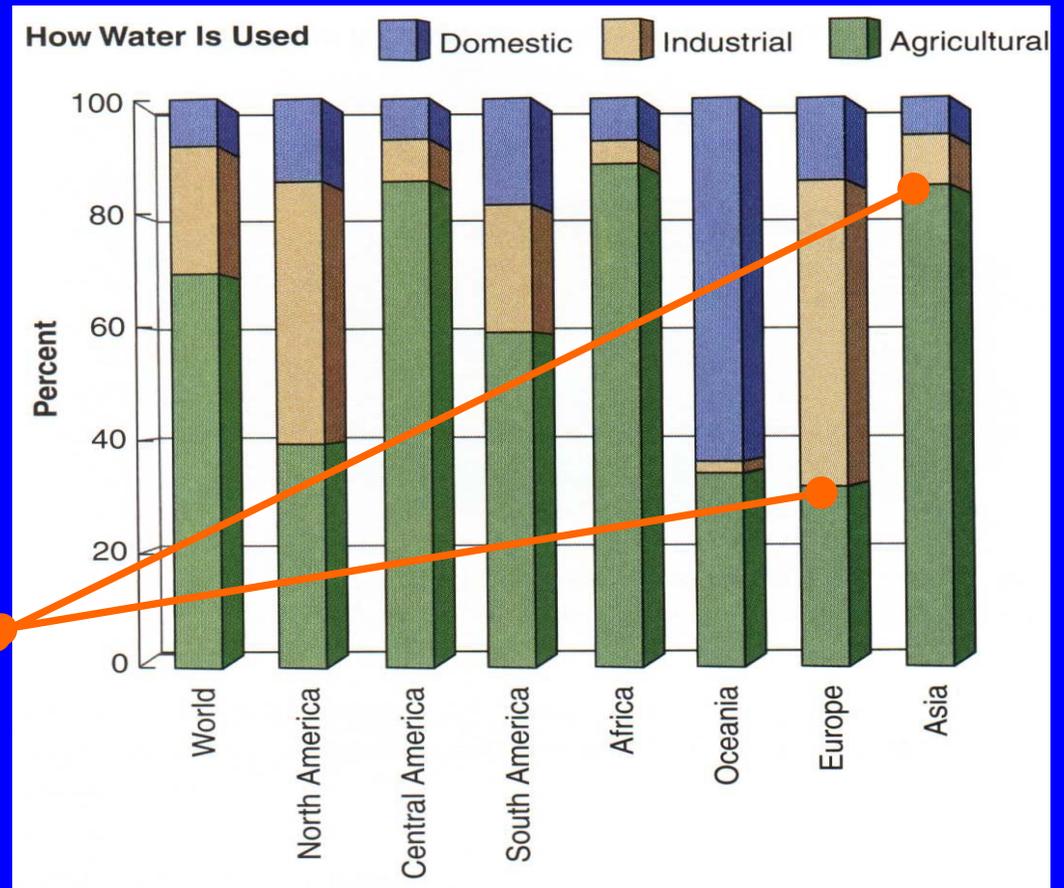
Ways to conserve water

Conservative use will save water		Normal use will waste water
Wet down, soap up, rinse off 15 liters (4 gal)		Regular shower 95 liters (25 gal)
May we suggest a shower?		Full tub 135 liters (36 gal)
Minimize flushing Each use consumes 20-25 liters (5-7 gal) New toilets use 6 liters (1.6 gal)		Frequent flushing is very wasteful
Fill basin 4 liters (1 gal)		Tap running 8 liters (2 gal)
Fill basin 4 liters (1 gal)		Tap running 75 liters (20 gal)
Wet brush, rinse briefly 2 liters (1/2 gal)		Tap running 38 liters (10 gal)
Take only as much as you require		Unused ice goes down drain
Please report immediately		A small drip wastes 95 liters (25 gal) per week
Turn off light, TV, heaters, and air conditioning when not in room		Wasting energy also wastes water

Agricultural Water Use

- Irrigation is the major consumptive use of water in most of parts of the world.

Accounts for about 85 percent of all the water consumed in Asia, while approximately 30 percent of all the water consumed in Europe.

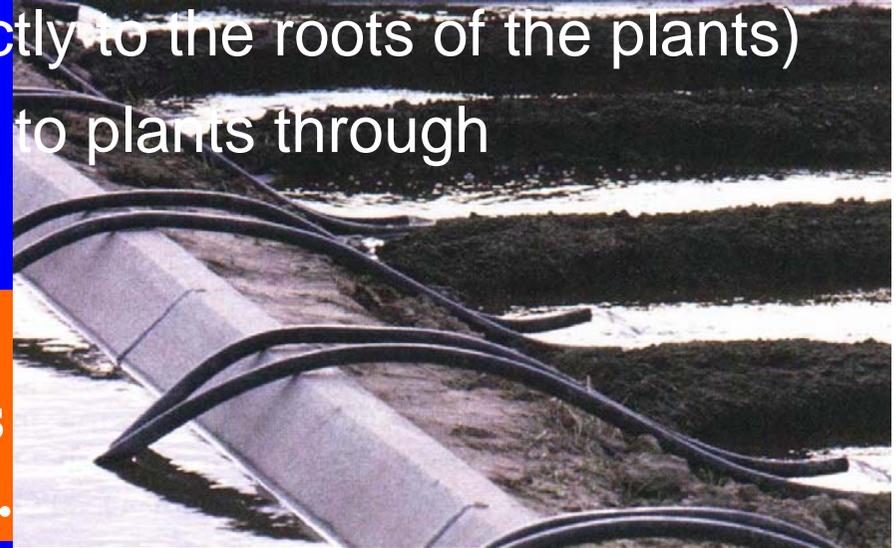


Agricultural Water Use

- Agricultural demand for water will depend on the following factors:
 - ◇ the cost of the water for irrigation;
 - ◇ the demand for agricultural products, food, and fiber;
 - ◇ governmental policies;
 - ◇ the development of new technology;
 - ◇ the competition for water from a growing human population.

- Four common irrigation methods:
 - ◇ **Surface / Flood** (the water flow over the field)
 - ◇ **Spray** (spray the water on the crop)
 - ◇ **Trickle** (water is delivered directly to the roots of the plants)
 - ◇ **Sub-irrigation** (supplying water to plants through underground pipes)

Each of these methods has its drawbacks and advantages as well as conditions under which it works well.



Agricultural Water Use

- Many forms of irrigation require a great deal of energy;
- It is often necessary to transport water great distance to water crops, therefore, extensive canals are required;
- Irrigation often relies on groundwater, and the water table is dropping rapidly.

Therefore, it is necessary to modify irrigation practices to use less water and irrigate the field with recycled water from the municipal wastewater treatment plant (WWTP).

Industrial Water Use

- Accounts for nearly 50 percent of all water withdrawal in US, about 70 percent in Canada, and 23 percent worldwide.
- 90% of water used by industry is for cooling, and is returned to the source.
 - Very little actually consumed.
 - Most processes involve heat exchange. If the water heated in the industrial process is discharged directly into a watercourse, it significantly changes the water temperature.

This affects the aquatic ecosystem by increasing the metabolism of the organisms and reducing the water's ability to hold dissolved oxygen.

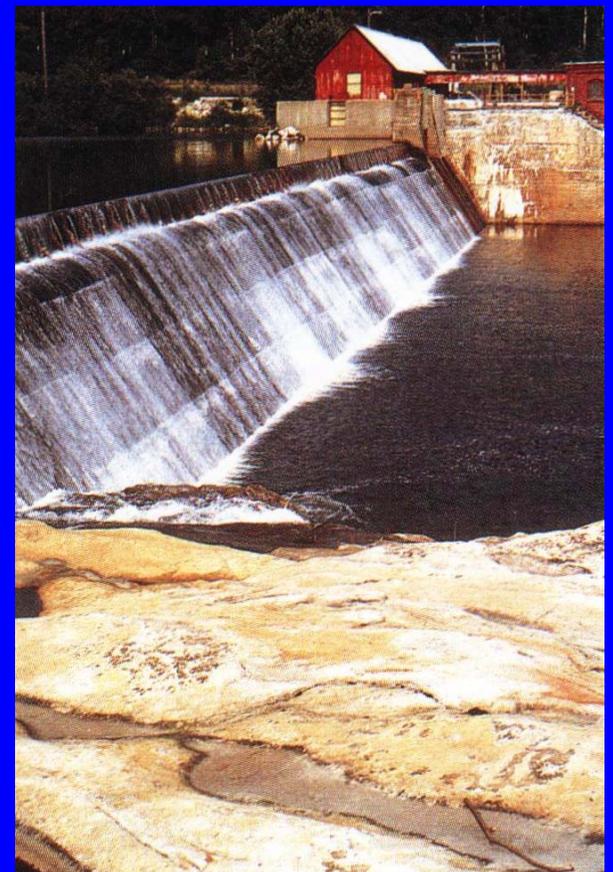
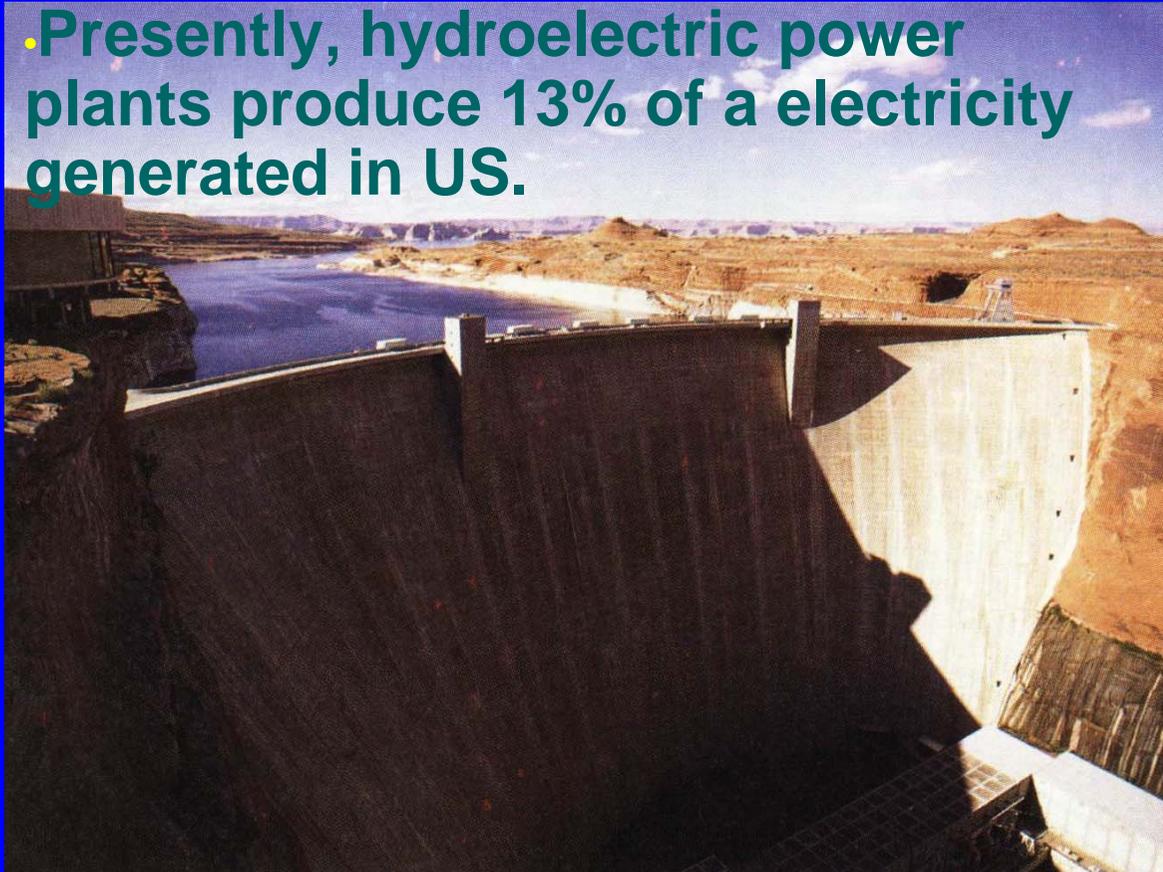
Industrial Water Use

- Industry also uses water to dissipate and transport waste.
 - **Stream and lake degradation:** many streams and lakes are now overused for this purpose. This degrades the quality of the water and may reduce its usefulness for other purposes.
- Historically, industrial waste and heat were major causes of pollution. Many nations have passed laws that severely restrict industrial discharge of waste or heated water into watercourses.
- **However**, many countries in the developing world have done little to control industrial pollution, and water quality is significantly reduced by careless use.

In-Stream Uses

- In-stream uses make use of water in its channels and basins.
 - Non-consumptive.
- Major in-stream uses are hydroelectric power, recreation, and navigation.

• Presently, hydroelectric power plants produce 13% of a electricity generated in US.



In-Stream Uses

- Although, in-stream uses does not remove water, they may require modification of the direction, time, or volume of flow and can negatively affect the watercourse.
- Although, hydroelectric power plants do not consume water and do not add waste products to it. However, the dams needed for the plants have definite disadvantages.

In-Stream Uses: Dams

- Drawbacks of the hydroelectric dams:
 - High construction costs.
 - Destruction of the natural habitat in streams and surrounding land.
 - Retard stream flow and silt deposition.
 - Impounded water has elevated evaporation rate and the amount of water lost can be serious in arid regions.
 - While dams reduce flooding, they do not eliminate it.

Kinds and Sources of Water Pollution

- **Water pollution occurs** when something enters water that changes the natural ecosystem or interferes with water use by segments of society.
- In an industrialized society, maintaining completely unpolluted water in all drain, streams, rivers, and lakes is probably impossible.

Inorganic pollutants

organic pollutants

Biological pollutants

pH, Alkalinity, Chloride, Sulfate, Metals, Suspended Solids, Nutrient (N, P), Organic matters (BOD, COD), Toxic chemicals, Disease-causing organisms,

Kinds and Sources of Water Pollution

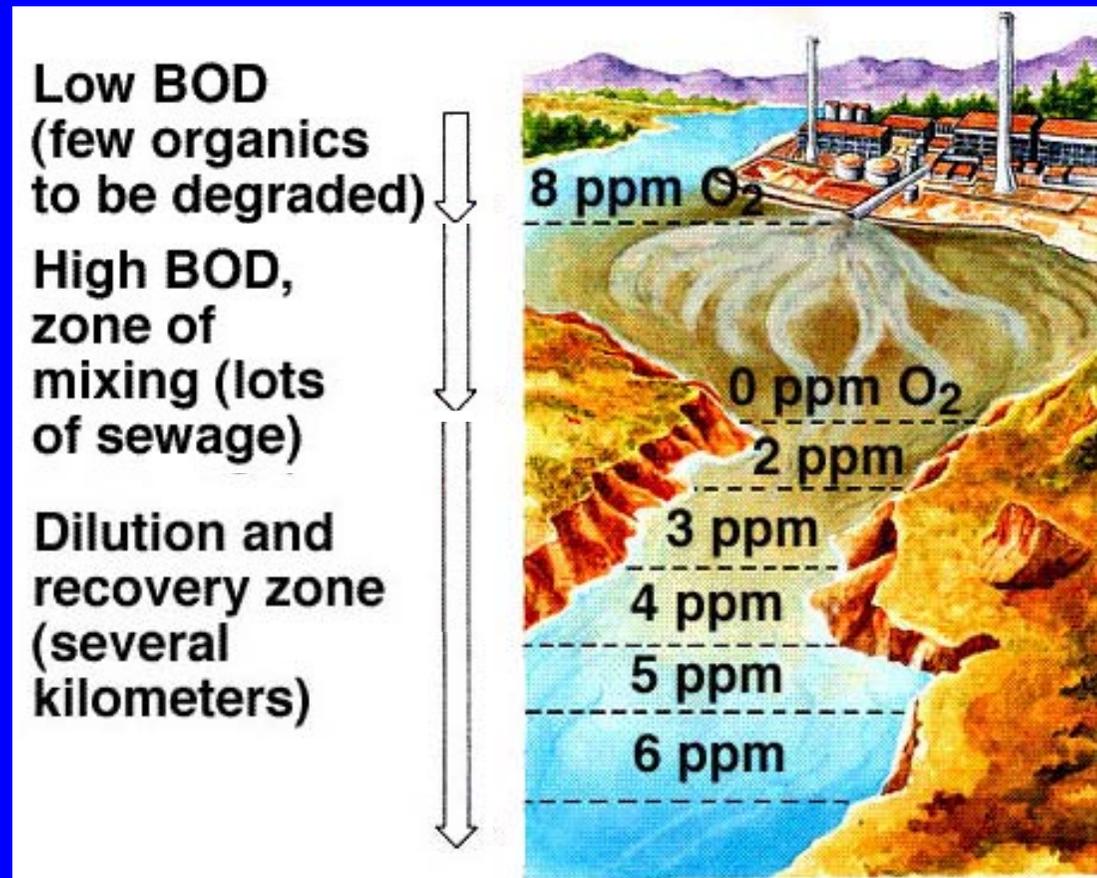
- Some pollutants seriously affect the quality and possible use of water.
- **Toxic chemical and acid:** kill organisms; make the water unfit for human use; may bioaccumulate in individual organisms and biomagnify in food chains.
- **Organic matter:** is a significant water pollution problem: as the microorganisms naturally present in water breakdown the organic matter, they use up available dissolved oxygen from water.

Kinds and Sources of Water Pollution

- **Organic matter:** The most widely used parameter of organic pollution applied to both wastewater and surface water is the 5-day **Biochemical Oxygen Demand** (BOD₅) and/or the chemical oxygen demand (COD).
 - ❖ Amount of oxygen required to decay a certain amount of organic matter;
 - ❖ This determination involves the measurement of the dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter.

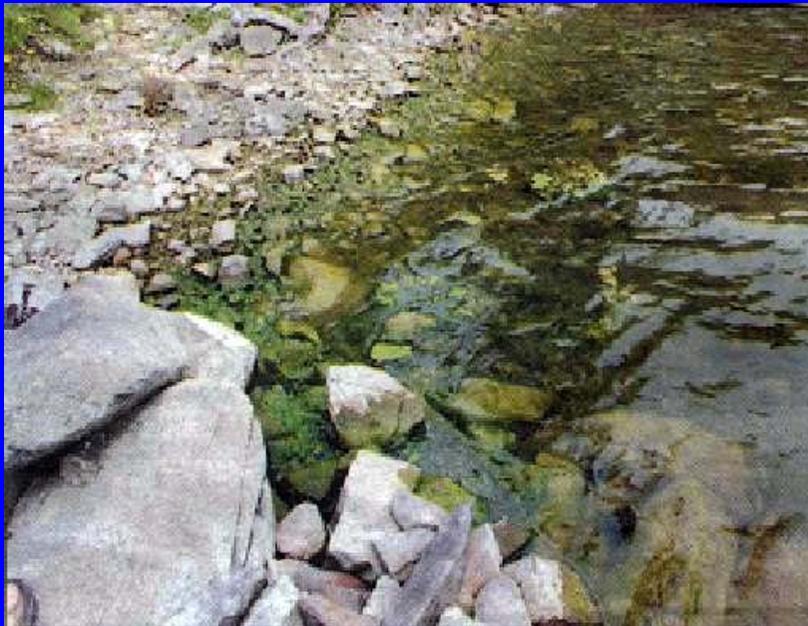
Kinds and Sources of Water Pollution

- ❖ Measuring the BOD of a body of water is one way to determine how polluted it is; to determine the approximate of quantity of oxygen that will be required to biologically stabilize the organic matter present;
- ❖ If too much organic matter is added, all available oxygen will be used up.
 - Anaerobic bacteria begins to break-down waste.



Kinds and Sources of Water Pollution

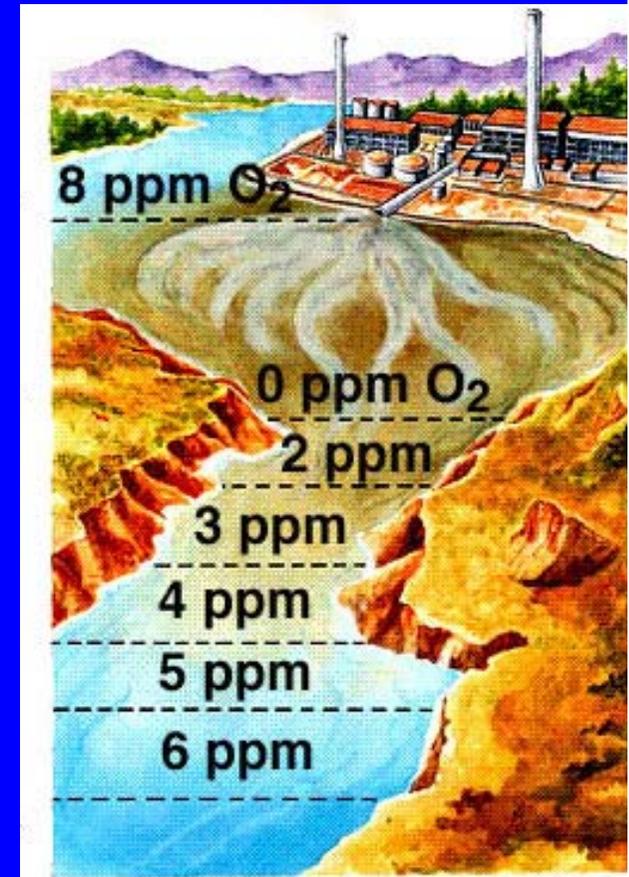
- **Nutrients** can also be a pollution problem.
 - **Eutrophication** - excessive growth of algae and aquatic plants due to added nutrients.



- As the algae and aquatic plants decay, oxygen level decrease, and fish and other aquatic species die.

Kinds and Sources of Water Pollution

- Pollution Sources:
 - **Point source** - Source of pollution readily located and identified because it has a definite source and place where it enters the water.
 - ❖ Municipal and industrial waste discharge pipes.
 - **Non-Point source** - Diffuse pollutants.
 - ❖ Agricultural land
 - ❖ Urban paved surface
 - ❖ Acid rain



Municipal Water Pollution

- **Municipal Water Pollution:** storm-water runoff, industrial wastewater, domestic wastewater.
- Wastes from homes consists primarily of organic matter from garbage, food preparation, cleaning of clothes and dishes, and human waste.
 - **Organic matters:** BOD or COD
 - **Nutrients:** N, P
 - **Biological pollutants:** Fecal Coliform Bacteria – such as *E. Coli.*, found in human, and other warm-blooded animal.
 - **Suspended solids (SS):** inorganic SS and organic SS

Agricultural Water Pollution

- Agricultural activities are the primary cause of water pollution problems.
 - **Nutrients (N, P):** excessive use of fertilizer - eutrophication.
 - ❖ Often nonpoint sources (agricultural runoff; runoff from animal feedlots);
 - **Suspended solids:** Soil erosion;
 - ❖ Reduce runoff: conservation tillage;
 - **Organic matters:** runoff from animal feedlots; pesticides
 - **Biological pollutants:** farm waste

Industrial Water Pollution

- Depending on the type of industry involved, these wastes contain organic matters, petroleum products, metals, acids, toxic materials, organisms, nutrients, or particulates.
- Often point sources.

Factories and industrial complexes frequently dispose of waste in municipal sewage systems.

- The municipal wastewater treatment plant will require the industry pretreat the waste before sending it to the WWTP.
- **Discharge of water treatment sludge to receiving water:** meet the discharge standards.

The selection of the treatment process is highly dependent on the nature and concentration of the wastes in the industrial wastewater.

Thermal Pollution

- **Thermal Pollution** - occurs when water is withdrawn, used for cooling purposes, and heated water then returned to original source.
 - Steam from steam turbines must be condensed into water after leaving turbine for maximum efficiency.
- **An increase in temperature**, even a few degrees:
 - ◇ may significantly alter some aquatic ecosystems;
 - ◇ result in a decrease in the amount of oxygen dissolved in the water.
- **Thermal wastewater treatment**
 - construct a large shallow pond and pump the hot water into one end of the pond;
 - use a cooling tower (heated water is sprayed into the air);
 - use a dry tower (heated water is pumped through tubes).

Marine Oil Pollution

- **Marine Oil Pollution**

- ◇ Tanker accidents and oil-drilling blowouts

- ◇ But more oil is released as a result of small, regular releases from other sources. 2/3 of all human-caused marine oil pollution comes from:

- ❖ Street run-off.

- ❖ Improper disposal of lubricating oil.

- ❖ Intentional oil discharges during tanker loading and unloading.

- **Methods to reduce marine oil pollution**

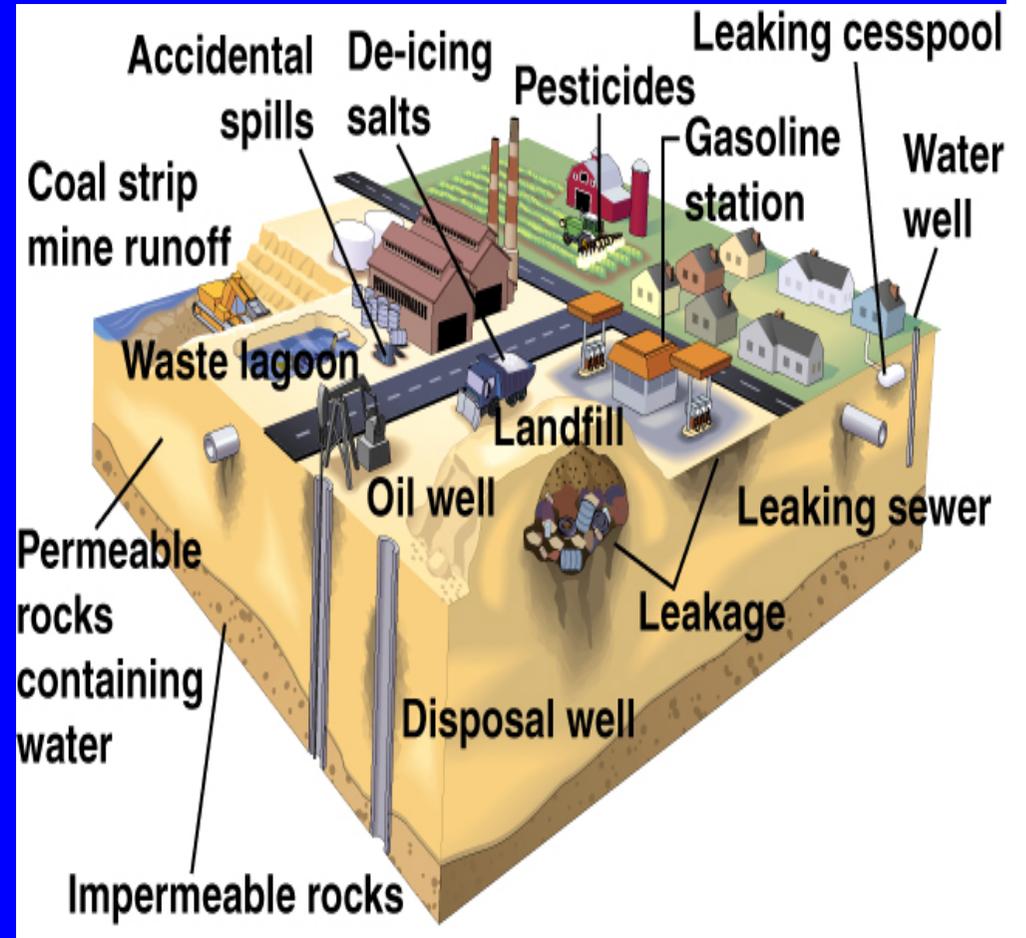
- ◇ Recycling and reprocessing the used oil and grease

- ◇ 1992, an international agreement was reached - New oil tankers must be double-hulled.

- Currently 15% of all tankers double-hulled.

Groundwater Pollution

- Major Sources:
 - Agricultural Products
 - Underground Storage Tanks
 - Landfills
 - Septic Tanks
 - Surface Impoundments



Water Use Planning Issues

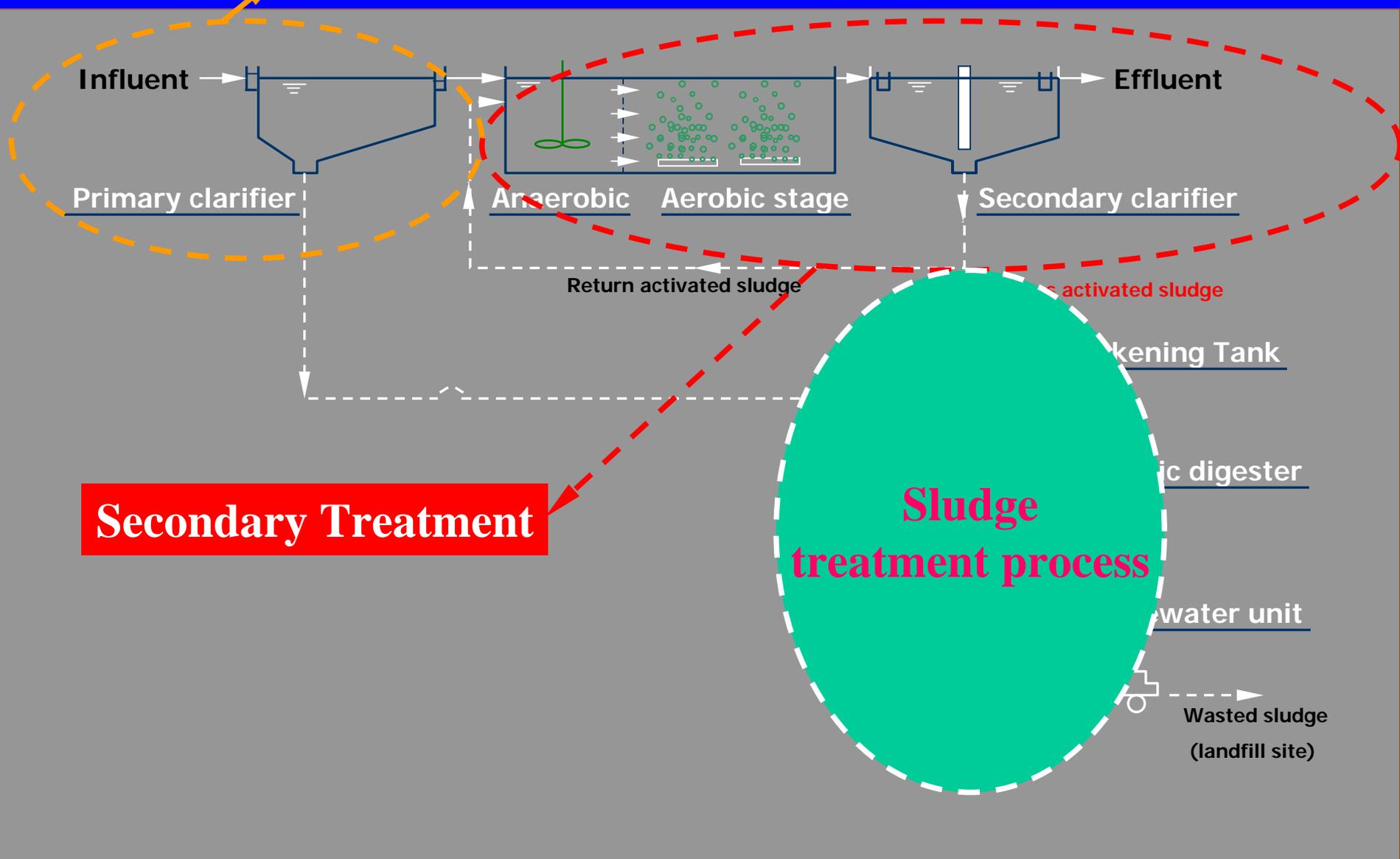
- **The quantity of water:** As the population has grown and the need for irrigation and domestic water has intensified, in many part of the world, there has not been enough water to satisfy everyone's needs;
- **The quality of water:** Water need to be treated before and after used.
- metropolitan areas must deal with and provide three basic services:
 - Water supply for domestic and industrial needs
 - Wastewater collection and treatment
 - Storm-water collection and management

Water Use Planning Issues

- **Water sources:** water sources must be identified and preserved for use;
- **Water diversion:** is the physical process of transferring water from one area to another.
 - ◇ One major consequence of diverting water for irrigation and other purposes is that the water bodies of downstream of the diversion are deprived of their source of water.

Wastewater Treatment

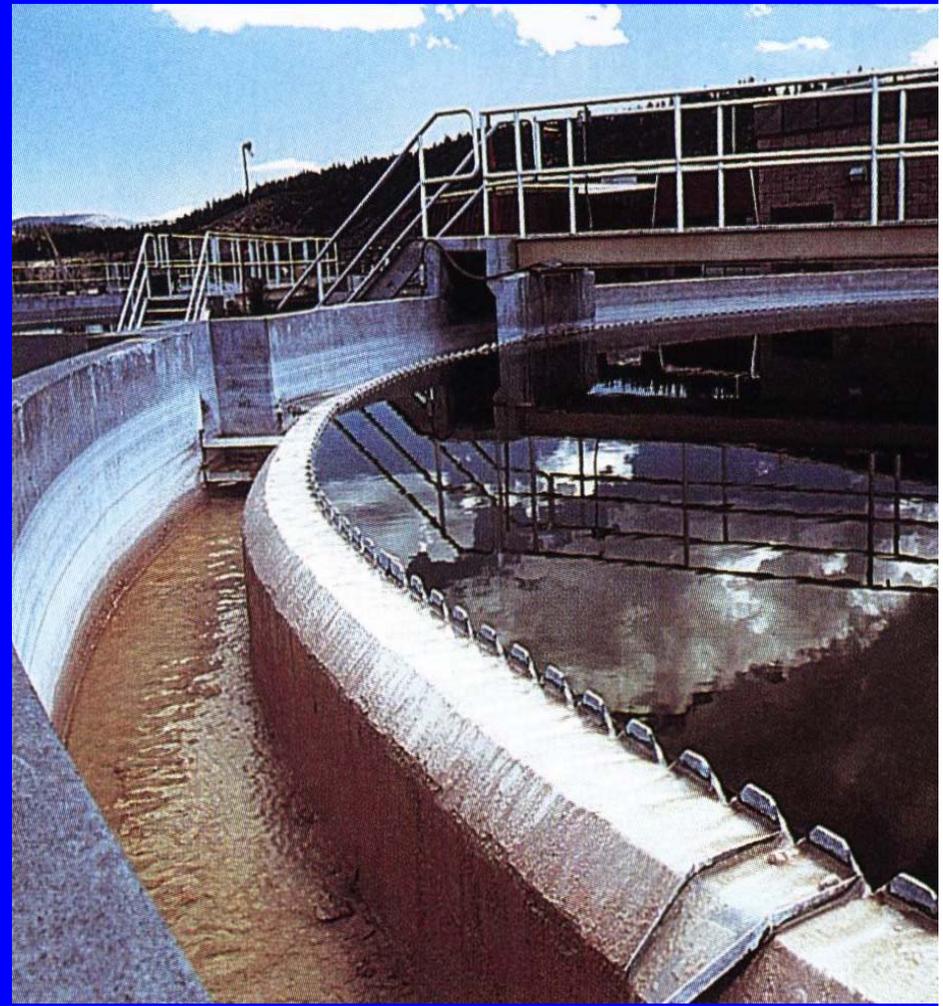
- **Primary Treatment** : Removes large particles



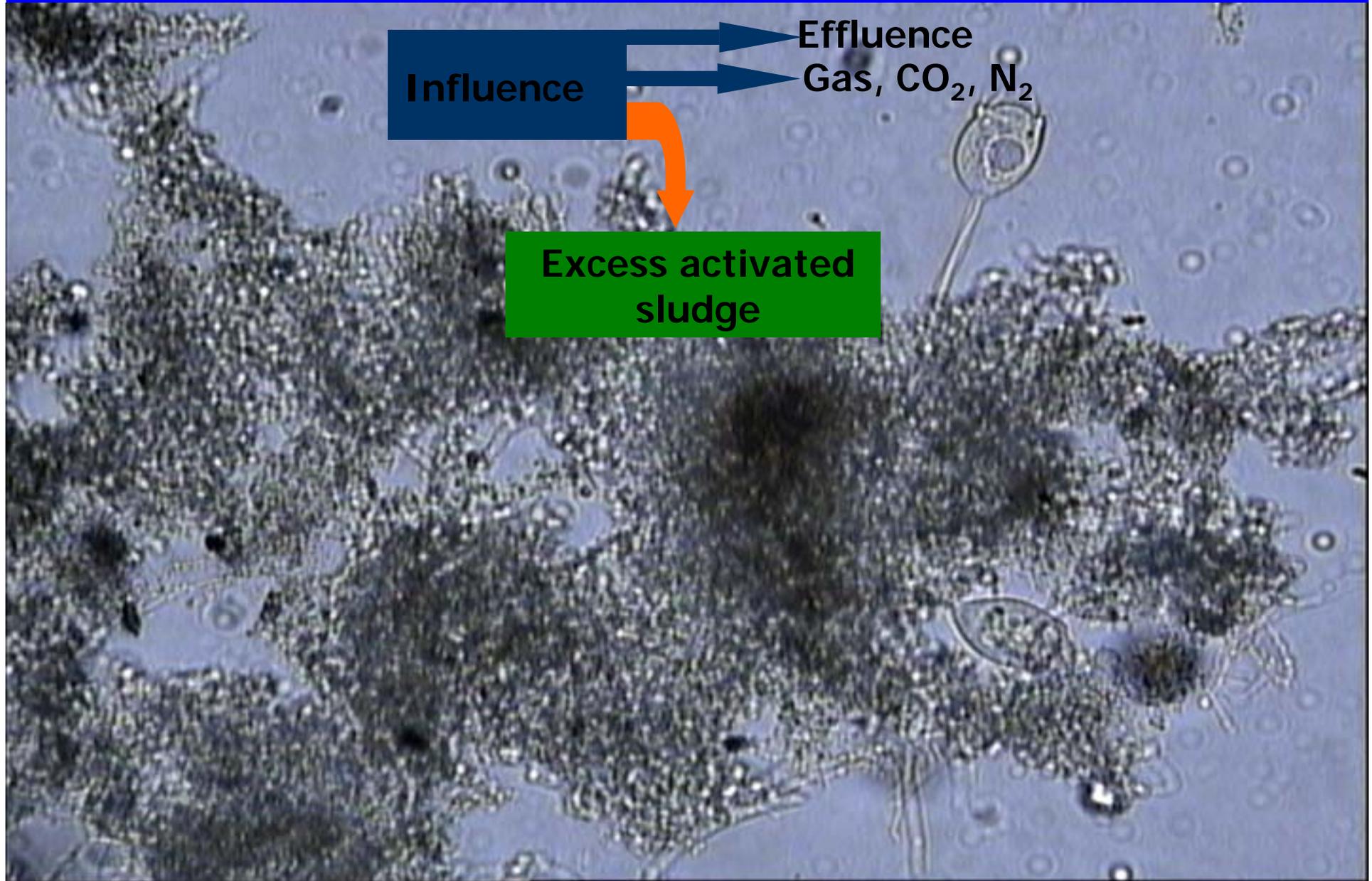
Wastewater Treatment

- **Secondary Treatment:** Facilities designed to remove organic matter, N, and P by promoting bacterial and other microorganism growth while the microorganisms responsible for the conversion of organic matter and other constituents in the wastewater to gas, and cell tissue .
 - In the biological treatment process, anaerobic/anoxic/aerobic conditions were provided
 - activated sludge processes (microorganisms are maintained in suspension) and attached-growth processes (biofilm process, microorganisms are attached to some inert medium, such as rock, slag or specially designed materials) .
- Discharged water must still be disinfected.
 - Usually accomplished via chlorine.

Secondary Treatment



Secondary Treatment



Wastewater Treatment

- **Tertiary Treatment** : Some plants now utilize an additional stage to remove even more dissolved pollutants i.e. phosphorous and nitrogen.
- Extremely costly
 - Some municipalities using natural or constructed wetlands.
 - Some areas use effluent as fertilizer.

Salinization

- As plants extract water from the ground, salt content of the ground increases.



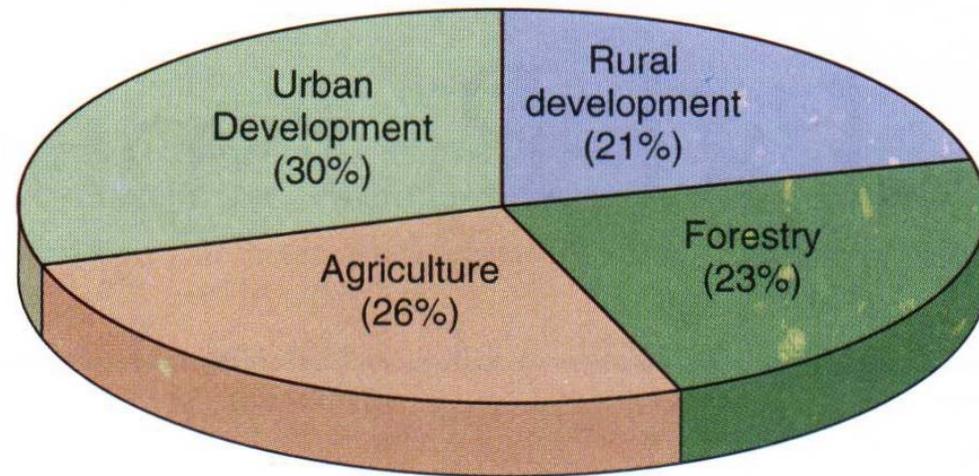
Preserving Scenic Areas

- Filter toxic wastes, excess nutrients, sediments, and other pollutants
- Help prevent erosion
- Reduce flooding by storing stormwater

- Reduce storm damage by absorbing waves
- Are feeding and resting spots for migratory waterfowl

- Provide food and habitat for other aquatic species

- Provide nursery sites for the young of a number of species, including oysters, clams, crabs, and shrimp



Wetlands Conversion

The Value of Wetland

Summary

- **Hydrologic Cycle:** energy; evapotranspiration; evaporation; precipitation; surface runoff; groundwater.
- **Water Use:** Domestic; Agricultural; Industrial and in-stream.
- **Kinds and Sources of Water Pollution:** municipal sewage, industrial wastes, and agricultural runoff; oxygen depletion; eutrophication;
- **Water Use Planning Issues:** the quantity and quality of water
- **Wastewater Treatment:** primary (a physical settling process), secondary (biological degradation of waste), and tertiary treatment (physical and/or chemical treatment to remove specific components)
- **Groundwater pollution**
- **Salinization**

Concept map

Construct a map to show the relationships among the following concepts:

- Hydrologic cycle
- Water distribution
- Water use
- Water pollution
- Wastewater treatment
- Salinization
- Groundwater
- Water diversion

Review Questions

- Describe the hydrologic cycle.
- What are the similarities between domestic and industrial water use? How are they different from in-stream use?
- What is biochemical oxygen demand? How is it related to water quality?
- Differentiate between point and nonpoint sources of water pollution.
- How are most industrial waters disposed of? How has this changed over the past 25 years?
- What is thermal pollution? How it can be controlled?
- Describe primary, secondary, and tertiary sewage treatment.
- What are the types of waste associated with agriculture?
- Define groundwater mining.
- How does irrigation increase salinity?

