

Membrane Applications in Water Reuse Projects

Overview of Water Reuse

Water Reuse is receiving increased national and international attention as an approach to effectively address sustainable water management mandates and proactive water supply planning. Effective reuse allows the implementation of safe, fit for purpose, and cost-effective water solutions that reduce or eliminate the unnecessary waste of limited water supplies. In parts of the world challenged by population growth, increased urbanization, ageing infrastructure, or climate change, water reuse has become an integral component of strategic water management planning. Water reuse can be implemented in either centralized or decentralized treatment facilities. Centralized water reuse refers to the use of a central wastewater treatment plant effluent for various agricultural, industrial, commercial, environmental, or drinking water supply applications. At facilities utilizing Indirect Potable Reuse (IPR) or Direct Potable Reuse (DPR), additional advanced water treatment processes beyond traditional wastewater treatment are often employed. In contrast, decentralized water reuse includes the collection of various combinations of localized wastewater or graywater sources for non-potable uses. Decentralized reuse systems provide water for subsurface and spray irrigation, toilet flushing, vehicle washing, industrial cooling applications, zoo animal washing, construction, and other non-potable applications.

Types of Membrane Based Reuse

The efficacy of membrane technologies in wastewater treatment has resulted in a variety of water reuse alternatives, including both non-potable and potable reuse. Wastewater has been intentionally reused for non-potable purposes in the United States since the 1800's; however, it was not until the 1960's that reuse was first intentionally applied to replenish drinking water supplies. Advanced treatment of wastewater using Reverse Osmosis (RO) membranes for indirect potable reuse began in Orange County, California in the mid-1970's. Today membranes are used in hundreds of reuse applications around the United States and the world, allowing utilities and industries to target the removal of specific contaminants, including pathogenic organisms, dissolved salts, or trace organic compounds (TrOCs). Four primary membrane types account for the majority of the membrane based reuse applications. These include:

- Membrane filtration for turbidity and pathogen reduction, including Microfiltration (MF) and Ultrafiltration (UF)
- High pressure membranes for salinity and TrOC reduction, including RO and nanofiltration (NF)



This indirect potable reuse facility in California includes two microfiltration stages and three reverse osmosis stages to operate at an overall plant recovery of 92.5%.

- Electrical potential based desalination for salinity reduction, including Electro-Dialysis (ED) and Electro-Dialysis Reversal (EDR)
- Membrane bioreactors (MBR) for a combined process that provides both secondary wastewater treatment and filtration

Each of these applications is discussed briefly below.

Membrane Filtration

The use of MF and UF in tertiary filtration continues to increase as membranes prove their reliability. Membrane filters provide almost complete removal of bacterial and protozoan pathogens while consistently providing high quality filtrate with turbidity values of under 0.1 NTU. Because membrane filters do not rely on coagulants for suspended solid and pathogen removal, they offer reliable alternatives for remotely operated or

minimally staffed facilities. More compact plant foot-prints often allow significant increases in plant capacity when membranes are installed within existing media filter bays. Membrane filtration has also become the standard pretreatment technique for wastewater RO facilities used in either potable or non-potable reuse applications.

Reverse Osmosis and Nanofiltration

RO and NF are being used for the removal of TDS and TrOC in potable reuse applications, industrial reuse, and irrigation reuse, where low TDS supplies are required. RO and NF systems typically require membrane filtration as pretreatment to reduce the rate of biofouling, organic fouling, and particulate fouling. Lower fluxes are typically applied with wastewater supplies and a continuous chloramine residual is often employed to prevent biogrowth on the membranes. RO membranes have proven effective at greater than 99 percent removal of emerging contaminants such as endocrine disruptors, pharmaceuticals, personal care products and other trace organic compounds with the exception of some low molecular weight, neutrally charged compounds such as nitrosamines, trihalomethanes, and 1,4-dioxane. They have also been granted 2-log (99 percent) pathogen reduction credits for viruses, Giardia, and Cryptosporidium at several locations. Further acceptance will be a function of adequate integrity testing through online monitoring of conductivity, total organic carbon (TOC), or other applicable testing methods. There is ongoing research to identify methods for RO integrity testing that would be more widely accepted.

Electrodialysis and Electrodialysis Reversal

ED and EDR are being used in select reuse applications where TDS reduction is required but the removal of

organics and pathogens are not essential. While Electrodialysis technologies are not as commonly used as RO for wastewater treatment, they can provide a cost effective alternative for the removal of dissolved salts and do not require membrane filtration as pretreatment. Because electrodialysis technologies employ electrical potential to attract positively and negatively charged ions, they are not effective at removing pathogens or weakly charged organic molecules, and are therefore not currently used in potable reuse applications.

Membrane Bioreactors

MBR has seen a rapid increase in usage over the last decade, allowing secondary and tertiary treatment to be accomplished in a single process. MBR is considerably more compact than traditional wastewater processes, can be operated at higher mixed liquor suspended solids concentrations, and provides product water with turbidity values that are consistently less than 0.1 NTU. Because of the consistent quality of the permeate, MBR systems can also be used upstream of RO membranes, where TDS and near complete TOC reduction are required. To date, MBR has mainly been used in non-potable reuse applications; however, it provides a potential treatment step for



This food processing facility uses MBR and RO to recover process water and minimize the water footprint at a highly water stressed location in Arizona.



This non-potable reuse facility in California employs Electrodialysis Reversal for the reduction of dissolved solids, supplying a new source of water for irrigation and industrial uses.

potable reuse if membrane integrity testing is incorporated into the process. MBR can also provide a unique opportunity for scalping plants and decentralized reuse facilities due to the small footprint and high level of automation.

Membranes offer a wide range of benefits for reuse

- Near complete pathogen and suspended solids reduction
- Direct and indirect integrity monitoring to ensure the effectiveness of the treatment process
- Full automation, often allowing unstaffed facilities
- Alternatives for reducing salinity and dissolved inorganic constituents
- Near complete removal of TrOCs and other constituents of emerging concern (CECs)

Future of Membranes in Water Reuse Applications

Membranes (including MF, UF, NF, RO, ED, EDR and MBR) have already been successfully used for a wide range of centralized and decentralized water reuse applications. The reliability and consistency in providing predictable



water quality will ensure that membrane treatment processes will continue to make significant contributions in producing “fit for purpose” water quality and provide a clear advantage for many water reuse applications. The future advances in membrane technology will no doubt result in even more creative applications and possibilities for water reuse.

Areas for potential advancement that are currently under development include backwashable NF membranes that will allow the removal of organic material with limited pretreatment, chlorine tolerant RO and NF membranes, and methods for more widely accepted RO and NF integrity testing to demonstrate effective reduction of pathogens.

This material has been prepared as an educational tool by the American Membrane Technology Association (AMTA). It is designed for dissemination to the public to further the understanding of the contribution that membrane water treatment technologies can make toward improving the quality of water supplies in the US and throughout the world.

For more information, please contact:

American Membrane Technology
Association (AMTA)
2409 SE Dixie Highway
Stuart, Florida 34996
Phone: (772) 463-0820
Fax: (772) 463-0860
Email: admin@amtaorg.com

or visit our website at:
www.amtaorg.com