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# Drinking Water Quality from Water Vending Machines in Selected Public Schools in Cebu City, Philippines

**Marchee Tabotabo-Picardal[1], Emily May G. Rapirap[2], Ofelia N. Barrientos[3], Mary Jane B. Tura[4], Arnulfo C. Sarnillo[5], Adelaida L. Porol[6], Rey A. Kimilat[7]**

[1]*Don Vicente Rama Memorial National High School Department of Education, Cebu City Division, Region 7, Philippines*

[2]*Don Vicente Rama Memorial National High School Department of Education, Cebu City Division, Region 7, Philippines*

[3]*Pardo National High School Department of Education, Cebu City Division, Region 7, Philippines*

[4]*Ramon Duterte Memorial National High School Department of Education, Cebu City Division, Region 7, Philippines*

[5]*Madridejos National High School's Department of Education, Cebu Province Division, Region 7, Philippines*

[6]*SAGE Prep Schoolhouse, Cebu City Philippines*

[7]*Abellana National School Department of Education, Cebu City Division, Region 7, Philippines*

## Abstract

Drinking water from Water Vending Machines (WVM) may pose health risks to consumers especially to students who are primary end-users in the public school setting. A one-shot survey of WVM water samples from 8 public schools in Cebu City Philippines was analyzed for microbial test and 3 schools were further investigated for physicochemical analysis. Results revealed that 8 water samples registered a total coliform count of 2.6 CFU/mL while specific *E.coli* testing posted (<1.1 to 2.6 CFU/mL). 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). The water samples passed the physicochemical evaluation but failed in the microbiological test due to the presence of high levels of E.coli. Hence, water dispensed from the WVM is not safe for students' consumption. Schools and other institutions that utilized WVM must require private companies as well as the management also of the institutions to routinely check, clean, and maintain the machine to avoid accumulation of coliforms and E.*coli* contamination.



***Keywords***

water vending machine; public schools health; coliform; water assessment; Philippines

## 1. Introduction

The need to ensure safe drinking water especially for a vulnerable subpopulation such as school children and the students is anchored on the millennium development goal on environmental sustainability. Water vending is usually associated to private vending of drinking water which World Health Organization (2011) highly recommends that there is a need to constantly monitor the chemical and microbial parameters as part of the requirement for the suitability of water for human consumptions. Furthermore, it will also serve as a basis for the control measure such as water treatment requirements. Water that is supplied to the schools for consumption should meet the guidelines set by the regulatory agencies standards because the quality and adequacy of water supplies vary.

In the Philippines, commercially sold vended water usually is supplied from private and registered water companies in which water is treated prior to delivery and mode of access is through conventionally supplied tankers, others in coin-operated standpipes and/or water kiosks. Hence, good hygiene in handling vended water and its machine is required in order to avoid water-borne diseases caused by disease-causing bacteria and other microorganisms. Ideally, drinking water should not contain pathogenic organism such as E.coli which is considered to be a fecal indicator for water quality test. The presence of this thermotolerant coliform has been conventionally employed to monitor drinking-water quality up to the present time. As reported by Hutin, Luby & Paquet (2003) that vended water has been associated with gastrointestinal diseases such as diarrhea. Such diseases can adversely affect the performance of the students especially on their attendance (Jasper, Le, & Bartram, 2012).

The issue of clean and potable water is a pressing global concern. Issues on water security, water sanitation, and adequacy of water supply are considered a barometer of economic development of a nation in general and local districts in particular. In the local scenario, the Metropolitan Cebu Water District [MCWD] facilitates the equitable distribution of clean water for all domestic purposes. MCWD operates under a strict compliance to standard water sanitation practices, thereby rendering its water safe for human consumption. However, the course to which clean and potable MCWD's water reaches the household is affected by the following factors, namely: (a) stability and well-maintained pipes; (b) presence of septic tanks to which these pipes flow; (c) "pipe-tapping devices", an illegal form of drawing water from the main water lines; and (d) hygiene and sanitation practices in the end-user's household.

Ideally, MCWDs water is clean, purified, underwent standard chlorination, filtration and ozonation processes and are essentially ready for consumption. These protocols increase consumers' trust and confidence that such an affordable water supply is free from pathogenic organisms and has tolerable limits of dissolved metals. Despite MCWD's provided assurance to their consumers as to the safety of the water for drinking, a majority of local people prefer to buy purified water from water refilling stations. Local anecdotal reports from consumers argue on the increased safety once community water provided by MCWD passed through the second filtration process performed by refilling stations.

All over the Philippines, modes of delivery are observed either through the use of water dispensers in households and offices or water vending machines (WVM) in public places. The latter is commonly accessed in public elementary and secondary schools (i.e. where there is an absence of sterile water fountains as in the case of private schools), and these WVMs are operated by private franchisees which do not usually undergo strict sanitary monitoring due to the inherent trust of the schools to these WVMs operators. Drinking water from bottle-less coolers such that of the water vending machines may pose some public health risks to consumers due to either chemical or microbiological contamination (Hussein, Hassan & Bakr, 2009). The lack of sanitary monitoring paved the way for increased complacency on ensuring regular cleaning of WVMs, replacement of old gallons, removal of accumulated residues from biological and non-biological matter.

This alarming condition is a perennial concern especially in public schools where the population is large and children whose ages are vulnerable to gastrointestinal diseases. WHO statistics shows that there are approximately 94,000 deaths occurred in NCR due to diarrhea in 2014 caused by lack of safe water, sanitation and hygiene (WASH) services (WPRO, 2017). As to the report of the Department of Health that in 2018, within a month, 1,051 acute bloody diarrhea cases were reported and this is caused by exposure to various pathogens in food and water.

Such precedence is the standpoint of this initial assessment in order to investigate the quality of drinking water distributed through water vending machines located in different public schools in Cebu City.

## 2. Review of Related Literature

It is an inherent right for every citizen to have access to safe drinking water (WHO, 2011). Due to the increase in demand for potable water by the growing population, water service providers respond to the need through the placement of Water Vending Machines in populated areas such as in schools. The Philippine government must strengthen the regulation of these water supplies by ensuring them to be compliant to the national standard (i.e., PNSDW) for drinking water and that of the international institutions (i.e., WHO and US-EPA) (Del Rosario, Migo, Clemente, Cerbolles, & Tecson-Mendoza, 2012). Water dispensed by the WVM comes in the form of bottled water hence; the agency responsible for the regulating and monitoring of water is the Department of Health (DOH) Food and Drug Administration. This agency utilizes The Philippine National Standards for Drinking Water (PNSDW) 2007 in determining the water quality (Del Rosario et al., 2012). To ensure implementation of the task at the local level, the Local Water Utilities Administration (LWUA) was created through Presidential Decree 198 (1973) to monitor the local water standards and assess its compliance with the national standard. Administrative Order 0012 s. 2017 stipulates the guidelines for monitoring water vending machines such that the minimum frequency of sampling should be conducted once a month for a microbiological test and twice a year for physico-chemical analysis. Despite the tasked force and legal mandate, access to safe drinking water still remains an issue which prompted researchers to conduct an independent and third-party assessment of the water quality in their locality.

In the published reports conducted in the Philippines, Tonog and Poblete (2015) looked into the quality of drinking water obtained from various sources such as deep well, pump well and communal faucets in some barangays in Northern Samar and found out that all water samples were positive for fecal coliforms. Meanwhile, Alambatin, Germano, Pagaspas, Peñas, Pun-an, & Galarpe (2017) evaluated the physicochemical parameters of drinking water samples in Cagayan de Oro and found out that water is fit for human consumption, however; findings lack analysis on the presence of heavy metals, pathogens, and organic components. Meanwhile, Austero, Bernardes, Dael, dela Cruz, Honkulada, Jawadil, Stacy, & Uy (2013) evaluated the water samples collected from water vending machines within the radius of the hospital, and found out that all of the samples were positive for total coliform, total bacterial and fecal coliform count which rendered the water unfit for drinking.

In the global scenario, this water quality monitoring has been practiced. Decades ago, Chaidez, Rusin, Naranjo, & Gerba (1999) have already initially assessed the water vending machine in terms of microbiological and physico-chemical parameters. They concluded that there is a high bacterial concentration of total coliforms and *Escherichia coli* detected in the drain samples. No significant correlations were found between the physicochemical and bacteriological parameters. Similarly, Al Moosa, Ali Khan, Alalami, & Hussain (2015) investigated the water dispenser machines installed in schools and universities in UAE in terms of a microbial parameter. They concluded that the water samples were found unsatisfactory as total coliform and E.coli were detected. They attributed it to the low maintenance and improper hygiene and unsanitary conditions of the water dispenser machines. The aforementioned condition of water implies the need for ensuring water quality locally. From the prevailing scenarios both at the local and global scene, similar conclusions have been presented on the water samples collected — that it is not fit for human consumption due to the presence of pathogenic organisms. US-EPA (2018) strongly emphasized that there should be zero tolerance for the presence of fecal coliform in drinking water. Hence, this present study would like to verify if the water vending machines located in schools in Cebu are compliant with that national and global standard.

## 3. Materials and Methods

### 3.1. Study Site

This descriptive survey was conducted in eight (8) randomly selected public schools (composed of 4 elementary schools and 4 high schools) located in different regions within the city (refer to Figure 1). The number of schools selected as a sampling site is ten percent of the overall number of public schools in the whole division of Cebu City. In addition, the schools belong to the criteria of very large population size and the presence of WVM in the school premises. The city is divided into two congressional districts, north and south. There were four schools purposively selected for each of the district (comprised of 2 elementary schools and 2 secondary schools). From each school, water sample [total 2.5L] was collected from 10:00-11: 00 AM for the summer month of April 2017 on the same day and these were analyzed for microbial contaminants (i.e. total coliform). Meanwhile, three schools were randomly chosen from the six schools that registered higher than the normal level of *E. coli* test results ($<$1.1 CFU/ml) using a fishbowl technique (composed of one elementary and two high schools) for further physicochemical testing of the water from WVM found in the school for the pH, hardness and presence of heavy metals (Hg, Pb and As).

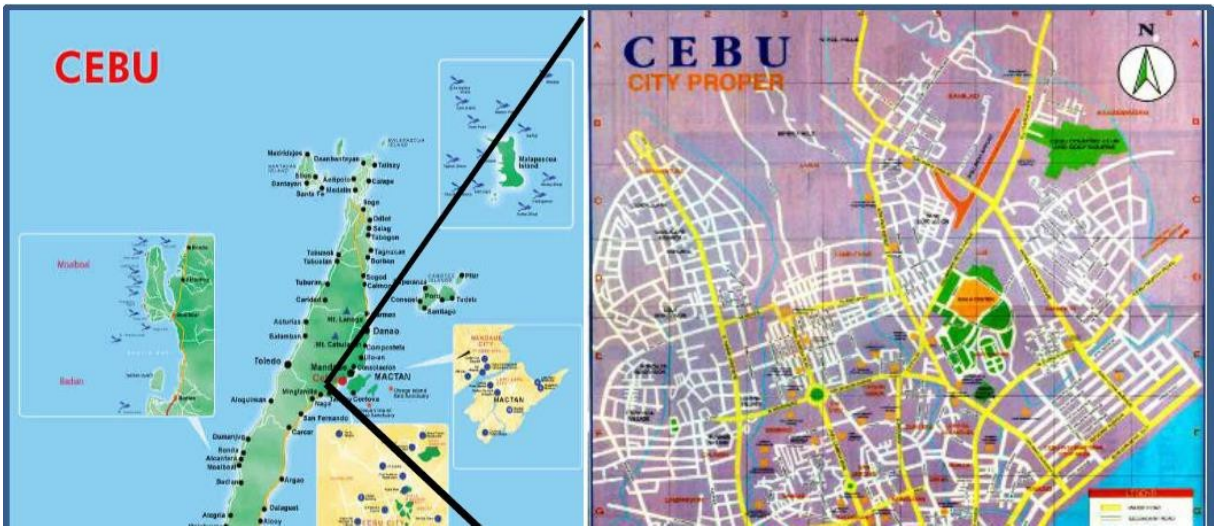


Figure 1. Map of Cebu City Proper where sampling stations were located.

### 3.2. Sampling

Water samples were collected from the water vending machines installed in randomly selected schools (names withheld for privacy and anonymity and ethical considerations). Specifically, *grab sampling* technique was employed in this study in which a sample was collected from those chosen schools simultaneously during the Month of April 2017 and is assumed to represent the composition of the water only at that time and place. In each school, the researchers collected 1.5 liters (L) water sample for chemical analysis and 1L water sample for the microbiological test. To avoid affecting the quality of data, the first and second running of water were disregarded. The third time was then used as the sample and was then taken into sterile containers without superficial disinfection of the outlet nozzles. Specimens were then submitted to the laboratory of MCWD in a cool box within 6 hours. Analyses of the physical property (i.e. pH and hardness) of the water samples were done at the Chemistry laboratory of a university. Heavy metal concentrations were analyzed at the Metro Cebu Water District.

### 3.3. Physicochemical and Microbiological Analysis

The drinking water samples were taken directly from the nozzle of the water dispenser machine. The samples were stored in a pre-sterilized 500 ml bottle. Right after the collection, drinking water samples were immediately submitted to the microbiological laboratory for the analysis. The colilert reagent was used to identify the presence of total coliform and *E.coli*.

### 3.4. Data Analysis

Data from diagnostic laboratories were collated, tabulated and analyzed using descriptive statistics (i.e. mean+S.D.) for parameters with 1 sample/trial. All data were presented and were correspondingly compared versus permissible limits (i.e. standard values published by United States Environmental Protection Agency [US EPA] 2018, World Health Organization [WHO], 2011 and Philippine National Standards for Drinking Water [PNSDW], 2007 for each heavy metal (see Table 3) and microbiological component (see Table 1).

## 4. Results and Discussion

Water quality is assessed in terms of the following parameters: biological, chemical and physical properties and these parameters are presented in separate tables below. Briefly, chemical properties include dissolved heavy metals alone while physical properties include pH and water hardness in terms of concentration of CaCl. For microbiological attributes, the presence of fecal coliform and total coliform counts were determined.

### 4.1. Biological Property of Water from WVM

The biological component of drinking water was assessed using Multiple Tube Fermentation Technique (MTFT) in two parameters, namely: appearance (in terms of colonies) and total coliform as well as fecal coliform (Table 1). The result shows that all eight samples did not show any remarkable appearance of colonies in the growth media, indicating the insignificant bacterial growth in the water samples. Meanwhile, total coliform registered 2.6 CFU/mL while specific *E.coli* testing posted <1.1 to 2.6 CFU/ml. Total coliform test for all samples (2.6 CFU/ml) were all higher than the Philippines standard value for clean water (i.e. <1.1/100 ml) and international standard set by WHO and US EPA which is 0.00. *E. coli* test, on the other hand, resulted to normal levels (<1.1 CFU/ml) in 2 (School B and H) of the 8 schools sampled if based on PNSDW standard but still violates the strict international standard. Although such colony counts were within the standard values for *E.coli* testing, its total coliform counts were beyond standard values (see Table 1) and this finding is in consonance to Prasai, Lekhak, Joshi, & Baral (2007) that registered 82.6% and 92.4% of drinking water samples found to cross the WHO guideline value for drinking water. Furthermore, the same finding also agrees with the studies of Tonog and Poblete (2015) and Al Moosa et al. (2015) on the unsatisfactory condition of drinking water due to the observed and identified total coliform and E.coli.

These indicate that still, samples from School B and H, like the rest of the samples, and are also not safe for human consumption in the long run as purported by Prasai et al. (2007) that bacteriological pollution is increasing alarmingly in drinking water supplies when he analyzed drinking water in Kathmandu valley.

There are factors to be considered in this result such as the [1] temperature (Al Moosa, Ali Khan, Alalami & Hussain, 2015) as most of the WVM are placed where direct sunlight can reach it, [2] handling and delivery of the water during refilling process and replacement of gallons from the station to the vending machine, and [3] exposure of nozzle and carbon filter itself to dust or soil particles that may contaminate the water sample (Al Moosa et al., 2015; Chaidez, Rusin, Naranjo & Gerba, 1999).

Appearance refers to the presence or absence of visible colonies of bacteria when grown in growth media during testing. Total coliform refers to the Gram-negative non-spore forming and motile or non-motile bacteria which

Table 1. Themicrobiological test result of water from WVMs among selected public schools in Cebu City

| Sampling Site (School) | | Analysis | | Remarks |
|---|---|---|---|---|
| | Appearance | Total coliform CFU/mL | E. coli CFU/mL | |
| A | clear | 2.6 | 2.6 | Failed |
| | clear | 2.6 | <1.1 | Failed |
| C | clear | 2.6 | 2.6 | Failed |
| D | clear | 2.6 | 2.6 | Failed |
| E | clear | 2.6 | 2.6 | Failed |
| F | clear | 2.6 | 2.6 | Failed |
| G | clear | 2.6 | 2.6 | Failed |
| H | clear | 2.6 | <1.1 | Failed |
| Standard Value of PNSDW (2007) | | <1.1/100 ml | <1.1/100 ml | |
| Standard Value of US EPA (2018) | | 0.00 | 0.00 | |
| Standard Value of WHO (2011) | | 0.00 | 0.00 | |

under the suitable environmental condition of 35–37°C can ferment lactose with the production of acid and gas (Edberg, Rice, Karlin, & Allen, 2000). As purported by Omer, Algamidi, Algamidi, Fadlelmula, and Aklsubaie (2014) that contaminated water is a suitable medium to transmit diseases which is why E.coli is commonly used indicator of sanitary quality of water. Their presence is used to indicate that other pathogenic organisms of fecal origin may be present (Onichandran, 2014). The coliform index is also a rating of the purity of water based on the fecal bacterial count (Prasai, Lekhak, Joshi & Baral, 2007; Edberg et al., 2000 & Tan, Arifullah, & Soon, 2016). These bacteria originate from the intestine of warm-blooded animals (like humans and most mammals). Evaluation of total coliform is an important measure of whether the water came in contact with human feces (fecal-oral route) along the way to the pipes (processing to filtration) and eventually to human (Chaidez et al., 1999). Hence, in this study, the majority of the water samples is not fit for human consumption due to the presence of fecal coliform as it did not qualify for the permissible standard value set by the PNSDW, US EPA, and WHO. This finding also implies that it may cause an adverse effect on the gastrointestinal health of the consumers. It is not an assurance that although the water appears clears it is free from contamination (LeChevallier, 2003).

**Chemical Property of Water from WVM**

Majority of the reported and recorded water-related health problems is due to the microbial contamination and also brought about by chemical contamination of drinking water (WHO, 2011)

Table 2. Heavymetal test on water samples from WVMs from selected public schools in Cebu City

| School | Heavy Metals | Test Value* (mg/L) | Reading / Interpretation |
|---|---|---|---|
| | | | |
| A | Mercury | 0.001 | Negligible |
| | Lead | 0.000 | Normal |
| | Arsenic | 0.000 | Normal |
| | Mercury | 0.000 | Normal |
| | Lead | 0.002 | With dissolved units – check the tubing |
| | Arsenic | 0.000 | Normal |
| C | Mercury | 0.000 | Normal |
| | Lead | 0.004 | With dissolved units – check the tubing |
| | Arsenic | 0.000 | Normal |

**Results are for extracted heavy metals using pH 4.8 ammonium acetate using Atomic Absorption Spectroscopy. For drinking water, 000/-000 is the most ideal concentration (i.e. absence of heavy metals)*

*Note: WHO Standard for hardness test (McGowan, 2000):*

Table 3. Permissible Limits of drinking water quality forinorganic chemical constituents (mg/L) recommended by various agenciesconcerned on food and water quality and sanitation

| Heavy metals | Philippine National Standards for Drinking Water [PNSDW, 2007] | The United States Environmental Protection Agency [US-EPA, 2018] | World Health Organization [WHO, 2011] |
|---|---|---|---|
| Mercury (Hg) | 0.001 | 0.002 | 0.001 |
| Lead (Pb) | 0.01 | 0.00 | 0.05 |
| Arsenic (As) | 0.05 | 0.05 | 0.05 |

Table 4. Hardnesstest result (concentration of CaCl) of water samples from WVMs

| School | Calcium Chloride (mg/L) | Classification |
|---|---|---|
| A | 18.5 | Soft |
| | 7.9 | Soft |
| C | 9.0 | Soft |

*<60 mg/l = soft; 60–120 mg/l = moderately hard; 120–180 mg/l = hard; >180 mg/l, very hard*

The typical contribution of calcium in the diet is 5–20% of the drinking water and the rest of it are obtained from food sources for the recommended 80% dietary intake. Mineral-rich drinking water can be a good source of these recommended nutrients and may supplement the needed calcium requirement by the body, in addition to main food sources of Calcium such as milk, cheese, and other dairy products (WHO, 2011).

Table 5. pHof water samples from WVMs from public schools in Cebu City.

| School | pH | | | Mean + SD | *Standard Value | Interpretation |
|---|---|---|---|---|---|---|
| | Trial 1 Trial 2 Trial 3 | | | | | |
| A | 7 | 7.5 | 6.5 | 7.00 + 0.500 | 6.5 – 8.5 | Normal |
| | 5.5 | 5 | 6 | 5.50 + 0.500 | 6.5 – 8.5 | Slightly Acidic |
| C | 6.5 | 7 | 7 | 6.83 + 0.288 | 6.5 – 8.5 | Normal |

**US-EPA 2018 Standard Drinking Water Regulation (pH = 6.5 – 8.5)*

The pH of water from different WVMs ranges from 5.50 (slightly acidic) to 7.00 (neutral). Normally, pH range for drinking water is between 6.50 to 8.50 (Tan et al., 2016), thus except for one sample (School B), the two other schools have WVMs providing a water with acceptable pH level. This may suggest a slightly higher concentration of hydrogen ion in the water medium due to rapid loss of electrolytes like sodium, calcium, and magnesium. Water samples from WVMs came from water refilling stations that employ purification process hence the water is slightly acidic as it becomes an active absorber of carbon dioxide as it comes in contact with air (Flanagan & McCauley, 2010). The acidity can be linked to poor maintenance of either the container, nozzle tube or the entire machine in general.

In general, water with a pH $< 6.5$ could be classified as acidic, soft, and corrosive. The acidity of the water may indicate a significant amount of metal ions such as Fe, Mn, Co, Pb, and Zn. Hence, acidic water contains a high amount of toxic metals which may be associated with health risks and pose a detrimental effect on the human body. Thus, neutralizing solutions are used (i.e. containing sodium carbonate or commonly known as soda ash) which may eventually increase pH level. On the other hand, the hardness of water is indicated by a pH level of $>8.5$ which is considered alkaline which does not pose a health risk. However, hard water may cause aesthetic problems such as alkali taste, the formation of scale deposits on the surface that comes in contact with the water, slippery and difficult to lather for soaps and sometimes forms insoluble precipitates on clothing. While the ideal pH level of drinking water should be between 6.50 - 8.50 (US-EPA, 2018), the human body has the ability to maintain pH equilibrium regularly regardless of the water intake. For instance, our stomach maintains a naturally low pH level of 2 which is needed and aids in the digestion of food.

## 5. Conclusion

Based on the results of the study, chemical and physical test were within the acceptable levels as heavy metals (which are known to be toxic in large amounts) were at the negligible to a normal level, pH was relatively acceptable, and hardness level is acceptable. However, the water samples obtained from the WVM were relatively unclear of coliform bacteria such as *E.coli* and total coliform count as evidenced by a relatively higher CFU/mL compared to the acceptable values in drinking water. Hence, the study concluded that the water sample is unfit for human consumption. As the results may suggest, these water vending machines need routine cleaning and maintenance to avoid accumulation of coliforms and contamination of *E.coli*.

## 6. Recommendations

In order to ensure the quality of drinking water accessed by the public through vending machines installed in schools, it should be regularly cleaned, monitored and tested by the company owner to comply with the guidelines and also by the designated government agency for public safety and welfare. Furthermore, hygienic conditions in handling, delivery, and storage of water should be given utmost priority. A school administrator also must create and implement guidelines and protocols in regulating the bottles of water supplied, machines installed in schools, as well as the usage and maintenance of the overall facility to ensure utmost compliance to the standard for safe drinking water. Local Government Units must conduct regular monitoring as mandated in the Administrative Order 0012 s. 2007 that all the water vending machines installed in public places be analyzed for microbiological constituent monthly and physicochemical analysis twice a week not just in schools but also in eateries and convenient stores where most of the water vending machines are placed.

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