TW ENVIRONMENTAL

New Technologies for Water & Wastewater Treatment System

Presenter Profile

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Education Qualification

1. PhD (Chemical Engineering), UMPSA
2. Master in Business Administration (MBA), UUM
3. B. Eng.(Hons.) Chemical Engineering, UMPSA
4. B. App. Sc. (Hons) Analytical Chemistry, USM

Professional Qualification

1. MIC - Professional Chemist (ChM.)
2. MBOT - Professional Technologist (Ts.)
3. BEM - Graduate Engineer (Grad. Eng.)
4. IChemE - Associate Member (AMIChemE)

Abbreviation:

MIC - Malaysia Institute of Chemistry
MBOT - Malaysia Board of Technologists
BEM - Board of Engineers Malaysia
IChemE - Institution of Chemical Engineers, UK

Professional Certification

No.	Certification	Area	Certified by
1	Certified Environmental Professionals in the Operation of Industrial Effluent Treatment Systems (Physical Chemical Process), CePIETSO (PCP)	Industrial Effluent	Department of Environment (DOE), Malaysia
2	Certified Environmental Professionals in the Operation of Industrial Effluent Treatment Systems (Biological Process), CePIETSO (BP)	Industrial Effluent	
3	Certified Environmental Professional in Scheduled Waste Management, CePSWaM	Scheduled Waste/ Hazardous Waste	
4	Certified Environmental Professionals in Scrubber Operation, CePSO	Air Pollution Control	
5	Accredited Trainer	Training	Human Resources Development Corporation (HRD Corp)

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Professional Services:

- ***Consultation***
- ***Training***
- ***Research & Development***

Sustainable Environmental Solution

Content

1. Overview of Water and Wastewater Treatment System
2. New Technologies for Water Treatment System
3. New Technologies for Wastewater Treatment System

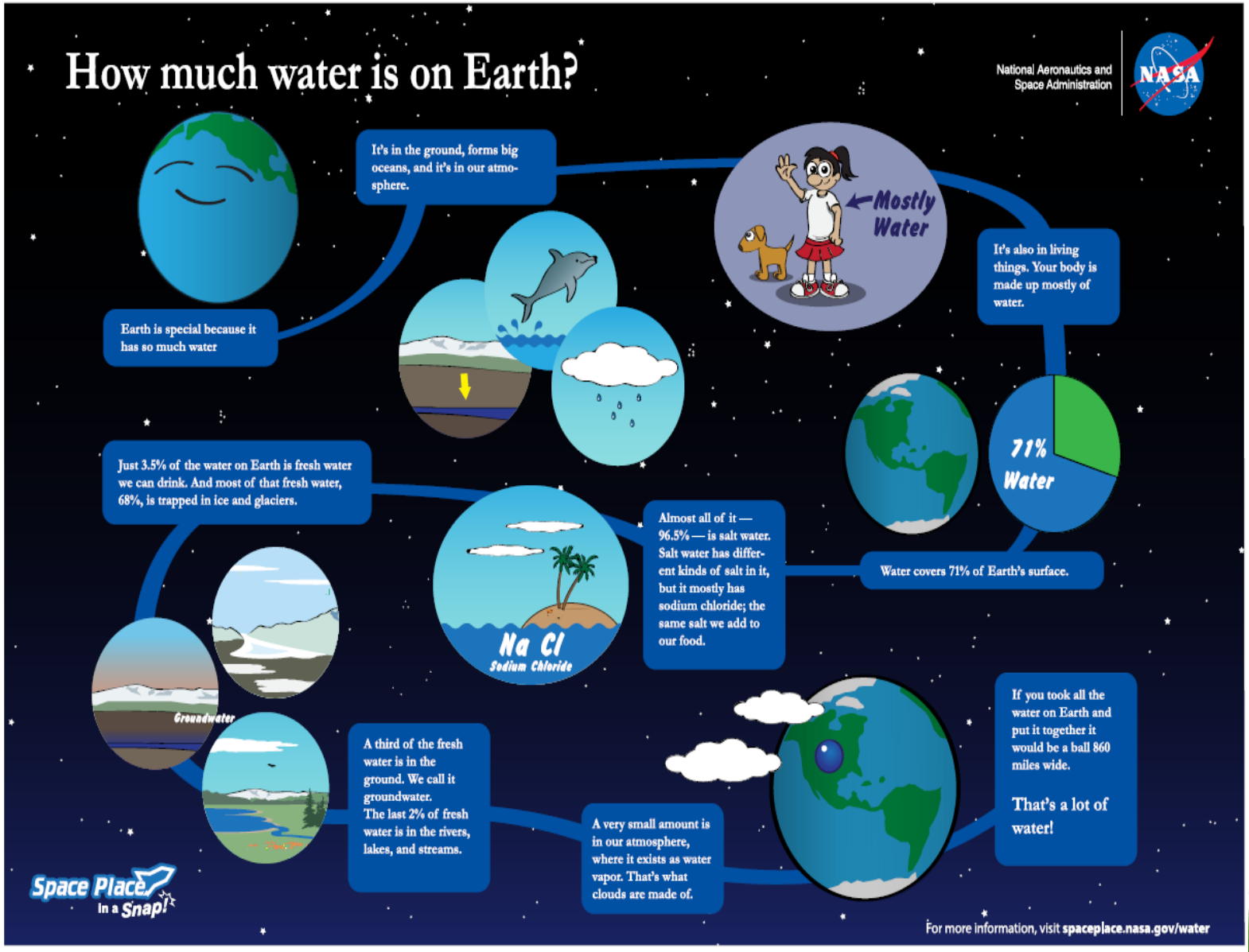
Overview of Water and Wastewater Treatment System

Overview of Water & Wastewater Treatment System

Water (H_2O)

- Universal solvent (Able to dissolved most chemical)
- Colorless, Odorless & Tasteless Liquid
- Exist in nature:
  - Solid (Ice)
  - Liquid (Water)
  - Gas (Vapor)
- Density: 1 g/ml
- Freezes at 0^{o}C; Boils at 100^{o}C

Overview of Water & Wastewater Treatment System

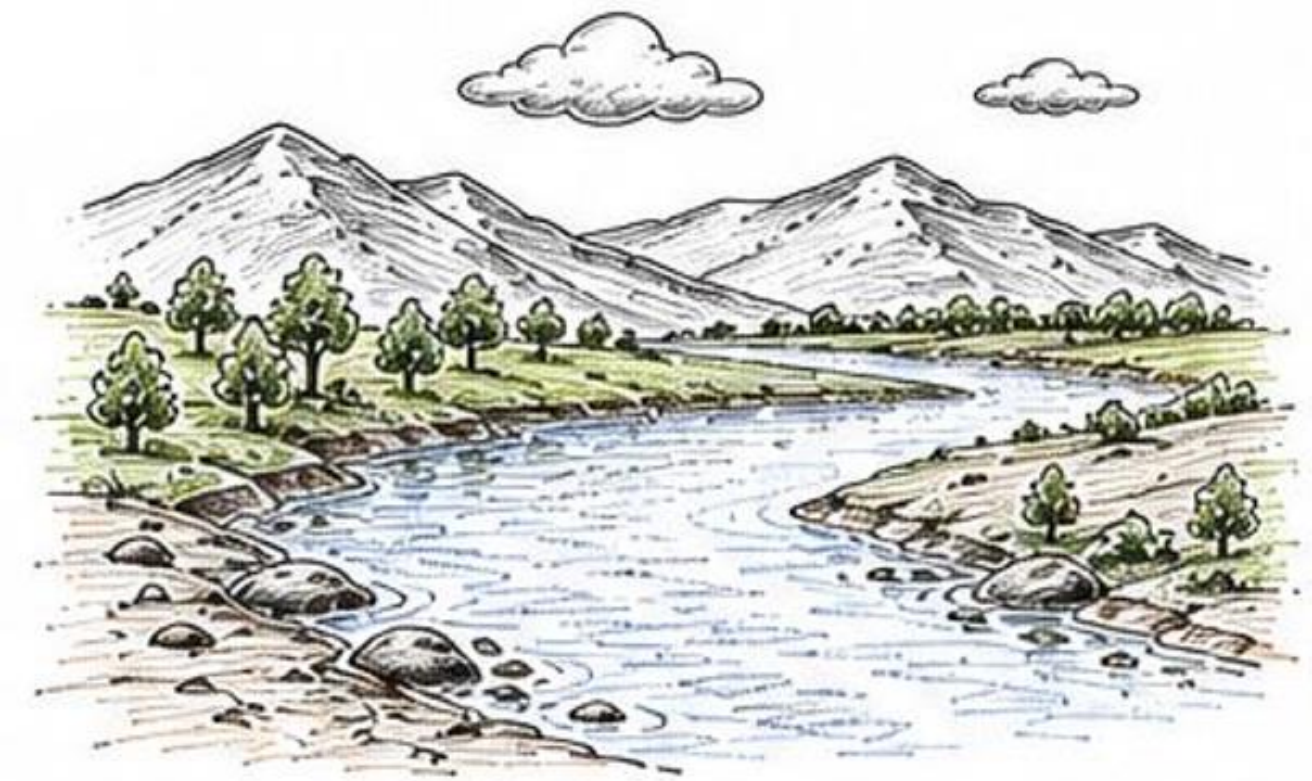


- H_2O = 71% of Earth
  - 96.5% Salt Water
    - ≈ 67% - Ice & Glaciers
    - ≈ 30% - Underground
  - 3.5% Fresh Water
    - ≈ 2% - River, Lakes & Streams
    - < 1% - Water Vapor

Overview of Water & Wastewater Treatment System

BEYOND AVAILABILITY

Water availability means water exits in a source. Water quality determines if it is safe and usable for people, ecosystems, and economic activities.



Overview of Water & Wastewater Treatment System

USABILITY DEPENDS ON QUALITY

Drinking

Safe water is essential for human health.

Agriculture

Clean water supports crop production & food security.

Industry

Quality water ensures efficient & safe industrial processes.

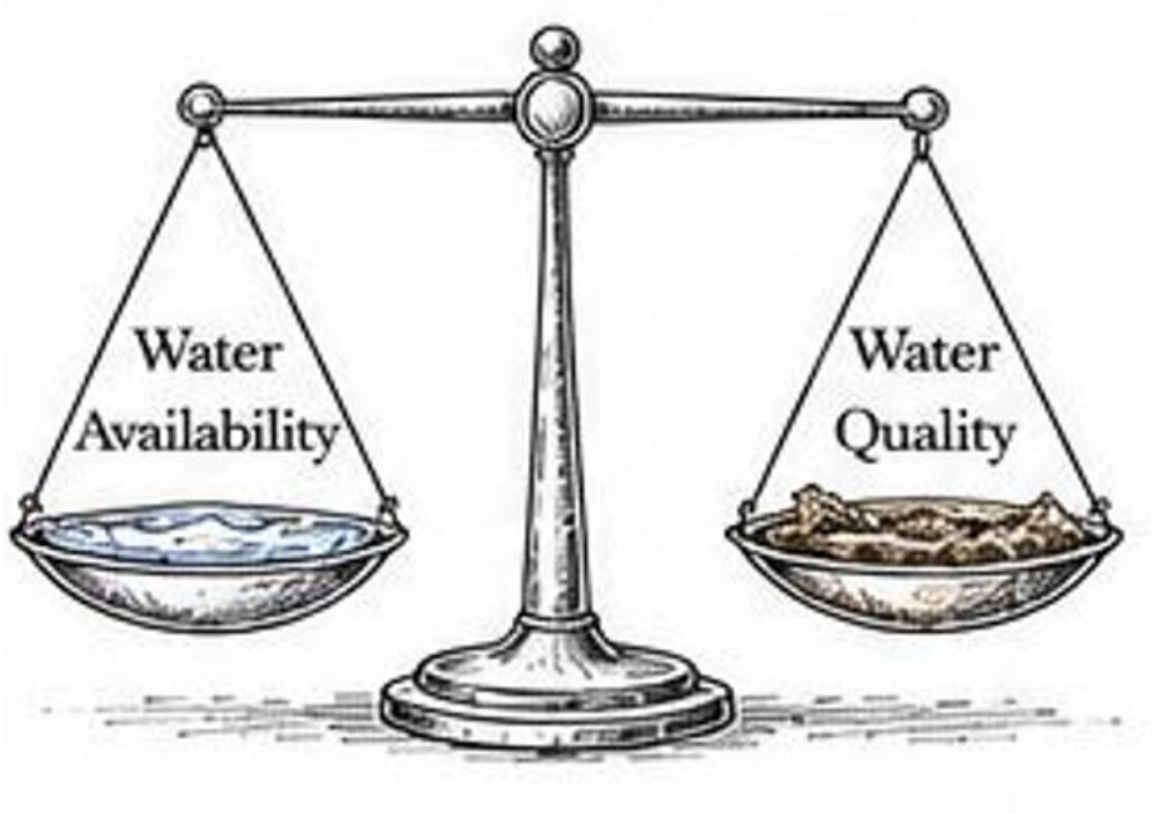
Ecosystems

Healty ecosystems depend on clean and unpolluted water.

THE HIDDEN SCARCITY

Water may be available, but if the quality is poor, it cannot be used.

Poor quality water creates a hidden form of scarcity that affects health, livelihoods, and development.



IMPACTS OF POOR WATER QUALITY

Health Risks

Contaminated water causes diseases & health problems.

Reduced Productivity

Poor quality water reduces crop yields & economic output.

Ecosystem Damage

Pollution harms aquatic life & disrupts ecosystem balance.

High Treatment Cost

Cleaning polluted water requires more energy, technology & money

Social Inequity

Communities with less resources are affected the most.

Overview of Water & Wastewater Treatment System

SOURCES OF WATER POLLUTION

Domestic Sewage

Untreated wastewater contaminates water sources.

Industrial Effluents

Chemicals & toxins from industries degrade water quality.

Agricultural Runoff

Fertilizers & pesticides wash into water bodies & cause pollution.

Solid Waste

Improper waste disposal leads to leachate & water contamination.

Urban Runoff

Oil, heavy metals & other pollutants flow into water bodies.

Overview of Water & Wastewater Treatment System

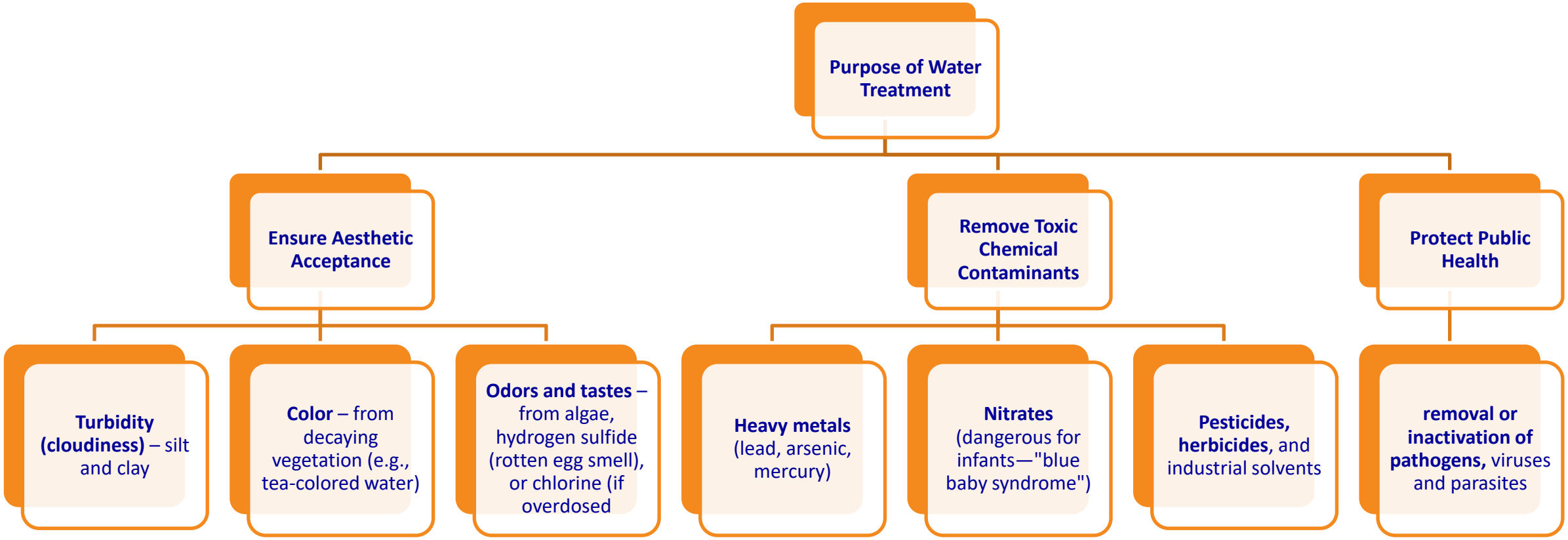
WHAT CAN WE DO

- ✓ Prevent pollution at the source
- ✓ Treat wastewater before discharge
- ✓ Promote sustainable agriculture
- ✓ Proper waste management
- ✓ Protect water bodies and wetlands
- ✓ Monitor and enforce water quality standards
- ✓ Raise awareness and build responsibility

Overview of Water & Wastewater Treatment System

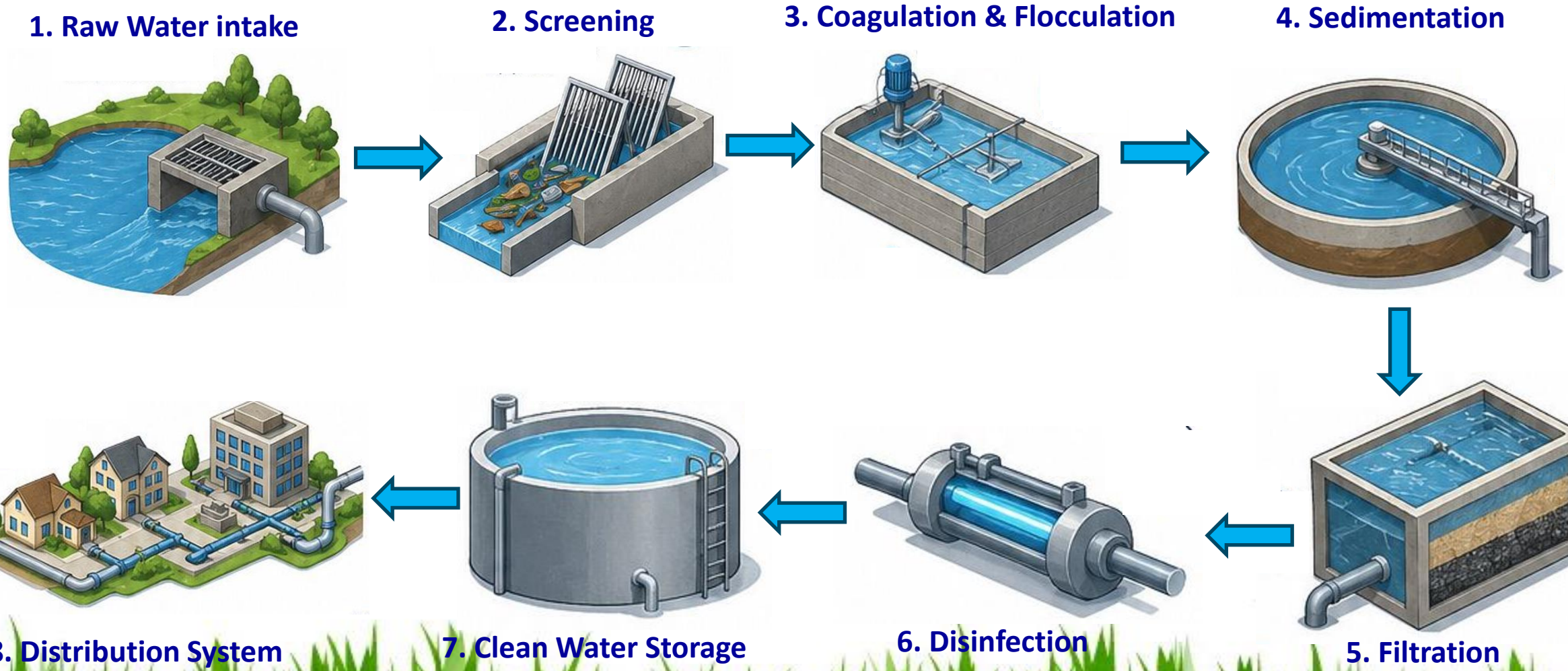
WATER TREATMENT SYSTEM

Overview of Water & Wastewater Treatment System



Overview of Water & Wastewater Treatment System

WATER TREATMENT PLANT PROCESS FLOW



Overview of Water & Wastewater Treatment System

FUNCTION OF OPERATION UNIT IN WATER TREATMENT PLANT

1. Raw Water intake

Withdraw raw water from source at controlled rate

2. Screening

Remove large debris to protect equipment

3. Coagulation & Flocculation

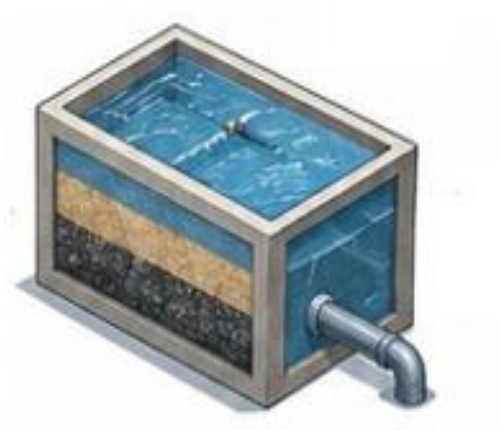
Aggregate fine particles into settleable flocs

4. Sedimentation

Remove flocs by gravity settling

Overview of Water & Wastewater Treatment System

FUNCTION OF OPERATION UNIT IN WATER TREATMENT PLANT



5. Filtration

Remove remaining fine particles and microbes

6. Disinfection

Kill pathogens and maintain residual in pipes

7. Clean Water Storage

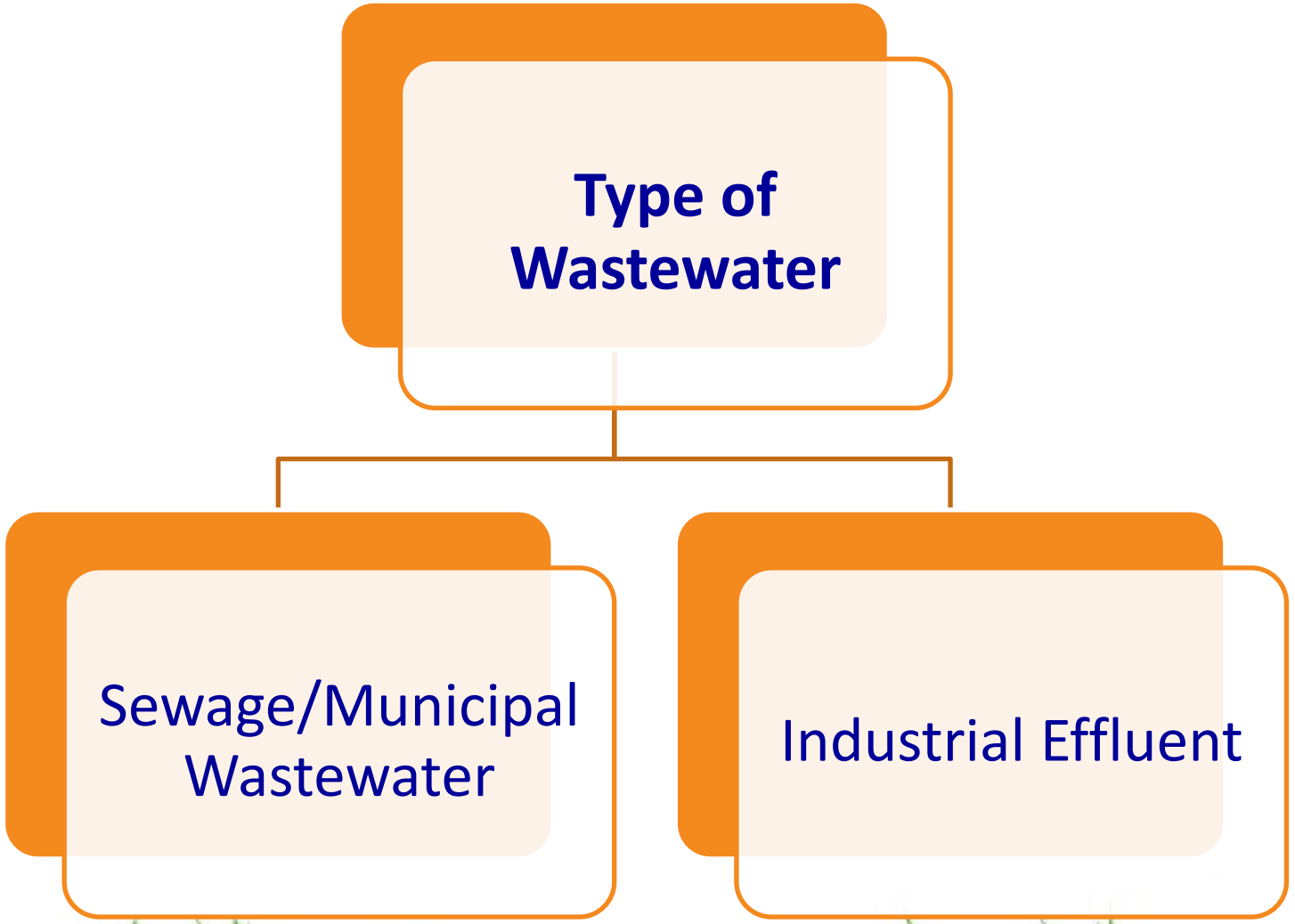
Store treated water

8. Distribution System

Deliver safe water to users

WASTEWATER TREATMENT SYSTEM

Overview of Water & Wastewater Treatment System



Overview of Water & Wastewater Treatment System

1. Environmental Conservation Law (2012)
2. Environmental Conservation Rules (2014)
3. National Environmental Quality (Emission) Guidelines (2015)

Purpose of Wastewater Treatment

- Reducing the impact of impurities on the environment and public health
- Removal of impurities and contaminants to enable discharge or re-use
- Ensuring conformity with legislation, regulations, standards and codes

Overview of Water & Wastewater Treatment System

WASTEWATER TREATMENT PLANT PROCESS FLOW – Sewage

Sewage

1. Screening

2. Grit Chamber

3. Primary Clarifier

4. Aeration Tank

5. Secondary Clarifier

6. Treated Water

Overview of Water & Wastewater Treatment System

WASTEWATER TREATMENT PLANT PROCESS FLOW – Industrial Effluent

Raw Influent

1. Equalization Tank

2. Coagulation & Flocculation

3. Primary Clarifier

4. Aeration Tank

5. Secondary Clarifier

6. Tertiary Treatment

Final Discharge

Overview of Water & Wastewater Treatment System

FUNCTION OF OPERATION UNIT IN WATER TREATMENT PLANT

-Sewage

1. Screening

Removes large floating and suspended solids (e.g., rags, sticks, plastics, debris) to protect downstream equipment from clogging, damage, or wear.

2. Grit Chamber

Removes heavy inorganic particles such as sand, gravel, grit, and eggshells by reducing flow velocity, preventing abrasion of mechanical equipment and accumulation in digesters or pipelines.

3. Primary Clarifier

Reduces flow velocity further to allow settleable organic and inorganic solids (primary sludge) to settle by gravity, and floating materials (scum) to rise and be skimmed off.

Overview of Water & Wastewater Treatment System

FUNCTION OF OPERATION UNIT IN WATER TREATMENT PLANT -Sewage

4. Aeration Tank

Provides oxygen and mixing to support aerobic microorganisms that biologically degrade dissolved and colloidal organic matter (eg: BOD and COD).

5. Secondary Clarifier

Separates biological flocs (activated sludge) from the treated wastewater and settled sludge by gravity settling.

6. Treated Water

Clarified and biologically treated sewage that has met discharge or reuse standards

FUNCTION OF OPERATION UNIT IN WATER TREATMENT PLANT

-Industrial Effluent

1. Equalization Tank

Dampens flow and concentration fluctuations (hydraulic and organic shock loads) ensuring a consistent flow rate and pollutant load for stable treatment performance

2. Coagulation & Flocculation

- **Coagulation:** Neutralizes the negative charges on fine suspended particles and colloids
- **Flocculation:** Gently mixes the water to promote collisions among destabilized particles, forming larger, settleable flocs

3. Primary Clarifier

Removes settleable organic and inorganic solids by gravity sedimentation, and skims off floating scum (oil, grease).

FUNCTION OF OPERATION UNIT IN WATER TREATMENT PLANT

-Industrial Effluent

4. Aeration Tank

Provides oxygen and mixing to support aerobic microorganisms that biologically degrade dissolved and colloidal organic matter (eg: BOD and COD).

5. Secondary Clarifier

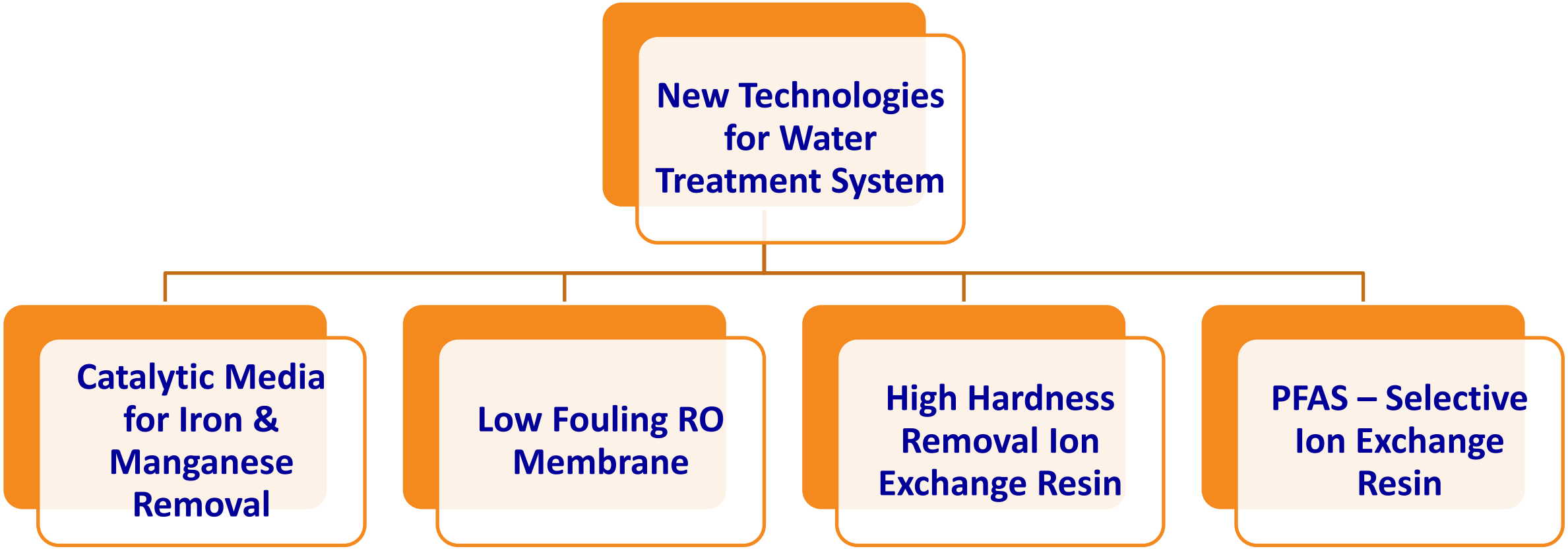
Separates biological flocs (activated sludge) from the treated wastewater and settled sludge by gravity settling.

6. Tertiary Treatment

Provides advanced polishing beyond secondary treatment to remove residual suspended solids and dissolved organics.

New Technologies for Water Treatment System

New Technologies for Water Treatment System



New Technologies for Water Treatment System

1. Catalytic Media for Iron & Manganese Removal

New Technologies for Water Treatment System

Problem Statement of Iron & Manganese in Water

Aesthetic -

Color, turbidity & odor

Operational –

Pipe & Equipment Scaling, membrane fouling

Economic –

Increase energy & replacement cost

Core Principles

- Both iron and manganese are naturally found in groundwater in dissolved forms (ferrous iron, Fe^{2+}, and manganese(II), Mn^{2+}).
- When these dissolved forms come into contact with a strong enough oxidant (like oxygen in the air), they undergo a chemical reaction.
- This process, called oxidation, transforms them into solid, particle forms (ferric iron, Fe^{3+}, and manganese(IV), Mn^{4+}).
- These solid particles are then large enough to be trapped and removed by a filter, typically a media filter.

Conventional Treatment Methods

No	Treatment Method	Descriptiond
1	Aeration + Sand Filter	Low cost, minimal chemicals, but not effective for manganese.
2	Chemical Oxidation + Filter	Very effective for both metals but requires handling and storage of chemicals.

Description of Catalytic Media

- Catalytic media for the removal of dissolved iron and manganese compound in raw water.
- Working mechanism: Enhance the reaction between dissolved oxygen (DO) and the iron & manganese compound.

Chemistry Mechanism

Iron Removal:

- Dissolved iron in water is typically present as ferrous bicarbonate, $Fe(HCO_3)_2$. When in contact with a catalytic media, the media acts as a catalyst between dissolved oxygen and the soluble iron compounds, accelerating the oxidation of ferrous iron (Fe^{2+}) to ferric iron (Fe^{3+}). The resulting ferric ions then form ferric hydroxide, $Fe(OH)_3$, which precipitates out of solution.
- .

Manganese Removal:

- Dissolved manganese is usually found as manganese(II) compounds. Upon reaction with the catalytic media, manganese(II) is oxidized and precipitated as manganese(IV) oxide (MnO_2).

Advantage of Catalytic Media

- **Low Maintenance & Cost** – No chemicals or regenerants required; only periodic backwashing.
- **Environmentally Friendly** – Backwash water contains only oxidized iron (rust), free of toxic chemicals.
- **Removal Efficiency** – Extremely high.
- **Economical** – The media is not consumed during the reaction, ensuring a long lifespan, and the system typically has a lower purchase cost.

Disadvantage of Catalytic Media

- **Strict Water Requirements**: It **cannot** be used if your water contains hydrogen sulfide (rotten egg smell), oil, or chlorine, as these substances will damage the media .
- **Needs Oxygen**: Dissolved oxygen is required; aeration system may need to be installed at upstream

Conditions for Operation

- Alkalinity should be greater than two times the combined sulfate and chloride concentration.
- pH should be 6.8 – 8.0.
- Dissolved Oxygen content must be equal to at least 15% of the iron (or iron and manganese) content.
- Bed Depth: 0.75 – 0.90 meter
- Backwash rate: 410 to 490 LPM per square meter
- Backwash bed expansion: 35% to 50%.

2. Low Fouling RO Membrane

Core Concept of Filtration Process

- **Filtration is a physical or mechanical separation process** that divides a mixture into two distinct streams:
  1. **Filtrate (or Permeate):** The fluid (liquid or gas) that successfully passes through the filter medium.
  2. **Retentate (or Residue):** The solid particles that are captured and retained by the filter medium.

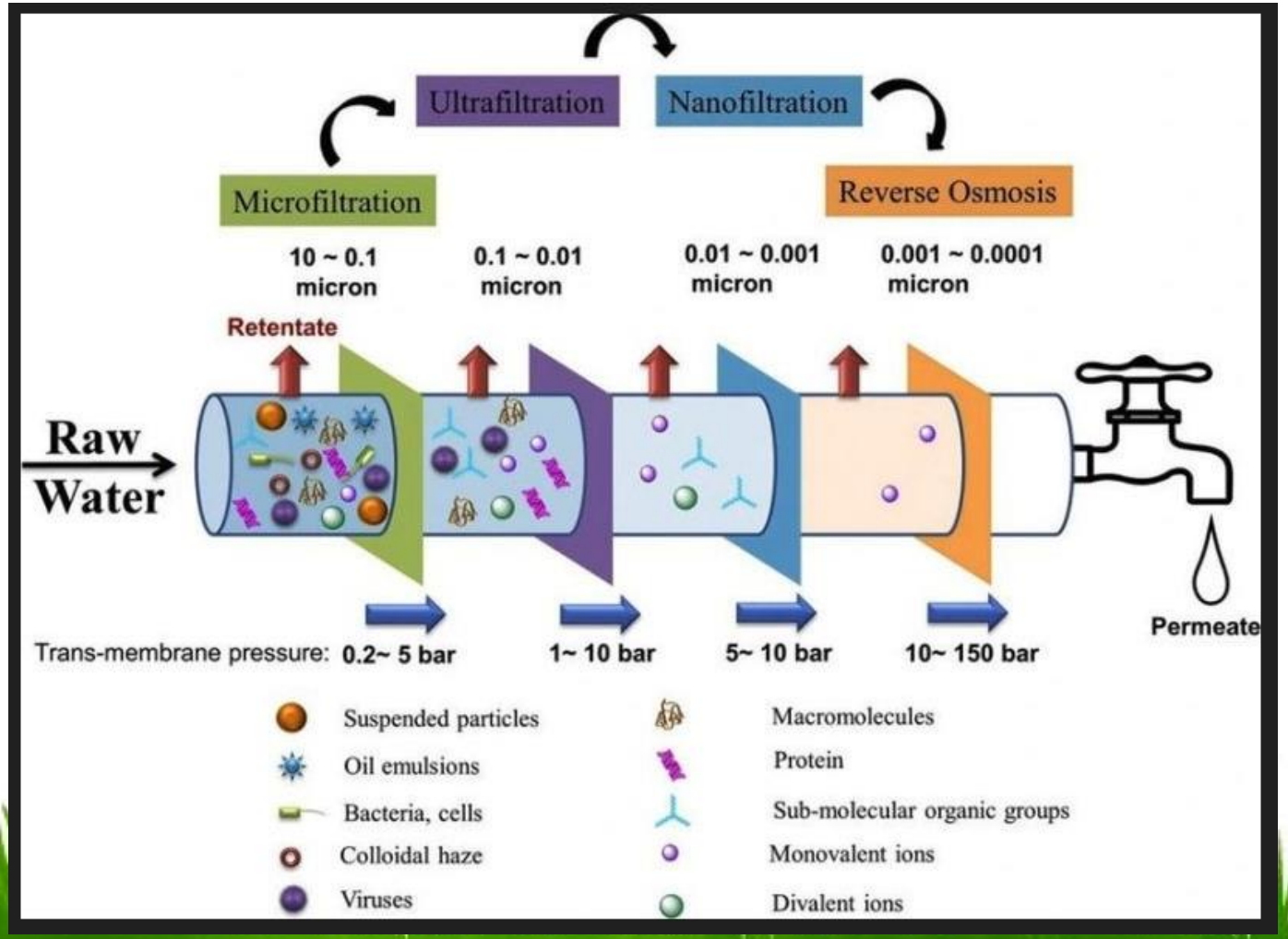
- The driving force behind filtration is always a **pressure difference** across the filter medium. Fluid flows from the high-pressure side (upstream) to the low-pressure side (downstream), while solids are blocked.

Membrane Filtration Process

- Membrane filtration is a pressure-driven separation process that uses **semi-permeable membranes** to remove particles, microorganisms, and dissolved substances from liquids.
- This technology is widely applied in water treatment, food processing, pharmaceuticals, and industrial wastewater management due to its high efficiency and compact design.

New Technologies for Water Treatment System

Type of Membrane Filtration Process

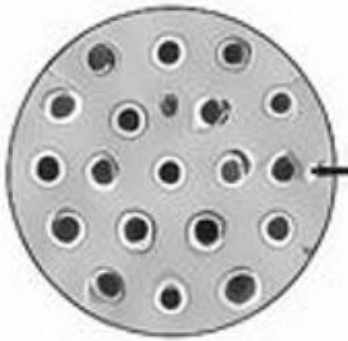


New Technologies for Water Treatment System

WHAT IS REVERSE OSMOSIS?

Reverse Osmosis (RO) is a water purification process that uses a semi-permeable membrane to remove dissolved salts, chemicals, heavy metals, bacteria, viruses and other contaminants from water.

SIZE OF RO MEMBRANE PORE



0.0001 micron
(0.1 nanometer)

Only water molecules can pass through these microscopic pores.

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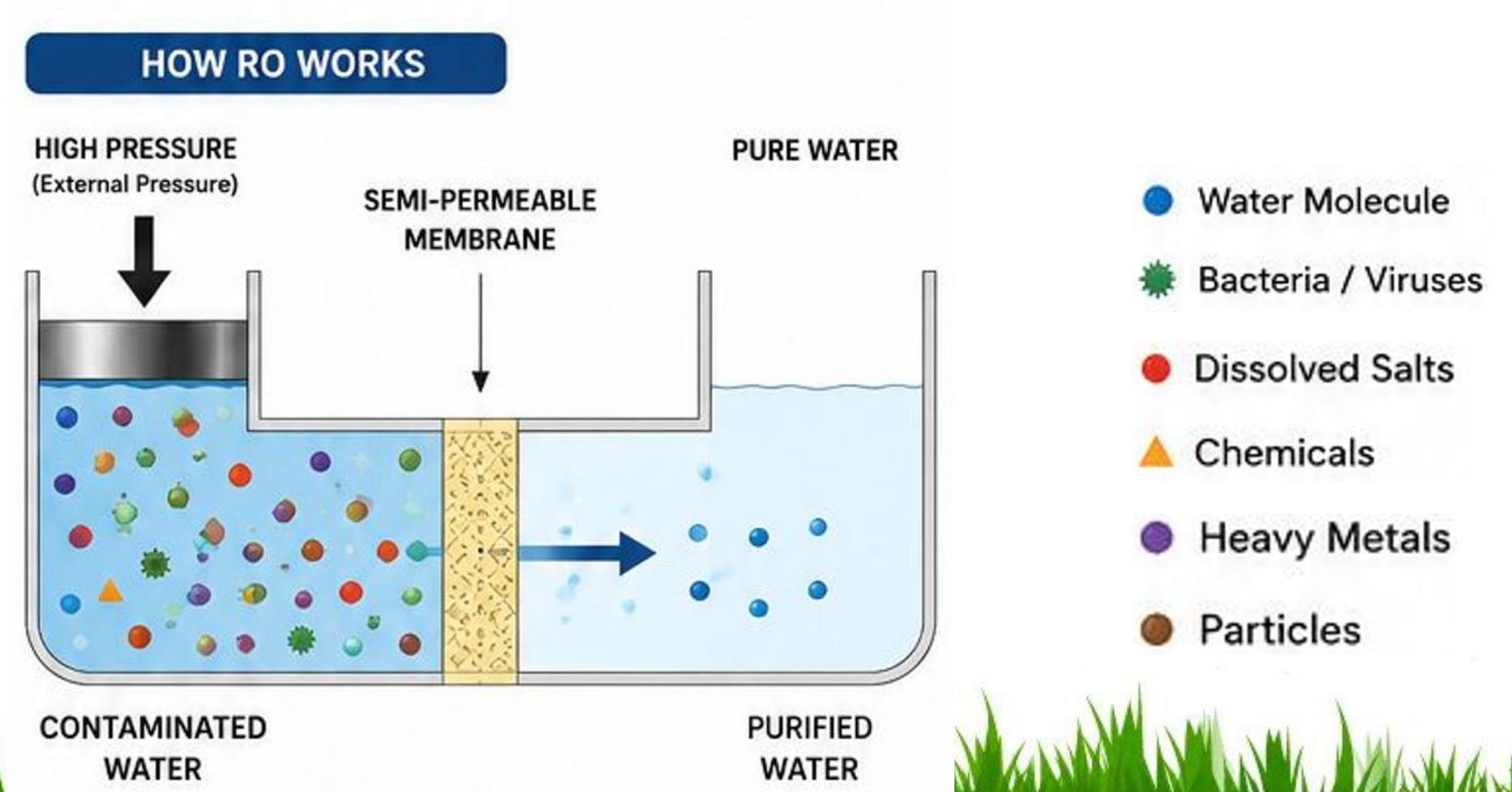

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TYPICAL REJECTION EFFICIENCY

95% –99%

of dissolved impurities and contaminants

COMMON OPERATING PRESSURE

- Brackish Water RO: 10 – 20 bar
- Seawater RO: 55 – 80 bar

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ADVANTAGES

- Produces highly purified water
- Removes dissolved salts effectively
- Compact and reliable system
- Essential for desalination
- Improves taste and odor

LIMITATIONS

- Water wastage in reject flow
- Requires electricity and pressure
- Removes beneficial minerals
- Membrane fouling can occur
- Requires periodic maintenance

APPLICATIONS

- Drinking water treatment plants
- Seawater & brackish water desalination
- Pharmaceutical industries
- Food & beverage industries
- Boiler feed water treatment
- Industrial water treatment
- Wastewater recycling

IMPORTANT PARAMETERS

TDS (Total Dissolved Solids)
WHO desirable level:
below 300 ppm
Acceptable up to 500 ppm

pH Range
Typical operating pH: 3 to 11
(depending on membrane type)

Recovery Ratio
% of purified water produced
Domestic RO: 25% – 50%
Industrial RO: 50% – 85%

What is Membrane Fouling?

- Membrane fouling is accumulation of unwanted materials on the membrane surface or inside the pores, which reduces permeate flow, increases pressure and decreases salt rejection.
- Fouling cannot be seen easily, but it slowly kills the performance and life of RO system.

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Types of Fouling

SCALING (INORGANIC)
$CaCO_3$, $CaSO_4$, $BaSO_4$, SiO_2, Metal Hydroxides

- Cause by high hardness, PH, TDS
- Forms hard scale on membrane

BIOFOULING (BIOLOGICAL)
Bacteria, Algae, Fungi, Slime

- Cause by bacteria growth
- Forms biofilm layer, blocks flow

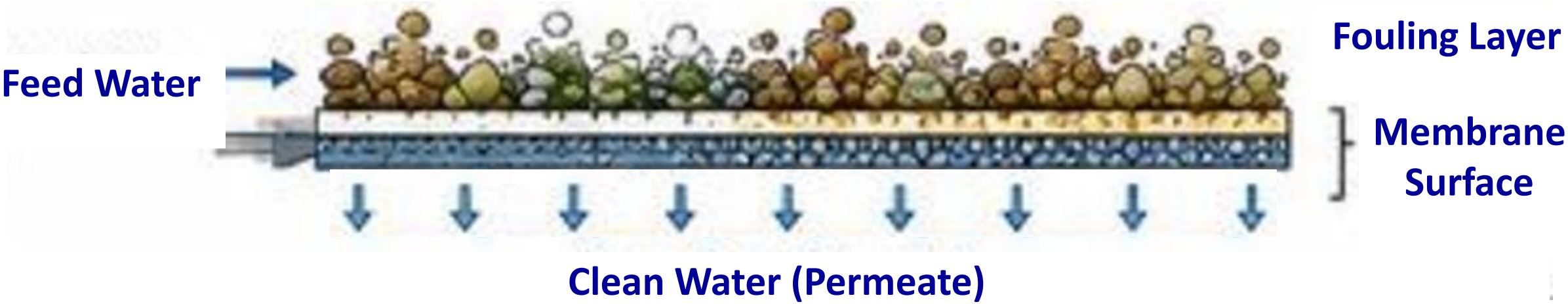
ORGANIC FOULING (ORGANIC MATTER)
Natural Organic Matter, Oils, Grease, TOC

- Cause by organic in feed water
- Forms sticky layers, reduces flux

COLLOIDAL FOULING (PARTICULATE)
Silts, Clays, Metal Oxides, Colloidal Particles

- Cause by fine suspended solids
- Blocks membrane pores

Membrane Fouling



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Effect of Membrane Fouling

Increase in Differential Pressure (ΔP)
High pressure drop across membrane

Decreases in Permeate Flow
Lower water production

Higher Energy Consumption
More power required

Poor Salt Rejection
High TDS in permeate

Frequent Cleaning Required
More downtime and maintenance

Shorter Membrane Life
High replacement cost

New Technologies for Water Treatment System

How to Prevent Membrane Fouling

Effective Pre-Treatment
Use MMF, ACF, UF to remove SDI, organic, turbidity

Anti-scalant Dosing
Prevents scale formation from hardness and silica

SDI Control
Maintain SDI < 3 for RO feed

Regular CIP Cleaning
Clean membranes before severe fouling develops

Proper Disinfection Control
Use non-oxidizing biocide as per guidelines

Operate Within Design Limits
Follow recommended recovery, flux and pressure limits

New RO Membrane Technology
Low Fouling (LF) RO Membrane

- A **Low Fouling (LF) RO membrane** is a type of reverse osmosis membrane whose surface has been chemically or physically modified to **resist the adhesion of contaminants** and enhance the **Hydrophilicity of RO membrane** that allow water spreads completely across the surface, forming an ultra-thin hydration layer to increase the flux (LMH) or permeate.

New Technologies for Water Treatment System

Key Characteristic of LF RO Membrane

Features	Conventional RO Membrane	LF RO Membrane
Surface Property	Neutral or slightly hydrophobic	Super Hydrophilic
Foulant Interaction	High adsorption of organic/bacteria	Low adhesion, easier to clean
Flux Decline	Rapid (eg: 47% drop in testing)	Slower (eg: 27% drop)
Cleanability	Poor flux recovery after washing	High recovery
Feed Spacer	28 mil	34 mil

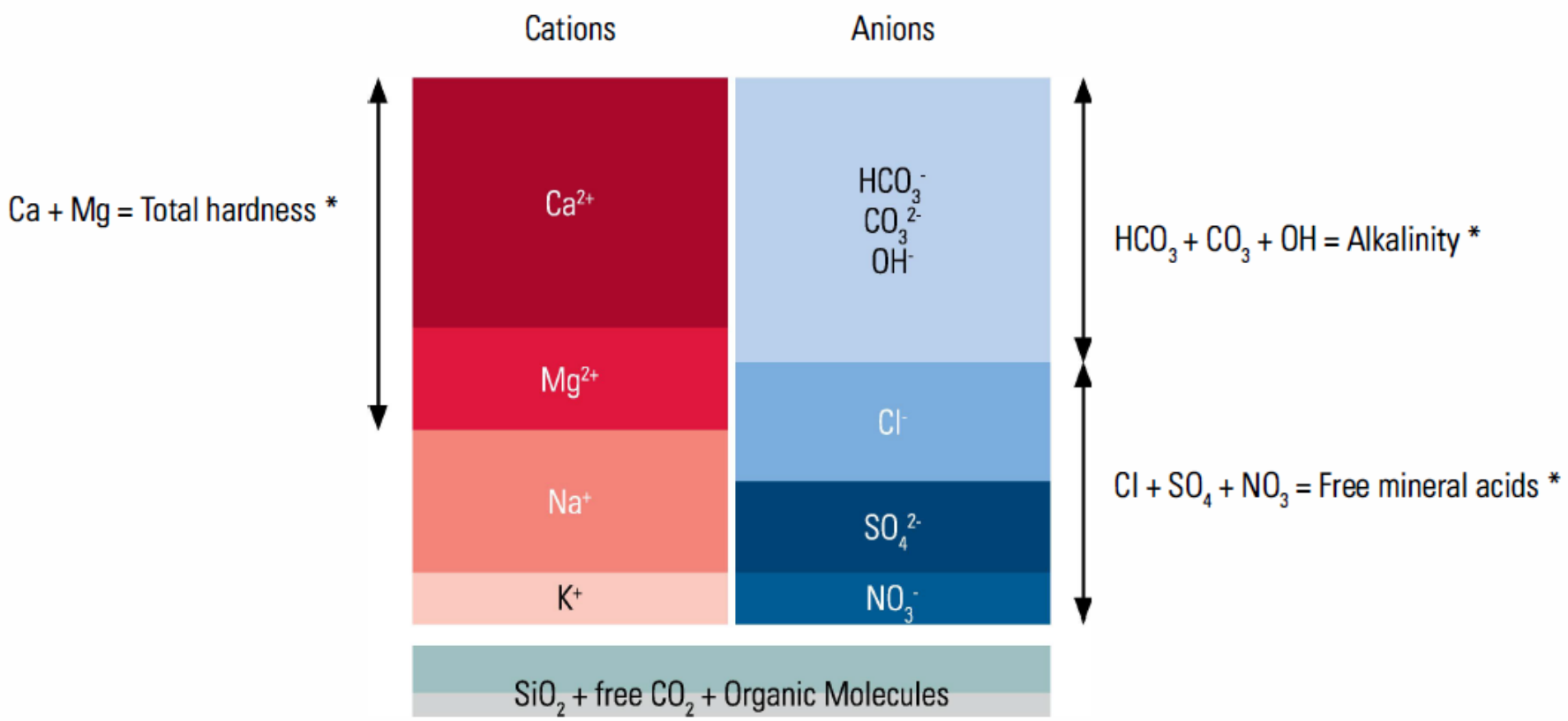
New Technologies for Water Treatment System

Key Features of LF RO Membrane

3. High Hardness Removal Ion Exchange Resin

Composition of Water

- In general, water may contain cationic, anionic, and neutral molecules.



Problem Statement

- The core problem is that standard methods of water treatment (simple filtration or disinfection) do not remove these ions, leading to two distinct operational failures:
  - **Temporary Hardness (Carbonate):** When water containing calcium bicarbonate ($Ca(HCO_3)_2$) is heated, it decomposes to form insoluble calcium carbonate ($CaCO_3$) scale.
  - **Permanent Hardness (Non-Carbonate):** Ions paired with sulfates (SO_4^{2-}) or chlorides (Cl^-) do not precipitate upon heating but interfere with surfactants and industrial processes.

New Technologies for Water Treatment System

- A water supply is considered problematic if total hardness exceeds 120 ppm as $CaCO_3$. The specific problems include:
  - **Domestic & Laundry:** Soap precipitation (scum), reducing cleaning efficiency by 30-50%, and fabric damage.
  - **Industrial (Boilers):** Scale formation (every 1 mm of scale increases fuel costs by 2-5%) and tube overheating/failure due to low thermal conductivity of scale (1-3 W/m·K vs. steel at 45 W/m·K).
  - I**ndustrial (Cooling Towers):** Fouling of heat exchange surfaces and promotion of corrosion under scale deposits.
  - **Municipal:** Increased coagulant demand in water treatment plants and customer complaints regarding taste and dry skin/hair.

Conventional Method of Hardness Removal

- The conventional method to remove hardness in waster is by precipitate process and follow up solid-liquid separation.
- The process uses two primary chemicals:
  a) **Lime (Calcium Hydroxide, $Ca(OH)_2$):** Used primarily to remove **carbonate hardness** (temporary hardness) .
  b) **Soda Ash (Sodium Carbonate, Na_2CO_3):** Used to remove **non-carbonate hardness** (permanent hardness) .

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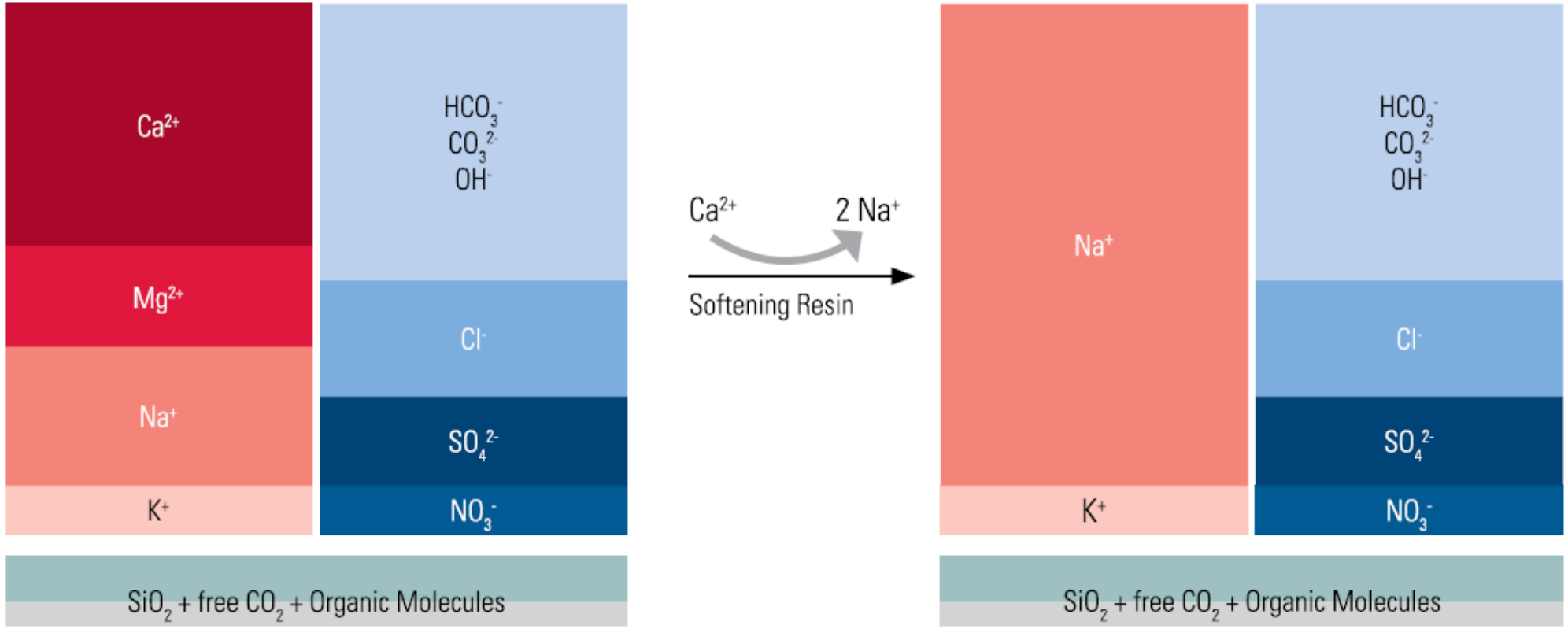
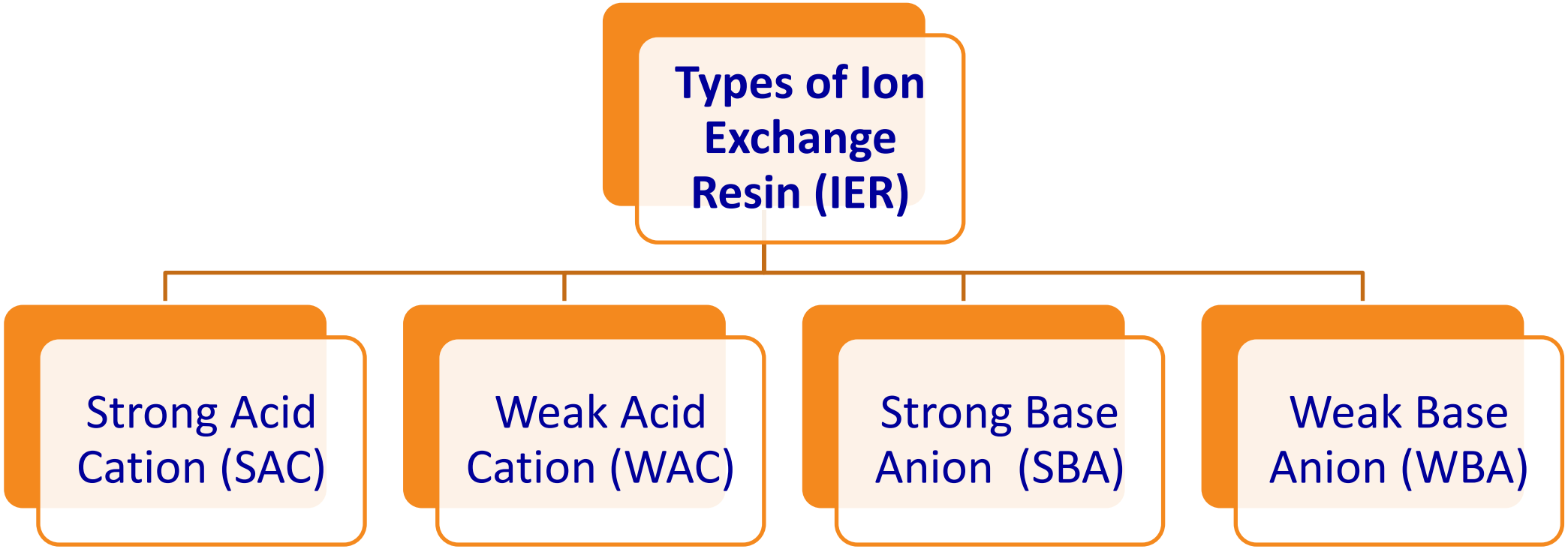
New Hardness Removal Methods

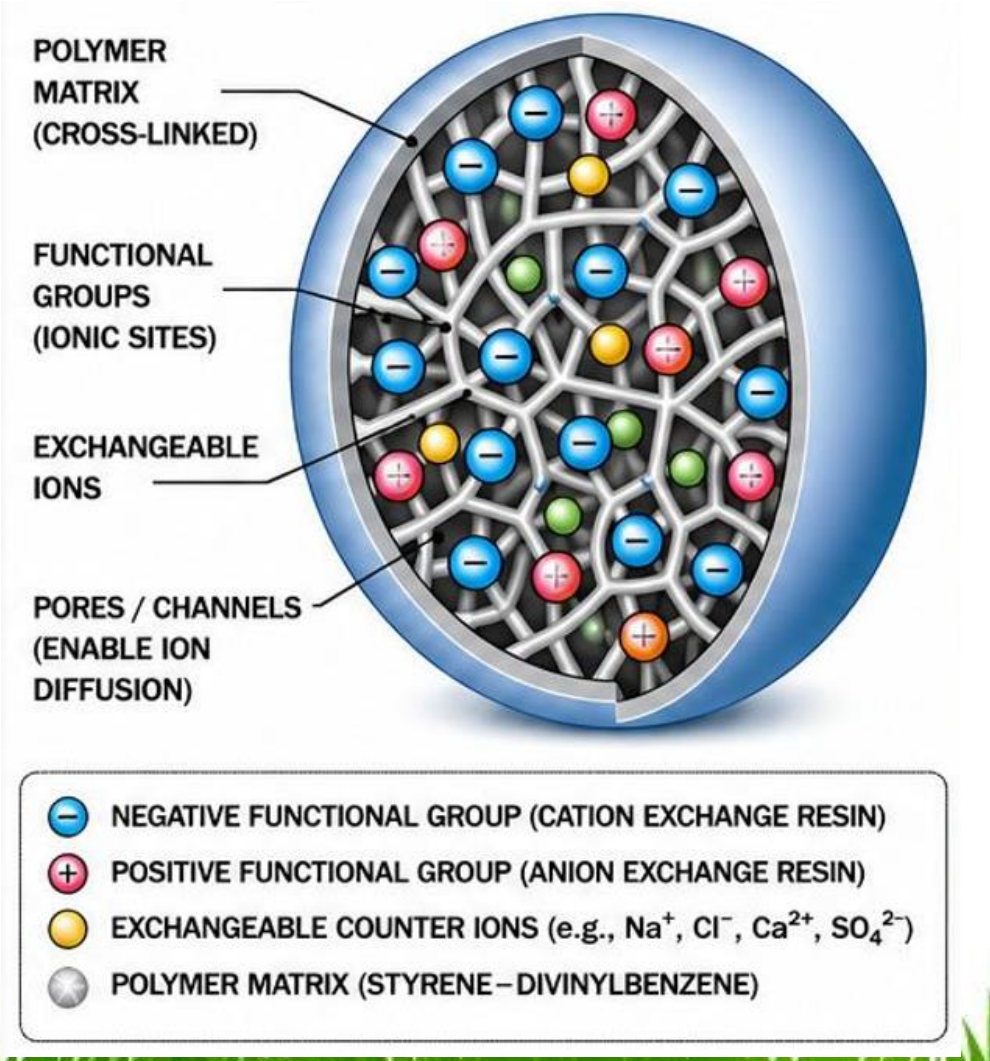
- To remove hardness from water, softening is commonly used using Ion Exchange Resin (IER).



New Technologies for Water Treatment System



Structure of Ion Exchange Resin Bead



The common functional groups are in four categories:

- ✓ Strongly acidic (Sulfonate, $-SO_3^-$)
- ✓ Weakly acidic (Carboxylate, $-COO^-$)
- ✓ Strongly basic (Quaternary amine, $-N^+(CH_3)_3$
- ✓ Weakly basic (tertiary amine, $-N(CH_3)_2$

Water Softening

Current Practice in Water Softening

Softening Process by Strong Acid Cation, SAC

Softening Process:

$$Resin^{-}Na^{+} + Ca^{2+} \rightarrow Resin^{-}Ca^{2+} + Na^{+}$$

Regeneration Process (Use NaCl as regenerant):

$$Resin^{-}Ca^{2+} + Na^{+} \rightarrow Resin^{-}Na^{+} + Ca^{2+}$$

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Disadvantage/ Limitation of SAC

- Increasing of Total Dissolved Solid (TDS) in water
- Requires a large excess of regenerant (salt)
- Unable to treat the water with high hardness (Temporary Hardness)

New Application for Water Softening

Softening Process by Weak Acid Cation, WAC

Softening Process:

$$Resin^{-}H^{+} + Ca^{2+} \rightarrow Resin^{-}Ca^{2+} + H^{+}$$

Regeneration Process (use HCl or H_2SO_4 as regenerant)

$$Resin^{-}Ca^{2+} + H^{+} \rightarrow Resin^{-}H^{+} + Ca^{2+}$$

New Technologies for Water Treatment System

Advantage of WAC

- No Increasing of Total Dissolved Solid (TDS)
- Use Less regenerant (HCl or H_2SO_4)
- Able to treat the water with high hardness (Temporary Hardness) √

Comparison of SAC & WAC

Properties	Strong Acid Cation (SAC)	Weak Acid Cation (WAC)
Ionic form	H^+ or Na^+	H^+
Structure	Polystyrene crosslinked with DVB	Crosslinked polyacrylate, macroporous
Functional group	SO_3H or SO_3Na	Carboxylic acid
Total exchange capacity	≥ 1.8 eq/L (H^+ form) ≥ 2.0 eq/L (Na^+ form)	≥ 4.3 eq/L

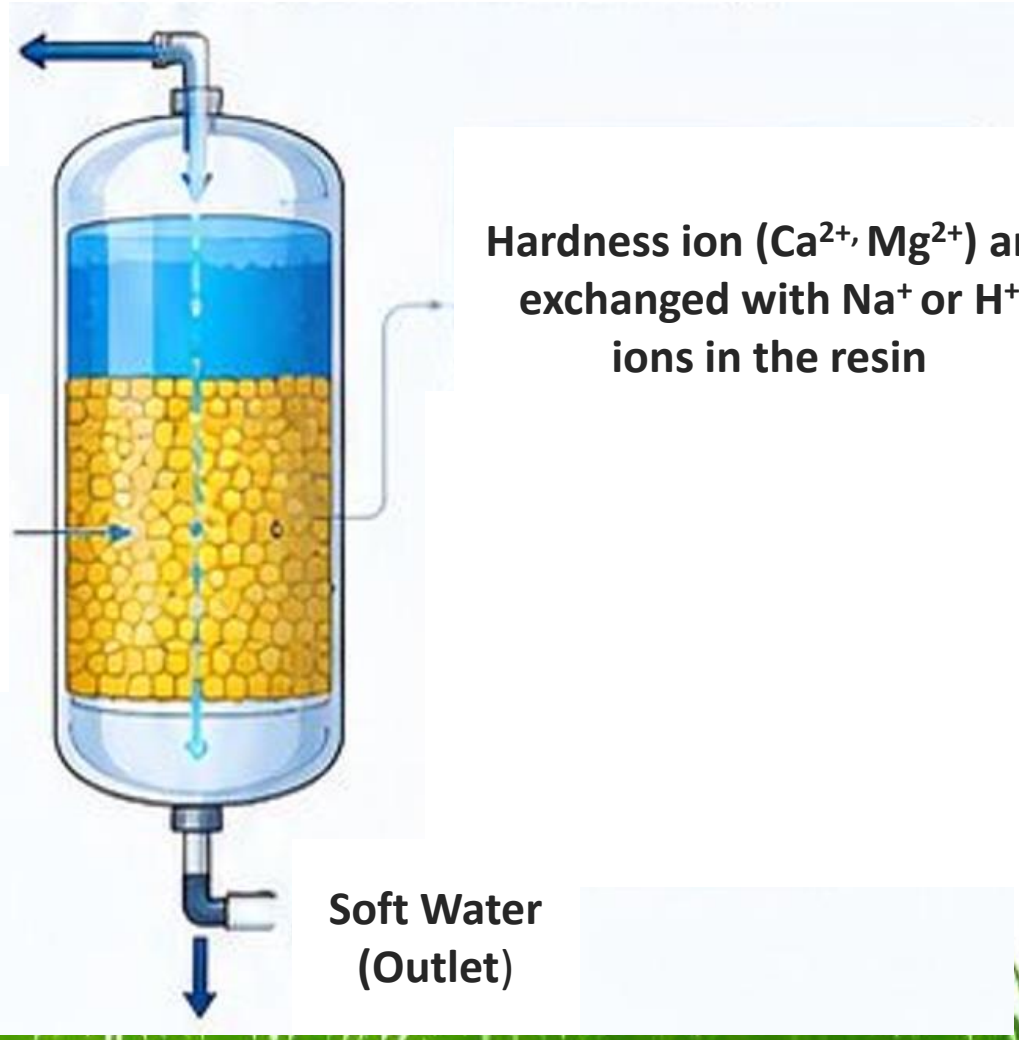
New Technologies for Water Treatment System

Disadvantage/Limitation of WAC

- Only Temporary Hardness (Total Alkalinity > Total Hardness)
- Able to remove majority of hardness, but not to near-zero hardness level
- Usage of hazardous chemical (HCl or H_2SO_4) – Safety issue

New Technologies for Water Treatment System

Working Principle of Softening Process



New Technologies for Water Treatment System

4. PFAS – Selective Ion Exchange Resin

What is PFAS?

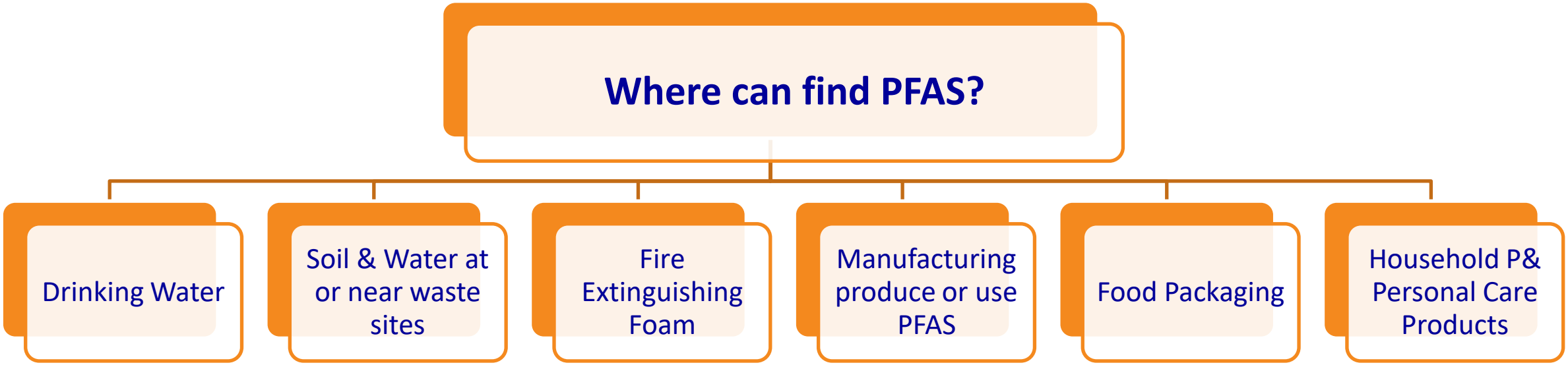
- **PFAS** = Per- and polyfluoroalkyl substances
- The unique behavior of PFAS arises from one of the strongest bonds in organic chemistry: the carbon-fluorine (C–F) bond.
  - **Carbon (C)** forms the backbone of organic molecules.
  - **Fluorine (F)** is one of the most electronegative (electron-attracting) elements.

New Technologies for Water Treatment System

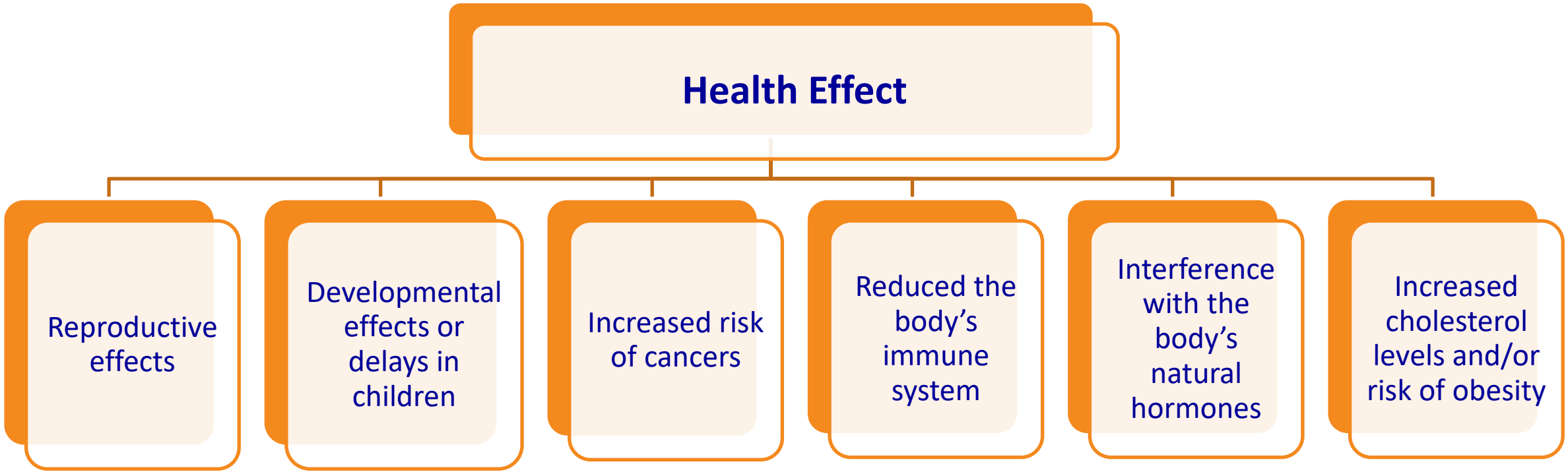
Characteristic of PFAS

- Resistance to Degradation ("Forever Chemicals")
- Resistance to Oil, Water, and Stains

New Technologies for Water Treatment System

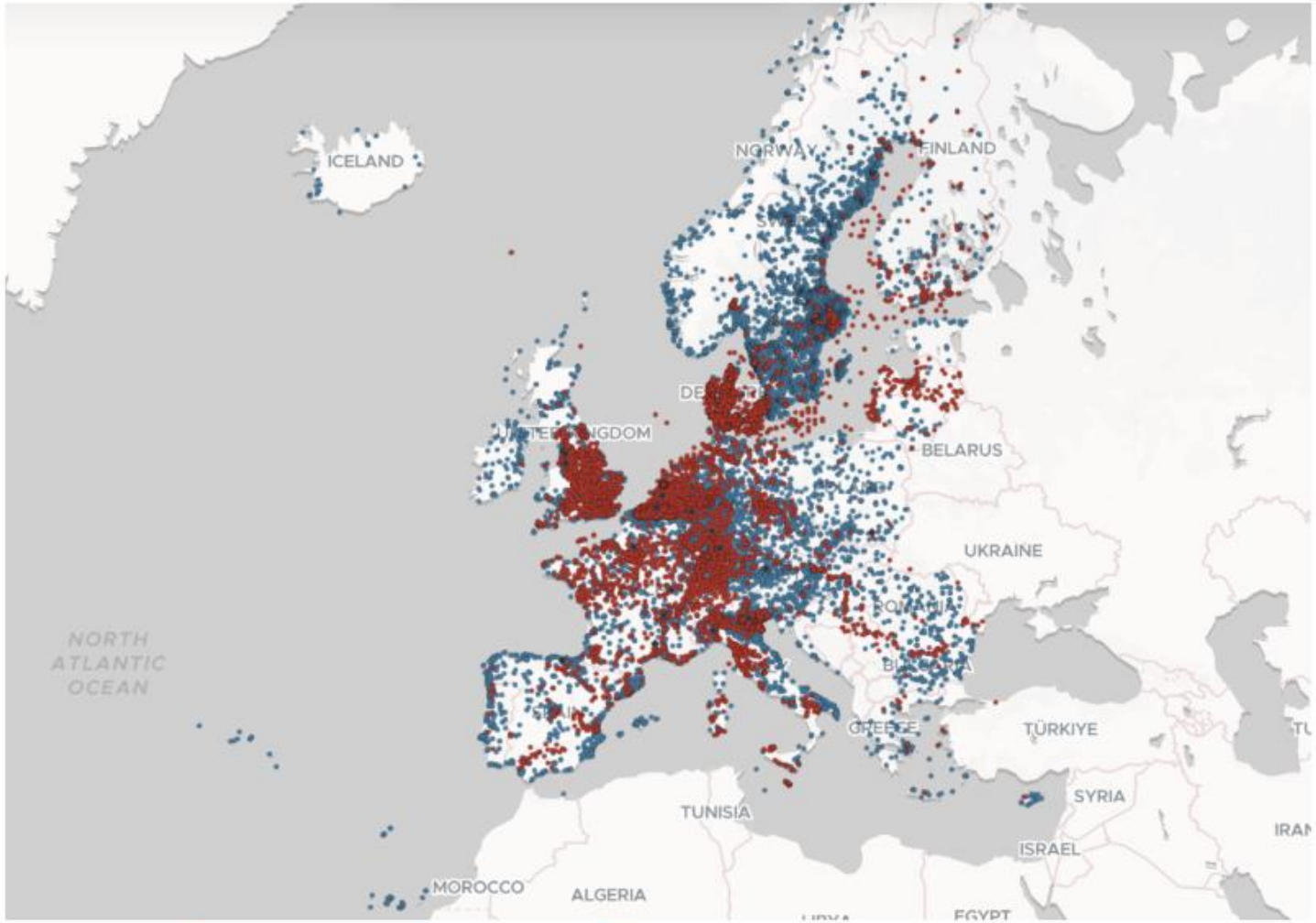


New Technologies for Water Treatment System



New Technologies for Water Treatment System

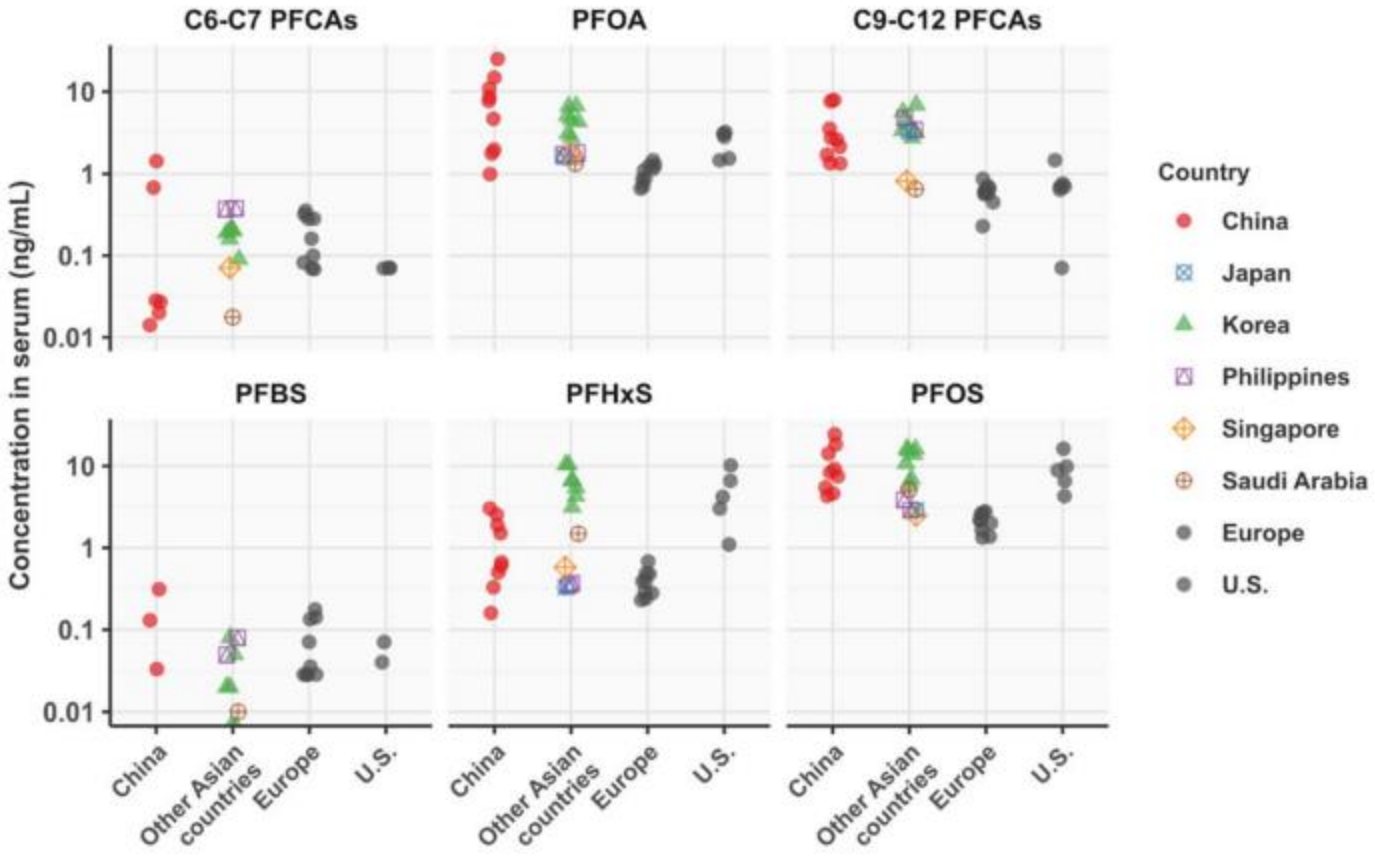
PFAS Pollution Issues in Europe



EEB
European Environmental Bureau

Source: https://eeb.org/en/work-areas/industry-health/pfas/

New Technologies for Water Treatment System

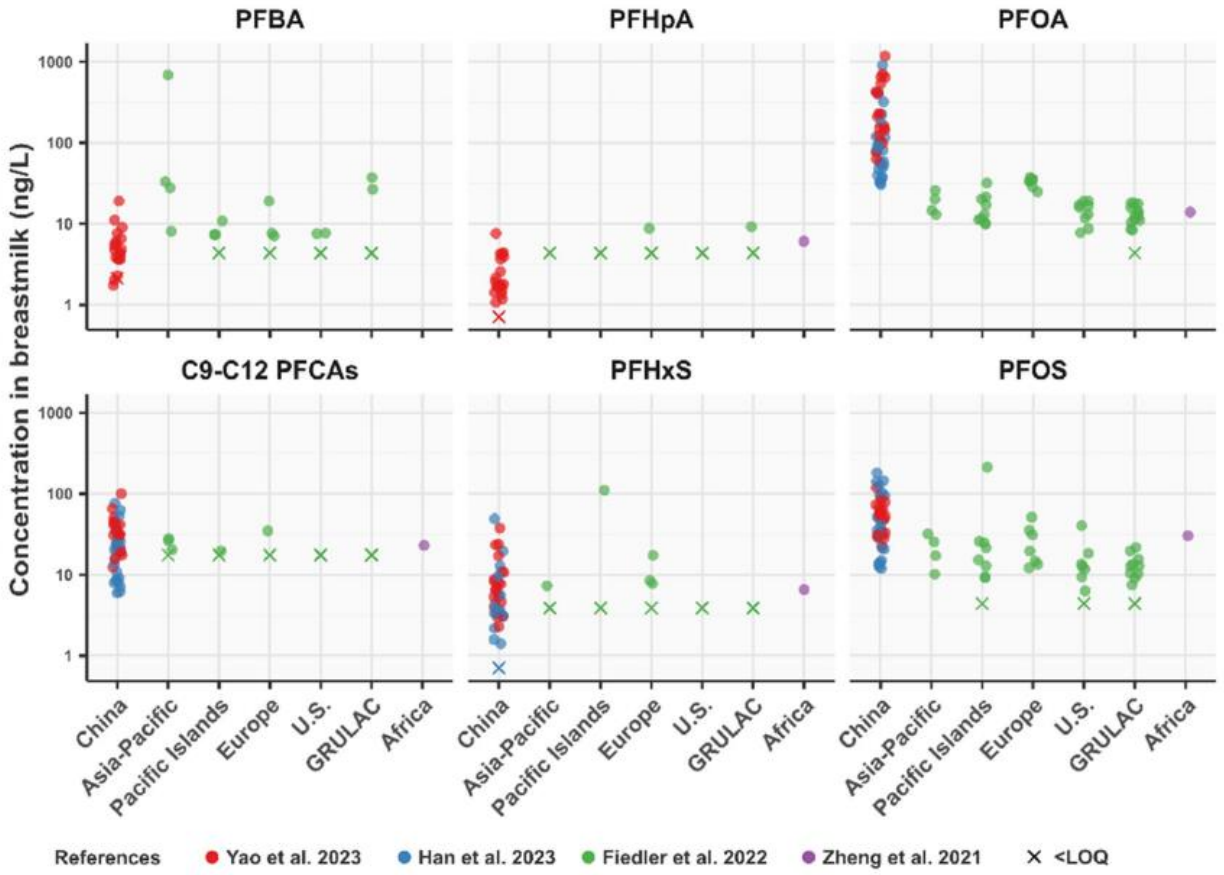


Concentrations of PFAAs in serum in Asia and other regions sampled between 2013 and 2021

Research About PFAS Pollution Issues

Source: Kookana, R.S., Sha, B., Jobriell, C., Baluyot, Bowles, K.C., Kah, M., Padhye, L.P., Ying, G.G., Navarro, D., Velarde, M.C., Higgins, C.P., and Cousins, I. T. (2025). **Human exposure to per- and poly-fluoroalkyl substances (PFAS) in Asia and contributing factors, with a focus on East Asia**. *Environmental Science Processes & Impacts.* DOI: 10.1039/d5em00396b.

New Technologies for Water Treatment System



Concentrations of PFAAs in breast milk sampled between 2015 and 2020

Research About PFAS Pollution Issues

Source: Kookana, R.S., Sha, B., Jobriell, C., Baluyot, Bowles, K.C., Kah, M., Padhye, L.P., Ying, G.G., Navarro, D., Velarde, M.C., Higgins, C.P., and Cousins, I. T. (2025). **Human exposure to per- and poly-fluoroalkyl substances (PFAS) in Asia and contributing factors, with a focus on East Asia**. *Environmental Science Processes & Impacts.* DOI: 10.1039/d5em00396b.

New Technologies for Water Treatment System

New EU law to better protect water enters into force

EU rules that update the lists of pollutants in surface and groundwaters have entered into force. This will add

commission.europa.eu

Source: https://commission.europa.eu/news-and-media/news/new-eu-law-better-protect-water-enters-force-2026-05-13_en

- The new EU water directive distinguishes between regulated contaminants and watch-list contaminants for **PFAS (regulated)**
- For drinking water, the EU's existing Drinking Water Directive now requires monitoring against two PFAS parameters:
  - **PFAS (selected PFAS compounds)- 0.10 µg/L @ppb (100 ng/L)**
  - **PFAS Total - 0.50 µg/L @ ppb (500 ng/L)**
- These limits became mandatory across EU Member States on 12 January 2026.

New Technology for PFAS Removal in Water
Selective Ion Exchange Resin

- Specific ion exchange resins can be used for the removal of PFAS from water sources. Typical applications are the removal of PFAS from **drinking water**, from processing water for food stuff, **from groundwater** or **from wastewater**.
- Other applications such as wastewater or ground water treatment may require special processes or pretreatment due to a very high level of PFAS, or high sulphate levels, the presence of suspended solids or organic matter.

Removal Mechanism

- At neutral pH (6.5-7.5) some dissolved PFAS are negatively charged and can be “exchanged” with the chloride ion of the specialized PFAS removal resin.
- PFAS can be adsorbed strongly on the resin surface by Van der Waals forces
- Depending on the inlet and outlet concentration the cycle time can be more than 1 year (100,000-200,000 BV).

Ion Exchange Resin Selection

- PFAS could be exchanged by most of the **Strong Base Anion (SBA)** resin in **chloride form and** has been specifically developed for this application where it has a more selective functional group which is more hydrophobic than the functional group in conventional anionic resins.

Ion Exchange Resin Regeneration

- The high selectivity of PFAS selective resins explains the very low leakage and long cycle time of the resin until it is saturated.
- This high selectivity makes it **difficult to regenerate** the PFAS resin, unless using solvents and NaCl.
- In this case, the regenerant has to be disposed or destroyed.
- Therefore, the PFAS resins are generally **single-use**, and are disposed of as a solid waste or incinerated in accordance with the local governmental regulations.

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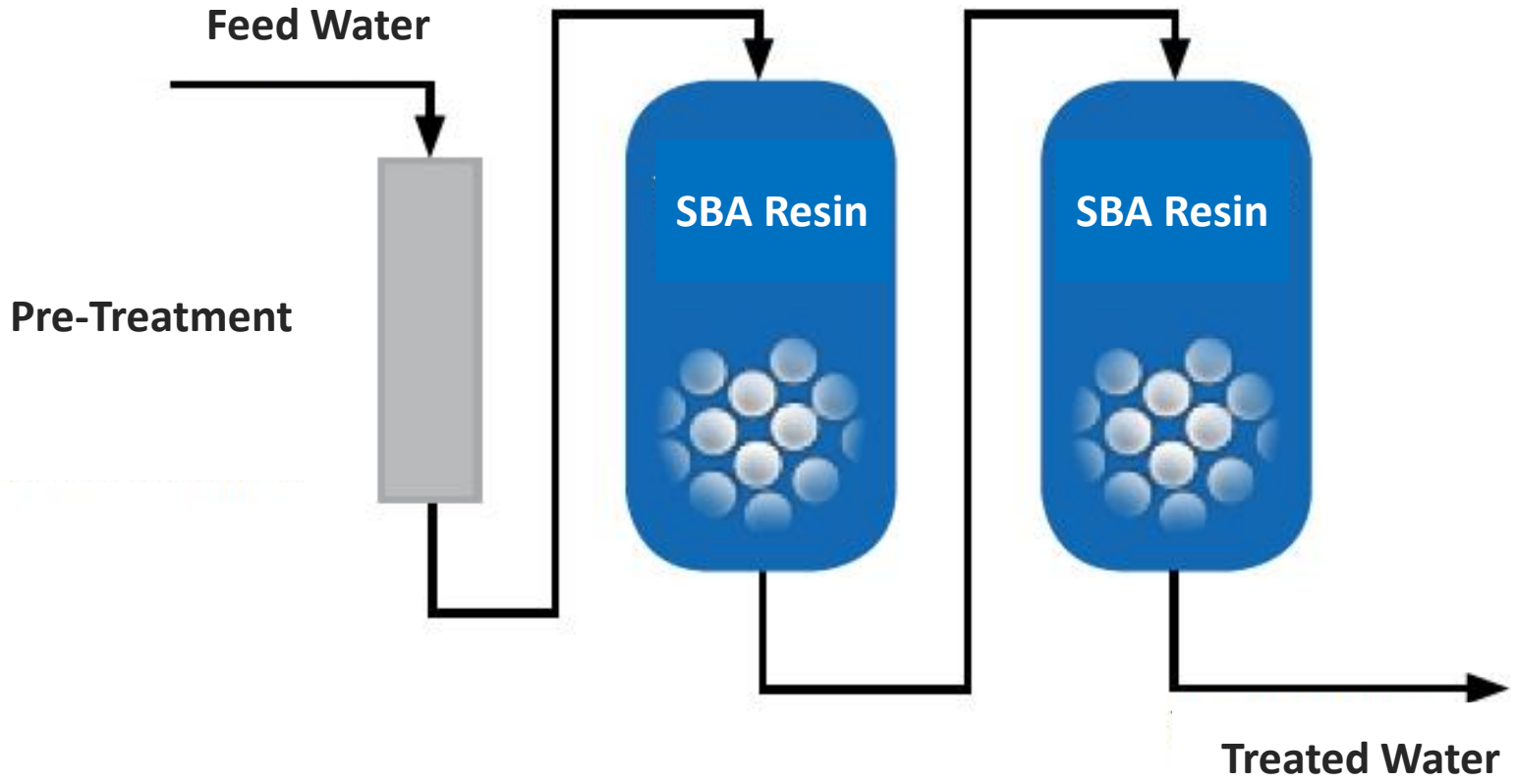
Properties of IER for PFAS Removal

Properties	TREVERLITE XS130800 Strong Base Anion (SBA)
Ionic form	Chloride
Structure	Crosslinked Polystyrene, gel
Functional group	Quaternary Ammomium
Total exchange capacity	≥ 0.75 eq/L

New Technologies for Water Treatment System

IER Process for PFAS Removal



New Technologies for Wastewater Treatment System

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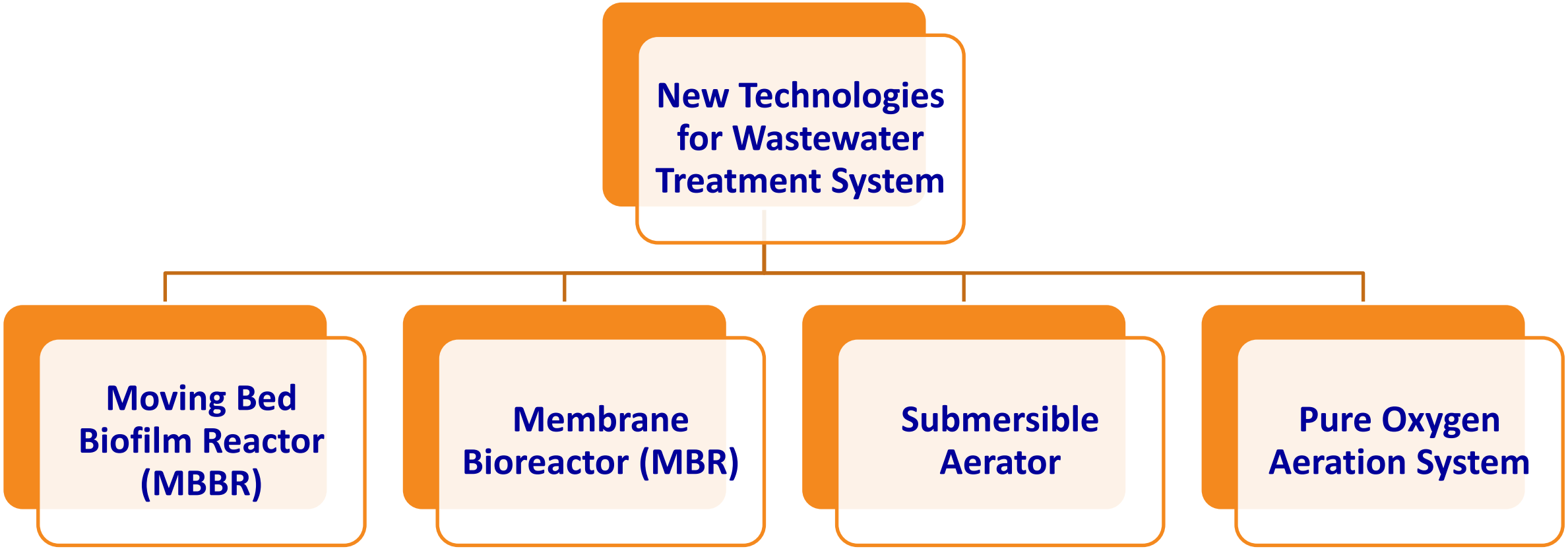

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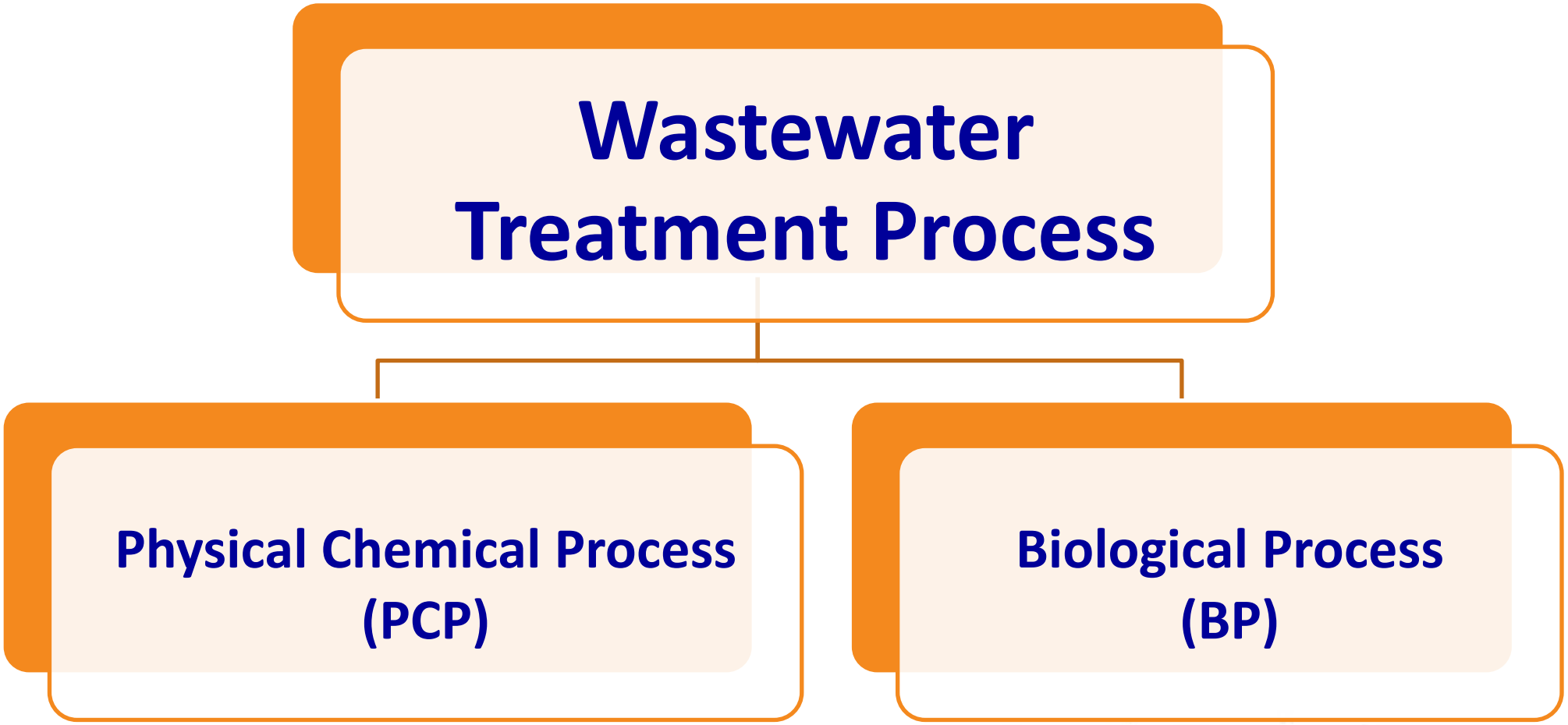
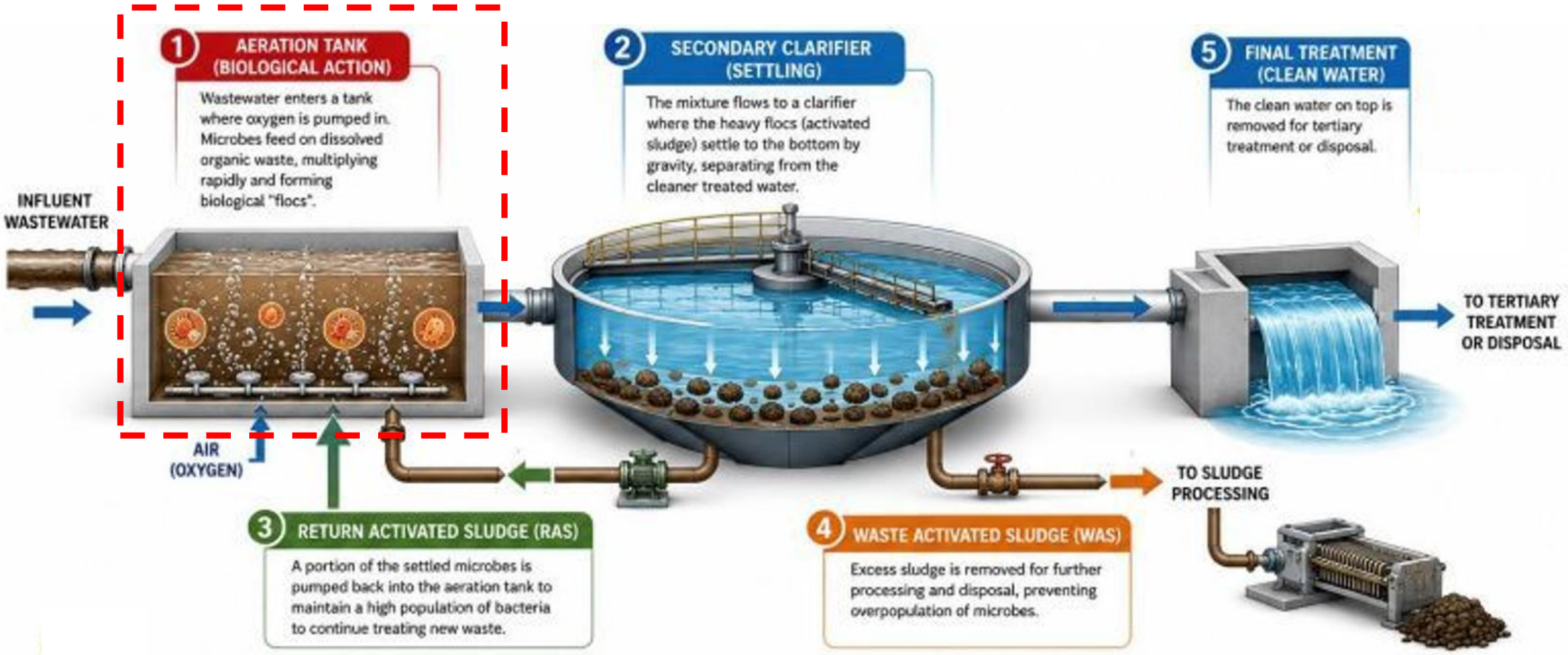
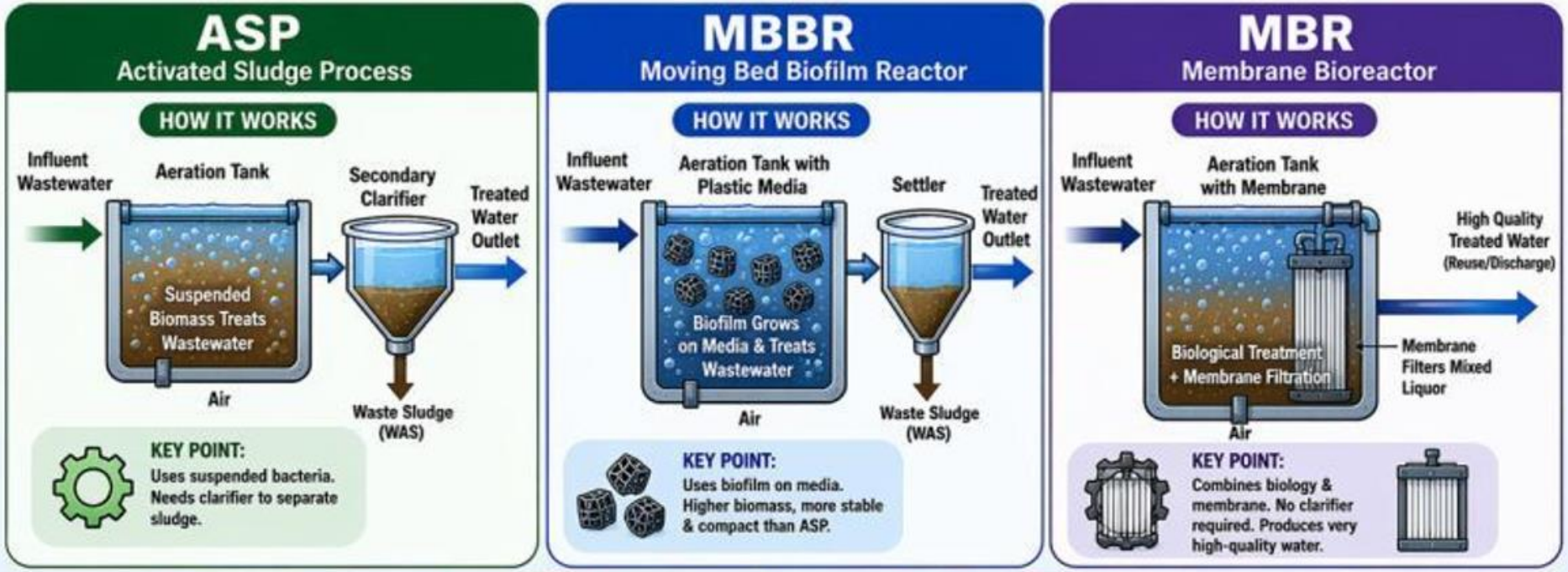


New Technologies for Wastewater Treatment System

Wastewater Treatment – Biological Process

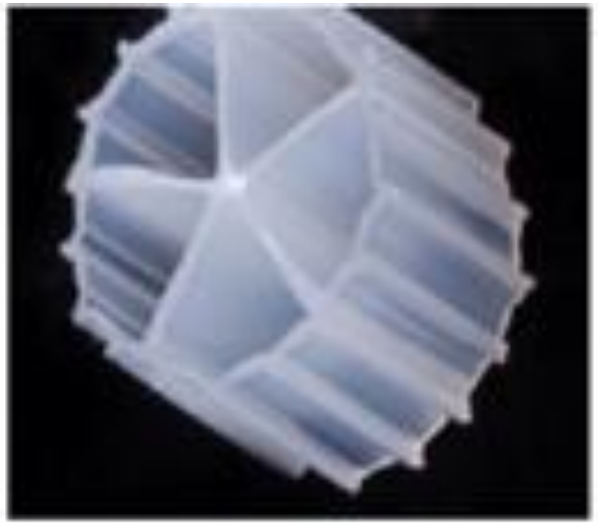


New Technologies for Wastewater Treatment System



PARAMETER	ASP	MBBR	MBR
PRINCIPLE	Suspended Growth	Attached Growth (Biofilm)	Suspended Growth + Membrane Filtration
BIOMASS CONCENTRATION	Low to Medium	Higher than ASP	Very High (MLSS can be high)
NEED OF SECONDARY CLARIFIER	Yes	Yes (Usually)	No
EFFLUENT QUALITY	Good	Better	Excellent (Very High Quality)
FOOTPRINT	Large	Compact	Very Compact
COST	Low	Medium	High
OPERATION & MAINTENANCE	Simple	Moderate	Skilled & Careful (Membrane Cleaning)
TYPICAL APPLICATION	Municipal & Standard ETP	Space-Limited Projects, Upgradation, Industrial ETP	Reuse Projects, High Quality Discharge, Strict Regulations

1. Moving Bed Biofilm Reactor (MBBR)



Moving Bed Biofilm Reactor (MBBR)

- **MBBR** is a biological wastewater treatment process that combines the best features of activated sludge (suspended growth) and biofilters (attached growth).
- It uses thousands of small plastic carriers (media) that move freely within a reactor tank.
- Microorganisms grow as a biofilm on the protected inner surfaces of these carriers.

Key Principle

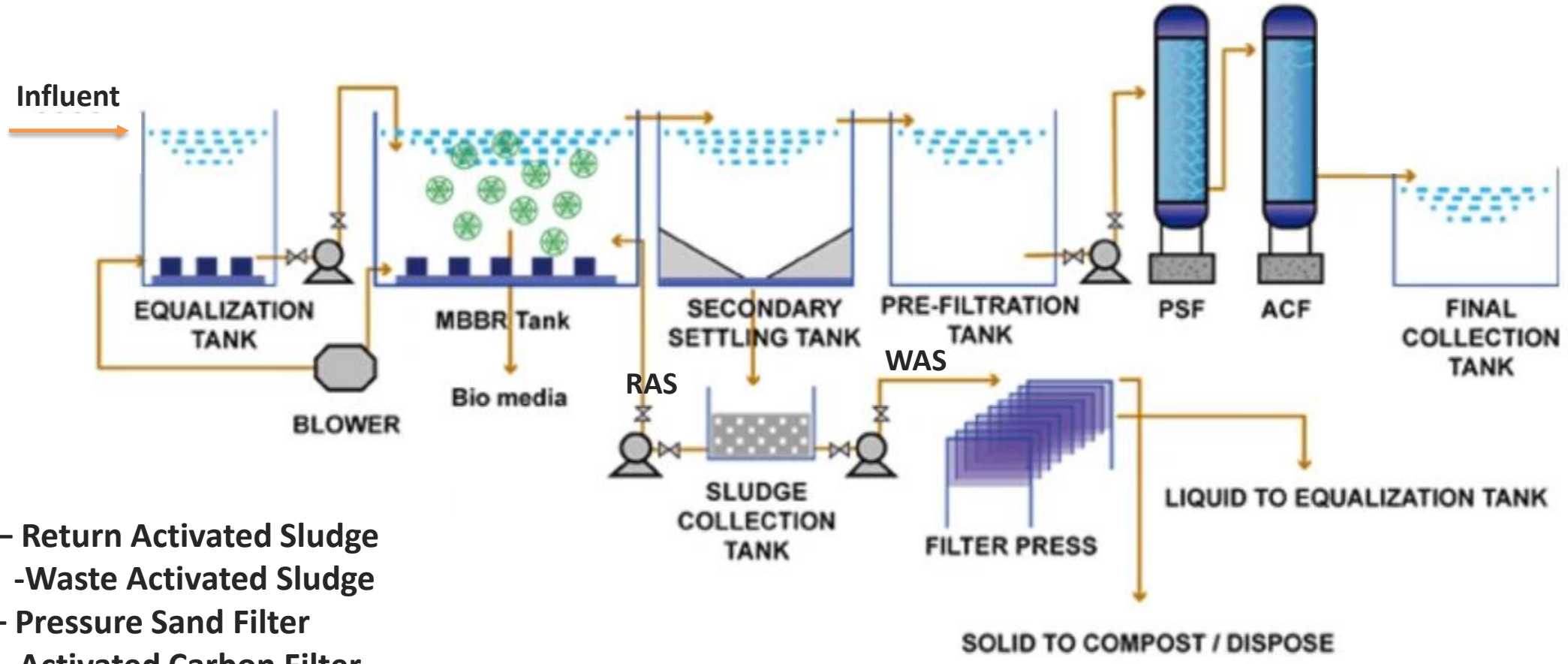
- **Attached growth** on carriers + **mixing** by aeration or mechanical stirrer.
- Carriers are retained in the reactor by a mesh screen at the outlet.
- Excess biofilm shears off naturally and is separated in a downstream clarifier.

Process Type

- **Aerobic MBBR** – For carbon removal and nitrification. Requires oxygen (2–5 mg/L DO).
- **Anoxic MBBR** – For denitrification. Requires mixing, no oxygen, and a carbon source (if BOD is low).
- **Anaerobic MBBR** – For high-strength organic waste or specific industrial applications.

New Technologies for Wastewater Treatment System

MBBR Process Flow



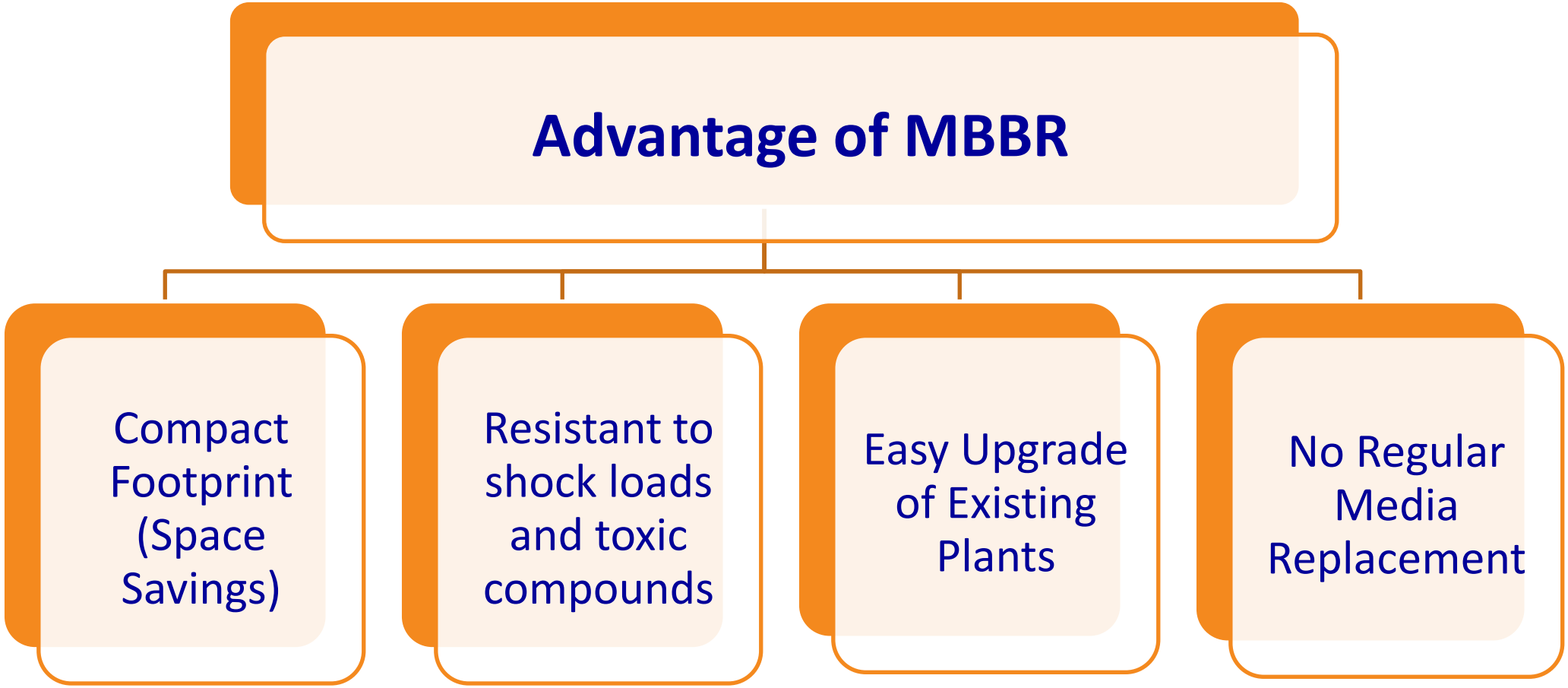
RAS – Return Activated Sludge
WAS -Waste Activated Sludge
PSF – Pressure Sand Filter
ACF – Activated Carbon Filter

How MBBR Work

MBBR Design Parameters

1. Specific Surface Area, m^2/m^3 (Carrier Specification from Manufacturer)
2. BOD Loading Rate, g/day
3. Surface Area Loading Rate (SALR), $g/m^2.day$
4. Media Filling Ratio (MFR), %
5. Hydraulic Retention Time (HRT), day

New Technologies for Wastewater Treatment System



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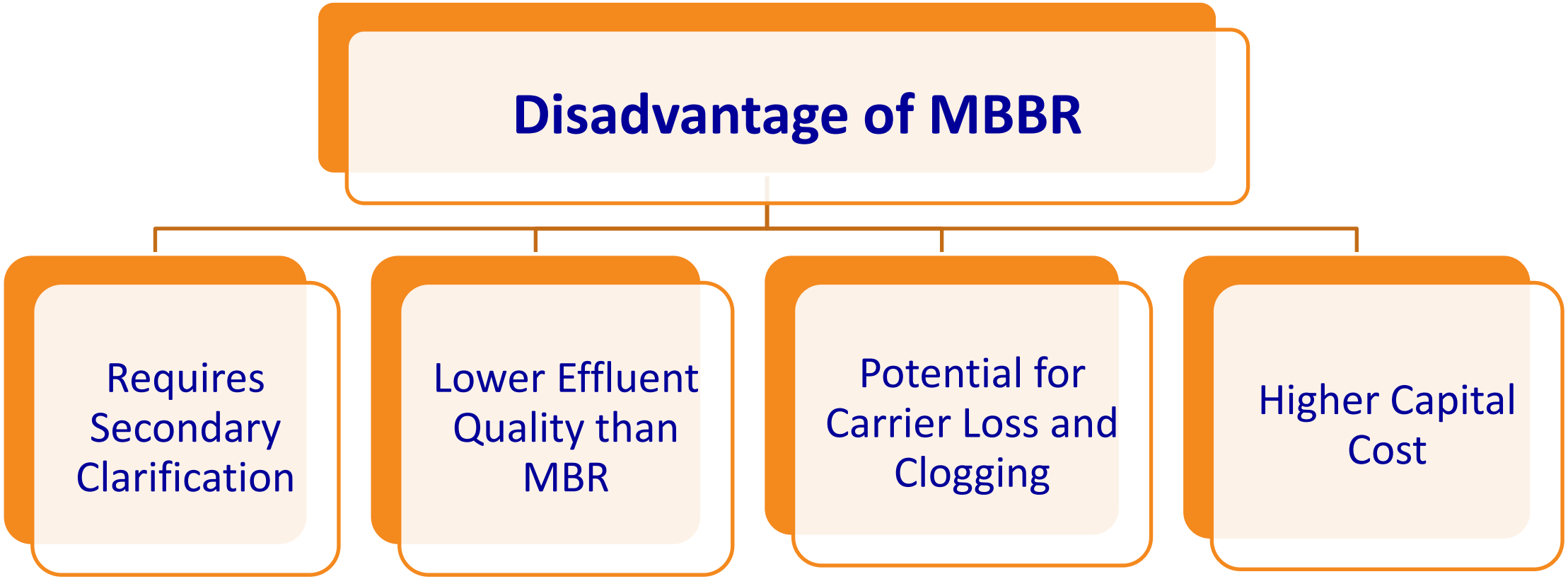


2. Membrane Bioreactor (MBR)

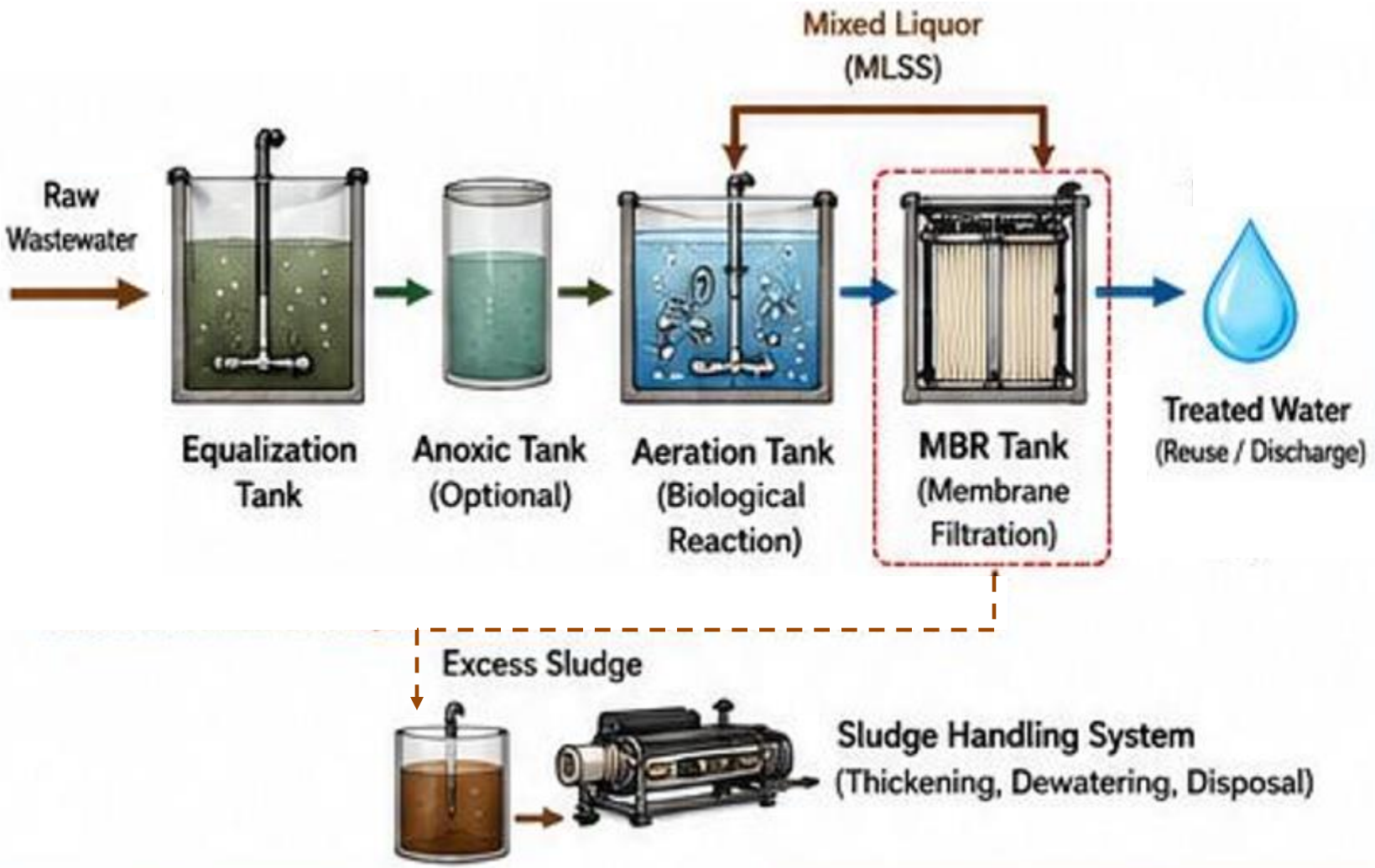
Membrane Bioreactor (MBR)

A **Membrane Bioreactor (MBR)** is an advanced wastewater treatment process that combines a **biological reactor** (activated sludge process) with **membrane filtration** (typically microfiltration or ultrafiltration) to separate and clarify treated water from suspended solids and microorganisms.

How it Works – The Two-in-One Process

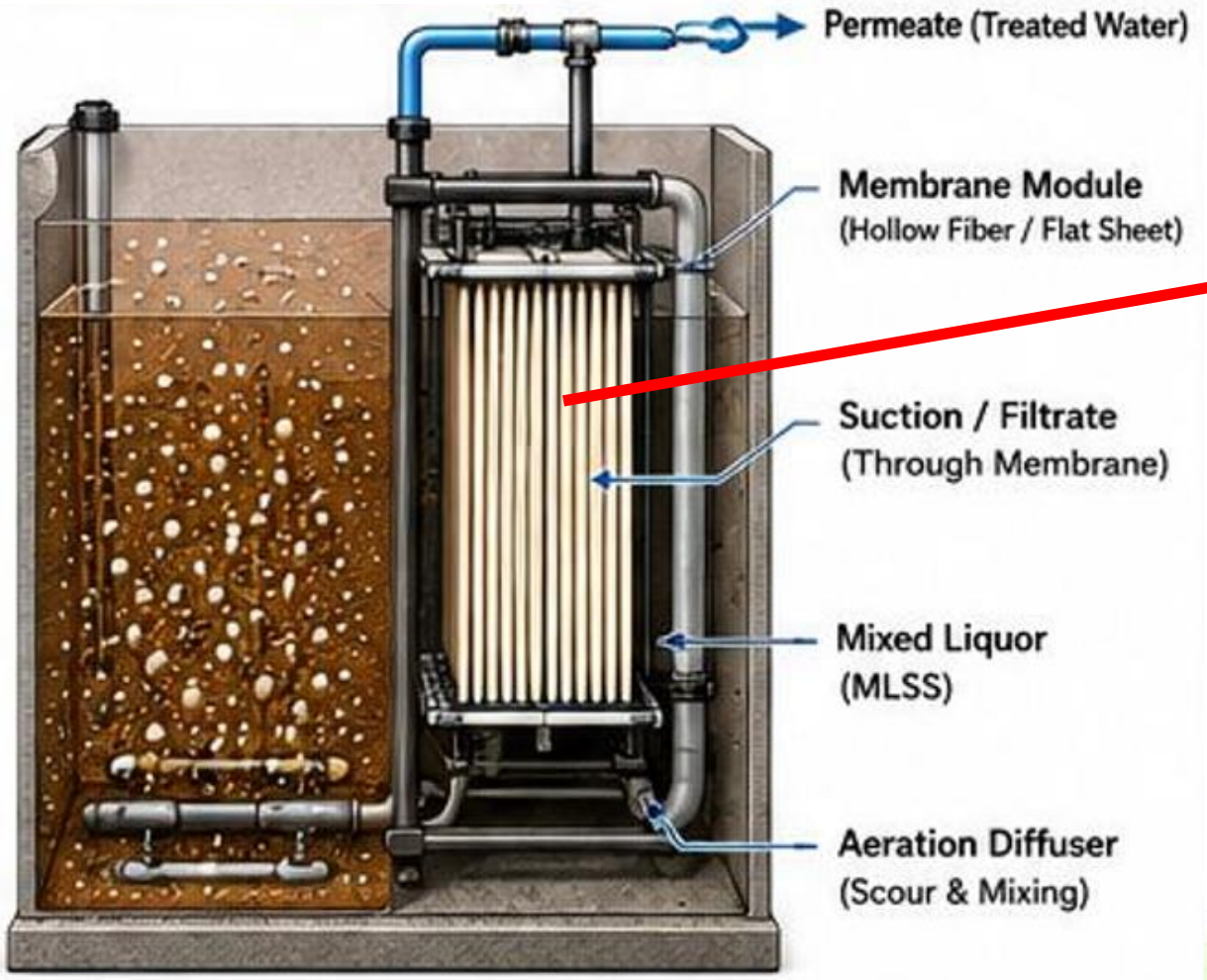
1. **Biological Treatment (Activated Sludge):** Uses bacteria and microorganisms to break down organic matter and pollutants in the wastewater.
2. **Membrane Filtration (Microfiltration/Ultrafiltration):** Uses hollow fiber or flat sheet membranes with microscopic pores (typically 0.01–0.04 microns) to physically filter out biomass in aeration tank.

MBR Process Flow



New Technologies for Wastewater Treatment System

How MBR Work



Membrane Types

Hollow Fiber Membrane

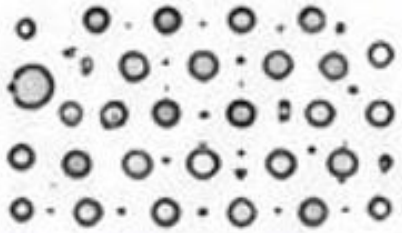
Flat Sheet Membrane

Pore Size

Microfiltration / Ultrafiltration

0.01 – 0.1 micron

(0.00001 – 0.0001 mm)



Membrane Function

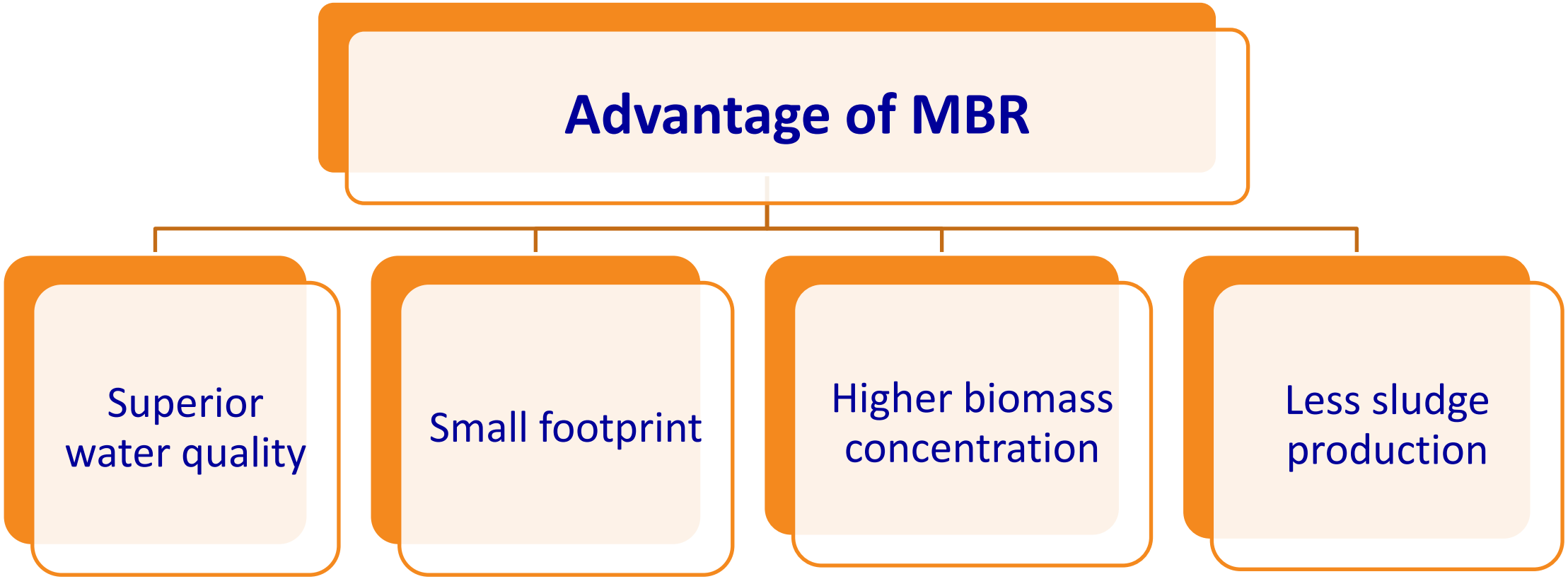
Membrane physically retains suspended solids, bacteria, colloids and pathogens, allowing only clean water to pass through.

MBR Design Parameters

The design process is generally divided into two important interconnected parts: **Biological Process**, and **Membrane Filtration Process**.

Part	Design Parameters
Biological Process	Organic Loading Rate (OLR), Mixed Suspended Solid (MLSS), Hydraulic Retention Time (HRT), Solid Retention Time (SRT), Food-to-Mass Ratio (F/M Ratio), Oxygen required (DO for Aeration Tank & Membrane Tank)
Membrane Filtration Process	Flux, Peak Flux, Transmembrane Pressure(TMP),

New Technologies for Wastewater Treatment System



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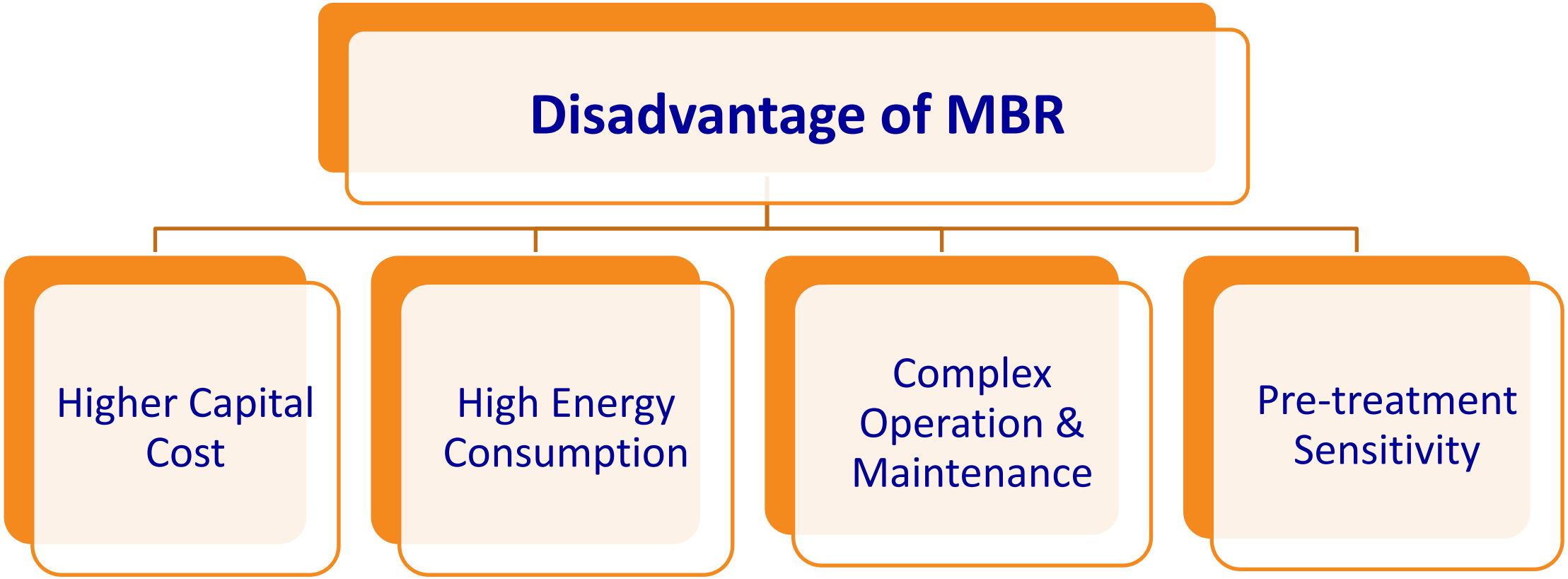


New Technologies for Wastewater Treatment System

When to use ASP, MBBR & MBR?

CHOOSE ASP WHEN:

- Budget is Limited
- Enough Space is Available
- Treatment Requirements are Standard

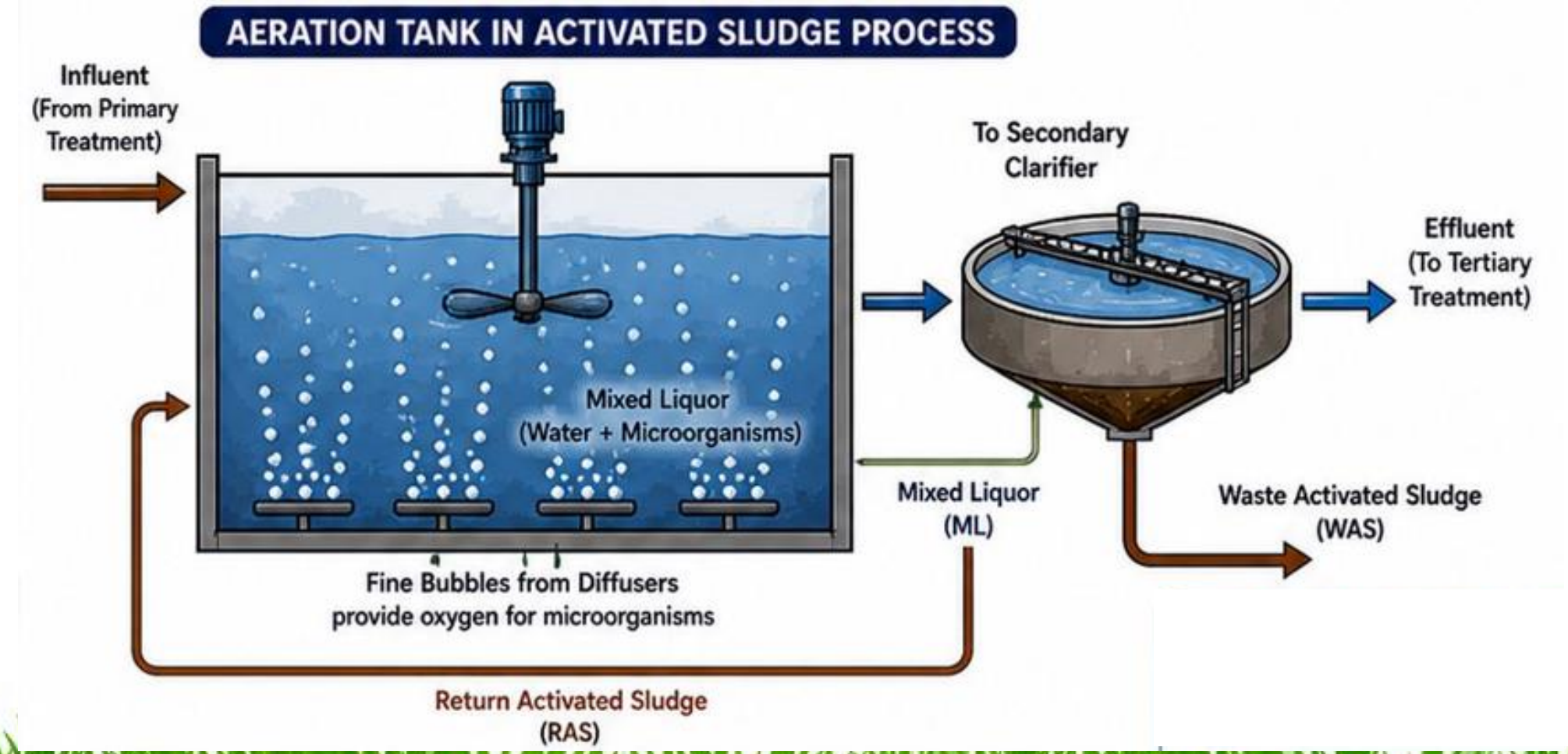
CHOOSE MBBR WHEN:

- You Need a Compact & Stable System
- Higher Fluctuation in Wastewater Load
- Upgrading Existing Plant

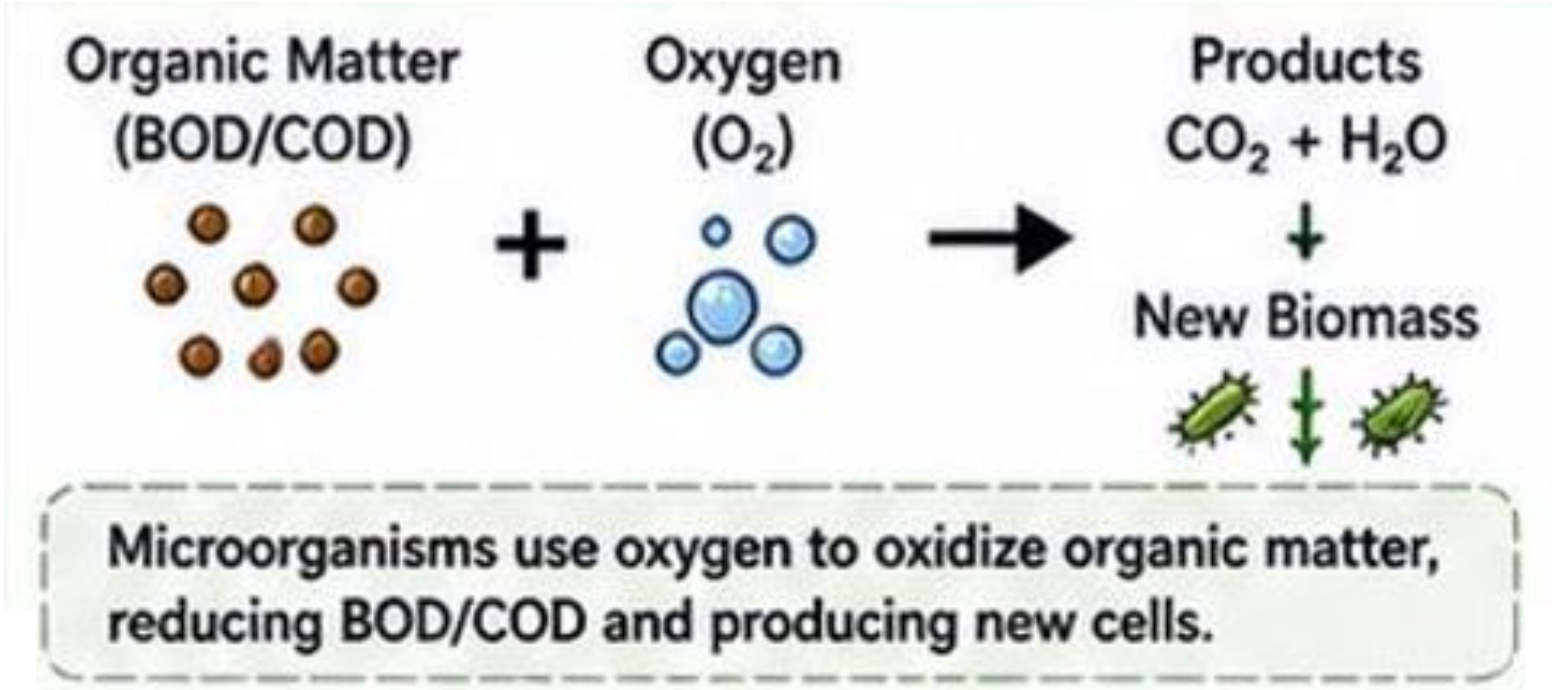
CHOOSE MBR WHEN:

- You Need Very High Quality Treated Water
- Water Reuse is the Goal
- Space is Limited & Performance is Priority

Aeration Tank – The Heart of Biological Process



Reaction in Aeration Tank



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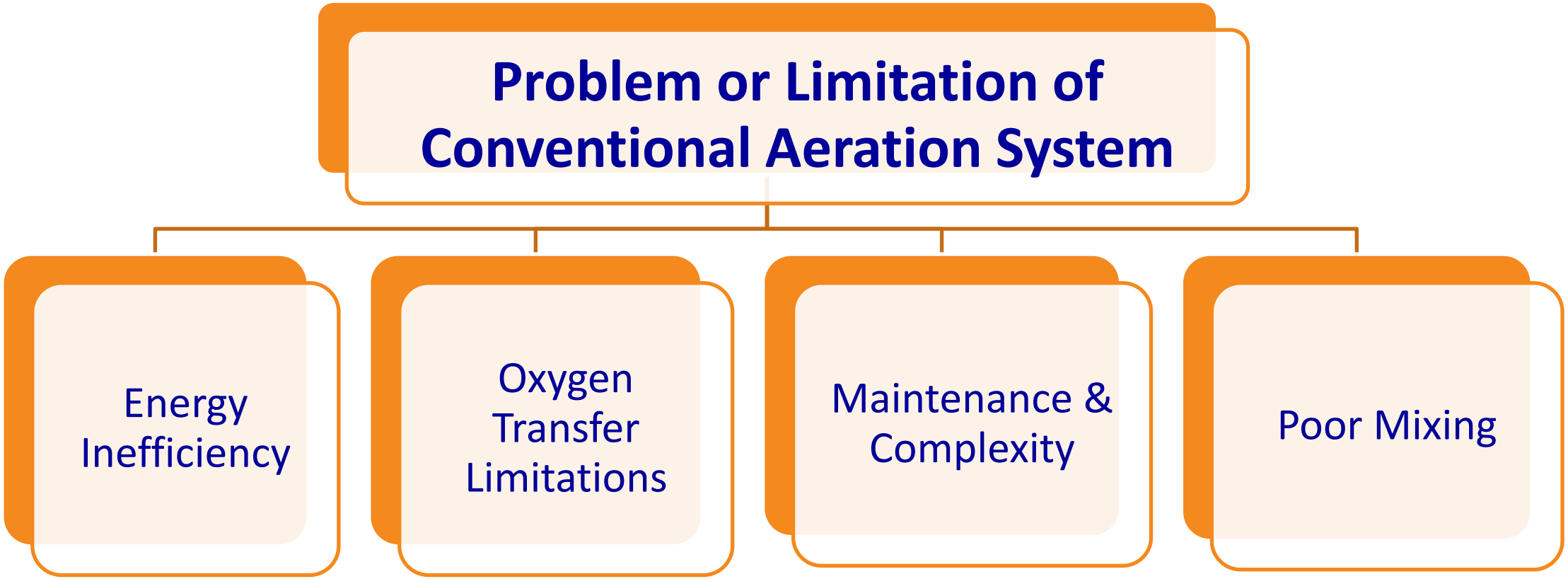


3. Submersible Aerator

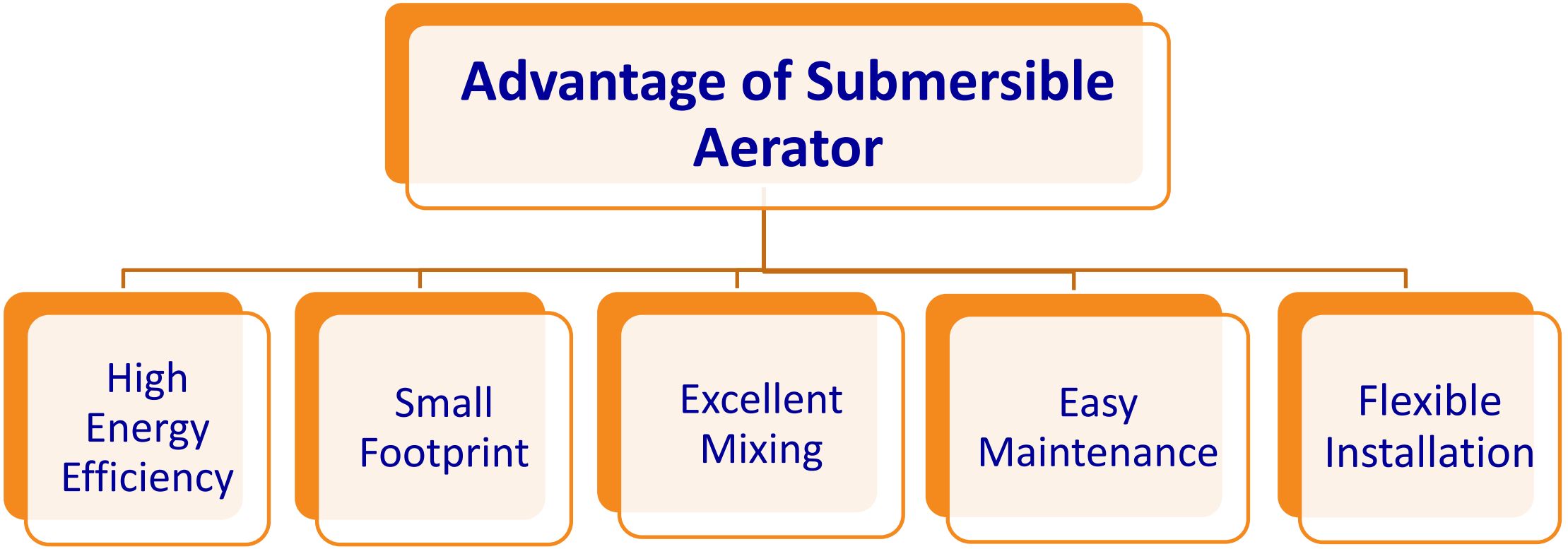
Submersible Aerator

- A **Submersible Aerator** is a compact, electrically driven device that operates fully submerged in wastewater.
- It combines a motor, a pump/impeller, and an air intake system into a single unit to draw in atmospheric air and mix it with the surrounding liquid, simultaneously adding oxygen (aeration) and creating circulation (mixing) to support biological treatment.

How Submersible Aerator Work

1. **Powerful Pumping:** A submersible motor drives a specially designed, semi-open impeller at high speed.
2. **Creating a Vacuum:** The rotation of the impeller creates a negative pressure (a vacuum) on its backside.
3. **Drawing in Air:** This vacuum pulls atmospheric air from above the water's surface down through an air intake pipe and into the heart of the impeller.
4. **Mixing & Shredding:** Inside the impeller, the air is violently mixed with the liquid and shredded into millions of tiny bubbles.
5. **Discharge:** This frothy air-water mixture is then expelled, often in multiple directions, creating a powerful flow that circulates throughout the tan

New Technologies for Wastewater Treatment System



New Technologies for Wastewater Treatment System

Disadvantage of Submersible Aerator

- Limited Depth for Self-Aspiration
- Shorter Bubble Contact Time
- Not Ideal for Very Large, Shallow Basins
- Higher Motor Heat Load

4. Pure Oxygen Aeration System

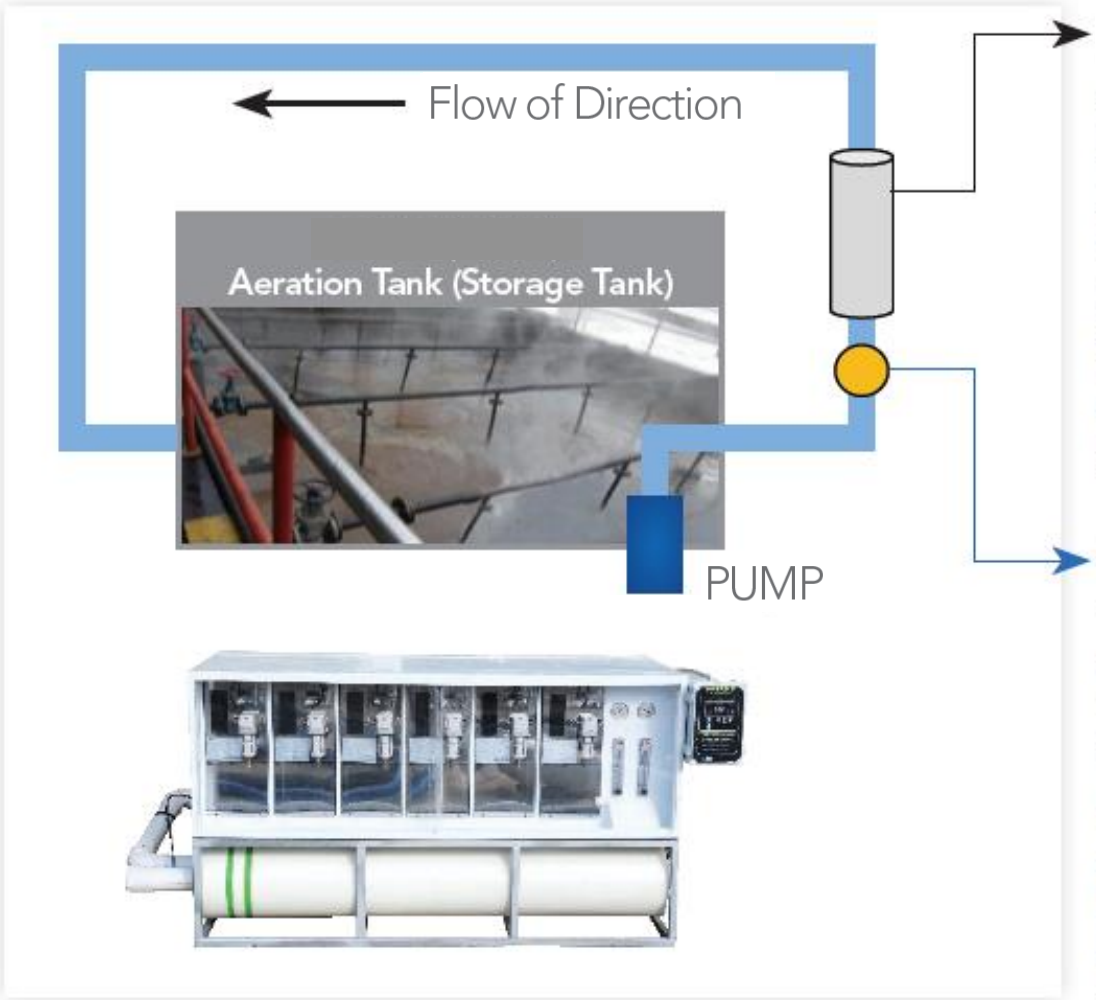
Pure Oxygen Aeration System

Pure Oxygen Aeration System

A **Pure Oxygen Aeration System** is a wastewater treatment process that uses oxygen gas with a purity of 90% to 95% (rather than ambient air, which contains only 21% oxygen) to supply the dissolved oxygen required by aerobic microorganisms. This system operates within a gas-tight, covered reactor to prevent the loss of oxygen gas to the atmosphere and typically employs pressurized mixing devices to achieve a significantly higher oxygen transfer efficiency than conventional air aeration.

New Technologies for Wastewater Treatment System

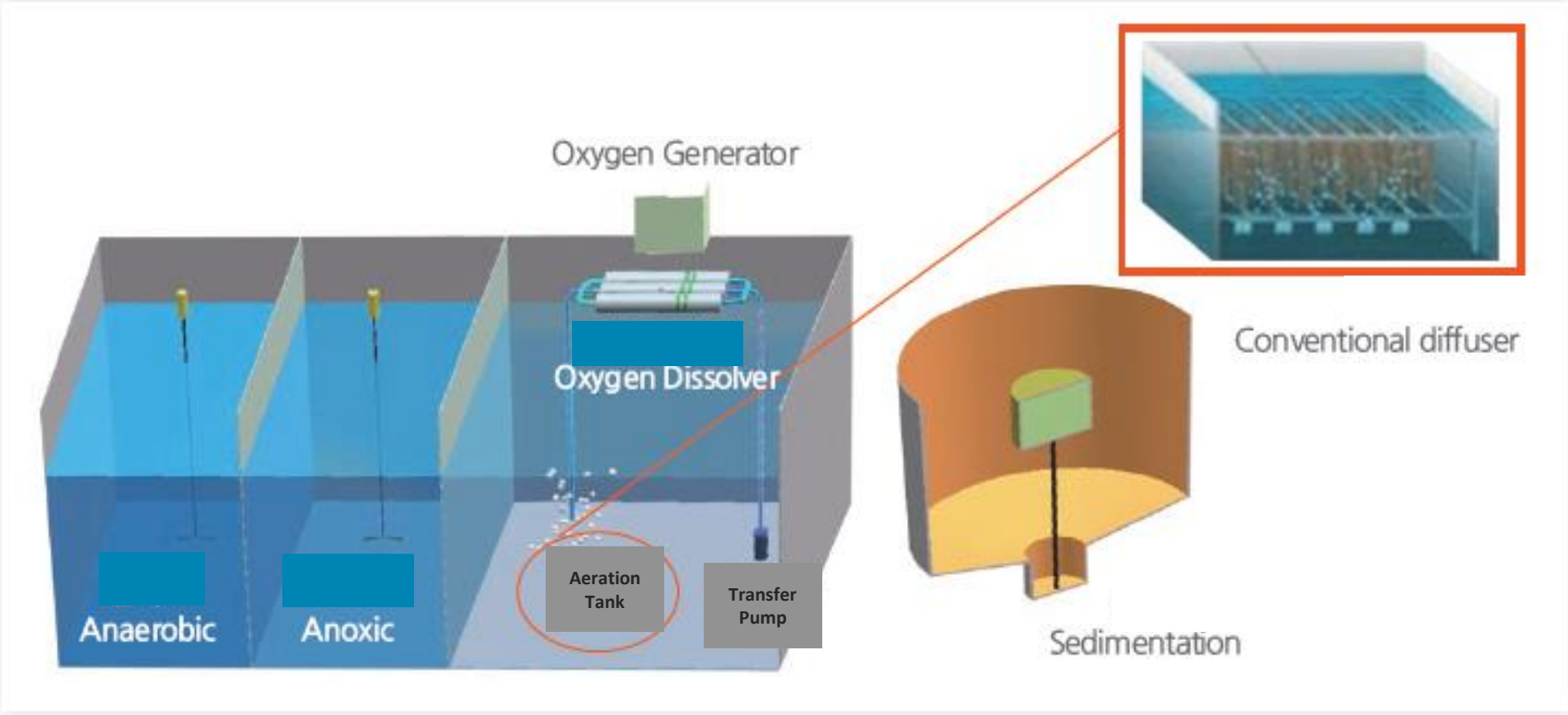
Pure Oxygen Aeration System Parts



Oxygen Dissolver

Oxygen Generator

Process Flow of Pure Oxygen Aeration System



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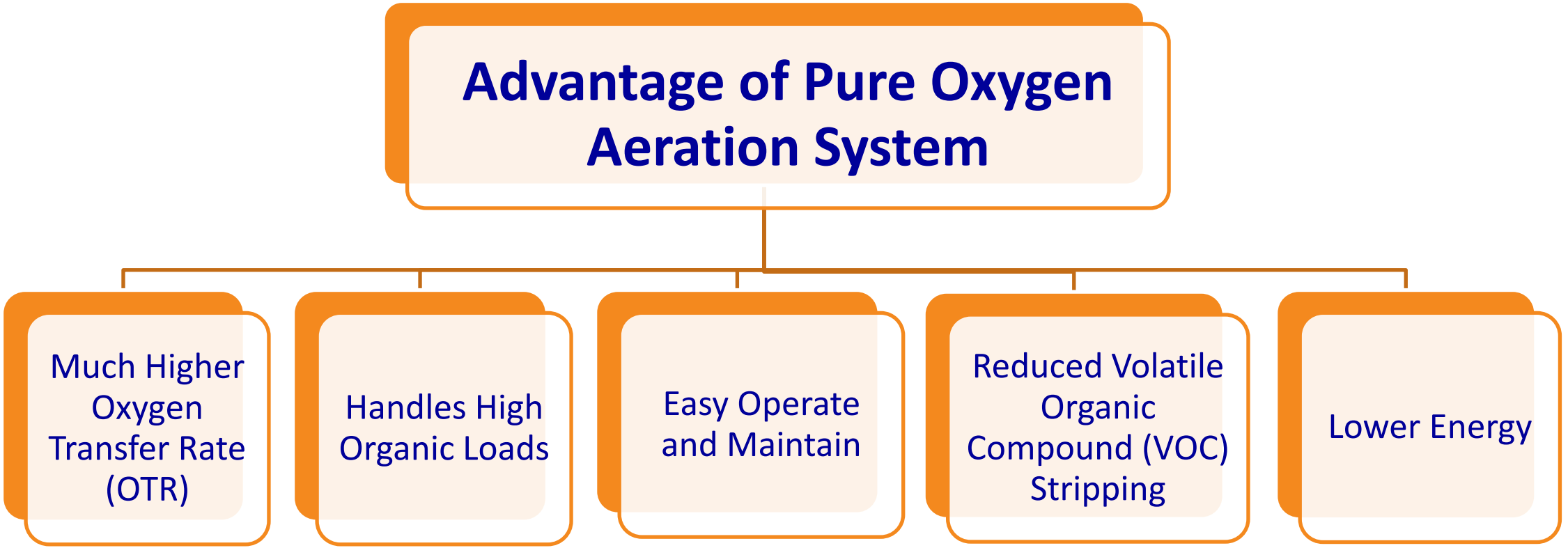
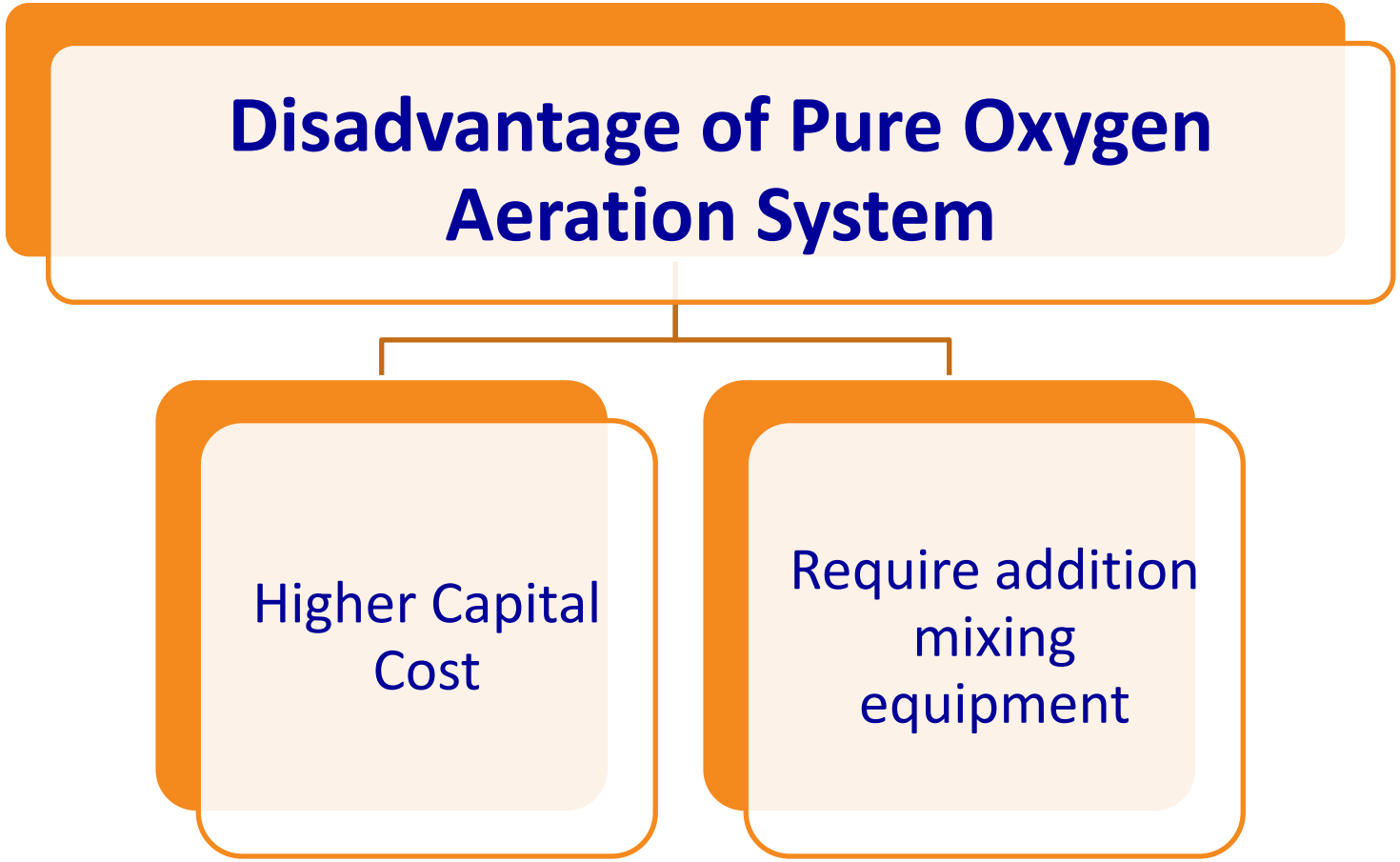


New Technologies for Wastewater Treatment System



Conclusion

Conclusion

- Mastering the fundamentals of **Physical Chemical Processes (PCP)** and **Biological Processes (BP)** remains essential and crucial, even with the adoption of new technologies in WWTPs.
- Therefore, all relevant personnel must receive both **basic theoretical knowledge** and **hands-on practical training** to become Competent Persons in WWTP operation.

Thank You

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