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Challenges and a Pilot Study on Cyanobacteria and Small Drinking Water Systems

NCCEH Environmental Health Seminar Series

March 27, 2019

Walkerton Clean Water Centre

Walkerton Clean Water Centre

Mission:
The Centre exists for the purpose of educating and supporting our clients as they address their water system risks in order to safeguard Ontario's drinking water.

Cyanobacteria and Cyanotoxins

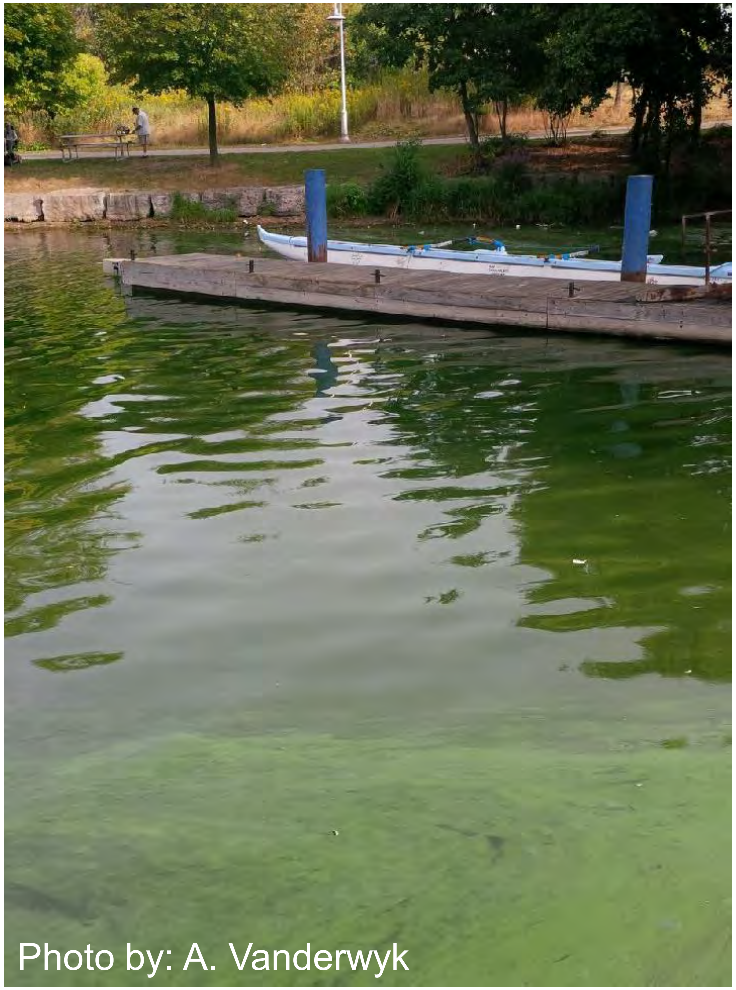

Photo by: A. Vanderwyk

Photo by: B Dallner

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Microcystis sp.

- One of the more common cyanobacteria genus found in Canada and Ontario
- Usually implicated with toxicity
- Capable of producing cyanotoxin, Microcystins

Cyanotoxins

Health Implications in Mammals:

Cyanotoxins	Health effects
Anatoxin (AnTX)	Nervous system
Saxitoxin (STX)	Nervous system
Microcystins (MC)	Liver Tumor promoting effects
Nodularins (Nod)	Liver
Cylindrospermopsin (CYN)	Liver and kidney Tumor promoting effects

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Microcystin

- Over 70 variants of Microcystins (MC)
- Microcystin-LR is the most common and toxic variant
- Guidelines for Canadian Drinking Water Quality: Cyanobacterial Toxins – Seasonal MAC 1.5 µg/L for total microcystins
- The Ontario Drinking Water Quality Standard is 1.5 µg/L MC-LR

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Cell Density and Toxin Levels

- Most often, toxin-containing blooms that are not dense will have very low levels of cyanotoxins.

…However, some cases have shown low density blooms and high levels of cyanotoxins.

Cell Density and Toxin Levels

- Cyanobacteria bloom detected.
- No toxins detected at the intake.

Photo by: Ohio Environmental Protection Agency 2011

Cell Density and Toxin Levels

- Cyanobacteria was spread out in the water column.
- A bloom is not evident from the surface.
- Microcystins > 5.0 µg/L at the intake.

Photo by: Ohio Environmental Protection Agency 2011

Challenges:

1. Aging cyanobacteria cells

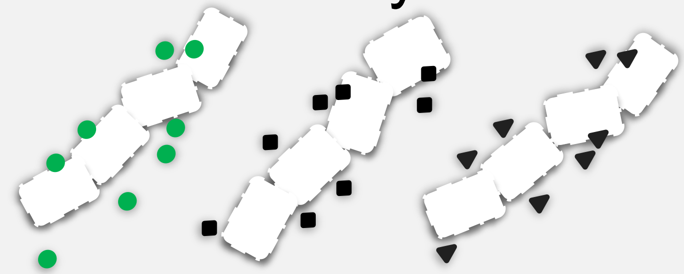
Healthy

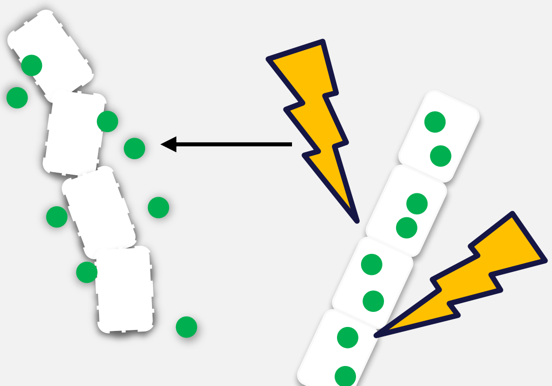
Cell-bound Toxins

Unhealthy

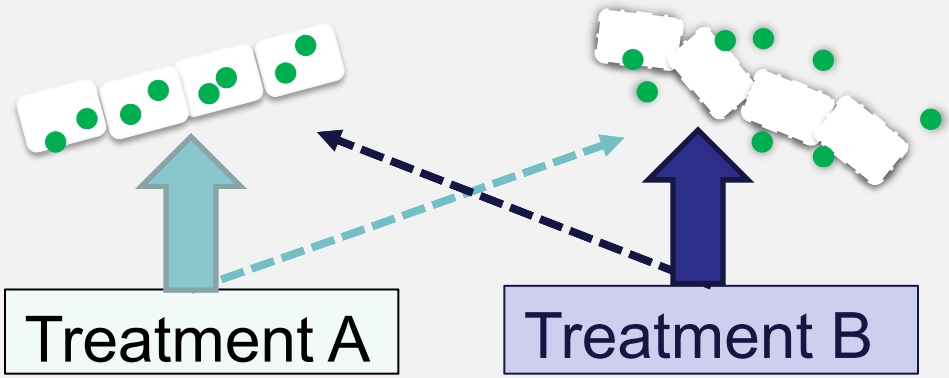
Released Toxins

4. Treatment effectiveness varies with cyanotoxins





2. Some treatment cause cell rupture



3. Treatment effectiveness varies with cell-bound and released cyanotoxins

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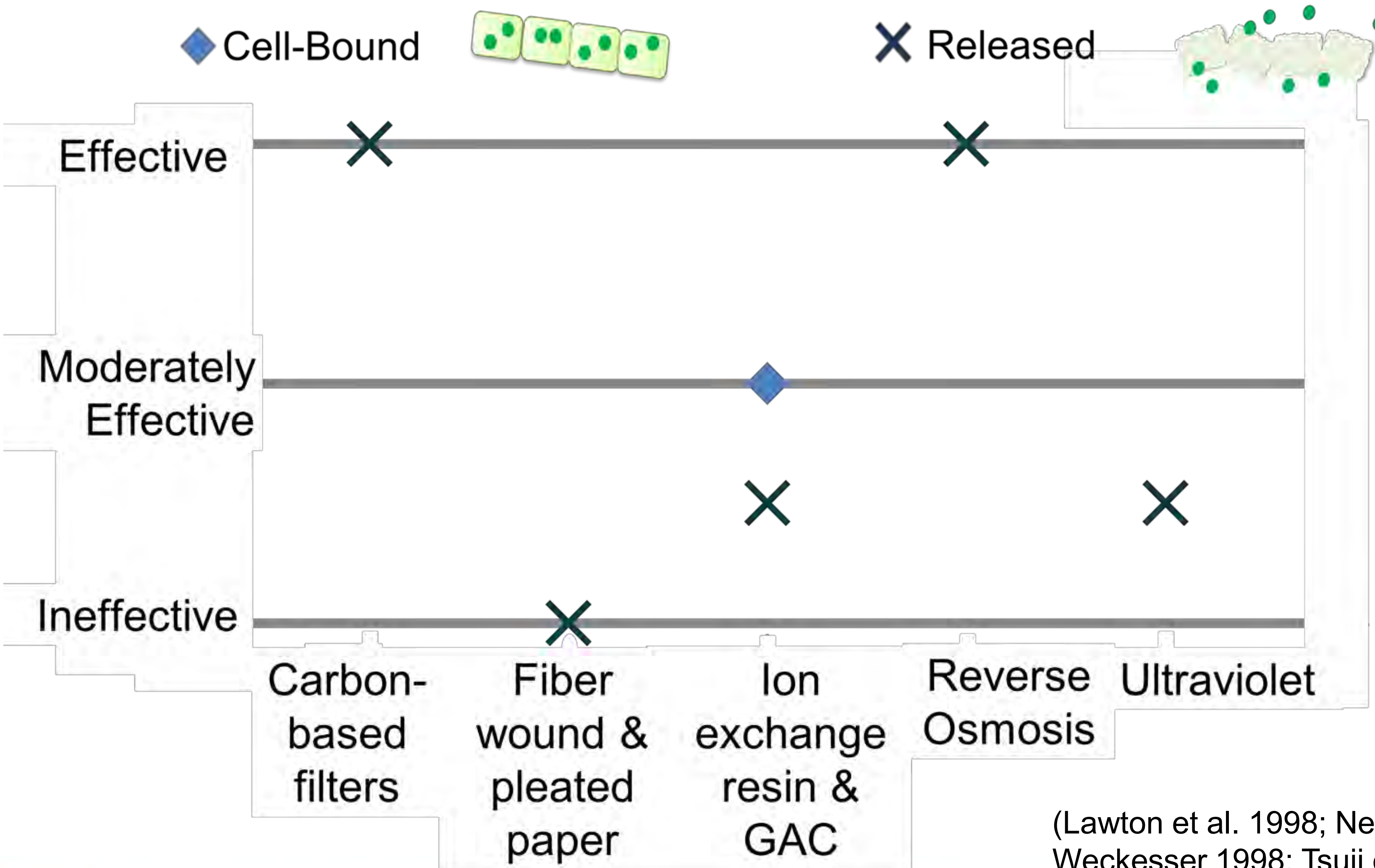
Small Drinking Water Systems

- Approximately 18,000 small drinking water systems are governed by the Ministry of Health and Long-Term Care in Ontario (MOHLTC 2009).
- Very few studies have investigated the effect of small drinking water system technologies on the removal of cyanobacteria or cyanotoxins.

Literature Review



(Lawton et al. 1998; Neumann and Weckesser 1998; Tsuji et al. 1997)

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Objective

To investigate the effectiveness of typical small drinking water filtration systems on cyanobacteria cell and microcystin removal.

- Reverse Osmosis
- Nanofiltration
- Ultrafiltration
- Ceramic Microfiltration
- Carbon Block Filtration
- Ion Exchange
- Slow Sand Filtration

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Raw Water Collection

Photo by: A. Vanderwyk

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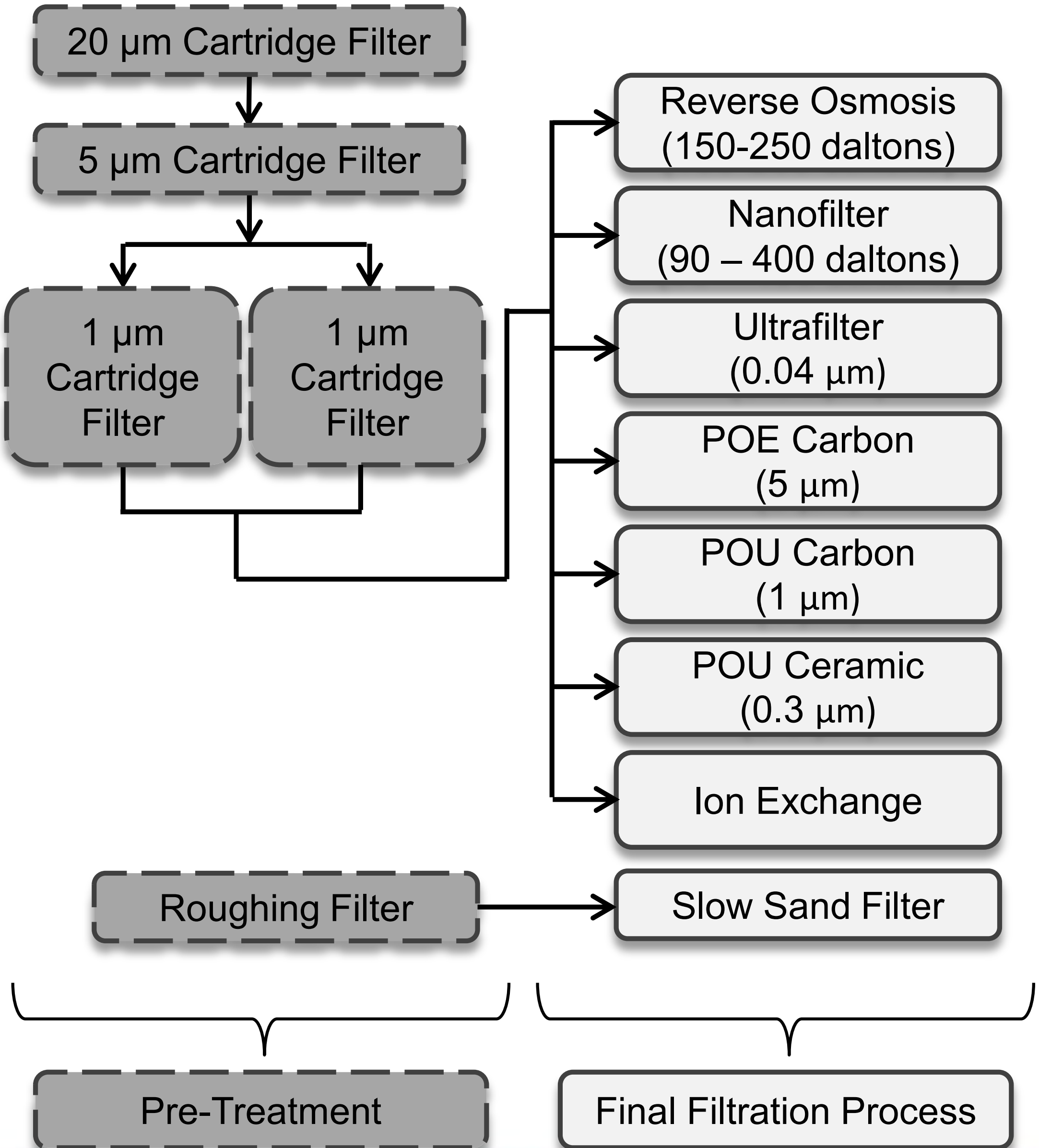
DANGER



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Sample Collection

- Repeated experiments three times
- Collected water samples at:
  - Time 0 Hr – All Systems
  - Time 4.5 Hr – Ultrafiltration
  - Time 6 Hr – Reverse Osmosis
    - Nanofiltration
    - Ceramic Microfilter
    - Carbon Block Filter
    - Ion Exchange

Sample Analysis

- Cyanobacteria and Cyanotoxin
  - Cyanobacteria cell counts
  - Microcystin-LR equivalence: ELISA kit
  - Microcystin variants: LC-MS/MS
- Other water quality parameters
  - Temperature, turbidity, pH, DOC, UV absorbance, conductivity and TDS

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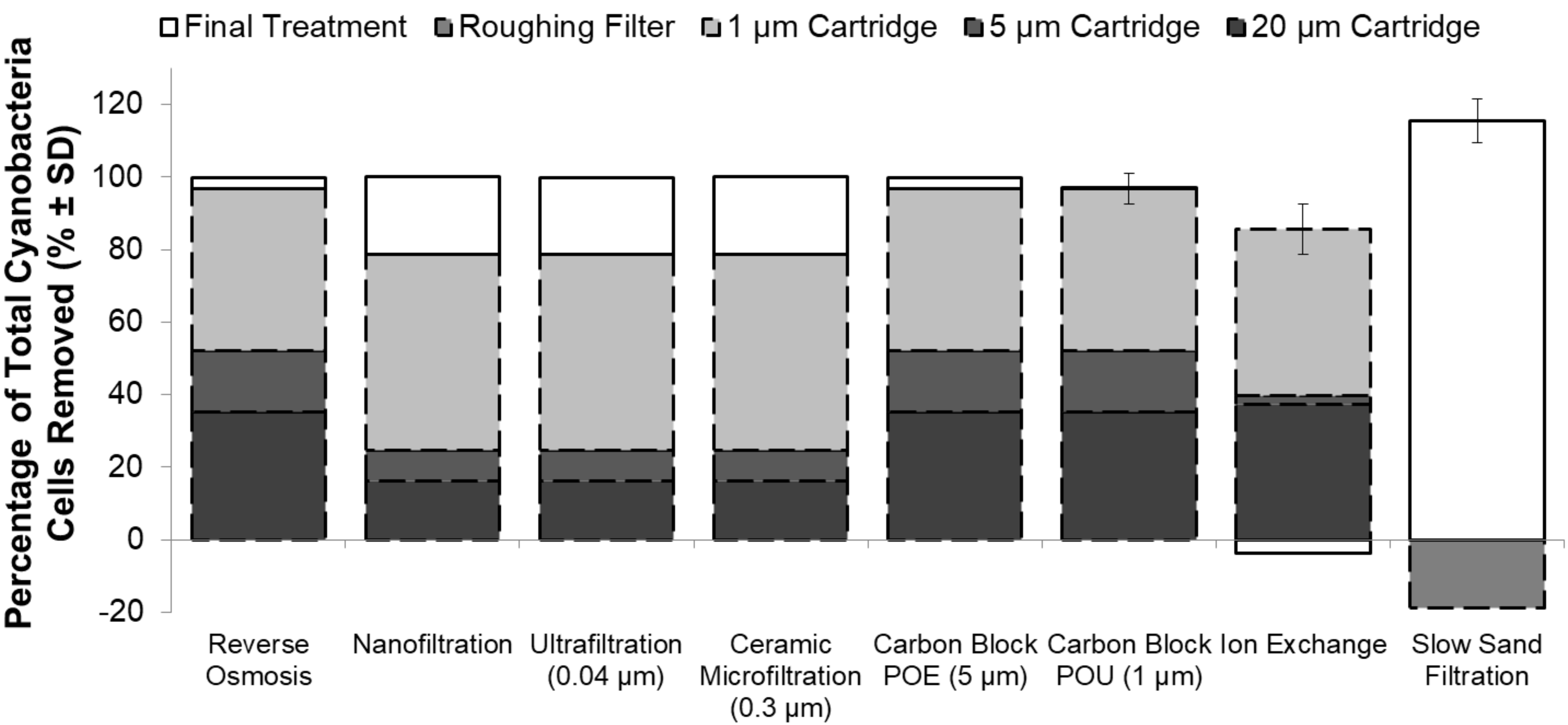
% Removal of Cyanobacteria Cells



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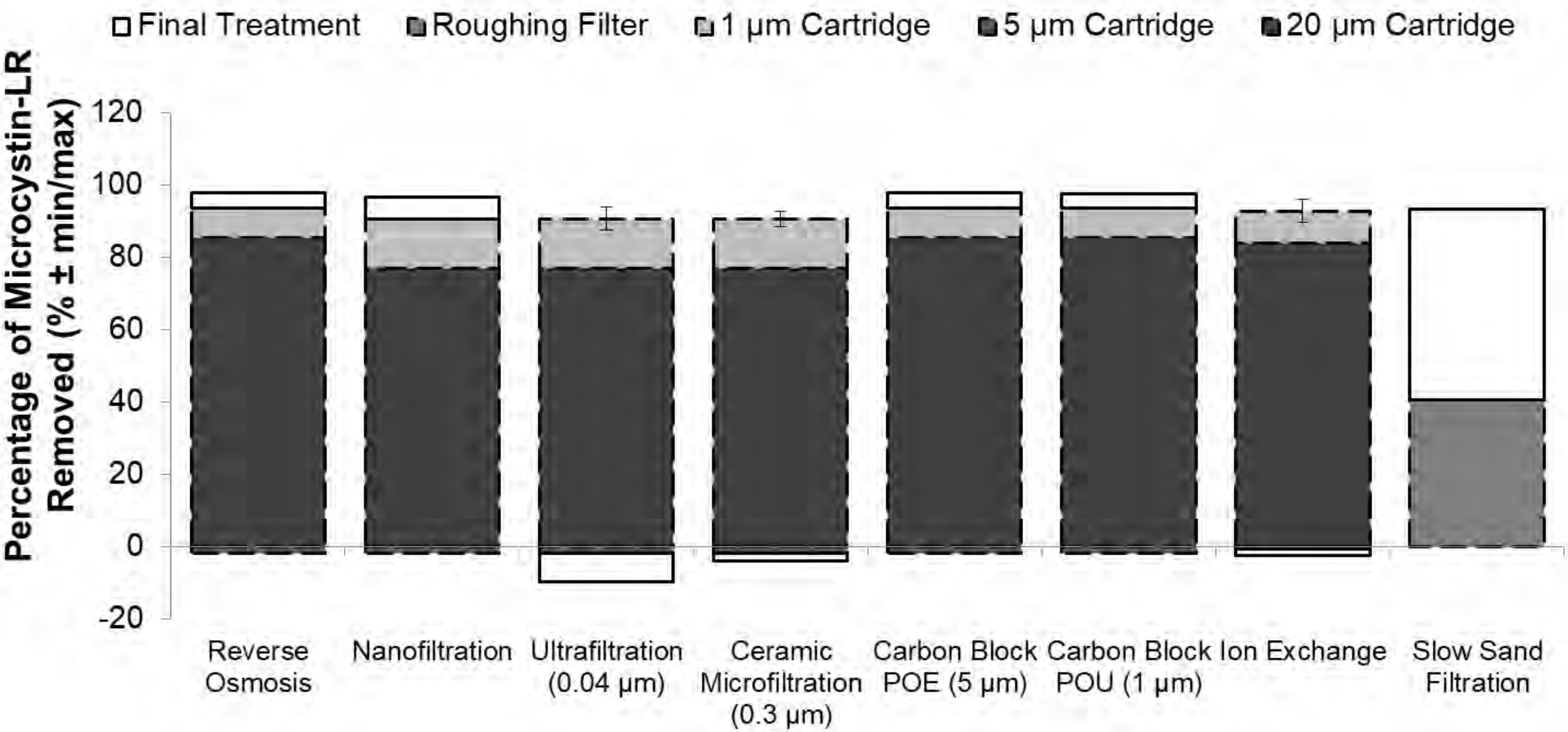
% Removal of MC-LR



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Conclusions

- Cartridge filters were effective barriers for pre-treatment after 6 hours of operations under these experimental conditions.
- Additional stress may be added to pre-treatment systems if higher toxin or cell count levels.
- With effective pre-treatment, all treatment processes were effective at removing MC-LR and total cyanobacteria cells.

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Conclusions

Treatment	100% Cyanobacteria Cells Removed	≥ 95% MC-LR Removed
Reverse Osmosis	✓	✓
Nanofiltration	✓	✓
Carbon Block (POE)		✓
Carbon Block (POU)		✓
Ion Exchange		
Ultrafiltration	✓	
Ceramic Microfiltration	✓	
Slow Sand Filtration		✓

Note. This table is a summary of results from the specific experimental conditions.

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Acknowledgements

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Thank you!

WCWC is committed to supporting the owners, operators and operating authorities of Ontario's drinking water systems

- Hands-on training
- Public & on-site courses
- Helpline
- Pilot testing
- Drinking Water Resource Library

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