Thermally-driven Membrane Separation for Clean Water Production from Super-concentrated Wastewater

Stream

The Industrial Doctorate Centre for the Water Sector

Farhad Kamranvand[1] , Chris Davey[1] , Ewan McAdam[1]

[1] Water Science Institute, Cranfield University

Introduction

1

2.4 billion people live without access to proper sanitation (WHO, 2018)

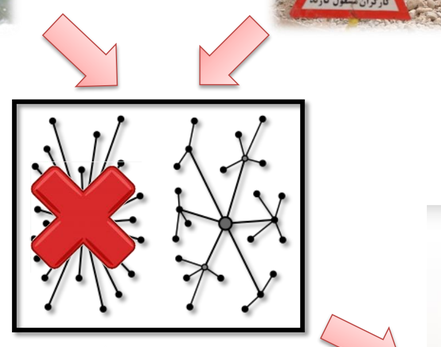
Poor sanitation results in 700,000 child death annually (WHO, 2016)

2

40% of the world population discharge their wastewater into open environment

3

Creation of large-scale piped infrastructure to provide centralised treatment in developing countries is not a sustainable solution (Hutton and Haller, 2012)



4

Decentralised wastewater treatment at a single-household scale is an attractive solution

5

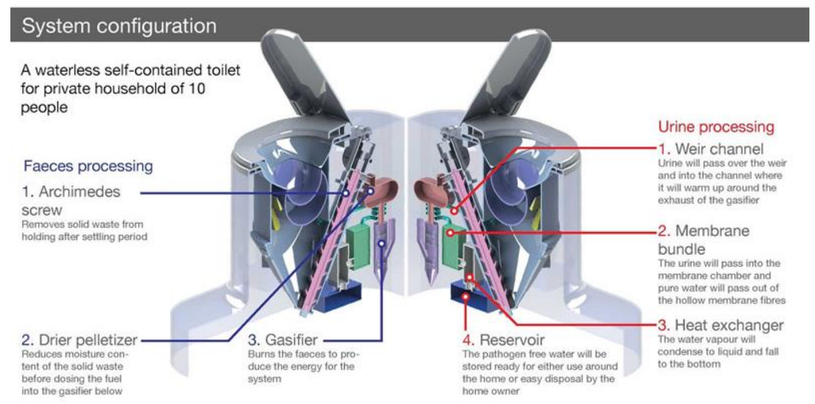
The Nanomembrane Toilet could be the solution

6

Thermal gradient can be achieved using under-development combustion technologies for faecal sludge at a single-household scale (Hanak et al., 2016)

System configuration

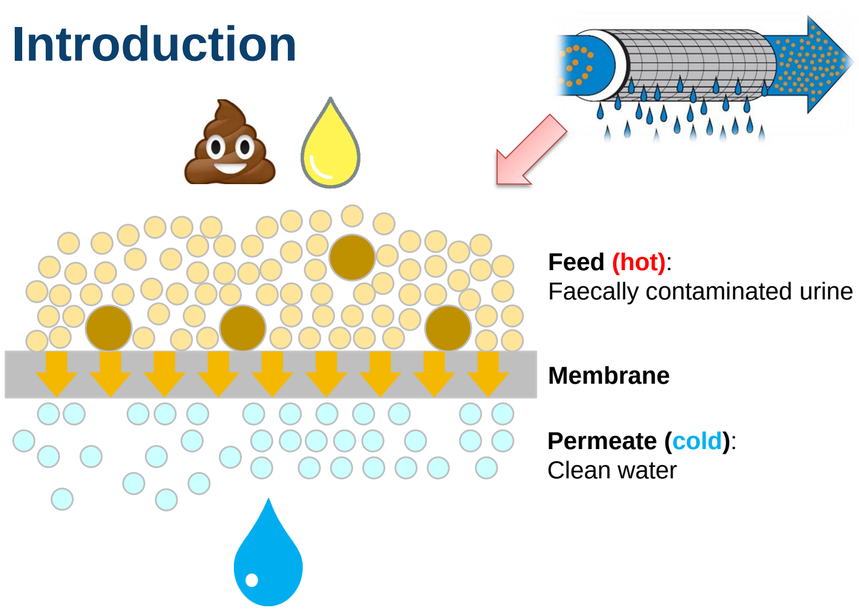
A waterless self-contained toilet for private household of 10 people

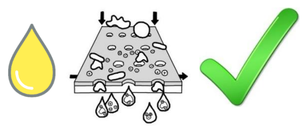


7

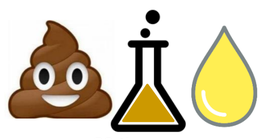
Developing thermally driven membrane process to treat urine or faecally contaminated urine

Introduction





urine treatment by various membrane processes has been investigated (Zhao et al., 2013; Künzle et al., 2015)



20 times more concentrated than conventional wastewater

Super-concentrated faecally contaminated urine (FCU) treatment is not comprehensively studied!

Pressure driven and thermally driven membrane technologies were evaluated (Mercer, 2018)

Membrane Distillation (MD) demonstrated the greatest potential for purified water production.

MD: Advantages

- Relatively lower working temperature and pressure, thus lower OPEX and less stringent mechanical properties
- Offering 100% retention for non-volatile dissolved matters theoretically

Aim & Objectives

AIM: Separation of clean water from super-concentrated wastewater in a single treatment stage.

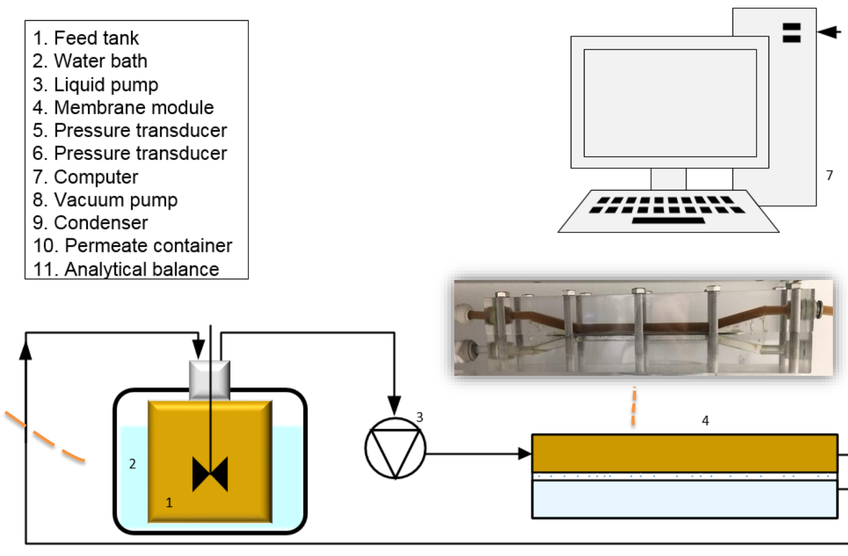
Objective: Identifying an appropriate pore size and operational temperature which can facilitate selective water separation from super-concentrated wastewater, in a single stage, sufficient to meet the proposed ISO discharge standard for small-scale decentralised wastewater treatment.

Materials & Methods

nominal pore sizes of **0.1, 0.45, 1, 3, and 5 µm**

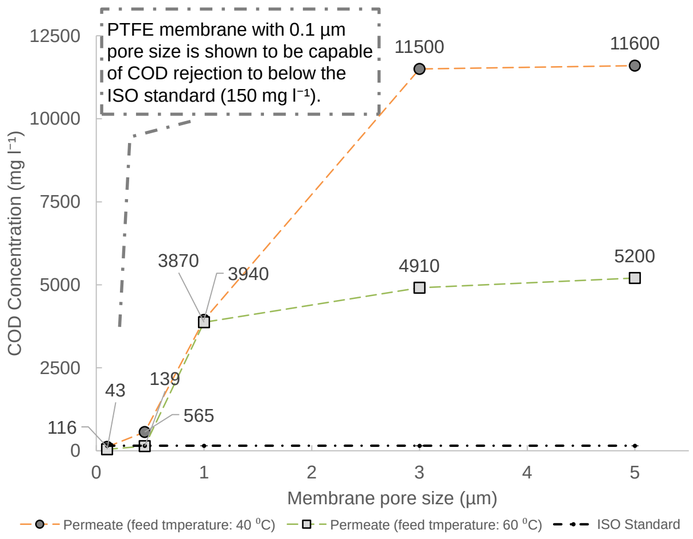
feed temperature: **40 and 60 ^{0}C**

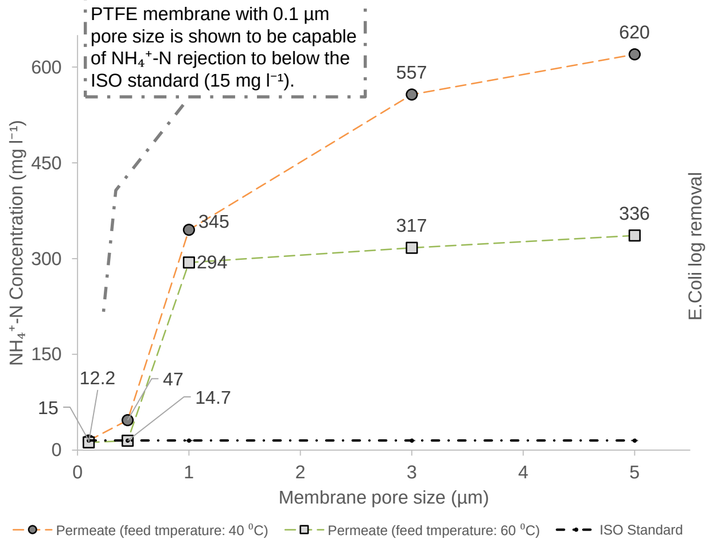
1. Feed tank
2. Water bath
3. Liquid pump
4. Membrane module
5. Pressure transducer
6. Pressure transducer
7. Computer
8. Vacuum pump
9. Condenser
10. Permeate container
11. Analytical balance

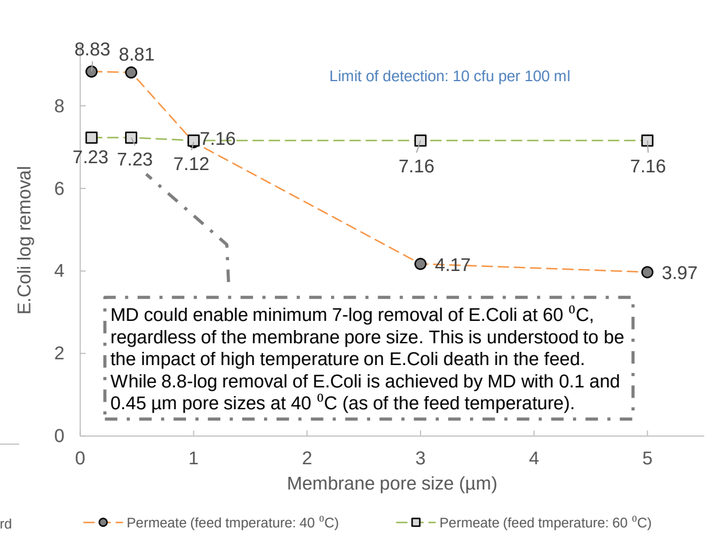


Results & Discussion

*Lines are only for guidance







Conclusions

This research has identified the optimum membrane pore size and optimum operational temperature for the membrane distillation process, which can facilitate clean water separation from super-concentrated wastewater in a single stage treatment.

Pore size: 0.1 µm
Temperature: 60 ^{0}C

www.stream-idc.net

For further information: F.Kamranvand@Cranfield.ac.uk
Postal Address: Cranfield University, Cranfield, Bedfordshire, MK43 0AL

Cranfield University
Bill & Melinda Gates foundation
EPSRC Engineering and Physical Sciences Research Council