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Ozone-biological activated carbon as a pretreatment process for reverse osmosis brine treatment and recovery

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ABSTRACT

Ozonation was used in this study to improve biodegradability of RO brine from water reclamation facilities. An ozone dosage ranging from 3 to 10 mg O_3/L and contact times of 10 and 20 min in batch studies were found to increase the biodegradability (BOD_5/TOC ratio) of the RO brine by 1.8–3.5 times. At the same time, total organic carbon (TOC) removal was in the range of 5.3–24.5%. The lab-scale ozone-biological activated carbon (BAC) at an ozone dosage of 6.0 mg O_3/L with 20-min contact time was able to achieve 3 times higher TOC removal compared to using BAC alone. Further processing with Capacitive Deionization (CDI) process was able to generate a product water with better water quality than the RO feed water, i.e., with more than 80% ions removal and a lower TOC concentration. The ozone-BAC pretreatment has the potential of reducing fouling in the CDI process.

1. Introduction

Reverse osmosis (RO) process is a widely used technology in water reclamation. In most reclamation processes using RO technology, 75–85% of feed water is reclaimed, leaving the remaining as concentrate waste stream (commonly known as RO brine) for disposal (Ng et al., 2008; Wilf, 2008). Proper handling and management of this wastewater is required to meet local discharge regulations. Surface discharge provides the simplest and most economical way of RO brine disposal for reclamation facilities located near the coastal area. However, this does not provide a long-term sustainable solution for water reclamation practices. High quality water can still be recovered from the RO brine, provided a cost-effective technology is available to treat and remove the persistent organics and high concentration of salts in the brine. Treatment and recovery of RO brine will provide a two-way solution to water reclamation plant, namely, increasing the efficiency of reclaimed water and providing a solution to brine handling and disposal. Further recovery of RO brine will generate a more concentrate stream which will further lower the volume and hence the cost for disposal.

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Table 1 – The different dosages and contact times used for RO brine treatment in batch studies.

Batch	1a	1b	1c	2a	2b	2c
Contact time (min)	10	10	10	20	20	20
Dosage (mg O_3/L)	3.0	6.0	10.0	3.0	6.0	10.0

In RO brine recovery, pretreatment to remove the organics has been shown to be an important step to reduce fouling of the downstream desalting process. The Capacitive Deionization (CDI) process is an attractive option for desalting due to its lower energy demand compared with RO (Welgemoed and Schutte, 2005). An electrical field is applied in the CDI process to generate a potential difference between two electrodes which attracts and remove the anions and cations in the feed stream to produce a product stream with lower salt content. The CDI process has been demonstrated to be a feasible process which was able to remove more than 90% of salt from the RO brine generated by a domestic sewage water reclamation plant (Ng et al., 2008).

Organics removal using physical–chemical methods such as alum coagulation and activated carbon adsorption were able to remove up to 42 and 91.3% of dissolved organic carbon (DOC) in the RO brine of an Membrane Bioreactor (MBR) effluent, respectively. Alternatively, oxidation methods such as electrolytic oxidation, UVA/TiO_2 photocatalysis and sonolysis were reported to achieve up to 50% organics removal (Dialynas et al., 2008). It is noted that high organics removal is attainable with activated carbon adsorption but this will require regeneration of high volume of activated carbon for large scale RO brine treatment. Hence, activated carbon adsorption would not be a cost-effective treatment for long-term operation.

Biological pretreatment methods using biological activated carbon (BAC) was only able to achieve about 20% total organic carbon (TOC) removal (Ng et al., 2008). This shows that the organics in the RO brine is highly resistant to further biodegradation. This is because these organics are originated from secondary effluent that has been subjected to extensive biodegradation in the activated sludge process. The organics generally comprise of soluble microbial products and other

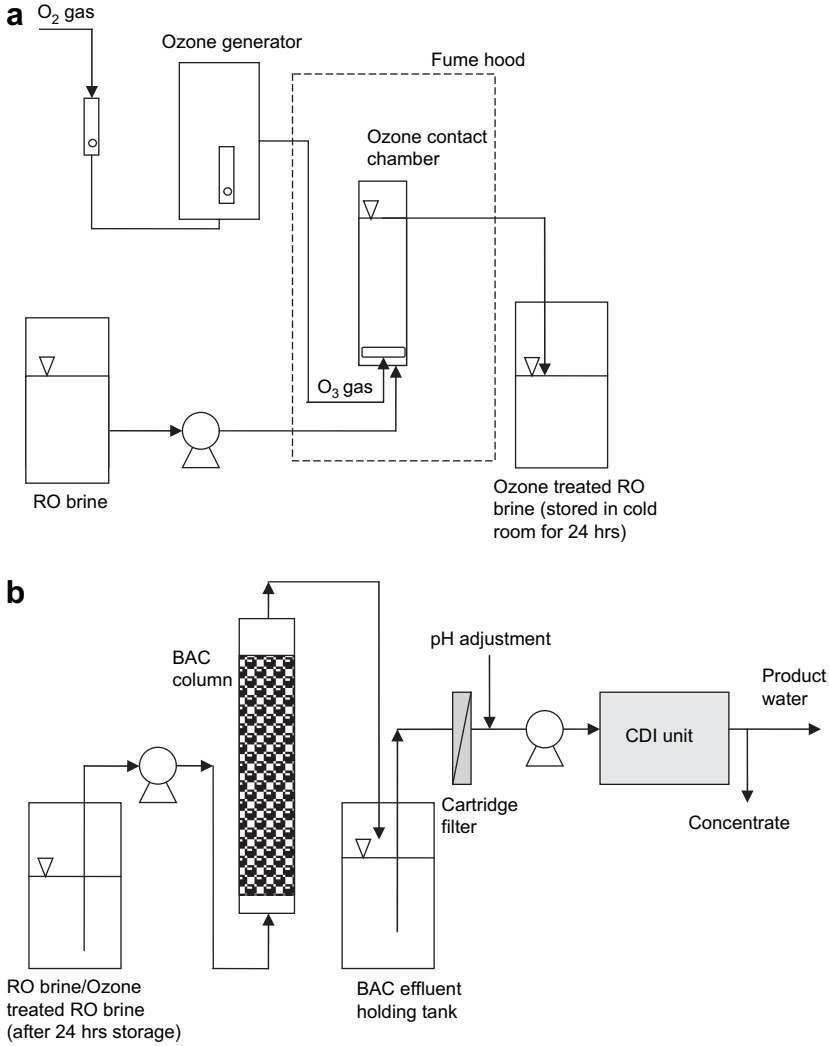

Fig. 1 – Experimental set-up for treatment of RO brine using (a) ozone; followed by (b) BAC column for removal of organics before RO brine recovery using CDI process.