Winter 1-8-2019

Commercial Water Claims: City of London Assessment of Claims Made by London Residents

Jonathan Abbruzzese
Western University, jabbruzz@uwo.ca

Yousir Aldin
Western University, yaldin@uwo.ca

Christine Eagles
Western University, ceagles3@uwo.ca

Karen Lemon
Western University, klemon9@uwo.ca

Alexander Watson
Western University, awatso92@uwo.ca

Commercial Water Claims: City of London Assessment of Claims Made by London Residents

Abbruzzese, J., Aldin, Y., Eagles, C., Lemon, K., Watson, A..

Abstract

The City of London has a mandate to provide its residents with high grade water and yet there have been complaints concerning the impurities, otherwise known as residuals, and the overall quality. This paper delves into the truth about the contents of the municipal water system and what the effects of its components are to the London populace. A public survey asked residents questions about their concerns and water drinking habits. The survey pointed to concerns about fluoride, residual chlorine and overall taste of water among others. Fluoride is known to reduce tooth decay (CDC, 2018) and any negative consequences of fluoride ingestion are negligible due to the amount physically present in the water. Chlorine is in water to eliminate bacteria (WHO, 2017). Taste is the main deterring factor for residents not consuming municipal water. With consistent monitoring, there is no risk to the health and safety of London residents who consume municipal water.

Keywords:

Fluoride, chloride, tap water, bottled water, London, public health, infrastructure, potability.

Introduction

Clean, safe and publicly available drinking water is one of the hallmarks of modern life. Consequently, the public places a significant amount of trust in complex water treatment and delivery infrastructure. When this system fails, distrust can be sown among the general population. Events contributing to public concern about their local drinking water include the waterborne

infections in Walkerton, ON and North Battleford, SK. The Walkerton event in 2000 consisted of an outbreak of *Escherichia coli* (*E. coli*) entering a well that routinely used less chlorine than required for purification (Salvadori et al., 2009). Some chemicals that invoke concern in drinking water, such as chlorine, have necessary uses that contribute to the potability of tap water when used in appropriate quantities. For the event in North Battleford, the illness from their contaminated water source was due to neglected water treatment practices (Woo & Vicente, 2003). These events illustrate that some health concerns about drinking water are valid, and therefore reaffirms the need for constant attention to the safety of drinking water sources.

This report is an attempt to respond to the importance of clean, safe drinking water. It is a collaborative effort between students at Western University and the City of London to address how London residents interact with claims made regarding their drinking water. Specifically, the two main goals of this report are to evaluate how London residents perceive the health and safety of their municipal water supply, and how this compares to their perception of commercially available drinking water. To guide and supplement the content of this report, a survey was administered to allow the public to share their thoughts and concerns about commercial and municipal sources of water. These claims and concerns will be evaluated to determine their validity.

Strategy/Approach

The administered survey took a two-pronged approach to the topic of London and its interactions with drinking water sources. Firstly, claims made by residents about London's municipal water system were gathered. Secondly, the claims made regarding commercial water sources and auxiliary water treatment systems were collected in a similar manner. The results of

the survey – and therefore the concerns of London residents- will be used to direct the content addressed by this report.

The survey was distributed to residents of London on the City of London's Facebook page. It asked residents to rank their feelings about the safety of both bottled water and tap water and gave them opportunities to state concerns about the health, safety and quality of the water sources. The survey also sought to identify reasons why individuals consume bottled water, as opposed to drinking tap water. In addition, the survey asked about auxiliary treatments individuals use once the water has reached their home, such as filters and water softeners.

Survey Results

Over a sample size of 326 responses, the survey found that 65% of respondents gave London's tap water safety a ranking of 5 out of 5, (where 5 is the highest quality) while only 36% of respondents gave bottled water safety a ranking of 5 (Figure 1). In terms of quality, 49% of respondents gave London's tap water a ranking of 5, while only 24% of respondents gave bottled water a ranking of 5 (Figure 2). Although these differences suggest that the majority of individuals find London's tap water safe and of high quality, it is vital to assess the concerns of those who do not think as highly of London's water. Common concerns raised by survey respondents included the concentrations of chemicals and metals in the water, notably fluoride and chlorine. Respondents also expressed concern over the appearance, smell and taste of their tap water. These concerns lead to further questions about the concentrations of contaminants in the water and about the quality of London's water infrastructure. It was also found that among individuals who purchase bottled water, 42% purchase it out of convenience. Similarly, respondents expressed doubts about the safety of commercially bottled water. The most common concerns were plastic

leaching from the bottles into the water and the environmental impact of plastic waste. This report will explore the validity of these concerns as well as other questions raised by the respondents of the survey.

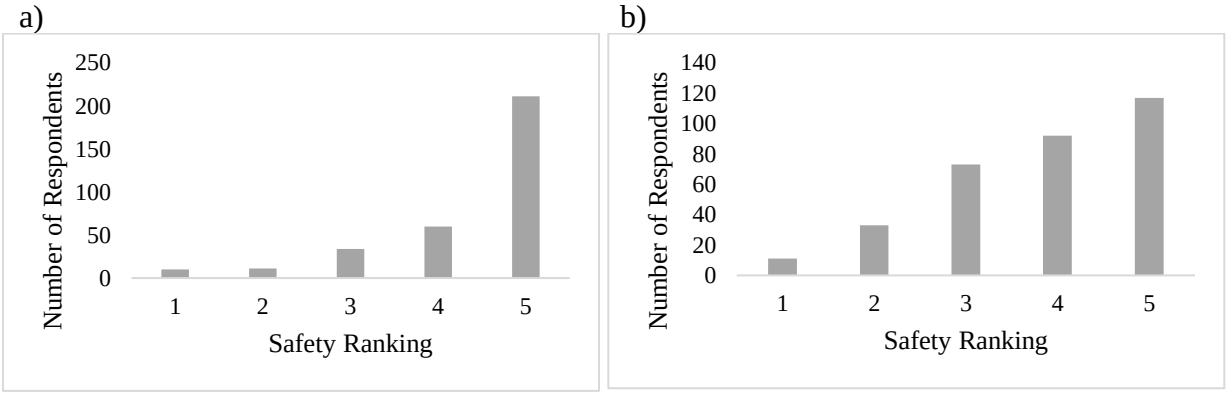


Figure 1. a) Survey respondents' rankings the City of London's tap water safety on a scale of 1 (lowest) to 5 (highest) (n = 326). b) Survey respondents' rankings bottled water safety on a scale of 1 (lowest) to 5 (highest) (n = 326).

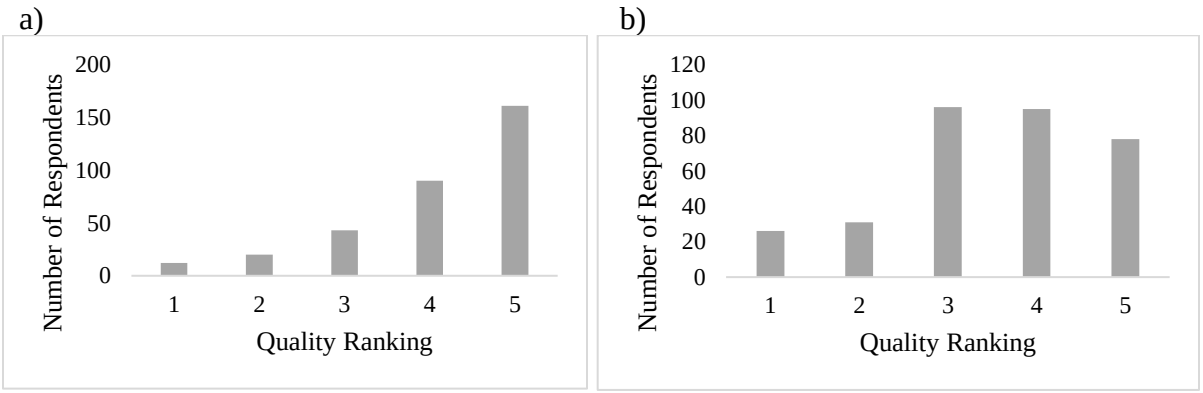


Figure 2. a) Survey respondents' rankings of the City of London's tap water quality on a scale of 1 (lowest) to 5 (highest) (n = 326). b) Survey respondents' rankings of bottled water quality on a scale of 1 (lowest) to 5 (highest) (n = 326).

Figures 3 and 4, analyze the quality of London's tap water, the quality of commercial water, and London's tap water safety, respectively. Each figure has a corresponding box plot, figure b,

that illustrates the demographics associated with each submission. By analyzing the figures, it is evident that there is no correlation with an individual's generational status. Generally, indigenous peoples follow a trend of stating that London's tap water quality and safety is low, which agrees with their response of bottled water being of high quality. With that being said, this category is not significant because there is only one respondent. Analyzing other categories, such as first, second, and third generation Canadians, all generally agree that London's tap water quality and safety is of mid to high ranking, with the exception of a few outliers.

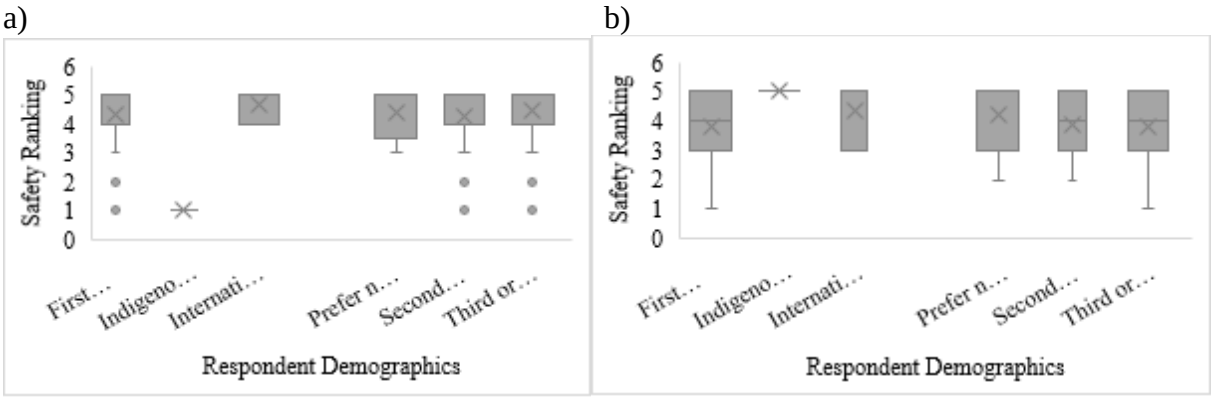


Figure 3. a) Boxplot of survey respondents' rankings of the City of London's tap water safety on a scale of 1 (lowest) to 5 (highest) based on respondents' demographics ($n_{\text{first-generation}} = 46$, $n_{\text{indigenous}} = 1$, $n_{\text{international student}} = 3$, $n_{\text{second-generation}} = 78$, $n_{\text{third or more generation}} = 191$, $n_{\text{prefer not to say}} = 5$). b) Boxplot of survey respondents' rankings of bottled water safety on a scale of 1 (lowest) to 5 (highest) based on respondents' demographics ($n_{\text{first-generation}} = 46$, $n_{\text{indigenous}} = 1$, $n_{\text{international student}} = 3$, $n_{\text{second-generation}} = 78$, $n_{\text{third or more generation}} = 191$, $n_{\text{prefer not to say}} = 5$).

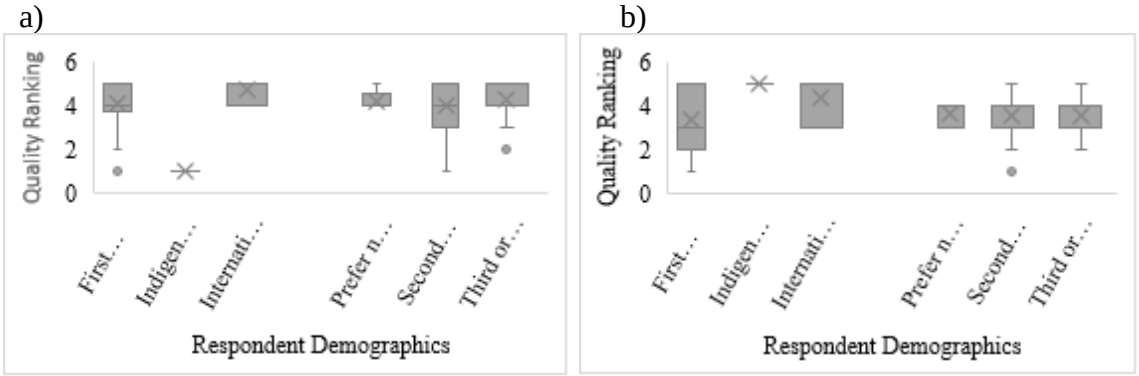


Figure 4. a) Boxplot of survey respondents' rankings of the City of London's tap water quality on a scale of 1 (lowest) to 5 (highest) based on respondents' demographics ($n_{\text{first-generation}} = 46$, $n_{\text{indigenous}} = 1$, $n_{\text{international student}} = 3$, $n_{\text{second-generation}} = 78$, $n_{\text{third or more generation}} = 191$, $n_{\text{prefer not to say}} = 5$). b) Boxplot of survey respondents' rankings of bottled water quality on a scale of 1 (lowest) to 5 (highest) based on respondents' demographics ($n_{\text{first-generation}} = 46$, $n_{\text{indigenous}} = 1$, $n_{\text{international student}} = 3$, $n_{\text{second-generation}} = 78$, $n_{\text{third or more generation}} = 191$, $n_{\text{prefer not to say}} = 5$).

Discussion

Fluoridation

The practice of fluoridating drinking water is over 70 years old in Canada, and the levels of fluoride in water were adjusted throughout this period (Government of Canada, 2016). London, alongside most major population centers in Canada, practices fluoridation of its municipal drinking water. Fluoride is added to drinking water to decrease levels of tooth decay in the population. The Centers for Disease Control and Prevention (CDC) found that drinking fluoridated water reduces cavities by about 25% in children and adults (CDC, 2018). Despite these health benefits, the presence of fluoride in drinking water is a contentious topic. Some survey respondents were concerned that fluoride in drinking water is dangerous or is present at unsafe concentrations. In general, those in opposition to fluoridated water cite negative health impacts from its consumption. According to Health Canada (2017), over 90 national, international and governmental organizations endorse water fluoridation. In controlled quantities, fluoride is safe to drink, effective and an equitable treatment that is proven to reduce tooth decay (Government of Canada, 2016).

Health Canada (2017) set the maximum acceptable concentration (MAC) of artificial fluorine concentration in drinking water at 1.5 mg/L, due to the cosmetic consideration moderate dental fluorosis. The World Health Organization (WHO) (2017) provides a guideline, which accounts for health effects, of 0.5 mg/L to 1.0 mg/L. Excess levels of fluoride can have negative

health impacts ranging from nausea to death (Kanduti, Sterbenk, & Artnik, 2016). For this reason, fluoride concentrations are constantly monitored by the City of London (City of London, 2017). In 2017, the City of London reported fluoride concentrations of 0.13 mg/L - 0.87 mg/L. These comply with the MAC set by Health Canada (2017) and the WHO (2017). Therefore, the concentration of fluoride in London's drinking water is within a range that does not result in negative health impacts of fluoride consumption, but instead provides a health benefit to the entire community.

Pesticides

In general, pesticides can contaminate water systems by seeping off of farmland and into the groundwater. Pesticide concentrations are tested on a monthly basis by the City of London, though this practice is not strictly required (City of London, 2017). The concentrations allowed are based on WHO (2017) regulations and the water is not allowed to leave the facility if these stipulations are not met. As an example, atrazine, a recently controversial herbicide, was found to have concentrations between 0.01 to 0.03 μg/L, (City of London, 2017) while the WHO (2017) has set 5 μg/L as the maximum acceptable concentration. Therefore, through ongoing testing, the concentration of some pesticides in drinking water are monitored and remain at acceptable concentrations.

Pharmaceuticals

An additional concern about the safety of London's municipal water supply is the presence of pharmaceuticals in the water. The term pharmaceuticals denote chemicals found in drugs and medication, with the concern being adverse health effects of their consumption through drinking

contaminated water. This contamination would be the result of improper disposal of pharmaceuticals into the water system or through the excretions of people who have consumed these chemicals. The WHO (2012) found that there are measurable quantities of pharmaceuticals and their metabolites in water systems. However, the WHO cites typical concentrations of less than 50 ng/L in treated water. This concentration is consistently several orders of magnitude less than the minimum therapeutic dose of a typical pharmaceutical. Man-made treatment processes such as chlorination, together with natural water cycle processes, were found to keep pharmaceutical contaminant levels at negligible concentrations. Therefore, the WHO concludes that the margin of safety between the measured concentrations of pharmaceuticals and the concentration required for adverse effects is so substantial that there is very low risk to human health. The WHO even recommends that water sanitization practices focus on more pressing matters.

Old Pipe Rust and Contaminants

The intermittent use of pipes causes copper and lead to leach from the pipes into drinking water (Barn et al., 2014). In 2017, the City of London reported 2.3 μg/L to 3.18 μg/L of copper in municipal water. This measured concentration does not exceed the guideline of 2 mg/L set by the World Health Organization (2017). However, the water measured by the City only passes through the primary water pipes. This means that there is no regulation for water that flows through the individual pipes responsible for supplying water to London residences. Therefore, excess levels of copper and lead in drinking water is a valid concern, especially in areas of the city with aging infrastructure. A surplus of lead is also toxic to the body (Health Canada, 2017). Lead effects the biochemical, neurobehavioral and nervous systems of young individuals (Health Canada, 2017).

As an example of the validity of this concern, in 2014, copper and lead concentrations exceeded guidelines in some British Columbian schools due to intermittent pipe use (Barn et al. 2014). This demonstrates that copper and lead concentrations in tap water can be present at dangerous levels while still being measured within guidelines at water distribution centers. For this reason, the City of London offers free lead testing for London residents living in older houses (City of London, n.d.) and Health Canada (2017) encourages periodic flushing of pipes before consumption to lower heavy metal concentrations.

Chlorine

Chlorine is a disinfectant that is added to water in its purification process. The purpose of using chlorine is to eliminate bacteria and viruses to reduce the risk of waterborne diseases (WHO, 2017). Chlorine residual is often used as a preservative during transport of water to residents (WHO, 2017). Chlorine can form carcinogenic chlorine compound by-products (Health Canada, 2017), though the formation of these compounds is more likely when chlorine is in high concentrations. To minimize the formation of these compounds, London maintains a chlorine concentration of 0.4 mg/L to 2.0 mg/L (City of London, 2017), which is below the WHO guideline of 5mg/l (WHO, 2017). London's chlorine residuals in tap water ranges from 0.1mg/L to 3.00mg/L (City of London, 2017).

Taste

Taste, appearance and smell are factors that affect an individual's opinion on the potability of their municipal drinking water. 9% of survey respondents agree that they drink bottled water as opposed to tap water, due to their preference in taste or appearance. Therefore, these factors serve as a potential deterrent to the consumption of tap water. Individuals are able to taste or smell

chlorine at concentrations of 0.3mg/L and copper at 2.5 mg/L (WHO, 2017). As a result, some survey responses listed the smell or taste of chlorine as a concern for consuming the tap water gives a bitter taste which may discourage residents from drinking their tap water. Even though a safe range of the metal or ion is reached, there is always the possibility that the individual will be repelled from consuming it due to the smell and taste.

Bacteria and Metals - Bottled Water in Comparison to London's Tap Water

Although the majority of respondents stated that they don't purchase bottled water many individuals reported they purchase bottled water for convenience or taste preference (Figure #). Bottled water is often treated as an analog to tap water, but an analysis of the number of bacteria in bottled water versus tap water showed that bottled water is not always cleaner than tap water. The tested bottled water had a range of less than 1 CFU (colony forming units) per 100 mL to over 490,000 CFUs per 100 mL (Lalumandier and Ayers, 2000). The concentration of coliforms in London's tap water in 2017 ranged from 0 CFUs per 100 mL to 30 CFUs per 100 mL (City of London, 2017). These concentrations demonstrate that while London residents may be worried about coliform bacteria in their tap water, this issue is potentially more severe in commercial water sources.

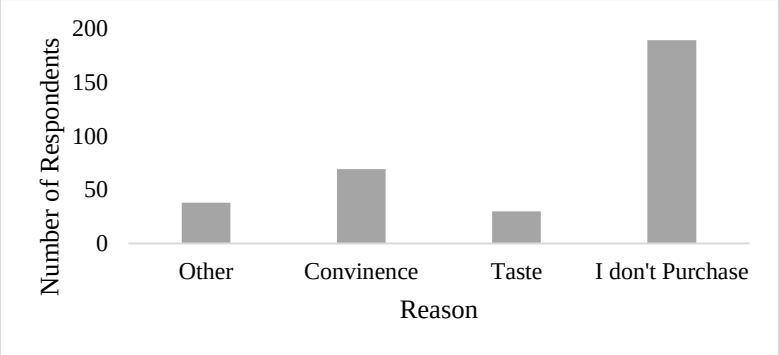


Figure 5. Survey respondents' reasons for purchasing bottled water (n = 326).

Table 1. Comparison of the concentration of various chemical contaminants in some brands of water sold in Canada with the concentration of the metals in the City of London's tap water. Bottled water concentration data from Diduch et al., 2011; London's tap water concentration data from City of London, 2017.

Bottled Water Brand	Contaminant	Bottled Water	London Water (2017)
Evian	Cadmium Copper Magnesium	0.2 μg/L 0.2 μg/L 1-24 mg/L	0.003-0.008 μg/L 2.31-3.18 μg/L 7.78-8.78 mg/L
Aquafina	Arsenic Cadmium Lead	11.9 ± 9.1 μg/L 1.0 ± 1.9 μg/L 0.03 ± 0.7 μg/L	1.0-1.7 μg/L 0.003-0.008 μg/L 0.02 μg/L

Table 1 demonstrates that the concentrations of the selected contaminants is generally higher in bottled water than London's tap water, with the exception of copper. One possible reason that copper concentrations are higher in London's 2017 tap water than Evian is leaching from pipes used for municipal water. For all metals except magnesium, both bottled water and tap water are within the acceptable standards set by Health Canada in 2017. These findings concerning the concentrations of coliform bacteria and metals suggest that there is no health advantage to drinking bottled water instead of tap water.

Environmental Impacts of Bottled Water

Plastic waste from the use of single use water bottles is a significant environmental concern. Regulating bottled water also regulates waste, which would decrease the environmental footprint of plastic water bottles. The breakdown of plastic in the environment occurs by biodegradation, mechanical weathering and UV radiation. UV radiation causes photo and thermal

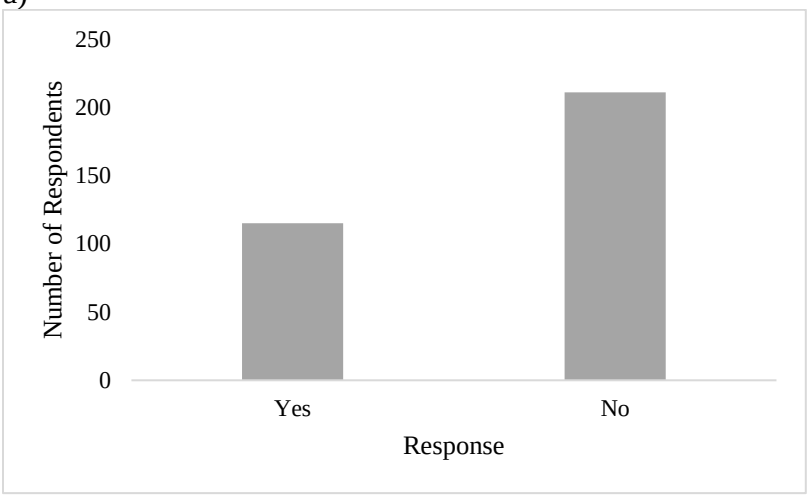
oxidative degradation. The environmental problem with bottled water is that it can take thousands of years to break down the plastic, if it is able to decompose at all (Andrady et al., 2011 as cited in Driedger et al., 2015).

This type of plastic pollution is found in Lake Huron and Erie, the sources of London's drinking water. This pollution can cause detrimental effects on the aquatic life in those bodies of water. Plastic materials are made up of chemicals. These chemicals leach into the water and disrupt the endocrine functioning of the aquatic life, which therefore affects the wildlife. (Meeker et al., 2009 as cited in Driedger et al., 2015).

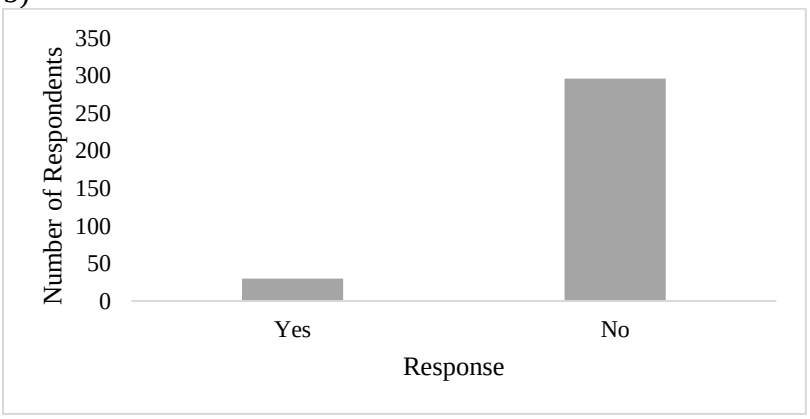
Auxiliary Treatment Systems

From the survey results, over a third of respondents said they feel the need to use some type of auxiliary treatment system for their tap water, such as a Brita filter jug or tap mounted filter (Figure #). Point-of-use water filter systems generally use some mix of cation exchange resin and activated carbon filter to treat tap water. Trace metals in the water are effectively filtered out by these systems (Ahmedna et al., 2004) but there is also potential for an increase in microbiological contamination as a result of the filtration process (Daschner et al., 1996). Based on responses regarding the safety of London's tap water, it seems that auxiliary filters are used to change the taste of the water or to filter out any perceived contaminants. However, the analysis above has demonstrated that heavy metals are not present in drinking water at dangerous concentrations. Unless significant contamination occurs between the testing of tap water and its delivery to the resident then an auxiliary treatment system represents more of a health risk than a benefit.

a)



b)



c)

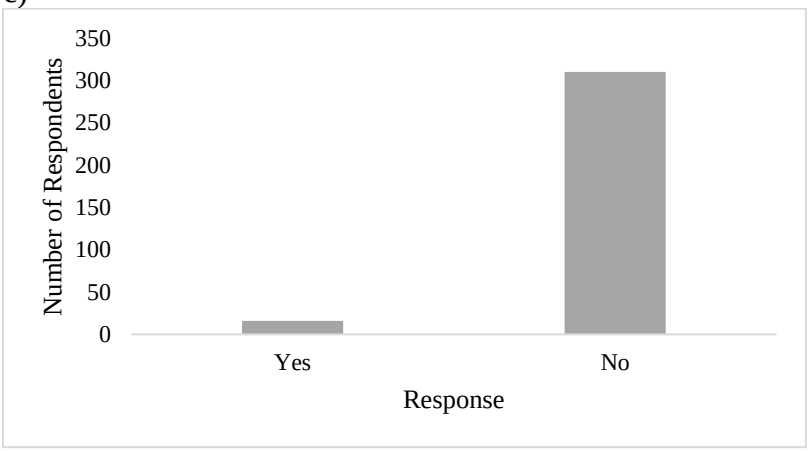


Figure 6. a) Number of survey respondents who use water filters (ie. Brita) (n = 326). b) Number of survey respondents who use a water treatment system (n = 326). c) Number of survey respondents who use water softeners (n = 326).

Source

Several survey responses demonstrated misconceptions regarding the source of London's drinking water. The City of London's municipal water supply is drawn from Lake Erie and Lake Huron, (City of London, 2016) not the Thames river, as some individuals believe.

Figure 7. Map showing Lake Erie and Lake Huron as London's water sources.

Chemical Leaching from Bottled Water

An additional concern of some survey respondents is the possibility of chemicals leaching into water from disposable plastic water bottles. Some plastic water bottles are made of polyethylene terephthalate (PET). It has been found that PET water bottles may leach antimony into the water contained within the bottle (Shotyk et al., 2005). The concentrations of antimony found in the water were below the Health Canada (2017) guidelines however. In addition, it has been found that antimony leaching is stimulated by higher temperatures. (Westerhoff et al., 2008). This can be problematic because people do not always properly refrigerate their water bottles and store them in places, such as garages or cars, that can heat up over the summer. This leaching effect is a risk associated with bottled water that is not present in municipal tap water.

Conclusions and Recommendations

There are a multitude of claims made within the London community about the quality and safety of London's municipal water system. The aim of this report was to compile scientific research regarding the ultimate safety of London's water system and how it compares to commercial water.

The investigation of survey results found varying levels of support for each claim. The concentration of fluoride and chlorine measured in London's tap water are not high enough to trigger negative health effects, but are large enough to provide benefits. With consistent monitoring, there is no risk to the health and safety of consumers. With regards to pharmaceutical presence in drinking water, the measured levels are not high enough to have any impact on human health. Copper and lead leaching from pipes pose a unique concern in that the quality of pipes leading to an individual's residence cannot be regulated. The concerns about the taste of water, which is primarily due to the concentration of chlorine, is consistent with the amount of chlorine present in London's water. The concentrations causing the taste however are not harmful to humans. Thus, the concerns of London residents about tap water are not concerns for health with the present concentrations of water testing by the city. Bottled water is preferred, because of the absence of the chlorine residuals taste or for convenience.

Bacteria is more closely regulated in municipal water than commercial water through testing regulations. There is a greater concern for plastic pollution associated with bottled water than tap water, resulting in environmental impacts. Overall there are more potential concerns over the health and safety of bottled water than municipal water.

Based on the conclusions above, this report recommends maintaining the current level of water treatment and monitoring. Additional awareness of treatment methods and frequencies relating to pipe contaminants should be spread to the public. An example of such awareness would be periodic encouragement for residents to go get their water tested by the city of London for lead if they live in an area with old water infrastructure.

Appendix

Survey Questions

What are the first three digits of your postal code?
[written response]

Please select which of the following you identify as?
First generation Canadian -- not born in Canada
Second generation -- born in Canada with at least one parent born outside Canada
Third or more generation Canadian -- born in Canada with both parents born in Canada
Indigenous peoples
Prefer not to say
Other: _____

London's tap water is safe to drink and of high quality.
(strongly disagree) 1 2 3 4 5 (strongly agree)

London's tap water is of high quality.
(strongly disagree) 1 2 3 4 5 (strongly agree)

What are some concerns you have about the health, safety and quality of London's tap water?
[written response]

Bottled water is safe to drink and of high quality.
(strongly disagree) 1 2 3 4 5 (strongly agree)

Bottled water is of high quality.
(strongly disagree) 1 2 3 4 5 (strongly agree)

What is your reason for purchasing bottled water?
Convenience
Health or safety concerns about tap water
Taste preference
I don't purchase bottled water
Other (please specify)

What are some concerns you have about the health, safety and quality of commercially available bottled water?
[written response]

Do you feel it is necessary to use a filter (e.g. Brita filter jug, faucet mount filter) when drinking tap water?
Yes
No

Do you use a treatment system (e.g. reverse osmosis system, UV treatment) when drinking tap water? (Excluding “Brita” type filters)

Yes
No

Do you use a water softener?

Yes
No

Limitations of Study Design

This survey was a voluntary response, convenience sample. This survey type causes limitations in the generalizability of the results of our study because people who respond to these types of surveys tend to have extreme opinions. Therefore, these results and opinions may not be representative of everyone in the City of London. In addition, some of the questions may have been leading questions which caused individuals to answer questions differently. For example, the questions ranking the quality of water uses the word ‘high’ which may have caused individuals to give the water quality a higher ranking than they would have if the question had simply asked them to rank the water quality.

CEL Survey Results and interpretations

Question 1: What are the first three digits of your postal code?

- This was used to help culminate responses from London residents specifically.
- This helps us make this a geographical specific survey so that the only data collected applies directly to London residents.

Question 2: Please select which of the following you identify as?

- This is to help determine if generation has an effect on people's thoughts on water quality or treatment.
- About ~59% were third generation Canadian, with ~38% either first or second generation Canadian and the other ~3% is comprised of a variety of identifications including those who prefer not to say, international and those who are not born in Canada but their parents are Canadian.

Question 3: London's tap water is safe to drink

- This was on a scale from 1 to 5 with 1 being completely unsafe to drink and a 5 being completely safe to drink
- The results are as follows:

Water safety on a scale of 1-5	Proportion of the responses
1	3.1
2	3.4

3	10.5
4	18.6
5	64.4

- Looking at these results it is clear that more than 83% believe that the London water system is distributing water that meets the expectations of the London population.
- When putting this question in the survey it is not clear which response would have the most results. I think that this is in part due to the project itself, if people really are making claims against the London water then there must be a lot of people who do not actually believe that the water is safe to drink.

Question 4: London's tap water is high quality

- This is set up as a leading question in that it gets the responder thinking about what would make the water quality good or bad.
- The results are consistent with the last question proportion wise.
- In summary

Level of quality on a scale of 1-5	Percentage of people who answered for each
1	3.7
2	6.2
3	13.3
4	27.6
5	49.2

Question 5: What are some concerns you may have about the health, safety, and quality of London's tap water?

- Our group had some thoughts about what we would see including chlorine and fluoride content in the water as residual cleaning. However, many of the issues that responders gave lined up perfectly with the points we learned while doing research.
- There were a few people that specified other
- What was interesting was that some people said that they wanted to know what was in their water
    - We should maybe link the London water treatment plans/ measures of everything in the water. Then people who read this will be able to see exactly what is in it.

- The main things that were repeatedly brought up was the taste of the water, the chlorine/fluoride content and that it just is not enjoyable to drink.

Question 6: bottled water is safe to drink

- This question is used as a comparison to question 4 where we can now compare the thoughts on bottled water vs tap water safety

Bottled water safety on a scale of 1-5	Percentage of people who answered each
1	3.4
2	10.2
3	22.3
4	28.5
5	35.6

- The responses for bottled water safety had more spread than the commercial water safety responses.

Question 7: bottled water is high quality

- This distribution is more centralized around the 3
- It's hard to describe if these results are not biased by the questions themselves - the fact that we are asking these questions - or if people truly think that bottled water quality is that bad

Question 8: what is the reason you buy bottled water?

- Of those who did purchase bottled water, the highest response was convenience.
- This makes inherent sense as the benefit of having water on your person and not having to worry about getting a drink from somewhere.
- Our society has become very convenience based so of course water bottles are going to fit in that way.

Question 9: What are some concerns you may have about the health, safety, and quality of commercially available bottled water?

- The most consistent answer was plastic in the water.
- This is a valid statement since water is the universal solvent and even in water bottles ex. BPA.
- Some people mention the environmental impact as well as the privatization of water.

Question 10: Do you feel it necessary to use a filter?

- Most people said no ~35%

- This question is used to see if people want their own purifying technology available in order to satisfy their own queries about the water they drink.

Question 11: Do you use a treatment system?

- More than 90% said that no, they do not use a treatment system.
- These are expensive and we can prove that they are not needed.
- It is surprising that almost 10% of Londoners have purchased one.

Question 12: Do you use a water softener?

- I do not think that this question is too relevant to Londoners because the water here is inherently soft.
- Whereas in places further north, the water is harder and the need for a water softener is greater.
- But more than 95% said that they do not use a water softener.

Bibliography

Ahmedna, M., Marshall, W. E., Husseiny, A. A., Rao, R. M., & Goktepe, I. (2004). The use of nutshell carbons in drinking water filters for removal of trace metals. Water Research, 38(4), 1062–1068. https://doi.org/10.1016/J.WATRES.2003.10.047

Barn, P., Nicol, A.-M., Struck, S., Dosanjh, S., Li, R., & Kosatsky, T. (2013). Investigating elevated copper and lead levels in school drinking water. Environmental Health Review, 56(04), 96–102. https://doi.org/10.5864/d2014-006

Botto, S., Niccolucci, V., Rugani, B., Nicolardi, V., Bastianoni, S., & Gaggi, C. (2011). Towards lower carbon footprint patterns of consumption: The case of drinking water in Italy. Environmental Science and Policy, 14(4), 388–395. https://doi.org/10.1016/j.envsci.2011.01.004

Centers for Disease Control and Prevention. (2018). Community Water Fluoridation. Retrieved November 16, 2018, from https://www.cdc.gov/fluoridation/index.html

Chang, C.-W. (2015). *A Study on the Social and the Environmental Impacts of Bottled Water & A Design Solution to Improve the User Experience of Reusable Water Bottles*. From,https://search.proquest.com/docview/1707335938?accountid=15115&fbclid=IwAR2Nm7l DxGXW3P45Set1Y5zgr8pLquyyVM8JULUqxtpAlxS_vbZcc1FMiPk&pq-origsite=summon

City of London. (n.d.). Lead Water Services. Retrieved November 16, 2018, from https://www.london.ca/residents/Water/Water-System/Pages/Water-Quality-Lead.aspx

City of London. (2016). Water System. Retrieved November 15, 2018, from https://www.london.ca/residents/Water/Water-System/Pages/Water-System.aspx

Corinne J. Schuster, Andrea G. Ellis, William J. Robertson, Dominique F. Charron, Jeff J. Aramini, Barbara J. Marshall and Diane T. Medeiros (2005) Infectious disease outbreaks related to drinking water in Canada, 1974-2001. Canadian Journal of Public Health / Revue Canadienne de Santé Publique Vol. 96, No. 4 pp. 254-258

Daschner, F. D., Rüden, H., Simon, R., & Clotten, J. (1996). Microbiological contamination of drinking water in a commercial household water filter system. European Journal of Clinical Microbiology & Infectious Diseases, 15(3), 233–237. https://doi.org/10.1007/BF01591360

Diduch, M., Polkowska, Z., & Namieśnik, J. (2011). Chemical Quality of Bottled Waters: A Review. Journal of Food Science, 76(9), 178–196. https://doi.org/10.1111/j.1750-3841.2011.02386.x

Driedger, A. G. J., Dürr, H. H., Mitchell, K., & Van Cappellen, P. (2015). Plastic debris in the Laurentian Great Lakes: A review. *Journal of Great Lakes Research*, *41*(1), 9–19. https://doi.org/10.1016/J.JGLR.2014.12.020

Government of Canada. (2016). Fact sheet - Community water fluoridation. Retrieved November16,2018,from https://www.canada.ca/en/services/health/publications/healthy-living/fluoride-factsheet.html

Health Canada. (2017). Guidelines for Canadian Drinking Water Quality Summary Table Federal Provincial Territorial Committee on Drinking Water of the Federal Provincial Territorial Committee on Health and the Environment, (February 2017).https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/pubs/water-eau/sum_guide-res_recom/sum_guide-res_recom-eng.pdf

Lalumandier, JA. Ayers, LW. Fluoride and bacterial content of bottled water vs tap water. Arch FamMed2000;9246-250

Salvadori, M.I., Sontrop, J.M., Garg, A.X., Moist, L.M., Suri, R.S., Clark, W.F., 2009. Factors that led to the Walkerton tragedy. Kidney Int. Suppl. S33–S34.

Westerhoff, P., Prapaipong, P., Shock, E., & Hillaireau, A. (2008). Antimony leaching from polyethylene terephthalate (PET) plastic used for bottled drinking water. Water Research, 42(3), 551–556. https://doi.org/10.1016/j.watres.2007.07.048

Woo, D. M., & Vicente, K. J. (2003). Sociotechnical systems, risk management, and public health: Comparing the North Battleford and Walkerton outbreaks. Reliability Engineering and System Safety, 80(3), 253–269. https://doi.org/10.1016/S0951-8320(03)00052-8

World Health Organization. (2012). Pharmaceuticals in drinking-water. Geneva. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/44630/9789241502085_eng.pdf?sequence=1&isAllowed=y

World Health Organization. (2017). Guidelines for Drinking-water Quality. Geneva. Retrieved fromhttp://apps.who.int/iris/bitstream/handle/10665/254637/9789241549950-eng.pdf?sequence=1