ความรู้เกี่ยวกับมาตรการป้องกันการปนเปื้อนเชื้อจุลินทรีย์ของผู้ผลิต และคุณภาพน้ำบริโภคในภาชนะบรรจุที่ปิดสนิทของผู้ผลิตในเขตอำเภอเมือง จังหวัดชัยภูมิ
Knowledge of Preventive Measures of Microbial Contamination and Quality of Drinking Water in Sealed Containers of Manufacturers in Mueang District, Chaiyaphum Province

นิพนธ์ต้นฉบับ

Original Article

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บทคัดย่อ

วัตถุประสงค์: เพื่อประเมินความรู้เกี่ยวกับมาตรการป้องกันการปนเปื้อนเชื้อจุลินทรีย์ของผู้ผลิต สำรวจคุณภาพน้ำบริโภคในภาชนะบรรจุที่ปิดสนิทของผู้ผลิต และศึกษาความสัมพันธ์ระหว่างความรู้กับปัจจัยส่วนบุคคล สถานที่ผลิต และคุณภาพน้ำ **วิธีการศึกษา:** การวิจัยเชิงสำรวจ เก็บข้อมูลโดยใช้แบบสัมภาษณ์เจ้าของกิจการ 28 คน และพนักงาน 40 คน ที่ปฏิบัติงานในสถานที่ผลิตน้ำบริโภคในภาชนะบรรจุที่ปิดสนิทพื้นที่ อ.เมือง จังหวัดชัยภูมิ จำนวน 32 แห่ง และเก็บตัวอย่างน้ำดื่ม144 ตัวอย่าง เพื่อตรวจวิเคราะห์คุณภาพด้านเชื้อจุลินทรีย์ด้วยชุดตรวจภาคสนาม อ.11 วิเคราะห์ข้อมูลใช้สถิติเชิงพรรณนา การตัดสินว่ามีความรู้ใช้เกณฑ์ผ่านที่ร้อยละ 60 และทดสอบความสัมพันธ์ระหว่างความรู้ (ผ่าน/ไม่ผ่าน) กับปัจจัยส่วนบุคคล ประเภทและขนาดของสถานที่ผลิต และระหว่างความรู้กับคุณภาพน้ำด้านเชื้อจุลินทรีย์ โดยใช้สถิติ Fisher's exact test **ผลการศึกษา:** ผู้ผลิตน้ำบริโภคน้อยกว่าครึ่ง (ร้อยละ 45.59%) มีความรู้มากกว่าเกณฑ์ผ่าน โดยเฉพาะในส่วนขั้นตอนการล้างภาชนะบรรจุและฝาภาชนะบรรจุ พบว่ามีตัวอย่างน้ำดื่มที่มีเชื้อจุลินทรีย์ปนเปื้อนจำนวนมากถึง 63 ตัวอย่าง (ร้อยละ 43.75) โดยพบมากภาชนะบรรจุชนิดใช้ซ้ำ พบว่าความรู้ในขั้นตอนการล้างภาชนะบรรจุสัมพันธ์กับคุณภาพน้ำด้านเชื้อจุลินทรีย์อย่างมีนัยสำคัญทางสถิติ (*P*-vaue = 0.040) **สรุป:** น้อยกว่าครึ่งหนึ่งของผู้ผลิตใน อ.เมือง จ.ชัยภูมิ มีความรู้เกี่ยวกับมาตรการป้องกันการปนเปื้อนเชื้อจุลินทรีย์ที่ผ่านเกณฑ์ น้ำดื่มในภาชนะปิดสนิทจำนวนมากไม่ได้มาตรฐาน ความรู้เกี่ยวกับขั้นตอนการล้างภาชนะบรรจุและฝาภาชนะบรรจุสัมพันธ์กับคุณภาพน้ำด้านเชื้อจุลินทรีย์ การอบรมให้ความรู้ความเข้าใจแก่ผู้ผลิตเกี่ยวกับกระบวนการผลิตน้ำดื่ม การบำรุงรักษา จำเป็นต้องดำเนินการอย่างต่อเนื่อง

คำสำคัญ: น้ำบริโภคในภาชนะบรรจุที่ปิดสนิท, การปนเปื้อนเชื้อจุลินทรีย์, ความรู้เกี่ยวกับมาตรการป้องกันการปนเปื้อนเชื้อจุลินทรีย์, คุณภาพน้ำดื่ม, ผู้ผลิต

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Abstract

Objectives: To assess knowledge of drinking water manufacturers on preventive measures for microbial contamination of drinking water in sealed containers, examine the quality of drinking water, and examine relationships between the knowledge and personal factors, production site and water quality. **Methods:** In this survey study, data were collected through interviews with 28 business owners and 40 employees in 32 production facilities of drinking water in sealed containers in Mueang district, Chaiyaphum province. A total of 144 samples of drinking water were collected for assessment of microbialquality with field test kit DOH. 11. Descriptive statistics were used to summarize the findings. A cut-off of 60% of correct answers was used for pasiing the knowledge test. Fisher's exact test was used to test relationships between the knowledge (passed/failed) and personal factors, types and sizes of production sites, and microbial water quality. **Results:** Slightly less than half of the participants (owners and employees) passed the knowledge test (45.59%), especially on the process of washing containers and lids. Almost half of the drinking water samples (63 out of 144, or 43.75%) were microbially contaminated, especially those reusable containers. Knowledge of container cleaning procedure was significantly related to the quality of drinking water (*P*-vaue = 0.040). **Conclusion:** Less than half of manufacturers in Mueang district, Chaiyaphum province passed the knowledge of preventive measures for microbial contamination in drinking water in consealed containers. A large number of drinking water failed the microbial test. Knowledge of cleaning containers and lids was related to microbial quality of the drinking water. Manufacturers should be continuously provided with training for manufacturing and maintenance.

Keywords: drinking water in sealed containers, microbial contamination, knowledge of preventive measures of microbial contamination, quality of drinking water, manufacturers

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Introduction

Currently, the business of drinking water production in sealed containers is gaining popularity among high net worth and individual investors. With a considerable number of manufacturers, different issues of drinking water quality have manifested. In 2015, Department of Medical Sciences, Ministry of Public Health, assessed the quality of drinking water in sealed containers and ice manufactured and distributed across Thailand. It was found that 43.4% of drinking water in sealed containers and ice did not meet the standards: the pH values were found to exceed or were below the permissible limit and coliforms exceeded the standard level.[1] Similarly, the annual operation report of the 9th

Regional Medical Sciences Center Nakhon Ratchasima during the years 2015 – 2018 reported issues on the quality of drinking water in sealed containers in the 9th health region across four provinces, namely Nakhon Ratchasima, Chaiyaphum, Buriram, and Surin, in which 20.6%, 22.3%, 21.2% and 34.0%, respectively, of the samples of drinking water in sealed containers failed to meet the standard.[2]

Problems of microbiological quality of drinking water in sealed containers are prevalent. They can result in contamination of pathogenic bacteria and cause diarrhea for those consuming microbe contaminated drinking water.[1] With an aim to increase the quality of drinking water, the Food and Drug Administration of Thailand has established guidelines for the prevention of microbial contamination to raise awareness among consumers of drinking water in sealed containers. However, these problems still persist.[3] Prior studies have pointed out that manufacturers of drinking water in sealed containers lacked knowledge of proper manufacturing practices. If manufacturers are equipped with knowledge of measures for prevention of microbial contamination in food, it will help reduce risks of contamination.[4]

Through the random assessment of the samples of drinking water in sealed containers in Chaiyaphum province during the years 2016 - 2018, the Department of Consumer Protection, Chaiyaphum Provincial Health Office found the same problems of drinking water quality as the 9th health region; specifically, 22.2%, 33.3%, and 25.0% respectively of the samples did not reach the standard. This was caused by the poor microbiological standard, since the manifestation of coliforms exceeded the standard criteria and E. coli was found. A literature review has shown that there have not been studies on manufacturers of drinking water in sealed containers' knowledge of measures for prevention of microbiological contamination as well as factors potentially affecting their levels of knowledge and water quality. Thus, the present study aimed to 1) evaluate knowledge of measures for the prevention of microbial contamination among manufacturers of drinking water in sealed containers, 2) assess quality of drinking water in sealed containers among manufacturers in Mueang district, Chaiyaphum province, and 3) investigate the relationships between knowledge of preventive measures of microbial contamination and personal factors, production facility-related factors and water quality-related factors. In this study, independent variables were 1) personal factors, e.g. gender, age, incomes, status, responsibilities, and work experience, and 2) production facility-related factors, including types and sizes of production facilities. Dependent variables included knowledge of preventive measures of microbial contamination and water quality which only referred to microbial water quality.

Methods

This study was conducted via cross-sectional survey research from October to November, 2020. Four sample groups were used in this study as follows. First, 32 production sites of drinking water in sealed containers in Mueang district, Chaiyaphum province were recruited. Second, of the 32 manufacturers or business owners who were initially contacted, four of them could not participate, resulting in 28 of them participating. For each plant, one manufacturer or business owner was required to answer the questions. Third, all employees working at all participating plants were expected to participate. With the issues of inconvenience and voluntary nature of the study, 40 employees working in production sites were recruited. Fourth, 144 samples of drinking water in sealed containers were selected using a random sampling method from products in every type of containers produced on the date of data collection in each production site. For example, on a given day and plant, if the plant produced water in sealed container of 20 L, the researcher randomly selected three bottles of the product. In addition, if 600 mL plastic bottled water was produced, the researcher also randomly selected three bottles of this product.

Research instruments

Research instruments used in this study were a field test kit culture broth DOH.1 1 (Ministry of Public Health) for culturing coliform bacteria and an interview form. For the assessment of microbial water quality using the field test kit DOH. 11[5], water samples were filled in media bottles and incubated at room temperature for 24 h. The criteria to assess microbial water quality were as follows. If media bottles are red or orange, it indicates that the microbial water quality passes the standard criteria. On the other hand, when red media bottles turn yellow, it indicates that microbial water quality fails to meet the standard.

The interview form was used to assess the participants' knowledge of preventive measures of microbial contamination. The form consisted of two parts, the first part collecting socio-demographic data of samples and production sites, and the second part was to assess the knowledge of measures for the prevention of microbial contamination. This second part was divided into three sections or scenarios, namely (1) knowledge about raw water management and filtration, (2) knowledge about prevention of contamination during the filling process, and (3) knowledge about cleaning containers and lids, with five items for each section.

To assess the participants' knowledge of preventive measures of microbial contamination, the criteria of passing the evaluation had not been available. Therefore, the researchers set a criterion of a cut-off of 60% of the correct answers. This 60% cut-off was based on the criterion in evaluating the production sites as mandated by the evaluation form entitled "Tor Sor 3(50)" of the Thai Food and Drug Administration.[6] In evaluating the participant's knowledge, not only the grand total score of the overall test had to be at least 60%, but score of each of all three sections/scenarios had to be as well. For the overall knowledge test, to achieve 60% correct answers, 9 out of 15 points was needed to pass the test; while 3 out of 5 points for each of the three sections/scenarios was needed. Knowledge scores for production sites were calculated based on mean knowledge scores among business owners and employees in each of all given production site.

In terms of instrument quality, content validity of the interview for evaluating knowledge of preventive measures for microbial contamination was assessed by a qualified expert, and the interview form was revised accordingly before implementation. The internal consistency reliability of the interview form was conducted using KR20 and it was found to be high with a KR20 coefficient of 0.904. Interviews with business owners, sampling water from production sites, and interpretation of water sample test results were all carried out by the researcher.

Ethical consideration

The study obtained an ethical approval with an Accreditation No. HE632217 from the human research ethics committee of Khon Kaen University on August 24, 2020.

Data analysis

Descriptive statistics were used to summarize demographic data and all findings, including frequency with percentage and mean with standard deviation. Fisher's exact test was used to test relationships between the knowledge (passed/failed) and demographic characteristics, types and sizes of production sites, and microbial water quality. All statistical significance was set a type I error of 5% or *P*-value < 0.05. Statistical analysis was carried outusing Microsoft Excel® software program.

Results

The results showed that out of 68 participants, 41% of them were business owners, while the rest 59.00% were employees. In terms of gender, 59.00% of the participants were female. The mean age was 47.25 years, with a range of 20 to 68 years. Their monthly income ranged from 500 to 50,000 Baht with an average of 10,588.24 Baht. Most the participants were those working in the filling room (82%). Number of years of working experience was from 1 to 25 years, with an average of 5.14 years.

For the 32 manufacturing sites of drinking water in sealed containers in Mueang district in Chaiyaphum, 59.00% of them were recognized as non-factory production sites. These plants produced mostly drinking water in reusable containers (plastic bottle of 18 – 20 liters) for all sizes of production sites, followed by disposable plastic bottle water of 600 ml (Table 1).

Table 1 Demographic information of participants (owners and employees) and production sites.

Participants	Participants (N = 68)		Production sites	Production sites (N = 32)	
	n	%		n	%
Gender			**Type of production sites**		
Male	28	41.18	Recognized as factory	13	40.62
Female	40	58.82	Recognized as non-factory	19	59.37
Age (yr), mean = 47.25; range: 20 – 68.					
< 35	14	20.59			
35 – 55	37	54.41	**Products by size of production sites**		
> 55	17	25.00	*** Small (< 4 horsepower)**	8	25.00
Monthly income (Baht), mean = 588.24; range: 500 - 50,000.			18 - 20 L plastic bottle	8	25.00
< 10,000	39	57.35	600 ml plastic bottle	3	9.37
10,000 – 20,000	20	29.41	*** Medium (4 - 5 horsepower)**	19	59.37
> 20,000	9	13.23	18 - 20 liter plastic bottle	15	46.87
Status			900 ml plastic bottled water	1	3.12
Business owners	28	41.18	600 ml plastic bottled water	8	25.00
Employees	40	58.82	300 ml plastic bottled water	2	6.25
Responsibilities, working in fitting room.			220 ml plastic cup	1	3.12
Yes	56	82.35	*** Large (> 5 horsepower)**	5	15.62
No	12	17.65	18 - 20 liter plastic bottle	4	12.5
Work experience (yr), mean = 5.14, range = 1 – 25.			1,500 ml plastic bottle	2	6.25
< 2	18	26.47	600 ml plastic bottle	3	9.37
2 - 5	28	41.18	300 ml plastic bottle	1	3.12
> 5	22	32.35			

It was found that less than half of participants (owners and employees) and the production sites had a total score that passed the passing criteria cut-off of 60% correct answers (45.59% and 40.62%, respectively) (Table 2).

Table 2 Assessment of knowledge among participants (owners and employees) and production sites.

Levels of knowledge	Participants (N = 68)		Production sites (N = 32)	
	n	%	N	%
Failing (< 9 of 15 points)	37	54.41	19	59.37
Passing (≥ 9 of 15 points)	31	45.59	13	40.62

Regarding each step of production procedures, it was found that most of the manufacturers managed to pass Step 1 (raw water management and filtration) (66.18%) and Step 2 (prevention of microbial contamination during the filling process) (79.41%) (Table 3). Unfortunately, the participants failed Step 3 (cleaning containers and lids) (49.53%). When mean scores of participants in each production site was considered, proportions of correct answers for each step were slightly lower than those of individual participants and similar pattern was found. Specifically, Steps 1 and 2 were passed (59.37% and 68.75%, respectively), and Step 3 was failed (34.37%) (see Table 3).

Table 3 Assessment of knowledge by production steps.

Production procedures	Number of participants (owners and employees) passing the test (N = 68)		Number of production sites passing the test (N = 32)	
	n	%	n	%
Step 1: raw water management and filtration	45	66.18	19	59.37
Step 2: prevention of microbial contamination during the filling process	54	79.41	22	68.75
Step 3: cleaning containers and lids	33	49.53	11	34.37

Once each item was considered, questions 6 and 8 were answered correctly by 88.23% and 80.88% of the participants, respectively (Table 4). Since questions 6 and 8 were in Step 2 which concerns prevention of contamination during the filling process, this suggested that the majority of them possessed a good knowledge of regulations (e.g., wearing boots in a filling room, washing hands before entering a filling room, prohibiting people with medical conditions from working in a filling room, and prohibiting wearing any accessories while working in a filling room) and practices for working in a filling room. However, most of the participants missed questions 9 (Step 2), 12, 14, and 15 (Step 3). It could be inferred that they lacked knowledge of Step 3 on cleaning containers and lids, especially question 14 on properly managing container cleaning staff and wearing uniforms while cleaning containers and question 15 on monitoring microbial water quality and container cleaning efficiency (Table 4).

Table 4 Proportions of correct answers of knowledge of preventive measures of microbial contamination by items in a descending order.

Question number	Topics	Production procedure	Number of participants with correct response (N = 68)	
			n	%
6	Wearing boots in a filling room, washing hands before entering a filling room, prohibiting people with medical conditions from working in the filling room, and prohibiting wearing any accessories while working in the filling room.	Step 2	60	88.23
8	Practices for working in a filling room.	Step 2	55	80.88
5	Properties of disinfectants, cleansing agents, and cleanness of groundwater.	Step 1	53	77.94
13	Container storage and quality control of disposable containers.	Step 3	51	75.00
1	Optimal period for filter backwashing, usage of a water chlorine meter, and measurement of pH of water.	Step 1	44	64.70
4	Practices for prevention of microbial contamination.	Step 1	44	64.70
11	Cleaning containers properly.	Step 3	44	64.70
10	Wearing proper clothes to work in a filling room.	Step 2	42	61.76
3	Benefits of Total Dissolved Solids (TDS) Meter, pH Meter, and UV sterilizer.	Step 1	39	57.35
2	Properties of groundwater, raw water improvement, and raw water storage.	Step 1	31	45.59
7	Cleanliness of a filling room and prohibition on performing water filling outside the room.	Step 2	28	41.18
12	Cleanness of 18 – 20 L plastic containers after cleaning and proper cleaning of unsanitary bottles.	Step 3	26	38.23
9	Disinfection of 18 – 20 L plastic containers before filling and prevention on performing water filling outside filling room.	Step 2	24	35.29
15	Monitoring microbial water quality and container cleaning efficiency.	Step 3	14	20.59
14	Properly managing container cleaning staff and wearing uniforms while cleaning containers.	Step 3	13	19.12

Note:
Step 1: raw water management and filtration.
Step 2: prevention of contamination during the filling process.
Step 3: cleaning containers and lids.

Microbial water quality of manufacturers

Of the 144 samples of water products obtained from 32 production sites, low proportions of water in reusable containers (18 – 20 L plastic bottle and 900 ml plastic bottle) passed the coliform microbial test by the DOH.11 field test kit (40.74% and 0.00%, respectively) (Table 5). On the other hand, water in disposable containers passed the coliform test with higher proportions, from 66.67% to 100.00%.

Relationship between knowledge of preventive measures of microbial contamination and various factors

The study found no statistically significant relationships between knowledge of preventive measures of microbial contamination and various factors including gender, age, incomes, status, responsibilities, work experience, and types and sizes of production sites (Table 6).

Table 5 Evaluation results of microbial water quality using DOH.11 test kit.

Type of products	Total number (bottles)	Number of water samples achieving the standard (N = 144)	
		n	%
Reusable container			
1. 18 – 20 L plastic bottle	81	33	40.74
2. 900 ml plastic bottle	3	0	0
Disposable container			
3. 1,500 ml plastic bottle	6	6	100.00
4. 600 ml plastic bottle	42	33	78.57
5. 300 ml plastic bottle	9	6	66.67
6. 220 ml plastic cup	3	3	100.00

Table 6 Relationships between knowledge of preventive measures of microbial contamination and selected factors.

Selected factors	Knowledge assessment results, N (%) (N = 68)		*P*-value*
	Failing (n = 37)	Passing (n = 31)	
Gender			0.358
Male	14 (37.84)	14 (45.16)	
Female	23 (62.16)	17 (54.84)	
Age (yr)			0.081
< 35	8 (21.62)	6 (19.35)	
35 – 55	16 (43.24)	21 (67.74)	
> 55	13 (35.13)	4 (12.90)	
Monthly income (Baht)			0.298
< 10,000	24 (64.86)	15 (48.39)	
10,000 – 20,000	8 (21.62)	12 (38.71)	
> 20,000	5 (13.51)	4 (12.90)	
Status			0.552
Business owners	15 (40.54)	13 (41.94)	
Employees	22 (59.46)	18 (58.06)	
Responsibilities, working in fitting room.			0.103
Yes	28 (75.67)	28 (90.32)	
No	9 (24.32)	3 (9.68)	
Work experience (yr)			0.746
< 2	11 (29.73)	7 (22.58)	
2 - 5	14 (37.84)	14 (45.16)	
> 5	12 (32.43)	10 (32.26)	
	by production sites (N = 32)		
	(n = 19)	(n = 13)	
Type of production sites			0.565
Recognized as factory	8 (42.10)	5 (38.46)	
Recognized as non-factory	11 (57.90)	8 (61.54)	
Size of production sites			0.311
Small (< 4 horsepower)	3 (15.79)	5 (38.46)	
Medium (4 - 5 horsepower)	12 (63.16)	7 (53.85)	
Large (> 5 horsepower)	4 (21.05)	1 (7.69)	

* Fisher's exact test.

It was discovered that no association between knowledge of preventive measures of microbial contamination and microbial water quality (Table 7). Once each production step was considered separately, knowledge of preventive measures of microbial contamination in Step 3 (cleaning containers and lids) was statistically significantly related to microbial water quality (*P*-value = 0.040) where plants that passed the microbial test were more likely to pass the knowledge test of Step 3.

Table 7 Relationship between knowledge of preventive measures of microbial contamination and microbial water quality by production step.

Levels of knowledge	Evaluation results of microbial water quality of production sites, N (%) (N = 32)		*P*-value*
	Passing (n = 15)	Failing (n = 17)	
Overall knowledge			0.615
Failing	9 (28.1)	10 (31.3)	
Passing	6 (18.8)	7 (21.9)	
Knowledge of Step 1: raw water management and filtration			0.610
Failing	5 (45.5)	6 (54.5)	
Passing	9 (47.4)	10 (52.6)	
Knowledge of Step 2: prevention of contamination during the filling process			0.445
Failing	4 (40.0)	6 (60.0)	
Passing	11 (50.0)	11 (50.0)	
Knowledge of Step 3: cleaning containers and lids			0.040
Failing	7 (33.3)	14 (66.7)	
Passing	8 (72.7)	3 (27.3)	

* Fisher's exact test.

Discussions and Conclusion

Most of the manufacturers of drinking water in sealed containers in Mueang district, Chaiyaphum province, obtained knowledge scores lower than 60%, which was considered failing. In fact, they lacked knowledge of various aspects, particularly in relation to procedures for cleaning containers and lids which were statistically significantly related to microbial water quality. As most of the water samples in this study (81 of 144 water samples) were 18 – 20 liter plastic bottles and were in reusable containers, a lack of knowledge in such procedures could potentially affect water quality in a large scale.

The roots of this incident may lie in the fact that there is not any on-site training about cleaning containers in place and that information is only available from salespersons of water purifier companies that supply only recommendations about water purifier usage, a filtration system, and equipment maintenance. This is consistent with the study of Kongjing et al[7] which stated that proprietors were only supplied with knowledge or practical recommendations from water purifier salespersons without awareness of functions and performance of different purifier types. In the assessment on manufacturers before licensing, the offiials of Province Health Office perform the on-site inspection only based on the form "Tor Sor3(50)" where the score of less than 60% is considered failing.

Our study observed no association between overall knowledge of preventive measures of microbial contamination and microbial water quality. This incident could be explained by the fact that knowledge of Step 1 and Step 2 does not serve as an important factor which affects microbial water quality, particularly drinking water in reusable containers (18 – 20 L plastic bottles) which was the majority of the samples in this study. The intriguing point to be made is that most of the manufacturers seem to possess a good share of knowledge of Step 2 on prevention of contamination during the filling process as this area is strictly inspected by officials, e.g. if it appears that manufacturers use rubber tubes for the filling process, they will be prosecuted.

In terms of microbial water quality, the results pointed out that microbial contamination exceeded the acceptable standard, i.e., 44% of them failed to meet the standard. This is consistent with studies of Meksawasdichai et al[8] Polying et al[9], and Kongjing et al[7] which found that drinking water in sealed containers failed to comply with the microbiological standard; in fact, it was the most common problem, accounting for 22%, 31%, and 52.9% respectively. Additionally, sorted by types of containers, drinking water in reusable containers (18 – 20 L plastic bottle) was found to be microbially-contaminated above the permissible limit; specifically, 59.26% of the water samples were not compliant with the standard (40.74% compliant with the standard).

Our finding conforms to Baipaisan's study[10] which found that 38.8% of drinking water in reusable containers failed to comply with the microbiological standard. However, drinking water in disposable containers was microbially-contaminated above the standard less than that in reusable containers. In fact, 78.57% of 600 ml bottled drinking water met the microbial standard which meant that as high as 21.43% of them did not, which was still considered quite high.

This study had certain limitations. Most of production sites of drinking water in sealed containers in Mueang district, Chaiyaphum province, were medium and small-sized and had a relatively small number of staff, and some of them refused to participate in this study since they were afraid that they would not be able to meet the deadline of the specified distribution period. Therefore, the number of the participants was lower than the predetermined sample size. Generalizability of the levels of knowledge among manufacturers should be cautious. However, this study has shed more light on the quality of sealed water and their knowledge on of preventive measures of microbial contamination.

The results pointed out three important issues as follows. First, the quality of water in sealed containers was below the standard, especially microbial contamination. Second, manufacturers lacked knowledge of preventive measures of microbial contamination. Third, there was a relationship between knowledge of procedures for cleaning containers and lids and microbial water quality. Concerned parties are urged to address these problems, and training courses about the drinking water production processes and drinking water treatment should be constantly provided for manufacturers. Further studies should investigate guidelines to improve knowledge and introduce proper practices to manufacturers, officials, and concerned individuals.

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