National Collaborating Centre for Environmental Health

Centre de collaboration nationale en santé environnementale

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evidence review

When can Point-of-Use Water Filters be used for Removal of Protozoa?

Introduction

While boiling water is an effective way to kill most microbial pathogens, research performed in the United Kingdom has shown that people do not necessarily comply with boil water advisories[1,2]. Similarly, in Walkerton, Ontario in 2000, only 44% of respondents reported that they were aware of the order to boil water when it was first issued on the local radio at the start of the outbreak[3] and in Gideon, Michigan in 1993, 31% of persons investigated had consumed city tap water during the salmonellosis outbreak after the issuance of a boil water advisory.

Since research has proved that the heterotrophic bacterial regrowth occurring in point-of-use (POU) filters does not represent a health threat and may actually suppress the growth of pathogenic bacteria[4,5], POU filter systems have become the focus of increasing attention. This document examines how POU water filters can be used as an alternative water treatment to boiling water for *Cryptosporidium* oocyst and *Giardia* cyst removal during turbidity events, providing adequate disinfection is in place.

This document does not directly address the consideration around microbial disinfection.

A POU device is applied only to selected faucets in the house for the purpose of reducing contaminants in the water at each faucet[6]. Similar devices are also marketed as personal portable POU filters. The majority of water filters available in Canada are broken into three types: particle, ion-exchange resin, or activated carbon[7]. Figure 1 shows the common sink locations for POU filter systems at the household level.

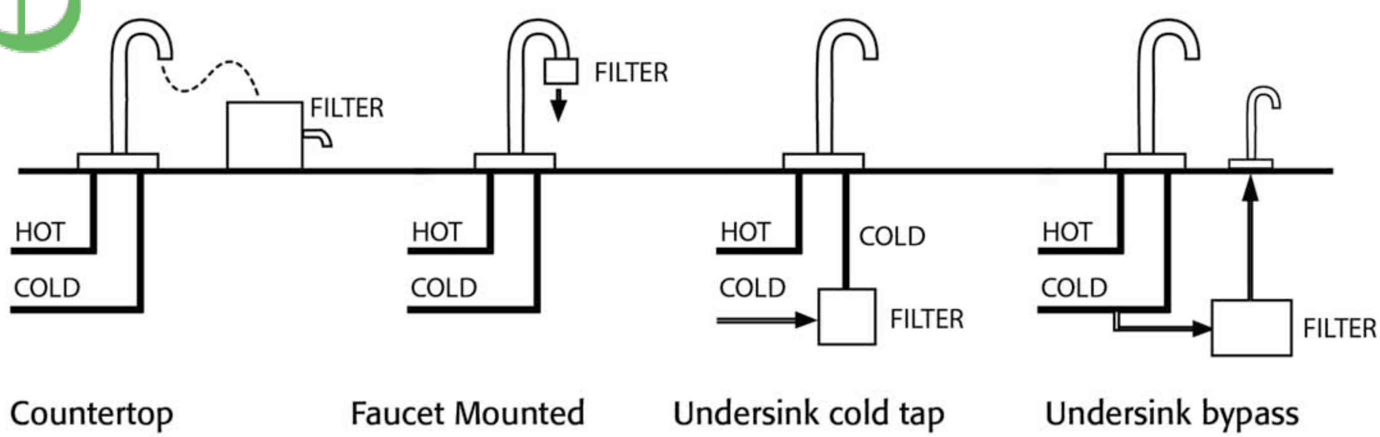

Figure 1. Common point-of-use water filter configurations[8] (Note: the dotted line indicates water to filter.)

Turbidity relates to the amount of light scattered by suspended particles in water, and the most common measure of turbidity is the nephelometric turbidity unit (NTU)[9]. Particles may inhibit or reduce the chemical disinfection of water[10,11], enhance the regrowth of pathogens in drinking water[10], or be associated with the presence of pathogens[12-15] including *Cryptosporidium* oocysts. Manufacturers have the option of certifying their products according to the criteria set by the National Sanitation Foundation/ American National Standards Institute (NSF/ANSI) under standards NSF/ANSI 53 and/or NSF/ANSI 42[16,17]. Specifically, the standard for removal of protozoa such as *Cryptosporidium* oocysts and *Giardia* cysts requires a minimum 3 $\log_{10}$ or 99.9% reduction in oocysts or cysts[18]. Products claiming to remove turbidity must be able to reduce turbidity from 11 NTUs to less than 0.5 NTUs[19]. A list of certified devices for cyst and turbidity removal is available on the NSF website[20].

Summary of evidence

Existing evidence on the applicability of POU devices at reducing turbidity is sparse. More attention has been given to specific organism removal or the regrowth of heterotrophic bacterial in POU system filters. The efficacy of different POU water filters for reducing turbidity and *Cryptosporidium* oocysts is summarized in Table 1.

Relevance to practice

- Activated carbon filters are effective at reducing turbidity (>95% reduction) [21,22] for particle size >1 µm[18].
- Turbidity removal improves as residue material builds up on the surface of filters[23], therefore increases in turbidity will improve filtration efficiency until the filter is blocked and no water can go through.
- A minimum of 3 $\log_{10}$ *Cryptosporidium* oocyst reduction is achieved with activated carbon filters (including 0.1-0.2 µm pre-filter/filter)[14,24], ceramic filters (0.2 µm)[24], and silver-coated filters[24].
- Under outbreak conditions such as the 1993 Milwaukee outbreak, submicron POU water filters are likely more effective at reducing the risk of waterborne cryptosporidiosis than filters with >1 µm pore size[25].
- If concentrations of oocysts or turbidity levels exceed NSF standards[15,19], then the effectiveness of water filters may be limited. Although fluctuation of microorganisms in water is often not known, achieving a 3 $\log_{10}$ reduction of cysts or oocysts through filtration may provide more health protection than relying on compliance with boil water advisories. In addition, some products have been demonstrated to be effective above the NSF requirements of a 3 $\log_{10}$ reduction for cysts/ oocysts removal and turbidity reduction of 11 NTU (Table 1).

Conclusion

Boil water advisories have been issued during turbidity events, and boiling water will ensure microbial safety if performed properly. However, the real world effectiveness of boil water advisories has not been well established. The time, effort, and energy costs associated with boiling water may work to compromise its effectiveness as a protective measure in community settings. Water filters are easier to use and as long as adequate disinfection is maintained, use of filters is a potentially effective means of reducing turbidity and providing protection against cysts. If adequate disinfection is in place and the manufacturer's instructions are followed, NSF approved filters will achieve at least a 3 $\log_{10}$ reduction in cysts. These filters are required to meet NSF/ANSI 42 Class I standards and NSF/ANSI 53 standard[17] for cyst reduction.

Table 1. Efficacy of different point-of-use (POU) water filters for removal of turbidity and/or *Cryptosporidium* oocysts

POU FILTER DEVICE	CHALLENGE TEST	REMOVAL EFFICIENCY	DESCRIPTION
GAC[a] with 1 µm pre-filter	1-60 µm volcanic ash at 13.2 mg/L (2.1 Tu[b])	• 98-100%	Laboratory study[21]
Faucet-mounted point-of-use filter: **a.** 1 µm activated carbon filter cartridge (with 5 µm pre-filter) **b.** 3 µm cotton filter cartridges (with 10 µm pre-filter) **c.** 5 µm polypropylene filter bag and cartridges (with 25 µm pre-filter)	Turbidity (mean 2.0 NTU[c])	• Poor turbidity reduction, 30-50% for most new filters • Turbidity removal improved as residue material built up on the surface of the filter	Laboratory study[23] • No units were consistently successful in lowering turbidity to <1.0 NTU[c] • Poor turbidity reduction thought to be due to the small size of particles present in the source water (<1 µm)
Personal portable point-of-use filters: **a.** Activated carbon (0.2 µm) **b.** Ceramic particle filter (0.2 µm) **c.** Matrix filters (0.4 µm)	Turbidity (10.4-52.3 NTU[c])	• Portable systems removed a minimum 95% of turbidity	Laboratory study[22] • Particle size not specified
Faucet-mounted point-of-use filter: GAC (with 0.1 µm pre-filter)	*Cryptosporidium* oocysts (3x10^7 oocysts/1050 mL)	• Minimum 3 $\log_{10}$ reduction (oocysts not detected in the water purifiers from all cartridges)	Laboratory study[14] • Cartridges tested at 25%, 50%, and 75% flow down using Arizona-dust
Portable water treatment systems: **a.** Ceramic particle filter (0.2 µm) **b.** Activated carbon (0.2 µm pre-filter) **c.** Silver-coated filter **d.** Reverse osmosis	Simultaneous removal capacity of the filter for *Cryptosporidium* oocysts (theoretical counts of 1.4x10^5 oocysts/L), bacteria, viral markers, and mycrocystins	• No detectable oocysts in filtered water (<5.1 $\log_{10}$ reduction)	Laboratory study[24]
Various point-of-use treatment devices tested (filters, including activated carbon filters or reverse osmosis)	Effectiveness of POU device at preventing *Cryptosporidium* illnesses in an outbreak situation (1993 Milwaukee *Cryptosporidium* outbreak)	• Only 20% (21 of the participants) of households using <1 µm pore size filter reported having diarrhea, compared to 43% (105 participants) of households utilizing POU filters >1 µm pore size ($p=0.001$)	Post hoc observational study[25] • POU devices with a filter pore diameter >1 µm significantly associated with the occurrence of diarrhea among participants ($p<0.05$) • Data indicated that use of submicron POU water filters may reduce risk of waterborne cryptosporidiosis

[a] granulated activated carbon filter; [b] turbidity unit; [c] nephelometric turbidity units

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