Desalination 364 (2015) 119–125

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Use of nanofiltration and reverse osmosis in reclaiming micro-filtered biologically treated sewage effluent for irrigation

Sukanyah Shanmuganathan, Saravanamuthu Vigneswaran *, Tien Vinh Nguyen, Paripurnanda Loganathan, Jaya Kandasamy

Faculty of Engineering, University of Technology Sydney (UTS), P.O. Box 123, Broadway, NSW 2007, Australia

HIGHLIGHTS

- Nanofiltration (NF) pre-treatment reduced reverse osmosis (RO) membrane fouling.
- Permeate blends of RO after NF treatment and NF only are suitable for irrigation.
- NF or RO, alone removed most pharmaceuticals and personnel care products (PPCPs).
- PPCPs removals by NF membranes were lower than those by RO membranes.

ARTICLE INFO

Article history:
Received 1 September 2014
Received in revised form 15 December 2014
Accepted 16 December 2014
Available online 23 December 2014

Keywords:
Irrigation
Nanofiltration
Reverse osmosis
Sodium adsorption ratio
Pharmaceuticals and personal care products

ABSTRACT

Micro-filtered, biologically treated sewage effluent (BTSE) generally has high sodium adsorption ratio (SAR) and sodium (Na) and chloride (Cl) concentrations. Therefore it cannot be directly used for irrigating sensitive crops. A study was conducted on a micro-filtered BTSE from a Sydney water treatment plant to determine whether the BTSE can be treated using nanofiltration (NF) and reverse osmosis (RO) to bring these risk parameters within safety limits. The study showed that using NF and RO alone could not produce the required ratio of SAR. Furthermore, NF alone did not remove the necessary levels of Na and Cl ions while RO did. However, blending equal proportions of NF permeate and RO permeate obtained from a two stages hybrid treatment system consisting of NF followed by RO resulted in a product quality suitable for irrigation in terms of the above mentioned risk factors. Utilizing NF prior to RO reduced the RO membrane fouling as well. Both NF and RO removed most of the pharmaceutical and personal care products from the feed water and this may subsequently protect soil and ground water from potential hazards.

1. Introduction

Reclaimed wastewater for irrigation serves as an economical water resource in many countries [1]. It also has several benefits in improving soil health and reducing the need to use fertilizers. However, excessive salts, pathogens, trace organics, sodium (Na) and chloride (Cl) can cause dangerous environmental risks. The water quality criteria for irrigation are mainly characterized in terms of salinity and Na hazards, pH, and concentrations of some specific ions such as Cl^-, borate (BO_3^{3-}), and nitrate (NO_3^-).

Salinity is a hazard that results from high salt content in the water which directly affects plant growth, crop performance and soil properties [2] and it can be expressed by electrical conductivity (EC). High EC may cause physiological drought in plants. Sodium hazard is measured by sodium adsorption ratio (SAR) which provides the relative concentration of Na to calcium (Ca) and magnesium (Mg) ions. An excessive level of Na in relation to Ca and Mg affects the permeability characteristics of soil profile by changing the soil structure [3]. In addition to these, some specific ions such as Cl^-, BO_3^{3-} and NO_3^- at excessive levels can severely damage plant growth.

According to Ayers and Westcot [4] an excess concentration of Cl^- in soil solution causes this element to accumulate in plant leaves and cause leaf burn/dead leaves. This eventually results in necrosis (dead tissue). While boron (B) is an essential element for plant growth the high concentration of this element causes older leaves to turn yellow and this ultimately causes chlorosis. Nitrogen (N) is also an important element but its over-supply may over-stimulate plant growth, leading to delayed maturity of produce and ultimately its poor quality. As such, nutrient balanced irrigation water is essential in order to have a positive impact on plant growth. According to the water quality standards reported by ANZECC [3], the allowable safety limits of SAR, Cl, Na and B are 2–8, <175 mg/L, <115 mg/L, and <0.5 mg/L for very sensitive crops. The desirable range of pH for irrigation water is 6.5 to 7.6. The pH beyond this

* Corresponding author.
E-mail address: s.vigneswaran@uts.edu.au (S. Vigneswaran).

http://dx.doi.org/10.1016/j.desal.2014.12.021
0011-9164/