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Nanofiltration of greywater for micropollutant removal

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Motivation

Separation of wastewater at the source into black water and greywater streams, with the intent of reuse, has gained popularity in the last three decades[1]. The separate collection of black- and greywater has several benefits such as higher concentrations of organics in black water leading to more efficient nutrient recovery and more efficient water use and reuse[2][3].
Prior research has shown the reuse potential of greywater, but risks associated with micropollutants, and other emerging contaminants must be considered[1][2][4]. Advanced oxidation processes and adsorption to remove these contaminants have been studied extensively in source-separated sanitation plants. However, membrane technologies, like spiral wound nanofiltration, have seen limited implementation, due their high fouling potential and the need for extensive pretreatment[5]. The emerging technology of hollow fiber nanofiltration membranes has the potential to alleviate these drawbacks and will be able to produce a high-quality water stream for reuse and increase the recovery of valuable resources[6][7].

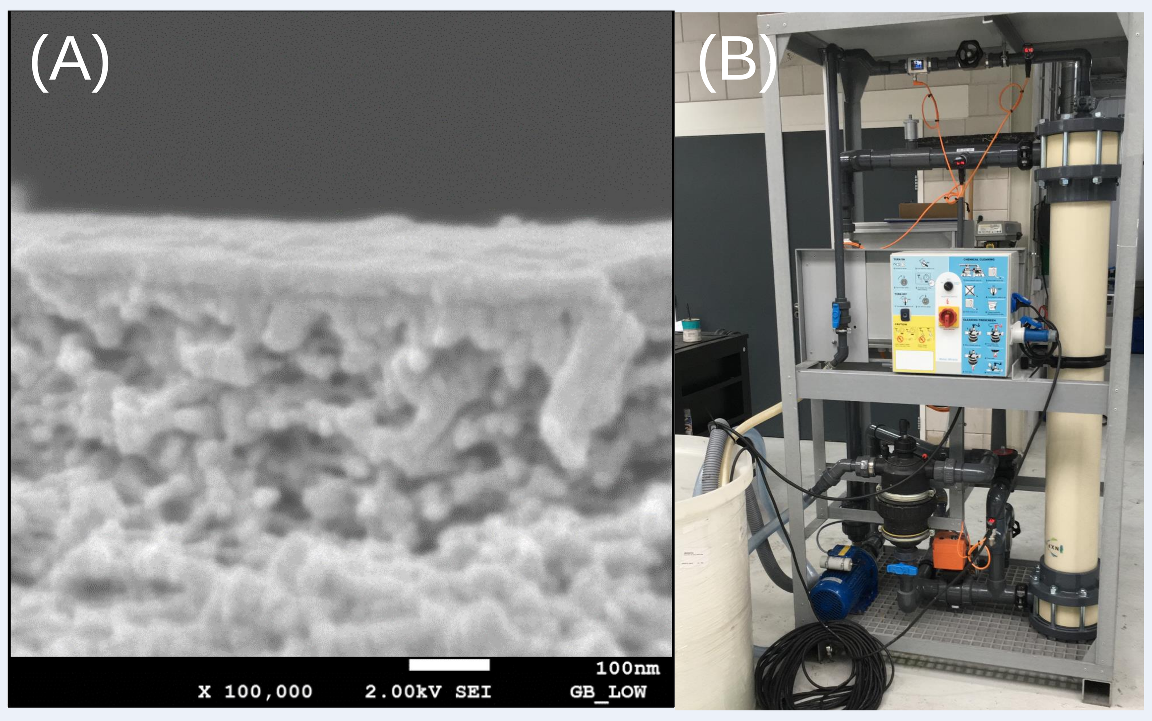

Fig 1. (A) SEM-picture of the hollow fiber with polyelectrolyte multilayer indicated[10]
(B) Pilot setup used during the project

Technological challenge

While the new generation of nanofiltration membranes which use polyelectrolyte multilayers as separation layer (Fig. 1A) have shown to be promising method for micropollutant removal[8], implementation of these membranes in full scale applications has not been studied in detail yet. Moreover, influences of the water matrix and membrane fouling on the rejection of micropollutants are yet to be studied.
Because of the decentralized nature of source separated sanitation, it is required to monitor membrane integrity and permeate quality in-line. While some research has been done[9], no sufficient methods has yet to be developed.
Lastly, while a high-quality permeate will lead to a multitude of water reuse possibilities, a highly contaminated concentrate stream will be produced as well. This concentrate stream could lead to potential increased resource recovery, but will also require a suitable treatment, which has not yet received much attention.

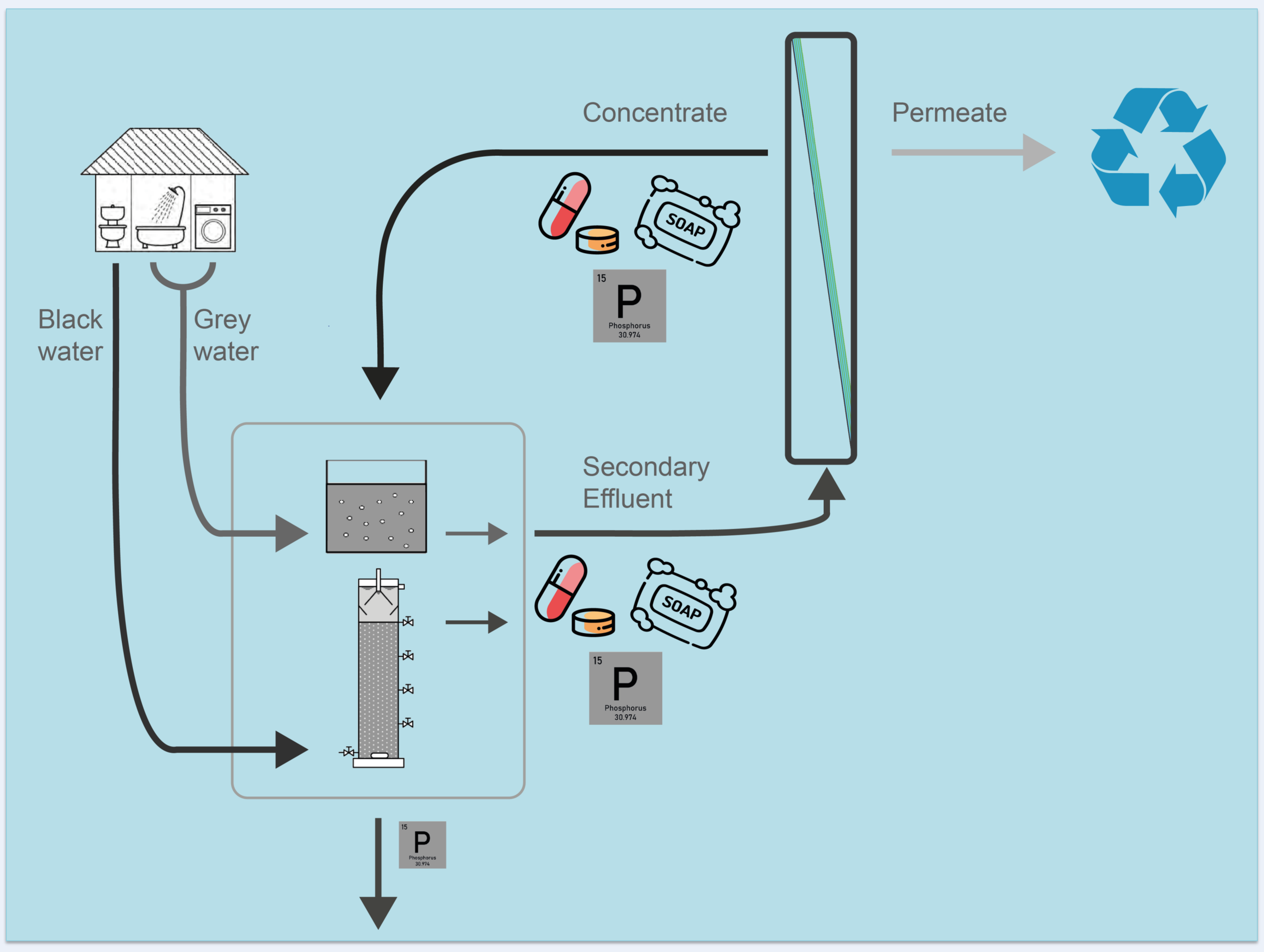

Fig 2. Graphical Abstract of the research project.

Research goals

During the project, the integration of a hollow fiber nanofiltration pilot (Fig 1B) in a full-scale source separated treatment plant will be studied. The goal of this integration is to create a self-sustaining treatment plant which will have a clean enough permeate to be re-used and an environmentally appropriate method to treat the concentrate treatment. The achieve this the following questions will be answered.

- How effective is the implementation of hollow fiber nanofiltration in terms of operational cost and treatment plant stability?
- What is the influence of process parameters, such as transmembrane pressure and crossflow velocity, on the permeate quality?
- What is the efficiency of the total source separated treatment plant in terms of micropollutant removal and resource recovery?
- What is the most suitable monitoring method for membrane integrity and permeate quality?
- What are potential areas of application for the nanofiltration permeate?

References
[1] A. Maimon and A. Gross (2018). Curr. Opin. Environ. Sci. Heal., 2, 1–6
[2] L. Hernández-Leal. (2010). Ph.D. thesis, Wageningen University
[3] H. Kjerstadius et al (2015). Environ. Technol., 36, 13, 1707–1720
[4] E. Eriksson et al. (2003). Water SA, 29, no. 2, 135–146
[5] C. Kappel et al. (2014). J. Memb. Sci., 453, 359–368
[6] J. de Grooth et al (2015). J. Memb. Sci., 489, 153–159
[7] S. Ilyas et al. (2015). J. Colloid Interface Sci., 446, 365–372
[8] S. Abtahi et al. (2018). J. Memb. Sci., 548, 654-666
[9] A. Liden et al. (2016). Water Res., 105, 231-240
[10] E. te Brinke et al. (2019). Appl. Mater. Today., xxx, xxx

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