Membrane Bio-Reactors

An Introduction

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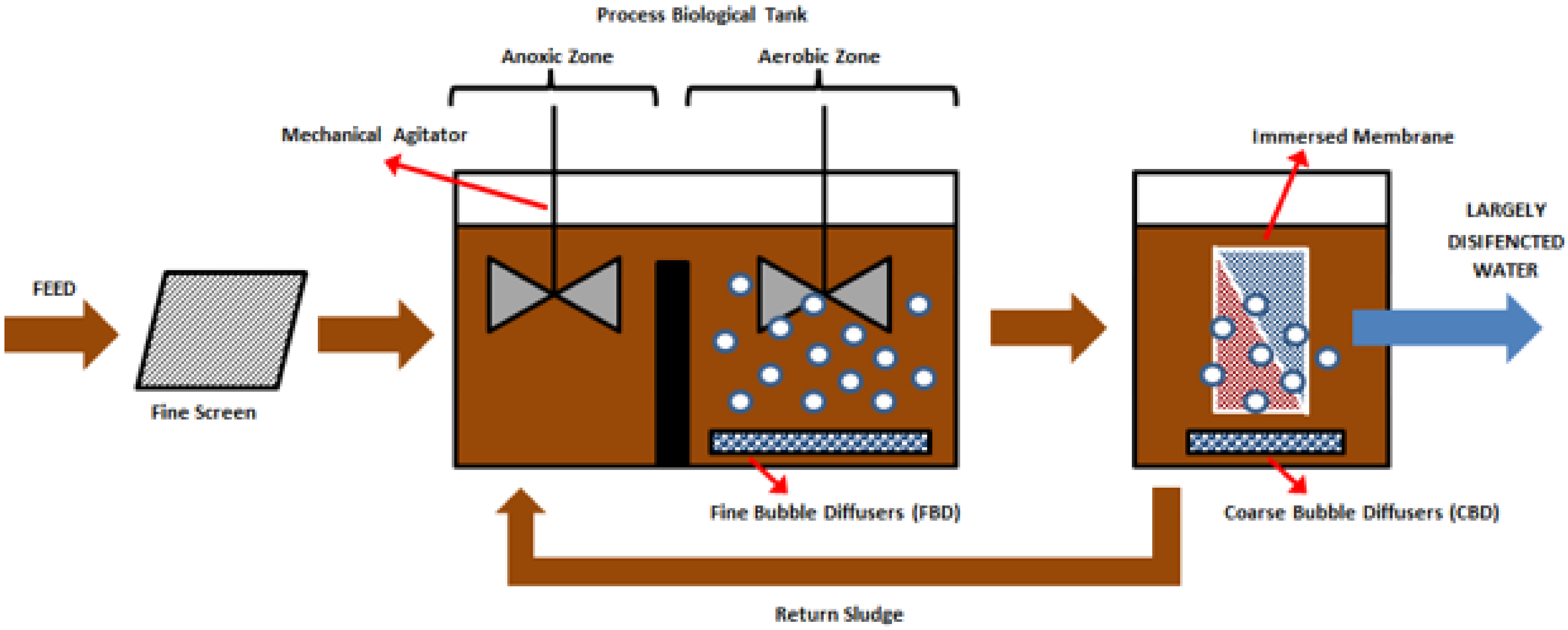
Definition

Membrane bioreactor (MBR) processes are mainly used for wastewater treatment by combining microfiltration (MF), ultrafiltration (UF) or Nanofiltration (NF) membrane separation and the biological process known as ASP (Activated Sludge Process). The membranes are employed as a filter removing the biological solids which are developed during the biological process, which gives a clear and nearly pathogen free product. The membrane separation replaces the settling clarifiers used in the classical ASP thus saving space.

Schematic of MBR



Parameters

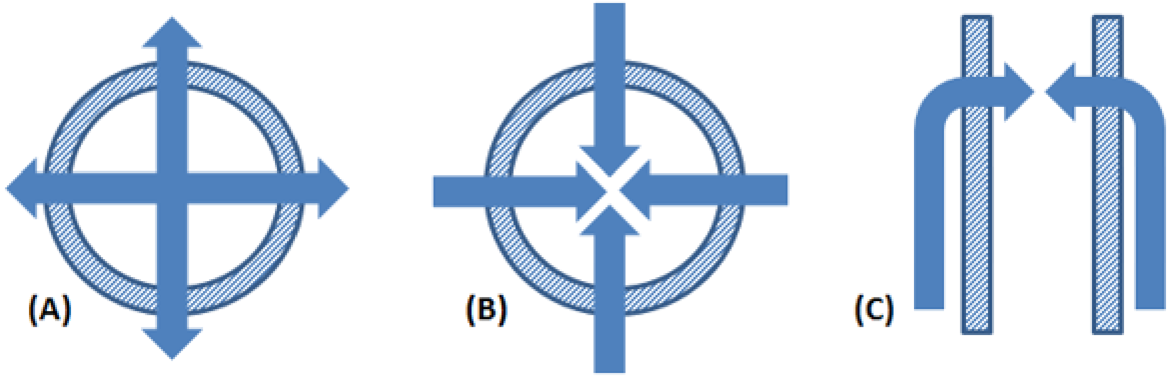
The MBR process operates over a considerably different range of parameters than the conventional activated sludge process:

- **SRT 5 -20 days for conventional system - 20 -30 days for MBR**
- **F/M 0.05 -1.5 d-1for conventional system - < 0.1 d-1for MBR**
- **MLSS 2,000 mg/L for conventional process - 5,000 -20,000 mg/L for MBR**

Configurations

In general MBRs have three distinct membrane configurations:

- **hollow fibre (HF) - A**
- **Multi-tube (MT aka Tubular) - B**
- **Flat Sheet (FS) - C**



HF vs MT vs FS MBR Module

Advantages of MBR

MBRs are generally a preferred option when:

- **There's limited space**
- **End user requires high quality treated water (e.g. for water reuse)**
- **Independent control of HRT and SRT**
- **Better biological treatment (due to higher SRT hence higher MLSS)**

Independent control of HRT and SRT

- As the biological solids (mixed liquor or sludge) are completely contained in the bioreactor, this allows for the solids retention time (SRT) to be controlled independently from the hydraulic retention time (HRT). In the CAS process, the flocculant solids (‘flocs’) that are essentially the biomass have to be allowed to grow in size to the point where they can be settled out in the secondary clarifier. So in CAS the HRT and SRT are connected; as the HRT increases, the flocs have to grow which then increases their settleability.

Better Bio-Treatment

- MBRs have higher SRT which tends to provide better overall bio-treatment due to encouraging the development of the slower-growing micro-organisms, specifically nitrifiers. This fact makes MBRs very effective at the biological removal of ammonia (‘nitrification’).

Disadvantages of MBRs

The key disadvantages of an MBR are the operational process complexity and the cost of CAPEX and OPEX.

- Both of the latter are due to the use of membranes.

  The OPEX is additionally a function of :

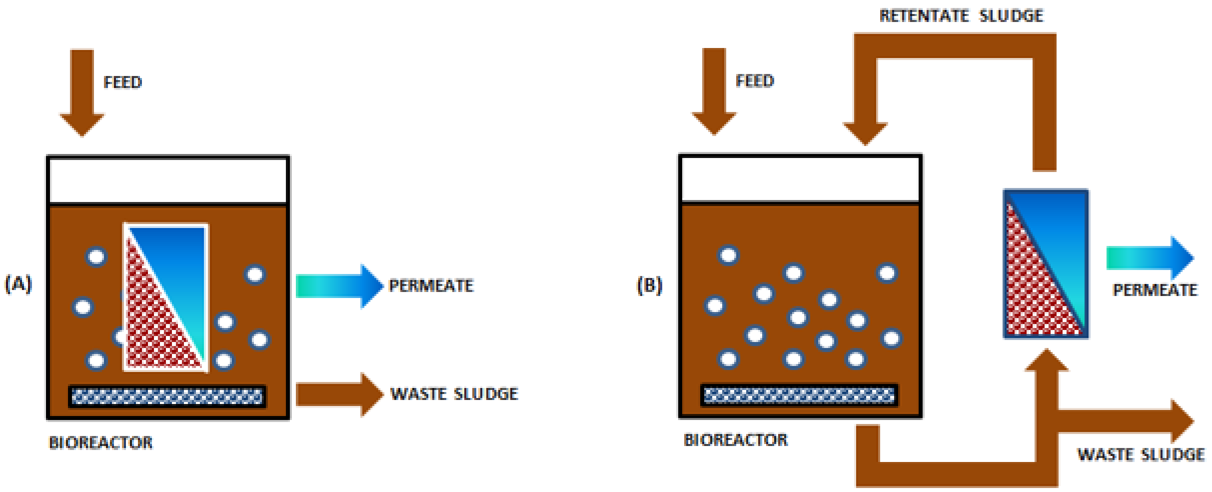
- the membrane life
- permeate flux
- the membrane air scour rate (air scour energy)
- Chemicals used in cleaning the membranes

MBR configurations

- MBR membrane filtration has two major configurations:

1) vacuum or suction driven membranes immersed directly into the bioreactor (iMBR) and

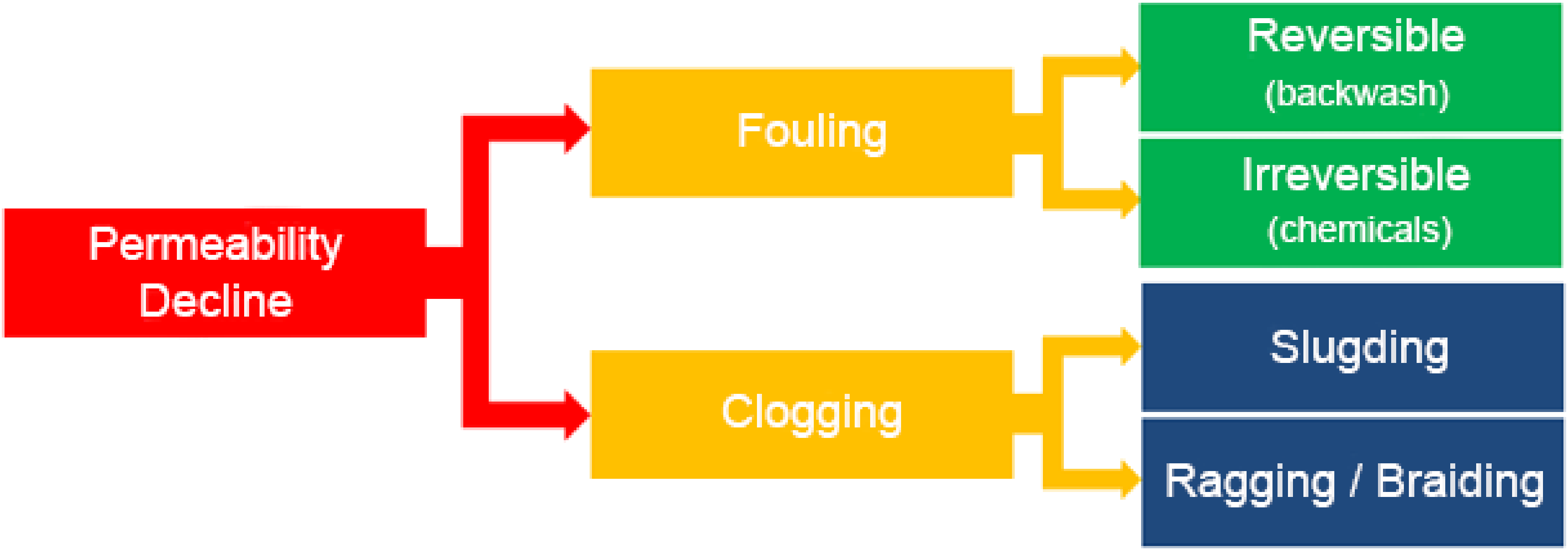
2) pressure-driven filtration in side-stream MBRs (sMBR)



sMBR vs iMBR

- For small flows of hard to treat effluents, the sMBR is often predominant due to its simple operation, smaller footprint and simpler maintenance especially when it comes to membrane replacement. For very large plants, the iMBR is always selected with the HF membranes since the OPEX is usually lower.

Permeability Decline



Fouling vs Clogging

‘Fouling’ is the coating of the membrane surface or the plugging of the membrane pores with dissolved, colloidal or fine solids. It is normally removed by the physical and chemical cleaning cycles.

By ‘clogging’ we mean the agglomeration of gross solids within or at the entrance to the membrane channels. Clogging within the channels is sometimes referred to as ‘sludging’.

MBR Chemical Cleaning

- Chemical cleaning of membrane elements should be conducted when the trans-membrane pressure rises to excess.
- Chemicals normally used:
  - NaOCl for cleaning organics
  - Oxalic or Citric Acid for cleaning in-organic foulants

References

- Lenntech Website
- The MBR Site
- Toray Membrane Technical Bulletins