



# Sampling in schools and large institutional buildings: Implications for regulations, exposure and management of lead and copper



Evelyne Doré<sup>a,\*</sup>, Elise Deshommès<sup>a</sup>, Robert C. Andrews<sup>b</sup>, Shokoufeh Nour<sup>a</sup>, Michèle Prévost<sup>a</sup>

<sup>a</sup> NSERC Industrial Chair on Drinking Water, Department of Civil, Mining and Geological Engineering, Polytechnique Montréal, Montréal, QC, Canada

<sup>b</sup> NSERC Industrial Chair in Drinking Water Research, Department of Civil Engineering, University of Toronto, Toronto, ON, Canada

## ARTICLE INFO

### Article history:

Received 1 March 2018

Received in revised form

17 April 2018

Accepted 18 April 2018

Available online 21 April 2018

### Keywords:

Lead  
Copper  
Drinking water  
Sampling  
Large building  
School

## ABSTRACT

Legacy lead and copper components are ubiquitous in plumbing of large buildings including schools that serve children most vulnerable to lead exposure. Lead and copper samples must be collected after varying stagnation times and interpreted in reference to different thresholds. A total of 130 outlets (fountains, bathroom and kitchen taps) were sampled for dissolved and particulate lead as well as copper. Sampling was conducted at 8 schools and 3 institutional (non-residential) buildings served by municipal water of varying corrosivity, with and without corrosion control (CC), and without a lead service line. Samples included first draw following overnight stagnation (>8h), partial (30 s) and fully (5 min) flushed, and first draw after 30 min of stagnation. Total lead concentrations in first draw samples after overnight stagnation varied widely from 0.07 to 19.9 µg Pb/L (median: 1.7 µg Pb/L) for large buildings served with non-corrosive water. Higher concentrations were observed in schools with corrosive water without CC (0.9–201 µg Pb/L, median: 14.3 µg Pb/L), while levels in schools with CC ranged from 0.2 to 45.1 µg Pb/L (median: 2.1 µg Pb/L). Partial flushing (30 s) and full flushing (5 min) reduced concentrations by 88% and 92% respectively for corrosive waters without CC. Lead concentrations were <10 µg Pb/L in all samples following 5 min of flushing. However, after only 30 min of stagnation, first draw concentrations increased back to >45% than values in 1st draw samples collected after overnight stagnation. Concentrations of particulate Pb varied widely (≥0.02–846 µg Pb/L) and was found to be the cause of very high total Pb concentrations in the 2% of samples exceeding 50 µg Pb/L. Pb levels across outlets within the same building varied widely (up to 1000X) especially in corrosive water (0.85–851 µg Pb/L after 30MS) confirming the need to sample at each outlet to identify high risk taps. Based on the much higher concentrations observed in first draw samples, even after a short stagnation, the first 250mL should be discarded unless no sources of lead are present. Results question the cost-benefit of daily or weekly flushing as a remediation strategy. As such, current regulatory requirements may fail to protect children as they may not identify problematic taps and effective mitigation measures.

© 2018 Elsevier Ltd. All rights reserved.

## 1. Introduction

The exposure of young children to lead from drinking tap water at schools is a serious concern to parents, utilities, school boards and health agencies as intellectual deficits have been reported even at low levels of exposure since it is a neurotoxic (Health Canada, 2013). Sampling protocols and action levels for lead and copper at

the tap vary significantly across Canada, the United States and the European Union (Table S1, in Supporting Information, SI). In Canada and the United States, the federal government provides recommendations for sampling. Canadian provinces and territories are the regulatory agencies. In the United States, most schools fall under the Lead Contamination Control Act as they are serviced by public water systems (Triantafyllidou and Edwards, 2012). A growing proportion of the states have recently regulated mandatory sampling for lead in schools and child care facilities (Government of California, 2018; New York State, 2018; State of Illinois, 2017). Lead in drinking water in schools is regulated in many provinces and states while this is not the case for copper.

\* Corresponding author. NSERC Industrial Chair on Drinking Water, Department of Civil, Mining and Geological Engineering, Polytechnique Montréal, P.O. Box 6079 Station Centre-ville, Montréal, QC, H3C 3A7, Canada. Tel.: 1 514 340 4711 Ext. 3711. E-mail address: [evelyne.dore@polymtl.ca](mailto:evelyne.dore@polymtl.ca) (E. Doré).

Concerns have been raised over the fact that current sampling protocols may not accurately measure total lead concentrations to which a child can be exposed, as they are unable to fully account for particulate lead (Deshommes et al., 2016a; Triantafyllidou et al., 2014) which can represent an important fraction of the total lead in large buildings (Deshommes et al., 2012; Triantafyllidou et al., 2007). Portable anodic stripping voltammetry, which has been approved by USEPA (Palintest Ltd, 1999; USEPA, 2016), has been successfully used to detect lead service lines (LSLs) in houses (Cartier et al., 2012a; Deshommes et al., 2016b). In large buildings, on-site measurements could also be considered as an alternative to reference ICP-MS analyses to detect taps with high lead levels.

Materials for piping, the use of solder as well as the quality of brass varies widely in large buildings (Cartier et al., 2012b; Deshommes et al., 2012; McIlwain et al., 2015) and these materials can release Pb and Cu in drinking water. Although new standards have lowered the lead content to 0.25% in brass (Health Canada, 2017; U. S. Government, 2011), schools must manage legacy plumbing. Current low lead certification processes have been questioned as certified materials may release more lead than authorized (Elfland et al., 2010; Triantafyllidou and Edwards, 2007).

Water quality, stagnation time and galvanic corrosion directly impact the extent of lead and copper release in large buildings (Boyd et al., 2008a; Cartier et al., 2012b). The solubility of lead and copper is influenced by pH, alkalinity, hardness, temperature, disinfectant residual (oxidation-reduction potential), chloride to sulfate mass ratio (CSMR), dissolved oxygen, natural organic matter (NOM) as well as the addition of phosphates (Schock and Lytle, 2011). Problematic taps, when considering lead and copper, are likely to vary, as critical water quality conditions for dissolved and particulate metals differ (Cartier et al., 2012b; Schock and Lytle, 2011). Alkalinities below 25 mg CaCO<sub>3</sub>/L and above 75 mg CaCO<sub>3</sub>/L are associated with the highest copper solubility (Schock et al., 1995).

High and varying lead concentrations have been reported in the literature for large buildings in Canada and the United States since the 1990s (SI, Table S2). These results should be considered in light of the specific sampling protocols and preservation techniques that were used. A meta-analysis of Canadian schools and large buildings demonstrated the importance of the sampling protocol and stagnation time prior to sampling (Deshommes et al., 2016a). First draw (>8h) 90<sup>th</sup> percentile lead concentrations reached 11 µg Pb/L (n = 31,679 taps) with a maximum concentration of 13,200 µg Pb/L; 90<sup>th</sup> percentile concentrations measured after 30 min of stagnation were lower (4.7 µg Pb/L) but still >400 µg Pb/L in specific worst-case schools investigated. Flushing for 30 s prior to sampling reduced the fraction of samples >20 µg Pb/L to 3% in Seattle Public Schools (n = 71) (Boyd et al., 2008b; Triantafyllidou et al., 2014). Similarly, this fraction decreased from 6% (1st draw) to 1% (30 s flush) in Los Angeles' schools (n = 629) (Sathyanarayana et al., 2006; Triantafyllidou et al., 2014). Finally, concentrations decreased from 71.1 to 5.0 µg Pb/L following flushing in 3 elementary schools in British-Columbia (Barn et al., 2014).

Solder and brass fixtures have been associated with high particulate lead release, accounting for up to 48% of total Pb concentrations (Cartier et al., 2012b; Deshommes et al., 2012). Correlating high Pb concentrations with other metals, such as Zn and Sn, can confirm brass fixtures as one of the sources of particulate Pb. Frequency of use of the taps also influences Pb concentration with low use fountains releasing more Pb than similar fountains with a higher water use (McIlwain et al., 2015).

The relative contribution of exposure through drinking tap water in schools to blood lead level (BLLs) of young children remains a challenge considering the need to reconstruct plausible exposure and determining the daily water intake. Biokinetic

modeling has been used to investigate the potential impact of lead in tap water consumed in schools on the BLL of children (Barn et al., 2014; Deshommes et al., 2016a; Sathyanarayana et al., 2006; Triantafyllidou et al., 2014). Most studies concur that specific large buildings and taps can contribute to BLL exceedances and underline the importance of identifying these buildings and taps to protect vulnerable populations (Barn et al., 2014; Deshommes et al., 2016a; Triantafyllidou et al., 2014). Differences in conclusions reflect: (1) the sampling protocols used, (2) the proportion of the water consumed at school, (3) the Pb concentration of water at home, (4) the proportion of flushed water values incorporated in the daily intake, and (5) the selection of the statistical reference water lead value to establish baseline and exposure scenarios.

The objectives of this study were to: (1) apply a combination of sampling protocols to quantify the source and occurrence of dissolved and particulate lead and copper, (2) investigate the importance of water quality and type of outlets on lead release, (3) document the extent and duration of the benefits associated with flushing (4) establish realistic exposure scenarios by combining results from several sampling protocols, and (5) discuss the efficacy and feasibility of management options to decrease exposure to lead and copper.

## 2. Materials and methods

### 2.1. Building selection and sampling campaign

In May and June 2012, drinking water was sampled in schools and large buildings located in two Canadian provinces. Buildings sampled were served by municipal distribution systems fed by surface water sources. Three types of buildings were sampled: (1) schools without corrosion control (CC) and low alkalinity water (<40 mg CaCO<sub>3</sub>/L), (2) schools with pH control (pH > 8.5) and low alkalinity, and (3) large building complexes with high alkalinity (>70 mg CaCO<sub>3</sub>/L) moderate pH (pH 7.5–8.0) without CC. In this context, schools were defined as small buildings with 80–850 students, large building complexes as multi-storey buildings with an average capacity ranging from 7000 to 60,000 people. Large buildings B9 and B11 are university complexes, building B10 is a pediatric hospital. There were no LSLs installed in the buildings sampled.

In total, 130 taps were sampled, including fountains, kitchen and bathroom faucets. Table 1 shows the number of samples collected, pH, alkalinity and mean temperature, the type of faucets and the year of construction of the building. The aggressivity index (AI) was computed, recognizing that it may not be the best predictor of lead release.  $AI = pH + \log(AH)$ , A being the alkalinity and H the hardness, both expressed as concentration of calcium or as mg/L equivalent CaCO<sub>3</sub> (AWWA, 1977).

### 2.2. Sampling protocol

The sampling protocol included the sequential collection of 5 samples at selected tap. Leaving the aerator in place, a first draw of 250 mL (1S > 8h) and second draw sample of 1.75 L (2S > 8h) were collected following at least 8h of stagnation. Immediately there after, the water was left running and two additional 250 mL samples were collected; one after 30 s of flushing (30sF) and the other after 5 min (5minF). Flushing was timed after the second draw (2S > 8h) was taken. Therefore, the 30sF sample corresponded more precisely to a sample collected between 30 s and 1 min of flushing. Finally, a stagnation of 30 min was performed, and a 250 mL sample was collected (30minS). Following completion of sampling, aerators were removed from kitchen and bathroom faucets such that particles could be collected, where possible.

Download English Version:

<https://daneshyari.com/en/article/8873824>

Download Persian Version:

<https://daneshyari.com/article/8873824>

[Daneshyari.com](https://daneshyari.com)