Chemical and microbial characteristics of municipal drinking water supply systems in the Canadian Arctic

Hansen, Lisbeth Truelstrup; Daley, Kiley; Piorkowski, Greg S.; McNeil, Kristin; Poltarowicz, Joanna; Hayward, Jenny; Jamieson, Rob C.

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Chemical and Microbial Characteristics of Municipal Drinking Water Supply Systems in the Canadian Arctic

Lisbeth Truelstrup Hansen[1]*, Kiley Daley[1], Greg S. Piorkowski[1], Kristin McNeil[1], Joanna Poltarowicz[1], Jenny Hayward[1] & Rob C. Jamieson[1]

[1] Department of Process Engineering and Applied Science, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4R2

* Speaker, e-mail: ltruelst@dal.ca

Short Description of the Abstract

Drinking water in the vast Arctic Canadian territory of Nunavut is obtained from surface water that is transferred to man-made or natural reservoirs, before being treated (chlorinated) and distributed to customers either by trucks delivering to a water tank inside buildings or through a heated distribution system. We studied the chemical and microbial drinking water quality from source to tap in three small (Coral Harbour, Pond Inlet and Pangnirtung) and one larger (Iqaluit) community. Generally, both the source and drinking water was of excellent microbiological quality, containing *Escherichia coli* levels of <1 MPN/100 mL with a few exceptions, and absence of selected pathogenic bacteria and protists. Tap water in households receiving trucked water contained less than the recommended 0.2 mg/mL of free chlorine, while piped drinking water in Iqaluit was compliant with Health Canada guidelines for chlorine residuals. Issues with premise plumbing were identified as the tap water in several individual households and/or buildings in the four communities contained manganese (Mn), copper (Cu), iron (Fe) and/or lead (Pb) concentrations above Health Canada guideline values for the aesthetic (Mn, Cu and Fe) and health (Pb) objectives. This study showed that the municipal drinking water supply in Nunavut is generally safe. However, our results point to the need for better control of the chlorine residual to prevent microbial regrowth in drinking water tanks in buildings on the trucked water service and strategies to replace problematic premise plumbing.

Abstract

Delivery of municipal drinking water in the Northern Canadian territory of Nunavut is constrained by the harsh arctic climate. In smaller communities such as Pond Inlet, Coral Harbour and Pangnirtung water is extracted from lakes, rivers or glacier streams during the brief summer and either piped or trucked to open reservoirs designed to have sufficient capacity to supply the community with potable water through the winter period. The water is chlorinated immediately before being transferred to trucks that deliver the drinking water to water tanks placed inside homes and public buildings. Nunavut's capital and largest community, Iqaluit, is served by an advanced water treatment plant, which uses a sand filter, chlorination and UV-technology to produce drinking water from Lake Geraldine. Iqaluit is served by a hybrid distribution system, where the majority of neighbourhoods receive drinking water through a heated pipe system while remaining neighbourhoods are serviced by water trucks.

There are several points along the delivery train where water may become contaminated. Contaminants may be either microbial (bacteria, viruses, protozoa) or chemical (heavy metals, organics, disinfection by-products) in nature. Also, the management and maintenance of municipal as well as in-home infrastructures may affect the potential for water contamination.

The overall objective of this study was to monitor and better understand drinking water quality and potential sources of contamination from the original source (e.g., lake, river, glacier) to the tap (the point of human use) within four Nunavut communities.

On separate sampling trips to the communities of Coral Harbour, Pond Inlet, Pangnirtung and Iqaluit (2 trips), we obtained samples of source, truck and tap water from domestic homes and public buildings throughout the communities. The water was analyzed for the following parameters: total and free chlorine, pH, temperature, conductivity, alkalinity, a suite of metals, *E. coli*, total coliforms, and presence/absence of panel of microbial pathogens (*Campylobacter, Helicobacter pylori, Listeria monocytogenes, Salmonella enterica, Giardia lamblia, Cryptosporidium* spp.).

Our results showed overwhelmingly that the tap water in buildings on trucked water service contained levels of free chlorine well below the recommended minimum concentration of 0.2 mg/L, while tap water in buildings serviced by Iqaluit's heated pipe system met the guidelines. The low chlorine levels appeared to be due to inconsistent chlorination practices in some communities as well as limited maintenance of building water tanks that developed high chlorine demands due to biofilm formation and growth permitting water temperatures (>15°C).

All water samples, including untreated source water, tested negative for the presence of pathogenic microorganisms. A few source water samples tested positive for coliform bacteria and *E. coli* indicating the presence of these bacteria in untreated water. While *E. coli* was not found in the drinking water in Iqaluit, 3 samples from the smaller communities tested positive for the fecal indicator bacterium raising some concerns due to the concurrent low free chlorine levels.

Issues with exceedance of the aesthetic guideline values for manganese (Mn), copper (Cu), and iron (Fe) were identified in several buildings throughout Nunavut. More concerning was the finding of elevated lead (Pb) levels above Health Canada's maximum acceptable concentration value (0.01 mg/mL) in the tap water of some buildings, pointing to an issue with the premise plumbing. Apart from replacing the plumbing in these buildings, flushing of the plumbing prior to consumption is recommended, although this may not be workable if the building is on trucked water service with a limited volume of water at its disposal.

In conclusion, our study showed that while the supply of drinking water in four Nunavut communities generally can be considered safe, it may be vulnerable to intrusion of pathogenic microorganisms due to inconsistent water treatment (chlorination) practices in some communities and issues with the quality of premise plumbing. It is recommended that water treatment practices are made more consistent, programs to regularly clean the water tanks in buildings are implemented and ageing or poor quality premise plumbing is replaced.