Industrial Wastewater Treatment

Presented by Ian Purssell

Syntek Environmental

About Syntek Environmental

- Established in 2006
- Focus on biological wastewater and solid waste treatment
- Work Australia wide
- Work with a range of industrial customers in industries that include
  - Corrugated Cardboard Box Plants
  - Dairy industries including milk, cheese and ice cream
  - Food Processing
  - Chemical and Petrochemical Plants
  - Oil refineries
  - Metal and glass works

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Presentation Outline

- Industrial wastewater treatment and waste management
- Treatment technologies for small, medium and large businesses
- Primary, secondary and tertiary treatment technologies
- Application of synergistically networked biological treatment and bioconversion technologies achieved minimal waste for many industries.

What is industrial wastewater treatment

- Treatment of wastewater generated as a byproduct of industrial activities for re-used on site or discharge from the site
- Whether discharging to a receiving sewer, creek or river, or used for irrigation on site, there are discharge requirements that must be met and often charges based on water quality for discharge to sewer
- Pre-treatment on site prior to discharge ensures wastewater leaving site meets water quality requirements and minimises the cost of discharge.

Small Business Waste Management

- Small business usually produces less than 5t/day of waste water and up to 1t a day solid waste.
- Primary treatment applies: waste collection, screening, sedimentation, pH adjustment
- Ultraverte bioconversion

Primary Treatment

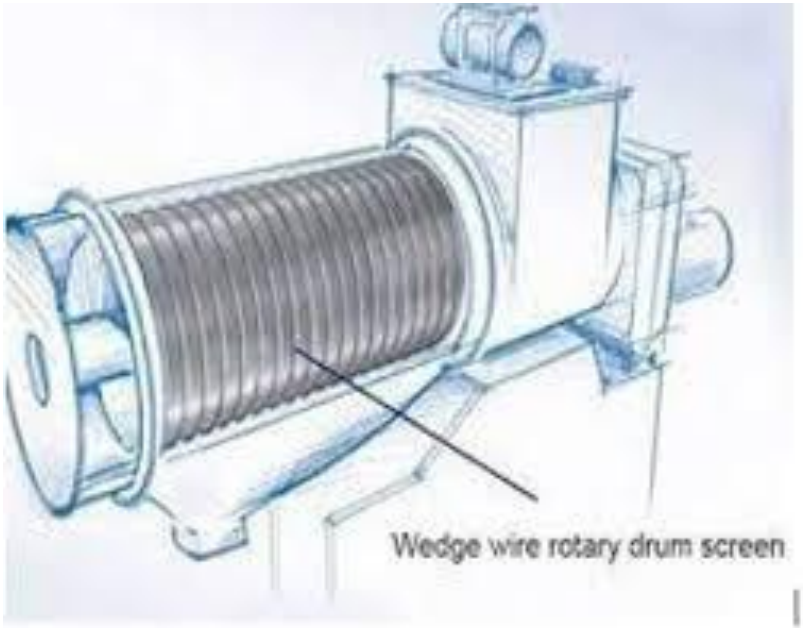
Primary treatment usually involves removal of solid material and prepares water for further treatment. Primary wastewater treatment uses gravity and physical processes to remove materials that can float or settle in the water.

Common primary treatment processes include:

- Flow balancing
- Sedimentation
- Screening
- Grit removal
- Dissolved air flotation
- PH adjustment
- New technology: Ultraverte bioconversion

Screening

The removal of large particulate matter before it enters the wastewater treatment plant helps reduce build up of solids in tanks and avoid pump and pipe blockages



Common screens include

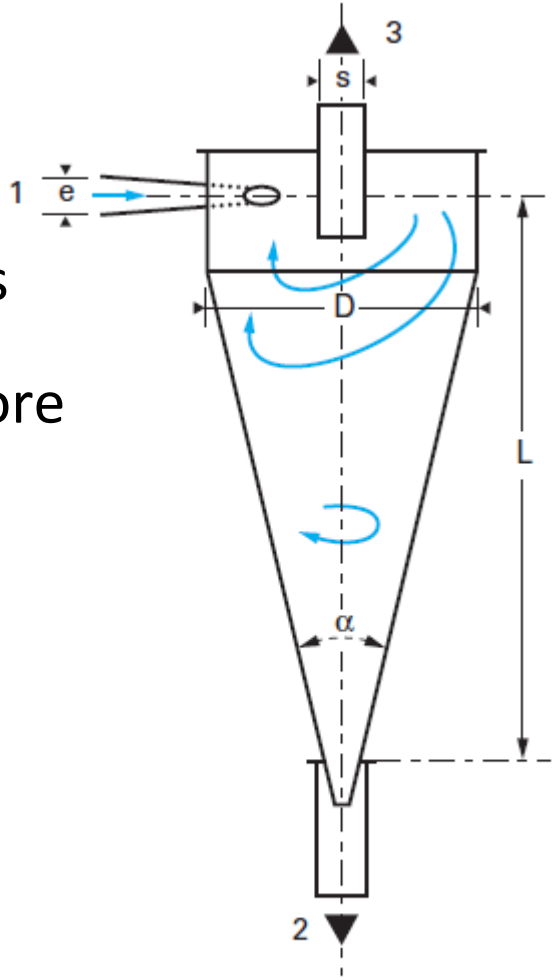
- Bow screens
- Rotary screens
- Step Screens

Grit Removal

Grit removal is only needed where the raw wastewater contains inorganic, readily settleable solids smaller than the inlet screen aperture, as such rarely used in industrial wastewater, much more common in municipal or specific industries

Considerations for grit system selection are

- Water flow rate
- Solids loading
- Solids density



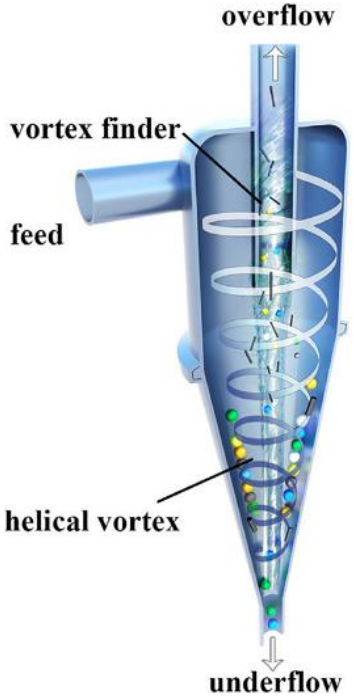
1. Inlet
2. Undreflow (sand)
3. Overflow (outlet)

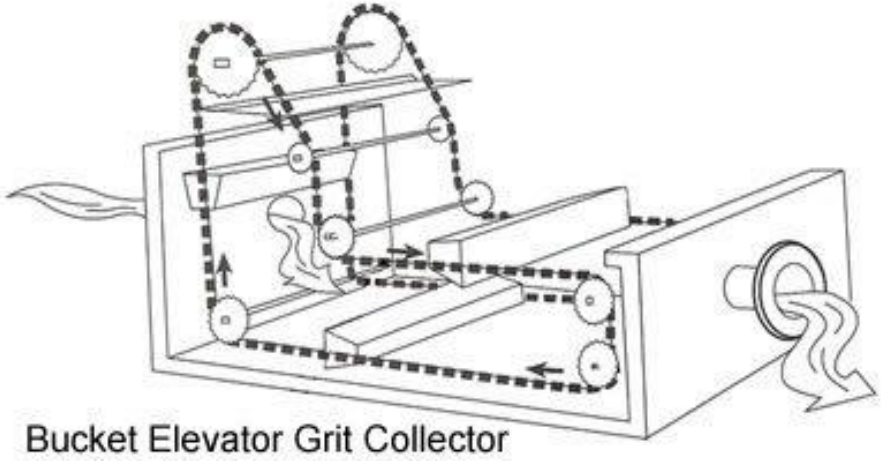
Grit Removal

There are several removal processes available including
- Hydro-cylones
- Chain and bucket systems

Hydrocyclone has no moving parts and requires pumped feed

Chain and bucket system can handle flow variations but grit build up can cause chain drive issues




Bucket Elevator Grit Collector

What is pH

pH measures the concentration of H^+ ions in a solution and is measured on a scale of 1 to 14

Acids have pH 1 to 7 and have an abundance of H^+ ions

Bases/Alkalis have pH 7 to 14 and have a low concentration of H^+ ions

Acid use in wastewater treatment

Common acids used in wastewater treatment include

- Sulphuric Acid
- Citric Acid

Uses for acids

- Coagulation
- pH adjustment for biological or chemical treatment
- Effluent pH adjustment

Alkali use in wastewater treatment

Common alkalies used in wastewater treatment include

- Sodium Hydroxide (caustic soda)
- Sodium carbonate (soda ash)
- Calcium hydroxide (hydrated Lime)

Uses for alkalies

- pH adjustment for biological or chemical treatment
- Effluent pH adjustment
- Precipitation of metals as hydroxides

Application of Ultraverte Bioconversion in Small Business

Unit is equipped with auger mixing, knife for shredding, with added bacteria and media, waste is rapidly converted to biogas and water vapour. Process with minimal odour.

Applied in treating daily waste liquid up to 1000L and solids up to 500kg. End product is inert dry solid in powder or small pieces.

Questions

For any additional questions feel free to contact me after the presentation.

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Medium Business Waste Management: Primary + secondary

- Medium business usually produces less than 500kL/day of waste water and up to 2t a day solid waste.
- Primary and secondary treatment applies: waste collection, screening, sedimentation, pH adjustment, chemical treatment involves coagulation, flocculation, disinfection, biological treatment involves anaerobic, aerobic, nutrients removal, Ecosynergy, hybrid system.
- Dewatering
- Ultraverte bioconversion

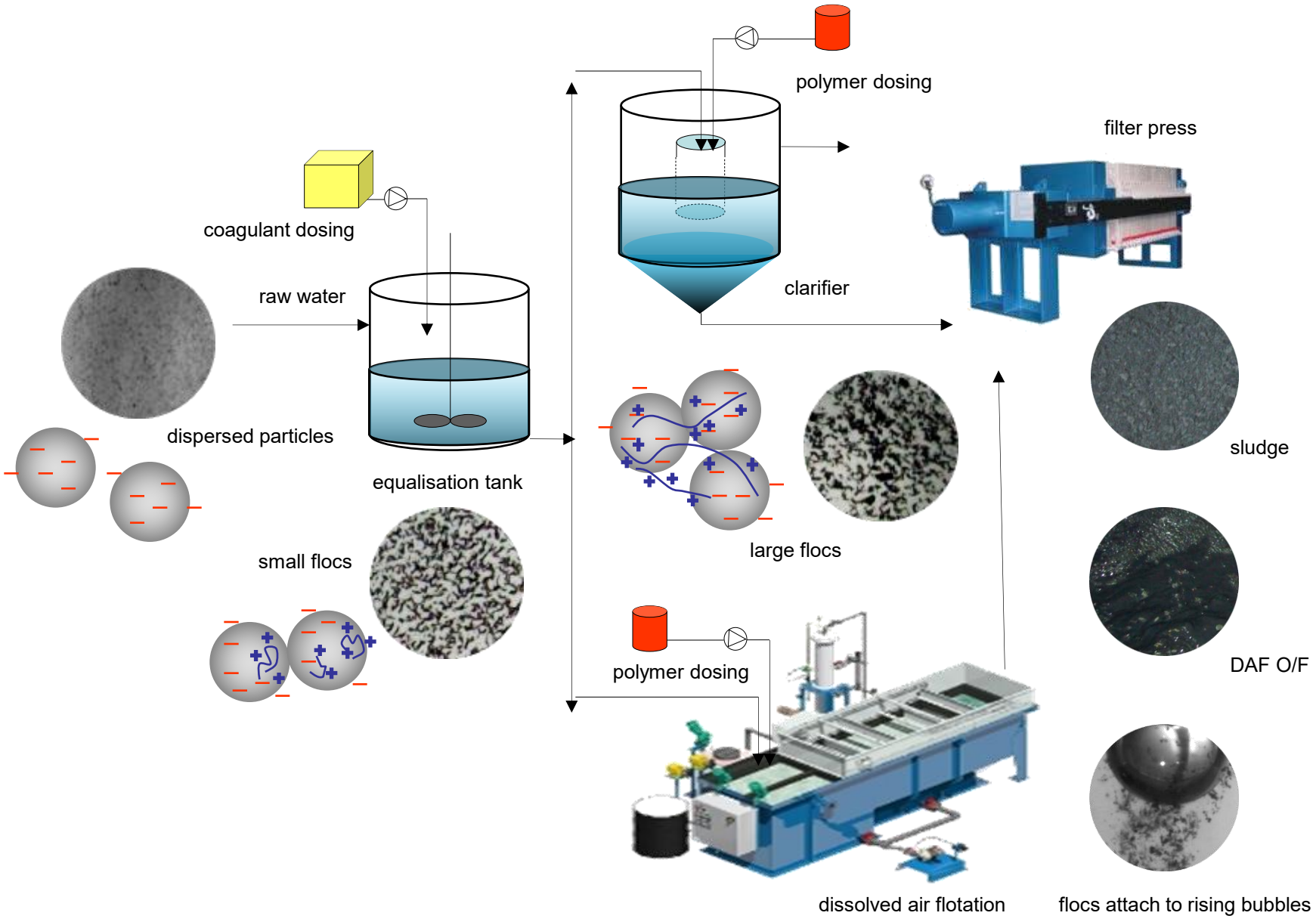
Secondary Treatment

Secondary treatment is traditionally considered to be biological treatment processes. However many industrial trade waste plants can/do undertake biological treatment prior to the chemical treatment or solids separation steps.

Common biological treatment processes include

- Ecosynergy
- Aerobic
- Anaerobic

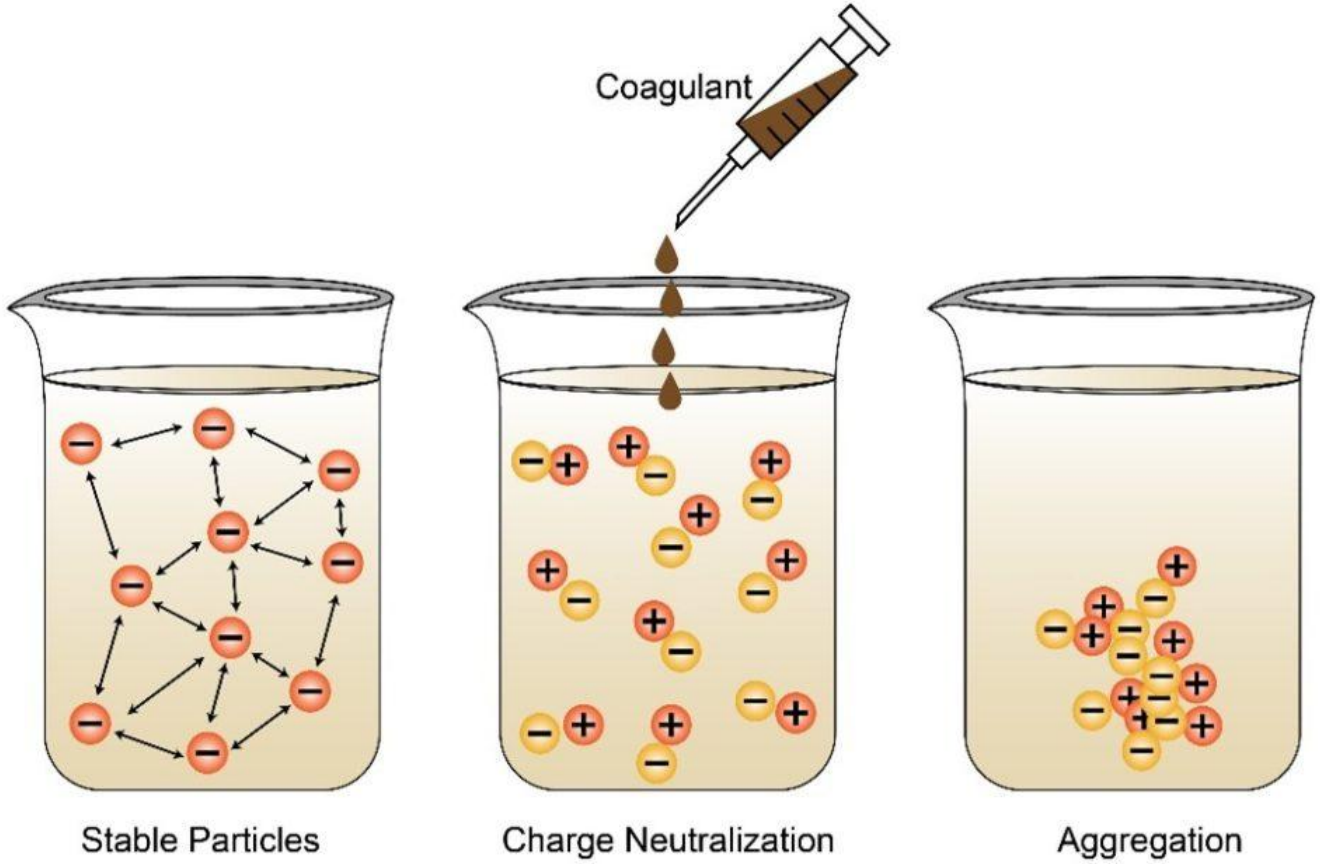
Medium businesses may involve primary and secondary treatment, both mechanical, chemical and biological.



Coagulation

What is coagulation

- Colloidal suspensions generally contain fine particles which are negatively charged and repel each other
- Oppositely charged coagulant neutralises the negative charges and allows the particles to aggregate



Coagulants used in wastewater treatment

Aluminium and Iron salts are commonly used such as

- Aluminium sulphate
- Poly aluminium chloride
- Ferric chloride

Other coagulants that see use are calcium and magnesium salts

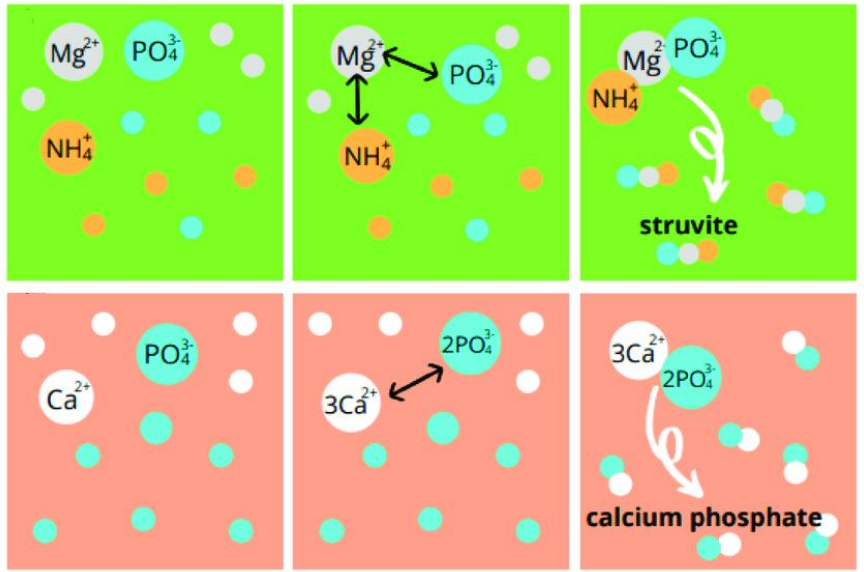
Turbulent mixing used which can be provided by an in vessel mixer or in-line mixer.

Organic coagulant and flocculant

Precipitation

Removes ionic species from solution

Removal of cations
- Calcium as carbonate
- Magnesium as hydroxide
- Metals as hydroxides, sulfates or carbonates



Removal of anions
- Sulfate with calcium or barium
- Phosphate with calcium
- Protein with lignosulfonates

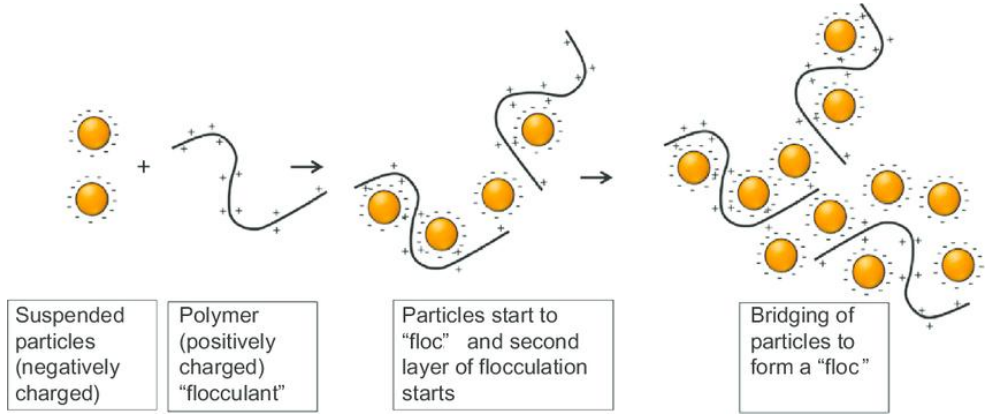
Precipitation is a fast reaction, as with coagulation, requiring fast mixing.

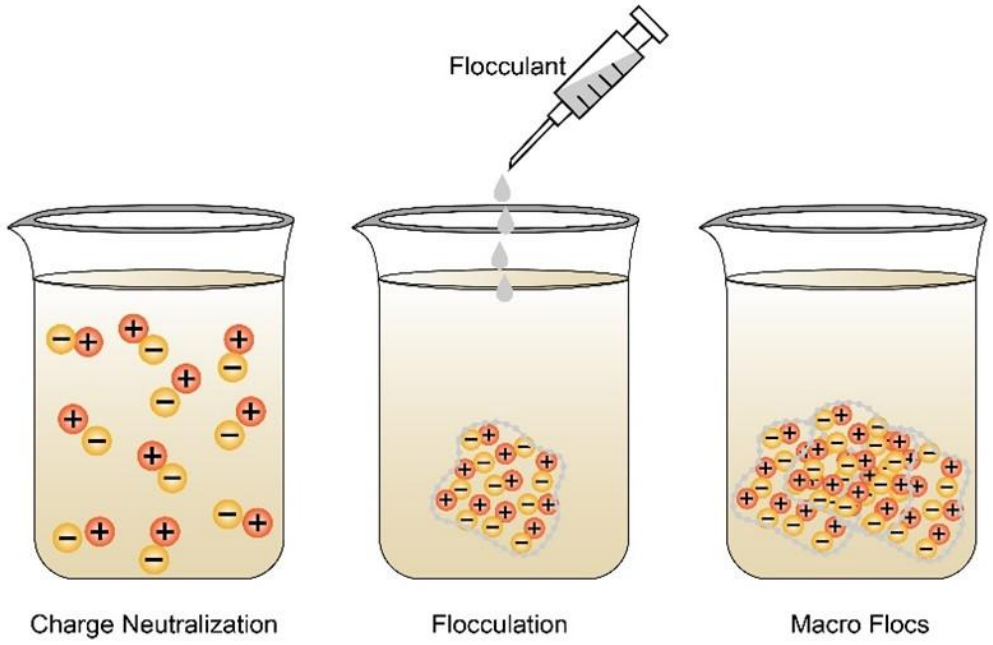
Flocculation

Flocculation is the agglomeration of smaller coagulated particles. This is done to improve separability.

Polymer is the most common flocculant. A wide range of polymers are available, the most suitable can be selected through bench scale testing.

A slower process than coagulation which requires gentle mixing



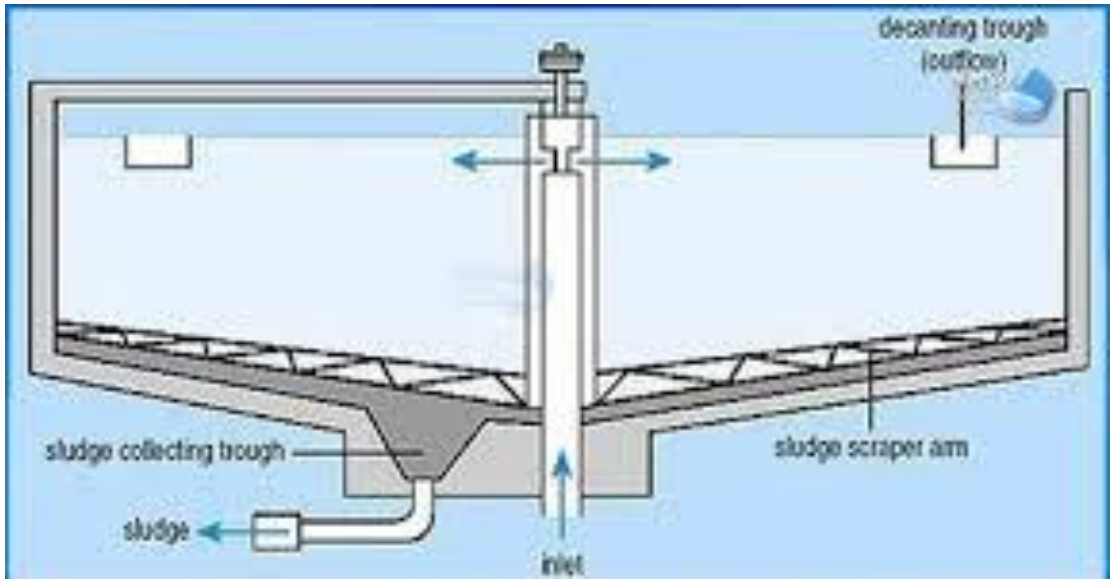


Settlement/Clarification

Collection of settleable solids whether from the raw wastewater or from secondary treatment processes

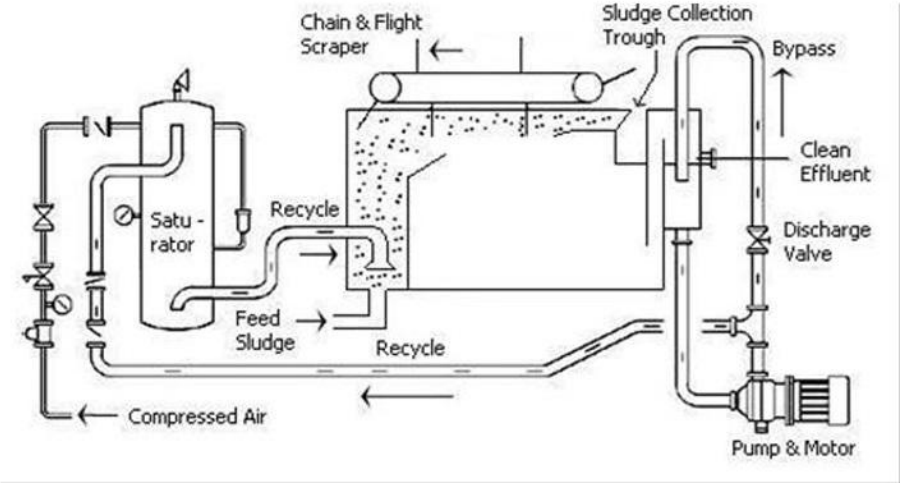
A number of clarifier configurations are possible including round or rectangular. In the design of each we must consider

- Residence time
- Solids Loading rate
- Weir loading rate
- Surface overflow rate
- Particle size cut off



Floatation

Floatation of solids in Dissolved Air Floatation (DAF) systems uses air, dissolved in water under pressure, to attach micro-bubbles to flocculated solids, inducing floatation



DAF systems have 3 key inlet streams

- Coagulated inlet solids
- Air saturated recirculation water
- Flocculant

An issue with any one of the inlet streams can cause solids to pass through the DAF instead of be collected

Biological treatment

Biological treatment seeks to use of microbes to degrade or consume contaminants thereby improving water treatability.

Treatment in the presence or absence of oxygen leads to different microbial mechanisms and treatment outcomes

Aerobic and Anaerobic processes

Aerobic refers to the presence of air and Anaerobic the lack of air when referring to biological treatment processes

Aerobic processes are commonly used to consume and convert soluble BOD to biomass, or remove ammonia

Anaerobic processes are used to breakdown organic material into simpler components such as volatile fatty acids, acetate and eventually methane

Aerobic

Aerobic biological treatment uses microbes to remove organic matter from the waste stream by pathways that utilise oxygen as an energy source

Successful aerobic treatment relies on the microbes having access to oxygen, food. The ideal conditions therefore are a well aerated, mixed vessel.

Activated sludge, membrane bioreactor and trickling filters are all examples of aerobic biological processes

Aerobic

Factors that need to be considered when using an aerobic biological system include

- Air requirement
- Residence time
- Reactor pH and temperature
- Available alkalinity
- C:N:P balance
- F/M ratio
- Sludge age

Aeration

Aeration provides dissolved oxygen which promotes microbial activity

The air requirement can be determined based on daily flow rate, BOD and ammonia concentration, water depth and bubble size

High rate aerobic processes

Moving bed biofilm reactor (MBBR)

Uses plastic media within the reaction vessel to help maximise the available surface area for biofilm growth

Some advantages compared to traditional aerobic processes

- Higher effective sludge retention time
- Lower hydraulic retention time
- Lower sludge production

Some disadvantages

- Manual bacteria monitoring required
- Skilled operators needed to operate the process

Anaerobic

Anaerobic biological treatment occurs in the absence of oxygen or nitrate as energy sources. Generally organic matter (solid and dissolved) are broken down by fermentation, acetogenic and methanogenic processes.

Anaerobic digestion is the predominant anaerobic process used in wastewater treatment with a number of digester configurations used.

Anaerobic

Aspects that need to be considered when designing or using anaerobic digester systems are

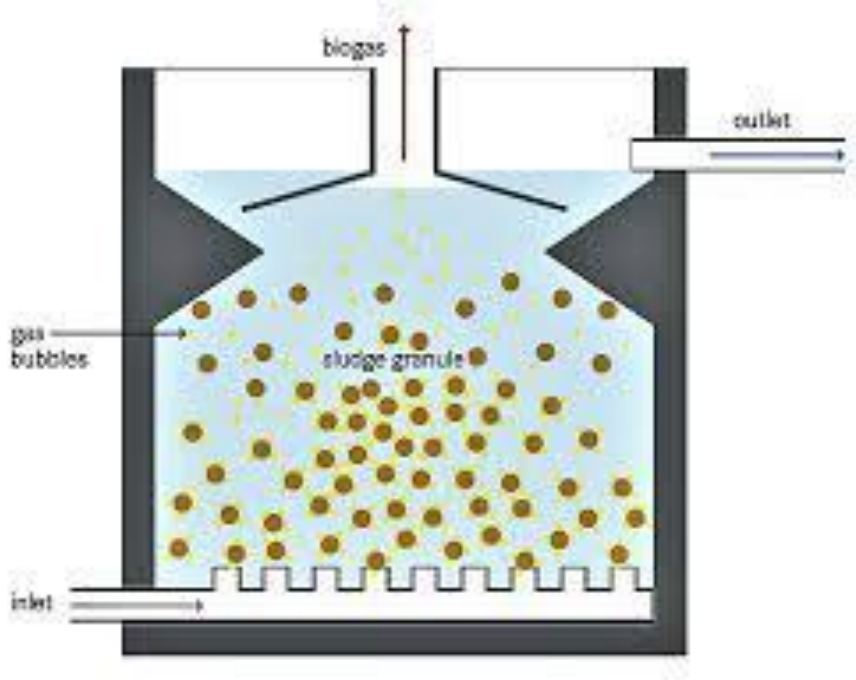
- Sludge flow rate and hydraulic residence time
- Organic loading rate
- Heating
- Moisture and pH
- Sludge biodegradability
- Methane potential of sludge material

High rate anaerobic processes

Seek to maximise the microbial population by minimising biomass losses or increasing the available space for microbial growth

High rate anaerobic processes fall into several catagories

- Fixed film reactors
- Suspended solids digestors
  - Up-flow anaerobic blanket (UASB)
  - Induced sludge blanket (ISB)
- Sequence batch reactors



Biogas

Methane rich biogas is a byproduct of anaerobic digestion

Biogas can be used for heating the digester to increase the rate of degredation in the digester

Excess gas should be flared, where a large enough volume of gas is available cogeneration can be considered

Hybrid Systems

Use of both aerobic and anaerobic processes in series to get the advantages of both

Scenarios

- High strength, high inlet flow
- Nitrogen removal
- Lagoon Systems

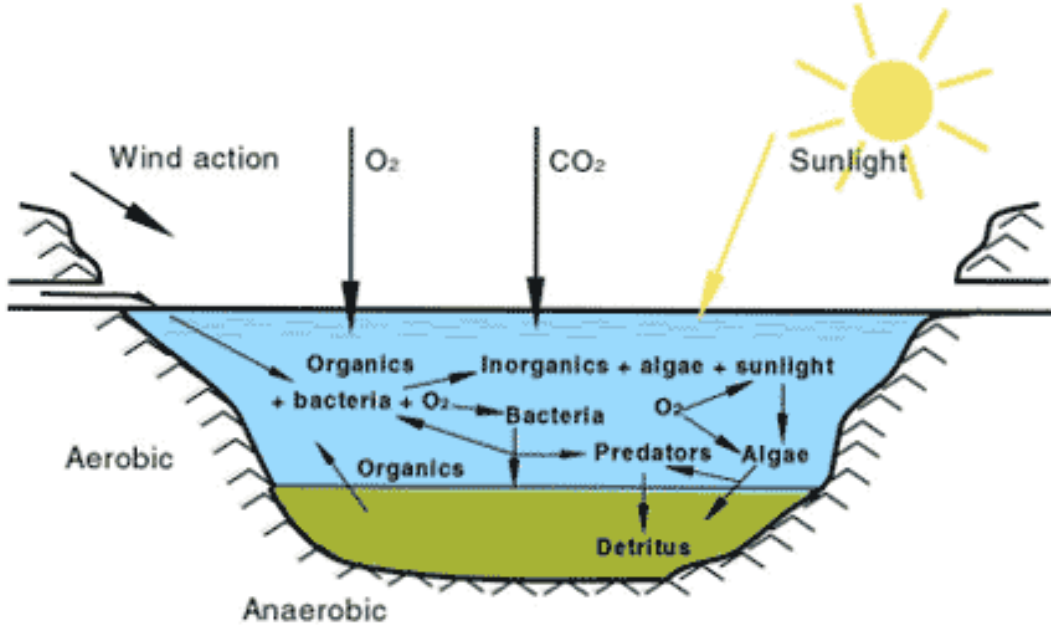
Lagoon Systems

Use of earthen ponds to biologically treat wastewater, the ponds can be aerobic, anaerobic or facultative

Aeration of lagoons generally provided by surface aerators

Cheap to build but need a large area

Release of high N and P from anaerobic ponds hard to treat in further ponds



Questions

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Ecosynergy and Ultraverte

The Ecosynergy® biological system involves the introduction of specifically selected synergistic bacteria strains, nutrients and specifically designed pathway reaction with biologically enhanced network incorporated into the wastewater treatment process . It is an facultative process which can be retrofitted into an existing treatment process or established in a purpose built plant

Reduces or eliminates BOD, fats/oils, hydrocarbons of all types, odour, suspended or dissolved solids and sludge. Reduces energy costs, chemical usage and retention times. Can allow for water reclaim and reuse. Ecosynergy™ is effective in waste waters containing acidity, alkalinity, high BOD/COD, excessive nutrients or pollutants, odour, toxic compounds and suspended matter

The Ultraverte® biological conversion system converts the synergy bacteria treated sludge into inert biogas, water vapour and remaining dry solids at 5-10% of its weight or volume of its original state.

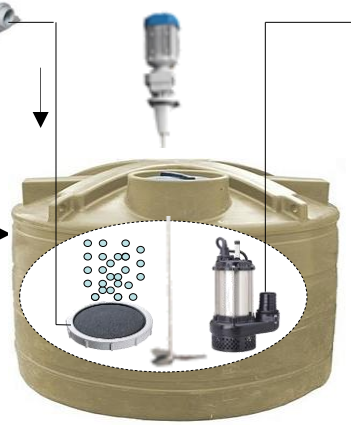
Benefits includes solids reduction, significant operational cost reduction, increased process plant capacity without capital project invest, pond and lagoon sludge reduction without the need to dredge, dewater and dispose of the solids. Conversion of organic or food processing waste to beneficial material at much reduced volume can be achieved on-site.

Ecosynergy for liquid waste

Ecosynergy™ bacteria

raw water

equalisation tank



aerated bioreactor

clarifier

treated water for discharge or reuse

co-treatment of biodegradable and hazardous waste

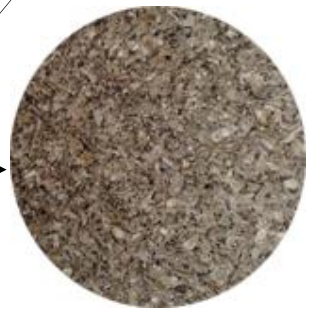
sludge

settled solids

Ecosynergy™ bacteria

organic media

bioconverter



converted sludge

Ultraverte for solid waste

Ecosynergy can be retrofitted to existing chemical and biological wastewater treatment

Ecosynergy autodoser

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Ecosynergy can allow for water reclaim and reuse

Residual solids management

Solids are a byproduct of most wastewater treatment processes

While some can be recycled, especially in biological systems to return biomass, a steady state must be reached where the solids created are removed from the system

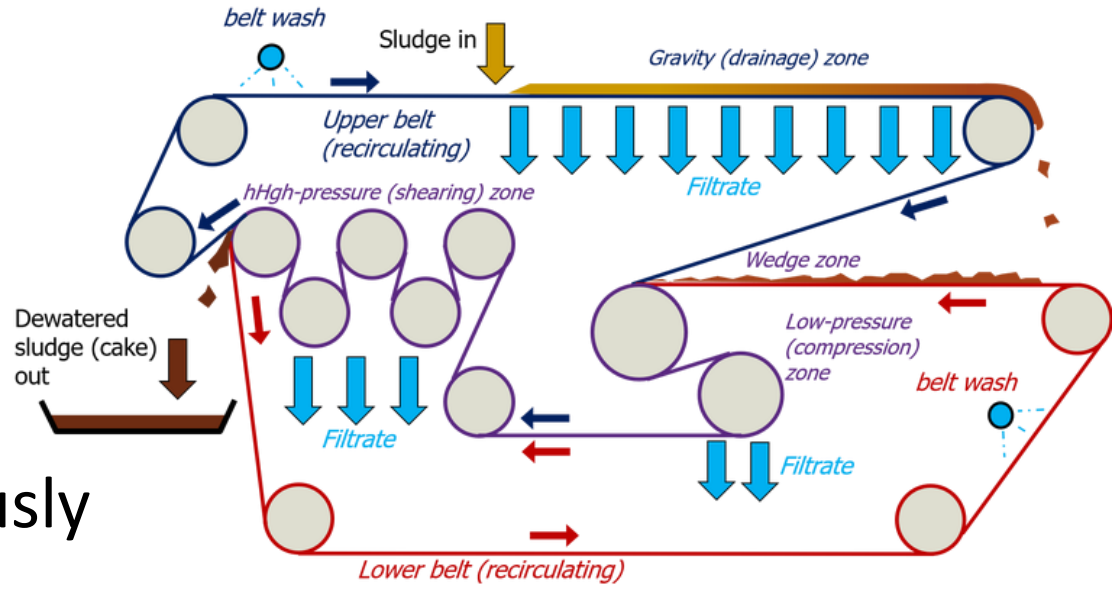
Belt Press

Belt presses squeeze water out of the sludge solids using 2 belts and a series of rollers

Cake solids content up to 22%,

generally 10-15%

Spray bars clean cloth belts continuously

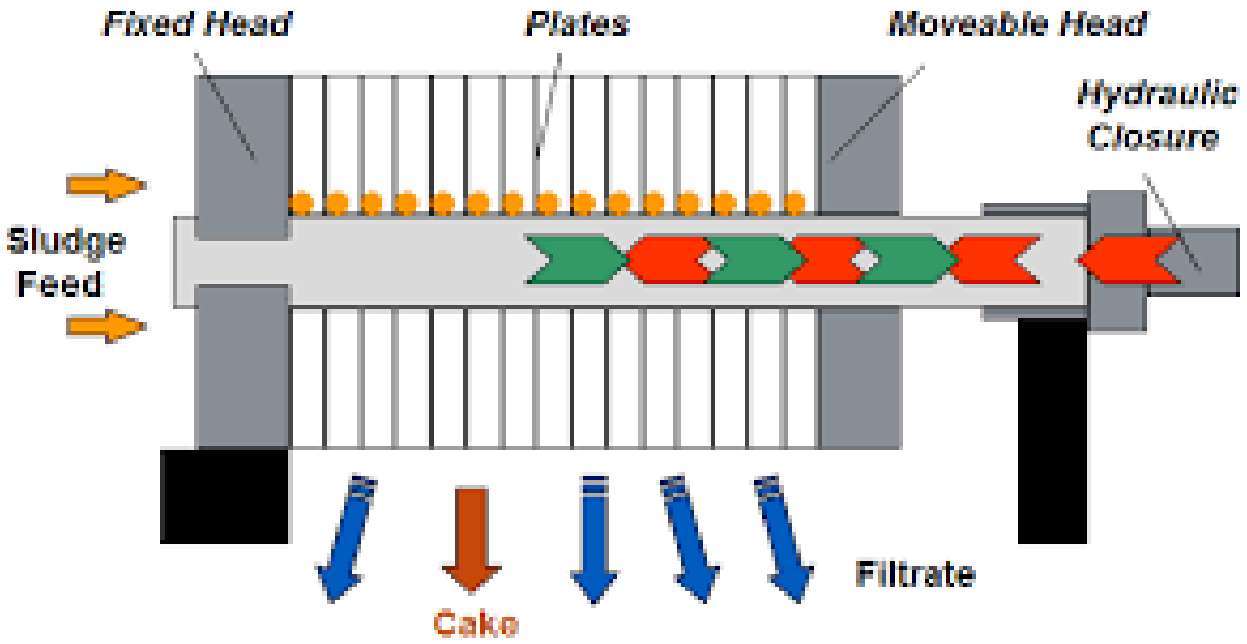


Filter Press

Use a series of plates with filter cloths to dewater sludge, pumped at high pressure

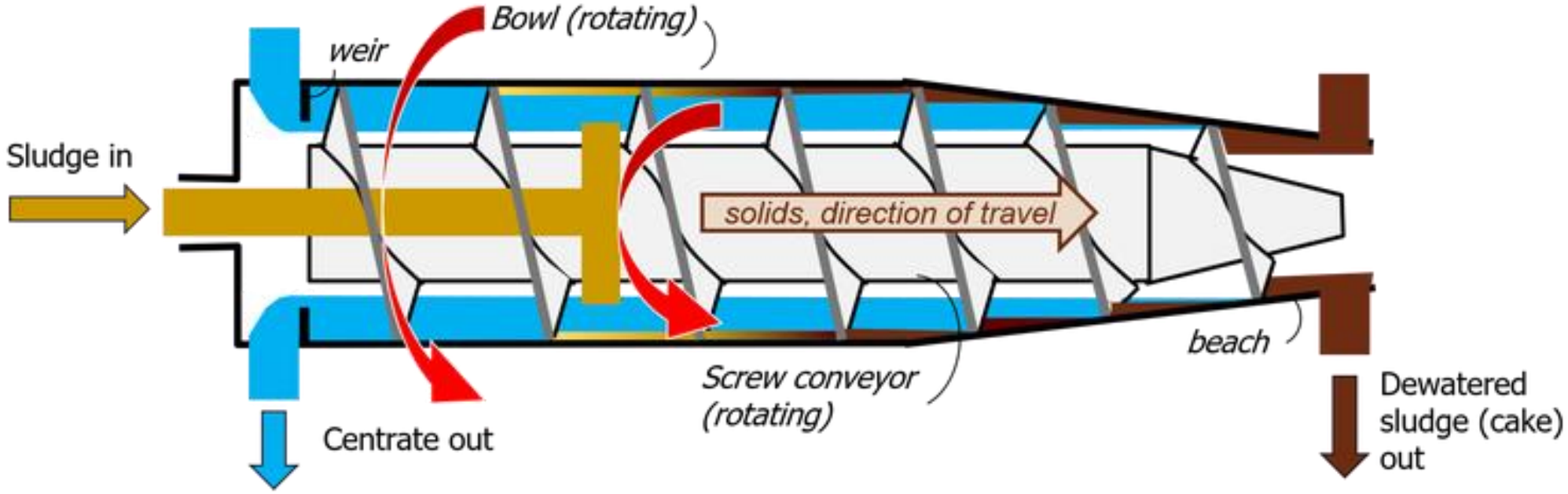
Cake solids content up to 70%, typically 25-40%

Auto-empty options available but generally manual empty and manual clean required



Centrifugal dewatering

Uses centrifugal force to separate clean water from the thickened sludge



Ultraverte Bioconversion

- Biosolids
- Fruit and vegetable
- Dairy sludge
- Cheese whey
- Leachate
- Shredded general waste (food packaging mix)
- Modular system treatment capacity: 2500kg to 40,000kg.
- System capacity can be expanded by applying multiple modular units.
- Waste reduction: >90% (by weight and volume)
- Typical reaction time: 12-24hours.
- End product reuse: landfill, compost starter, soil conditioner

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Modular Ultraverte system can be used with medium businesses

Raw waste

End product use as soil additive

Ultraverte® Bioconversion -Application in treating general waste

General waste containing plastics, wood, paper, organic waste can be directly biologically converted to dry and fine powder, within 12-24 hours.

Waste reduction in volume and weight is in range of 30-40%, subject to amount of inert material contained.

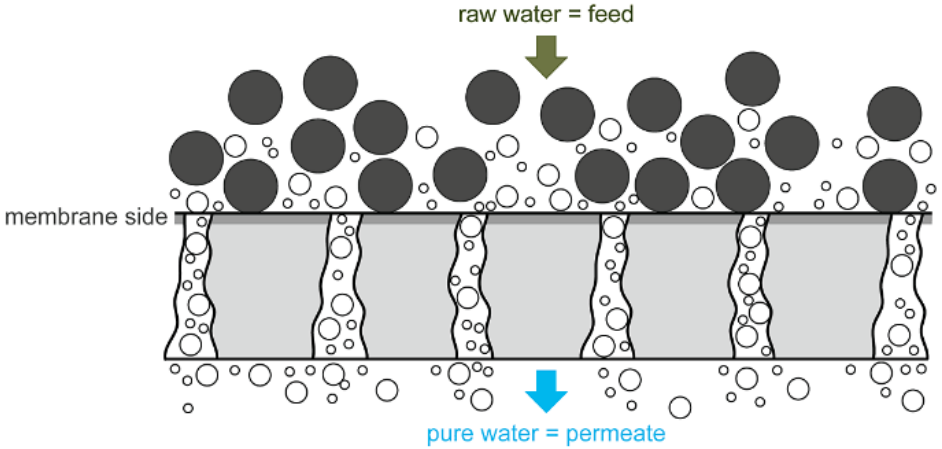
Converted material is pathogen free, contains beneficial strains that will assist in landfill waste degradation and odour control.

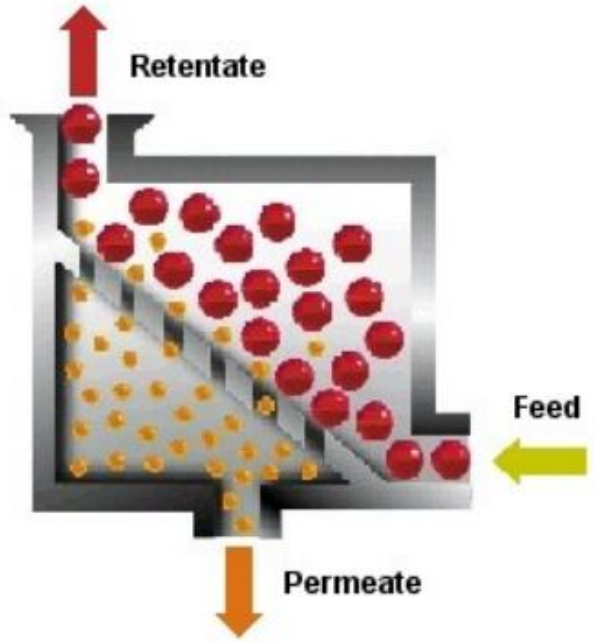
Large Business Waste Management

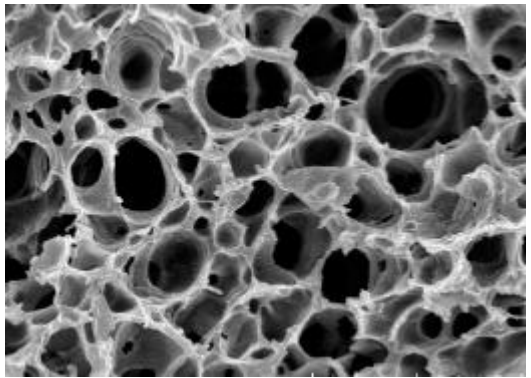
- Large business usually produces over 500t/day of waste water and over 5t a day solid waste.
- Usually requires primary, secondary and tertiary treatment.
- Water reuse has been applied in large municipal waste plant using membrane technologies.

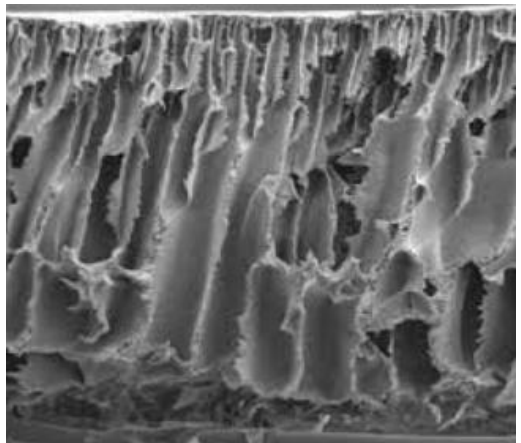
Membrane Technologies

A membrane is a barrier which separates two phases from each other by restricting movement of components through it in a selective way. They can be thought of as fine sieves which consist of porous films with defined pore diameters. Pressure driven membrane processes are by far the most widely applied membrane processes in wastewater treatment.









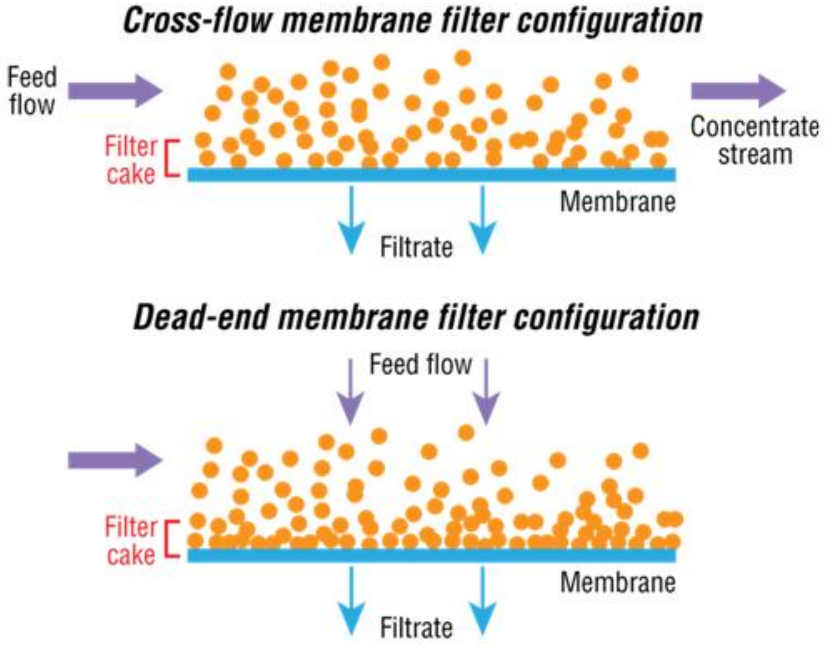
There are four main types of pressure driven membrane processes . These are microfiltration (MF), ultrafiltration (UF), nano filtration (NF), and reverse osmosis (RO). The main difference exhibited by these processes, apart from their pressure requirements, is their membrane pore sizes.

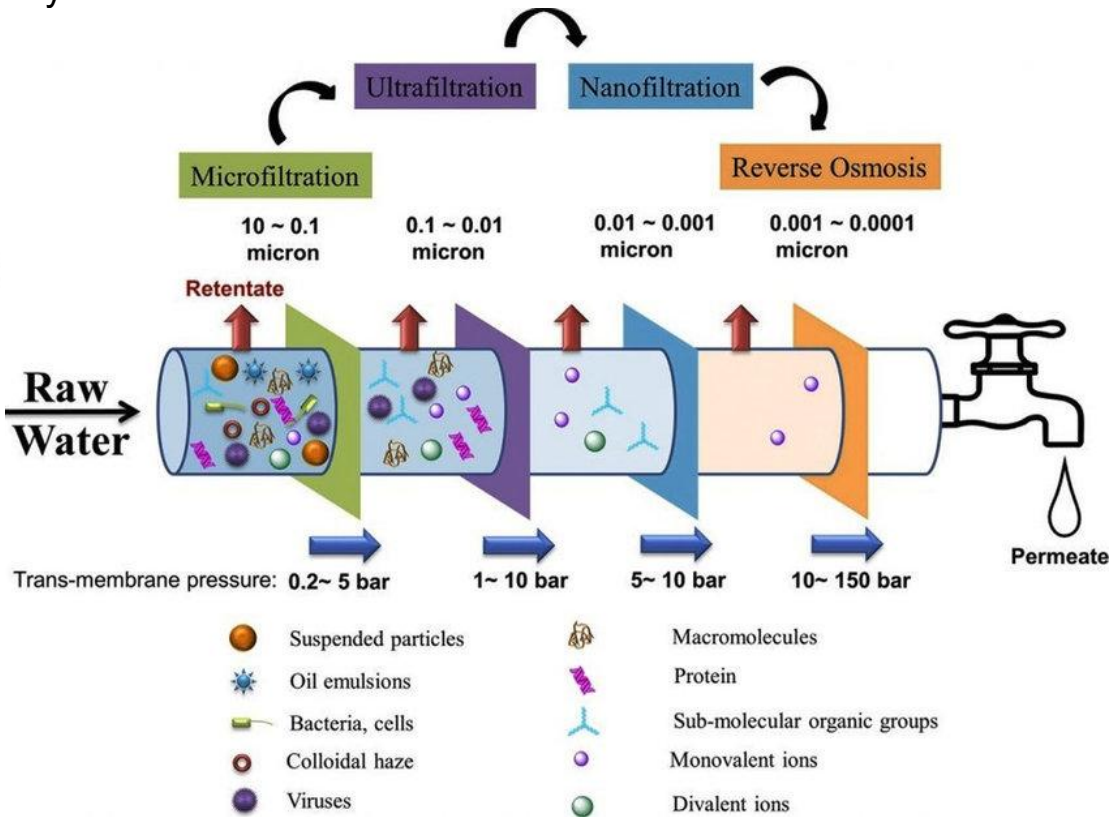
Microfiltration (MF) -Removal of bacteria, separation of macromolecules

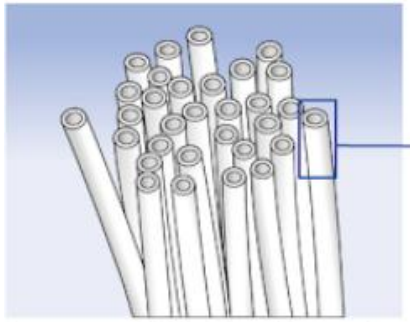
Ultrafiltration (UF) -Concentration of large and macro molecules

Nanofiltration (NF) - Concentration of organic components by removal of part of monovalent ions like sodium and chlorine (partial demineralisation)

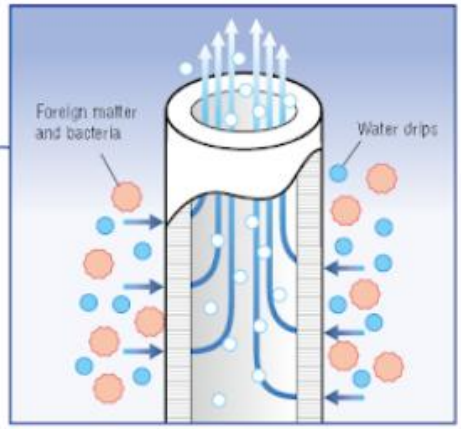
Reverse osmosis (RO) - Concentration of solution by removal of water



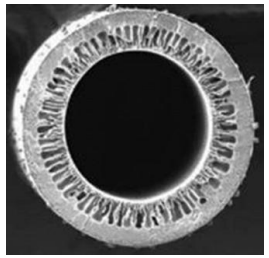




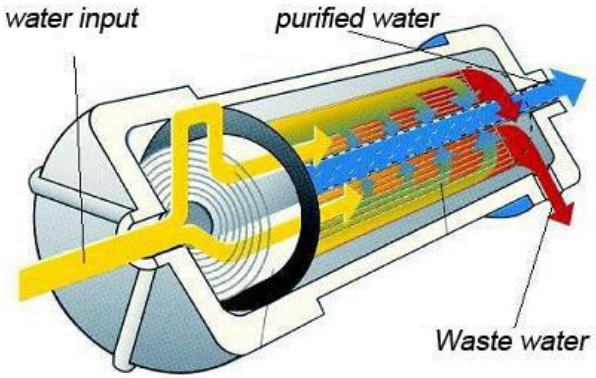
An aggregate of hollow fibers (like straws)
The surface is porous with many fine holes

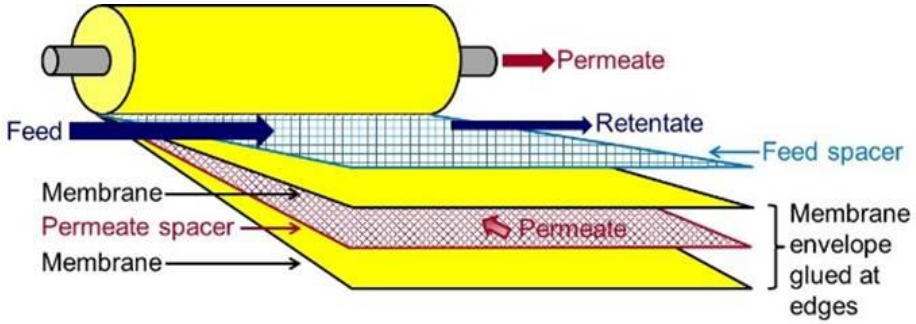


Filtrates minute foreign matter, bacteria, and water drips in pipes from air,
which passes through the hollow fiber membrane, and provides a clean air environment.

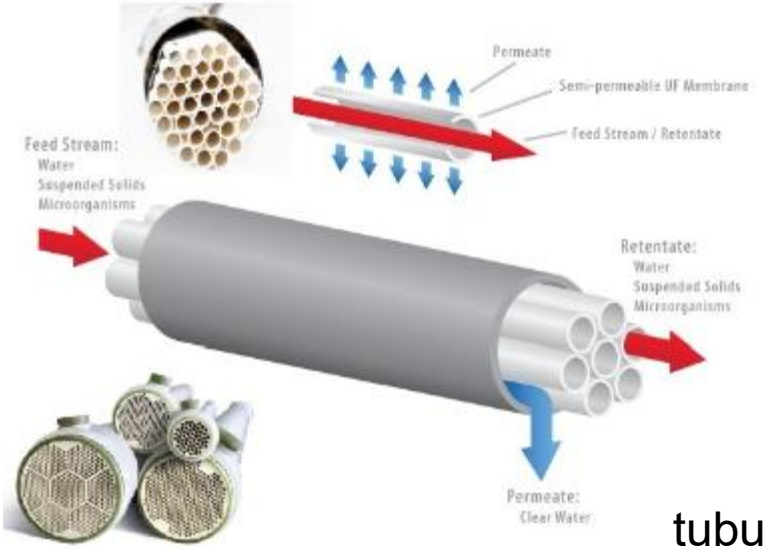


hollow fibre membrane



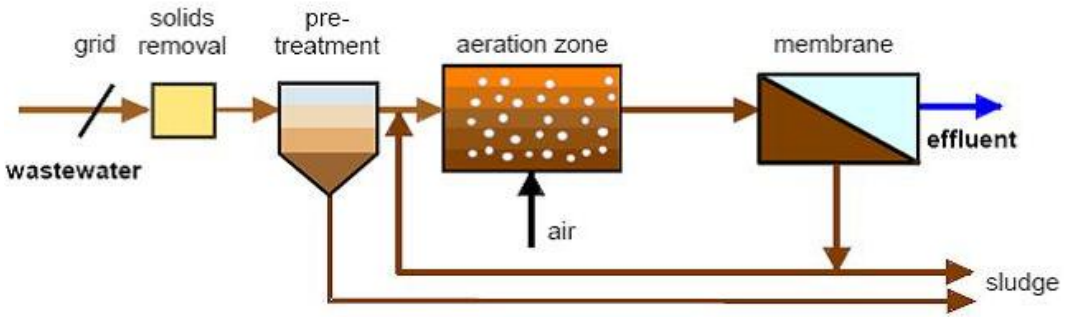


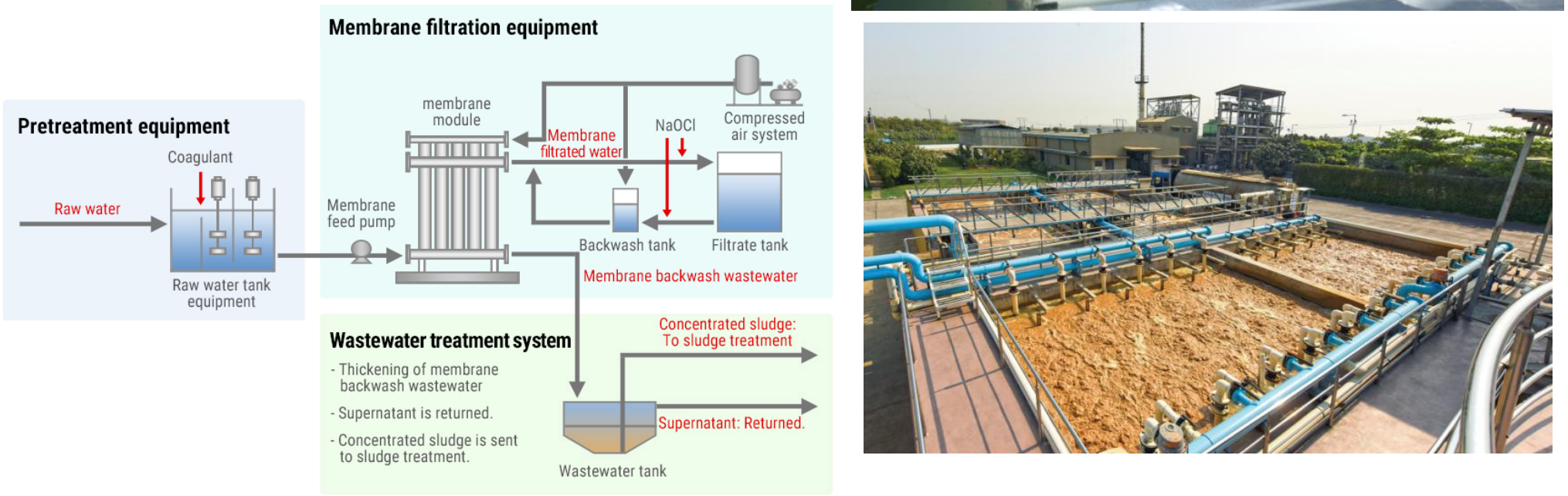
spiral wound membrane



tubular membrane

Membrane bioreactors are combinations of membrane processes like microfiltration or ultrafiltration with a biological wastewater treatment process, such as the activated sludge process.



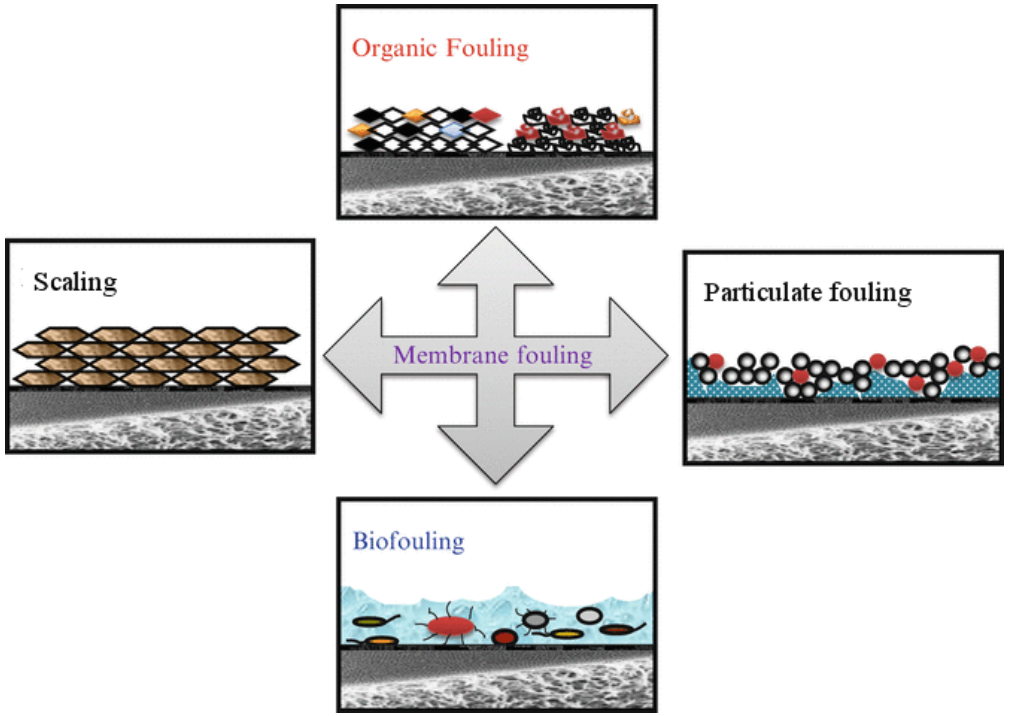


Membrane fouling

Over time the efficiency of membrane processes decreases due to the accumulation of suspended particles on the membrane. This is called membrane fouling and is irreversible during processing. In surface fouling the foulant appears an evenly deposited layer on the membrane surface. It can be easily removed by cleaning solution and the permeation rate of membrane can be regenerated by cleaning. Pore fouling is caused by particulate matter diffusing into the membrane. The membrane flux cannot be regenerated by cleaning. Organic fouling consists of the formation of an organic layer on the surface and is linked to the concentration of dissolved organic compounds in the feed water. Scaling is the most common type of inorganic fouling in desalination processes; it is due to the direct formation of crystals on the membrane surface through precipitation. Biofouling is an undesirable accumulation of microorganisms which occurs by attachment, growth and metabolism of bacteria on the membranes.

Flat sheet module

Spiral wound module



Disinfection

When discharging to waterways or to onsite re-use, disinfection should be used to remove pathogens such as E.Coli and Faecal coliforms from the effluent stream

Common means of disinfection include

- Ultraviolet light (UV)
- Chlorine
- Ozone

Ion-Exchange

Removes undesirable ionic compounds from water by exchanging them with other ionic species. Commonly uses resins impregnates with the donor ion.

Used to remove ionic compounds that can't be treated by other means due to low reactivity or low concentration.

Advantages: Highly selective, high efficiency at low concentrations

Disadvantages: Easily fouled, high cost