Comparison of filtration methods for concentrating pathogens in recreational waters

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Introduction

Information is needed on the types of pathogens present in recreational waters, their relations to fecal indicator bacteria concentrations, and environmental variables that could be used to predict pathogen occurrence. Because viral, bacterial, and protozoan pathogens are typically found in low concentrations in environmental waters, it would be efficient and cost-effective to simultaneously concentrate all classes of pathogens from large sample volumes using a common filtration method.

This study was done to compare recoveries of pathogens in water matrices using different filtration methods and begin to identify the presence of viral and protozoan pathogens in recreational waters.

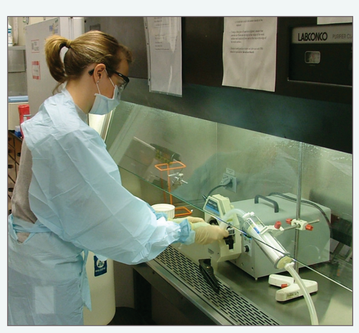
Methods

Microorganisms

10-L of dechlorinated tap water was seeded with nine microorganisms.

- *Enterococcus faecalis (E. faecalis)*
- *Escherichia coli (E. coli)*
- MS2 bacteriophage
- Adenovirus, enterovirus, and norovirus
- Avian influenza virus
- *Cryptosporidium parvum*
- *Giardia lamblia*

Filtration methods



Envirocheck HV filtration

- **Virus adsorption-elution (VIRADEL) filter methods**
  - Glass-wool fiber filter (USDA/USGS Laboratory, Marshfield, Wis.)
  - Virosorb 1MDS filter (Cuno Inc., Meriden, Conn.)
  - NanoCeram© filter (Argonide, Inc., Sanford, Fl)
- **Ultrafiltration (UF) methods, REXEED-25S** (Asahi Kasei Kuraray Medical Co., Ltd., Japan)
  - Portable UF sampler (U.S. EPA, National Homeland Security Research Center)
  - Dead-end hollow-fiber UF (Centers for Disease Control and Prevention)
- **Centrifugal force centrifugation (CFC) with ViroCap© capsule filters (Scientific Methods, Granger, In)**
- **Protozoan concentration methods**
  - Envirochek™ HV filter (Pall Corp., Post Washington, NY)

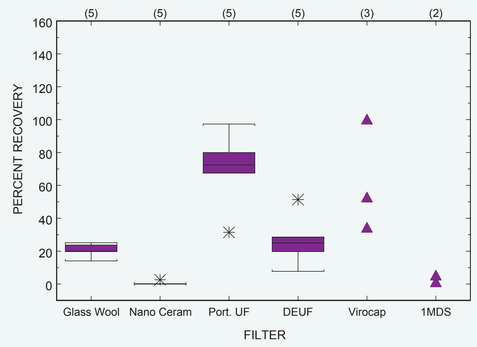
Portable ultrafiltration (above) and glass-wool filtration (above left) at Point Beach State Park, Manitowoc Co., Wis.

For seeding experiments, 10-L aliquots of tap or lake water were seeded with nine target organisms. For comparisons of recoveries of naturally occurring microorganisms, 10 to 200 L of lake water was filtered on site.

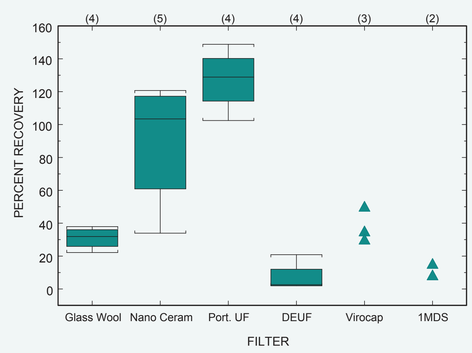
Results – Tap water

Median recoveries by filter method for *E. coli* ranged from 0.05 to 1.4%, for *E. faecalis* from 0.09 to 72%, and for MS2 from 2.6 to 129%.

***E. faecalis* recovery in tap water**

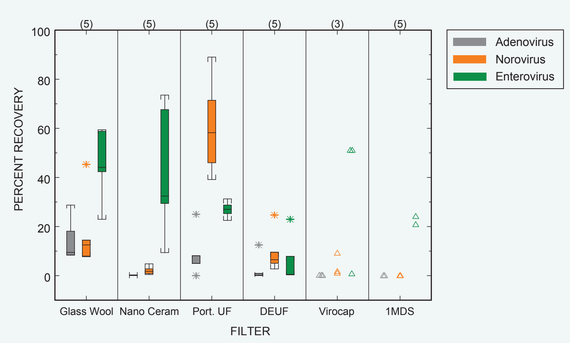


MS2 recovery in tap water

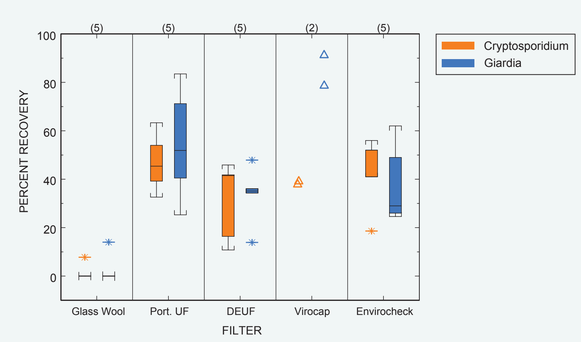


A wide range of median recoveries was also found for enteric viruses, ranging from 0.09 to 58%. Median recoveries of avian influenza virus ranged from 0.02% (NanoCeram©) to 5.9% (Portable UF). Median protozoan recoveries ranged from 0 to 85%.

Enteric virus recovery in tap water



Protozoa recovery in tap water



Results – Lake water

Lake water samples in Ohio and Wisconsin were filtered by use of the glass-wool filter and portable UF. Recoveries of naturally occurring *E. coli*, enterococci, and F-specific coliphage were greater for the portable UF than for the glass-wool filter. Wide ranges of recoveries were found, influenced by water turbidity, volume of water sampled, presence of algae, and whether or not a prefilter or end connector was used. Protozoan samples from Edgewater and Villa Angela were not readable because of excessive algae. Low concentrations of *Cryptosporidium* were found in samples from Point Beach and YMCA (0.06 oocysts/L); *Giardia* was not found in any samples. Virus results are pending.

Recoveries of naturally occuring indicators in lake water

Site	Volume filtered (L)	Other info and limtations	Date	Turbidity (NTRU)	Recoveries of indicators: *E. coli* (%)	Recoveries of indicators: Entero-cocci (%)	Recoveries of indicators: F-spec coli-phage (%)
Glass-wool filtration (with 150 µm prefilter)							
Crystal Beach, Buckeye Lake, Ohio	10	Lab filtration	7/29	21	1.0	3.6	
Edgewater, Cleveland, Ohio	150		8/10	6	7.4	0.8	
Villa Angela, Cleveland, Ohio	150		8/10	3	6.7	1.9	
Hika Park 1, Cleveland, Wis.	22.4	High algae, tubing clogged, acidic conditions	9/6	281	0.4	0.8	
Red Arrow, Manitowoc, Wis.	14.4	High algae, tubing clogged	9/6	101	0.3	4.1	
Hika Park 2, Cleveland, Wis.	149	High algae, used end connector to filter algae, possible acidic conditions	9/7	224	0.04	0.09	
Point Beach, Manitowoc Co., Wis.	200	Used end connector	9/8	20	2.3	0.3	0
Neshotah, Two Rivers, Wis	226		9/9	13	4.7	2.4	0
YMCA, Manitowoc, Wis.	207		9/9	8	4.0	4.6	0.7
Portable ultrafiltration							
Crystal Beach, Buckeye Lake, Ohio	10	Lab filtration	7/27	22	80.0	82.8	
Edgewater, Cleveland, Ohio	150	Prefilter used	8/10	6	43.5	11.3	
Villa Angela, Cleveland, Ohio	150	Prefilter used	8/10	3	159	238	
Hika Park 1, Cleveland, Wis.	16.8	High algae, tubing clogged, used prefilter	9/6	281	23.3	33.3	
Red Arrow, Manitowoc, Wis.	28.9	High algae, tubing clogged, no prefilter	9/6	101	4.5	10.4	
Hika Park 2, Cleveland, Wis.	41	High algae, used end connector and prefilter	9/7	224	35.6	38.1	
Point Beach, Manitowoc Co., Wis.	103	Used end connector, no prefilter	9/8	20	68.8	12.7	13.0
Neshotah, Two Rivers, Wis	200		9/9	13	129	81.5	14.0
YMCA, Manitowoc, Wis.	200		9/9	8	88.9	59.1	33.3

Glass wool filtration in the field

Portable ultrafiltration in the field

End connector

Prefilter

Conclusions

- In tap water, the highest median recoveries for adenovirus and enterovirus were found using the glass-wool filter; the highest for norovirus was found using the portable UF.
- In tap water, the highest median recoveries for *Cryptospoiridium* were found using the Envirocheck HV, followed by the portable and dead-end UF; the highest for *Giardia* was found using the Virocap.
- Recoveries by use of UF in lake-water samples were considerably higher for naturally occurring *E. coli* (4.5 to 159%) than for seeded laboratory strains (<0.007 to 7.5%).
- Preliminary results indicate that the portable UF may be most promising in recovering different classes of microorganisms from tap and lake water.

Acknowledgements

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