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Beyond chlorine: alternative sustainable compounds to remove biofilms in drinking water environments

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Motivation

The drinking water sector depends heavily on drinking water distribution systems (DWDS), and the safety of the water is directly related to people's health. However, the main challenge is to deliver a product that is both aesthetically pleasing and microbially and chemically safe.
One of the main contaminants of DWDS is biofilm growth. In biofilms, microorganisms produce a matrix of extracellular polymeric substances (EPS) rich in proteins and polysaccharides, protecting them from external stresses. Biofilm formation and its detachment into the water stream affects the taste, odor and color of drinking water. Biofilm formation can also affect the drinking water production processes steps, such as ultrafiltration (UF) (Fig. 1). Drinking water utilities all over the world often rely on disinfection with chlorine for eliminating such biofilms, from which harmful disinfection by-products can be produced when interacting with EPS of biofilms [1].

For this reason, research into the application of novel, non harmful, effective anti-biofilm agents is at the core of this project.

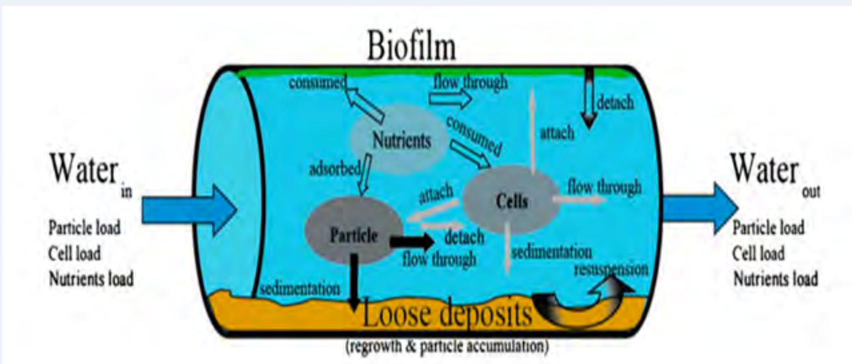

Fig 1. Schematic representation of microbial growth and biofilm formation within drinking water distribution pipes (adapted from [2])

Technological challenge

Once established, biofilms are very difficult to eradicate because the EPS layer protects bacteria from disinfection agents. The focus of this project is the utilization of amino acid derivatives as disinfection/cleaning agent, because their utilization is compatible with human consumption. An example is N-acetyl L-cysteine (NAC), an acetylated derivative of L-cysteine, which can disrupt or degrade EPS, causing the dispersal of existing biofilms (Fig. 2).

The challenges of this project lie in investigating
- Effectivity of NAC and other molecules in inhibiting bacterial growth and surface attachment
- Ability of these molecules to eradicate pre-formed biofilms on polymeric pipe surfaces and UF membrane materials
- Optimal concentration and durability of the effect of such molecules

This will be tested via several experiments and techniques in a laboratory setup mimicking DWDS conditions and utilizing real-grade pipe materials and UF membranes (Fig. 3).

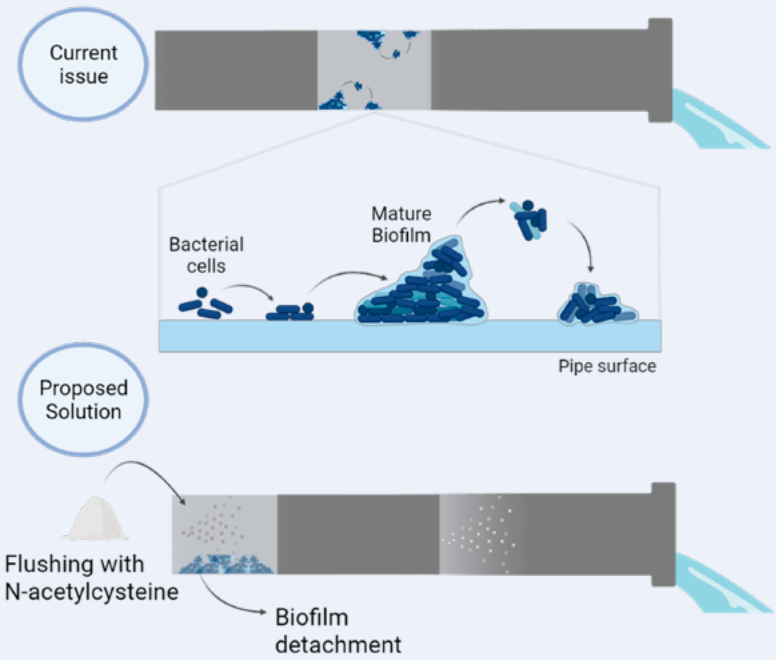

Fig 2. Schematic representation of the current issue and the proposed solution

Research goals

This project aims to:
- Identify non-harmful, sustainable compounds applicable in drinking water environment (from pipe materials to UF membranes)
- Understand their fundamental mechanism of action
- Produce a cost-effective protocol to be used as maintenance strategy or in contingency situations.

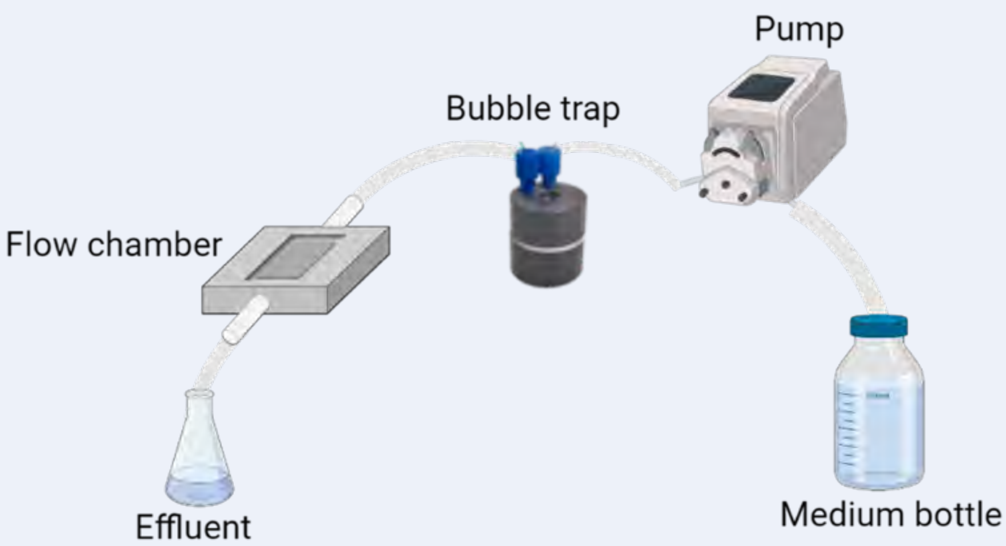

Fig 3. Example of basic flow chamber setup to monitor biofilm growth

References

[1] Zhao, Z., Zhang, Y., Wang, L., & Shi, W. (2022). Effect of Particle Concentration and Pipe Materials on the Formation of Biofilms in Drinking Water Distribution Systems. Water (Switzerland), 14(2). https://doi.org/10.3390/w14020224
[2] Liu, S., Gunawan, C., Barraud, N., Rice, S. A., Harry, E. J., & Amal, R. (2016). Understanding, monitoring, and controlling biofilm growth in drinking water distribution systems. In Environmental Science and Technology (Vol. 50, Issue 17, pp. 8954–8976). American Chemical Society. https://doi.org/10.1021/acs.est.6b00835

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101034321.

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