Exploring the Differences between Continuously and Intermittently Operated Slow Sand Filters

By Candice Young-Rojanschi; Supervisor Dr. Chandra Madramootoo
Brace Centre, McGill University, Macdonald Campus, Ste. Anne de Bellevue, QC, Canada

Introduction

Intermittently operated slow sand filters, known as Biosand filters, are among the most promising of household water treatment technologies, with approximately 200 000 in use in over 70 countries as of 2009.

Most papers written about this technology describe it as a conventional slow sand filter, operated by adding water once or twice per day rather than by continuous pumping. However, until twenty years ago, studies had shown that slow sand filters could not be run intermittently. It was theorized that this was due to the development of anaerobic zones within the biologically active zone of the filter during paused periods. To solve this issue a simple change was applied to intermittent filters: a reduced standing head, which allows for oxygen diffusion to the sand surface . A diffuser plate was also added to protect the sand from scouring during dosing, which might occur with the reduced standing head. Laboratory and field trials have since shown that filters with this modification do work when operated under intermittent conditions.

However, though trials have shown Biosand filters to be successful at reducing E.coli concentrations in water, removal rates to date have tended to be lower than for conventional slow sand filtration. It is difficult to compare independent studies under different conditions, though, making it unclear whether the differences are due to intermittent operation , or another parameter, such as a deeper sand bed or the lower standing head.

This study compares intermittent versus continuous operation of sand columns under similar conditions to determine whether the performance of the slow sand columns is impacted by intermittent operation.

Methodology

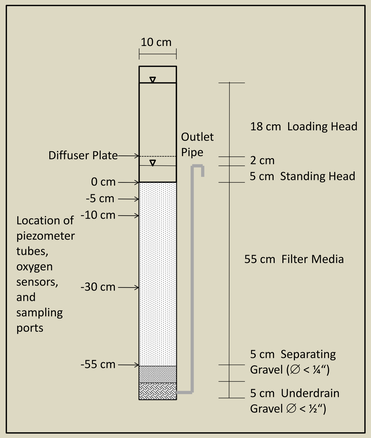
Each experimental run consisted of one column which was dosed continuously with a peristaltic pump, and one which was dosed all at once each day. Each column was dosed with the same total daily volume of influent water, equivalent to the pore volume of the sand contained in the column (1.8 L). The experiment was run three times. All samples were taken in weeks 6 to 8 of operation.

Turbidity (using a Lamotte 2020e), pH, and electroconductivity (using a YSI 556 MPS) were measured immediately after sampling. Dissolved carbon and nitrogen samples were filtered with a 45 µm membrane. Nitrite samples were processed within 48 hours. E.coli samples were processed immediately after sampling using the membrane filtration method and m-coliblue as a substrate. Dissolved oxygen was measured using a Neofox probe with Red Eye patches.

Influent water was collected daily from a nearby lake, allowed to sit for 24 hours to bring to room temperature, then dosed with an aliquot of E.coli B immediately before adding to columns.

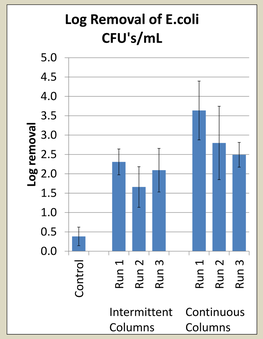
Columns were kept dark by covering with black plastic during operation. The temperature of the columns was kept at approximately 20 C for all three runs.

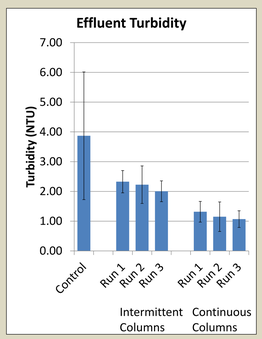
Column Design

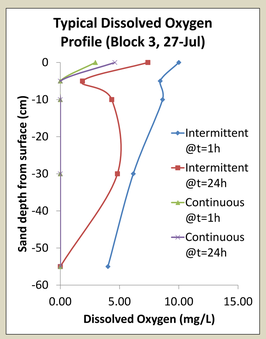


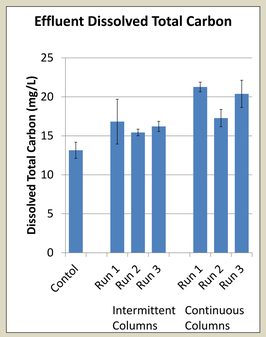
4 of the columns before uninstalling, uncovered, pumps removed

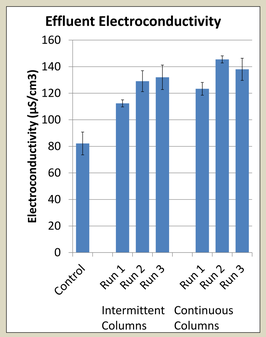
Preliminary Results

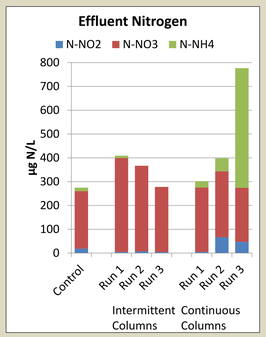


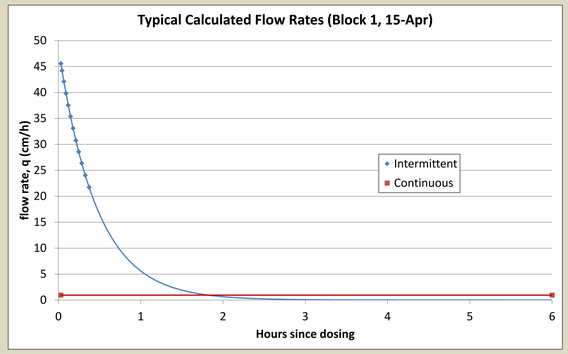












Discussion

• Differences between continuous and intermittent operation of the filters were evident. There was a trend of improved log removal of E.coli and lower turbidity in the effluent of the continuous filters.
• The maximum velocities in the intermittent filters were much higher than in the continuous filters.
• Two of the three continuous filters had negligible oxygen levels at the bottom four sensors (-5 cm, -10 cm, -30 cm, and -55 cm) during the 4 test days, indicating anaerobic conditions. The three continuous filters also had the highest levels of NH_4.
•Electroconductivity increased in the effluent from both treatments as compared to the control. Dissolved carbon was not removed by the sand columns.

Next Steps

• Statistical analysis of collected data
• Looking at impact of time between intermittent doses (i.e. multi-day pause period)

Acknowledgements

Funding for this project was provided by McGill University, and the Caribbean Water Resources Initiative.

The columns were designed and built with assistance from research associate Dr. Darwin Lyew and technician Scott Manktelow .

Summer research assistants Francis Filion, Jane Morrison, and Tyler Palov helped construct, run, and sample the columns.