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## **Drinking water quality and evaluation of environmental conditions of water vending machines**

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### **Abstract**

A survey of 55 water vending machines in Chiang Khrua sub-district, Mueang district, Sakon Nakhon province was conducted to evaluate the quality of drinking water machines and environmental conditions of their locations. Laboratory analysis of the samples consisted of: pH, turbidity, total solid, total dissolved solid, hardness, total coliform, fecal coliform, in addition to a survey of general hygiene each location. The results showed that the turbidity value met the drinking water standard and the pH value baseline was in the range 6.5-8.5. Some of the water samples exceeded the limit set by the drinking water standard. Hardness values set in the Public Health Act 1992, under the Department of Health are 100 mg/l as CaCO<sub>3</sub> or less. Total coliform bacteria were in the range 2-2,400 MPN/100 ml and fecal coliform bacteria in the range 0-2 MPN/100 ml. Sanitation of the surrounding conditions was evaluated according to six items and was determined to be at should improve level for recording and reporting and drinking water quality control. Maintenance and hygienic was poor level. The relevant government sector should control entrepreneurs and monitor the drinking water quality. Entrepreneurs should always maintain the regulated water quality standard.

**Keywords:** Drinking water, Vending machine, Drinking water quality

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### **1. Introduction**

Water is vital to our lives. In the past, collected rainwater and water from natural resources were consumed after boiling for sanitization. Later, water was extracted from wells, and then bottled water in various sizes was sold in markets and gained popularity. In Thailand, the evolution of drinking water has occurred in accordance with the modern lifestyle in which potable water is needed even during a recession. In response, many firms have adapted by introducing drinking water vending machines which include an effective filter system. The filtration can be applied to both ground and tap water, and consumers bring their own containers [1]. This implementation has been well received among consumers who want to buy water at an inexpensive price of 1-2 baht/l. Consequently, the drinking water vending machine business has grown rapidly and widely across Thailand. However, no authorities are responsible for controlling, and monitoring the quality of water from the vending machines which have been installed without any supervision [6].

The Division of Food Quality and Safety, Ministry of Public Health, Medical Sciences Center, Office of Provincial Public Health, in coordination with local administrators, suggested a means of controlling drinking water vending machines and proposed that local administrations should implement municipal laws or regulations to ensure suitable hygiene, required maintenance, and general site cleanliness. Moreover, the production requirements or standards should be set properly, so that the machines are in safe and clean condition resulting in the provision of drinking water suitable for consumers. Entrepreneurs who do not have permission are guilty according to Chapter 7 of the Public Health Act 1992[7], which cover Business Detrimental to Health. The penalty can be imprisonment not exceeding six months, or a fine not exceeding 10,000 baht, or both [4].

In the areas around Kasetsart University Chalermphrakiat, Sakon Nakhon province campus there are many dormitories; consequently, entrepreneurs and residential owners have installed water vending machines to gain more income and to provide a necessary service to those who rent rooms. The objective of this study was to

investigate the water quality and sanitary standard of water vending machines in order to develop an approach to control the water quality from the vending machine to meet the required standards and ensure suitable consumer safety.

## 2. Materials and Methods

The study population 55 vending machines were collected in Chiang Khrua sub-district, Mueang district, Sakon Nakhon province.

### 2.1 Water quality analyses

The drinking water samples were analyzed in the laboratory for pH, turbidity and hardness are quantified by electrometric measurement method, Nephelometric method and EDTA titrimetric method respectively. Total coliform bacteria and fecal coliform bacteria were quantified by Most Probable Number (MPN) test. All of parameters were performed according to the standard methods for the examination of water and wastewater, 22<sup>nd</sup> editions.

### 2.2 Environmental conditions around water machines

The environmental conditions around each water machine were determined using an evaluation form by Handbook of Drinking Water Vending Machines, Business Detrimental to Health, in the Public Health Act 1992 and the Ministry of Public Health announcement (No. 362) of 2013.

## 3. Results

### 3.1 Drinking water quality

#### 3.1.1 Physical characteristics

Turbidity was in the range 0-0.58 NTU which is within the drinking water standards set by the Public Health Act 1992, under the Department of Health of 5 NTU or less.

The pH value of the samples ranged from 5.47 to 7.64 and was slightly acidic (Table 1). The standard water quality should have a pH baseline in the range 6.5-8.5.

The total hardness ranged from 3.47 to 289.07 mg/l as CaCO<sub>3</sub>. The standard water quality hardness baseline is 100 mg/l as CaCO<sub>3</sub>. Thus, this study showed that some water samples exceeded the limit set by drinking water standards in the Public Health Act 1992.

The maximum total solids (TS) in drinking water samples from the vending machines was 0.05 mg/l while the minimum TS was 0 mg/l (Table 1). These results showed that the drinking water from the vending machines was fit for drinking in terms of TS.

The total dissolved solids had a maximum of 419.00 mg/l while the minimum was 3.00 mg/l (Table 1), showing that the drinking water was fit for drinking in terms of TDS.

The pH and hardness standards set by the Public Health Act 1992 were exceeded in 27 and 11 water samples, respectively.

#### 3.1.2 Biological characteristics

The total coliform bacteria were in the range 2-2400 MPN/100 ml and fecal coliform bacteria were in the range 0-2 MPN/100 ml and consequently total coliform bacteria and fecal coliform bacteria exceeded the standards set by the Public Health Act 1992 in 16 and 1 vending machine, respectively.

### 3.2 Results of evaluation of environmental conditions of the drinking water vending machines

There were 55 vending machines in operation, which were evaluated for sanitation and the surrounding conditions according to the six items listed in the Handbook of Drinking Water Vending Machines, Business Detrimental to Health, in the Public Health Act 1992 and the Ministry of Public Health announcement (No. 362) of 2013, regarding drinking water from a vending machine as follows:

- 1) Location
- 2) Characteristics of the vending machine
- 3) Water resource and water quality improvement
- 4) Drinking water quality control

- 5) Maintenance and hygienic
- 6) Recording and reporting

The criteria for assessing the sanitization and the vending machine surrounds were categorized as: covering all items listed = good level; covering some items listed = poor level; and covering none of the items listed = should-improve level as follow table 2

**Table 1** Characteristics of drinking water quality from vending machines (N =55)

Characteristic	Unit	Min-Max	Number of machines (%) Pass standard	Drinking water standard
<b>Physical</b>				
Turbidity	NTU	0.00-1.58	55(100)	5 or less
<b>Chemical</b>				
pH	-	5.47-7.64	55(100)	6.50 - 8.50
Total hardness	mg/l as CaCO <sub>3</sub>	3.47-289.07	44(80)	100 or less
Total solids	mg/l	0.00-0.05	55(100)	500 or less
Total dissolved solids	mg/l	74-184	55(100)	500 or less
<b>Biological</b>				
Total coliform bacteria	MPN/100 ml	2-2400	40(72.72)	Not detectable
Fecal coliform bacteria	MPN/100 ml	0-2	54(98.19)	Not detectable

**Table 2** Evaluation of environmental conditions of the drinking water vending machines

Items	Number of machines (%)			Evaluation level
	Good	Poor	Should improve	
Location:				
1. The location should be away from water drainage at least 30 meter	15 (27.27)	28 (50.91)	12 (21.82)	Poor
2. The location was not any drainage around the water vending machines	31 (56.36)	14 (25.45)	10 (18.18)	
3. The vending machines should be covered with a cap on the inlet to prevent insects	41 (74.55)	8 (14.55)	6 (10.90)	Good
4. The vending machines were installed at least 10 cm above the ground as indicated by stability, to prevent short-circuit	30 (54.55)	20 (36.36)	5 (9.09)	Good
5.Should be provided the container above the ground	35 (63.64)	18 (32.73)	2 (3.64)	Good
Condition of machines				
6. The machines inspected had no rusted, stability, to prevent short-circuit	24 (43.63)	26 (47.27)	5 (9.10)	Poor
7. Parts exposed directly to the water were made of the materials used with food, without odor, color, or taste that may affect water quality	41 (74.55)	11 (20.00)	3 (5.45)	Good
8. Their outlet and the container resting part were at least 60 cm above the ground so that neither insects nor infectious animals could enter	40 (72.73)	9 (16.36)	6 (10.90)	Good
9. Parts exposed directly to the water were not thallophytic plants were evident	26 (47.27)	18 (32.72)	11 (20.00)	Good
Water resources and quality improvement				
10. Water resources and quality were clean with no contamination, adverse color, smell, or taste	45 (81.82)	10 (18.18)	0 (0.00)	Good
11. Water resources were satisfactory being clean such as water supply and ground water	54 (98.18)	1 (1.82)	0 (0.00)	Good

**Table 2** Evaluation of environmental conditions of the drinking water vending machines (Continue)

Items	Number of machines (%)			Evaluation level
	Good	Poor	Should improve	
12. The water quality should be met the standards for drinking water Drinking water standardized quality control	19 (34.55)	35 (63.64)	1 (1.82)	Poor
13. Water sampling to test for physical characteristic, chemical characteristic and bacteria at least 1 time/year	6 (10.91)	0 (0.00)	49 (89.09)	should improve
14. Use the simple test kit to check for coliform bacteria at least 1 time/month Maintenance and servicing	4 (7.27)	1 (1.82)	50 (90.91)	Should improve
15. Checking the machines system follow by the machine company	29 (52.73)	11 (20.00)	15 (27.27)	Good
16. Cleaning the machines setting every day to prevent dust was spreading	14 (25.45)	23 (41.82)	18 (32.73)	Poor
17. Cleaning the outlet and water container every day to prevent dust was spreading	15 (27.27)	22 (40.00)	18 (32.73)	Poor
18. Cleaning water storage at least 1 time/month	19 (34.55)	14 (25.45)	22 (40.00)	Should improve
19. Cleaning and change filter follow by the machine company Recording and reporting	20 (36.36)	12 (21.82)	23 (41.82)	Should improve
20. Water quality record and Maintenance record	10 (18.18)	2 (3.64)	43 (78.18)	Should improve
21. Inform customers for water quality	13 (23.64)	11 (20.00)	31 (56.36)	Should improve
22. Monitor drinking water quality	9 (16.36)	3 (5.45)	43 (78.18)	Should improve

### 3.2.1 Location

The assessment results suggested good locations for 80 % of all the vending machines, as indicated by stability, no stagnant water, cleanliness, and sanitary drainage. The vending machines were installed at least 10 cm above the ground with a cap on the inlet to prevent insects and other infectious animals from entering the machine, which therefore decreases contamination. The other 20 % of machines were ranked as poor, due to such issues as were being installed near waste water drainage or near a waste area, or at the entrance to dormitories where dirt was spreading.

### 3.2.2 Condition of the machines

It was found that 75% of the vending machines were categorized as good, according to the assessment result. Their outlet and the container resting part were at least 60 cm above the ground so that neither insects nor infectious animals could enter. Parts exposed directly to the water were made of the materials used with food, without odor, color, or taste that may affect water quality. Water coming out of the machines was clean, and no thallophytic plants were evident. The remaining 25% of the machines inspected had some rusted parts, and unorganized wires that touched the water.

### 3.2.3 Water resources and quality improvement

The results showed that 67% of the machines were at a decent level. Water resources and quality were satisfactory being clean with no contamination, adverse color, smell, or taste. The remaining 33% were rated as poor, because the entrepreneurs had not bothered to check whether or not the water resources and quality met the standards.

### *3.2.4 Drinking water standardized quality control*

All 55 samples assessed were at the should-improve level, since the entrepreneurs were not aware of having the water inspected in terms of physical, chemical, and biological conditions. In fact, they lacked knowledge regarding the use of the simple test kit to check for coliform bacteria.

### *3.2.5 Maintenance and Servicing*

The assessment results indicated pronounced that 20% of the samples were at the decent level and were serviced according to the manufacturer's instructions. Forty percent were adequate the machines and their surroundings were cleaned 3 times a week. The other 40 % were at the should-improve level, as the entrepreneurs did not know how to clean the water collector, or how to change the filter and they had to wait for the machine company to come and change the filter for them. Some of the machines in this group had not been serviced for one year, and some never.

### *3.2.6 Recording and Reporting*

The assessment results revealed that all 55 samples were at the should-improve level, as the entrepreneurs did not record the date they changed filters and did not notify customers. They had records only of the filtering system and the brand.

## **4. Discussion**

The result showed that total coliform bacteria (TCB) and fecal coliform bacteria (FCB) were the only bacteriological contamination in drinking water. The water quality analysis indicated that the coliform bacteria group analysis has long been recognized as a suitable microbial indicator of drinking water quality [10]. Drinking Water pollution caused by fecal contamination is a serious problem due to the potential for contracting diseases from pathogens. Fecal Coliform bacteria indicate contamination of water with fecal waste that may contain other harmful or disease causing organisms, including bacteria, viruses, or parasites such as Giardia, the cause of beaver fever. Total coliform bacteria include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste. For the study found that total coliform bacteria contamination higher than fecal coliform bacteria may have been caused by accumulate from condition of machine such as faucet [3]. Water hardness has always been investigated as an important factor that causes clogging of membrane filter [4]. The pH value and total dissolved can influence the growth of bacteria [2]. For the evaluation conditions of vending machines found that the owner did not record on water machines maintenance. The lack of regular maintenance, cleaning leads to possible higher level of bacteria [2]. They should be complete up-to date record, changing the filter twice a year and water quality testing should be conducted every three months [4].

## **5. Conclusions**

The water quality parameter test, it was found that the major contamination in drinking water were total coliform bacteria and fecal coliform bacteria, followed by hardness, which indicated that the owners were not aware of having the water inspected in terms of physical, chemical, and biological conditions and water supply system is not complete, and entrepreneurs do not conduct water quality testing.

This research concern regarding the water quality and environmental conditions, the results showed that these factors affect the water quality. The finding of this study suggests that the relevant government sector should control entrepreneurs and monitor drinking water quality. Entrepreneurs should always maintain the water.

## **6. Acknowledgement**

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