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Cleanliness of Drinking Water Faucets in Public Facilities

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Abstract

Water is essential for human life. In Japan, average daily water use is about 500 L. We conducted a survey of the cleanliness of publicly used drinking facilities. The water faucets in some public facilities (such as parks, public baths) in Japan are used by many people in quick need of water. It is accepted that such faucets are beneficial in preventing disease and for general health. These faucets are regularly cleaned. However, since they are partly installed outdoors and have many users, there are doubts over their actual cleanliness. It is therefore necessary for the sake of public health to examine the safety of such facilities. In this study, we examined contamination by general bacteria and coliforms in tap water as well as on the faucet handles and intake ports using instrumental analysis and simple tests. The measured factors were total coliforms, general bacteria, residual chlorine, ammonia, nitrite, chemical oxygen demand, and pH. We detected bacteria in some drinking and bathing water samples. We believed the cause to be inadequate addition of chlorine or reduction due to consumption. We consider it necessary to introduce counter measures to prevent infection.

Keywords: Cleanliness; Public facility; Drinking water

Introduction

Water is essential for human life [1]. A person's necessary daily water intake is 2 L to 3 L [2]. In addition, in developed countries, a minimum of 20 to 30 times that amount of water is required for such domestic uses as cooking and washing as well as for industry and public facilities [1]. In the case of Japan, the per capita use of water is about 200 times the necessary daily intake [1,2]. In that country, very clean water suitable for drinking is frequently used for other purposes, such as for cleaning, in toilets, and in fountains.

In this study, we conducted a survey of the cleanliness of publicly used drinking facilities (park tap and hot-spring water) in Japan. Drinking facilities installed in parks and public baths are utilized by an unspecified number of users. They are convenient to use and provide ready sources of water.

The facilities are sometimes important in disease prevention, such as with heat stroke, and in general health promotion. Such facilities are usually supposed to undergo regular maintenance, such as cleaning by administrators. However, since the facilities are partly installed outdoors and have many users, it is probable that they soon become contaminated. Owing to the likelihood that public health safety could be impaired through the continued use of such facilities, it is necessary to determine their actual state. As defined by the Water Supply Act, the tap water supply in Japan is treated by means of chlorine disinfection [3].

This process treats the bacteria and organic substances present in raw water; the residual chlorine is reduced by chlorination or oxidation, and there is an increase in chloride ions in the water. Chlorine is also present in the water largely in the form of hypochlorite ions at around neutral pH. An equilibrium relationship thus develops with hypochlorite and gaseous chlorine molecules, which are easily vaporized by acidification and warming. Chlorine vaporizes into the air from a faucet even if the faucet is unused, thereby lowering the concentration of chlorine in the tap water.

In this study, we took samples of tap water that remained in the pipe leading to the faucet (the water that flowed immediately after turning the faucet handle), in parks and drinking fountains in Japan. We subjected the samples to instrumental analysis and simple tests to determine the state of cleanliness. The factors measured were the total coliforms, general bacteria, residual chlorine, ammonia, nitrite, chemical oxygen demand (COD), and pH in the water.

Materials and Methods

Apparatus and reagents

We measured the pH using a pH meter (F-22; Horiba, Kyoto, Japan). We determined the levels of total coliforms and general bacteria using experimental paper (Sibata Scientific Technology Ltd., Soka, Japan) according to the manufacturer's instructions. We used Packtests of N,N-diethyl-1,4-phenylenediamine, indophenol, naphthylphenylenediamine, and alkali permanganic acid (Kyoritsu Chemical-Check Lab, Tokyo, Japan) to measure residual chlorine, ammonia, nitrite, and COD, respectively [4]. We employed purified water (>18 MΩcm, Elix 3/Element A10, Merck-Millipore, Billerica, MA) for reagent preparation. All the other reagents were of special grade and commercially available.

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Sampling and pretreatment

We took the following samples: 10 water samples from the water supply in a public park in the Tokyo metropolitan area; three samples from natural hot springs (drinking fountain, bathing water, and at source) at an inn located in the mountainous area of Atami, Shizuoka Prefecture; three samples from a natural hot spring (footbath water, bathing water, and at the source at Umezono Shrine) close to the sea in Atami. There were thus 16 samples (Table 1). We took the samples in October and November 2010. With the hot-spring water samples, we took care to ensure that the water did not enter the bubble in the polyethylene collection container. We obtained the faucet samples in the park immediately after opening the faucet.

We also took samples of any deposits present on the faucet handle and water intake port and subjected them to bacterial tests. For these tests, we added the deposit samples to 10 mL of sterile water in a sterile container. We obtained the deposit samples by means of a sterile cotton swab moistened with sterile water, which was then returned to sterile container and mixed with the water. We used the resultant suspension as our sample.

We subjected the water samples to the pack tests, pH measurement, and bacterial tests as quickly as possible. If we were unable to make immediate measurements, we refrigerated the samples at 4 until the following day.

Point No.	Points	Kinds	Date
Parks, Tokyo			
1	Ueno	Tap water	Nov. 2010
2	Ikebukuro West	Tap water	Nov. 2010
3	Shinjuku Central	Tap water	Nov. 2010
4	Yoyogi	Tap water	Nov. 2010
5	Hibiya	Tap water	Nov. 2010
6	Roppongi Midtown	Tap water	Nov. 2010
7	Suido (Suidobashi)	Tap water	Nov. 2010
8	Ohyama	Tap water	Nov. 2010
9	Hachimanyama	Tap water	Nov. 2010
10	Arisugawa (Hiroo)	Tap water	Nov. 2010
Hot springs, Atami			
11	Hotel	Springhead	Oct. 2010
12	Hotel	Bath	Oct. 2010
13	Hotel	Spring for drinking	Oct. 2010
14	Public bathhouse	Spring for drinking	Oct. 2010
15	Public bathhouse	Footbath	Oct. 2010
16	Umezono shrine	Springhead	Oct. 2010

Table 1: Sampling points.

Results and Discussion

Residual chlorine, nitrite, ammonium, COD, and pH

The results appear in Table 2. The level of residual chlorine tended to be low in the hot-spring water samples. We detected nitrite in some hot-spring water samples; however, we were unable to determine whether this was the result of nitrate reduction by bacteria or human waste contamination. We detected ammonia nitrogen in some of the park water and all of the hot-spring water samples. Taken together, these two results strongly suggest human waste contamination. We believed that the high COD levels were due to the mineral components in the hot-spring water and soil contamination with the faucet water. It has been reported that ammonia nitrogen, nitrite, and COD undergo oxidation and increased concentration owing to the high concentration of chlorine during the disinfection of tap water [5]. However, with water treatment in Japan, the amount of chlorine added is adjusted to an appropriate concentration in the final stages of disinfection [6]; thus, this would not appear to be the source of the increase. We found a slightly higher pH only with the hot-spring water at the inn; we believed that to be due to the alkaline nature of the source water.

Point No.	Residual chlorine (mg/L)	Nitrite (mg/L)	Ammonium (mg/L)	COD (mg/L)	pH
1	0.4	<0.02	0.2	3	7.69
2	1	<0.02	<0.2	4	7.71
3	0.4	<0.02	0.5	2	7.76
4	1.5	<0.02	<0.2	3	7.78
5	0.4	<0.02	<0.2	1	7.8
6	0.4	<0.02	0.5	3	7.79
7	0.4	<0.02	1	6	7.79
8	0.1	<0.02	<0.2	2	7.77
9	0.4	<0.02	<0.2	3	7.95
10	0.4	<0.02	<0.2	4	7.66
11	<0.1	<0.02	0.2	2	9.56
12	0.1	<0.02	0.2	5	9.49
13	<0.1	<0.02	0.2	2	9.64
14	<0.1	0.2	0.5	5	7.24
15	<0.1	0.1	0.5	4	7.59
16	<0.1	<0.02	0.2	2	8.11

Residual chlorine, nitrite, and COD were measured using commercial kits. The values were determined by examining the solution color in each kit and comparing it with the index color. The point numbers are the same as in Table 1.

Table 2: Results of water samples measured with pack tests and a pH meter.

General bacteria and total coliforms

The results appear in Figure 1. The results of the bacterial tests are presented as number per milliliter for the water samples and the total number (present in 10 mL sterile water) from the faucet handle and intake port samples. We detected general bacteria in the hot-spring water and some of the water samples; we found coliforms only in the hot-spring bathing water. However, we detected general bacteria in most of the park samples and coliforms in about half of the park samples in the deposits around the faucet. This result points to the risk of contamination to the tap water. In the tap water, we did not find levels of general bacteria and Escherichia coli in excess of the standards defined by of the Water Supply Act (100 cells/mL and not detected in 100 mL, respectively). However, the hot-spring water samples did not meet these criteria. This may have been because of the reduced amount of chlorine in the hot-spring water owing to degradation of components by residual chlorine or because of the unpleasant smell of chlorine when bathing [7]. The high temperatures of the water in hot-spring bathing are suitable for bacterial propagation, and bacterial proliferation may have been promoted by human bathing and human waste contamination [8]. However, we did not detect bacteria in the drinking fountain water.

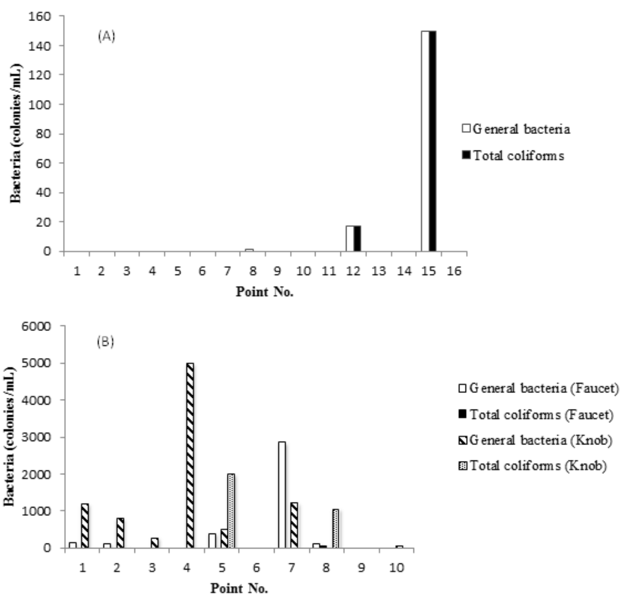

Figure 1: Bacteria in the water samples (A) and on the faucets and handles (B) Bacteria on the faucets and handles were investigated only with tap water (No. 1-10). The point numbers are the same as in Table 1.

Conclusion

In this study, we examined the cleanliness of commonly used drinking facilities in terms of such factors as inorganic components, residual chlorine, and bacteria in tap and hot-spring waters. We found coliforms and general bacteria in some of the drinking water and bathing water samples. This would appear to depend on the amount of residual chlorine. In a large park in Tokyo, the amount of drinking water consumed is relatively small. The levels of residual chlorine we observed were in line with Japan's health standards, and the bacterial levels were small. However, in the case of hot-spring water, residual chlorine is not maintained at a high concentration. That could have led to the bacterial propagation we observed there. Our results indicate bacterial propagation as a result of bathing and human waste contamination. We believe it is necessary to take appropriate steps to prevent infection in this regard.

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