Contamination of Tap Water by Lead Pipe and Solder

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We report here potential sources of lead contamination from a tap water distributing system using lead service pipes and soldering alloy to join copper pipes. In this note, we present data of lead levels in tap water of the City of Victoria, B.C., Canada and our findings on the dissolution of lead from the distributing system. Lead service pipes were used in the city of Victoria about 40 years ago to convey water from the city main to about 8,000 to 10,000 older houses.

MATERIALS AND METHODS

Water samples were collected from the city reservoir and from the taps of households in areas with and without lead pipe delivery system. The lead concentrations in water were analyzed by a flameless atomic absorption technique in a lead-free clean room. All water samples were collected and stored in acid cleaned polyethylene bottles, acidified immediately to a pH of about one with quartz-distilled nitric acid and analyzed within eight hours of collection. The lead concentrations were determined by pipetting 50µl aliquots of sample onto the tantalum ribbon atomizer MTA-2 of a double-beam Jarrell-Ash 82-810 atomic absorption spectrophotometer and measuring the absorption at 2833 Å using a specially-built fast response peak reader. A non-absorbing lead-line at 2820 Å was used for background correction.

RESULTS

The results showed that the levels of lead varied with the volume of water flushed through the plumbing system before sampling (Table 1).

Thus, lead-piped water has apparently higher lead content, but sampling by disconnecting lead pipes at 5 a.m. could produce lead files not representative of a normal situation. To determine the

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TABLE 1

Concentration of Lead in Drinking Water from Various Sources

System	Volume of Water Flushed Through System Prior to Sampling (ℓ)	Number of Samples Collected	Lead Concentration (ppb)
Reservoir	-	1	< 1
Tap Water (non-lead pipe area)	20	9	1-13
Lead pipe (sampled at 5 a.m. by disconnecting underground lead service pipe)	0.5	8	60-2,600
	25	6	20-260

extent of contamination in situations of normal water usage, the lead contents in tap water were collected in the morning, at noon and in the evening from 55 homes with lead service pipes. The results indicated 1% of the samples had lead concentrations higher than 100 ppb, 5% higher than 50 ppb*, 74% between 25 ppb and 50 ppb and 16% below 25 ppb. The average daily value, however, showed only 4% (two houses) between 100 and 50 ppb, 5% (three houses) between 50 and 25 ppb and 91% below 25 ppb. In areas with copper service pipes, the morning, noon and evening samples all were below 25 ppb with the exception of two samples at 25 and 27 ppb at noon. Daily averages for water from non-lead pipes were all below 25 ppb.

However, abnormally low water usage from plumbing with soldered copper pipes can produce accumulation of lead to dangerous levels as we discovered in our laboratory tap water. Our laboratory was built in late 1972 and some of the taps were unused or occasionally used. Results of lead concentrations in water collected (24 hours after the last flushing) from an occasionally used tap and a tap known to be unused for about six months are given in Tables 2 and 3 respectively.

*The Canadian federal limit for lead in drinking water is 50 ppb.

TABLE 2 Lead in Water taken from an Occasionally Used Tap 24 Hours after Last Flushing

Volume of Water Flushed Through Tap (ℓ)	Lead Concentration (ppb)
0.005	130
0.020	130
0.060	240
0.125	410
0.310	330
0.615	60
1.220	16
2.425	17
300.000	7

TABLE 3 Lead in Water Taken From A Tap Not Used For About Six Months

Volume of Water Flushed Through Tap (ℓ)	Lead Concentration (ppb)
0.005	390
0.025	3,000
0.055	2,300
0.105	2,100
0.210	2,500
0.415	490
0.920	190
1.920	64
6.920	15
200.0	12

To confirm that lead solders used in copper plumbing contaminates the water, we fabricated a system with 50 feet of 1/2" copper tubings soldered together with 20 soldered joints using a 50/50 (tin/lead) solder, 60/40, 95/5 and silver solder. The results (Table 4) indicated that the 50/50 and 60/40 tin/lead solders commonly used in soldering household copper plumbing would produce water above the Canadian federal limit of 50 ppb for the first 12,000 liters of water usage. The 95/5 and silver solder yield very low lead content.

TABLE 4

Lead Concentration (ppb) in Water Stagnant for One Hour in a New Simulated Household Copper Plumbing System (50 feet copper tubings joined by 20 soldered joints).

Solder	Volume of water flushed through the system(ℓ) 80	1200	12000	25000	150000
50/50	1200	150	96	34	9
60/40	1100	130	49	25	7
95/5	3	2	-	1	-
Silver	2	2	-	1	-
Copper Only	1	2	-	1	-

After our simulated system for 50/50 solder was flushed with 150,000 ℓ of water, equivalent to the normal water usage of about one year, the average dissolution rate was found to be 0.4 μg Pb/solder joint/hr., for water stagnant for one hour, and 0.1 μg Pb/joint/hr. for water stagnant for 24 hours. Tests on the real system of a one year old house yielded a dissolution rate of 0.4 μg Pb/joint/hr. The implication is that water stagnant in a one year old household plumbing system (about 2 ℓ) could exceed the Canadian federal limit of 50 ppb after 4-20 hours, assuming a dissolution rate of 0.1 to 0.5 μg Pb/solder joint/hr. For lead pipes, we found the problem to be more serious: a dissolution rate of 30-240 μg Pb/hr. for old lead service pipes and 480 μg/hr. for a new lead service pipe. Thus, water in contact with lead pipe could exceed the Canadian federal limit in only 10-100 minutes.

We suggest the following steps for minimizing the danger from lead contamination in tap water:
(1) Substitute the tin/lead solder commonly used in house plumbing with a 95/5 tin/lead solder.
(2) Flush the plumbing system in new houses with water equivalent to a year's normal usage.
(3) Do not use the first two liters of water from taps for human consumption if stagnant for a day.

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