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Urban wastewater disinfection by filtration technologies

M. Gómez[a], A. de la Rua[a], G. Garralón[b], F. Plaza[b], E. Hontoria[a], M.A. Gómez[a*]

[a]*Environmental Microbiology Group, Institute of Water Research and Department of Civil Engineering, University of Granada, 18071 Granada, Spain*
Tel. +34 (958) 246153; Fax: +34 (958) 246138; email: mgomezn@ugr.es
[b]*Department of Research and Development, Cadagua S.A., Gran Vía 45, 7ª, 48011 Bilbao, Spain*

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Abstract

The microbiological quality of effluents from different macrofiltration systems (pressure sand filter and disc filter) used as pre-treatment and membrane technologies (microfiltration and ultrafiltration) was evaluated in order to determine their possible application as alternatives to disinfection of urban wastewater prior to reutilization. Microbiological quality was determined by reference to nematode egg content, fecal coliforms, *E.coli* and somatic coliphages. Pathogenic nematode eggs were efficiently retained by the macrofiltration systems. However, since other types of nematode eggs were present in the effluents treated by both systems, the possibility of such infective agents appearing after this type of treatment cannot be discounted. The membrane technologies proved highly efficient at retaining micro-organisms, achieving effluents of excellent microbiological quality. However, the effluents could not be classified as sterile, since contamination of permeation zones gave rise to the presence of micro-organisms. This result casts doubt on the validity of using the fecal coliform indicator to assess microbiological quality of effluents from these systems. Differences between the two membrane technologies were noted with regard to viral particle retention capacity, with only the ultrafiltration module achieving effluents with total absence of fecal contamination indicators. The macrofiltration systems may present problems when used as pre-treatments to standard disinfection systems (UV radiation, reactive oxidant disinfection). Such problems do not arise with the membrane technologies, which offer a valid alternative for the disinfection of urban wastewater prior to reutilization.

Keywords: Wastewater disinfection; Microfiltration; Ultrafiltration; Nematode eggs, *E. coli*; Coliphages

1. Introduction

Reclamation and reuse of urban wastewater have increased in recent years, largely due to lack of water resources and inadequate economic structures, particularly in arid and semi-arid countries. However, reuse must be safe to avoid damaging public health and the environment [1].

Although conventional treatment processes (primary and secondary treatments) are known to

*Corresponding author.

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remove up to 95–99% of some micro-organisms, characteristics of treated wastewater render it inappropriate for direct reuse, mainly due to the presence of a high concentration of pathogenic micro-organisms [2]. The safe operation of water reuse systems therefore depends on wastewater disinfection, which is the most widely used treatment for public health protection.

Requirements for wastewater reuse are determined by regionally-specific standards and recommendations, and there is some controversy regarding the quality that effluents should attain. However, all standards and recommendations are based principally on biological quality considerations [3]. These standards are becoming increasingly stringent in order to avoid hazards to public health and the environment [4].

To date, chlorination is the most widely used means to inactivate pathogenic micro-organisms in water and wastewater and is the principal method for preventing waterborne infectious diseases throughout the world. However, several studies have reported that the effectiveness of the process is reduced by turbidity, suspended solids and the presence of nitrogen compounds such as ammonia and nitrite [5]. Furthermore, the use of chlorine in wastewater gives rise to undesirable by-products suspected to pose a hazard to humans and the environment [6].

In view of such problems, alternative technologies have been developed in recent years such us ozonization, UV disinfection, and paracetic acid [7]. Ozone has proved to be one of the most effective disinfectants [8]. However, because of operational and maintenance problems, it is generally considered a less attractive alternative to chlorine than UV disinfection. Yet the performance of UV disinfection is influenced by water turbidity and UV lamp intensity, which may be reduced by lamp age and fouling characteristics of the wastewater [9]. Moreover, it has been shown that UV can react with aromatic compounds and nitrate, both present in treated wastewater to produce compounds that exhibit mutagenic activity [10].

In addition to these drawbacks, certain micro-organisms may resist the disinfection process. The diversity of pathogens found in treated wastewater is high, and it is implausible that each and every micro-organism will be removed with the same efficiency by the applied technology. Pathogenic parasites, such us parasite ova, cyst and some viruses, are likely to occur in local wastewater and are reportedly resistant to chemical disinfectants and UV irradiation [11].

Membrane technologies offer an alternative to the disinfection process. Such technologies produce a high-quality clarified effluent and do not require the addition of chemical reagent, thus avoiding the formation of harmful by-products. In the past, membrane technologies have been considered unsuitable owing to high operating costs. However, use of membrane technologies in wastewater treatment has expanded significantly over the past 10 years as a result of increasingly stringent discharge standards, technological advances, and decreased costs associated with membrane technologies [9,12].

Disinfection by reagent or by UV irradiation requires a pre-treatment stage to remove suspended solids or reduce turbidity [5]. Similarly, membrane technologies require suitable pretreatment in order to maintain membrane efficiency by preventing fouling and module damage [12]. Traditionally, the most frequently applied pre-treatment for tertiary treatment has consisted of macrofiltration processes [9], which have proven effective in reducing certain pathogen groups [13].

In view of these considerations, the aim of the present study was to assess the microbiological quality (based on the parameters fecal coliform, *E. coli*, coliphages and nematode eggs) of different effluents from two macrofiltration processes (pressure sand filter and disc filter) used as pretreatment and membrane technologies (micro-