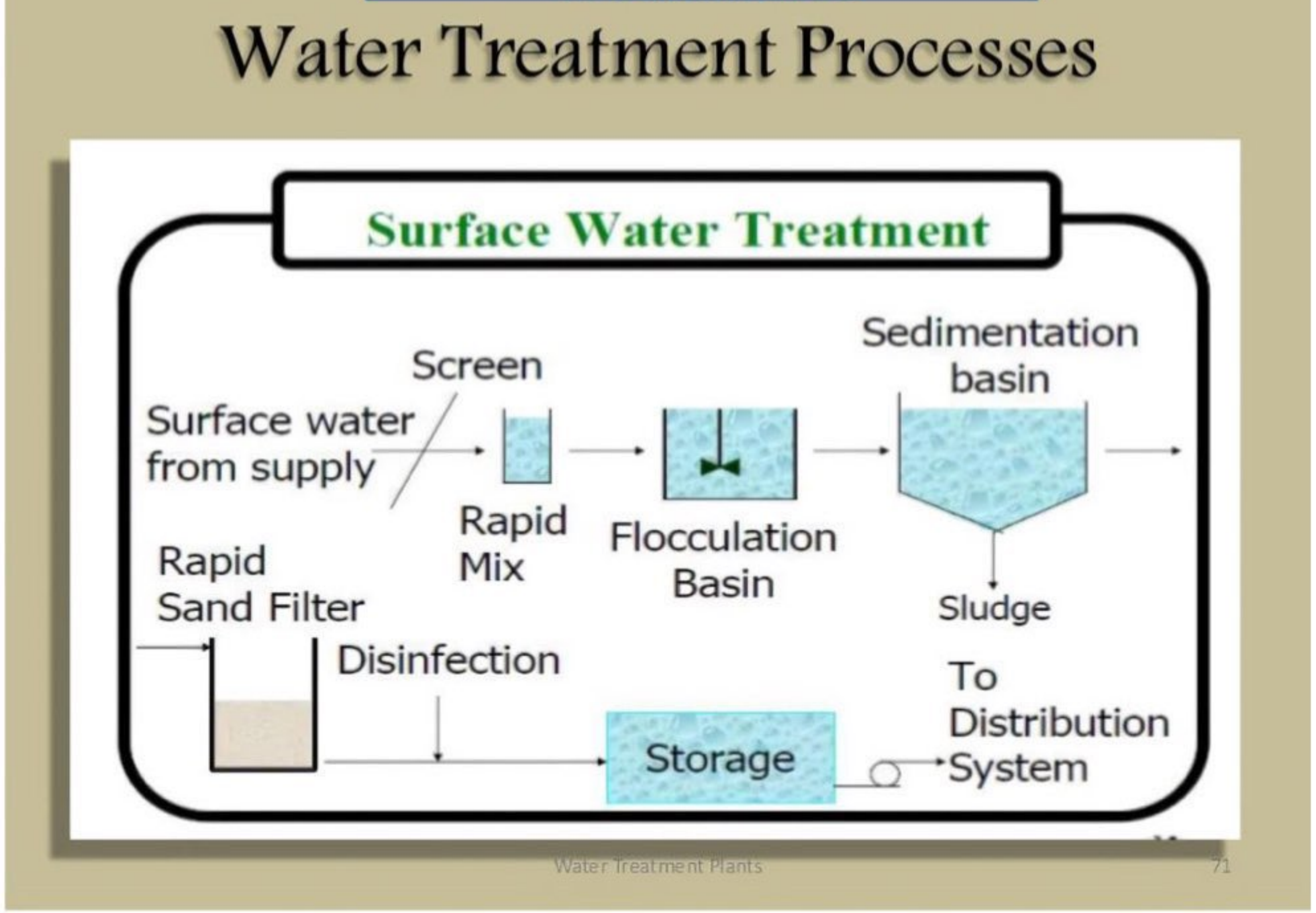
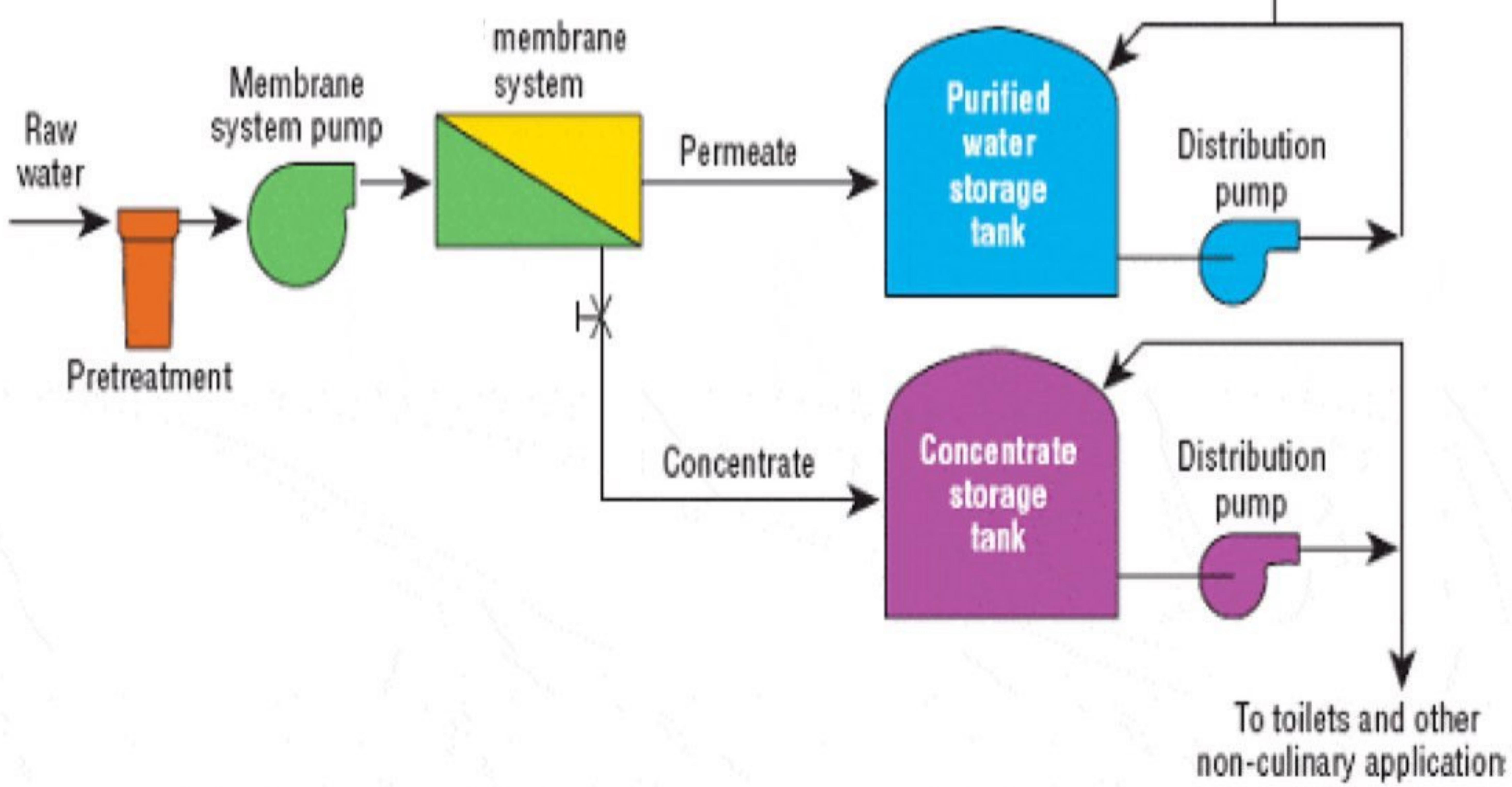
Using membranes for surface water treatment examples

Conventional Treatment

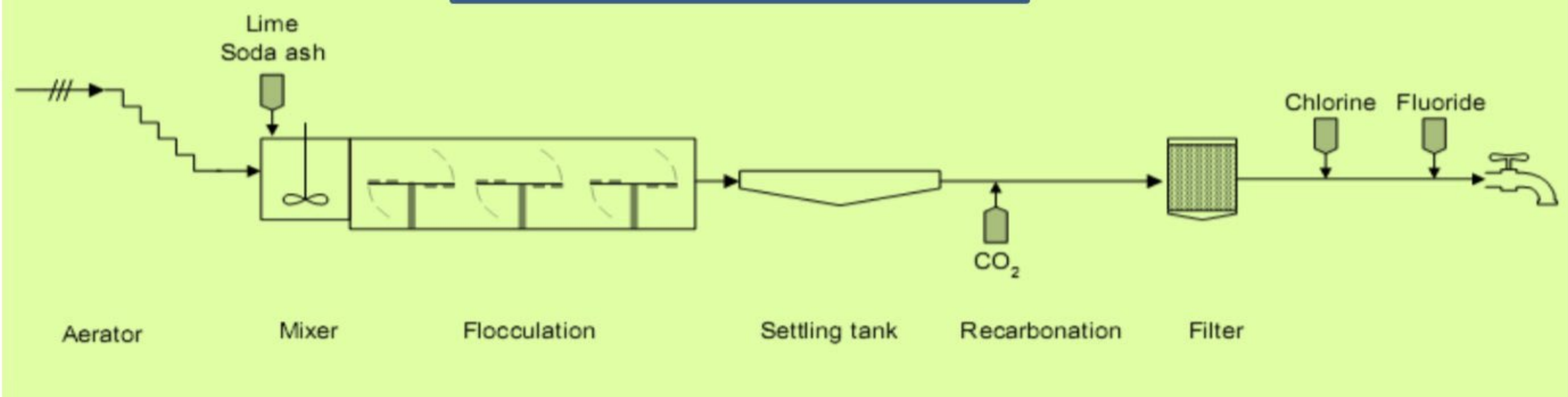


Using Membranes

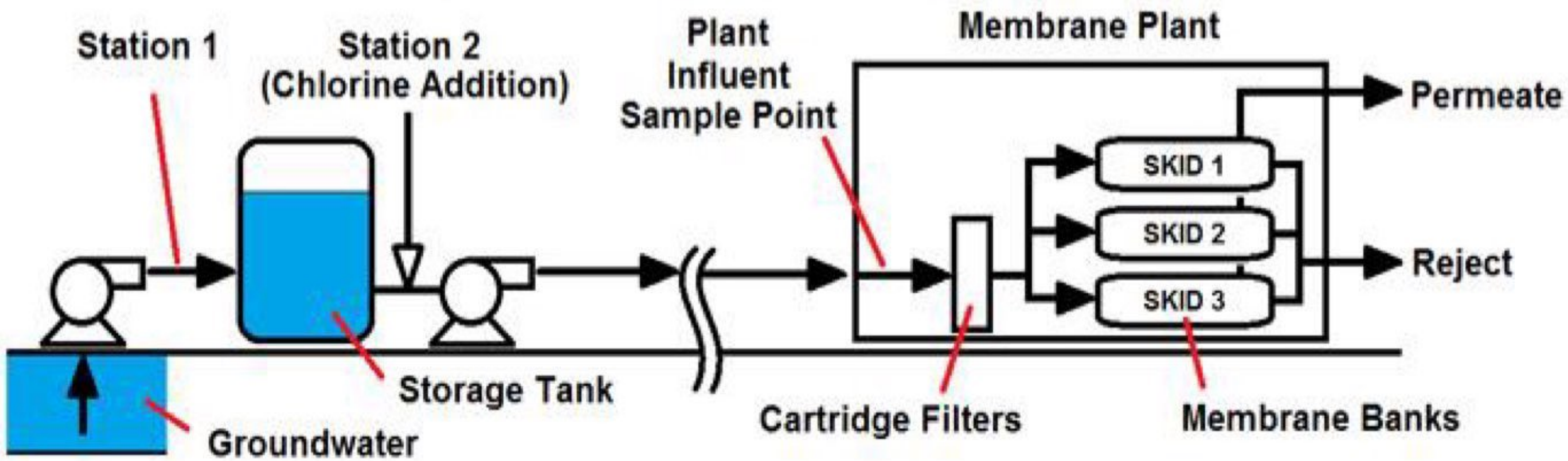


Using membranes for ground water treatment examples

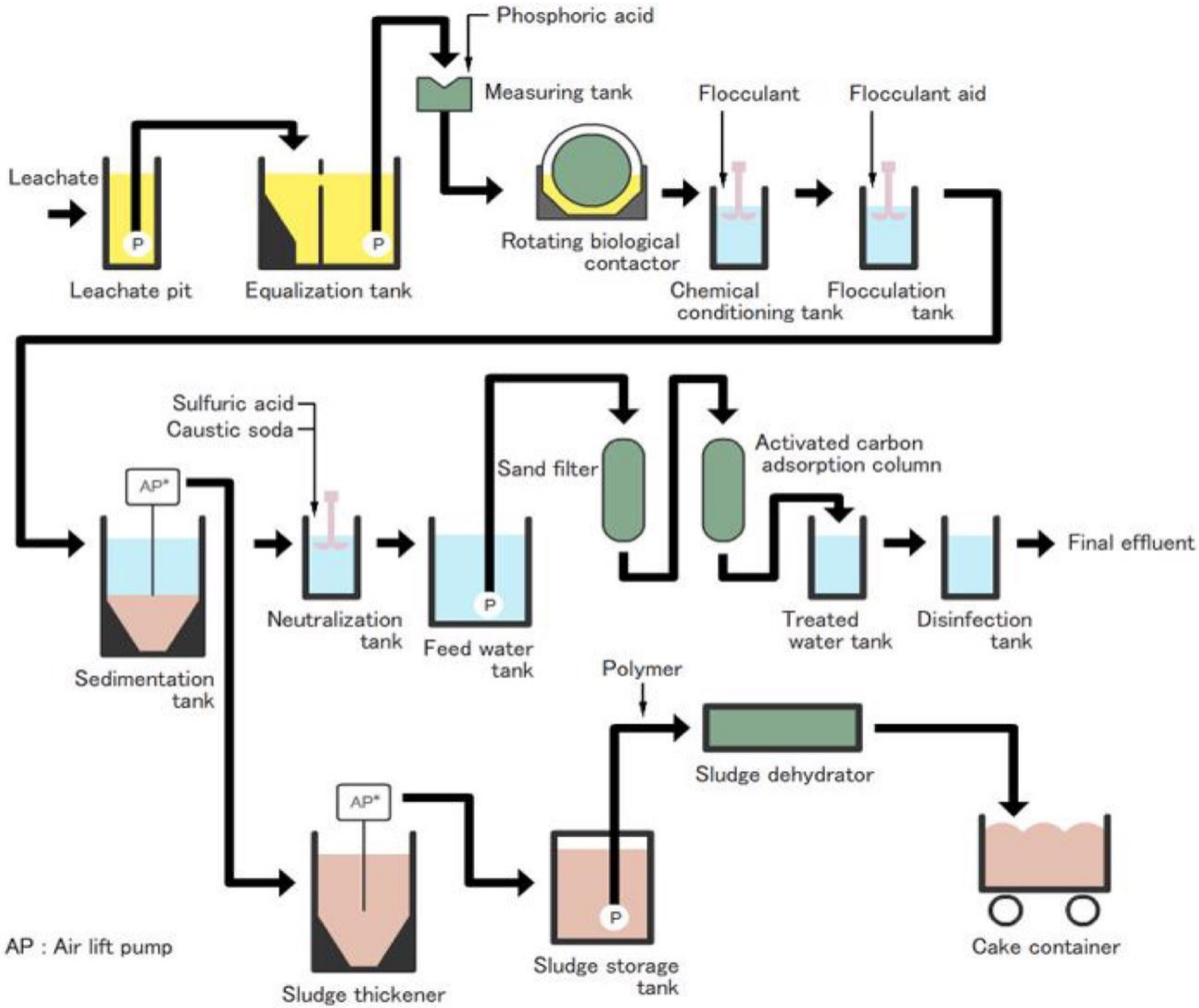
Conventional Treatment



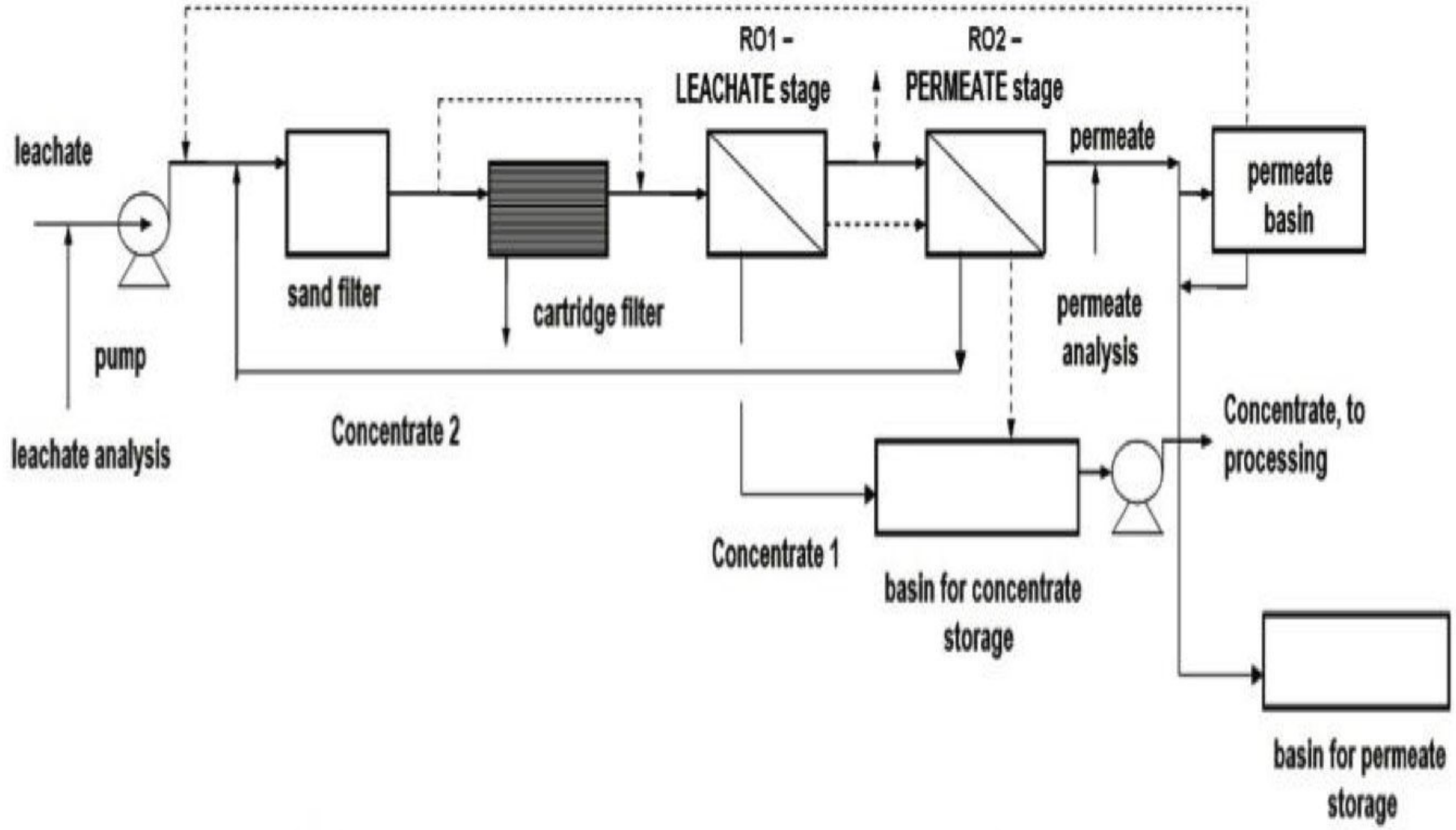
Using Membranes



Using membranes for leachate treatment

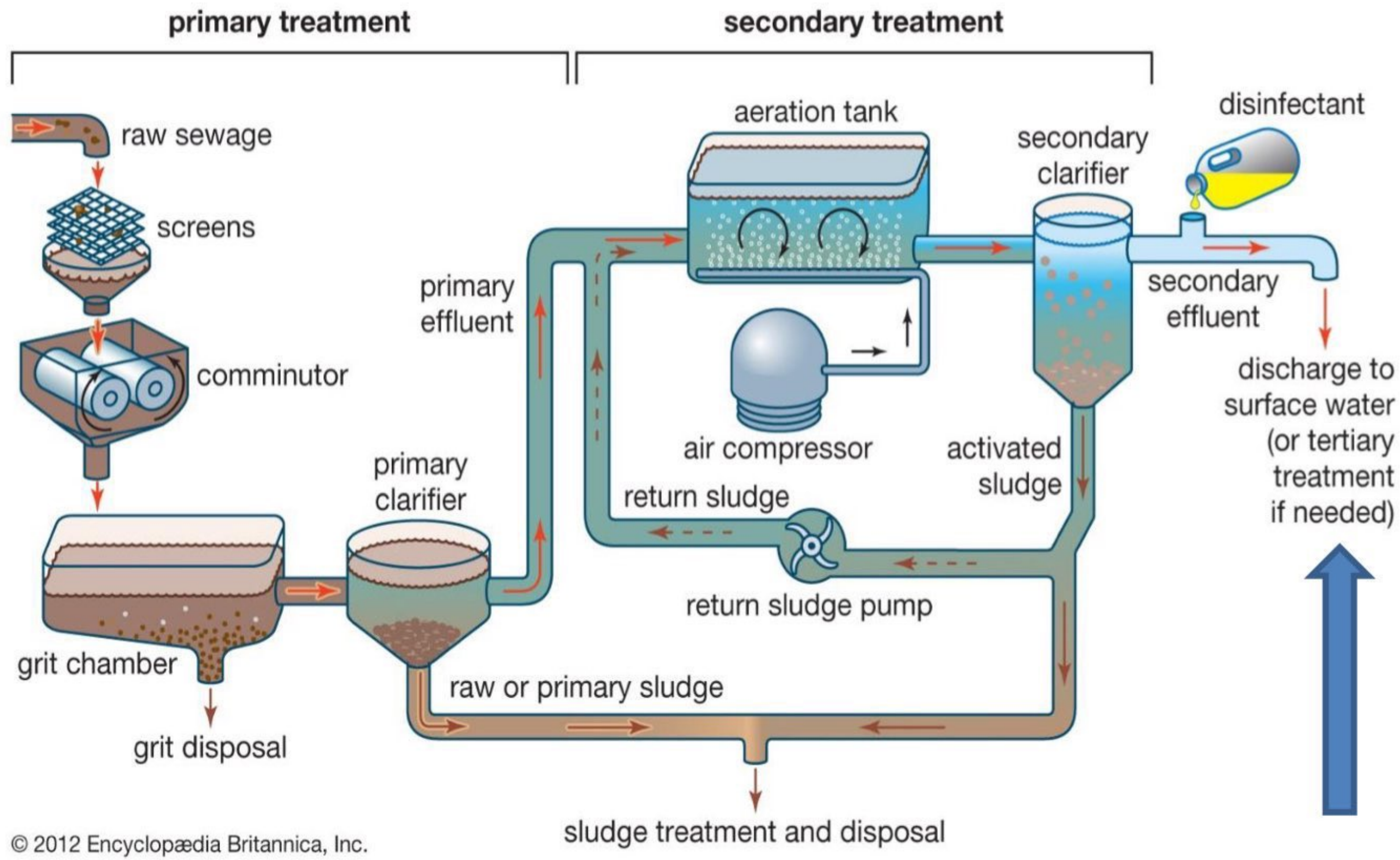


Using membranes for leachate treatment

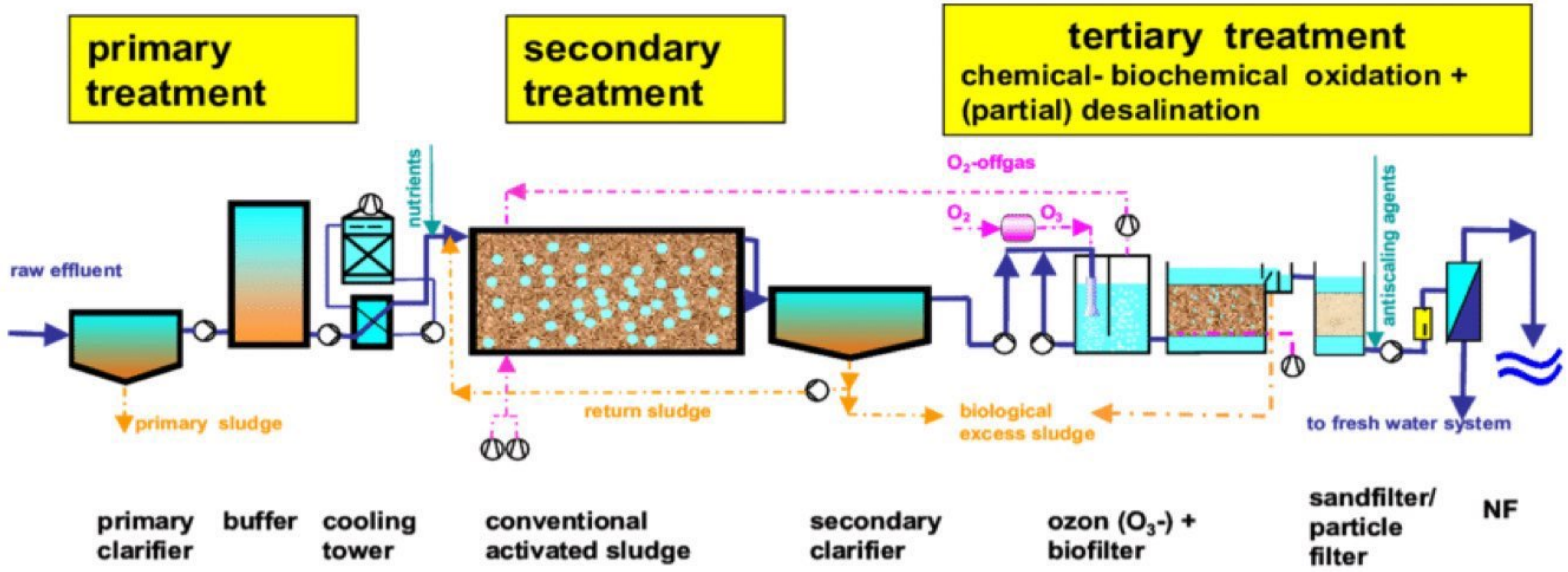


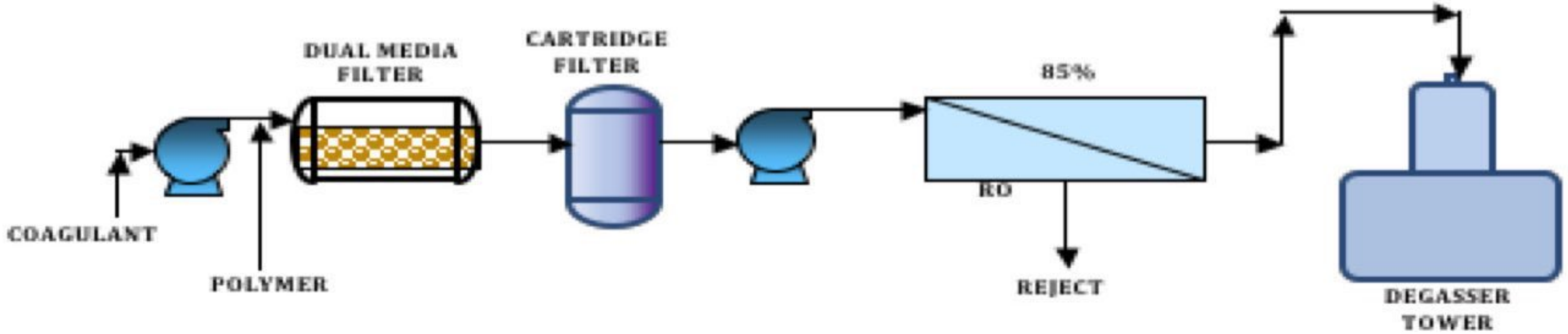
Sea Water Treatment (Desalination)

Conventional Wastewater Treatment

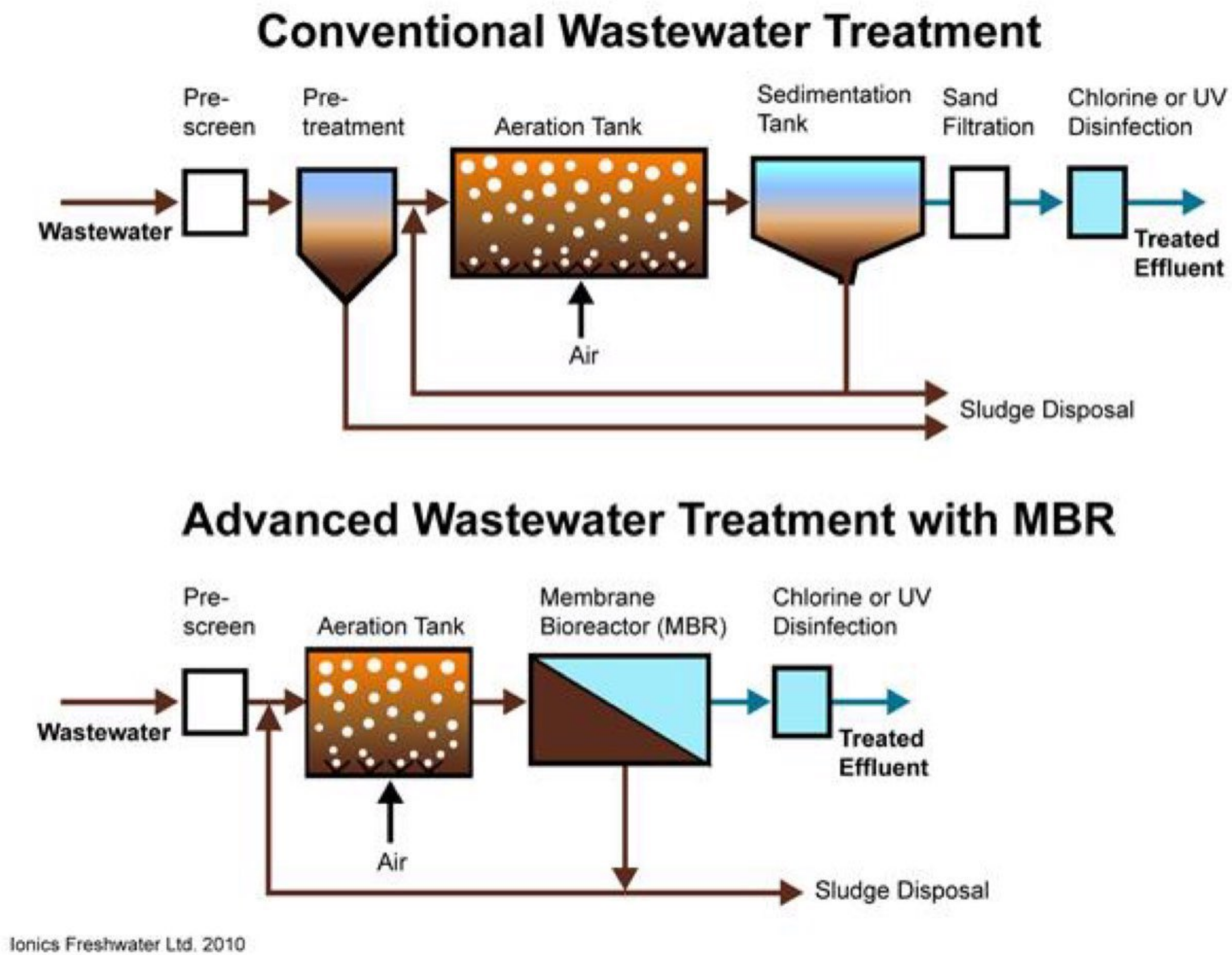


Advanced (Tertiary) Wastewater Treatment

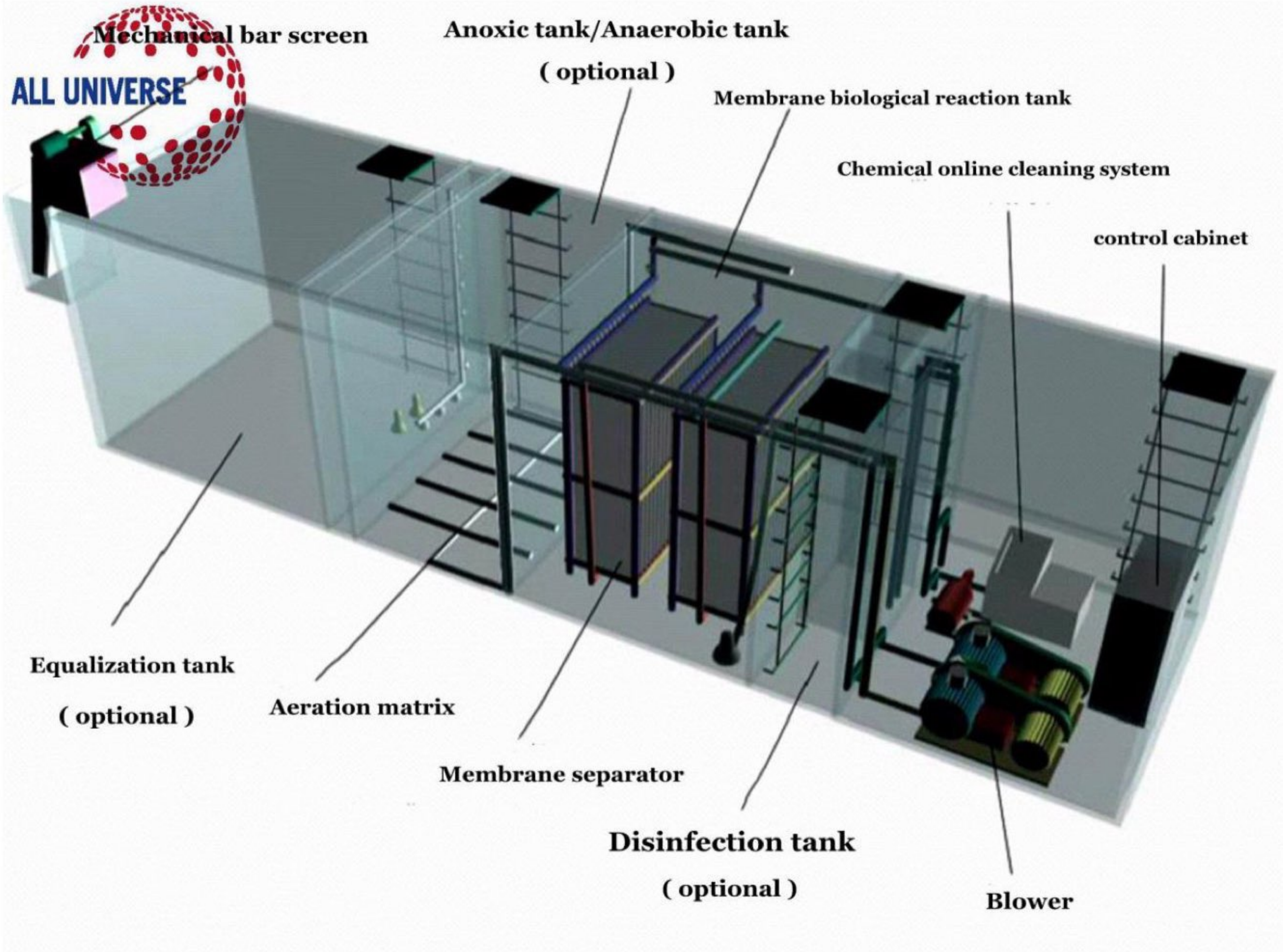




Using Membrane Bio-Reactor (MBR)



Membrane Bio-Reactor (MBR)



Membrane Bio-Reactor (MBR)

Membrane bioreactor (MBR) technology has emerged as a wastewater treatment technology of choice over the activated sludge process (ASP), which has been the conventional municipal wastewater technology over the last century. MBR is, in fact, one of the most important innovations in wastewater treatment, as it **overcomes the drawbacks of the conventional ASP, including**:

- large space requirement for secondary clarifiers,
- liquid–solid separation issues,
- production of excess sludge, and
- limitations with removal of recalcitrants.

MBRs have been used for both municipal and industrial wastewater treatment and reclamation. An MBR is a hybrid of a conventional biological treatment system and physical liquid–solid separation using membrane filtration in one system. **The MBR technology provides the following advantages over ASP:**

- High-quality effluent
- higher volumetric loading rates
- shorter hydraulic retention times (HRT)
- longer solid retention times (SRT)
- less sludge production
- potential for simultaneous nitrification/denitrification in long SRTs
- The inclusion of membranes in the system eliminates the need for secondary clarifiers.

Membrane Bio-Reactor (MBR)

The elimination of secondary clarifiers and operation of MBR at a shorter HRT results in significantly reduced plant area requirements. However, **the use of MBR technology has disadvantages**, including

- higher energy costs,
- the need to control membrane fouling problems, and
- potential high costs of periodic membrane replacement

Membrane Bio-Reactor (MBR)

Fouling in MBRs occurs in different forms, namely, pore narrowing, pore clogging and, cake formation. **Pore clogging** refers to the blocking of membrane micro pores by foulants. Pore clogging depends, to a large extent, on the size of the particle and the membrane pore size. The attachment of the materials in the pores is aided by sticky substances in the solution. **Cake formation,** on the other hand, results from the continuous accumulation of bacteria clusters, biopolymers and inorganic matter, which form a layer (biocake) on the membrane. The cake layer increases membrane filtration resistance.

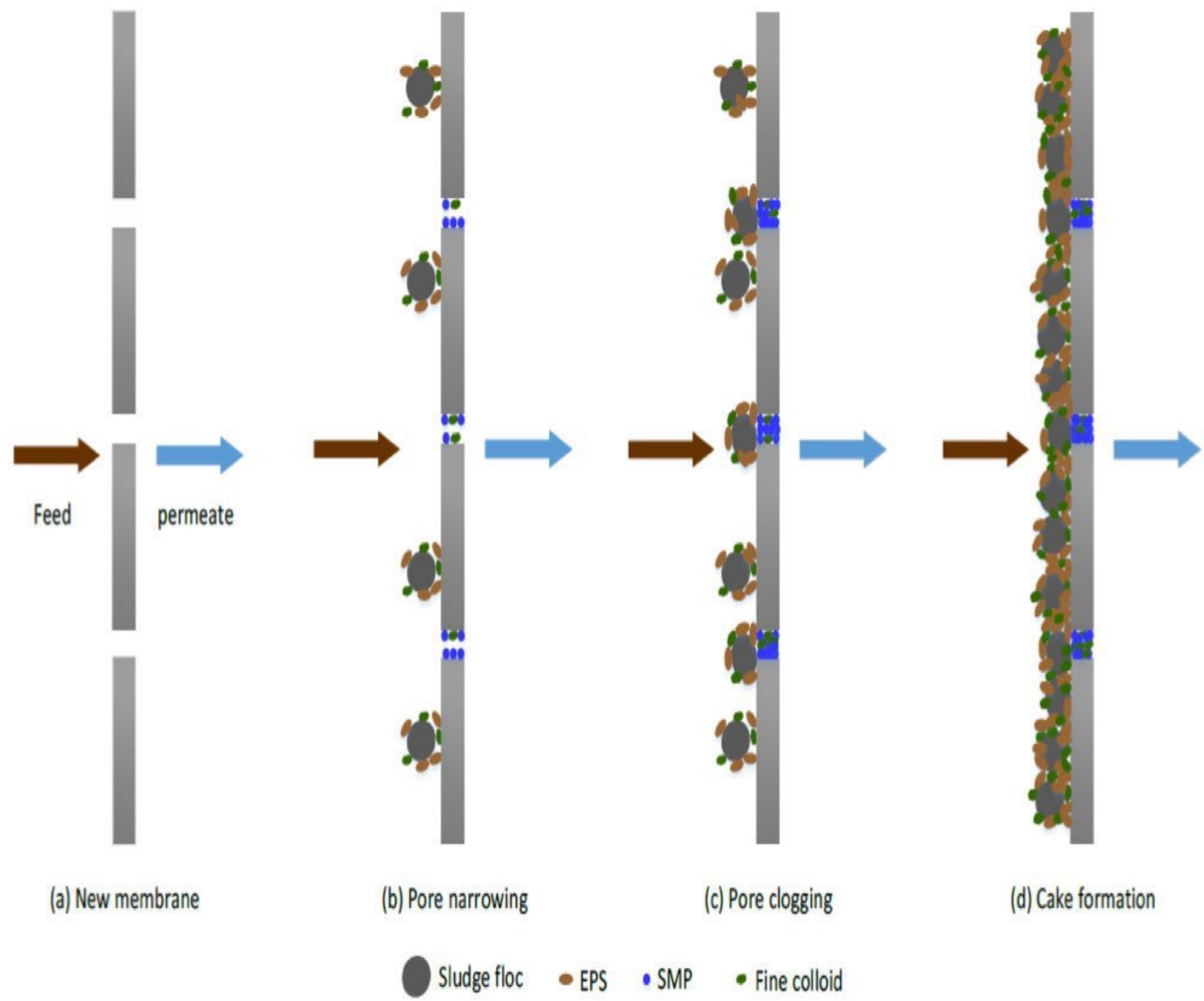
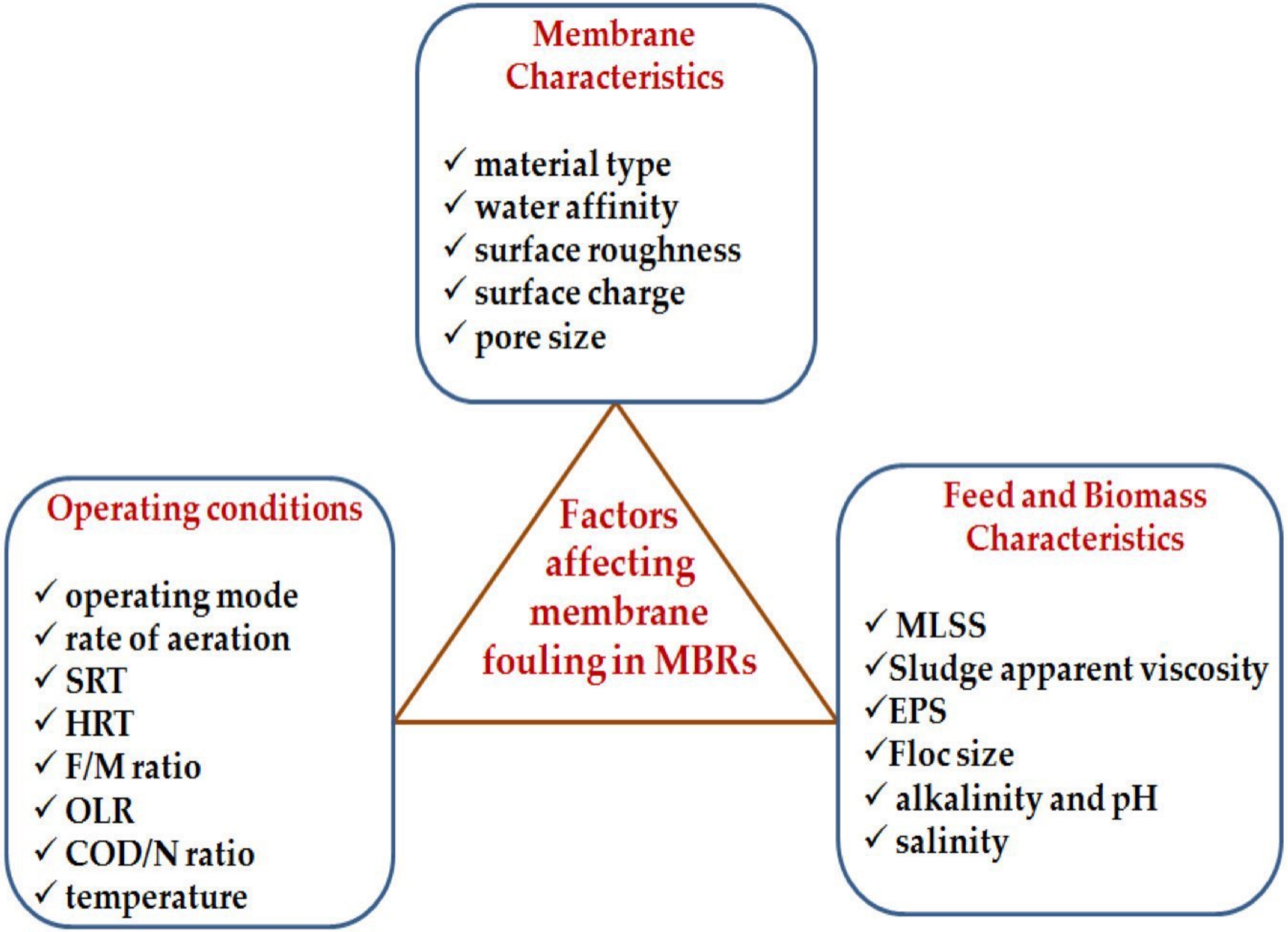


Figure 1. Mechanisms of membrane fouling in membrane bioreactors (MBR).

Membrane Bio-Reactor (MBR)



Membrane Bio-Reactor (MBR)

Factor	Effect on Membrane Fouling
Membrane Characteristics	
Membrane Material	Ceramic membranes are hydrophilic, hence they foul less. Polymeric membranes are mostly hydrophobic and exhibit more fouling
Water affinity	Increasing hydrophilicity indicates less membrane fouling propensity while hydrophobicity correlates well with increase propensity for membrane fouling
Membrane surface roughness	Membrane fouling tends to increase with increasing surface roughness as the rough surface provides a valley for the colloidal particles in the wastewater to accumulate on. However, higher projections on the membrane surface exhibit higher antifouling property and better permeability recovery after backflushing than gentle roughness.
Membrane surface charge	The colloidal particles depositing on the membrane makes them negatively charged, hence they can attract cations in the MLSS, such as Ca^{2+} and Al^{3+} leading to inorganic fouling
Membrane pore size	Increasing membrane pore size increases the tendency for pore blocking mechanism

Membrane Bio-Reactor (MBR)

Operating Conditions	
Operating mode	Operating in cross-flow filtration mode reduces cake layer formation on the membrane surface
Aeration	Increasing aeration rates results in a reduction in membrane fouling
Solids retention time (SRT)	Operating at high SRTs reduces the production of EPS, hence reduced fouling. However, extremely high SRTs rather increase membrane fouling due to the accumulation of MLSS and increased sludge viscosity
Hydraulic retention time (HRT)	Decreasing HRTs results in increasing rate of membrane fouling. However, extremely high HRTs leads to an accumulation of foulants
Food-microorganisms (F/M) ratio	The rate of membrane fouling in MBRs increases with increasing F/M ratio due high food utilisation by biomass resulting in increased EPS production
Organic loading rate (OLR)	Membranes foul more as OLR increases
COD/N ratio	Operating at higher COD/N ratio reduces rate of membrane fouling, improved membrane performance and a longer operation period before membrane cleaning
	On the contrary, other studies found that low COD/N ratio results in lower MLSS concentration, lower SMPs production, lower carbohydrates, proteins, and humic acids in LB-EPS; hence, low membrane fouling
Temperature	Low temperatures increase the propensity for membrane fouling as more EPS are released by bacteria and the number of filamentous bacteria increases. Sudden temperature changes also increase fouling rate due to spontaneous release of SMPs

Membrane Bio-Reactor (MBR)

Feed/biomass characteristics	
Mixed liquor suspended solids (MLSS)	Increasing MLSS correlate with increased rate of membrane fouling
	Other studies report no (or little) effect of MLSS on membrane fouling
Sludge apparent viscosity	Increasing the viscosity results in increased membrane fouling
Extracellular polymeric substances (EPS)	Increase in the concentration of EPS (bound EPS and SMPs) result in membrane fouling
Floc size	Decrease in floc size increases membrane fouling
pH	Decrease in pH results in increased rate of membrane fouling
Salinity	Increasing salinity increases membrane fouling by altering biomass characteristic like more release of bound EPS and SMPs, floc size and zeta potential

Current Research Trends for Membrane Fouling Abatement in MBR

1. Addition of Coagulants

- The addition of coagulants to water and wastewater treatment systems facilitates the formation of large flocs from fine particulates in solution. In MBRs, the coagulants help the formation of larger size sludge flocs which enhance membrane filtration.
- The addition of these coagulants resulted in membrane fouling control through the reduction of the initial TMP and the rate of TMP increase. This was attributed to the ability of the coagulants to restrain the formation of gel layer, decelerate foulants development, and remove stable foulants from the surface of the membrane.

Current Research Trends for Membrane Fouling Abatement in MBR

2. Adsorbent Addition

- Adsorbents provide a large surface area for the adsorption of materials in water and wastewater.
- In MBR, adsorbents offer the potential to adsorb dissolved organic polymers, notably SMPs, hence reducing membrane fouling propensity.
- Powdered activated carbon (PAC) is typically applied in MBRs for the purpose of reducing organic fouling and biofouling. PAC also serves as media for bacterial attachment and subsequent growth

Current Research Trends for Membrane Fouling Abatement in MBR

3. Use of Granular Materials with Aeration

- To enhance the detachment of foulants from the membrane in MBR, research has focused on using granular materials (granular activated carbon (GAC)) with air scouring to provide continuous mechanical cleaning.
- The introduction of the granular materials also allowed MBR operation at a higher permeate flux (more than 20% higher) compared to the conventional MBR.

Thank You