Household POU Filters: Sentinels for Long-term Tap Water Quality Monitoring

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Complete and reliable water quality monitoring of tap water supplies is a challenge for both municipal and private water consumers. Water quality can vary rapidly over time and space, whether seasonally, diurnally or in response to acute (i.e., rainfall, flooding, one-time spill) or chronic (consistent infiltration from septic tank leaks or nearby factory discharge) contamination events. These events may not directly coincide with water quality sampling timelines. We know there is a wide disconnect between recorded waterborne outbreak data and population estimates of waterborne disease. This is in part due to deficient monitoring schemes and the potential to miss sporadic contamination events. Here we propose a new method to evaluate drinking water quality at the point of use via in-line POU device filters.

Daily exposure potentials

The Food and Drug Administration (FDA) reports that bottled water is a close second to the most popular beverage in the US: carbonated soda. Considering tap water consumption exceeds bottled water consumption, drinking water easily garners top billing of the most consumed drink among Americans. Expert opinions vary on how much water one should drink per day, as consumption volume needed for proper hydration is dictated by individual health and nutrition status, activity levels and environmental factors. For example, people who are more active or live in hot or dry climates should consume more water. According to an extensive US dietary and nutritional survey of 16,566 individuals, 76 percent of Americans over the age of two consume plain drinking water every day.[1] While the average daily intake is 3.9 cups (0.9 liter), 25 percent report drinking >5.7 cups (1.3 L) and 10 percent report drinking >9.8 cups (2.3 liters) of water per day. Of the drinking water consumed, 69 percent is drunk at home and the majority (75 percent) is from the tap.

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Given that it is healthy to consume water frequently throughout the day, the quality of that water is of primary importance. Monitoring drinking water sources and results reporting, however, is a complicated process. Despite federal regulations and quality control actions, tap water supplies are not completely free of harmful chemical, physical, biological and radiological hazards. Understanding the true burden of waterborne disease is important for consideration of acceptable risk limits associated with water contaminants.

US waterborne disease incidence

Federal standards require frequent monitoring of municipal water supplies. Water monitoring methods, such as measuring pH, temperature, turbidity, etc., are easy to perform in the field and in real, or near real, time. Measurements for chemical or microbial hazards, however, typically require more extensive laboratory tests and can take hours to days to perform. Microbial contaminants routinely impact drinking water quality and share a significant burden of disease both in the US and worldwide. According to the Centers for Disease Control and Prevention (CDC), 32 drinking water outbreaks were investigated and reported from 2011-2012, resulting in 431 cases of illness, 102 hospitalizations and one death.[2] The CDC outbreak database only captures a fraction of the true waterborne disease incidence, which researchers estimate to be closer to 19-32 million illnesses per year, resulting in 1,000 deaths.[3-5] In theory, all of the CDC reported outbreaks and much of the endemic waterborne disease could be prevented by the use of an appropriate POU device.

Municipal drinking water sources are routinely monitored throughout the delivery chain but not in real time. Grab samples at random points in the treatment and distribution system fail to provide continuous, large-volume, long-term assessments of water quality. In addition, more than 15 million US households are served by private water wells and typically lack routine monitoring. Even when municipal treatment is effective and private water supplies pristine, growth of bacteria in distribution pipes and premise plumbing, during even brief periods of stagnation, can lead to significant health risks. One study found a 10- to 1,000,000-fold increase in bacteria concentrations from the source water to the household tap.[6]

Novel tools for monitoring tap water quality

Evaluating drinking water contamination that leads to the US disease burden is not an easy task. Since low levels (i.e., 1-100 infectious units) of microbes can cause human infection, illness and sometimes death, it is important to maximize our ability to detect very low levels of contamination in large volumes of water. Small-volume grab sampling fails to detect random contamination occurrences over long periods of time that are typical of drinking water. POU devices, however, are continuously removing waterborne contaminants. Many of these contaminants stick to POU device prefilters as large water volumes routinely pass through. Although most household POU device filters consist of prefilters to an inline microbial reduction treatment (i.e., RO, UV, ozone, etc.), even these prefilters trap microbes and provide a more accurate picture of tap water quality over longer times and larger volume assessments. Therefore, not only are POU devices useful for improving drinking water quality but they can also be used for more extensive monitoring of water quality. Collecting spent POU filters from households, during routine maintenance checks, provides a means for direct monitoring of microbial pathogens. Here, public and private supply, distribution system and premise-plumbing hazards can all be assessed at the point of use from filters at or near their end of life expectancy.

Although no studies have been published using spent POU filters from household devices to quantify tap water quality, a similar study was conducted using prefilters from water vending machines. Funded by a group of POU industry supporters, it showed that more than half of POU prefilters tested were positive for a water quality indicator or infectious enteric virus. In a sample of only 48 POU filters, 13 percent were positive for total coliforms, 19 percent for fecal enterococci, five percent for fecal *E. coli* and three percent for infectious human enteroviruses.[7]

These results suggest that POU filters are appropriate to monitor large volumes of tap water and detect the incidence of water quality indicators and pathogens that may be present at low concentrations. Our previous study shows that post-treated water often contains water quality indicator and pathogenic organisms at the tap and POU devices provide a way for improved monitoring.

Conclusion

Improved monitoring for drinking water is needed as we recognize the extensive burden of waterborne disease. Such data improvement will benefit the POU industry overall by quantifying microbial exposure and risk potentials in tap water sources. POU device monitoring could also aid the CDC in tracking outbreaks and determining outbreak endpoints, given that a POU filter may be installed and retrieved at any time during an outbreak event. Overall, POU monitoring data can be used to better predict the waterborne disease burden and quantify health and cost benefits of POU devices.

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