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Extended Biostability of Potable Water Through Sustainable Non-Chemical Treatment

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Motivation

Many types of bacteria belonging to various genera are present in the water ecosystem. Indeed, different sources of water highly influence the composition of the water microbiome.
Moreover, drinking water is characterized by its ratio of high nucleic acid (HNA) content bacteria and low nucleic acid (LNA) content bacteria where generally pathogenic organisms belong to the HNA group and normal flora organisms belong to the LNA group [1] [2].
Bacteria in the LNA cluster are the most dominant in freshwater environments due to their oligotrophic properties[2]. These two groups of bacteria could be differentiated by flow cytometry where the fluorescence intensity is the indicator of nucleic acid content and the scatter signals as an indicator of cell size[3].
Microbial calcium carbonate precipitation (MICP) is a natural phenomenon that is hardly done without the creation of bacterial biofilms[2]. $CaCO_3$ precipitates in stages: first, the formation of amorphous calcium carbonate (ACC), then the creation of one of the three crystals respectively from least to most stable: vaterite, aragonite, and calcite. Nucleation is a very important step in the precipitation process and genetics play an important role as well in the process of MICP.
Magnetic water treatment (MWT) has always focused on the physico-chemical properties of water instead of its microbiological properties. It has been demonstrated that MWT could help increase the formation of dynamically ordered liquid-like oxyanion polymers (DOLLOPs) that account for > 50% of the calcium found in a given solution[4].
Since the precipitation of calcium carbonate in drinking water can be performed in various ways including by indigenous water bacteria; it has been a cause of nuisance in water piping systems where biofouling and scaling occur; resulting in the clogging of these pipes[2].

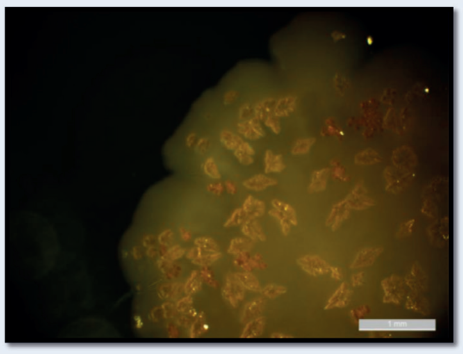
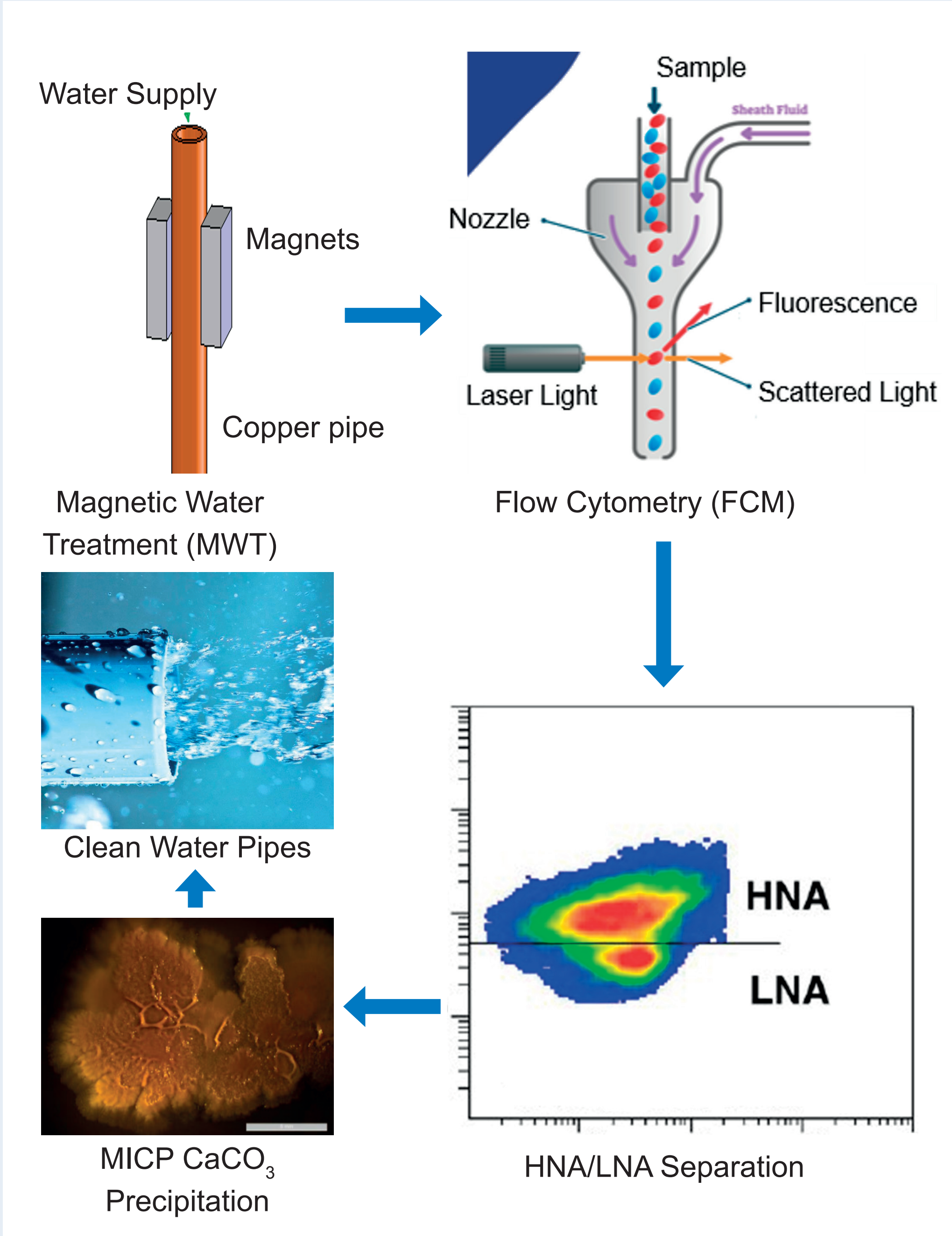


Fig 1. Bacterial culture with $CaCO_3$ precipitation

Technological challenge

- Accurate detection of the conditions in which HNA and LNA bacteria interchange roles.
- Recording small mutations and other factors involved in the MICP process as well as the outcome of MWT in the genetic changes of the concerned bacteria.
- The successful $CaCO_3$ precipitation in a manner that does not accumulate on water pipes' surfaces



Research goals

- Detection of the conditions of HNA/LNA shift in drinking water bacteria if any shift happens at all.
- Identification of the genetics behind MICP phenomena and ultimately identifying the effect of MWT on the drinking water itself and the behavior of the water's microbiome.
- Determining whether MWT can eventually increase $CaCO_3$ precipitation in a manner that does not cause scaling on water pipes' peripheries.

References

[1] Proctor C. R., Besmer M. D., Langenegger T., Beck K., Walser J. C., Ackermann M., Burgmann H. and Hammes F. (2018). Phylogenetic clustering of small low nucleic acid-content bacteria across diverse freshwater ecosystems. *The ISME Journal*, 12: 1344-1359.
[2] Liu X., Zarfel G., Van Der Weijden R., Loiskandl W., Bitschnau B., Dinkla I. J. T., Fuchs E. C. and Paulitsch-Fuchs A. H. (2021). Density-dependent microbial calcium carbonate precipitation by drinking water bacteria via amino acid metabolism and biosorption. *Water Research*, 202(2021): 117444.
[3] Lebaron P., Servais P., Agogué H., Courties C. and Joux F. (2001). Does the high nucleic acid content of individual bacterial cells allow us to discriminate between active cells and inactive cells in aquatic systems? *Applied and Environmental Microbiology*, 67(4): 1775-1782.
[4] Sammer M., Kamp C., Paulitsch-Fuchs A. H., Wexler A. D., Buisman C. J. N. and Fuchs E. C. (2016). Strong Gradients in Weak Magnetic Fields Induce DOLLOP Formation in Tap Water. Water, 8:79.

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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