

## **GLOSSARY - MBR**

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## GLOSSARY – MEMBRANE BIOREACTOR (MBR)

### A

#### **AEROBIC**

Conditions where oxygen acts as *electron donor* for biochemical reactions

#### **AERATION**

Process of adding air to wastewater for aerobic microbiological degradation

#### **AERATION TANK/BASIN**

Tank/basin wherein diffusers are laid and provide air for biological oxidation of pollutants – COD, BOD<sub>5</sub> in sewage / wastewater → also called “Aerobic Biological Reactor”

#### **AEROBIC BIOLOGICAL REACTOR**

See **Aeration Tank**

#### **AIR SCOURING**

Diffusers placed below the membrane modules generate air bubbles in water that scour (rub) the membrane surface and keep it clean

#### **ALLOCHTHONOUS**

Of terrestrial origin

#### **ANAEROBIC**

Conditions where biochemical reactions take place in the absence of oxygen

#### **ANAEROBIC BIOLOGICAL REACTOR**

- Anaerobic biological reactor is used as a pretreatment to the main aerobic biological reactor for high-strength industrial wastewaters, or in some cases even for high-strength sewage
- Anaerobic (in the absence of oxygen) decomposition breaks down large molecules into small molecules for easy assimilation by the aerobic bacteria in the aeration tank

#### **ANAEROBIC DECOMPOSITION**

- Decomposition of cellulose and proteins occurring in the absence of oxygen, such as in landfill waste, producing methane and carbon dioxide
- Anaerobic bioreactors increase the rate of methane generation, which can then be collected and used for energy recovery

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**ANISOTROPIC**

Having symmetry only in one plane

**anMBR**

Anaerobic membrane bioreactor

**ANNULAR FLOW**

Flow through an annulus (or gap created concentric cylinders)

**ANOXIC**

Conditions where some species other than oxygen acts as the electron donor for biochemical reactions

**ANTHROPOGENIC**

Of human origin or derived from human activity

**AUTOCHTHONUS**

Of microbial origin

**AUTOTROPHIC**

Using carbon dioxide as the sole carbon source for growth and development

**B**

**BACKFLUSHING**

Reversing flow through a membrane to remove foulants

**BIOFILM**

Film or layer of biological material

**BIOLOGICAL TREATMENT (or BIOTREATMENT)**

Process whereby dissolved organic chemical constituents are removed through biodegradation

**BIOMASS**

Visible (living) microorganisms used to achieve removal of organics through biotreatment

**BUBBLE FLOW**

Air/liquid two-phase flow where liquid is the continuum

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## C

### **CAKE**

Solid material formed on the membrane during operation

### **CASSETTE**

Smallest practical unit containing one or more membranes and supporting structures - also called "**Module**", "**Stack**"

### **CHURN FLOW**

Air/liquid two-phase flow at high air/liquid ratio

### **CLOGGING / SLUDGING**

Accumulation of solids within the membrane channels

### **CONCENTRATION FACTOR**

In membrane separations, concentration factor is the ratio of volume or concentrations of the solute (dissolved species) in the concentrate or reject stream to its volume or concentration in the feed stream

### **CONCENTRATION POLARIZATION (CP)**

- Tendency of solute to accumulate at membrane - solution interface within concentration boundary layer, or liquid film during crossflow operation – development of a concentration gradient of the retained components across the boundary layer near the membrane surface
- At significant concentrations, resistance due to polarization becomes the controlling factor of permeate flux
- Polarization can be minimized by increasing turbulence at the membrane surface to decrease the concentration of gradient thickness

### **CONFIGURATION**

- In membrane separation technology, configuration of a membrane product describes its construction or membrane spatial arrangement
- Basic membrane configurations include hollow fibre, spiral, tubular, and flat-sheet

### **CONDITIONING FOULING**

First stage of membrane fouling through adsorption of material

### **CONTAMINANT**

A source of contamination, an impurity → any substance in water which is not H<sub>2</sub>O

### **CRITICAL FLUX**

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Flux below which permeability decline is considered negligible

### **CRITICAL SUCTION PRESSURE**

Threshold pressure arising during sub-critical flux fouling

### **CROSSFLOW**

Retentate flow parallel to the membrane surface – flow of liquid which sweeps along the inside surface of the membrane, minimizing the cake buildup seen with non-crossflow, dead end conventional filtration

### **CUTOFF**

Used to characterize a membrane by indicating the smallest molecular weight components retained at a given coefficient of retention – most often 0.90

### **CYCLIC AERATION**

Aeration on  $n$ -s-on /  $n$ -s-off basis, where  $n$  is normally between 5 and 30 s

## **D**

### **DEAD END**

A mode of operation where the whole feed is forced to pass through the filter as in conventional cartridge-type filtration i.e., there is not tangential / crossflow in the design

### **DEATH COEFFICIENT**

A biokinetic parameter

### **DENITRIFICATION**

Biochemical reduction of nitrate to nitrogen gas

### **DENSE MEMBRANE**

Membrane of high selectivity attained by specific physicochemical interactions between solute and membrane

### **DONNAN EFFECT**

Rejection or diffusion of external ions by a semipermeable membrane because of a high internal concentration of ions of the same charge

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## EDS

- Energy-Dispersive X-Ray Spectroscopy – an analytical technique that qualitatively identifies the elemental composition of materials analyzed in an SEM (scanning electron microscope)
- EDS analyzes the top two microns of the sample with a spatial resolution of one micron
- Beryllium-windowed EDS detects all elements with atomic numbers greater than oxygen at concentrations greater than 0.1%
- “**Windowless**” EDS detectors can also detect carbon, nitrogen, and oxygen at concentrations greater than 1.0%
- An important tool in the troubleshooting and identification of inorganic fouling material of fouled membranes

## E

### ELECTRODIALYSIS

Membrane separation process by which ions are removed via ion-exchange membranes under the influence of an electromotive force (voltage)

### ELECTRON DONOR

Species capable of donating an electron to a suitable acceptor and is oxidized as a result

### EMBR

**Extractive MBR** – MBR configured so that priority pollutants are selectively extracted into the bioreactor via the membrane

### ENDOGENOUS METABOLISM

Developing or originating within, or part of, a microorganism or cell

### EQUALIZATION TANK

Used for equalization of flow and composition of wastewater – also called “Buffer Tank”, “Surge Tank”, “Holding Tank”

### EUTROPHICATION

- Slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears
- During the later stages of eutrophication, water body is choked by an abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorus → **human activities can accelerate the process**

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## **EXOGENOUS**

Originating outside the microorganism or cell

## **F/M (RATIO)**

Food-to-microorganism ratio (F/M) – rate at which substrate is fed to the biomass compared to the mass of biomass solids

## **FEED**

Feed is the term used to define fluid entering a membrane module or wastewater treatment plant

## **FILAMENT**

Single hollow fibre or capillary tube (“spaghetti”)

## **FILAMENTOUS INDEX**

Parameter indicating relative presence of filamentous bacteria in sludge

## **FILTER CAKE**

Accumulated particles on a filter surface

## **FILTRATE**

Portion of the feed stream which has passed through a filter → also known as “permeate” in membrane systems

## **FILTRATION**

Process of separating solids from a liquid by means of a porous substance through which only liquid passes

## **FIXED-FILM PROCESS**

Process configured with the biofilm attached to a solid medium (which may be a membrane)

## **FLOC**

Aggregated solid (biomass) particle

## **FLUX (or PERMEATE VELOCITY)**

Quantity of material passing through an area of membrane per unit time – usually expresses LMH ( $L/m^2 \cdot h$ ), or gfd ( $gal/ft^2 \cdot d$ )

## **FLUX-STEP**

Critical flux identification method whereby flux is incrementally increased and the TMP or permeability response recorded

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## **FORWARD FLOW**

In the hollow fiber system, recirculation flow direction of the retentate

## **FOULING**

Processes leading to deterioration of flux due to surface or internal blockage of the membrane

**FOULING INDEX** → see SDI

## **GAS/AIR SPARGING**

Introduction of gas/air bubbles

## **GEL LAYER FORMATION**

- Precipitation of sparingly soluble macromolecular species at membrane surface – a builtup layer of retained material at increased concentration (relative to the bulk material) at the membrane surface
- Gel layer results in increased resistance to flux and generally the thicker the gel layer, the lower the flux
- Gel layer resistance can be minimized by increasing tangential flow and/or feed conditioning and pretreatment to optimize the flux → see **Concentration Polarization**

## **HETEROTROPHIC**

Requiring an organic substrate to get carbon for growth and development

## **HOLDING TANK**

A tank which provides one- to two-day holding capacity of the wastewater – it is located ahead of the process or working tank in a membrane system → also known as “Equalization” or “Surge Tank”

## **HOLDUP VOLUME**

- Volume in a membrane system from the feed inlet to the retentate outlet on the retentate side of a module or a whole plant → also used in describing tank sizes
- Example: a one-day holdup equalization tank has sufficient volume to hold 24 hours worth of wastewater feed

## **HOUSING**

Vessel which holds a membrane module

## **HUMIC MATTER**

Organic matter of terrestrial origin

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### **HYDRAULIC LOADING RATE**

Rate at which water enters the reactor

### **HYDROGENOTROPHIC**

Feeding of hydrogen

### **HYDROPHILIC (water-loving)**

Water-absorbent

### **HYDROPHOBIC (water-hating)**

Water-repellent

## **I**

### **INOCULUM**

Medium containing microorganisms initially introduced into a reactor to establish new populations and start the biotreatment process

### **INTENSIVE / RECOVERY CLEAN**

Cleaning with aggressive chemicals to recover membrane permeability

### **IRRECOVERABLE FOULING**

Fouling which is not removed by physical or chemical cleaning

### **IRREVERSIBLE / PERMANENT FOULING**

Not removed by physical cleaning but removed by chemical cleaning

### **ISOPOROSITY**

Property reflecting narrowness of pore size distribution

## **L**

### **LUMEN-SIDE**

Inside the fibre/filament/lumen

## **M**

### **MACROPORE**

Pore with diameter above 50 nm

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## **MAINTENANCE CLEANING**

Cleaning with less aggressive chemicals to maintain membrane permeability

## **MEMBRANE**

- A porous synthetic material which acts a highly efficient barrier or filter in the range of molecular dimensions – allowing passage of ions, water and other solvents, and very small molecules – but most impermeable to macromolecules
- Membrane classes include – MF (microfiltration), UF (ultrafiltration), NF (nanofiltration), RO (reverse osmosis)

## **MEMBRANE CONFIGURATION**

- In membrane separation technology, configuration of a membrane product describes its construction or membrane spatial arrangement
- Basic membrane configurations include hollow fibre, spiral, tubular, and flat-sheet

## **MEMBRANE PACKING DENSITY**

Membrane area per unit volume

## **MEMBRANE TANK / BASIN**

Tank/basin wherein membrane modules are placed

## **MESOPHILIC**

Thriving at intermediate temperatures – 20 to 45 °C → 15 °C optimum

## **MESOPORE**

Pore with diameter between 2 and 50 nm

## **METHANOGENS**

Microorganisms producing methane as a metabolic byproduct

## **MICROPORE**

Pore with diameter below 2 nm

## **MICROFILTRATION (MF)**

- A process using a membrane class to separate relatively large particles – 0.1 to 3 µm in diameter, with relatively low applied pressures
- In crossflow microfiltration system, feed solution flows perpendicular to the filter surface

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## **MIST FLOW**

Air/liquid two-phase flow where air is the continuum

## **MODULARIZATION**

Based on modules – using more modules at higher flows, rather than increasing the unit pore size

## **MODULE (membrane)**

Smallest practical unit containing one or more membranes and supporting structures

## **MONOD KINETICS**

Kinetics defining biomass growth and decay during biotreatment

## **NITRIFICATION**

Biochemical oxidation of ammonia to nitrate

## **(ORGANIC) LOADING RATE**

Rate at which (organic) matter is introduced into the reactor

## **PANEL**

FS (flat-sheet) membrane element

## **PERCOLATION THEORY**

Theory defining probability of water flowing through a medium containing three-dimensional network of interconnected pores

## **PERMEABLE**

Porous to the passage or penetration by fluids

## **PERMEABILITY**

Ease of flow through membrane – represented by flux:pressure ratio

## **PERMEATE**

Water or fluid which has passed through the membrane → also referred to as “filtrate”

## **PERMEATE PUMP**

Vacuum pump which draws permeate through the membrane – as in MBR

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## PERM-SELECTIVITY

Permeation of some components in preference to others – function of ion exchange membrane which can selectively exclude electrolytes based on charge

## PILOT-SCALE STUDY

A method of studying different ways of treating wastewater and solids or to obtain design criteria on a small scale in the field

## PLATE-AND-FRAME

Synonymous with “flat-sheet”

## PLEATED FILTER CARTRIDGE

Type of flat sheet module

## PLUG FLOW

Flow in which no back-mixing or dispersion occurs along the length of the pipe or reactor

## POLLUTANT

A contaminant at high enough concentration to endanger the aquatic environment or public health

## PORE

An opening in a membrane or filter matrix

## POROUS

Ability of certain substances to pass fluids due to an open physical structure

## POROUS PLUGGING

Type of membrane fouling – *due to pore blockage*

## POROUS MEMBRANE

Membrane of low selectivity operating by physical straining alone

## PRETREATMENT

- In membrane wastewater treatment systems, pretreatment is the initial processing of wastewater to prolong the life of a membrane system and to optimize membrane performance
- Pretreatment includes – screening, equalization, oil & grease removal, primary clarification, aeration to oxidize colloidal and dissolved organics in wastewater

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## **PSYCHROPHILIC**

Thriving at relatively low temperatures (0 – 20 °C)

## **RACK**

Smallest practical unit containing one or more membranes and supporting structures

## **RECOVERY or CONVERSION**

Fraction of feed water converted to permeate product

## **REDUCTION-OXIDATION (REDOX) CONDITIONS**

Conditions defined by the presence of either dissolved oxygen or some other species capable of providing oxygen for bioactivity

## **RELAXATION**

Ceasing permeation whilst continuing to scour the membrane with air bubbles

## **RESISTANCE**

Resistance to flow – proportional to flow rate-to-pressure ratio

## **RETENTATE**

Water or fluid which is rejected by the membrane – portion of the feed solution in UF and RO that does not pass through the membrane – also called “concentrate” or “reject”

## **REVERSIBLE OR TEMPORARY FOULING**

Gross solids attached to the membrane surface and which can be removed by physical cleaning relatively easily – such as backflushing or relaxation

## **SCALING**

Buildup of precipitated salts on a surface – such as pipes, tanks, boiler tubes, membrane surface (in RO, UF) resulting in a physical or chemical change

## **SCOURING**

See **Air Scouring**

## **SEMIPERMEABLE MEMBRANE**

A membrane which allows a solvent such as water to pass through while rejecting certain dissolved or colloidal substances

## **SEWER**

An artificial, usually subterranean conduit, used to carry off sewage or wastewater

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### **SILT DENSITY INDEX (SDI)**

A test used to measure the level of suspended solids in feedwater (especially for RO) – it is a measure of the tendency of water to foul a membrane, based on a timed flow through a membrane filter → 0.45 µm filter, at a constant pressure – also known as “fouling index”

### **SEPTUM**

Coarse membrane filter

### **SHEAR (STRESS)**

Force applied to a body which tends to produce a change in its shape, but not its volume

### **SHELL-SIDE**

Outside the membrane fibre/filament/lumen

### **SIDE-STREAM**

Stream outside the bioreactor

### **SLUG FLOW**

Air/liquid two-phase flow at moderate air/liquid ratios

### **SPIRAL WOUND**

Flat sheet UF, MF, NF, and RO membrane configuration where a membrane sheet (leaf or leaves) with feed spacer material is spirally wrapped around a central permeate collection tube

### **STACK**

Smallest practical unit containing one or more membranes and supporting structures

### **STRUVITE**

Magnesium ammonium phosphate salt

### **SUBSTRATE**

Surface or medium on which an organism grows or is attached

### **SUPERNATANT**

Liquid clarified by sedimentation

### **SURFACE POROSITY**

Percentage of the surface area occupied by the pores

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**SURFACE WATER**

Water in creeks, rivers, lakes, oceans, and reservoirs

**SURGE TANK**

See equalization tank

**SUSTAINABLE FLUX**

Flux for which the TMP (trans-membrane pressure) increases gradually at an acceptable rate, such that chemical cleaning is not necessary

**THERMOPHILIC**

Thriving at relatively high temperatures (49 – 57 °C, 45 °C optimum)

**TMP JUMP**

Sudden increase in TMP when operating under sub-critical flux conditions

**TMP-STEP METHOD**

Critical flux identification method where TMP is incrementally increased and the flux or permeability response recorded

**TORTUOSITY**

Ratio of pore length to membrane thickness

**TOTAL SOLIDS (TS)**

Total dissolved and undissolved solids in water or wastewater

**TOTAL SUSPENDED SOLIDS (TSS)**

Solids that are retained on a standard glass fibre filter disk (0.45 µm) after filtration and then drying at 103 – 105 °C

**TRANSMEMBRANE PRESSURE**

Pressure difference from the feed side of the membrane to the permeate side

**TRUE OIL AND GREASE**

See **Hydrocarbons**

**TURBIDITY**

1. A suspension of fine particles in water that obscure the light rays and cause cloudiness and will not readily settle due to small particle size

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2. Measure of the clarity of an otherwise clean liquid – cloudy or hazy appearance in a naturally clear liquid
3. Typically, turbidity of the MBR permeate is less than 1 N.T.U.

### **TURBIDITY UNITS**

Measurement of relative ability of a solution to allow a light beam to pass through it – usual units are N.T.U. (Nephelometric Turbidity Units)

### **ULTRAFILTER**

A mechanical unit used in the membrane separation process

### **ULTRAFILTRATE**

A synonym for UF “permeate”

### **ULTRAFILTRATION (UF)**

- Membrane separation process based on size exclusion
- UF operates in the molecular weight cut-off (MWCO) range from 1,000 MWCO to 200,000 MWCO, or 0.002  $\mu\text{m}$  to 0.1  $\mu\text{m}$
- Emulsified oils, suspended solids, bacteria, and large molecules are rejected by UF membranes
- Water and small molecules – dyes, surfactants, dissolved salts, and solvents pass through in the permeate

### **UPFLOW CLARIFICATION**

Dynamic clarification by sedimentation

### **VOLUMETRIC MASS TRANSFER COEFFICIENT**

A combination of (i) the overall liquid mass transfer coefficient and (ii) the specific area for mass transfer .The term measures the mass transfer of oxygen into the liquid via air bubbles

### **ZETA POTENTIAL**

Potential (in mV) at the shear plane of a solid-liquid interface

### **$\alpha$ or $\beta$ FACTOR**

Factors applied to correct biological aeration demand for dissolved and suspended solids content of biomass

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