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Analysis of heavy metal concentrations in drinking and non-drinking water in the Bao'an and Nanshan districts

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Abstract: *Water quality is a topic of concern in many areas around China, especially in the south-eastern parts where population is extremely dense. High concentrations of specific metals can be harmful to the general public, so it is important to observe whether these metal concentrations are within safe limits. Here, heavy metal concentrations in both direct-drinking water and running water were tested by ICP-MS in both Bao'an and Nanshan districts in Shenzhen. The manganese, copper, arsenic, selenium and cadmium concentrations were below the recommended regulatory values, but iron, zinc and lead concentrations were higher than the recommended regulatory values in certain samples in both districts. This is a potential health hazard that should be investigated further.*

Keywords: *water quality; Bao'an; Nanshan; heavy metals; ICP-MS; drinking water*

1. Introduction

It is important to have access to drinking water that has safe amounts of heavy metals. For example, chronic, excess zinc intake can result in copper deficiency and profound neurologic disease[1] and excess lead intake can result in cardiovascular issues, decreased kidney function and reproductive issues in adults and poor growth or behavioral or learning problems in children. [2,3]In China, various metal concentrations have been on the rise throughout the previous decade. In many districts around the country, some metal concentrations have started to slowly exceed the safe and recommended regulatory limits.[4] The government has realized the importance of having clean water and is attempting to provide safer water to citizens. However, more efforts have been made to deal with the water eutrophication problem, and not enough attention has been paid to the heavy metal concentrations in water.

In China, there are different pipes delivering running water and direct-drinking water to homes and parks; however, it is common practice for residents to simply boil the running water and use it for drinking. As a result, both types of water should be tested to check that heavy metal concentrations are in a safe range for drinking. Furthermore, although regulations on the concentrations of heavy metals have been set by the government, citizens cannot easily track the real concentration of heavy metals in the water that they are drinking or using.

In this project, the concentrations of Manganese, Iron, Copper, Zinc, Arsenic, Selenium, Cadmium, and Lead were measured by *ICP-MS* in drinking and running water at one park in each of the Bao'an (Figure 1) and Nanshan (Figure 2) districts in Shenzhen from Guangdong Province.

Figure 1: Water collection site in the Bao'an District.

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Figure 2: Water collecting site in the Nanshan District.

2. Methods

Nitric acid was purchased and used without further purification. Nalgene bottles were used for all sample collection and storage

Table 1. Concentrations of metal in drinking water and non-drinking water as detected by ICP-MS

	Direct-Drinking water in Bao'an District		Running water in Bao'an District		Direct-Drinking water in Nanshan District		Running water in Nanshan District		
Metal	Avg. St. Deviation (ppb)	Conc. with 95% confidence interval (ppb)	Avg. St. Deviation (ppb)	Conc. with 95% confidence interval (ppb)	Avg. St. Deviation (ppb)	Conc. with 95% confidence interval (ppb)	Avg. St. Deviation (ppb)	Conc. with 95% confidence interval (ppb)	Regulatory drinkable Value (ppb)5
Manganese	0.4	4.0 ± 0.5	2.8	7.2 ± 3.2	24.8	19 ± 28	3.2	16.9 ± 3.2	50
Iron	5.3	144 ± 6	18.8	157 ± 21	223	307 ± 253	11.2	405 ± 13	200
Copper	2.8	13 ± 5	4.4	10.3 ± 2.9	3.2	13.4 ± 3.2	3.3	10.2 ± 3.3	100
Zinc	52.8	95 ± 60	68.6	107 ± 78	53.5	216 ± 60	38.7	163 ± 44	100
Arsenic	0.017	0.73 ± 0.02	0.14	0.81 ± 0.16	0.57	1.38 ± 0.64	0.038	1.05 ± 0.07	10
Selenium	ND		ND		ND		ND		10
Cadmium	0.074	0.67 ± 0.08	0.08	0.65 ± 0.11	0.168	0.68 ± 0.19	0.113	0.60 ± 0.13	30
Lead	1.5	9.5 ± 1.8	3.7	10.3 ± 4.1	1.5	11.7 ± 1.7	1.3	8.0 ± 1.6	10

*Entries highlighted in grey are values of concern with respect to the regulatory drinkable value.
ICP-MS, inductively-coupled plasma mass spectrometry

Twelve water samples were collected from the Bao'an District and the Nanshan District in Shenzhen, China. Six water samples were collected at each site: three direct drinking water samples and three running water samples. Before water sampling, the cold water tap was turned on and allowed to run for 1 minute. Then, each bottle was rinsed three times with 150 mL of sample water before being filled, capped, stored and transferred at room temperature. The samples were tested 24 hours later.

0.25 mL of 69% nitric acid was added to 25 mL of each water sample just before analysis. The samples were then analyzed using an *ICP-MS* 7700 device. Inductively-coupled plasma mass spectrometry takes a small liquid sample and aerosolizes it before heating it up to evaporate any water. Then, any solutes from the sample pass through an inductively coupled plasma where they are broken down into their constituent ions or atoms. A mass spectrometer filters the ions by mass and determines the amount of each ion present. Each sample was added automatically to the device using an auto sampler, and the concentrations of iron, manganese, copper, zinc, arsenic, cadmium and lead were determined using *ICP-MS* with the help of a trained technician.

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3. Results and Discussion

The data (Table 1) shows that the concentrations of most metals are below the regulatory values for drinkable water, but the concentration of zinc in both the direct-drinking water (216 ppb) and the running water (163 ppb)samples in Nanshan district are beyond their reported regulatory concentrations of 100 ppb.[5] The direct drinking water has almost twice as much zinc as the regulation value. In previous tests,[4] zinc in the tap water and direct drinking water was also higher than other elements in Shenzhen.

The lead concentrations found in some of the water samples collected from both the Bao'an (running water, 10.3 ppb) and Nanshan districts (drinking water, 11.7 ppb) were also slightly beyond that of the national standard for drinkable water (10 ppb). The excess lead in drinking water could be caused by the PVC pipes, which also contain lead compounds that can be leached from them and result in high lead concentrations in drinking-water.[3]

The iron concentrations in both direct-drinking water (307 ppb) and running water (405 ppb) in the Nanshan district were also above the regulatory value of 200 ppb. The Iron concentration in the direct-drinking water sample was almost 1.5 times that of the drinkable standard, while the Iron concentration in the running water sample was approximately twice that of the drinkable standard. The heavier metals like arsenic, selenium, and cadmium were all below their standard values (10 ppb for arsenic, 10 ppb for selenium, 30 ppb for cadmium).

The standard deviations measured for copper, arsenic, selenium, cadmium, and lead in running water and direct-drinking water were relatively small compared to their actual concentrations in the water samples. However, manganese and iron concentrations varied significantly among the samples, especially in the drinking water samples from the Nanshan district.

One drinking water sample from the Nanshan district, in particular, had an extraordinarily large concentration of manganese, iron, and arsenic. This could be because the faucet was contaminated due to rust or other impurities since it was the first sample collected from this tap.

One non-drinking water sample from the Nanshan district, had a noticeably smaller concentration of copper compared to others from the same site and it is unclear why this is the case.

There may be trace amounts of selenium in the water samples taken from both districts but any selenium present in these districts was measured to be below the limit of detection for the *ICP-MS* 7700 instrument.

Although Nalgene bottles were used to collect water samples to avoid any metal contamination, it is possible that the brand new bottles could also have contained some unexpected metals since they were not washed with acid before use. This could have led to a higher measured concentration than the true value. If the experiment is repeated, the Nalgene bottles could be washed with nitric acid before the experiment to guarantee there is no metal in the bottle. Furthermore, for the samples that showed relatively high standard deviation or a single outlying result, repeated testing would be advised. Samples could also be collected and immediately tested so that the storing conditions would not affect the testing results.

4. Conclusions

Based on the results, the concentrations of zinc, iron, and lead are of concern since they were measured to be above the required safe-to-drink value.

The water at the two locations that were tested should not be consumed until further, more rigorous testing is completed. Furthermore, the concentrations of zinc and iron in the Nanshan district should be tested at a larger number of locations to check if there are potentially harmful levels of zinc and iron throughout the district or if the detected levels are localized to the two sites that were studied here.

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