Drinking Water Quality of Water Vending Machines in Parit Raja, Batu Pahat, Johor

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Abstract. An increased in demand from the consumer due to their perceptions on tap water quality is identified as one of the major factor on why they are mentally prepared to pay for the price of the better quality drinking water. The thought that filtered water quality including that are commercially available in the market such as mineral and bottled drinking water and from the drinking water vending machine makes they highly confident on the level of hygiene, safety and the mineral content of this type of drinking water. This study was investigated the vended water quality from the drinking water vending machine in eight locations in Parit Raja are in terms of pH, total dissolved solids (TDS), turbidity, mineral content (chromium, arsenic, cadmium, lead and nickel), total organic carbon (TOC), pH, total colony-forming units (CFU) and total coliform. All experiments were conducted in one month duration in triplicate samples for each sampling event. The results indicated the TDS and all heavy metals in eight vended water machines in Parit Raja area were found to be below the Food Act 1983, Regulation 360C (Standard for Packaged Drinking Water and Vended water, 2012) and Malaysian Drinking Water Quality, Ministry of Health 1983. No coliform was presence in any of the vended water samples. pH was found to be slightly excess the limit provided while turbidity was found to be 45 to 95 times more higher than 0.1 NTU as required by the Malaysian Food Act Regulation. The data obtained in this study would suggest the important of routine maintenance and inspection of vended water provider in order to maintain a good quality, hygienic and safety level of vended water.

Keywords: water quality, vending machine, drinking water.

1. Introduction
Water is essential in maintaining life in all organisms. Although it is abundantly available in most of the country however, according to WHO [1], 663 million people lack in access to improved drinking-water and 1.8 billion people use fecally contaminated drinking-water in their daily life. Drinking water must be well-treated and must be safe for consumption without any harm based on drinking water quality standard stated by WHO and health body in each country. In Malaysia, potable water sources that are mainly sourced from surface water is treated, distributed and extensively monitored by local authorities. For example, Syarikat Air Johor (SAJ) is a private company that responsible with the treatment and distributions of clean water supply in Johor.
Daily needs for water increases from the early infancy (about ~0.6 L) to 3.3 L for man with modest physical activity and can be up to 4.5 L for active man. In the other hand, women are generally exhibit lower (about 0.5 to 1 L less) than man [2]. In fact, drinking a lot of water has not only to avoid water dehydration and maintaining good body function but it also become a common practice in weight control [3]. Therefore, the water purity and and health implication of drinking water must be a priority to ensure there is no adverse effect for human due to drinking water consumption.

Issues on water resource and drinking water have grown worldwide and public concern have been raised over years on the water constituents even they are present in a trace concentration down to ng/L. In Malaysia, several studies have been recorded on the presence of organochlorine pesticides and plasticizers in a river basin [4], pharmaceuticals in surface water [5], heavy metals in freshwater [6], ammonia and manganese in drinking water treatment [7] and minerals content in drinking water [8].

Malaysian consumes several types of drinking water such as unfiltered tap water, filtered water, bottled water, mineral water and vending machines water. As conducted by Lee [9], boiled and unfiltered tap water was consumed by 52.3% of population compared to boiled and filtered water (25.6%) while 6.2% for bottled water. Although study by [8] shows that the mineral compositions in the tap water supplied were below the standard limits prescribed by the Malaysia Drinking Water Quality Standard 2010 [10] and WHO Guidelines [11] there are some perceptions of Malaysian tap water consumer regarding the unacceptable taste and unpleasant appearance of tap water [12]. In addition, the consumer also believed that the use of tap water could invite more health risk. As a result, many of them changed to filtered, bottled water (drinking and mineral water) and vending machines or water dispenser machine (usually claimed as reverse osmosis (RO) water).

There are several types of RO water machine available in Malaysia either for home used, or for commercial used. For home used RO comprises a simple machine or even a few filters together, joint between the pipe while for the commercial used, it commonly looks larger than the home used and exists in the form of vending machine type as it consists several filter systems inside the machine. Instead of the consumer perceptions and experience towards the tap water, the low cost of vending machine water as low as 20 cents per liter seems as a good choice for the consumer those who are not afford to buy the home used RO one, compared to bottle water which can cost more than RM 2 for the same amount [13]. However, reported by Aruna & Camoens [13], precautions have to be taken by the consumers when using this vending machine water as six out of 14 samples randomly picked from several places in Kuala Lumpur were found to have either coliform or E.coli and did not contain free chlorine for disinfection purpose. The similar cases were also reported in Los Angelas [14] and Dubai [15]. All incidents were concluded to be related to the poor maintenance and improper hygienic conditions of water vending machine.

Due to the local demand and requirement, the common placement of water vending machines is located in public are in university campus and hostel area. Therefore, in this study, samples from eight locations in Parit Raja area were collected in order to evaluate the quality of provided RO water vending machines in terms of physical, chemical and biological parameter. The parameters then were compared to Food Act [16], Regulation 360C (Standard for Packaged Drinking Water and Vended water, 2012) and Malaysian Drinking Water Quality, Ministry of Health 1983 to ensure their quality and safety. This information is important as it may reveal the level of quality and safety of vended water in Parit Raja to surrounded consumer.

2. Materials and methods
Parit Raja is a small town in Batu Pahat district, located about 95 km from Johor Baharu city, Johor, Malaysia. Parit Raja has undergone rapid development and substantial growth due to the expansion of Universiti Tun Hussien Onn Malaysia (UTHM) which accommodates approximately 15,300 students in varies education levels [17]. This study was investigated the quality of drinking water supplied by drinking water vending machines in Parit Raja area. A total of 64 samples of vended water were collected from eight drinking water vending machines (as in Figure 1) in Parit Raja area. From eight
selected locations, four of the vending machines were located in UTHM residential colleges, while another four were located at Parit Raja town (PR). Samples were collected twice a week for one month monitoring (April to June 2015) with triplicate samples for each sampling. All vending machine has claimed to use reverse osmosis (RO) system for their water drinking treatment.

Samples were collected in a 1 L plastic container which was preserved in a 1:1 nitric acid solution for 2 days and were rinsed with milli-Q ultrapure water (Millipore, US) prior to use. The vended water samples were collected in the morning in the container and were sealed and transported to the laboratory in a cold container with temperature around 4 to 6°C. Samples were filtered through 0.45 μm pore diameter membrane filters and undergone pH adjustment with nitric acid to pH 2 using HACH pH meter. No preservatives were added to any water samples and all testing were conducted within five days from the the day of collection.

![Figure 1. Drinking water vending machine.](image)

Samples were analyzed for heavy metals content which are cadmium (Cd), arsenic (As), lead (Pb), chromium (Cr) and nickel (Ni) using Inductive Couple Plasma – Mass Spectrometer ELAN 900 (Perkin Elmer, US). Total organic carbon was determined using Total Organic Carbon Analyzer TOC-VCSH (Shimadzu, Japan), turbidity with turbidity meter HACH 2010 (HACH, US) and total dissolved solid (TDS) by SenION 5 (HACH, US). Total colony forming unit (CFU) was determined at 37°C in 24 hours [18]. Colilert Reagent was added to the vended water samples in vessels prior to 35°C and 24 hours incubation for the coliforms and E.coli presence or absence test.

### 3. Results and Discussions

Concentrations of selected parameters were tabulated as in Table 1 to Table 4. Result was reported as a mean of triplicate samples. The concentrations of all determined parameters were compared with Food Act 1983, Regulation 360C (Vended water), Malaysian Food Regulation and Malaysian Drinking Water Standard. Table 1 shows the pH and TDS concentration for four consecutive weeks. All samples collected from PR were found to have higher pH (5.5 – 6.4) than the value stated in Malaysian Food regulation 1983 and Malaysian Drinking Water Standard during that month. Values given by vended water samples in UTHM somehow were slightly above both regulations. On the other hand, all TDS concentrations were in good agreement with Malaysian Drinking Water Standard as no value provided for TDS in Malaysian Food Regulation.
Table 1. pH and TDS concentration.

| Location | W1 | W2 | W3 | W4 | W1 | W2 | W3 | W4 |
|----------|----|----|----|----|----|----|----|----|
| UTHM 1   | 6.1| 5.7| 6.7| 7.1| 109.0|110.6|107.2|110.1|
| UTHM 2   | 7.1| 6.0| 6.4| 6.4| 9.9 | 9.9 |11.0 | 11.4|
| UTHM 3   | 6.7| 6.4| 6.6| 6.4| 4.3 | 4.2 | 4.9 | 5.0 |
| UTHM 4   | 6.5| 6.4| 6.2| 6.6| 4.9 | 6.0 | 5.0 | 5.2 |
| PR 1     | 5.9| 6.2| 5.9| 6.4| 14.2| 19.4| 21.2| 22.2|
| PR 2     | 5.5| 6.0| 5.9| 6.0| 95.9|103.9|103.4|101.9|
| PR 3     | 5.6| 5.9| 6.0| 6.1| 35.4| 44.5| 33.4| 37.3|
| PR 4     | 5.8| 6.1| 5.9| 5.9| 99.6|101.6|103.3|102.3|

Malaysian Food Regulation 1983; pH: 6.5 – 8.5
Malaysian Drinking Water Standard: pH 6.5 – 9.0, TDS: 1000 mg/L

Turbidity values given by all samples as tabulated in Table 2 were in the range of 4.5 to 9.5 mg/L. Based on both standards, these values were 45 to 95 times higher than the value set by Malaysian Food Regulation which is 0.1 NTU and almost doubled from the Malaysian Drinking Water Standard. Turbidity was set to be 0.1 NTU in vended water and 5 NTU in drinking water since turbidity was found to be associated with the presence of suspended matter such as clay, silt, organic or inorganic matter and might also contain other microorganisms [19]. As commercial RO membrane system was design to remove particle efficiently from at least 0.1 nm depending on the filter type, it is expected that this vended water has only containing the pure water and turbidity concentration less than raw water which is 5 NTU. This might suggest the inefficient filtration capacity of the RO system in the vending machine due to the originality of supplied RO membrane or the poor maintenance of the vending machine.

In TOC observation, none of the standards were regulated on TOC value. However, it can be presence in drinking water sample from less than 100 μg/L to up 25,000 μg/L [20] and indicates the presence of organic matter in the water samples. As indicated in the table, TOC concentrations were observed in relatively low level in all vended water samples.

Table 2. Turbidity and total organic carbon concentration.

| Location | W1 | W2 | W3 | W4 | W1 | W2 | W3 | W4 |
|----------|----|----|----|----|----|----|----|----|
| UTHM 1   | 5.0| 5.0| 4.5| 4.5| 2.7 | 3.1 |1.8 | 1.2 |
| UTHM 2   | 5.0| 9.0| 5.0| 5.0| 2.6 | 3.7 | 2.5 | 1.5 |
| UTHM 3   | 8.0| 9.5| 3.5| 5.0| 2.8 | 3.8 | 2.5 | 1.5 |
| UTHM 4   | 6.5| 7.5| 5.0| 3.5| 2.1 | 3.3 | 2.3 | 1.3 |
| PR 1     | 3.5| 4.0| 5.0| 4.5| 3.4 | 2.9 | 2.1 | 1.1 |
| PR 2     | 5.5| 4.5| 5.0| 5.5| 2.3 | 2.5 | 2.0 | 1.1 |
| PR 3     | 5.0| 6.0| 4.5| 4.5| 1.7 | 2.9 | 1.9 | 1.1 |
| PR 4     | 4.0| 3.5| 3.5| 5.0| 2.2 | 2.8 | 1.5 | 1.4 |

Malaysian Food Regulation 1983; Turbidity: 0.1 NTU
Malaysian Drinking Water Standard: Turbidity: 5 NTU

Table 3 shows the total colony forming unit in the samples. However, no testing was done on the presence of coliform in the water samples although it was set as one of the most important
requirement in both standards. Though, the numbers given by Table 3 indicated some types of microorganism were presence in the vended water samples and thus suggested water must be boiled first prior to used. Coliforms and E.coli presence and absence tests were performed using colilert powder indicated negative results when none of the vended sample water showing any colors of fluorescence. This result indicates that the vended water quality in Parit Raja area are still safe to be consumed in terms of total coliform presence as 6 samples over 49 samples were detected to contain total group members in dispenser machines in Ajman, UAE [15]. Similar observation was also revealed the presence of total coliforms in 13 samples out of 40 drinking water vending machines in Los Angeles due improper scheduled maintenance [14].

Table 3. Total Colony Forming Unit.

| Location | CFU (cell/ml) |
|----------|---------------|
| W1 | W2 | W3 | W4 |
| UTHM 1 | 62.5 | 64.5 | 67.5 | 73.5 |
| UTHM 2 | 34 | 58 | 54 | 60 |
| UTHM 3 | 51.5 | 68 | 68 | 79.5 |
| UTHM 4 | 36 | 63 | 40 | 45.5 |
| PR 1 | 76 | 91 | 89.5 | 96.5 |
| PR 2 | 63 | 84 | 68 | 88 |
| PR 3 | 49 | 58.5 | 60.5 | 67.5 |
| PR 4 | 82 | 91 | 88 | 82.5 |

All heavy metals were analyzed simultaneously and determinations were based on six point calibration curve as tabulated in Table 4. Cd in all vended water samples were found to be in the range of 0.03 to 0.15 μg/L. While As, Pb, Cr and Ni were determined as low as 0.04 μg/L and can be up to 0.68 μg/L, 0.17 μg/L to 1.53 μg/L, 0.12 μg/L to 0.78 μg/L and 0.19 μg/L to 0.82 μg/L, respectively. Malaysian Food Regulation has regulated more stringent value about five-fold increase for Cd, Pb, Cr and Ni, and 10-fold increase for As compared to Malaysian Drinking Water Standard. However, results have revealed that all samples were below the minimum concentration level recommended by Malaysian Food Regulation.

Based on the location, vended water at four stations in UTHM have recorded 0.03 to 0.10 μg/L of Cd, 0.04 to 0.68 μg/L of As, 0.17 to 1.43 μg/L of Pb, 0.12 to 0.57 μg/L of Pb and 0.12 to 0.57 μg/L of Cr. While in PR, four stations of vended water were recorded to have Cd in the range of 0.06 to 0.15 μg/L, 0.08 to 0.60 μg/L of As, 0.21 to 1.53 μg/L of Pb, 0.19 to 0.78 μg/L of Cr and 0.19 to 0.57 of Ni. In general, both locations have almost the similar values of the concentration range suggested that the performance of drinking water vending machines are in the satisfactory level for investigated heavy metals.

Table 5 shows the mean concentrations of Cd, As, Pb, Cr and Ni in all eight drinking water vending machines in both locations. From the mean concentrations, vended water from PR 2 drinking water vending machine has the highest concentration of Cd, Pb and Cr compared to other stations. Cd was recorded to be as high as 0.12 μg/L, 0.94 μg/L of Pb and 0.71 μg/L of Cr. While the highest As was observed at UTHM 1 with 0.62 μg/L and Ni at UTHM 2 with 0.55 μg/L. It may suggest that PR 2 vending machines was having poor maintenance and less inspection by the provider during the monitoring month.
Table 4. Cd, As, Cr, Pb and Ni concentration in vended water samples.

| Location | Cd  | As  | Pb  | Cr  | Ni  |
|----------|-----|-----|-----|-----|-----|
|          | W1  | W2  | W3  | W4  |     |
| UTHM 1   | 0.05| 0.06| 0.04| 0.10|     |
| UTHM 2   | 0.05| 0.03| 0.06| 0.07|     |
| UTHM 3   | 0.06| 0.04| 0.08| 0.08|     |
| UTHM 4   | 0.06| 0.07| 0.04| 0.10|     |
| PR 1     | 0.07| 0.06| 0.06| 0.11|     |
| PR 2     | 0.08| 0.15| 0.06| 0.16|     |
| PR 3     | 0.10| 0.05| 0.11| 0.07|     |
| PR 4     | 0.09| 0.08| 0.09| 0.15|     |

| Location | Cd  | As  | Pb  | Cr  | Ni  |
|----------|-----|-----|-----|-----|-----|
|          | W1  | W2  | W3  | W4  |     |
| UTHM 1   | 0.57| 0.49| 0.61| 0.48| 0.55|
| UTHM 2   | 0.44| 0.48| 0.54| 0.42| 0.38|
| UTHM 3   | 0.16| 0.17| 0.15| 0.23| 0.41|
| UTHM 4   | 0.12| 0.20| 0.12| 0.15| 0.39|
| PR 1     | 0.22| 0.30| 0.34| 0.19| 0.54|
| PR 2     | 0.64| 0.67| 0.78| 0.69| 0.52|
| PR 3     | 0.35| 0.36| 0.41| 0.36| 0.20|
| PR 4     | 0.40| 0.41| 0.59| 0.40| 0.57|

Malaysian Food Regulation 1983; Cd: 0.6 \( \mu \text{g/L} \); As: 1 \( \mu \text{g/L} \); Pb: 2 \( \mu \text{g/L} \); Cr: 10 \( \mu \text{g/L} \); Ni: 4 \( \mu \text{g/L} \)

Malaysian Drinking Water Standard: Cd: 3 \( \mu \text{g/L} \); As: 10 \( \mu \text{g/L} \); Pb: 10 \( \mu \text{g/L} \); 50 \( \mu \text{g/L} \); Ni: 20 \( \mu \text{g/L} \)

Table 5. The mean concentrations of heavy metals at UTHM and PR for the whole month.

| Location | Cd   | As   | Pb   | Cr   | Ni   |
|----------|------|------|------|------|------|
|          | W1   | W2   | W3   | W4   | W1   | W2   | W3   | W4   |
| UTHM 1   | 0.06±0.04| 0.62±0.10| 0.65±0.43| 0.53±0.14| 0.47±0.05|
| UTHM 2   | 0.05±0.03| 0.11±0.03| 0.92±0.34| 0.48±0.11| 0.55±0.33|
| UTHM 3   | 0.06±0.03| 0.08±0.01| 0.60±0.43| 0.18±0.07| 0.32±0.09|
| UTHM 4   | 0.07±0.03| 0.06±0.01| 0.46±0.28| 0.15±0.04| 0.44±0.18|
| PR 1     | 0.08±0.03| 0.09±0.01| 0.47±0.19| 0.27±0.09| 0.38±0.15|
| PR 2     | 0.12±0.05| 0.37±0.04| 0.94±0.51| 0.71±0.09| 0.50±0.08|
| PR 3     | 0.08±0.03| 0.23±0.04| 0.57±0.54| 0.37±0.05| 0.22±0.04|
| PR 4     | 0.11±0.03| 0.55±0.04| 0.69±0.29| 0.46±0.09| 0.54±0.05|

Drinking water standard supplied by water provider in Malaysia has to follow Malaysian Drinking Water Standard provided by Department of Environment. There were several studies in Malaysia investigated the presence of heavy metals in Malaysia drinking water. Reviewed by Hafiza et al. [21], Pb was detected in Malaysia drinking water due to the corrosion and plumbing system in water distribution system. Stagnation of water in a piping system caused the leached Pb to be in contact with stagnant water. The presence of heavy metals was also related to the source of the water supply such as groundwater and related activity occurred surrounding the water sources. After water treatment process, treated water supposedly reached the standards provided by Malaysian Drinking...
Water Standard. Water supply normally was boiled prior to use by household however, was filtered using self-use filter system, or paid filter system such as vending machine was expected to remove more trace metals and microorganism left in water supply. Once the maintenance and inspection are poor and improper, the hygienic aspect, the safety level and the filtration performance will reduce [14]. The reduction in vended water quality thus will cause infection, spreading of disease and toxic effect to consumer [8,14,15]. Furthermore, as reviewed by [21], heavy metals are now becoming a world concern due to their absorption and accumulation ability in human body, displacement of essential minerals and interruption on cell activity.

Instead of the maintenance and inspection by the provider, the installation site of the drinking water vending machine must be taken into account. Study by Al Moosa et al. [15] the placement of water dispenser in a playing area or being exposed to direct sunlight was observed to be high in total coliform as it increases with increases of ambient temperature.

4. Conclusion
This study determined the concentration of pH, turbidity, total dissolved solid (TDS), total organic carbon (TOC), total colony forming unit, and heavy metals (Pb, As, Cd, Cr and Ni) from eight drinking water vending machines in Parit Raja, Batu Pahat, Johor, Malaysia area. Presence and absence test of coliform was also conducted to all vended water samples. In conclusion, TDS and all heavy metals in eight vended water machines in Parit Raja area were found to be below the Food Act 1983, Regulation 360C (Standard for Packaged Drinking Water and Vended water, 2012) and Malaysian Drinking Water Quality, Ministry of Health 1983. No coliform was presence in any of the vended water samples. pH was found to be slightly excess the limit provided while turbidity was found to be 45 to 95 times more higher than 0.1 NTU as required by the Malaysian Food Act Regulation. The findings of this study suggest that regular and proper maintenance of drinking water vending machines by the provider must be conducted to ensure the level of hygiene, safety and satisfactory among consumer are always in the best place.

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