Ceramic filter augmentation for improved reduction of viruses in drinking water

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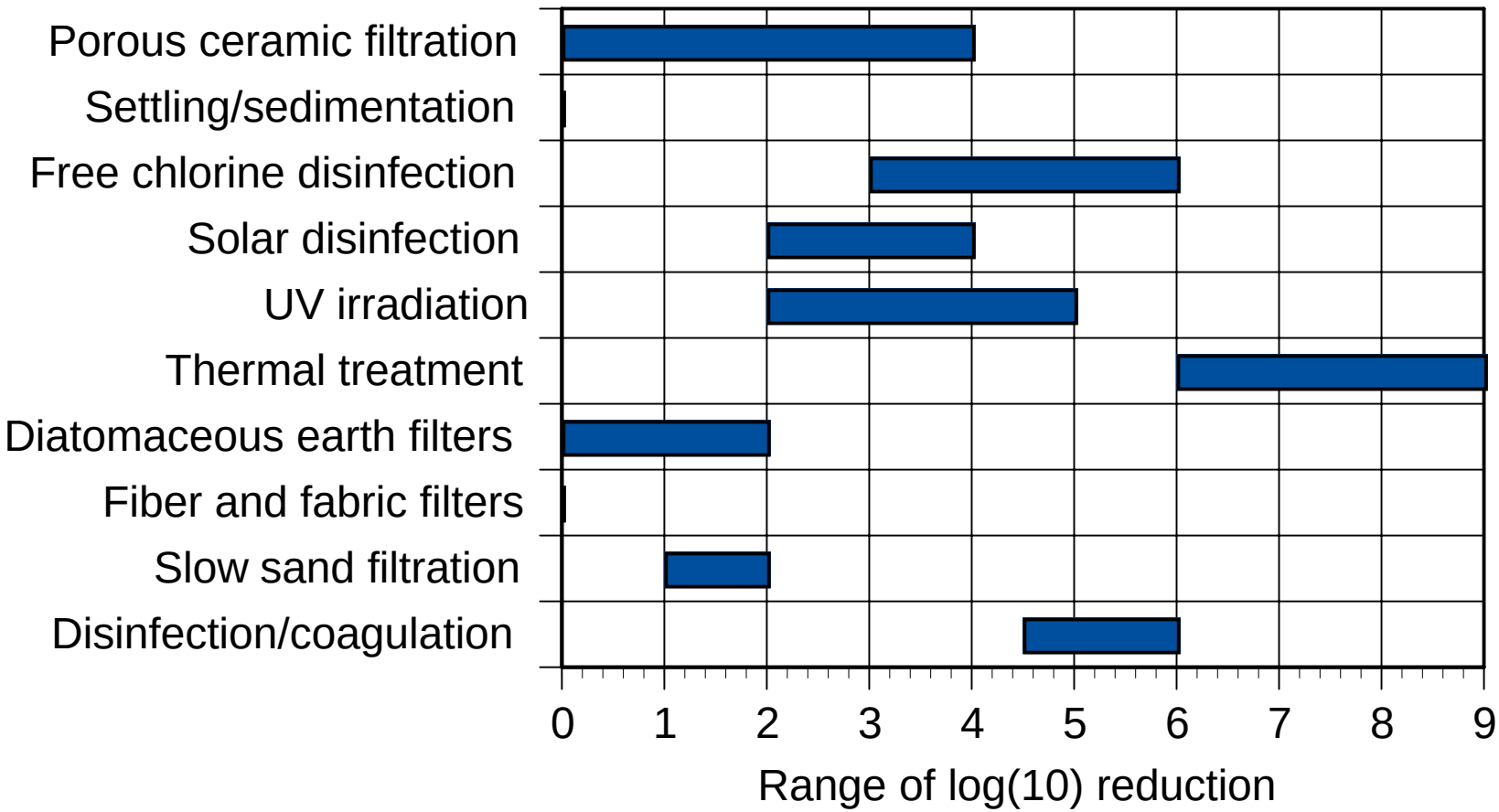
Outline

- Viruses in drinking water
- Effectiveness of HWTS against viruses
- Our work on ceramics
- Sorption and inactivation studies of modified ceramic surfaces
- Construction and initial testing of filters
- Conclusions, challenges, and future work

Viruses in drinking water

- Important class of pathogens in drinking water
- Norovirus, rotavirus, and others increasingly recognized as common etiologic agents of diarrhea worldwide
- Fecal-oral transmission
- Cannot reproduce outside host
- Much smaller in size than bacteria: too small to be removed by physical straining by ceramics
- Persistent in environment
- Less commonly measured in environmental samples, so good data are scarce

HWTS technology and viruses



Ceramic technology

- Pot, disk, or candle-shaped porous ceramic filters driven by gravity
- Pore sizes down to 0.2µm, efficiently removing bacteria and protozoa
- Virus reduction is a barrier to effectiveness and use as a health intervention

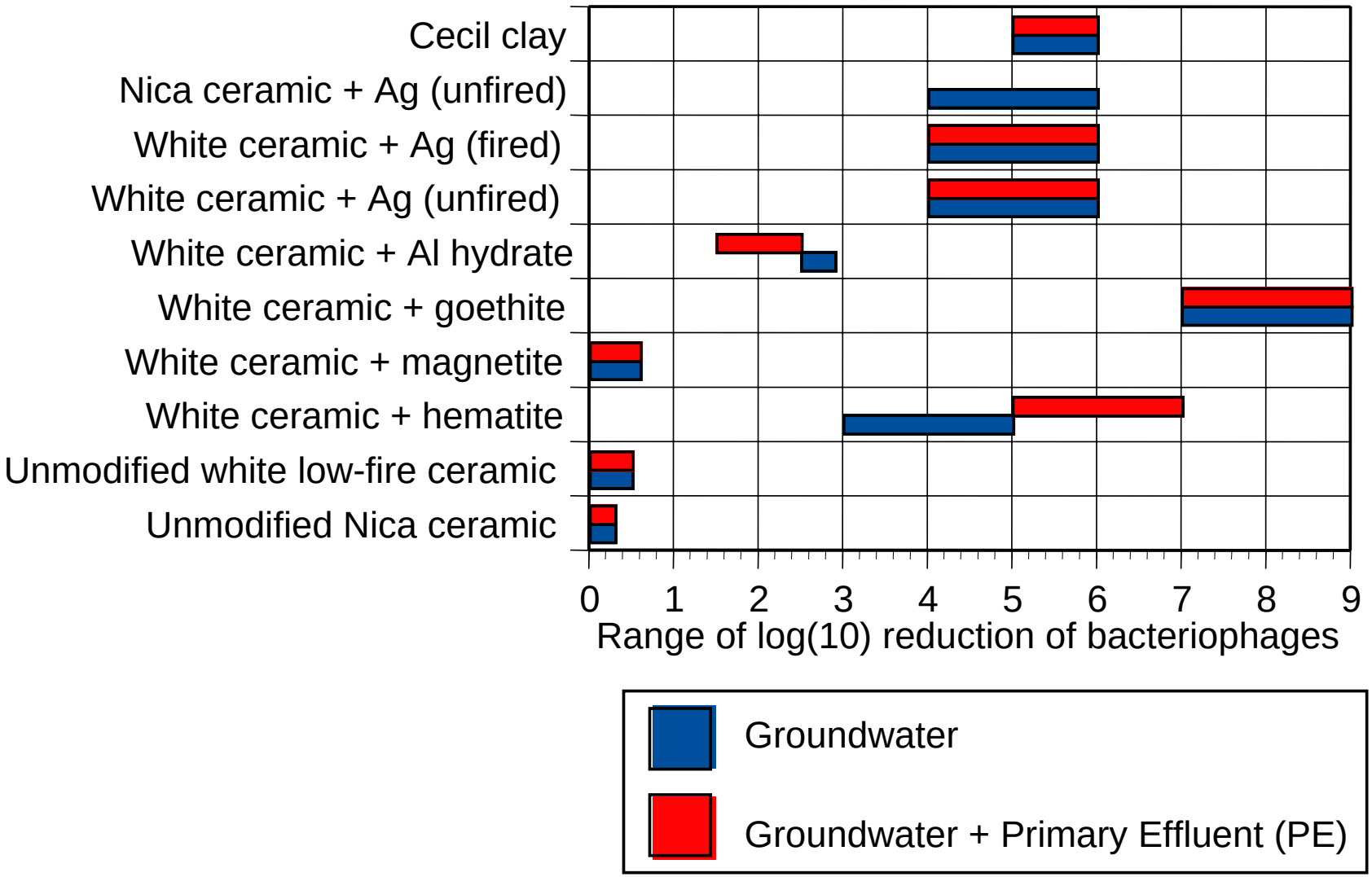
Goals of our work on ceramics

- Identify materials that can be used to capture and inactivate viruses in DW
- Incorporate these as active surfaces in porous ceramic or media filters for drinking water treatment
- Construct and test prototypes for the reduction of viruses in a range of test waters
- Identify operational parameters for filter performance optimization

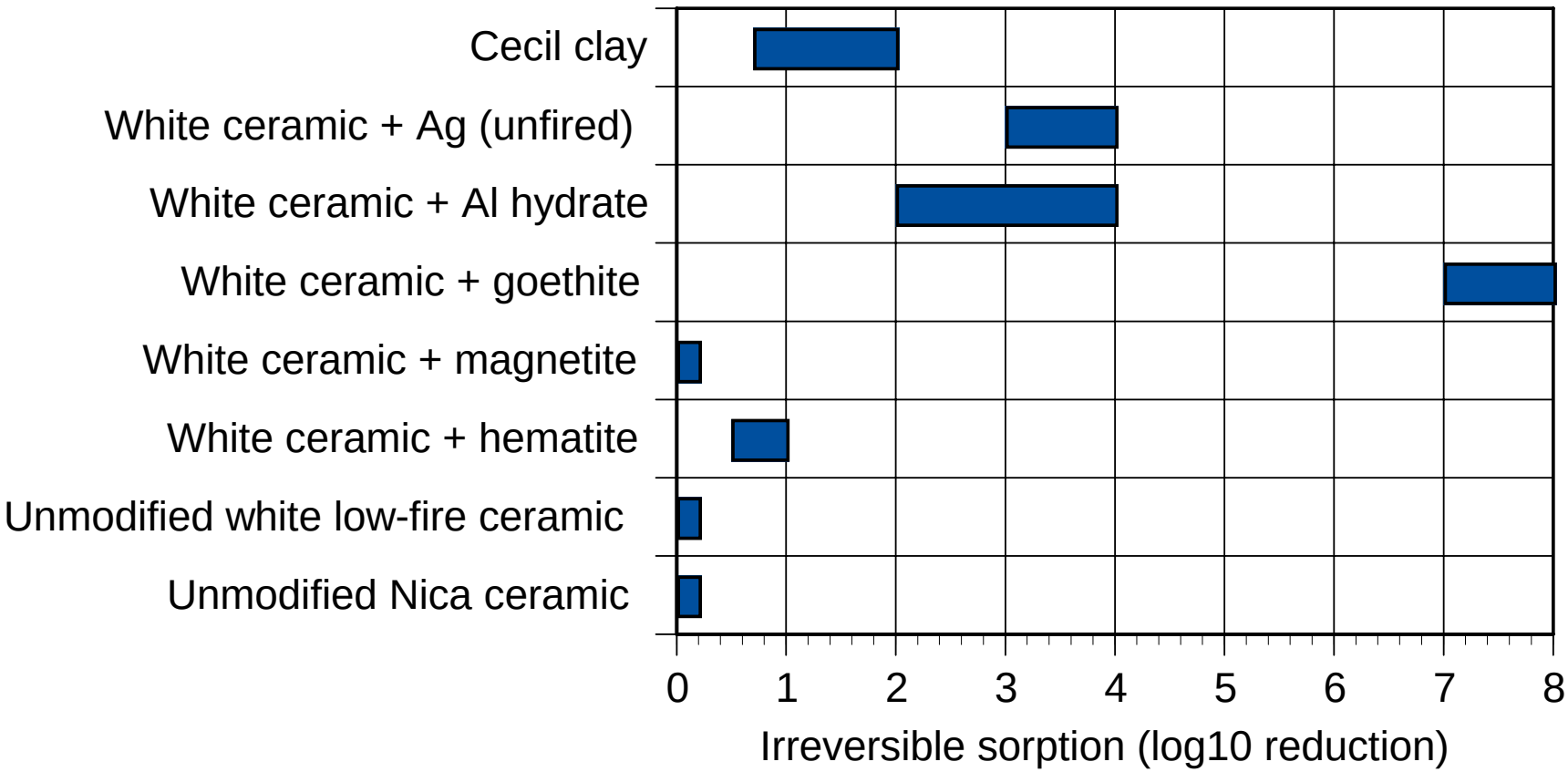
Batch equilibrium sorption tests

- Use bacteriophages (bacterial viruses) as surrogates for animal viruses
- Crushed ceramic and phage-spiked challenge water shaken until saturation as determined by kinetic testing (15 minutes)
- Assay of challenge water and supernatant for bacteriophages according to EPA standard Methods 1601/1602
- Elution of sorbed viruses and direct plating of sorbents to determine inactivation

Batch equilibrium studies: results



Virus inactivation following sorption



Virus inactivation appears to be associated with the strength of electrostatic attraction due to virus/surface charge differential, but may be due to other factors (Ryan et al. 2002, Gerba 1984, Murray & Laband 1979)

Filter modification

1. Enhanced Filtrón filter, by Potters for Peace, with yellow iron oxyhydroxides

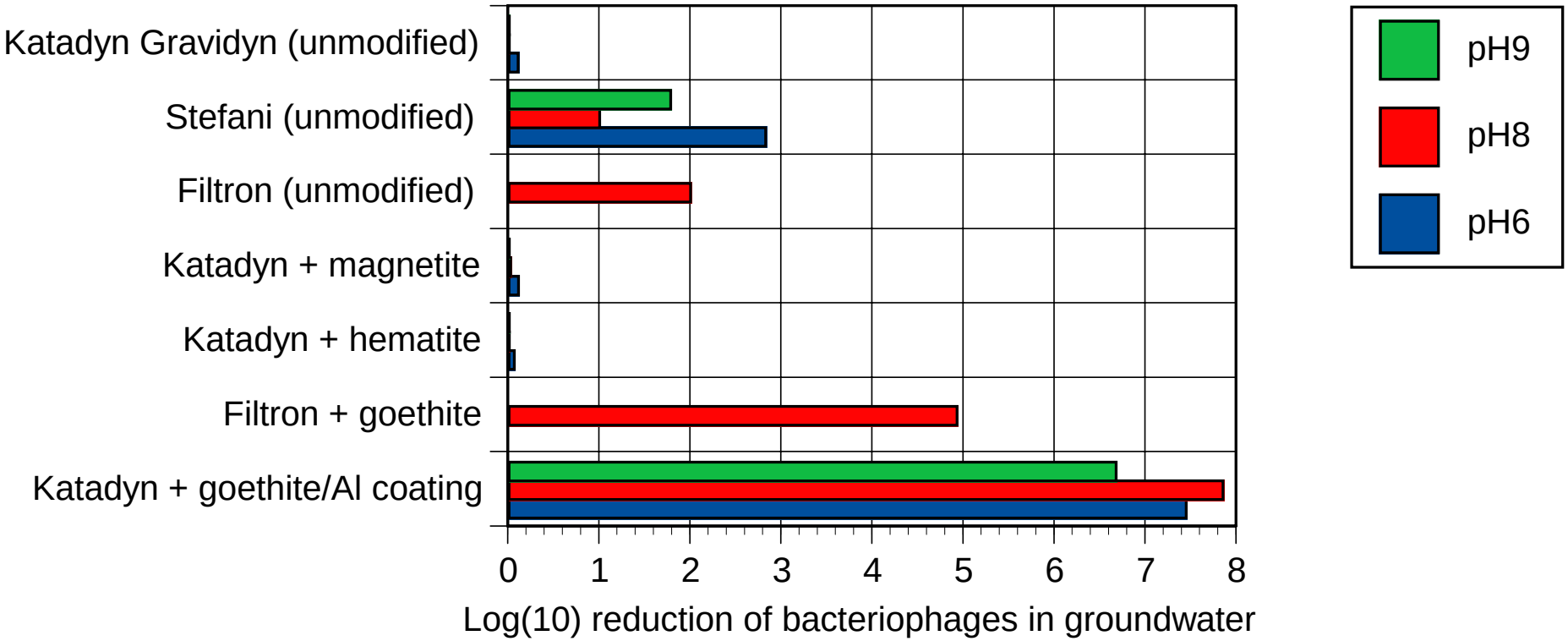
2. Katadyn filter coated by Al/Fe oxyhydroxides after method by Scott et al. 2002

3. Katadyn filter coated with magnetite, naturally occurring black iron oxide

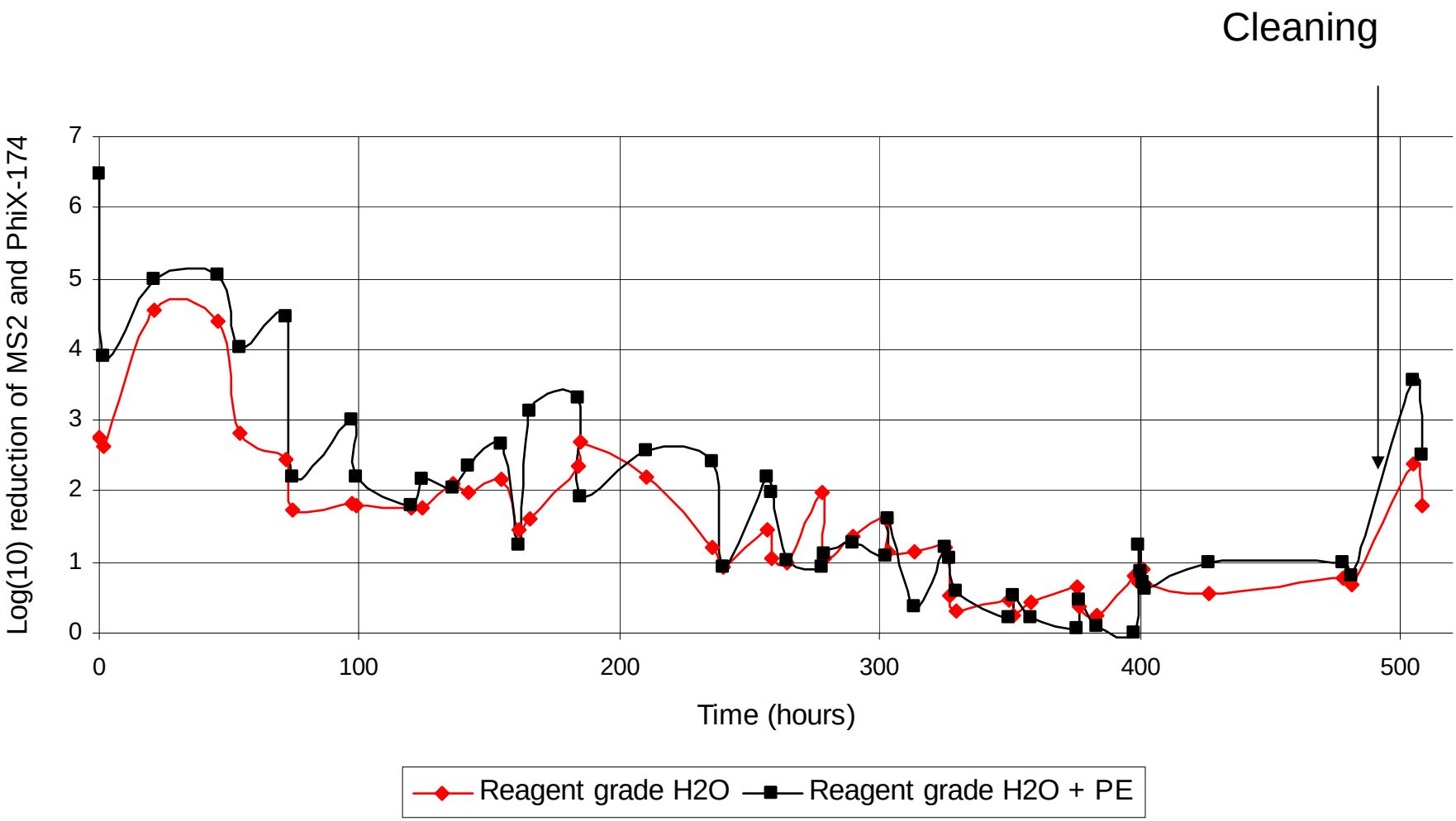
4. Katadyn filter coated with hematite, naturally occurring red iron oxide

5. Unmodified Stefani candle filter

Initial testing of modified and unmodified ceramic filters



Longitudinal challenge test of improved Filtrón filter



Conclusions

- Metal oxide-enhanced ceramic surfaces can capture and inactivate virus indicators in a wide range of waters
- The best candidate identified so far for filter enhancement is goethite
- Active sites can become clogged or blocked over time, reducing performance: regeneration is required to maintain effectiveness
- Regeneration possible through abrasive scrubbing; may affect filter life

Challenges and future work

- Performance over time in a household use setting
- Availability and cost effectiveness of additives
- Other potential additives
- Granular media filters
- More mechanistic work

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Questions?