Strategies to Reduce Lead Exposure from Drinking Water

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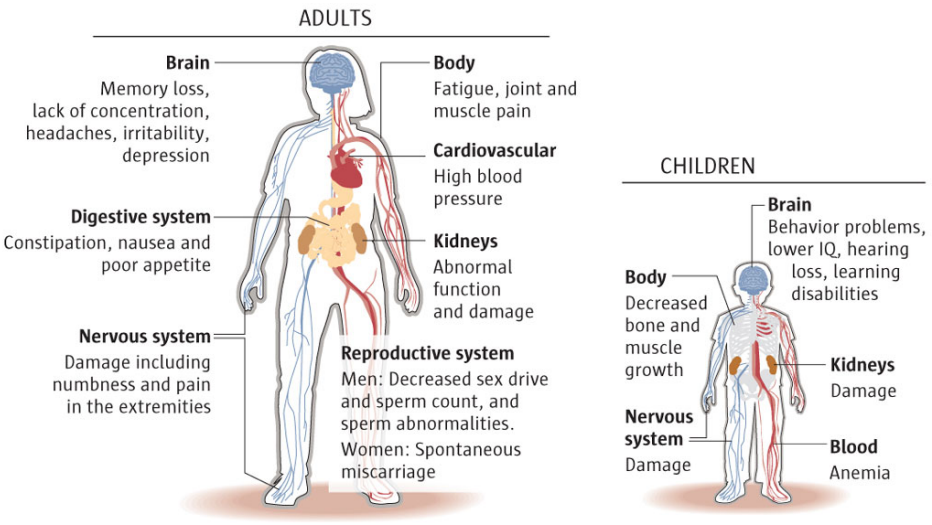
25 November 2015

Lead (Pb)

- is a naturally occurring toxic heavy metal
- widespread industrial uses (battery production, preparation of paints and petrol, etc)
- ubiquitous in the environment as a pollutant
- no known biologic role in human body
- interrupts various enzyme systems by binding to sulfhydryl groups
- no “safe” level in human – the lower the better

Toxic Effects of Lead



Population most susceptible to Lead

- Because of the neurodevelopmental effects, subgroups that are most sensitive to lead
  - **Fetuses (pregnant ladies)**
  - **Infants**
  - **Children**
- Pregnant lady
  - adverse outcomes of pregnancy (miscarriages, pre-eclampsia, pre-term labour, etc.)

WHO Pb level standard in drinking water : 10 µg/L

- Joint FAO/WHO Expert Committee on Food Additives (JECFA) Metabolic studies in infants showed that a mean daily intake of 3-4 µg/kg B.W. was not associated with an increase in blood lead levels or in the body burden of lead versus ≥5 µg/kg B.W. resulted in lead retention
- In 1986, JECFA established a provisional tolerable weekly intake (PTWI) of 25 µg of lead per kg B.W. (3.5 µg/kg per day s 7)
- Assuming a 50% allocation of the PTWI to drinking water for a 5kg bottle fed infant (the most vulnerable subject) consuming 0.75 litre of drinking water per day
- Guideline value = 3.5 µg/kg/d x 5kg x 50% ÷ 0.7L/d = 12.5 µg/L

WHO Guidelines for Drinking Water Quality, 4th ed
WHO/SED/WSH/03.04/09/Rev/1

WHO Pb level standard in drinking water : 10 µg/L

- JECFA re-evaluated lead in 2010, finding that exposure to lead is associated with a wide range of effects, including various neurodevelopmental effects, mortality (mainly CV diseases), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes
- The previously established PTWI of 25 mg/kg is associated with a ↓ of at least 3 IQ points in children and an ↑ in systolic blood pressure of approximately 3 mmHg in adults
- PTWI was withdrawn as it could no longer be considered health protective and it was not possible to establish a new PTWI
- The guideline value was renamed as “provisional”

WHO Guidelines for Drinking Water Quality, 4th ed
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People should try to drink water with as little lead as possible, especially those who are vulnerable

No level is considered completely safe

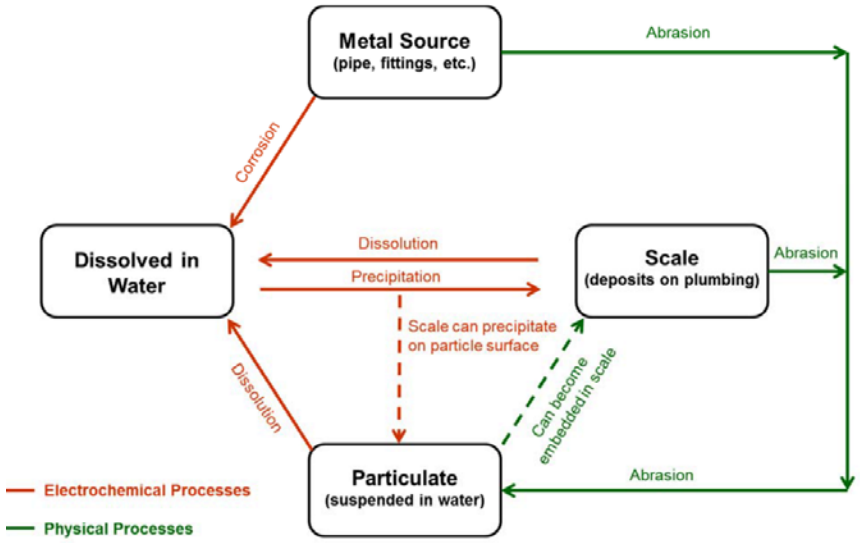
Health Services Executive (HSE) and Environmental Protection Agency (EPA) Joint Position Paper: Lead (Pb) in Drinking Water, December 2013

Source of lead in drinking water

- Lead seldom occurs naturally in water sources such as rivers and lakes
- Lead in drinking water at the customer tap is almost exclusively the result of water contact with lead-containing components in the distribution system or household plumbing
- These components can include **pipes containing lead**, **lead-based solder** used to join copper pipe, and **fixtures/faucets made of brass and chrome-plated brass**
- Lead can be present in the drinking water at customers' taps if corrosion of lead-containing piping, fixtures, or fittings occurs

Controlling Lead in Drinking Water, Water Research Foundation 2015
Lead in Drinking Water Mitigation Strategy, Toronto Water 2011

Sources and fates of lead in drinking water



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Lead (Pb) in drinking water

- The amount of lead dissolved from the plumbing system depends on several factors, including
  - pH
  - temperature
  - water hardness
- Lead concentrations can also vary according to the period in which the water has been in contact with the lead-containing materials

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Possible mechanisms for limiting lead release at the consumer's tap

- Removing any lead sources in the service lines and customer plumbing
- Controlling the chemistry of water entering the customer service line to limit the solubility of any lead in contact with water
- Installing an additional treatment barrier at the tap such as a point of use filter
- Measures at consumer level
  - Use only cold water for drinking and food preparation
  - Flush taps before use
  - Alternative source

Controlling Lead in Drinking Water, Water Research Foundation 2015
Reducing Lead in Drinking Water, Minnesota Department of Health 2014

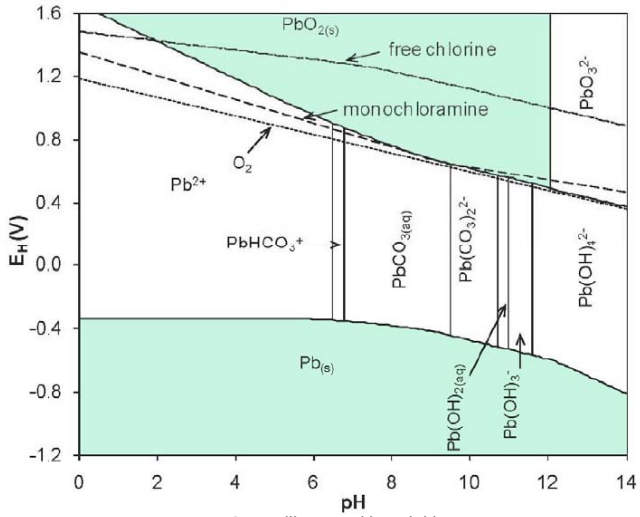
Remove all lead sources from the service lines and plumbing

- Removing all plumbing components that contain lead eliminates virtually all potential for customer exposure to lead from drinking tap water

Remove all lead sources from the service lines and plumbing

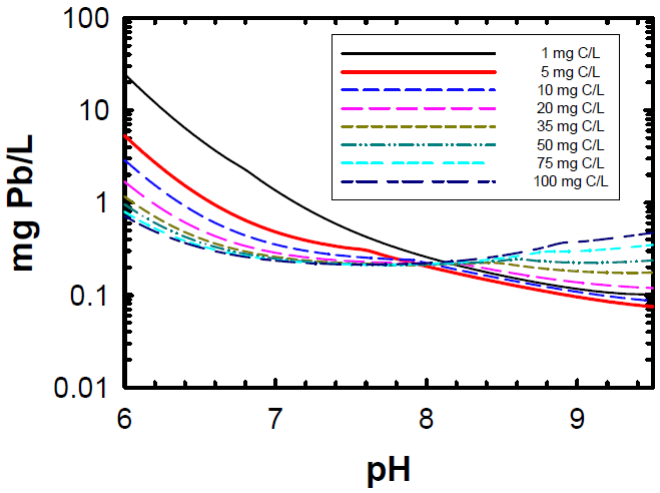
- For most systems, this solution is complicated by logistical constraints, and can become prohibitively expensive
- Lead-containing plumbing is the original source of lead in a structure but lead from these sources can migrate over the years and be deposited on other plumbing between the lead sources and the customer's tap
- In these cases, all the plumbing, not just the original lead-containing plumbing, needs to be replaced, thereby adding to the cost and complexity of this approach

Impact of pH and oxidation state on lead solubility in drinking water



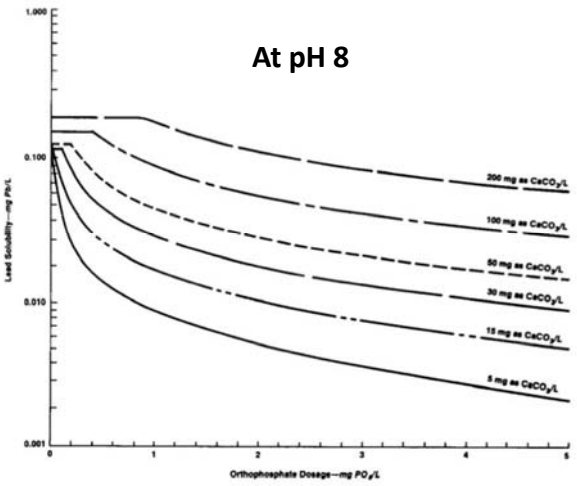
Controlling Lead in Drinking Water, Water Research Foundation 2015

Impact of pH and alkalinity (dissolved inorganic carbon, DIC) on lead solubility in drinking water



Controlling Lead in Drinking Water, Water Research Foundation 2015

Impact of DIC and orthophosphate on lead solubility



- Orthophosphate works by forming a protective coating inside water pipes

Helps reduce corrosion and the leaching of lead from surfaces in contact with drinking water

Ability to use orthophosphate to produce a lower lead solubility at lower pH values

Controlling Lead in Drinking Water, Water Research Foundation 2015

Control Water Chemistry

- Optimal corrosion control treatment (OCCR): minimizes the lead concentrations at users' taps while insuring that the treatment does not adversely affect the water quality
- Commonly used strategies:
  - The maintenance of oxidized conditions with high free chlorine residuals (typically >1 mg/L as Cl_2) to form and maintain insoluble Pb(IV) scale
  - The control of pH and alkalinity (DIC),
  - The use of orthophosphate within appropriate pH ranges.

Brown, R., et al. 2013. Jour. AWWA. 105(5):62-75.

Limitations and problems of optimal corrosion control treatment

- Maintenance of oxidized conditions to retain a Pb(IV) scale is sometimes difficult to reliably monitor and control
- Adjusting pH and alkalinity may not be suitable at all water utilities for reasons including scaling, formation of regulated disinfection by-products (DBPs), and difficulty in maintaining the required pH and alkalinity conditions
- Encourage microbial growth by orthophosphate
- Elevate phosphorus content of wastewater discharges

Controlling Lead in Drinking Water, Water Research Foundation 2015

Point of use water filter

- A point of use (POU) water treatment device may be installed at taps with lead levels exceeding the reference value
- The device should be approved to meet NSF Standard 53, NSF Standard 58, or an equivalent standard]
- It is to be installed, operated, and maintained in accordance with the manufacturer's recommendations.

Reducing Lead in Drinking Water, Minnesota Department of Health 2014

Measures at user level

- Use only cold water for drinking and food preparation:
  - Hot water is more likely to contain higher levels of lead than cold water.
  - Only water from the cold water tap should be used for drinking, preparing juice, mixing baby formula or food preparation
- Alternative source of drinking water

Reducing Lead in Drinking Water, Minnesota Department of Health 2014

Flush taps before use

- The longer water has been standing in the plumbing system, the more lead it may contain
- Running water at a tap for a period of time prior to using it for drinking or food preparation often works to reduce lead concentrations in drinking water by removing the water with the most lead from the system
- The effectiveness of flushing should be verified by testing the water before and after flushing

Lead in Drinking Water Mitigation Strategy, Toronto Water 2011
Reducing Lead in Drinking Water, Minnesota Department of Health 2014

Test the water for lead

- The only way to determine how much lead is present in the drinking water is to have the water tested
- Analyze the drinking water samples in certified laboratory
- First draw sample versus running water sample
- First draw sample
  - Sample collected before the fixture is used or flushed during the day
  - Testing the system for lead-containing components
- Running water sample
  - Sample obtained after flushing the tap for a period of time
  - May reflect more on the amount of lead in water used for drinking and cooking
  - To confirm the effect of flushing

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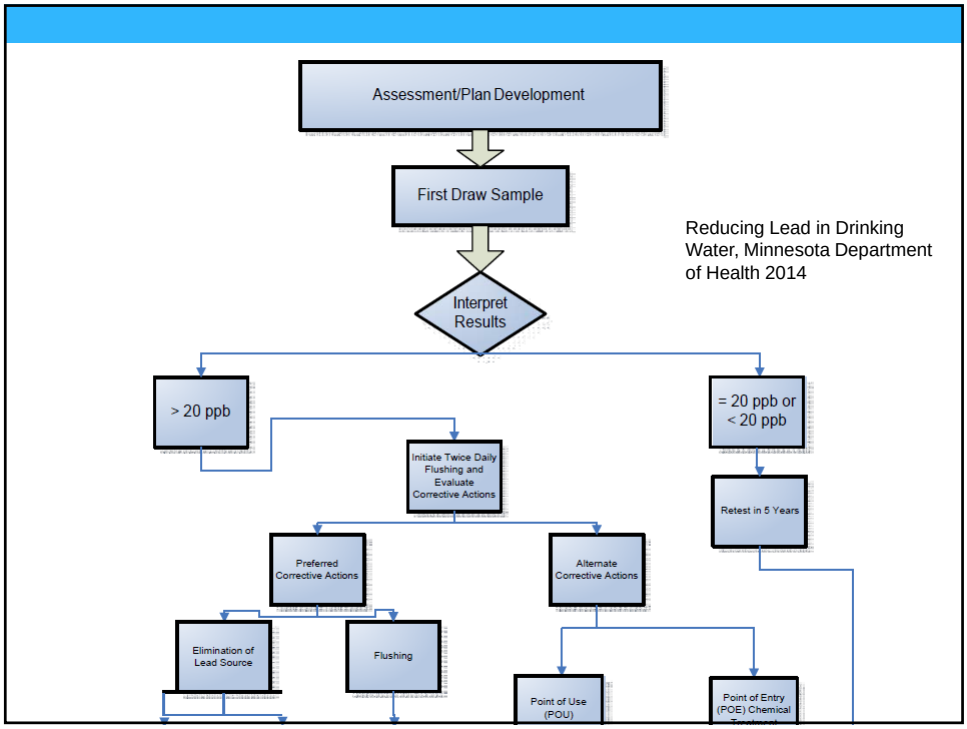

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Public Education & Communication

- A key element of any national strategy to reduce exposure to lead in drinking water
- Customer behavior and usage practices may have an impact on customer exposure to lead
- Raise the awareness amongst responsible bodies and consumers, particularly focused on vulnerable groups
- Important elements:
  - providing information on flushing practices
  - using cold water for drinking, cooking or preparing baby formula
  - requesting water quality testing

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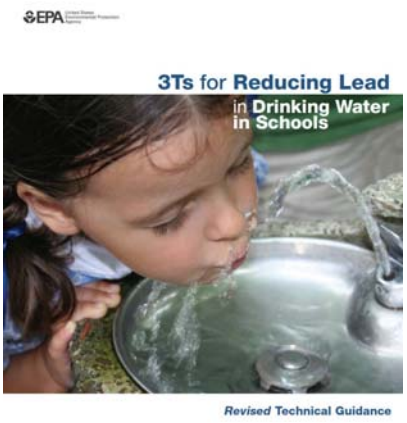
Policy & Responsibility

- Policy and legislation
- Guidance and protocols
  - E.g. EPA developed the 3Ts (**Training, Testing and Telling**) to assist all categories of schools in reducing lead in drinking water
- Responsibilities of various parties
  - Government, property owners, personnel installing or carrying out works on water supply pipes



Reducing Lead in Drinking Water, Minnesota Department of Health 2014
National Strategy to reduce exposure to Lead in Drinking Water, Ireland, 2015

Summary

- Exposure to lead is a significant health concern, particularly for young children and infants
- A number of strategies have been used in various countries to reduce lead exposure in drinking water, including:
  - Removing service lines and plumbing materials that contain lead
  - Adjusting the water chemistry to produce conditions that inhibit lead release
  - Installing a point of use filter
  - Measures at the user level: flushing, cold water for drinking, alternative source of drinking water
- The responsibility for actions to reduce the level of lead in drinking water is collective

Thank you

The End