RESOURCE RECOVERY FROM WASTEWATER – W8

Eco-efficiency resources for the food processing industry

Water, product, chemical and energy recovery

The potential of wastewater as a resource is often overlooked. It can be a great source of water, product, chemicals and energy. Below are a few ways to recover energy and materials from the wastewater stream. However, it is always best to reduce the amount of chemicals and products entering the wastewater stream – refer to the other water related fact sheets for more details.

Membrane technology

Membrane technology is becoming more widely used in industry for both water treatment and product/chemical recovery.

Traditionally membrane technology has extremely high capital costs and requires a significant amount of energy to operate, preventing it from being a cost effective activity. However, recent improvements in membrane technology have brought down the capital and operating costs, allowing membranes to be considered a potential option.

The membranes act as a physical barrier producing two streams: a 'permeate' that is formed through the pores of the membrane by pressure; and a concentrated 'retentate'. The size of the membrane pores, therefore, governs the types of molecules in the permeate.

Table 1 Common membrane types

Membrane	Filtration (microns)	Level of treatment	Typical uses for membranes
Microfiltration (MF)	Down to 0.45	Bacteria removal	Pretreatment for NF or RO Clarification of fruit juice, wine and beer
Ultrafiltration (UF)	Down to 0.01	Protein separation	Separation of protein in milk Pretreatment for NF or RO
Nanofiltration (NF)	Down to 0.001	Sugars, large salts, proteins, caustic from clean-in-place systems	Sugar decolourisation Desalting gelatine Concentration of food, dairy and beverage products or by-products
Reverse Osmosis (RO)	Down to 0.0001	Generates extremely pure water	Whey processing Water for beverage products such as beer Feed water for boilers and cooling towers
Electrodialysis	Uses electrical current to separate contaminants	Separates contaminants using charge particularly salts	Demineralisation of whey Wine stabilisation

Water treatment systems generally use UF or MF as a pretreatment system prior to RO. RO is often used to polish water rather than remove larger molecules. Pretreatment reduces membrane fouling and backwash requirements.

The main advantage of membranes is that they separate substances in an unchanged chemical form making them readily available for reuse. They also have the ability to generate a permeate stream of a consistently high quality.

While membranes have potentially high capital costs, they are becoming more competitively priced as their use becomes more widespread.

The processes are energy intensive and can be costly to operate and maintain. Cleaning the membrane when the pressure drops can improve its effectiveness but may also reduce the life of the membrane. The handling and management of contaminated chemicals necessitated by periodic cleaning also need consideration.

RO COMPARED WITH ION EXCHANGE

A brewery, Fosters Australia, was treating incoming mains water with an ion exchange system to reduce salt levels prior to use in the product.

This process required regeneration every 8–12 hours of operation and required discharge of regenerant solution into sewer which was at the limits of council acceptance.

In 2005 the plant changed to RO treatment of the incoming water achieving a 95 per cent recovery rate while requiring no regeneration. The amount of energy used in RO is similar to that in ion exchange.

To ensure the type of membrane and configuration best suit the plant's requirements it is critical to accurately assess the feed stream quality and variability, and the quality requirements of the recovered substance. It is also important to consider the conditions under which the membrane will have to operate, including the types of pressures, temperatures and pH.

The membrane technology systems can be quite sensitive to changes in the wastewater stream. Intensive pretreatment is generally required to ensure smooth operation and a treatment train to remove larger particles and fouling molecules prior to membrane treatment should always be considered. Waste disposal costs will also be associated with the concentrated backwash. Time and a high level of skill from the operator may be required to properly manage the system.

Membrane bioreactors

Membrane bioreactor (MBR) systems combine membranes with biological treatment of effluent. The membrane takes the role that clarifiers and separation technology take in other treatment processes and can reduce the space requirement of the system by up to 50 per cent.[1] MBR can provide a suitable pretreatment for reverse osmosis treatment.

Anaerobic digestion

The use of anaerobic digestion (AD) to treat wastewater streams is becoming more prevalent as companies aim to reduce the level of organic material in their tradewaste streams.

The benefit of AD is the significant reductions in organic materials that can be achieved through the process, which also reduces sludge production and subsequent sludge disposal costs. The by-product of biogas can be used to supplement energy supply onsite and reduce the company's carbon footprint.

Anaerobic digestion is a treatment process that occurs in an oxygen-free environment and is suitable for wastewater streams with high concentrations of organic matter. AD can reduce biochemical oxygen demand (BOD) by up to 90 per cent. During the digestion process biogas is produced which is a mixture of methane, carbon dioxide and other gases such as hydrogen sulphide. This gas can be captured and used as a fuel source. Refer to the *Energy fact sheets (E5)* for more details.

1 Layson, A. and L Sorgini, November 2007, "Low-pressure membranes help solve water scarcity", Water Australian Water Association, Volume 34, No 7. 34–36.

BENEFITS OF UASB

A brewery, Foster's Australia, uses an upflow anaerobic sludge blanket (UASB) process to reduce chemical oxygen demand in its wastewater stream from approximately 5,500 mg/L to 200 mg/L. Once in operation, the UASB is quite robust, responding quickly to start-up and shut down periods. In addition, biogas produced by the process is collected and used in the boiler providing 20 per cent of the site's energy use or approximately $750,000 in energy savings per year.

Aerobic digestion

Aerobic digestion is used to achieve a high level of removal of organic matter from wastewater streams, generally through the addition of air and sometimes oxygen. However, this is usually an energy intensive treatment process which produces a large amount of biomass that has to be disposed of.

Table 1 below provides a comparison of the advantages and disadvantages of anaerobic and aerobic digestion processes.

Table 1. Comparison of anaerobic to aerobic digestion[2]

Anaerobic processing	Aerobic processing
Benefits • conversion of up to 90 per cent of potential energy in carbon from wastewater into retrievable biogas • low energy requirement • small amount of biomass produced, therefore lower sludge disposal costs • lower requirements for nutrient dosing • smaller space requirements • good for treating high-strength waste streams	**Benefits** • robust, flexible, quick • adaptable for dilute waste streams • good for polishing of anaerobic effluent streams
Disadvantages • long start up periods and longer adjustment periods if waste stream composition changes – subject to shock • limited use for dilute waste streams • effluent output has slightly higher organic content then aerobically treated waste and may produce odours • may contain methane dissolved in effluent	**Disadvantages** • most of the energy generated in the process is lost as waste heat • high energy requirements for aeration • large amount of biomass produced and therefore high sludge disposal costs • higher costs for nutrient dosing • larger space requirements

This series of fact sheets provides examples and suggestions to the modern food processor on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website www.ecoefficiency.com.au for more ideas and case studies.

2 Kleerebezem, R. and Macarie, H. , April 2003, "Treating industrial wastewater: anaerobic digestion comes of age: anaerobic treatment systems offer important advantages over conventionally applied aerobic processes for removing organic pollutants from water-based streams". Chemical Engineering 110.4 56–65.

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