Islamic University of Gaza -Environmental Engineering Department

Water Treatment

EENV 4331

Lecture 1: Introduction

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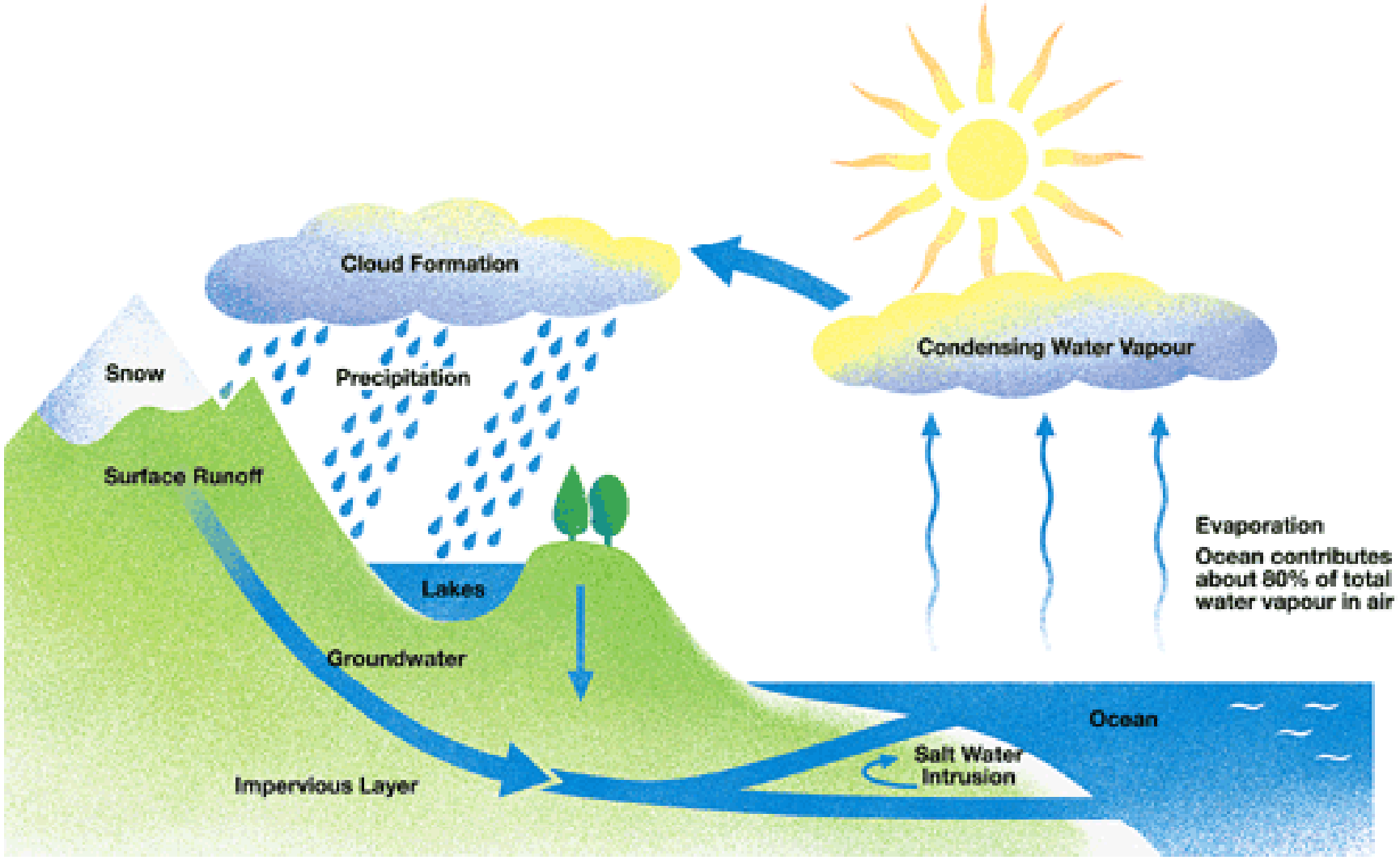
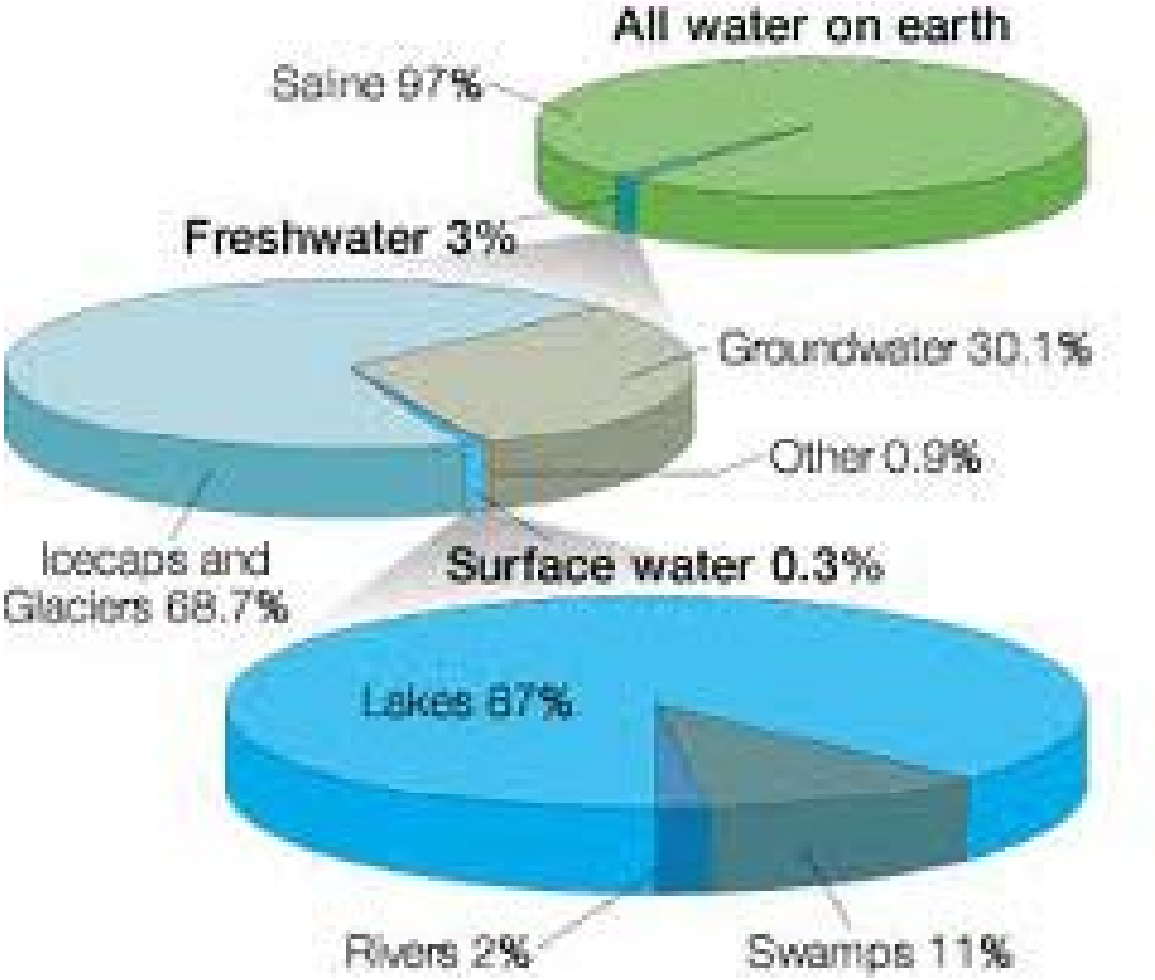
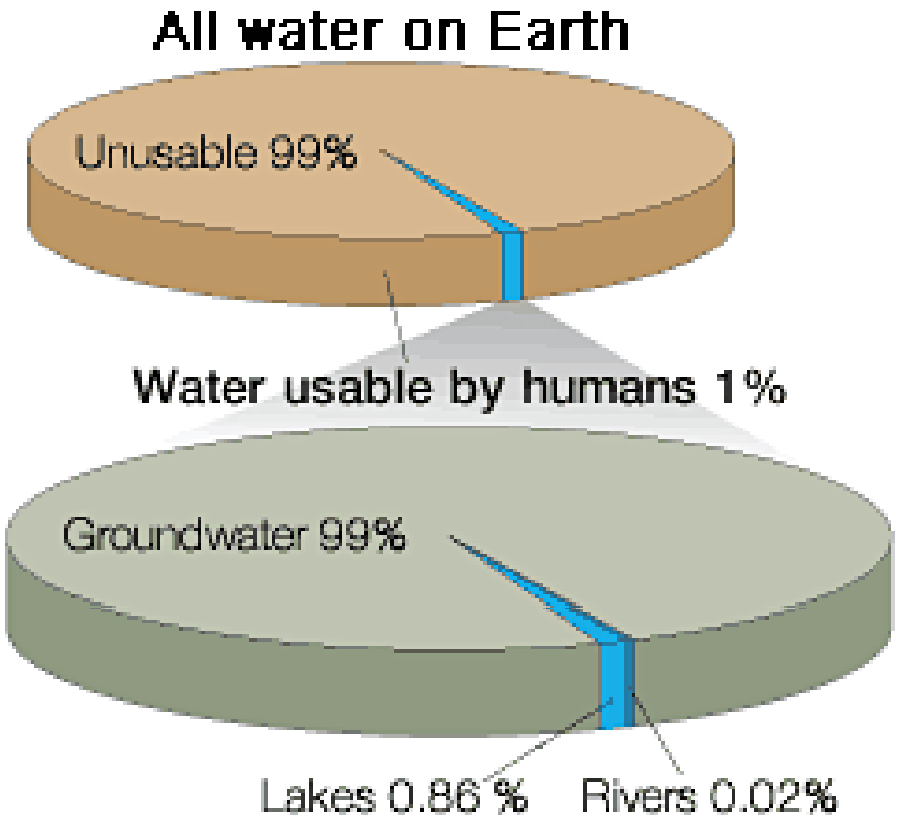
1.1 Water Cycle and Water Resources



1.2 Water Distribution on Earth



Percent of Usable Water



Usable Water quality

- Is the 1 % usable water quality suitable for direct use?

- Surface water is mostly contaminated and not suitable for direct usage. Surface water has open surfaces, consequently it is subjected to direct pollution from natural and human activities.
- Ground water is usually suitable for direct usage since it is naturally protected by the geological formations of earth. However, contamination may reach groundwater . In this case it should be purified before usage.

1.3 Definition of water Pollution

Water Pollution is defined as:

The presence of impurities in water in such quantity and of such nature as to impair the use of the water for a stated purpose.

Pollution = pure water + impurities

- Notice that pure water " H_2O" does not exist on earth.
- Water vapor can be considered as pure water. However, when it rains and runs over the earth surface or through the ground layers many impurities dissolve or stick to it.

1.4 Definition of water Treatment

Water treatment is defined as:

The process of reduction or removal of impurities from water to acceptable concentrations suitable for a stated usage.

Types of Impurities in water

- Dissolved solids (organic and inorganic)
- Suspended solids (organic and inorganic)
  - settleable
  - Non settleable
- Colloidal solids (organic and inorganic)

1.5 Water Treatment Methods

- Each type of the mentioned solids requires special method to be reduced or removed from water

-Water purification " treatment " methods are classified into three main categories:

-Physical methods

-Chemical methods

-Biological Methods

Water Treatment Methods

-Examples on each treatment category:

-Physical methods

- sedimentation
- Filtration
- Flocculation
- Adsorption
- air stripping
- Aeration
- Reverse Osmoses desalination " RO"

Water Treatment Methods

-Chemical methods

- Coagulation
- Softening
- Chemical precipitations
- Disinfection with chlorine and Ozone
- oxidation reduction reactions
- Desalination using Electodialysis.
- Ionic Exchange

Water Treatment Methods

-Biological methods

- Denitrification “nitrate removal“ using biological reactors.

Water Treatment Methods

-Biological methods

- Denitrification “nitrate removal“ using biological reactors.

1.6 Impurities in Water

Constituent	Chemical Formula	Difficulties Caused	Means of Treatment
Turbidity	----------	imparts unsightly appearance to water; deposits in water lines, process equipment, etc.; interferes with most process uses	coagulation, settling, and filtration
Hardness	calcium and magnesium salts, expressed as $CaCO_3$	chief source of scale in heat exchange equipment, boilers, pipe lines, etc.; forms curds with soap, interferes with dyeing, etc.	softening; demineralization
Alkalinity	bicarbonate(HCO_3^-), carbonate (CO_3^{2-}), and hydroxide(OH^-), expressed as $CaCO_3$	foam and carryover of solids with steam; embrittlement of boiler steel; bicarbonate and carbonate produce CO_2 in steam, a source of corrosion in condensate lines	lime and lime-soda softening; acid treatment; demineralization dealkalization by anion exchange

Impurities in Water

Constituent	Chemical Formula	Difficulties Caused	Means of Treatment
Free Mineral Acid	H_2SO_4 , HCl. etc., expressed as $CaCO_3$	corrosion	neutralization with alkalies
Carbon Dioxide	CO_2	corrosion in water lines	aeration, neutralization with alkalies
PH	hydrogen ion concentration defined as: $PH= - \log[H^+]$		

Impurities in Water

Constituent	Chemical Formula	Difficulties Caused	Means of Treatment
Sulfate	SO_4^{2-}	adds to solids content of water, but in itself is not usually significant, combines with calcium to form calcium sulfate scale	demineralization, reverse osmosis, electrodialysis, evaporation
Chloride	Cl^-	adds to solids content and increases corrosive character of water	demineralization, reverse osmosis, electrodialysis, evaporation
Nitrate	NO_3^-	adds to solids content, high concentrations cause methemoglobinemia in infants;	demineralization, reverse osmosis, Electodialysis, evaporation

Impurities in Water

Constituent	Chemical Formula	Difficulties Caused	Means of Treatment
Fluoride	F^-	cause of mottled enamel in teeth; also used for control of dental decay: not usually significant industrially	adsorption with magnesium hydroxide, calcium phosphate, or bone black; alum coagulation
Sodium	Na^+	adds to solids content of water: when combined with OH^-, causes corrosion in boilers under certain conditions	demineralization, reverse osmosis, Electodialysis, evaporation
Silica	SiO_2	scale in boilers and cooling water systems; insoluble turbine blade deposits due to silica vaporization	adsorption, demineralization, reverse osmosis, evaporation

Impurities in Water

Constituent	Chemical Formula	Difficulties Caused	Means of Treatment
Iron	Fe^{2+} (ferrous) Fe^{3+} (ferric)	source of deposits in water lines, boilers. etc.; interferes with dyeing, tanning, papermaking, etc.	aeration; coagulation and filtration; lime softening; cation exchange
Manganese	Mn^{2+}	same as iron	same as iron
Aluminum	Al^{3+}	usually present as a result of floc carryover from clarifier; can cause deposits in cooling systems and contribute to complex boiler scales	improved clarifier and filter operation

Impurities in Water

Constituent	Chemical Formula	Difficulties Caused	Means of Treatment
Oxygen	O_2	corrosion of : water lines, heat exchange equipment, boilers, return lines, etc.	sodium sulfite; corrosion inhibitors
Hydrogen Sulfide	H_2S	cause of "rotten egg" odor; corrosion	aeration; chlorination; highly basic anion exchange
Ammonia	NH_3	corrosion of copper and zinc alloys by formation of complex soluble ion	cation exchange with hydrogen zeolite; chlorination;

Impurities in Water

Constituent	Chemical Formula	Difficulties Caused	Means of Treatment
Dissolved Solids	none	refers to total amount of dissolved matter, determined by evaporation; high concentrations are objectionable because of process interference and as a cause of foaming in boilers	lime softening and cation exchange by hydrogen zeolite; demineralization, reverse osmosis, electrodialysis, evaporation
Suspended Solids	none	refers to the measure of undissolved matter, determined by filtration and drying	filtration, usually preceded by coagulation and settling
Total Solids	none	refers to the sum of dissolved and suspended solids,	see "Dissolved Solids" and "Suspended Solids"

1.7 Water quality characteristics

a. Physical characteristics:-

- **Turbidity**
- **Color**
- **Taste and odor**
- **Temperature**

b. Chemical characteristics:

- **Many dissolved chemicals exist in water and many of them are of concern such as:-**

Chloride, fluorides, Iron, lead, manganese, sodium, sulfate, zinc, toxic inorganic substances, toxic organic substances,

c. Microbiological characteristic:-

Pathogens: viruses, bacteria, protozoa, helminthes (warms)

1.8 Drinking Water Quality Standards

See also the EPA Primary drinking water standards

Guidelines for Drinking-water Quality

THIRD EDITION
INCORPORATING THE FIRST AND SECOND ADDENDA

Volume 1
Recommendations

World Health Organization

Geneva
2008

Drinking Water Quality Standards (WHO)

Element/Compound	Symbol	Acceptable Level (mg/l)	MCL (mg/l)
Total Disolves Solids	TDS	500	1500
Total Hardness	TH (CaCO3)	100	500
Detergents	ABS	0.5	1
Aluminum	Al	0.2	0.3
Iron	Fe	0.3	1
Manganese	Mn	0.1	0.2
Copper	Cu	1	1.5
Zinc	Zn	5	15
Sodium	Na	200	400
Nickel	Ni	0.05	0.1
Chloride	Cl	200	400
Fluoride	F	1	1.5
Sulfate	SO_4	200	500
Nitrate	NO_3	45	70
Silver	Ag	0.01	0.05
Magnesium	Mg	50	120
Calcium	Ca	100	200
Potassium	K	10	12

Drinking Water Quality Standards (WHO)

Chemical Standards
(Toxic elements)

Parameter	Symbol	MCL (mg/l)
Lead	Pb	0.01
Selenium	Se	0.01
Arsenic	As	0.05
Chromium	Cr	0.05
Cyanide	Cn	0.05
Cadmium	Cd	0.005
Mercury	Hg	0.001
Antimony	Sb	0.005
Nickel	Ni	0.05

Palestinian Water Quality Standards

Element/Compound	Symbol	MCL (mg/l)
Total Dissolves Solids	TDS	1500
Total Hardness	TH ($CaCO_3$)	600
Alkalinity		400
Detergents	ABS	0.5
Sodium	Na	200
Chloride	Cl	600
Fluoride	F	1.5
Sulfate	SO_4	400
Nitrate	NO_3	70
Nitrite	NO_2	0.1
Ammonium	NH_4	0.5
Magnesium	Mg	150
Calcium	Ca	100- 200
Potassium	K	12
Residual chlorine		0.2- 0.8

1.9 Most common water treatment plants

Water treatment plants can be classified as:-

A) Simple disinfection:- (Ground water)

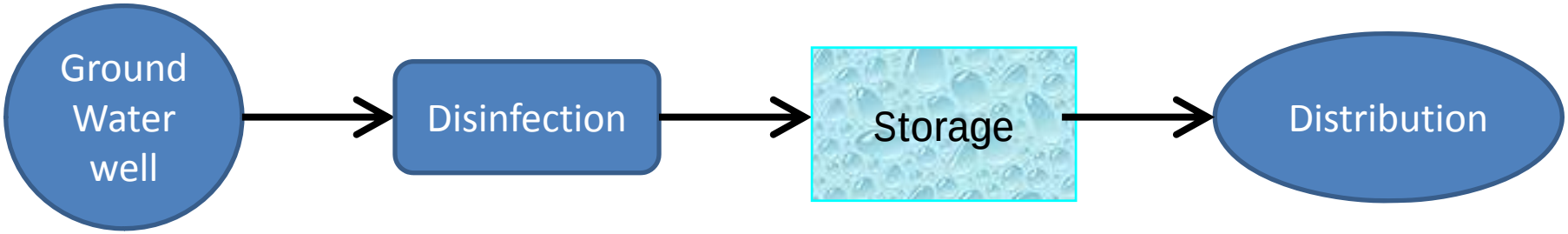
It is a direct pumping and chlorine injection. Used to treat high quality water.

B) Filtration plants: (surface water)

- Removes: color, turbidity, taste, odor, and bacteria
- if the source water has better quality with lower solids, flocculation and sedimentation can be omitted, this modification is called **direct filtration.**

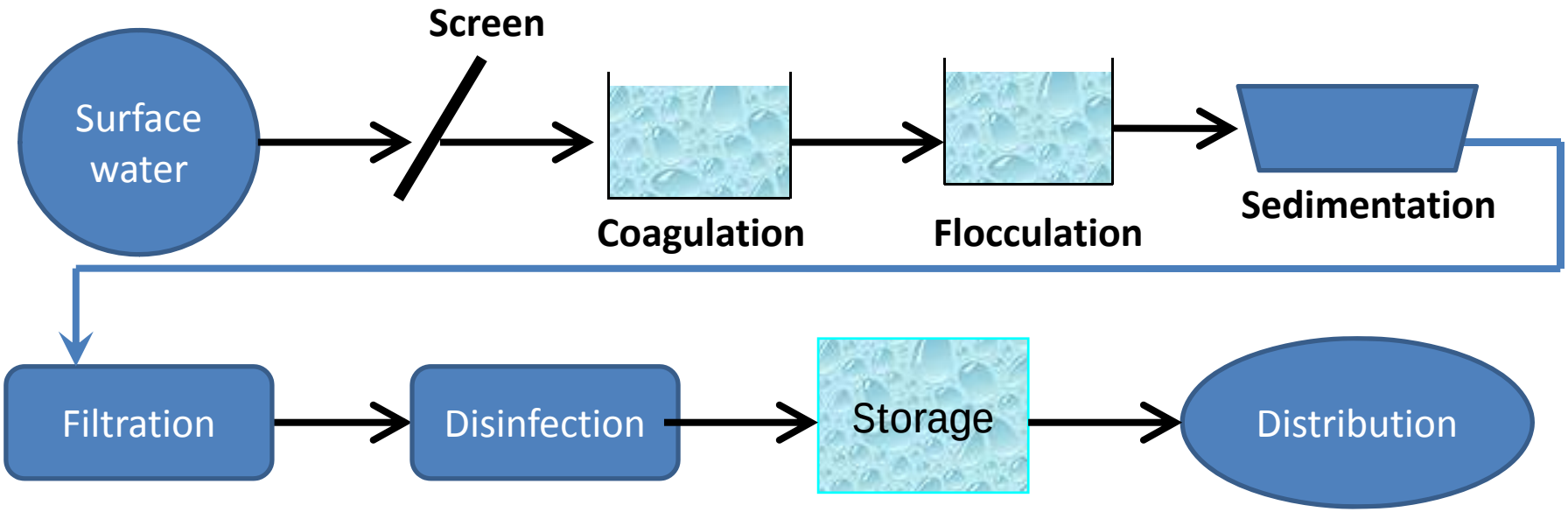
C) softening plants:- (ground water)

1.9 Most common water treatment plants



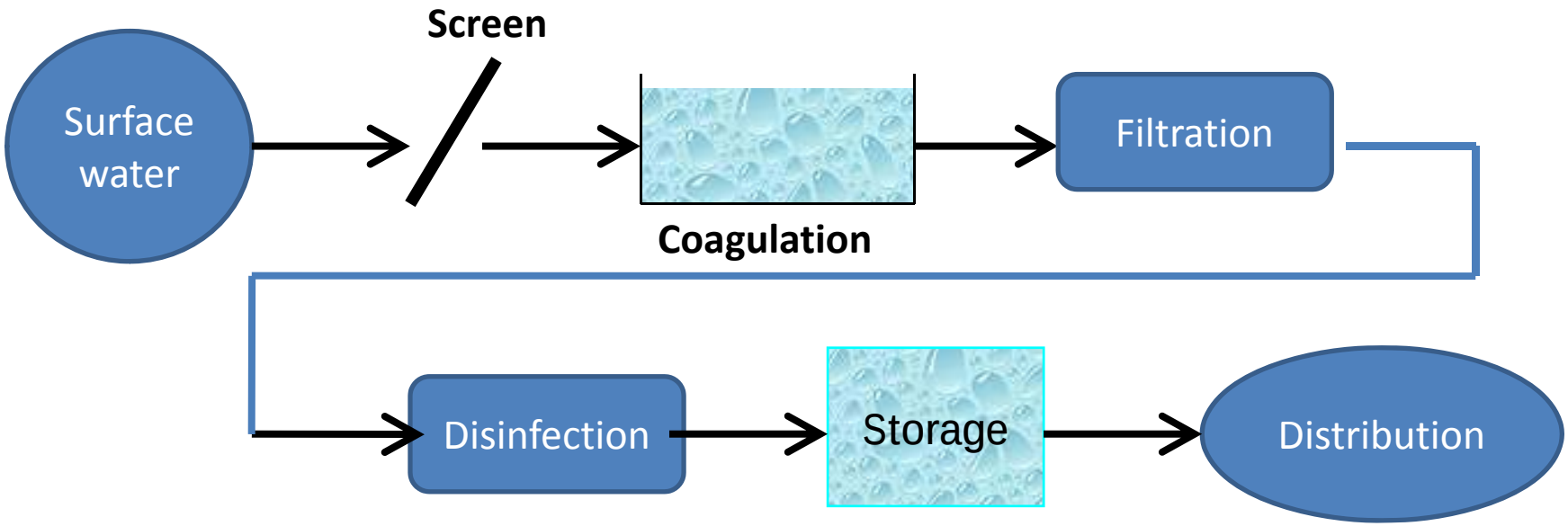
Simple Disinfection Treatment Plant

1.9 Most common water treatment plants



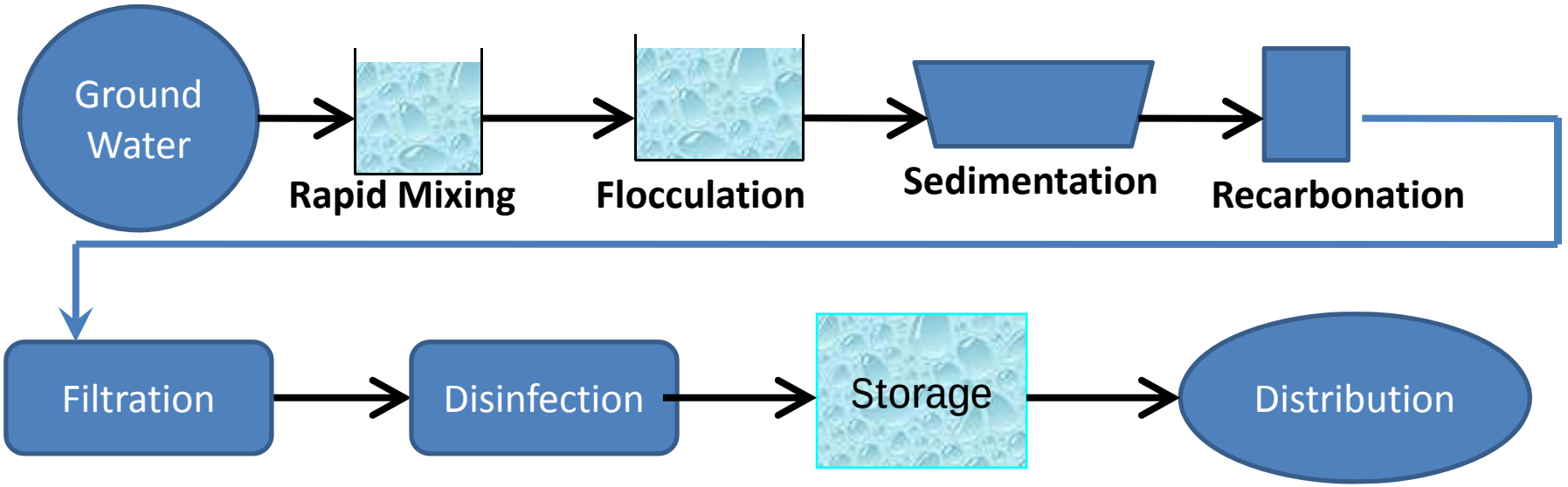
Filtration Treatment Plant

1.9 Most common water treatment plants



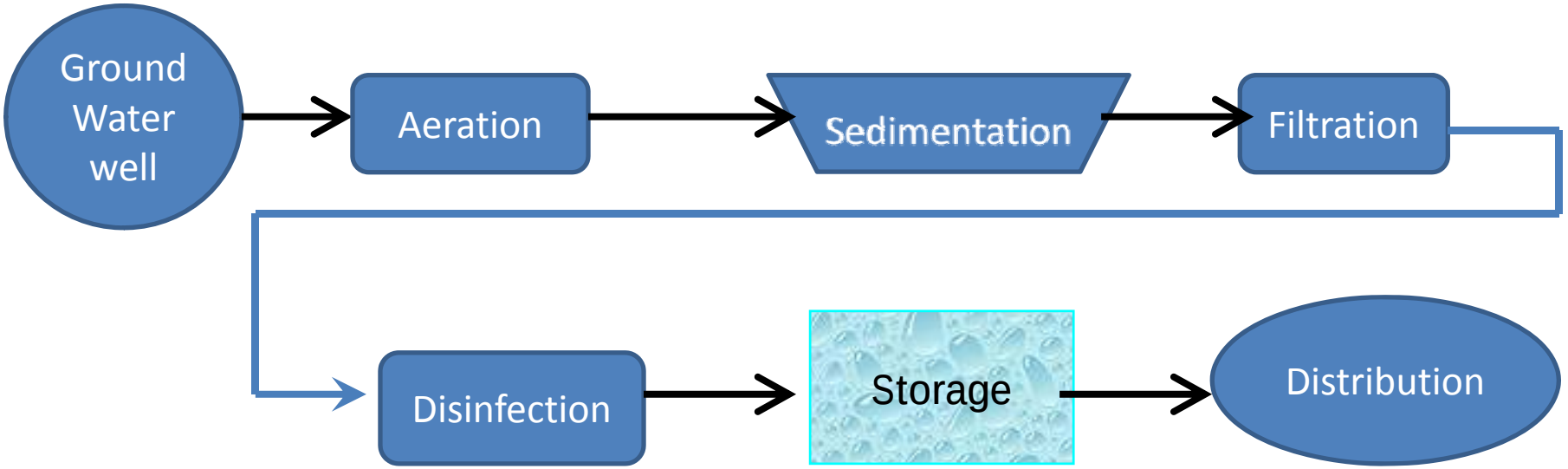
Direct Filtration Treatment Plant

1.9 Most common water treatment plants



Softening Treatment Plant
Single stage softening

1.9 Most common water treatment plants



Simple Disinfection Treatment Plant