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Review

Dissolved effluent organic matter: Characteristics and potential implications in wastewater treatment and reuse applications

I. Michael-Kordatou [a], C. Michael [a], X. Duan [a,b], X. He [a,b], D.D. Dionysiou [a,b], M.A. Mills [c], D. Fatta-Kassinos [a,*]

[a] Department of Civil and Environmental Engineering and Nireas-International Water Research Centre, School of Engineering, University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus

[b] Environmental Engineering and Science Program, University of Cincinnati, Cincinnati, OH 45221-0071, USA

[c] US EPA, Office of Research and Development, 26 W, Martin Luther King Drive, Cincinnati, OH 45268, USA

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ABSTRACT

Wastewater reuse is currently considered globally as the most critical element of sustainable water management. The dissolved effluent organic matter (dE_fOM) present in biologically treated urban wastewater, consists of a heterogeneous mixture of refractory organic compounds with diverse structures and varying origin, including dissolved natural organic matter, soluble microbial products, endocrine disrupting compounds, pharmaceuticals and personal care products residues, disinfection by-products, metabolites/transformation products and others, which can reach the aquatic environment through discharge and reuse applications. dE_fOM constitutes the major fraction of the effluent organic matter (E_fOM) and due to its chemical complexity, it is necessary to utilize a battery of complementary techniques to adequately describe its

Abbreviations: ABR, anaerobic baffled reactor; AC, activated carbon; AER, anion-exchange resin; AOPs, advanced chemical oxidation processes; ARB&ARG, antibiotic-resistant bacteria and genes; BAPs, biomass-associated products; BLM, biotic ligand model; BOD, biological oxygen demand; CAS, conventional activated sludge; CECs, contaminants of emerging concern; COD, chemical oxygen demand; DBPs, disinfection by-products; dE_fOM, dissolved effluent organic matter; DOC, dissolved organic carbon; DON, dissolved organic nitrogen; DPR, direct potable use; EC, European Commission; EDCs, endocrine disrupting chemicals; E_fOM, effluent organic matter; EQS, environmental quality standards; ESI-FT-ICR-MS, electrospray ionization Fourier transform ion cyclotron resonance mass spectrometry; FI, fluorescence index; FTIR, Fourier-transform infrared spectrometry; FT-MS, Orbitrap Fourier transform mass spectrometry; GAC, granular activated carbon; GC, gas chromatography; HAAs, haloacetic acids; HRT, Hydraulic retention time; HPSEC, high performance size-exclusion chromatography; IPR, indirect potable reuse; LEDs, light emitting diodes; LMM, low molar mass; MBR, membrane bioreactor; MF, microfiltration; MIEX®, magnetic ion-exchange resin; MS, mass spectroscopy; MW, molecular weight; MWCO, molecular weight cut-off; MWD, molecular weight distribution; NF, nanofiltration; NDMA, *N*-nitrosodimethylamine; NMR, nuclear magnetic resonance; NOM, natural organic matter; PAC, powdered activated carbon; pE_fOM, particulate effluent organic matter; PPCPs, pharmaceuticals and personal care products residues; RO, reverse osmosis; SBR, sequencing batch reactor; SEC, size-exclusion chromatography; SMPs, soluble microbial products; SRT, solid retention time; SUVA, specific UV absorbance at 254 nm; THMs, trihalomethanes; TSS, total suspended solids; UAPs, utilization-associated products; UF, ultrafiltration; USEPA, United States Environmental Protection Agency; UV_{254}, ultraviolet absorbance at 254 nm; UV/Vis, ultraviolet/visible spectrometry; WWTPs, wastewater treatment plants; WET, whole effluent toxicity; WHO, World Health Organization.

* *Corresponding author*. Tel.: +357 22893515; fax: +357 22895365.
E-mail address: dfatta@ucy.ac.cy (D. Fatta-Kassinos).

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structural and functional character. dE$_f$OM has been shown to exhibit contrasting effects towards various aquatic organisms. It decreases metal uptake, thus potentially reducing their bioavailability to exposed organisms. On the other hand, dE$_f$OM can be adsorbed on cell membranes inducing toxic effects. This review paper evaluates the performance of various advanced treatment processes (i.e., membrane filtration and separation processes, activated carbon adsorption, ion-exchange resin process, and advanced chemical oxidation processes) in removing dE$_f$OM from wastewater effluents. In general, the literature findings reveal that dE$_f$OM removal by advanced treatment processes depends on the type and the amount of organic compounds present in the aqueous matrix, as well as the operational parameters and the removal mechanisms taking place during the application of each treatment technology.

Contents

1. Introduction – current state of knowledge

Reuse of urban wastewater is considered as an important component of sustainable wastewater management practices worldwide, mainly for non-potable applications. Reclaimed wastewater is widely reused for surface and groundwater replenishment purposes, while agricultural and landscape irrigation (e.g., golf camp irrigation) in water-scarce regions such as Cyprus, France, Italy, Israel, Jordan, Lebanon, Malta, Spain, etc is widely implemented (Bdour et al., 2009; Muñoz et al., 2009; Pedrero et al., 2010; Kalavrouziotis et al., 2013; Becerra-Castro et al., 2015). Water scarcity, foreseen to aggravate in Mediterranean countries, led to the utilization of reclaimed wastewater, for the irrigation of forage and cereals, fruit trees and in some cases vegetables, depending on the discharge standards stated in the national legislation. According to Bixio et al. (2008), four non-potable uses of reclaimed wastewater are identified worldwide (mostly in Australia, Europe, Japan, and US): (i) agricultural irrigation, (ii) industry, (iii) urban, recreational and environmental uses (including aquifer recharge), and (iv) combinations of the above.

A distinction between '*indirect*' and '*direct*' potable reuse applications was proposed by USEPA (2004) and Gerrity et al. (2013), depending on whether the reclaimed wastewater is used directly or mixed with other sources. Indirect potable reuse (IPR) occurs through the augmentation of drinking water supplies with urban wastewater treated to a level suitable for IPR followed by an environmental buffer (e.g., rivers, dams,