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Drip Irrigation Efficiency and Biofilm Dynamics in Micro-Irrigation with Reclaimed Wastewater at the Field Scale

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Abstract

The development of water-saving irrigation techniques is more crucial than ever due to the rapid global climate change and the need of water resource conservation. Using treated wastewater emerges as a sustainable option to meet the expanding irrigation demands (Ait-Mouheb et al., 2018). Moreover, micro-irrigation techniques (e.g., drip irrigation) might allow saving up to 90% of water (versus ~50% with surface irrigation techniques). In micro-irrigation systems, drippers are composed of a flow path with a labyrinth conformation and an outlet chamber. However, drippers are sensitive to clogging due to the labyrinth conformation, slow flow rate and small flow section (close to 1 mm3). Clogging problems can affect the water delivery uniformity along the pipe and increase maintenance costs. The aim of this study was to evaluate the efficiency and biofouling of drip irrigation systems at the field scale during irrigation with treated wastewater. Six 100-m lines of commercial pipes with two dripper types (flow rate, Q, of 0.65 L h^{-1} and 1.5 L h^{-1}, respectively) were monitored for four months. Different zones along the pipes were selected to evaluate the influence of hydrodynamical conditions (Reynolds number = 5400 to 0) on biofouling. Destructive methods involving the biofilm extraction by mechanical means, showed little biofilm development without significant differences in dry and organic matter content in function of the sampling location along the pipe or dripper flow rate (Q0.65 and Q1.5). These results were confirmed by non-destructive methods, such as optical coherence tomography, that nevertheless showed that biofouling concerned 15-20% of the total dripper labyrinth volume. Total organic carbon monitoring and its composition (by three-dimensional excitation and emission matrix fluorescence microscopy) showed that the biofilm did not significantly influence the organic matter nature. Our results indicated that the biological activity and biofilm development in irrigation systems were more affected by the environmental conditions, particularly water temperature, rather than flow conditions. This confirmed that treated wastewater with low organic content can be used in micro-irrigation systems without significant loss of efficiency, even in conditions requiring intensive irrigation, such as the Mediterranean climate (Moulia et al. 2024).

Keywords: Biofouling, Pathogen indicators, Optical methods, Biological activities, Water Reuse

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