ENVE 301

Environmental Engineering Unit Operations

CHAPTER: 1

Quality of untreated water and wastewater

Treatment methods for water and wastewater

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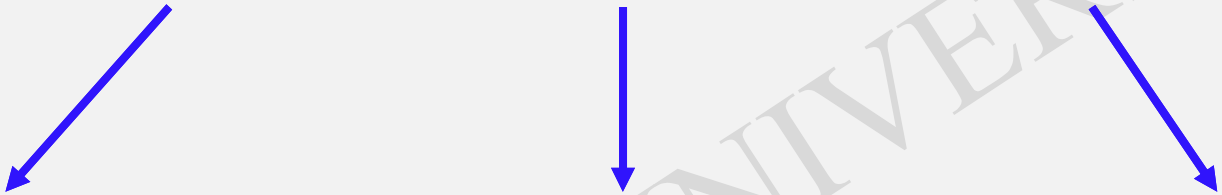
Treatment Methods For Water and Wastewater



Physical Unit Operations

Chemical Unit Operations (Processes)

Biological Unit Processes

Physical Unit Operations

Treatment operations in which the treatment is brought through the application of physical forces.

Examples:

- Screening
- Communition
- Aeration
- Mixing chemicals and gases with water
- Flocculation
- Gravity sedimentation
- Filtration
- Adsorption
- Gas Stripping
- Membrane processes (e.g. Reverse osmosis, electrodialysis, ultrafiltration)

Chemical Unit Operations (Processes)

Treatment operations(processes) in which the treatment of contaminants is brought by the addiction of chemicals or by chemical reactions.

Examples:

- Chemical precipitation
- Coagulation
- Disinfection
- Ion exchange

Biological Unit Processes

Treatment processes in which the treatment of contaminants is brought by biological means.

Examples:

- Aerobic processes
- Anaerobic processes
- Anoxic processes

Water Sources

Surface Water Sources

Streams

Lakes

Impounding Reservoirs

Saline Water

Sea Water

Ground Water Sources

Wells

Galleries

Spring Water

Brackish Water

Well water high in TDS as a result of salt water intrusion

A) Surface Water Sources (Streams, lakes, impounding reservoirs)

Streams or rivers

→ Rapid changes in water quality

→ Changes in turbidity and other constituents during heavy rains and run off

→ Require flexible and reliable treatment processes

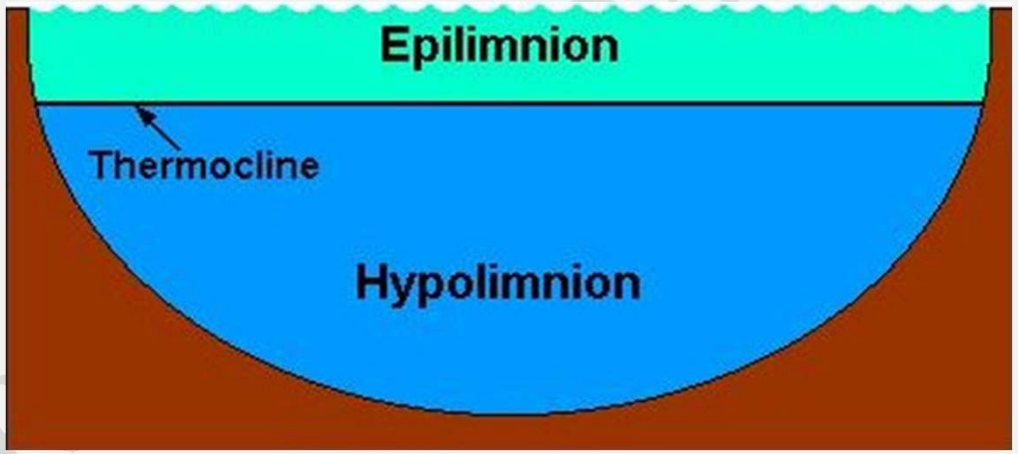
Lakes and impounding reservoirs

→ Seasonal changes in water quality

Thermal stratification

Thermal Stratification

Heat transfer in reservoirs and lakes is controlled by a phenomenon known as **THERMAL STRATIFICATION**.



Ref: http:/faculty.gvsu.edu/videticp/stratification.htm

Thermal stratification → Changes in the temperature profile with depth within a lake system.

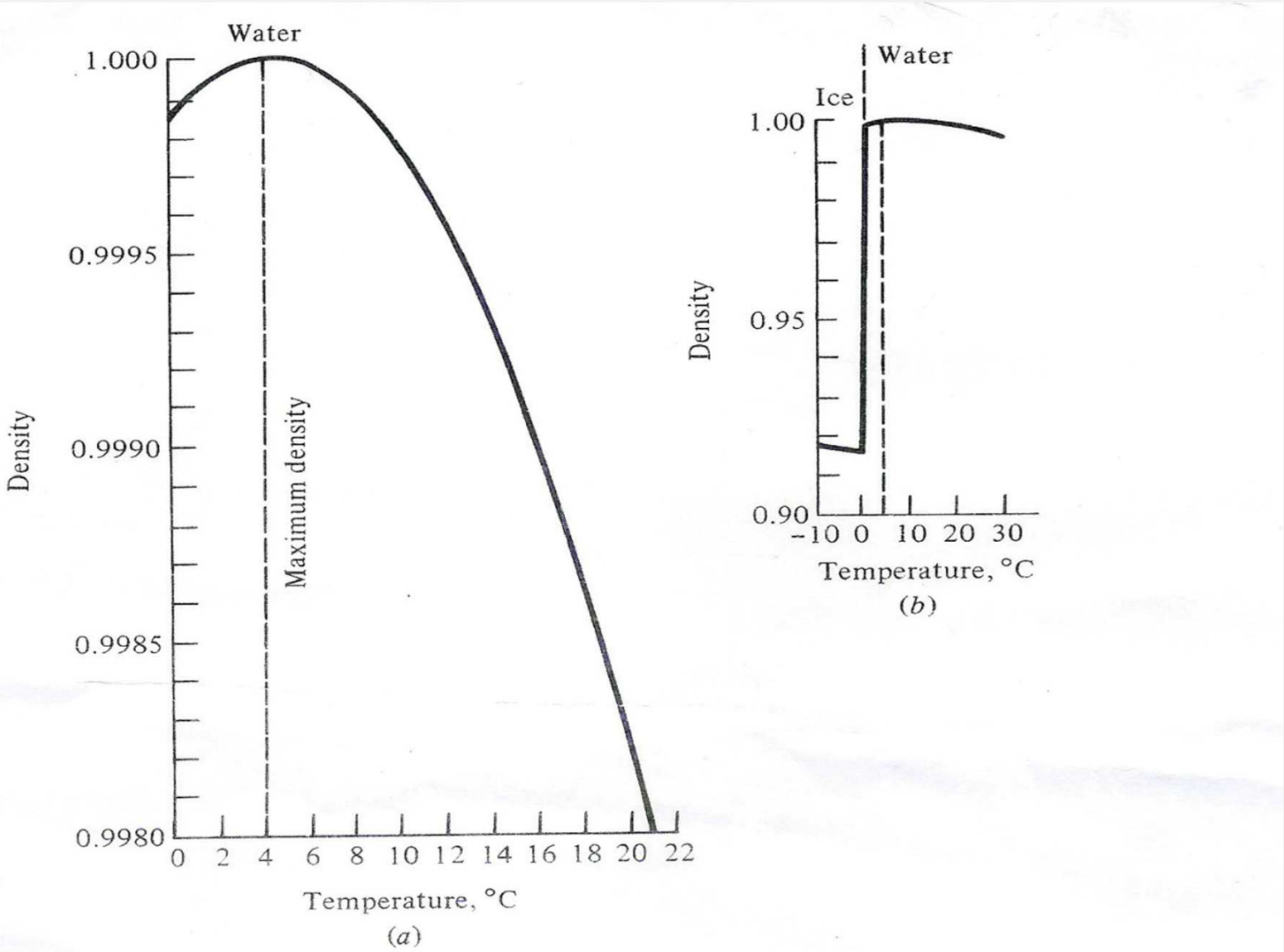
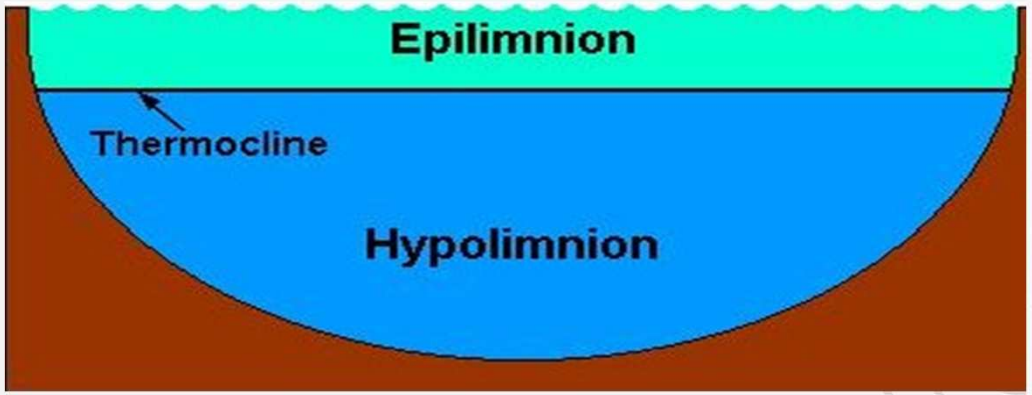


Figure 3-3 Changes in the density of (*a*) water and (*b*) ice with changes in temperature. (*From Warren* [3-27].) Ref: Peavy, McGraw-Hill, 1985

-Summer Stratification-



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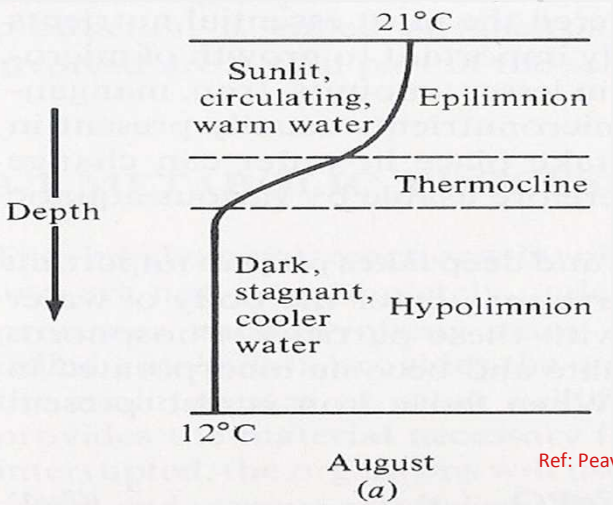


Ref: Peavy, McGraw-Hill, 1985

→As air temperature rises in late spring,

heat from the sun begins to warm the lake

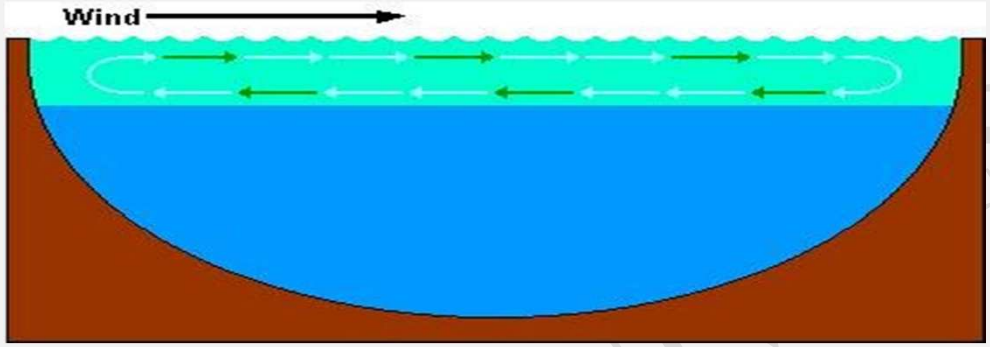
→As the amount of solar radiation absorbed decreases with depth

the lake heats from the surface down

→The warm water is less dense than the colder water below

resulting in a layer of warm water that floats over the cold water

Summer Stratification (continue)



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→ The warm water, abundant sunlight, and nutrients brought up from the lake bottom during spring overturn

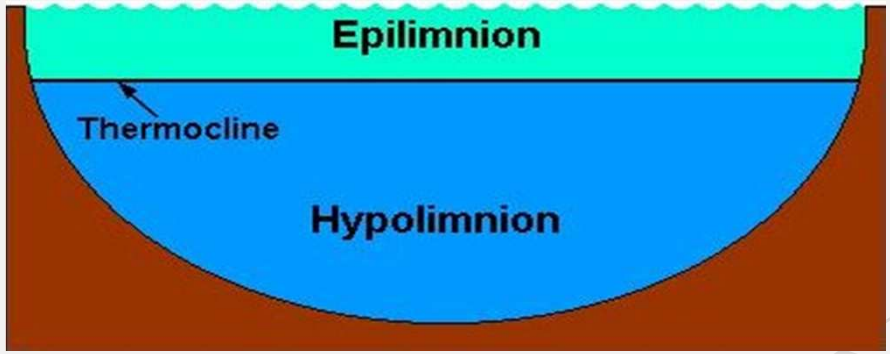
an ideal environment for algae growth within the epilimnion

→ Algal blooms tend to give the epilimnion a greenish hue

→ Wind circulates the surface water, but the warm water of the epilimnion is unable to drive through the cold, dense water of the hypolimnion

the water is only mixed in the epilimnion

Summer Stratification (continue)



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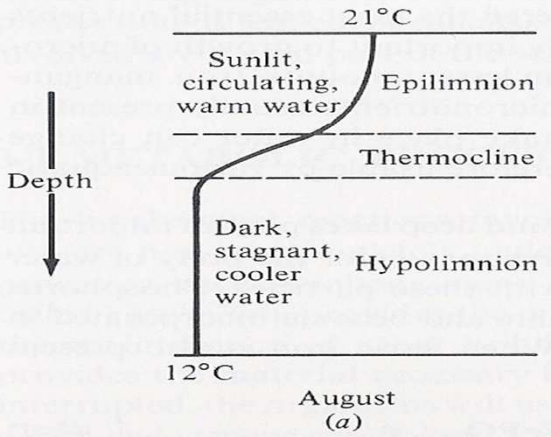


Ref: Peavy, McGraw-Hill, 1985

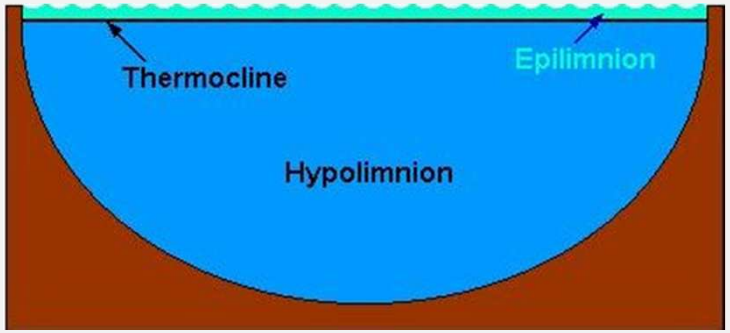
→ Dead algae sink to the lake bottom and are decomposed by bacteria

anaerobic bacteria begin to decompose organic material

anaerobic bacteria produce hydrogen sulfide (H_2S) gas
the odor of "rotten egg"

Dead algae accumulation rate >> organic matter decomposition rate of bacteria
sediment deposited in the lake will be rich in organics

-Autumn Turnover-



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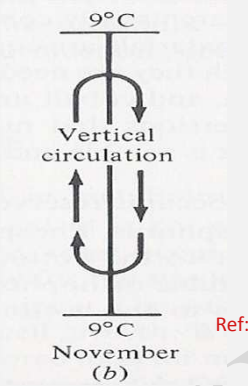


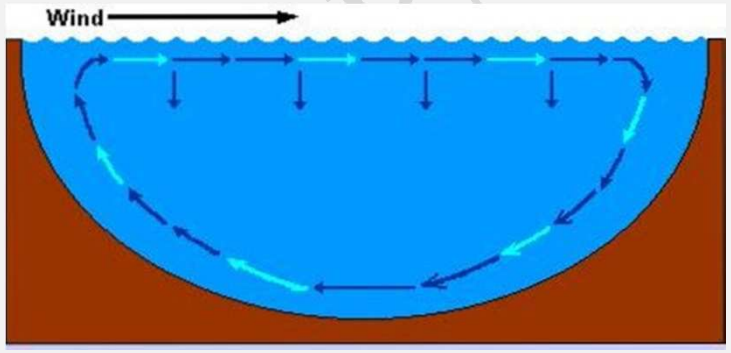
Ref: Peavy, McGraw-Hill, 1985

As autumn approaches and temperature decreases,

the epilimnion begins to decrease in depth

epilimnion gets so shallow, no longer be maintained as a separate layer

the lake loses its stratification



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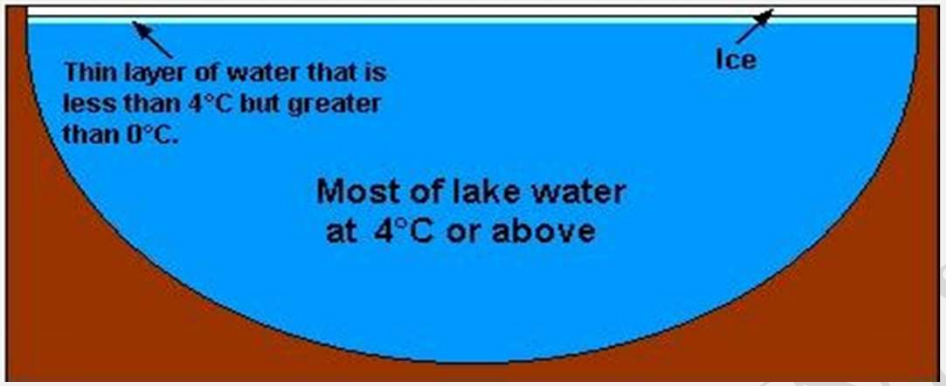
uniform temperature

wind can thoroughly mix the lake water

-Winter Stratification-



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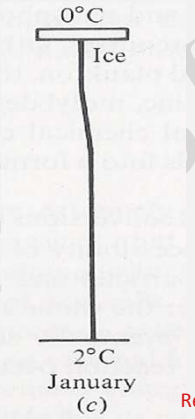


Ref: Peavy, McGraw-Hill, 1985

→ As winter approaches, the surface water is eventually cooled below 4°C.

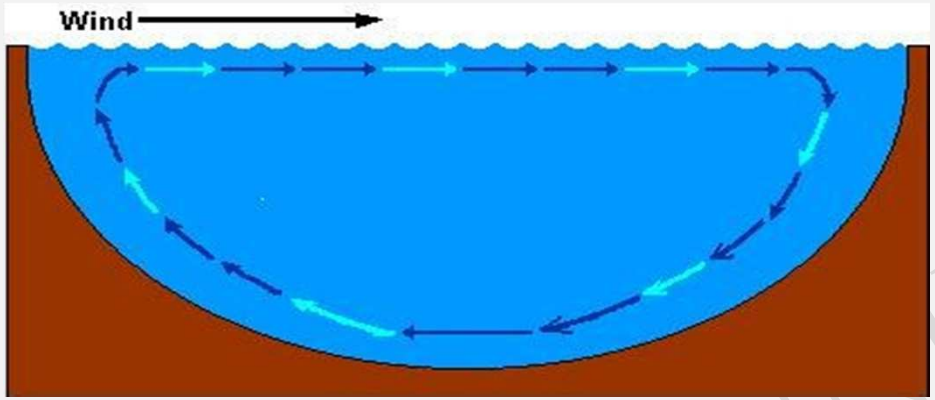
water no longer sinks

→ As water temperatures at the surface reach 0°C,

ice begins to cover the surface of the lake

ice cover prevents wind from mixing the lake water -STRATIFICATION-

-Spring Turnover-



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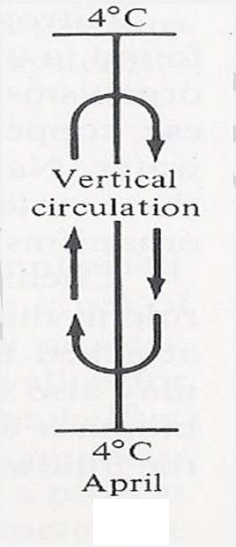


Ref: Peavy, McGraw-Hill, 1985

→ After the ice melts on a lake,

lake water is at the same temperature from the surface to the bottom

wind allows circulation and mixing of the lake water

large amounts of oxygen reaches to the bottom of the lake

Surface Water Contaminants

- Turbidity and Suspended Matter
- Color
- Taste and Odor
- Organic Matter
- Dissolved Gases
- Hardness Ions (Ca^{++}, Mg^{++})
- Iron and Manganese
- Pathogenic Organism

Surface Water Contaminants and Treatment Techniques Used (continue)

CONTAMINANT	SOURCE	TREATMENT
Turbidity and Suspended Matter	Inorganic solids such as clay, silt and other soil constituents	→ Screening → Coag/floc/sed./filt
Color	Organic debris such as leaves, needles of conifers and wood Tannin, humic acid, humates derived from the decomposition of plant matter Suspended matter	→ Coag/floc/sed/filt → Adsorption
Taste and Odor	nonvolatile organic metabolic products of blue green algae dissolved gases (e.g H_2S) some volatile organic chemicals	→ Chemical oxidation (commonly ozonation) prior to coagulation → Adsorption → Aeration

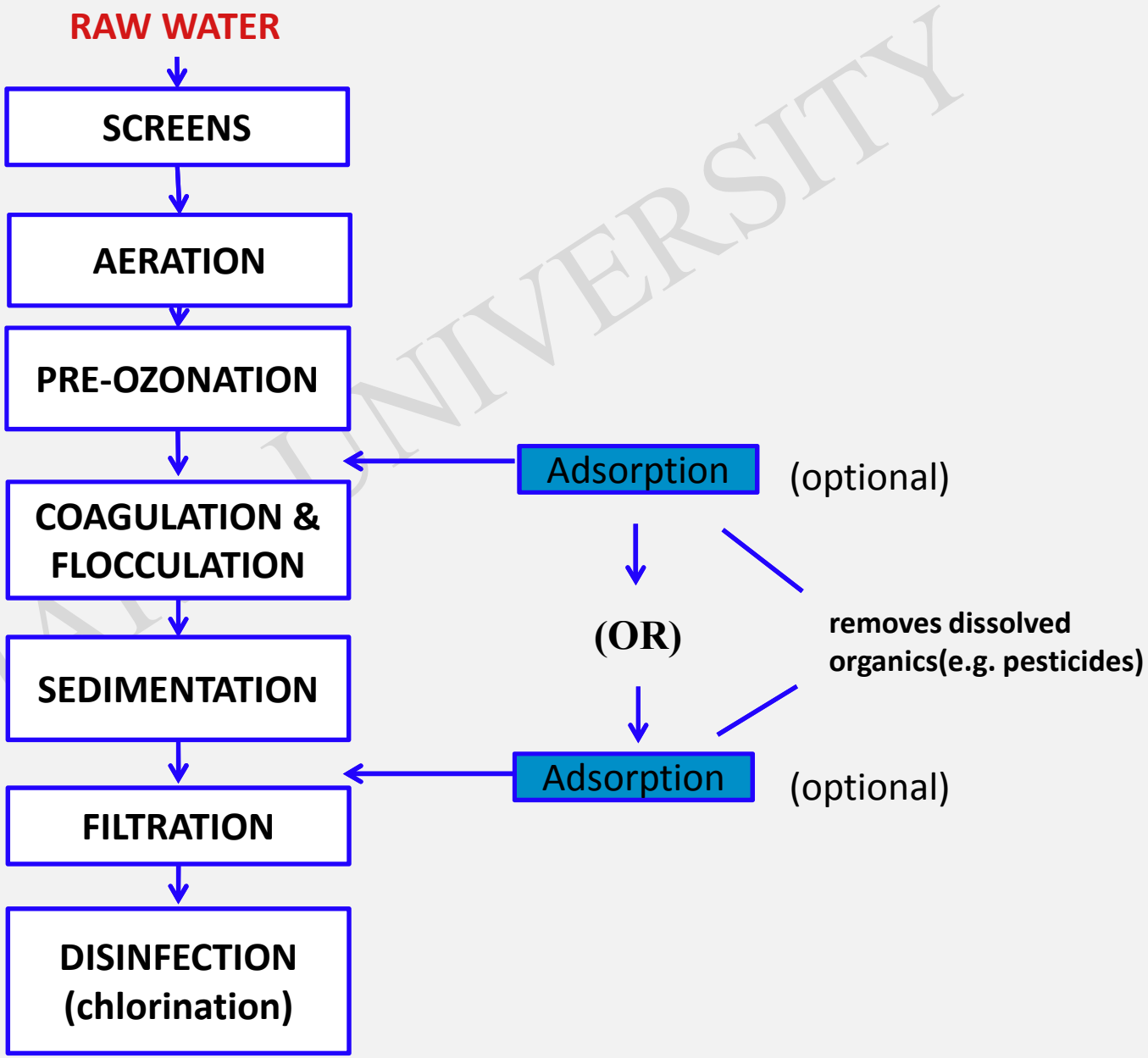
Surface Water Contaminants and Treatment Techniques Used (continue)

CONTAMINANT	SOURCE	TREATMENT
Organic Matter	*from natural sources;* decay products of organic solids, decaying weeds, leaves, especially humic acid derived from the decomposition of plant matter *from human activities;* wastewater discharges agricultural activities (e.g pesticides)	→ Chemical oxidation (e.g ozonation; alter and polymerize metastable organics) followed by coag/floc/sed/filt → Adsorption
Dissolved Gases	from atmosphere (CO_2) from decomposition of organic matter	→ Aeration
Hardness Ions (Ca^{++}, Mg^{++})	contact of water with mineral deposits	→ Chemical precipitation (water softening) *for low flowrates;* → Ion exchange

Surface Water Contaminants and Treatment Techniques Used (continue)

Iron and Manganese Fe^{+2} , Fe^{+3} Mn^{+2} ,Mn^{+4}	Soluble iron(Fe^{+2})and manganese (Mn^{+2}) released from the bottom mads in the waters of the hypolomnion (reservoirs that stratify) until the fall turnover occurs	→ Aeration will not provide oxidation and precip. within a reasonable time, especially for manganese Mn^{+2} Fe^{+2} Oxidation << Oxidation rate rate → Chemical oxid.(eg. ozonation)/precip/filt. → Ion exchange
Heavy Metals	industrial discharge	→ Chemical precipitation → Ion exchange
Pathogenic Organisms	sewage discharge	→ Disinfection

FLOW DIAGRAM THE TREATMENT OF TURBID SURFACE WATER WITH ORGANICS



B)Ground Water Sources (wells, galleries, spring water)

→ Relatively constant in quality from season to season

→ may be highly variable in quality from one well location to another due to changes in hydrogeological conditions

→ superior in quality with respect to surface water

LOW in { *bacteriological content*; *turbidity*; *total organic concentration* } DUE TO NATURAL FILTRATION

→ mineral content (hardness ions (Ca^{++}, Mg^{++}), iron, manganese) may be inferior

→ trace concentrations of organic chemicals (e.g pesticides, herbicides, solvents)

→ location of landfills, buried underground storage tanks etc. should be a part of groundwater quality evaluation

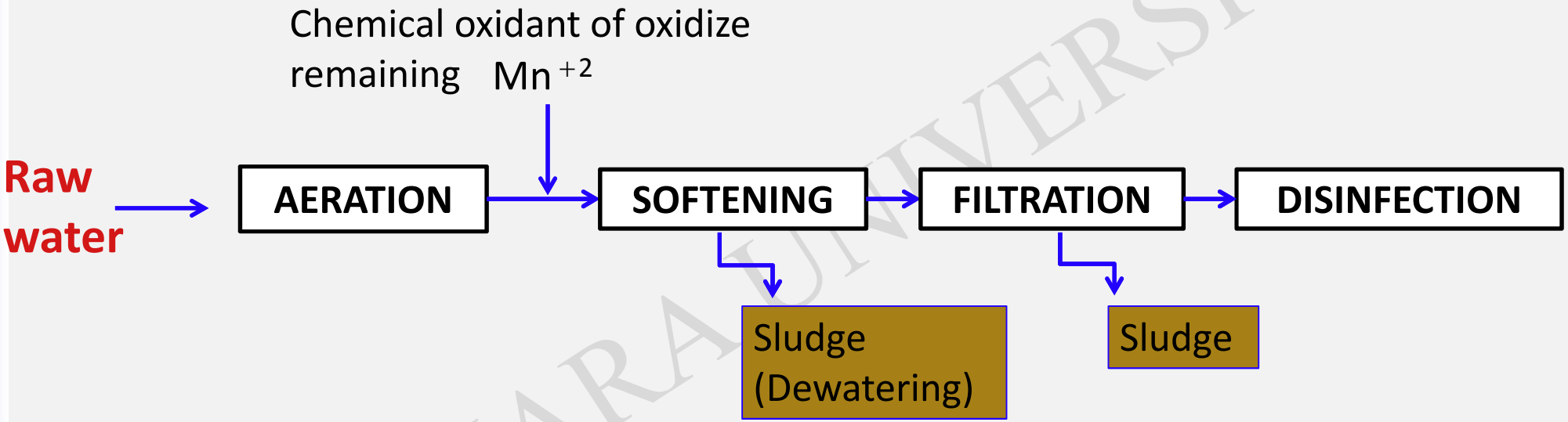
Ground Water Contaminants

- → Fe^{++}, Mn^{++}
- → Dissolved Gases
- → Hardness Ions (Ca^{++}, Mg^{++})
- → Volatile Organics
- → Non-volatile Organics

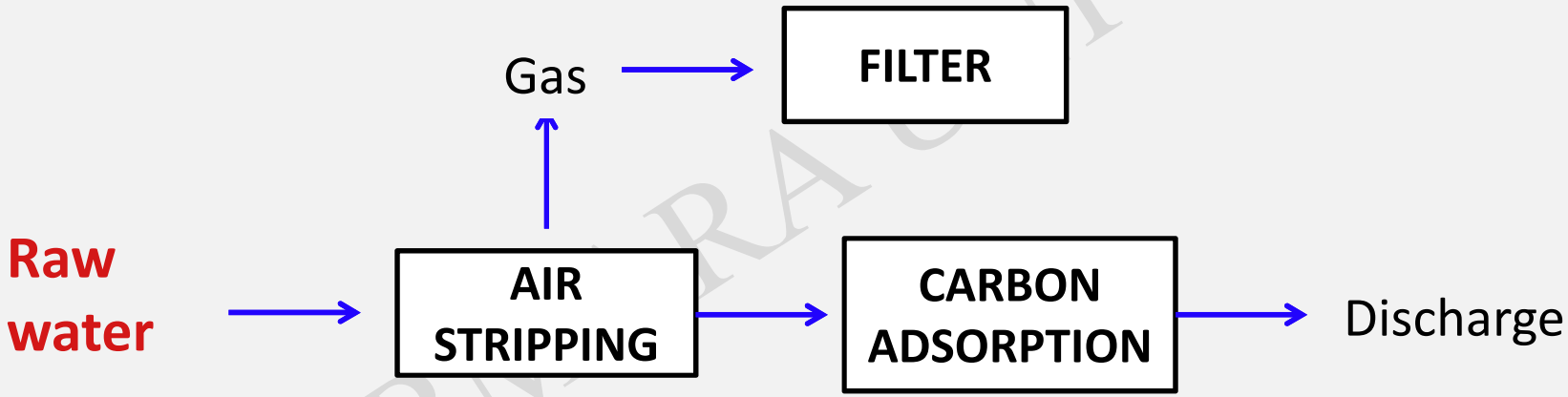
Groundwater Contaminants and Treatment Techniques Used

CONTAMINANT	TREATMENT
Fe^{++}, Mn^{++}	→ Aeration for Fe^{++} oxidation → To Fe^{+++} in some extent → Chemical oxidation for complete oxidation of Fe^{+2} to Fe^{+3}, Mn^{+2} to Mn^{+4}
Dissolved Gases	→ Aeration
Hardness Ions (Ca^{++}, Mg^{++})	→ Chemical Precipitation (water softening for high flowrates) → Ion exchange → Nanofiltration
Volatile Organics	→ Air stripping
Non-volatile Organics	→ Adsorption

Flow Diagram For The Treatment Of Hard Ground Water



Flow Diagram For The Treatment Of Groundwater Contaminated With Volatile & Nonvolatile Organic Compounds



C) Brackish And Saline Waters

Considerable interest in conversion of saline and brackish water as a result of ;

increasing water consumption

depletion of existing water resources

Cost of potable water production
from brackish and saline water >> treating fresh water.

C) Brackish And Saline Waters (Continue)

- May be economical where adequate fresh water is not available
- Treatment techniques used;

  Evaporators

  Ion exchange

  Electrodialysis

  Reverse osmosis

Wastewater

Domestic Wastewater

Industrial Wastewater

Untreated Wastewater Contaminants

- Suspended Solids
- Biodegredable Organics
- Pathogens
- Nutrients (nitrogen, phosphorus)
- Refractory Organics
- Heavy Metals
- Dissolved Inorganic Solids
- Volatile Organics

Quality Of Untreated Wastewater & Treatment Techniques Used

CONTAMINANT	TREATMENT
Suspended Solids	→ Screening, communition → Sedimentation → Floatation → Filtration → Coagulation/sedimentation
Biodegradable Organics	→ Suspended growth aerobic biological systems*(e.g, activated sludge)* → Attached growth aerobic biological systems*(e.g, RBC, trickling filter)* → Anaerobic biological systems
Pathogens	→ Disinfection

Quality Of Untreated Wastewater & Treatment Techniques Used (Continue)

CONTAMINANT	TREATMENT
Nutrients **a) Nitrogen in the form of NH_3** **b) Phosphorus**	→ Biological nitrification and denitrification → Ammonia stripping → Ion exchange → Breakpoint chlorination → Chemical precipitation → Biological phosphorus removal
Refractory Organics	→ Carbon adsorption → Ozonation
Heavy Metals	→ Chemical precipitation → Ion exchange
Dissolved Inorganic Solids	→ Ion exchange → Reverse osmosis → Electrodialysis
Volatile Organics	→ Air stripping

Typical Flow Diagram For The Treatment Of Domestic (Municipal) Wastewater