MAEH Journal of Environmental Health eISSN 2637-1359
Jurnal Kesihatan Persekitaran MAEH
Published By Malaysian Association of Environmental Health
http://www.maeh4u.org.my/journal

RESEARCH ARTICLE

Assessment of Drinking Water Quality and Environmental Conditions of Vending Machine in Larut, Matang and Selama (LMS), Taiping, Perak, Malaysia

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Abstract

Water vending machines are widely used in public areas particularly in urban regions. Assessment of physico-chemical and microbiological parameters that can alter the quality of drinking water is essential for the prevention of waterborne diseases outbreak in the future. The aim of this study was to determine the performance and water quality of vending machines (WVMs) in the LMS district of Perak. In this study, out of 15 WVMs, only 2 machines were grading as satisfactory level based on observation survey. Analysis of physico-chemical parameter indicated all the water samples tested were found complied for pH value (6.40-7.40), while not complied for turbidity (0.22-1.47 NTU). There was only one WVM that incompliance for residual chlorine with 0.11 mg/L to the Food Regulations 1985 (25th Schedule). There were 5 vending machines detected total coliform (1.0-56.8MPN/100 mL) and none of *E.coli* detected for microbiological analysis. There was correlation found between the total coliform and pattern maintenance (r= -0.718; n= 15; p= 0.003). In overall, this study shows that each installed WVM must be maintained on a regular basis in order to ensure that drinking water is always safe for drinking purposes and to prevent the growth of harmful microorganisms.

Keywords: Vending machine, drinking water, coliform, *Escherichia coli*, public health

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INTRODUCTION

Water is vital in people's daily lives as it is used for domestic, public and industrial, trade and agriculture purposes. Most percentage of the country's total water supply is for domestic use. Examples of domestic uses are including for drinking, food preparing and cooking, bathing, car washing, washing clothes and dishes and other purposes. Moreover, water is also recognized by all forms of life as one of essential basic elements to survive, including humankinds, flora, and fauna which frankly said, all may be died without water. It is continuing be an integral component for numerous processes of vital biochemical in human being [1]. For instance, water uses for cells, tissues and organs to help regulate temperature of body and maintain other bodily functions. It is encouraged that for every person is required to drink at least 8 glasses of plain water as equal as 2 L each day to maintain their good health [2]; the water need is increased to 3.3 L for man with modest physical activity and can be up to 4 till 5 L for active man [3].

In today's modern era, where time is equivalent to money, the rapidity of services becomes a significant factor affecting decision making which including water supplies [4]. In meeting such demand, the supply of filtered water like vending machine (VM) has been continue to gain encouraging response from consumers since it was first introduced. The number of water vending machine (WVM) vendors recently increasing in our country has made it easy for public to obtain filtered drinking water. The use of WVM is common among our Malaysian even though its safety for human consumption still remains unclear.

Basically, water vending machine (WVM) is defined as an automatic self-service machine that dispenses water into the container when sufficient coins, bills or tokens are inserted [5].

One of the great reasons may because they are readily available and sold at a low price, which be considered as a great choice for families or individuals without home water filter machine. Malaysian citizen thought on vending machine (VM) is the water produced by it safe to drink because they rely on the advertisement by the company provider not from the public health perspective [6]. But at the same time there is a lot of news that gone viral about this water quality from various sources and this has caused some users to doubt the content of drinking water on the VM.

Notwithstanding well-designed WVMs are established and provided water treatments via reverse osmosis (RO), which believed can retain 99 percent of bacterial cell on the membrane, leaving less than 50 cell/mL in drinking water [7-8]; there are still possibilities for microbe to be transmitted to WVM. The sanitation conditions and drinking water quality related to health would be potentially influenced by numerous microbes due to the low hygienic conditions of WVMs and improper environments [9]. Coliform bacteria can colonize the carbon filters of WVM resulting in high concentration of coliform bacteria in the final vended water. A researcher from Philippines was revealed that 8 water samples taken from 8 public schools in Cebu City registered a total coliform count of 2.6 CFU/mL, while specific *E.coli* testing posted (<1.1 to 2.6 CFU/mL) [10]. These data are higher than the national standard for permissible value for clean water (<1.1/100 ml) and international standard of 0.00 CFU/100ml except in 2 schools that fall within the normal level (<1.1 CFU/mL).

Another researcher also highlighted that 6 out of 14 samples randomly picked from some locations in Kuala Lumpur were found to have either coliform or *Escherichia coli* (*E. coli*) and did not contained enough free chlorine for disinfection purpose [11]. The similar cases were also reported by some researchers in Los Angeles and Dubai. All incidents were concluded to be related to the poor maintenance and improper hygienic conditions of WVM [12-13]. Maintenance and water quality are inseparable. Inadequate maintenance and low sanitation service is a part of man-made factor that usually related to the growth of heterotrophic organisms in water. For example, the physicochemical parameters (such as temperature, pH and dissolved organic compounds) can influence the growth of bacteria in surfaces of water dispensers [14].

Hence, the aim of this study is to assess and evaluate whether the quality of water supplied from VMs comply with physical and microbiological parameters set by the National Standard for Drinking Water Quality 2004 [15].

MATERIALS AND METHODS

Study location

This study was conducted in Larut, Matang, and Selama (LMS) district, Taiping Perak (Fig. 1). LMS is bordered on the north by the state of Kedah, on the south by the Manjung District, on the northwest by the Kerian District and on the east by the Hulu Perak and Kuala Kangsar Districts.

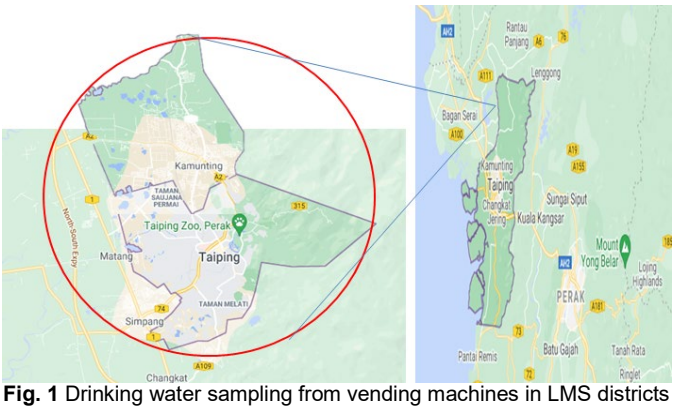

Fig. 1 Drinking water sampling from vending machines in LMS districts area.

Maintenance review and observation

Surrounding environment of where the water vending machine (WVM) located were observed in order to identify any potential risk that may affects the quality of water from vending machine (VM). A certified checklist was used to examine and observe for each WVM that involved in the study such as environmental surroundings, machine condition, hygiene status, and quality of filtered drinkable water, and most recent maintenance date. The checklist was used for score marking, which consists of 16 items. Each item that considered performed and done, had been given '1', whereas, if any not done or not known was scoring '0'. Total marks for every WVM had been categorized under low or moderate or high level (Table 2).

Table 2 Grading of observation score.

	Total possible score	Low/Poor <80%	Moderate/Satisfy 80-90%	High/Good >90%
Observation	0-16	0-12	13-14	15-16

Water sampling and analysis

A total of 15 samples of water drinking were collected randomly from water vending machines (WVMs) placed in 11 areas (Kampung Jambu, Medan Kamunting, Taman Jana, Taman Lela, Taman Jana Setia, Taman Saujana 2, Taman Jana Mulia, Medan Kamunting Jaya, Kampung Expo, Taman Mewah, and Perindustrian Kamunting) in Larut, Matang, and Selama (LMS) districts, Perak (Malaysia) that generally located at 4°55′N 100°45′E such in Fig. 1. A sampling form was created for the purpose of recording of sampling time, date, location, and physico-chemical test readings. While in field, physico-chemical test for turbidity, pH, and chlorine residue at the sampling station 'triplicate samples' were performed at first. All results physico-chemical analyses were recorded into dummy sampling forms.

For microbiological parameter test, nozzle and bottle sampler must be sterilized before water sampling process. The vessel cap need to be opened carefully and water sample was filled with 100 ml of 'FILL LINE' without rinsing first. Each vessel was required to be labeled with information such as station number, time, and date. Finally, all the collected samples must be kept inside cool box with ice packs and maintain temperature (1-4 °C) and analysed within 24 hours after collection. The collected water samples were analysed in laboratory according to the set procedure, which samples were filled into Quanti-Tray/2000 and incubated for 24 hours with temperature around 35 $\pm$0.5 ºC. After incubation, large and small positive wells were counted and recorded with referred to the Quanti-Tray/2000 MPN table to find the exact MPN.

RESULTS AND DISCUSSION

Environmental assessment

Data presented in Table 3 with regards to the first item of checklist, most of water vending machines (WVMs) (93.3%) were not labeled with registered name or address, which considered unknown status or not registered under Ministry of Health (MOH). Only 1 (6.7%) machine complied and proved with MOH sticker of registered name and address. The item no.2 was in a closely equal ratio between complied and non-complied machines that differs only 6.6%. 8 (53.3%) machines were not being placed suitably, which possibly can cause contamination and another 7 machines complied.

The third item from the checklist shown 40% of environment and surroundings of WVMs being located were not clean and sanitary. 7 out of 15 machines were not complied when their surrounding spaces and under the WVMs were quite inaccessible and seems potentially can become a nesting place for pests (item no.4). Regarding to the item no.5, floor condition and type, all were made of waterproof flat material and easy to clean. Approximately, 80% of WVMs for item no.6 were designed and built to facilitate cleaning and maintenance for all exterior and interior surfaces, whereas another 20% machines were incompliance. In item no. 7, 10 (66.7%) machines were observed to have all parts and surfaces of WVMs that come in contact with water were made of approved, corrosion-resistant, and impermeable materials that can withstand repeated cleaning and sanitation treatments. In addition, there were only 3 WVMs did not used corrosion-resistant or inflamed dispenser nozzle (item no.8), instead using flexible PVC pipe.

For item no.9, each WVM (15) have been observed built with treatment process that can be done effectively for the water sold through distillation, ion exchange, filtration, UV light, RO, or any other acceptable system. More than 50% WVMs have an effective system for handling water droplets, spills or overflows with regards to item no.10. Furthermore, there was only 1 (6.7%) machine that has a backwash system for all connections with water supply, while the other 93.3% WVMs were not being provided (item no.11). All WVMs complied on item no.12, which every machine dispenses water was disinfected through ozonisation or any other methods that approved by Director. For item no.13, more than 50% of WVMs involved were not equipped with self-closing door and not fitted neatly to the dispenser section or dispenser nozzle cover when it is not in use. Moreover, based on item no.14 shown less than 30% of machines that have been observed were clean and sanitary, free from dirt or pests.

Each vending machine (VM) was considered complied to item no.15 with using an approved public water supply. Last item in the checklist with regards to maintenance of machine, almost 75% of WVMs that have been observed did not displayed a sticker to certify their maintenance records, whereas only 4 (26.7%) machines were considered complied. If compared to Rapeepan's study, all 55 WVMs (100%) involved in the study did not record any date of maintenance, which means users will difficult to access and gain the maintenance information that should be displayed on the machines [16].

Table 3 Environment, conditions and maintenance of machine.

Item	Compliance	Frequency, N	Percentage, %
I. Registered name and address are labeled on WVM	No	14	93.3
	Yes	1	6.7
2. Protected from any contamination	No	8	53.3
	Yes	7	46.7
3. Clean and sanitary	No	6	40.0
	Yes	9	60.0
4. Spaces at surroundings and under the WVM are easily accessible and does not become a nesting place for pests	No	7	46.7
	Yes	8	53.3
5. Floor is made of waterproof flat material, easy to clean	No	0	0.0
	Yes	15	100.0
6. WVM is designed and built to facilitate cleaning and maintenance for all exterior and interior surfaces	No	3	20.0
	Yes	12	80.0
7. All parts and surfaces of WVM that come in contact with water are made of approved, corrosion-resistant, and impermeable materials that can withstand repeated cleaning and sanitation treatments	No	5	33.3
	Yes	10	66.7
8. WVM has corrosion-resistant or inflamed dispenser nozzle	No	3	20.0
	Yes	12	80.0
9. WVM is designed in such a way that all treatments for the water sold through distillation, ion exchange, filtration, ultraviolet light, reverse osmosis, mineral addition, or any other accepted process can be done effectively	No	0	0.0
	Yes	15	100.0
10. WVM has an effective system for handling water droplets, spills or overflows	No	7	46.7
	Yes	8	53.3
11. WVM has a backwash prevention device for all connections with water supply	No	14	93.3
	Yes	1	6.7
12. WVM that dispenses water is disinfected through ozonisation or other methods approved by Director	No	0	0.0
	Yes	15	100.0
13. WVM is equipped	No	8	53.3

with self-closing door and is fitted neatly to the dispenser section or dispenser nozzle cover when it is not in use	Yes	7	46.7
14. WVM is kept clean and sanitary, free from dirt or pests	No	11	73.3
	Yes	4	26.7
15. WVM uses an approved public water supply	No	0	0.0
	Yes	15	100.0
16. Maintenance and servicing record	No	11	73.3
	Yes	4	26.7

Physico-chemical analysis

The water samples from 15 machines that have been tested for physico-chemical analysis in this study are shown in the Table 4. On average, pH values were at 7.00, which indicated that most of water samples taken were in neutral category. The minimum and maximum readings (mean) data of pH parameter were between values 6.90 to 7.40. This shown that the pH value for each sample still ranging between values 6.5 to 8.5, which indicated that 100% has complied to set standard of 25th Schedule of Food Regulations 1985 [17]. Water research conducted in Parit Raja, Johor also obtained complied pH results for all VMs involved between values 6.2 to 6.62 [6]. These results were a bit different to the Tan's water study, when the pH value of water samples ranged between pH 6.23 and 8.75, which one out of 17 water samples taken was not complied when exceeded the permissible limit of WHO and EPA with a pH value of 8.75 [18].

However, there also some non-compliance to the drinking water quality standards of WVM for turbidity and chlorine residue parameters. All turbidity readings of water samples were over the acceptable maximum value and totally (100%) did not complied with the standard, which should be 0.1 NTU and below. The highest mean value recorded was 1.47 NTU from WVM 5 in Taman Lela, while the lowest mean value was 0.22 NTU (WVM 13) in Taman Mewah but still above the standard limit. Results similar to the study done in Johor, when the turbidity values for all water samples collected in Batu Pahat were in the range of 4.5 to 9.5 NTU that shown non-compliance [19]. Nonetheless, these values were 45 to 95 times higher than the set standard and also much different than the results that have been obtained in LMS district. It was emphasized that there is high chance for microorganisms might be presented in the drinking water due to increased protection from disinfectant, when turbidity level exceeded the acceptable NTU [18]. Normally, high turbidity value indicates lower quality of drinking water.

Furthermore, for chlorine residue readings (mean), one out 15 machines was considered non-compliance to the standard, which should be 0.04 mg/L and below. The eighth WVM point located in Taman Jana Mulia was the one that exceeded the limit of acceptance of Malaysian Food Regulations 1985 [17], which at value 0.11 mg/L as the highest mean value, whereas another 4 machines from different locations recorded the lowest readings at 0.01 mg/L (mean). On average, majority of machines were at 0.03 mg/L that shown the compliance of chlorine residue. Maximum residual chlorine from 30 WVMs found in Chaidez's study was 0.07 mg/L, which only difference 0.04 [20]. There was only little number among researchers monitored on chlorine residue with regards to VM drinking water, thus, caused lack of data that can be referred and compared.

Table 4 Physico-chemical results of water from VMs (n=15).

Vending machine	Location	Mean turbidity (NTU)	Mean pH	Mean chlorine residue
1	Kampung Jambu-Pt.1	1.31±0.03	7.00±0.04	0.02±0.00
2	Kampung Jambu-Pt.2	1.42±0.00	7.20±0.02	0.01±0.00
3	Medan Kamunting	0.53±0.01	6.90±0.03	0.01±0.00
4	Taman Jana	0.44±0.01	7.00±0.03	0.01±0.00
5	Taman Lela	1.47±0.05	7.00±0.05	0.01±0.00
6	Taman Jana Setia	0.29±0.01	7.00±0.00	0.03±0.02
7	Taman Saujana 2	0.28±0.03	6.90±0.04	0.04±0.01
8	Taman Jana Mulia	0.34±0.02	6.90±0.06	0.11±0.04
9	Medan Kamunting Jaya	0.36±0.02	7.20±0.06	0.03±0.02
10	Kampung Expo	0.32±0.06	7.20±0.05	0.02±0.01
11	Taman Mewah-Pt.1	1.21±0.03	7.20±0.02	0.04±0.00
12	Taman Mewah-Pt.2	0.44±0.01	6.90±0.01	0.03±0.01
13	Taman Mewah-Pt.3	0.22±0.03	7.00±0.00	0.03±0.01
14	Taman Mewah-Pt.4	0.63±0.04	7.40±0.02	0.02±0.00
15	Perindustrian Kamunting	0.49±0.05	6.90±0.02	0.02±0.01
Average		0.65	7.00	0.03

Total coliform and *E.coli* test

Fortunately, data shown in Table 5, there was no incompliance indicated for parameter of *E.coli*. The *E.coli* was absent and not detected in each 100mL water sample taken. Hence, water consumption from tested WVMs in LMS district might be considered safe. In comparison, there were found *E.coli* in Seri Serdang with 45-68 CFU and Taman Pinggiran Putra 45-62 CFU from 100mL WVM samples. *E. coli* levels in drinking water samples from these WVMs were definitely exceeded the standard guidelines [21]. Additionally, all water samples taken by a researcher from several selected public schools in Cebu City, Philippines were positive *E.coli*, which 2 schools (<1.1/100mL) and 6 schools (2.6/100mL). It was considered that the results were non-compliance to the strict international standard of US EPA [10]. Therefore, findings of *E.coli* from both researchers respectively indicated that the filtered drinking water from those machines were absolutely not safe for consumers that potentially might cause diarrhoea or even worse effects.

Nevertheless, there were total coliform found positive in 5 tested water samples from WVMs in Perindustrian Kamunting (1), Taman Mewah (2), Taman Jana Mulia (1) and Kampung Jambu (1) within LMS district. Analyzed results obviously have shown that WVM 8 was the highest MPN value (56.8) if compared to other WVMs, which less than 10 MPN/100 mL detected. The detection was followed by 5.2 (WVM 13), 2.0 (WVM 1), 1.0 (WVM 15), and 1.0 (WVM 12). That means more

than 30% of the WVMs involved were positive detected of total coliform. If referred to drinking water quality standards of WVM, only one (WVM 8) located in Taman Jana Mulia was considered non-compliance and the rest were acceptable and complied the standard. In comparison, results from 3 locations obtained in Kelantan was obviously higher in detection of coliform bacteria, which 16 (94%) out of 17 samples tested were positive with total coliform [18]. Findings in Chiang Khruea Sub-district, Thailand indicated was even worse results when total coliform contained in tested samples reached over 2000 MPN/100mL due to improper maintenance and low hygienic condition of machines [16]. As a microbe indicator in drinking water, high coliform bacteria present normally indicate that the water treatment system in VMs were not being sanitized and maintained on a regular basis.

Table 5 Microbiological results of water from VMs (n=15).

Vending machine	Location	Total coliform (MPN/100mL)	*E.coli* (MPN/100mL)
1	Kampung Jambu-Pt.1	2.0	<1
2	Kampung Jambu-Pt.2	<1	<1
3	Medan Kamunting	<1	<1
4	Taman Jana	<1	<1
5	Taman Lela	<1	<1
6	Taman Jana Setia	<1	<1
7	Taman Saujana 2	<1	<1
8	Taman Jana Mulia	56.8	<1
9	Medan Kamunting Jaya	<1	<1
10	Kampung Expo	<1	<1
11	Taman Mewah-Pt.1	<1	<1
12	Taman Mewah-Pt.2	1.0	<1
13	Taman Mewah-Pt.3	5.2	<1
14	Taman Mewah-Pt.4	<1	<1
15	Perindustrian Kamunting	1.0	<1
Average		4.4	<1

Based on Table 6, the relationship between turbidity and pattern maintenance has a significant value (2-tailed) at 0.351>0.05; the relationship between pH and pattern maintenance has a significant value (2-tailed) at 0.122>0.05; and the significant value (2-tailed) for the relationship between chlorine residue and pattern maintenance at 0.799>0.05. All physico-chemical parameters have larger significant value (2-tailed) than the set alpha value (0.05) in this study. That means there is no any association for all three physico-chemical parameters with pattern maintenance, when failed to reject the H null.

Whereas, the significant value (2-tailed) for the relationship between total coliform and pattern maintenance has been 0.003, which is smaller than 0.05. Hence, there is an association between total coliform and pattern maintenance, when the H null was successfully rejected. It was also indicated that there was a strong negative correlation between the total coliform and pattern maintenance, r(13)= -0.718, p<0.05, with low level of pattern maintenance (survey marks) associated with high level of total coliform. Based on evaluation marks, all 5 machines that detected positive total coliform were categorized under low grade. Poor cleaning and sanitation of the WVMs might be the biggest factor to the growth of the coliform bacteria. In facts, with low quality of membrane filtration and lack of disinfection may contribute to bacteria re-growth after water treatment stages in machine [18]. This is supported by other researchers found that contamination of drinking water were contributed by bad condition and inadequate maintenance services of machines provided by the vendors [12-13]. As well, for safe water provision, it crucial to ensure that the drinkable water resources remain uncontaminated and clean [1, 22-23]. Unfortunately, the relationship between *E.coli* and pattern maintenance could not be proven when the data has been omitted due to constant trend.

Table 6 Correlations (Spearman's rho).

		Marks	Turbidity (<0.1)	pH (6.5-8.5)	Chlorine residue (<0.04)	Total coliform (<10mpn/100ml)
Marks	Correlation Coefficient	1.000	.259	.417	-.072	-.718**
	Sig. (2-tailed)	.	.351	.122	.799	.003
	N	15	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION

Through the water quality parameter tests, there were some non-compliances in filtered drinking water in LMS district such as for total coliform, turbidity, and followed by residual chlorine, which might be contaminant in drinkable water content. The highest MPN value of total coliform was found in water sample for vending machine (VM) located in Taman Jana Mulia ought to be prioritized by vendor. This indicated that many owners were not really aware of having the water inspections and test in terms of microbiological, physical, and chemical conditions. Most water vending machines (WVMs) found not being cared and maintained properly, which is believed might cause negative impacts to the consumers in the future if no remedial action be taken by the related vendors. This research concern towards the environmental conditions and machine maintenance, which the results showed these factors related to the quality of drinking water. However, further research for the study is recommended to obtain more solid answer.

ACKNOWLEDGEMENT

The authors would like to thank Faculty of Health Sciences, Universiti Teknologi MARA (UiTM) Puncak Alam and staff from Water Quality and Food Safety Units at LMS district for their full cooperation and assistance.

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