DEVELOPMENT AND VALIDATION OF A MODEL TO FORECAST LEAD LEVELS IN MUNICIPAL DRINKING WATER

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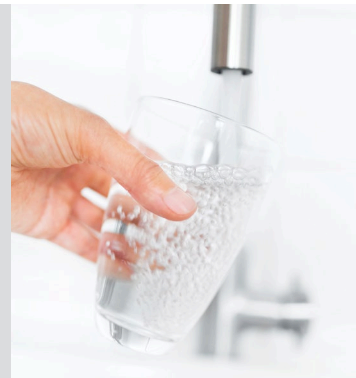
Research conducted 2012-2015, Report published August 2016

WHY DID WE DO THIS RESEARCH?

High lead levels in drinking water are a concern for Canadian communities that are still serviced by lead pipes, and are a serious public health threat. Lead is released into drinking water when the corrosion scale, which develops on the inner walls of lead pipes, become destabilized due to changes in water treatment, frequency of water use, or mechanical disturbance of the pipes (for instance during pipe replacement).

In the last century solid evidence has established the links between impaired cognitive development in children and childhood lead exposure, and to date there is not a safe blood lead threshold that would prevent the adverse effects of lead on children's neurodevelopment. Recent studies on exposure to lead through drinking water have caused a re-emergence of concern on the issues associated with lead contamination. Thus more stringent provincial guidelines for acceptable levels and monitoring of lead levels in drinking water are being considered. Adhering to these guidelines and regulations, however, results in additional costs for municipal water utilities. Implementing and assessing the effectiveness of lead corrosion control can also be costly, since lead service pipes will likely not be fully replaced in Canadian communities for some time. Thus, municipalities must understand what factors result in lead dissolution in their current drinking water systems and how to reduce it.



Reducing lead levels in drinking water requires understanding the relationships between source water chemistry, treated water quality parameters and chemical reactions in the water distribution infrastructure. This research (2012-2015) assessed the variables that control lead corrosion in drinking water systems and used field data to develop and validate a model to predict lead dissolution.

This tool provides water utility operators with the ability to specify existing or anticipated water and solid lead scale properties and provides customized information on water quality characteristics to avoid destabilization of inner pipe lead scale. As a result, lead dissolution and subsequent lead in drinking water will be reduced at the tap.

WHAT DID WE DO?

To understand the physical and chemical mechanisms regulating lead dissolution in drinking water distribution systems, this project included a detailed analysis of solid lead corrosion scales harvested from lead pipes from communities with different water quality characteristics, dissolution experiments of pure lead species and lead corrosion scales, and continuous pipe loop dissolution experiments using pipes harvested from Canadian communities and water from those communities. These findings were used to develop and validate a numerical modeling tool able to simulate conditions in the drinking water network.

WHAT WERE THE RESULTS?

The adjustment of water quality, i.e., the variation of drinking water composition at the water treatment plant, is currently used as the main component in a strategy for lead corrosion control. This approach is effective because lead concentrations in drinking water are mainly regulated by aqueous chemical processes within the inner scales of lead service lines. Lead carbonate was the main solid lead phase responsible for elevated levels of dissolved lead. The direct link between initial chlorination levels and final dissolved lead levels for corrosion scales rich in lead oxide needs to be reassessed, as our results suggest that the presence of other species in water play a main role in these processes. The project also developed a methodology for lead scale characterization.

WHAT ARE THE IMPLICATIONS FOR DECISION MAKERS?

In addition to chemical destabilization resulting from changes in water quality, other factors affect lead dissolution including mechanical disturbance of lead scale resulting from changes in drinking water flow regimes.

Identification of the phases responsible for lead dissolution in drinking water systems is necessary in order to develop lead dissolution control strategies.

The presence of other chemicals in drinking water (such as natural organic matter or other metal ions) affect the composition of the lead corrosion scale and its dissolution; therefore, complete water chemistry needs to be taken into account when implementing a lead dissolution control plan.

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