Original Article

Bacteriological Quality of Drinking Water and Hygienic Assessment of Water Cooler Dispensers in Higher Education Institution

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Abstract

Background: The bacteriological quality of drinking water has become a public health concern according to its association with water-borne diseases. Nowadays, there are several different types of drinking water, including water cooler dispensers (WCDs), which are becoming a popular device in educational institutions. Therefore, this study aims to determine the bacteriological quality of drinking water from WCDs, and inspect their hygienic conditions in students' dormitories at a university in Nakhon Si Thammarat, Thailand. **Methods:** Water samples from 53 WCDs installed in 13 dormitories were collected and analyzed coliform bacteria by using the multiple-tube fermentation technique. The hygienic inspection form from the Department of Health, Ministry of Public Health, was used for inspection of the sanitary conditions. The hygienic factors of water cooler sanitation were analyzed using the generalized linear model. **Results:** Coliform bacteria were found in 10 out of 53 samples; moreover, *Escherichia coli* was recovered in three samples. Maintenance/cleaning and monitoring were the most two sanitary issues found in 100% (53/53) of the WCDs. Location and features of machine were found the correlation with the prevalence of coliform bacteria in drinking water. **Conclusions:** The findings of this study suggest regular monitoring of water quality in educational institutions. Also, the Sanitary Standard and Operational Procedures (S.S.O.P.) should be developed to improve the hygienic conditions of the water cooler dispensers.

Keywords: *Drinking water, environmental monitoring, hygiene, water quality*

Introduction

The quality of drinking water has become a significant concern for public health issues, which are associated factors of water-borne diseases.[1,2] World Health Organization (WHO) has reported that inadequate water contributed to at least 2 billion people use a fecal contamination of drinking water source.[3] Moreover, unsafe drinking water and hand hygiene caused 829,000 people to die each year from diarrhea. However, water-borne disease could be reduced by providing adequate water supply and facilities.[4] Therefore, safe drinking water and water supply systems can contribute to the public health resolution goal.

Nowadays, water cooler dispenser (WCD) has become a popular device of drinking water sources in tropical countries, particularly in public institutions and workplaces. However, the dispenser machines can contain various microbial pathogens.[5] The significant findings showed that the bacterial contamination in WCDs tank were higher than water supplied to them.[6] The hygienic conditions, machine characters, and maintenance services could affect the bacteriological quality of drinking water.[7] According to the WHO guideline, the quality of drinking water should be considered for turbidity, pH, residual free chlorine, coliform bacteria, and other microbial pathogens.[3] All of these, the crucial concern is microbial contamination that can contribute the severe health problems as water-borne diseases. Coliform bacteria have commonly been used for microbiological investigation of fecal contamination in drinking water.[8]

Due to the extension of the dormitory and a higher number of students, university has to provide safe drinking water to them. WCDs are essential equipment that can facilitate in the daily life of students. To our knowledge, several studies have performed on the bacteriological quality of drinking water in household and office building, while there are few studies on WCDs in educational

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places.[6,7,9-12] Regarding the essential of safe drinking water supply for the student, this study aims to investigate the hygienic conditions of WCDs and bacteriological quality of drinking water distributed through WCDs located in a student dormitory at the university campus in Nakhon Si Thammarat, Thailand.

Methods

Water samples collection

A total of 53 drinking-water samples were collected from 53 WCDs that located in all 13 dormitories of Walailak University, during August–October 2017. A 100-mL water sample was collected from each device by using sterile sample bottles containing sodium thiosulfate to neutralize the effect of chlorine.[13] Collected samples were kept in the icebox and transported to the laboratory for bacteriological analysis within 6 h. The procedures had been performed under aseptic technique.

Bacteriological analysis

The microbial indicator of fecal contamination, coliform bacteria namely total coliform bacteria, fecal coliform bacteria, and *Escherichia coli (E. coli)* in water samples were identified in this study. Total coliform bacteria in the water sample were measured using the most probable number (MPN) test method. To investigate the coliform bacteria in drinking water based on MPN, single- and double-strength concentrations of Lauryl Tryptose Broth (LTB) medium (HiMedia Laboratories, India) were used for the presumptive test. Brilliant Green Lactose Bile Broth (BGLB) medium (HiMedia Laboratories, India) was used to confirm the total coliform bacteria at 35–37°C for 24–48 h, while EC broth medium (HiMedia Laboratories, India) was applied for selective enumeration of fecal coliform bacteria at of 44.5–45.5°C for 24 h. The number of positive tubes were recorded from each set and compare with the MPN table to give the amount of total coliform bacteria and fecal coliform bacteria, respectively. For *E. coli* identification, all positive EC broth was inoculated and cultured in Eosin Methylene Blue (EMB) medium (HiMedia Laboratories, India) was used to differentiate *E. coli* from other gram-negative coliform bacteria by specific colony morphology. The metallic green sheen colony on EMB were selected to identify using biochemical tests of Indole, Methyl red, Voges-Proskauer, and Citrate utilization (IMViC).[14]

WCD hygiene assessment

To perform the survey, 53 WCDs in dormitories were assessed using hygienic management of WCDs form. The hygienic assessment form was applied from the Handbook of Drinking Water Vending Machines and a previous study.[15,16] The information was divided into six requirements with 18 items in total listed: (1) location, (2) feature of water dispenser, (3) water source and water quality improvement, (4) water quality control, (5) maintenance and cleaning, and (6) monitoring. The WCDs hygiene assessment results were categorized as "satisfactory" and "unsatisfactory" by applying criteria from the Department of Health, Ministry of Public Health.[15]

Ethical considerations

The data collection was conducted after ethical approval from the Human Research Ethics Committee of Walailak University, Thailand (WUEC-16-076-01).

Statistical analysis

The association between hygienic conditions (18 items) and fecal coliform bacteria was statistically analyzed using the generalized linear model. The associations are shown as correlation coefficients using STATA version 13. P value <0.05 was considered as the significant level.

Results

Total coliform and fecal coliform bacteria were detected in 10 of 53 (18.87%) WCDs, which has distributed among 6 of 13 dormitories. The bacteriological analysis of 10 WCDs were higher than the drinking water standard for total coliform and fecal coliform bacteria (<2.2 MPN/100 mL) according to Thai Industrial Standards Institute, 2006. The range of MPN value of total coliform and fecal coliform bacteria measured in 10 water samples from unsatisfactory WCDs were shown in Table 1. Moreover, *E. coli* was detected 1.59% (3/10) from those 10 WCDs.

Hygienic assessment results of 53 WCDs in 13 student dormitories, Walailak University, were shown in Table 2. A total of 53 WCDs showed unsatisfactory assessments, which were mostly found in 4 of 6 hygienic requirements. The WCDs showed the most unsatisfactory issue in terms of location part particularly, improper machine installation sites and feature part, only clean without any dirt on the machine (parts exposed directly to the water were not presented thallophytic plants or any unsanitary). However, the hygienic assessment of all WCDs was satisfactory for the water sources and improvement and drinking water standard quality control, while the maintenance/cleaning and monitoring parts showed unsatisfactory.

Eighteen items of hygienic conditions were statistically tested for the correlation with fecal coliform bacteria. The results found that only three items were correlated with fecal coliform bacteria. The correlation coefficient of the three hygienic items and the prevalence of fecal coliform bacteria were shown in Table 3.

Discussion

The coliform and *E. coli* are the common indicators of fecal contamination in drinking water, which are used as microbiological parameters to be regulated by Thai

Table 1: The results of bacteriological analysis of drinking water from WCDs

Water quality parameters	Range (*n*=53)	Drinking water quality Std*
Total coliform bacteria (MPN/100 mL)	2.2-17	<2.2
Fecal coliform bacteria (MPN/100 mL)	2.2-34	<2.2
E. coli	Detected	nd†

WCDs=Water cooler dispensers. *Reference from Thai Industrial Standards Institute (2006). †nd=Non-detected in 100 mL of water samples

Table 2: Assessment of hygienic conditions of the drinking water dispenser machines (*n*=53)

Items	WCDs evaluation*	
	Satisfactory *n* (%)	Unsatisfactory *n* (%)
Location:		
1. The location should be away from dust particles, water drainage, and garbage at least 30 m	28 (52.83)	25 (47.17)
2. The location was not wet and unsanitary condition around the water dispenser machines and have proper water drainage	43 (81.13)	10 (18.87)
3. The dispenser machines should be covered with a cap on the inlet to prevent insects	45 (84.91)	8 (15.09)
4. The dispenser machines were installed at least 10 cm above the ground as indicated by stability	38 (71.70)	15 (28.30)
5. There is the electric system to prevent a short-circuit and equipment grounding conductor	53 (100)	0 (0.00)
6. Should be provided the container above the ground properly	53 (100)	0 (0.00)
Features of machine:		
7. The machines inspected had no rusted, stability, to prevent short-circuit	53 (100)	0 (0.00)
8. Parts exposed directly to the water were made of the materials used with food, without odor, color, or taste that may affect water quality	53 (100)	0 (0.00)
9. The water faucet was at least 60 cm above the ground	53 (100)	0 (0.00)
10. Parts exposed directly to the water were not presented thallophytic plants or any unsanitary	40 (75.47)	13 (24.53)
Water resources and quality improvement:		
11. Water resources were satisfactory being clean such as water supply and groundwater	53 (100)	0 (0.00)
Drinking water standardized quality control:		
12. Water sampling to test for physical characteristic, chemical characteristic and bacteria at least 1 time/year	53 (100)	0 (0.00)
Maintenance and cleaning:		
13. Cleaning the machines setting every day to prevent dust was spreading	0 (0.00)	53 (100)
14. Cleaning the outlet and water container every day to prevent dust was spreading	0 (0.00)	53 (100)
15. Cleaning water storage at least 1 time/month	0 (0.00)	53 (100)
16. Cleaning and change filter membrane according to the machine company	0 (0.00)	53 (100)
Monitoring		
17. Water quality record and Maintenance record by specify performance details	0 (0.00)	53 (100)
18. Show the information of water quality for customers	0 (0.00)	53 (100)

WCDs=Water cooler dispensers. *Reference from Business Detrimental to Health, in the Public Health Act 1992 and the Ministry of Public Health announcement (no. 362) of 2013

Table 3: The correlation analysis of hygienic condition and fecal coliform

Hygienic conditions	Correlation coefficient (r_{xy})	95% CI for r_{xy}	*P*
The location should be away from dust particles, water drainage and garbage at least 30 m	0.139	0.001-0.278	0.05
The location was not wet and unsanitary condition around the water dispenser machines and have proper water drainage	0.566	0.338-0.794	<0.0001
Parts exposed directly to the water were not presented thallophytic plants or any unsanitary	-0.068	-0.197-0.061	0.303

CI=Confidence interval

legislation for drinking water quality investigation.[17] Bacteriological quality of drinking water from WCDs was analyzed using the standard method of MPN, which is widely used for drinking water quality measurement.[18-20] According to Thailand standard of drinking water, the recommended coliform bacteria should be at least 2.2 MPN/100 ml, while the 10 of 53 WCDs exceeded the standard. These data are comparable with research by Rakkamon *et al*. (2012) where coliform bacteria were found in all WCDs at a university in Thailand.[21] Although it was not the most approach of the actual number of bacteria present in the sample, MPN was

the index of bacterial indicator number.[22] In this study, a few number of *E. coli* were detected in drinking water from WCDs as well as the previous studies in- and around the educational institutions in Thailand.[7,16,23] The low level of *E. coli* in this study might show the low risk of illness from *E. coli* exposure as described in the previous quantitative microbial risk assessment (QMRA) of drinking water in Mahasarakham province of Thailand.[23] In addition, *E. coli* detected in drinking water can be implied that pathogenic bacteria, viruses, and parasites may also be contaminated.

The quality of drinking water and hygienic conditions of WCDs should be routinely investigated. However, various studies in Thailand had indicated that dispenser machines were lack of proper hygienic management.[7,16,23] The hygienic assessment of WCDs showed unsatisfactory results for all dispenser machines, which were due to a lack of monitoring evidence and its consequential effect in the maintenance and cleaning section. These two sections have not found the evidence from any documents or dormitory manager. The irregular maintenance and cleaning are the critical issue of bacterial contamination in WCDs, which should change the membrane filter every 6 months and circulate water within dispensers.[6,7,15,24] Although the results showed that the improper condition of WCDs locations and unclean dispenser surface are associated with the number of fecal coliform bacteria, only machines location are the significant factor of this issue. These may be described as the poor hygiene of dispensers machines are located nearby the garbage or dust generating sources and the unclean of the faucets and dispenser surfaces, which are the suitable point of bacterial growth and biofilm formation.[9,19]

The results of this study had indicated that the irregular cleaning and improper installation sites can influence the abundance of bacteria on faucets and dispenser body that probably distribute pathogens through drinking water consumption from WCDs.[25] Furthermore, physicochemical parameters are also essential factors for drinking water quality analysis and bacterial contamination in WCDs.[26,27] These parameters should be more investigated to combine with bacteriological results for more clarification of bacterial contamination in WCDs.

Conclusions

Drinking water quality in an educational institution is essential for student health due to its necessity for daily life consumption. This study had revealed the fundamental problem of drinking water in an educational institution, which can indicate the sanitation issue of water supply systems for drinking water and may encourage the threat to student health. Therefore, the awareness and knowledge on basic of Sanitary Standard and Operational Procedures (S.S.O.P.) should be raised for safe drinking water, and the correlation between bacteriological water quality from WCDs and gastrointestinal disease hospital admission should be done for further studies.

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Conflicts of interest

There are no conflicts of interest.

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