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626

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The effect of flushing on lead concentrations in drinking water

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Abstract

Current Environmental Health Standing Committee (enHealth) advice recommends flushing kitchen taps for 30 seconds each morning, because lead can leach into water that has been in contact with brass plumbing fittings for an extended period. A study of 108 Sydney households identified that a five to ten second flush was sufficient to reduce lead concentrations below the Australian Drinking Water Guidelines (ADWG) in all kitchen tap water samples. This supports a change to enHealth recommendations, as a five to ten second flush not only meets public health requirements but is also more realistic for customers to achieve and increases water savings.

Key words: brass, drinking water, flushing, lead, plumbing

Highlights

- Water samples were collected from kitchen taps at various flushing times.
- Eight per cent of 'First Flush' samples exceeded the ADWG for lead.
- A five to ten second flush ensured all samples met the ADWG for lead.
- Greater lead concentrations were found in properties with taps installed post 2000.

INTRODUCTION

Every day, Sydney Water supplies over 1.5 billion litres of safe drinking water to over five million customers. Under their operating licence, Sydney Water must provide drinking water which meets the Australian Drinking Water Guidelines (ADWG) (NHMRC 2011). Sydney Water's compliance water-testing results are reported to customers and non-compliances are reported to NSW Health.

The Australian Government National Health and Medical Research Council (NHMRC) states that blood lead levels exceeding ten micrograms per decilitre can be harmful to organs and bodily functions, particularly in unborn babies, infants and children (NHMRC 2015). In a study by Harvey *et al.* (2016), brass fittings were found to be the primary source of lead leaching into water in NSW, Australia. The Australian Standard (AS/NZS 3718:2005) permits up to 4.5% lead content in brass fittings, compared with 0.25% in the USA and Canada (NSF 2016). Other sources of lead in drinking water could include lead-based solder and lead service lines, but both are rare in Australia. The background lead concentration in drinking water supplied by Sydney Water ranges from 0.10 μg/L to 0.70 μg/L, with an average of 0.34 μg/L. The current ADWG health guideline value for lead is 10 μg/L.

The role of internal household plumbing in the exposure of people to lead is well known (Taylor *et al.* 2018). In July 2018, the Environmental Health Standing Committee (enHealth) issued a guidance note recommending that Australian households flush taps used for drinking and cooking for at least 30 seconds after periods of overnight stagnation, and up to three minutes after extended

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non-use (enHealth 2018). This advice was issued after several high-profile incidents in which high lead concentrations were detected in drinking water that had been in contact with brass plumbing fittings for extended periods.

Currently, there is limited evidence to support 30 seconds as the best flushing time to reduce lead concentrations in drinking water. While conservative from a public health perspective, a 30-second flush may not be realistic for most households. Furthermore, during times of drought, advice to flush taps for 30 seconds contradicts messages to save water. Following discussion with NSW Health, a study was undertaken to investigate the impact of tap flushing time on the concentration of lead in household drinking water.

METHODS

Water samples were collected from the kitchen taps of 108 properties within the greater Sydney, Illawarra and Blue Mountains regions after at least eight hours of overnight stagnation. Sydney Water staff volunteer participants were provided with a sampling kit and instructions to collect four 250 mL water samples from their kitchen tap; the first flush, and after five seconds, 30 seconds and two minutes of flushing at moderate flow. All sampling procedures were based on the Australian Standard (AS/NZS 5667.5:1998), and the method and instructions were designed to be simple to follow by people with no water sampling experience.

Samples were refrigerated before being taken to Sydney Water Monitoring Services Laboratories, where they were analysed for aluminium, chromium, copper, iron, lead, manganese, nickel and zinc, and assessed against the ADWG health guideline values. Additional and usually standard determinations like pH and conductivity were not undertaken due to limited field instrument access and inexperienced participants. To enable comparative analysis, Sydney Water's supply zone compliance sampling data (routine samples taken from over 750 properties across Sydney Water's area of supply) was used to represent local water chemistry. Participants were also asked to complete a survey about the property's age and plumbing, and sampling details.

RESULTS AND DISCUSSION

Assumption regarding flushing times

Participants were instructed to begin timing their flush after collecting the 'first flush' sample, so that the 'five second' sample was taken after the first flush plus five additional seconds of flushing and so on. As participants ran their taps at different flow rates, the 'five second' samples collected for the study probably represent ten seconds of flushing. This is a conservative assumption and it is recommended that future studies take the issue into account.

Summary of analyses

Apart from lead and nickel, all metals analysed were below the ADWG health and aesthetic values for all first flush and subsequent samples. Lead, nickel and zinc all showed a distinct decrease in concentration between the first flush and five second samples, while copper concentrations were consistent across the two minute sampling time. First flush nickel exceedances were not investigated further in this study, but it should be noted that all five second and subsequent samples were below the ADWG health guideline value for nickel.

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Change in lead concentration with flushing time

Figure 1 shows the change in lead concentration with sample flushing time. Eight per cent of first flush samples exceeded the 10 μg/L ADWG value for lead, but all subsequent samples were below guideline values. This shows that a five second flush was sufficient to ensure that all samples were below the ADWG health guideline value for lead. It is important to note that the further reduction in lead concentration from the five second sample to the two minute sample was less significant.

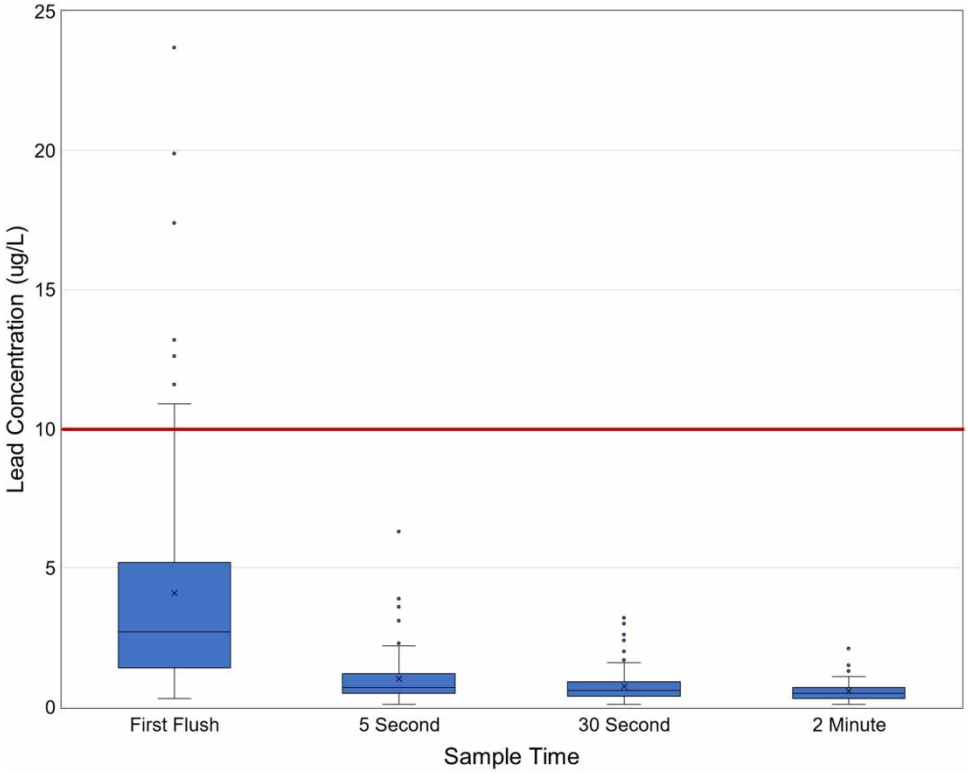

Figure 1 | Change in lead concentration with flushing time.

Year of kitchen tap installation

The survey results enabled comparison between first flush lead concentration and other variables. Figure 2 shows the relationship between the year the kitchen tap was installed and the first flush lead concentration. Despite the trendline having a low R^2 value (0.13), it is apparent that recently installed kitchen taps were more likely to yield higher first flush lead concentrations.

The Australian Standard (AS/NZS 3718:2005) permits up to 4.5% lead content in brass fittings. It is likely that newer taps have a greater amount of lead accessible on the surface of the brass fitting, resulting in a high first flush lead concentration, while the majority of accessible lead has already leached out of older taps, so that their first flush lead concentration is lower.

Lead concentrations across Sydney Water's drinking water network

The background lead concentration in Sydney Water's supply delivery networks was determined from compliance sampling program data from January 2018 to May 2019. Compliance samples are taken from over 750 customers' front garden taps after three minutes of flushing.

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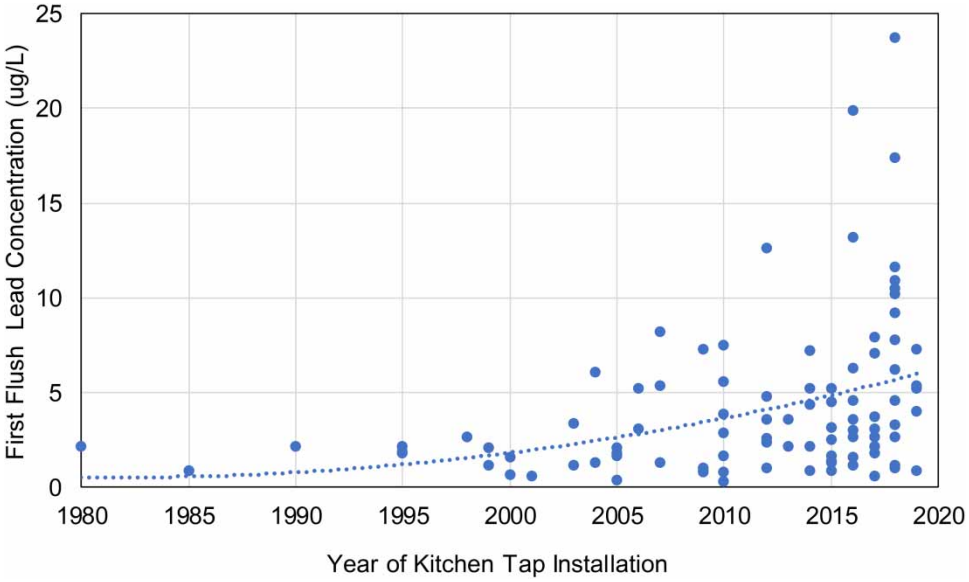

Figure 2 | Relationship between lead concentration of first flush sample and kitchen tap installation year.

The background lead concentrations ranged from 0.10 μg/L to 0.70 μg/L, with a general average of 0.34 μg-Pb/L. Any additional lead present in samples taken for this study is assumed to have leached from plumbing fittings within the residential property.

Lead concentration and water chemistry

The background pH, conductivity and hardness levels across the drinking water supply network were obtained from the compliance sampling program. The results were compared with the first flush lead concentrations to determine whether there was any correlation between water supply corrosivity and the concentration of lead dissolved from household plumbing.

Figure 3 overlays the first flush sample lead concentrations on the background pH of the water supply networks. The small sample size meant that statistical analysis was not possible, but results were compared spatially and no clear spatial relationship between the water supply network and lead concentration was found. In future studies, consideration should be given to collecting water chemistry data at the kitchen tap to enable more accurate analysis.

CONCLUSIONS

The impact of flushing time on lead concentrations is important. This study shows that a five to ten second flush is sufficient to ensure that water meets the ADWG health guideline value for lead. The findings support a change in the enHealth flushing time recommendation from 30 to 10 seconds. This will meet public health requirements, and is more realistically achievable for the customer and more water efficient.

The results also support recent research identifying end-of-line domestic plumbing fittings as one cause of increased lead levels in drinking water, providing support for a review of the Australian Standard (AS/NZS 3718:2005) for allowable lead content in brass plumbing fittings.

This study, and subsequent reviews of the enHealth flushing recommendation and Australian Standards would be further enhanced by similar studies undertaken on a national scale to improve understanding of the impact of flushing times and household plumbing on lead concentrations in drinking water.

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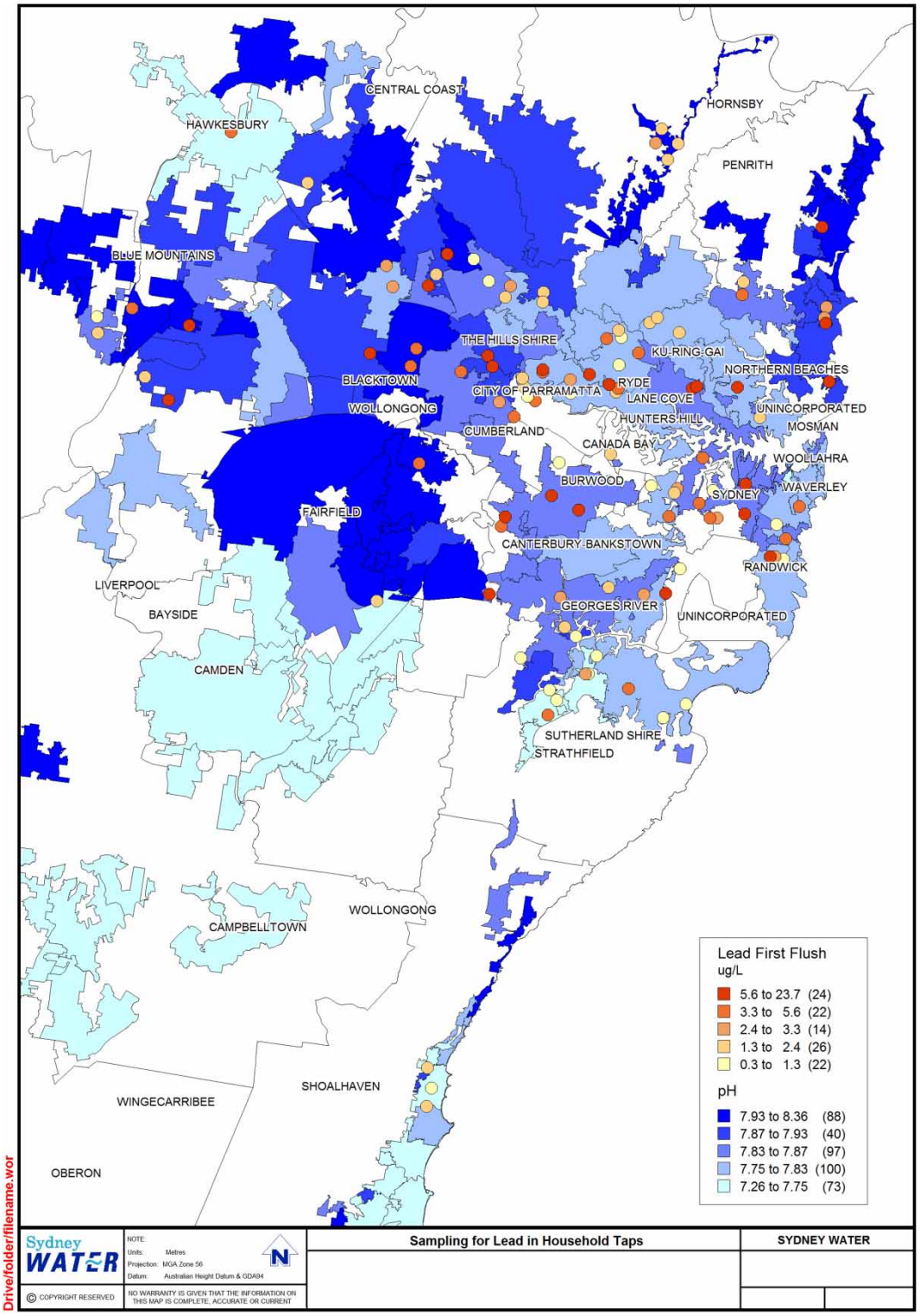

Figure 3 | Relationship between pH and first flush sample lead concentrations.

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