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# Performance of water recycling technologies

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by

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**Declaration**

I hereby declare that this submission is my own work and to the best of my knowledge it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at the University of Wollongong or any other educational institution, except where due acknowledgement is made in the text. Any contribution made to the research by others, with whom I have worked at UoW or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.

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# Abstract

Prolonged drought conditions and increased water consumption, especially in Australia, have forced water authorities, consumers and local councils to consider wastewater recycling as a supplementary water supply. As a consequence there is a growing momentum favouring reuse of wastewater. Due to a fear of the potential effects of micro-pollutants on wildlife and human health, there has been a concomitant increase in resistance to such schemes.

Three Australian wastewater recycling schemes have been studied for their ability to remove trace organic contaminants. Two of these schemes employ reverse osmosis (RO) technology and the other applies ozonation and biological activated carbon filtration (BAC). Contaminant concentrations were determined using a sensitive analytical method, developed in this study, comprising solid phase extraction (SPE), derivatization and gas chromatography (GC) with mass spectrometry detector (MS) using selected ion monitoring (SIM). In addition, a range of other standard characterization techniques including total organic carbon, total nitrogen, turbidity, UV absorbance and pH were used. In raw wastewaters, analgesics and non-steroidal anti-inflammatory medications present were similar in nature and concentration to those found in wastewaters around the world. Remarkably, removal efficiencies for the three schemes were superior to literature values and RO was responsible for the greatest proportion of contaminant removal.

A comprehensive one year study was conducted to investigate the occurrence, persistence and fate of a range of organic compounds at different processing points at the Luggage Point Water Reclamation Plant in Brisbane, Australia. The treatment applied consists of screening, grit removal and diffused activated sludge followed by microfiltration (MF) and reverse osmosis (RO). It was found that salicylic acid was the most abundant contaminant in the influent with a concentration range of 11,065 - 38,490 ng/L followed by bisphenol A with a range of 6,330 - 23,020 ng/L. The concentration of all analytes decreased on average by one order of magnitude during primary and secondary treatments. Gemfibrozil, primidone and carbamazepine were found to have relatively low removal efficiencies (74-78%) during these stages compared to the other compounds which would indicate lower biodegradability. Furthermore, a positive relation

was found between metal concentration and their removal from the wastewater treatment plant resulting in a concentration less than 0.05 mg/Lfor most metals in the secondary effluent.

The RO system was found to play an important role in further lowering these concentrations by another order of magnitude. The overall removal efficiencies in the final recycled water were between of 97-100% resulting in most compound concentrations in the product water being lower than 100ng/L. An exception to this was bisphenol A (which was present at concentrations of up to 500 ng/L).

Notably, the RO membrane serves as a large reservoir for organic matter (i.e., high organic carbon, TN and absorbance measurements) as well as trace organic compounds such as PhACs and EDCs due to the adsorption of contaminants on membranes and their likely release in the brine. The concentrations of trace organic compounds reached µg/L levels. The concentration factor for the detected compounds ranged between one and five for all detected trace compounds. With regard to the metals content of the brine (anions, cations and heavy metals), the RO membrane concentrates these metals by a factor of between three and five.

The demonstrated ability of RO membranes to concentrate many of the compounds highlights the need for continued research into monitoring wastewater treatment, concentrate disposal, improved water recycling schemes and ultimately, safer water and a cleaner environment.

Fully investigation of the micropollutants fate in the wastewater treatement plants was impossible due to both time constraints and the fact that little systematic relationships were found between the removal of organic contaminants and water treatment processes. It was not possible to pursue studies of the mechanisms of removal for the treatment plants under investigation.

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