Applied Water Physics

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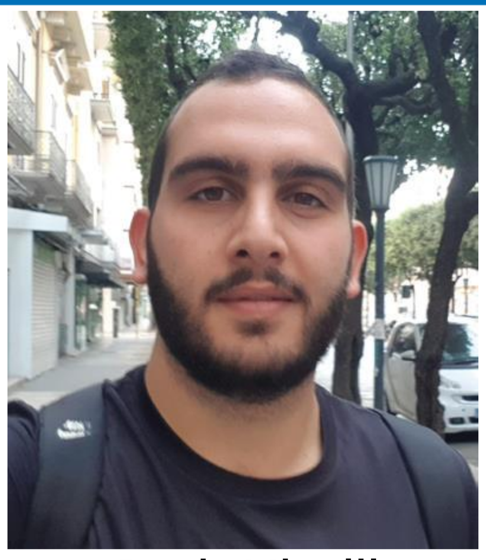
Extended Biostability of Potable Water Through Sustainable Non-Chemical Treatment



Jack Khalil

jack.khalil@wetsus.nl

Motivation

Many bacterial species are present in the water ecosystem, and indeed, different sources of water highly influence the composition of the water microbiome.
Moreover, drinking water can be characterized by its ratio of high nucleic acid (HNA) and low nucleic acid (LNA) content bacteria. Recently, it has been uncovered that, generally, pathogenic organisms tend to belong to the HNA group rather than the LNA group due to their eutrophic lifestyle [1] [2].
These two groups of bacteria can be differentiated by flow cytometry where the fluorescence intensity is the indicator of nucleic acid content and the side scatter signals as an indicator of cell size [3]. LNA bacteria dominate over HNA bacteria in freshwater environments due to their oligotrophic properties. Having a high LNA/HNA ratio may result in a more biostable water [2].

Another phenomenon that is relevant to the biostability of water is microbial calcium carbonate precipitation (MICP). It is a natural phenomenon that hardly occurs without the creation of bacterial biofilms [2]. $CaCO_3$ precipitates in stages and leads to 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.

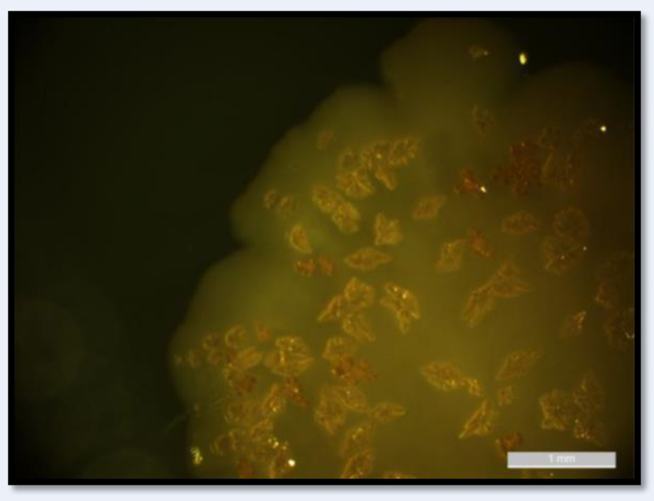


Fig 2. Bacterial culture with $CaCO_3$ precipitation
(Source: X. Liu, 2020)

Magnetic water treatment (MWT) has positive effects on both phenomena (high LNA/HNA ratio and MICP) but it 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]. Additionally, electromagnetic (EM) radiation has been proven to have conflicting effects on tested bacteria sometimes enhancing growth and other times enhancing antimicrobial susceptibility/resistance [5].
Calcium carbonate precipitation in drinking water has been a cause of nuisance in water piping systems where biofouling and scaling occur; resulting in the clogging of these pipes [2].

Technological challenge

- Accurate detection of the conditions in which HNA and LNA bacteria interchange roles.
- Measuring metabolic processes that are involved in the MICP as well as assessing the effects of MWT and EM radiation in the behavioural changes of the concerned bacteria.
- Establishing $CaCO_3$ precipitation in a manner that does not accumulate on water pipes' surfaces.

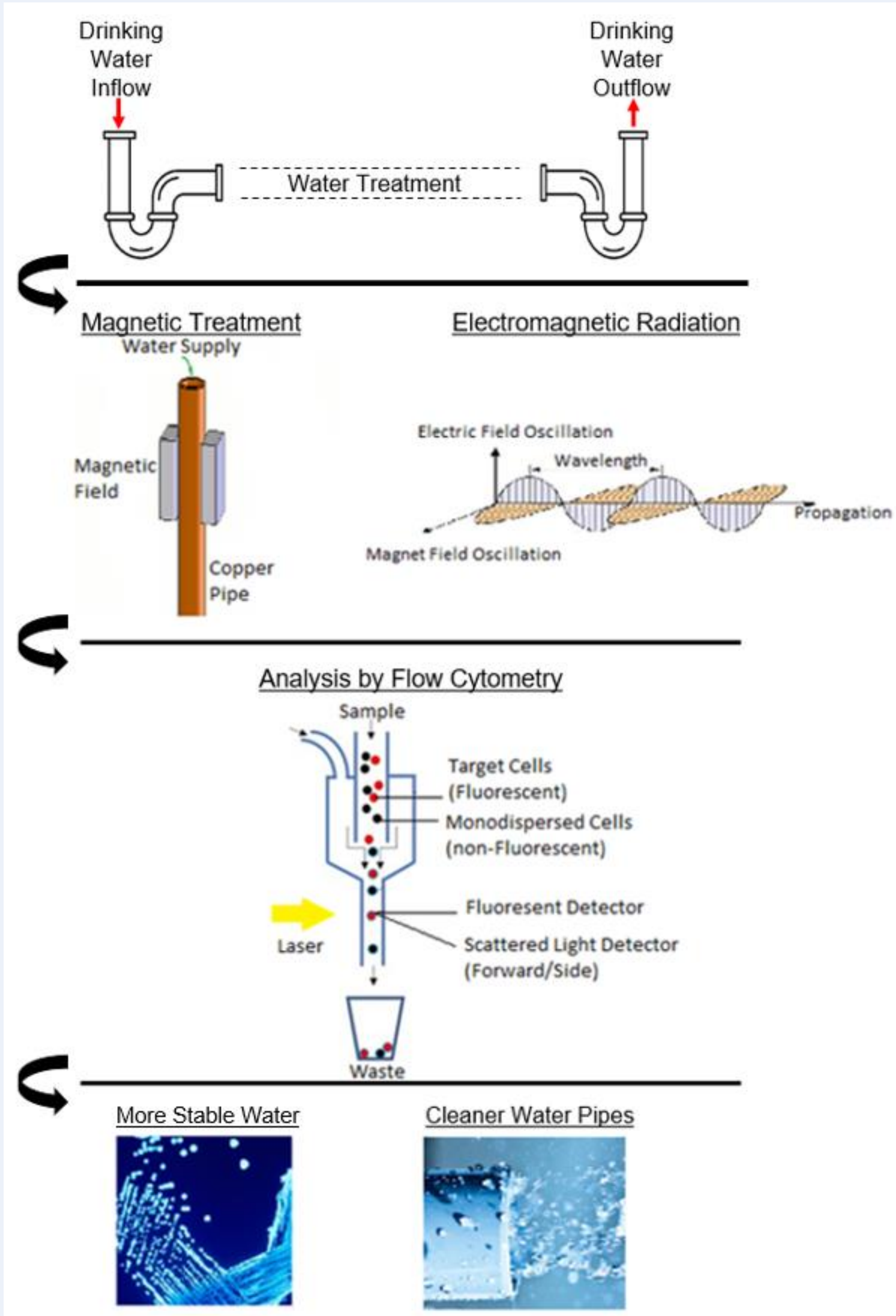


Fig 1. Schematic representation of the project's workflow

Research goals

- Understanding possible shifts of HNA and LNA populations due to changes in water conditions; and the consequences on water biostability.
- Identification of the genetics behind MICP phenomena.
- Identification of the effects of EM radiation on drinking water bacteria.
- Determining whether MWT can influence the water microbiome and eventually control $CaCO_3$ precipitation in a manner that does not cause scaling on water pipes' peripheries.

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J. Khalil, MSc., dr. E. C. Fuchs, dr. I.J.T. Dinkla, dr. A. H. Paulitsch-Fuchs, prof. dr. G. Zarfel, X. Liu, prof. dr. T. Ertl

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