CHM 240
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The Lead Concentration in Drinking Water in Grinnell

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Introduction

Lead is a toxic heavy metal. One of the main sources of lead exposure in our daily life is drinking water. Prolonged exposure to lead be at risk for high blood pressure, heart disease, kidney disease, and reduced fertility. Children is particularly vulnerable to lead exposure, even at a low concentration, because lead is a strong neurotoxin, and can influence the development of cognition, language ability etc.

Safe Water Drinking Act only allow the usage of lead-free material for plumbing facilities before 1986. Therefore, houses built before then may still face the risk of exposure. The solid lead in the pipe or solder can react with the chlorine in the water, and become aqueous form, which is more mobile and bioavailable.

To investigate the level of lead exposure from drinking water in Grinnell, we collected in total 44 water samples from 18 houses and measured the lead concentration. Most of the samples turned out to be significant lower than the EPA action level which is 15μg/L. Beside lead concentration, we also measured iron and phosphorous concentration, as iron is a good indicator of the level of pipe corrosion, and phosphorus is a common additive in water to control the lead concentration.

Methods

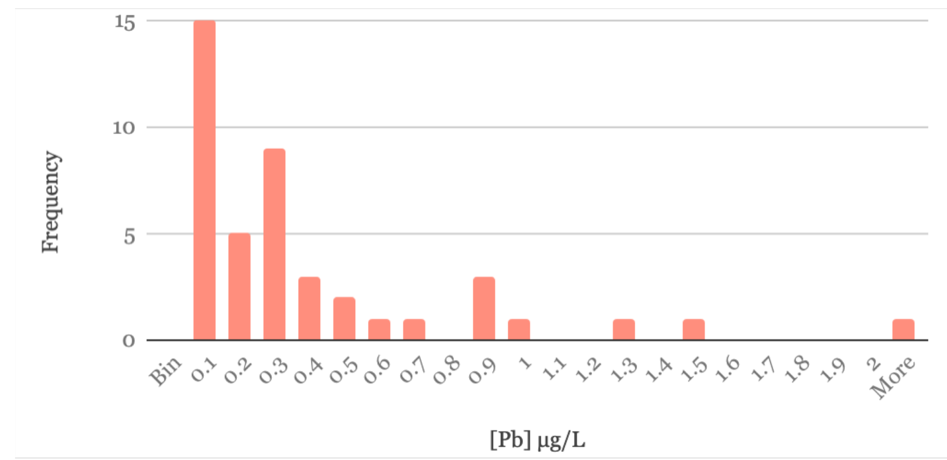
To get a comprehensive understanding of the lead exposure from drinking water under different condition in Grinnell, we collected the water samples from the houses built in different time period and with the pipe made with different materials. Lead, copper, galvanized, and PVC pipes may contain different lead levels. Furthermore, we also collected the water of all kinds that each single house had (tap water from all, filtered water and soften water if available). For each water type we collected two types of samples: first flush and normal flush; first flush is the water that has stagnated in pipes for more than 6 hours, which allows more lead to dissolve in the water theoretically; this is the high bar of the risk, and also the standard sample to take. Normal flush is taken after letting water run for 2 mins at the max rate. To eliminate the possible contamination from the air, we also took field blank samples by placing the ultrapure water in the room with lid open.

We acidified water samples to dissolve the solid lead particulates. We ran the samples through ICP-MS to measure [Pb] and [Fe], and randomly picked samples to measure [P]. All of data are interpreted using a calculated calibration curve.

Results

Overall result:

All five field blank samples have lead below the detection level, so we can safely ignore the influence of lead particulate in the air. The 18 houses we took samples from vary in built years, ranging from 1900 to 2000, and the they cover copper, galvanized, PVC pipe types. Among the 44 samples, the overall lead concentration is very low. With all of them under EPA's action level, the mean [Pb] is 0.60 μg/L, the median is 0.22 μg/L and the standard deviation is 1.97. With just 4 outliers, all of the samples have lead concentration below 1μg/L (Figure 1). The only extreme sample is a first flush tap water sample with [Pb] of 13.3 μg/L, because the water was stagnated for at least six months according to the water sample donor and thus a high lead concentration is expected.



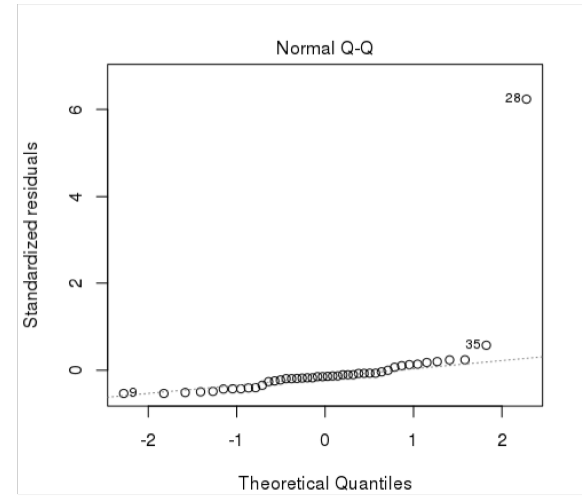
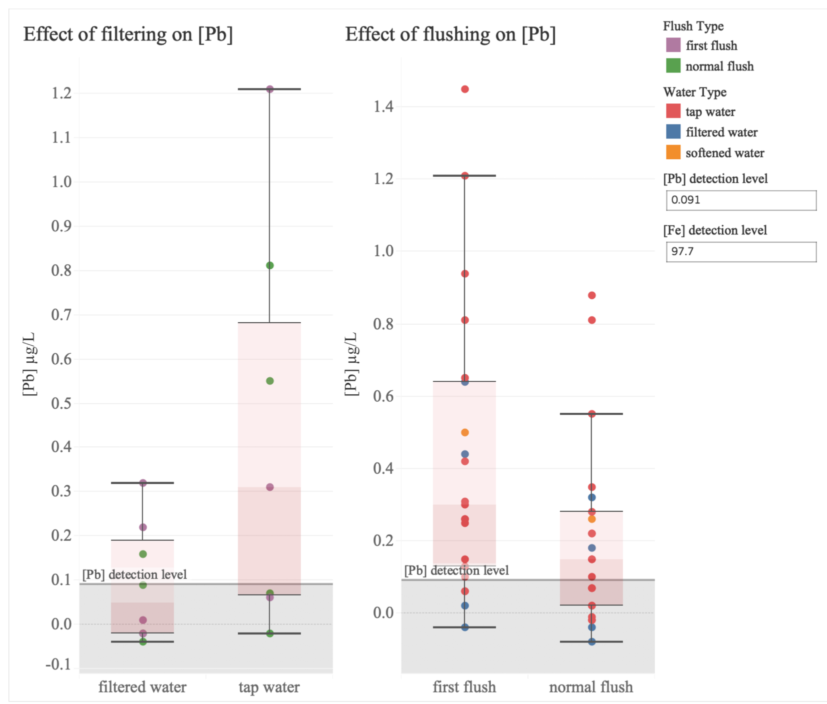


Figure 1. Histogram of [Pb]
Figure 2. Q-Q plot modeling on the flush type (first or normal flush) and water type (tap, softened, filtered water)

Effect of flushing and filtering:

Except the one extreme value, most samples fit into a normal distribution nicely (Figure 2). ANOVA single factor tests were implemented to verify the effect of flushing and filtering on lead reduction in the water. Although there is no statistical significance (P-value$_{flush}$=0.22, P-value$_{filter}$=0.25), the reduction effect is still obvious numerically, excluding the one extreme value mentioned (Figure 3). A linear model on the the filtered and tap water samples also suggests a reliable reduction performance by filtering (Figure 4).



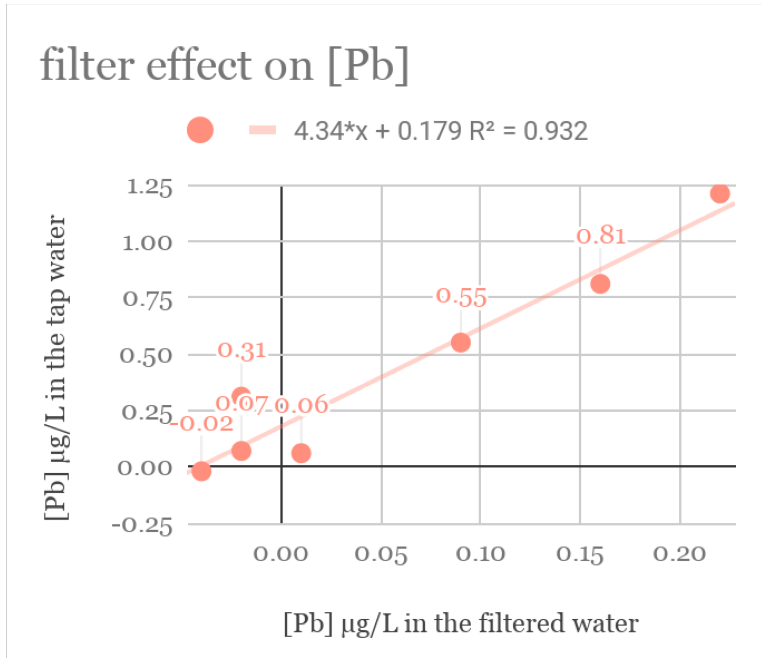


Figure 3. Comparison between different types of samples
Figure 4. Linear regression: the pair of filtered and tap water samples of the same flush type and same house

Possible indicators, Fe and P:

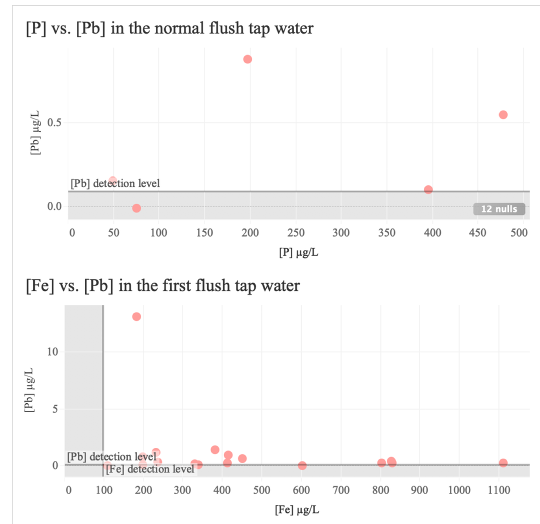
There is no clear linear relation between [Pb] and [Fe] or [P] in the tap water (Figure 5).

Conclusions

Overall, the lead concentration in Grinnell's drinking water is very low, but still distant from lead free. There is not a clear geographic trend, and we also acknowledge that the samples collected for this experiment cannot comprehensively represent the lead concentration level in Grinnell area, because all the samples are from houses for professors and students of the Grinnell College.

We also confirm that flushing and filtering can be very effective methods for protecting against lead exposure from the drinking water, even if the water has been stagnated for a long period. Although we expected that [Fe] or [P] can be a good indicator of lead concentration, the experiment proves that this is wrong.

To further investigate the source of the lead, we will need a well-recorded dataset of pipe material and plumbing material information.



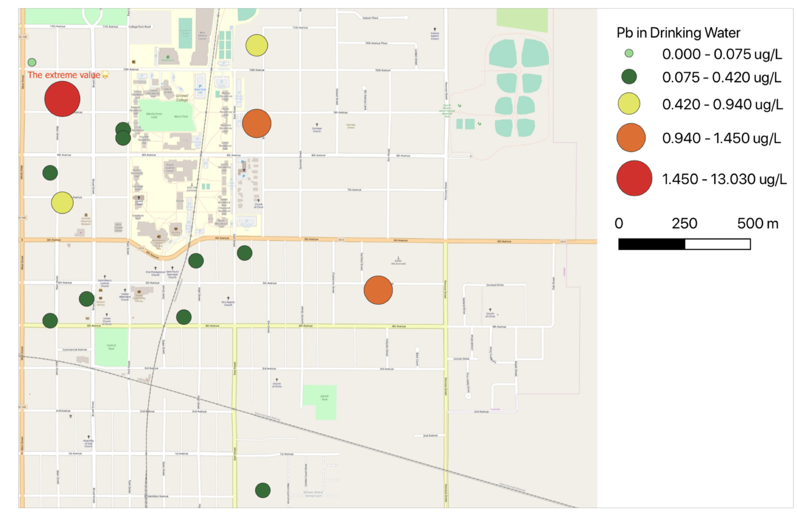


Figure 5. [Fe] or [P] vs. [Pb] in tap water
Figure 6. GIS mapping of the sampling locations

Acknowledgements

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