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Research Article

Assessment of microbial quality of bottled water from street vendors and sundry stores in Metro Manila, Philippines

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Abstract
The consumption of bottled drinking water sold by street vendors and sundry stores in Metro Manila has increased because it is expected to be microbiologically safe and is readily available for purchase by commuters, especially in a tropical country with warm and humid weather. Thus, this study investigated the microbial quality of bottled water sold within Metro Manila. Eighty samples representing sixteen brands of bottled water were purchased and analyzed for heterotrophic plate count bacteria (HPC), total coliforms (TC), *Escherichia coli* and yeast/moulds (YM). The percentage of bottled water samples that did not meet the microbial quality standard was 15%, 24%, and 6% for HPC, YM, and TC, respectively in accordance to the Philippine National Standards for Drinking Water of 2017. HPC bacteria and coliform concentrations were positively correlated with each other ($p < 0.01$), whereas HPC and YM concentrations were positively correlated with the bottled water's chloride levels ($p < 0.05$). Coliform isolates from five samples were identified as *Klebsiella pneumoniae*, with four exhibiting resistance to ampicillin but remaining susceptible to the other 20 tested antibiotics. These findings highlight potential health risks associated with generic bottled water and emphasize the need for stricter quality control to prevent waterborne diseases.

Keywords: Bottled water, Coliform, Heterotropic plate count (HPC) bacteria, Microbial standard, Mold, Yeast

INTRODUCTION

Street vendors and sundry stores are commonly seen along the streets of Metro Manila, selling generic bottled water to pedestrians and commuters in private and public utility vehicles. There is a demand for bottled drinking water, as it is readily available for purchase and is expected to be microbiologically safe and suitable for immediate consumption (Doria, 2006; Puspita *et al*., 2023; Tabar *et al*., 2023; Walter *et al*., 2017). However, several studies have shown that the bacteriological qualities of some bottled water, which they claim as purified water, may not conform to national and international standards as expected by its consumers, so therefore, may not be suitable for human consumption (Mills *et al*., 2018; Pant *et al*., 2016; Traoré *et al*., 2023). There may be contamination of the bottled drinking water during its treatment, bottling, and sealing process, either by human or animal faeces or heterotrophic bacteria (Bedada *et al*., 2018; Momtaz *et al*., 2013). The common manifestation of waterborne diseases is digestive disturbances. However, in an increasing numbers of susceptible individuals, such as ambulatory but immunocompromised individuals and elderly persons, the effects may be more severe (WHO, 2022). In addition, the potential presence of multiple antibiotic-resistant bacteria may limit therapeutic options once these bacteria cause the infection (Aguilar-Salazar *et al*., 2023). Currently, there is limited data on the microbial quality of bottled water sold by sidewalk vendors or sundry stores in Metro Manila. Thus, there was a need for a study of this bottled water if they have met the microbial standards set by the Department of Health's (DOH) Philippine National Standards for Drinking Water (PNSDW) (DOH, 2017), World Health Organization's (WHO) Guidelines for Drinking Water Quality (GDWQ) (WHO, 2022), and the fungal quality standards for non-alcoholic beverages by the Food and Drug Administration Philippines (FDA, 2018). The present study aimed to determine the presence and concentration of the microbial quality indicators in bottled water in Metro Manila, including *Escherichia coli* (EC), total coliforms (TC), heterotrophic plate count bacteria (HPC), and yeasts/molds (YM).

MATERIALS AND METHODS

Sample collection

A total of 80 samples (250–1000 mL) of generic polyethylene terephthalate (PET) bottled water were obtained from street vendors and sundry stores across four districts of Metro Manila: 1st (Capital district), 2nd (Eastern Manila), 3rd (Northern Manila), and 4th (Southern Manila) (Fig. 1). These samples comprised 16 different generic brand coded as A through P, with four brands selected per district and five bottles collected per brand, yielding 20 samples per district and a total of 80 samples. Each sample was transported to the laboratory in an ice bucket to maintain a cold temperature and was processed within four hours of purchase.

Microbial quality testing

Before collecting the sample, the bottle cap and neck were disinfected with a sterile gauze soaked in 70% ethanol, allowed to air dry, and then briefly flamed using an alcohol lamp. The bottle was then opened aseptically, ensuring that the inner rim was not touched. Each bottled water was sampled for the enumeration of HPC bacteria, *E. coli*/total coliform, and yeasts/molds. Specifically, using the 3M Petrifilm™ Aqua Heterotrophic Count (HC) Plate, *E. coli*/Coliform Count (EC) Plate, and Yeast and Mold Count (YM) Plate, respectively, in accordance with the manufacturer's instructions.

Heterotrophic plate count (HPC) bacteria

HPC bacteria were determined using a Petrifilm HC Plate. Two 1-mL volumes of samples were used. One sample was distributed undiluted onto one HC plate, while another sample with a 1:10 dilution (using a sterile 0.9% saline solution as the diluent) was distributed onto another HC plate. The Petrifilms were then incubated at 37 ± 0.1 °C for 48 ± 1 hours, with a maximum of 5 stacks. After incubation, colony-forming units (CFU's) were enumerated using a standard colony counter. All red CFU's were counted regardless of size

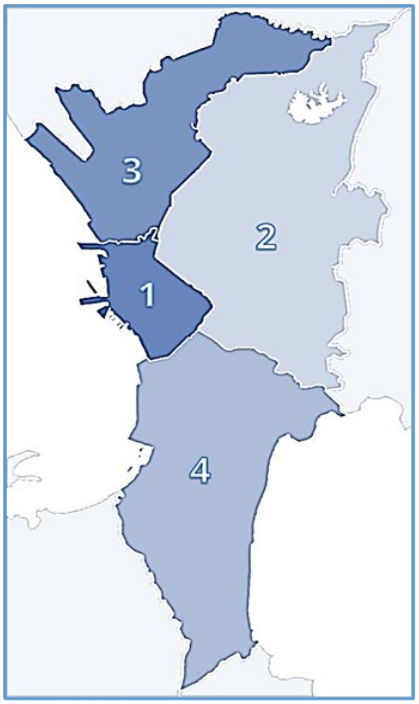

Fig. 1. *A map showing the districts of Metro Manila: 1st District (Capital district); 2nd District (Eastern Manila); 3rd District (Northern Manila); 4th District (Southern Manila)*

or color intensity. If the CFU's were "too many to count" (TNTC) in the HC plate containing the undiluted sample, the accompanying HC plate with a sample dilution of 1:10 was counted. The count was then multiplied by 10 to report the final count.

Total coliforms and *Eschericia coli*

Counts for total coliforms and *E. coli* were determined using a Petrifilm EC plate. Like the HPC procedure, a 1 -mL volume of the sample was distributed onto the media. The EC plate was then incubated at 37 ± 0.1 °C for 48 ± 1 hours, with a maximum of 5 stacks. After incubation, colonies were enumerated using a colony counter. All red CFU's beside gas bubbles were enumerated as presumptive coliforms, and blue CFU's beside gas bubbles as presumptive *E. coli*. Total coliforms were determined by adding the numbers of blue and red CFU's beside the gas bubbles (Schraft and Watterworth, 2005).

Total yeast and molds

Yeast and mold counts were determined using a Petrifilm YM plate. One 1-mL volume of the sample was also distributed onto the media. The YM plate was then incubated at 25±0.1°C for up to 5 days, with a maximum of 5 stacks. After incubation, colonies were enumerated using a colony counter**.** Colonies that were small with defined edges, monochromatic, and that may appear raised with no dark center were counted as yeasts. In contrast, colonies that grow large, flat, and have diffuse edges, with various pigments (e.g., blue-green, beige, orange, tan) and a darker, differently coloured centre, were counted as moulds (Bird *et al*., 2015). The total yeasts and molds count was then added to determine the total fungal colony-forming units.

Biochemical identification of presumptive coliforms

All red and blue colonies with gas bubbles that grew in EC plates were identified and further determined for their antimicrobial susceptibility profile. Briefly, presumptive coliform colonies in EC plates were further subcultured in MacConkey (MAC) agar (HiMedia Laboratories Pvt. Ltd., Mumbai, India) by isolation streaking. The MAC agar was then incubated at 37°C ± 0.5°C for 18 hours. On MAC agar, presumptive colonies of *E. coli* and other coliforms appeared as pink colonies, sometimes accompanied by a pink halo.

Antimicrobial susceptibility testing

Bacterial suspensions were prepared from MAC by emulsifying the bacterial isolates in 0.5% sodium chloride. Using the VITEK DensiChek™ (bioMérieux), the turbidity of the bacterial suspension was adjusted to match the 0.6 McFarland standard. Afterward, the bacterial suspension and the VITEK 2 ID-N261 card were loaded into the VITEK 2 system (bioMérieux, Inc., Durham, NC, USA). VITEK 2 testing was conducted using the AST-N261 card and the software version 9.03.3, according to the manufacturer's instructions. The VITEK 2 ESBL (Extended-Spectrum Beta-Lactamase) test was included on the AST-N261 card for *E. coli* and *K. pneumoniae*.

Selected isolates were tested to sixteen antibiotics covering six different antimicrobial classes: penicillin's (amoxicillin/clavulanic acid, ampicillin, and piperacillin/tazobactam), cephalosporins (cefepime, cefoxitin, ceftazidime, ceftriaxone, cefuroxime, and cefuroxime axetil), and carbapenems (ertapenem, imipenem, and meropenem) for β-lactams; amikacin and gentamicin for aminoglycosides; ciprofloxacin for quinolones; and cotrimoxazole for sulfonamides. The isolates were then classified as resistant, intermediate, or sensitive based on their minimum inhibitory concentrations (MIC's) following the CLSI (Clinical and Laboratory Standards Institute) guidelines (CLSI, 2021). In addition, a Sensititre™ plate (Sensititre™, Thermo Fisher, Dardilly, France) was used. AST was further determined for an additional five antibiotics covering penicillin [ampicillin/sulbactam (SAM)], cephalosporins [cefotaxime (CTX), ceftazidime/avibactam (CZA)], and carbapenems [imipenem/relebactam (IMIREL), and meropenem/vaborbactam (MEMV)] for a total of twenty-one antibiotics. The results were interpreted in accordance with the EUCAST guidelines (Bonnin *et al*., 2022; Thermo Fisher Scientific, 2018).

Microbial quality standard

After testing for the bacteriological and mycological quality of water samples, it was determined whether they met the standards set by the GDWQ (WHO, 2022) and the PNSDW (DOH, 2017) for bacterial quality (e.g., HPC bacteria, coliform, and *E. coli*). In addition, the Food and Drug Administration Philippines (FDA, 2018) fungal quality standards for non-alcoholic beverages (e.g., energy drinks, soft drinks, fruit juice) were also used as criteria for bottled water (Table 1) since there are no quality standards for mycological quality of drinking water set by the GDWQ and the PNSDW.

Physicochemical analysis

After sampling for microbial quality testing, each bottled water sample from all brands underwent physicochemical analysis within one hour. Chloride levels, pH, and turbidity were measured using ion chromatography, the electrometric method, and turbidimetry, respectively. The results were evaluated against the limits set by the Philippine National Standards for Drinking Water (PNSDW).

Data analysis

To determine the association between the brand of bottled water and meeting of the microbial standard for

drinking water, as well as the relationship between the physicochemical characteristics and microbial concentrations, the data were analyzed using the SPSS version 28.0 (SPSS Inc., Chicago, IL, USA) by running the Fisher's exact test and Spearman's rank correlation, respectively. P-values of ≤0.05 were considered significant.

RESULTS

Microbial quality and physicochemical characteristics of bottled water

The average concentration of HPC, TC, and YM per brand is listed in Table 2. Among the sampled brands, C and D have the highest average HPC (1022 and 1290 CFU/mL, respectively), C and L have the highest average TC (0.6 and 1.8 CFU/mL, respectively), whereas brands D and M had the highest average YM concentrations (2.6 and 244 CFU/mL, respectively). No presumptive *E. coli* colonies (blue with gas bubbles) were detected in all samples.

The average pH of bottled water ranged from 5.35 to 7.52, and five brands (C, E, F, I, and N) had pH levels that fell outside the maximum allowable level (MAL) of 6.5 to 8.5 as set by the PNSDW. Furthermore, the average chloride levels range from <0.5 ppm to 4.64 ppm, with all samples having chloride levels that were significantly below the MAL of 250 ppm as set by the PNSDW. Lastly, all the samples had turbidity below the detection limit of 0.5 nephelometric turbidity units (NTU), which is way below the MAL of 5.00 NTU.

Additionally, the frequency of bottled water brands that did not meet microbial standards is presented in Table 3. The results indicate a significant association between

Table 1. Microbial standard set for drinking water/non-alcoholic beverages

Parameters	Standard Values	Unit of measurement
HPC	<500	CFU / mL
Total coliform / E. coli	<1	CFU / 100 mL
Total yeast/mold	<1	CFU / mL
pH (25^{o}C)	6.5-8.5	
Chloride	250	PPM
Turbidity	5	NTU

CFU, colony forming units; HPC, heterotrophic plate count bacteria; mL, milliliter; NTU, nephelometric turbidity units; PPM, parts per million

Table 2. The microbial and physicochemical characteristics of bottled water samples

Brand code	HPC (CFU/mL)	TC (CFU/mL)	YM (CFU/mL)	pH (25^{o}C)	Chloride (PPM)	Turbidity (NTU)
A	2.4±3.9	0	0.6±1.34	7.42	3.24±0.03	<1.0
B	47.8±34.2	0	0	6.99	<0.5	<1.0
C	1022±157	0.6±0.89	0.4±0.55	6.42	<0.5	<1.0
D	1290±243	0.2±0.45	2.6±1.67	7.52	4.64±0.04	<1.0
E	2.4±5.4	0	0	5.62	<0.5	<1.0
F	0	0	0	6.26	<0.5	<1.0
G	112±245	0	0.2±0.45	6.67	1.50±0.04	<1.0
H	0	0	0	6.74	<0.5	<1.0
I	0	0	0	5.35	<0.5	<1.0
J	0	0	0.2±0.45	6.62	<0.5	<1.0
K	3.8±6.5	0	0.2±0.45	7.08	<0.5	<1.0
L	271.6±87	1.8±3.49	0	6.58	<0.5	<1.0
M	1.4±3.13	0	244±31	6.75	<0.5	<1.0
N	146±163	0	0.4±0.55	6.02	<0.5	<1.0
O	0	0	0.2±0.45	6.97	<0.5	<1.0
P	44.6±44.1	0	39.6±65.12	6.56	<0.5	<1.0
MAL	<500	<1	<1	6.5-8.5	250	5

CFU, colony forming units; HPC, heterotrophic plate count bacteria; MAL, maximum allowable level; NTU, nephelometric turbidity units; PPM, parts per million; TC, total coliform; YM, yeast and mold

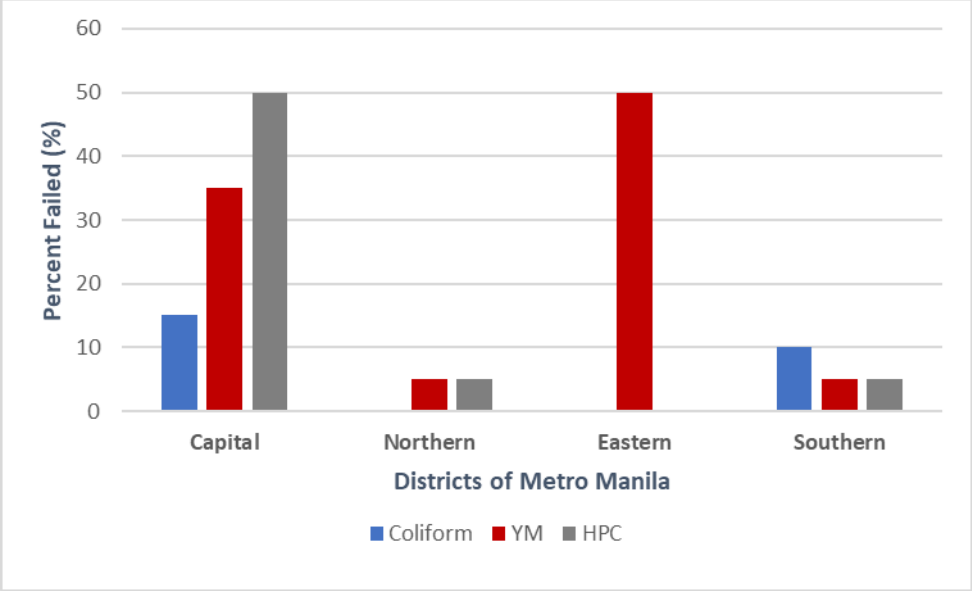

Fig. 2. *Percentage of bottled water samples that failed to meet the microbial standards per district, as defined by the PNSDW and FDA Philippines*

the brand of bottled water and exceeding the numerical limits for HPC and YM count ($p < 0.01$). Notably, not all brands indicated the water treatment methods used on their labels. Two of the samples from brand C, and one from brand D failed all the microbial standards. In contrast, six brands (B, E, F, H, I, and K) met all the microbial quality standards set by the PNSDW (DOH, 2017). Fig. 2 presents the percentage of bottled water samples per district that failed to meet microbial standards.

Relationships among the bottled waters' microbiological concentration and physicochemical characteristics

The relationship between CFU/mL of HPC bacteria, coliform, and yeast/molds with pH and chloride levels is shown in Table 4. Spearman correlation analysis revealed a significant correlation between pH and yeast/mold (YM) concentrations (Spearman $\rho = 0.232$, $p = 0.038$). Similarly, chloride levels showed significant correlations with YM (Spearman $\rho = 0.238$, $p = 0.033$) and HPC bacteria concentrations (Spearman $\rho = 0.239$, $p = 0.033$). However, coliform concentrations exhibited no significant relationship with pH or chloride levels. Additionally, Table 4 indicates a significant positive correlation between HPC bacteria and coliform concentrations (Spearman $\rho = 0.362$, $p = 0.001$).

Antibiotic susceptibility profile of isolated coliforms from the bottled water samples

In this study, 5 out of 80 bottled water samples (6.0%) exhibited presumptive coliform growth, characterised by the presence of red colonies with gas bubbles on EC Petrifilm plates. These isolates were further analyzed for phenotypic identification and antibiotic resistance patterns using the VITEK 2. All presumptive

Table 3. Frequency of samples failing to meet the microbial quality standard for drinking water

Brand code	HPC (CFU/mL)	TC (CFU/mL)	YM (CFU/mL)
A	0	0	1
B	0	0	0
C	5	2	2
D	5	1	4
E	0	0	0
F	0	0	0
G	1	0	1
H	0	0	0
I	0	0	0
J	1	0	1
K	0	0	0
L	0	2	0
M	0	0	5
N	0	0	2
O	0	0	1
P	0	0	2
n = 80 (%)	12 (15)	5 (6)	19 (24)
p value	<0.01	0.054	<0.01

HPC, heterotrophic plate count bacteria; TC, total coliform; YM, yeast and mold

Table 4. Spearman correlation coefficients and their respective p-values describing relationships between the variables

Variable	pH		Chloride (ppm)		HPC bacteria (CFU/mL)		Coliform (CFU/mL)	
	ρ	*p* value	ρ	*p* value	ρ	*p* value	ρ	*p* value
pH	1.000		**0.575**	**<0.01**	0.051	0.655	-0.033	0.774
Chloride	**0.575**	**<0.01**	1.000		**0.239**	**0.033**	0.060	0.596
HPC	0.051	0.655	**0.239**	**0.033**	1.000		**0.362**	**0.001**
Coliform	-0.033	0.774	0.060	0.596	**0.362**	**0.001**	1.000	
YM	**0.232**	**0.038**	**0.238**	**0.033**	0.163	0.149	0.163	0.147

CFU/mL, colony forming units/millilitre; HPC, heterotrophic plate count; ppm, parts per million; ρ, Spearman's rho; YM, yeast and molds

Table 5. Minimum inhibitory concentrations (MICs) of *Klebsiella pneumoniae* and their interpretation

Code	AMP	AMC	TZP	CXM	FOX	CAZ CRO	FEP	ETP	IMP MEM	AMK	GEN	CIP	SXT
C3	32 (R)	2 (S)	4 (S)	2 (S)	4 (S)	1 (S)	1 (S)	0.5 (S)	0.25 (S)	2 (S)	1 (S)	0.25 (S)	2 (S)
C5	16 (R)	2 (S)	4 (S)	2 (S)	4 (S)	1 (S)	1 (S)	0.5 (S)	0.25 (S)	2 (S)	1 (S)	0.25 (S)	2 (S)
D1	16 (R)	2 (S)	4 (S)	4 (S)	4 (S)	1 (S)	1 (S)	0.5 (S)	0.5 (S)	2 (S)	1 (S)	0.25 (S)	2 (S)
L3	16 (R)	2 (S)	4 (S)	2 (S)	4 (S)	1 (S)	1 (S)	0.5 (S)	0.25 (S)	2 (S)	1 (S)	0.25 (S)	2 (S)
L4	8 (S)	2 (S)	4 (S)	2 (S)	4 (S)	1 (S)	1 (S)	0.5 (S)	0.25 (S)	2 (S)	1 (S)	0.25 (S)	2 (S)

AMK, amikacin; AMP, ampicillin; AMC, amoxicillin/clavulanic acid; CAZ, ceftazidime; CIP, ciprofloxacin; CRO, ceftriaxone; CTX, cefotaxime; CXM, cefuroxime; CXMa, cefuroxime axetil; CZA/ ceftazidime/avibactam; ETP, ertapenem; FEP, cefepime; FOX, cefoxitin; GEN, gentamicin; IMIREL, imipenem/relebactam; IMP, imipenem; MEM, meropenem; meropenem/vaborbactam (MEMV); R, resistant; S, susceptible; SAM, ampicillin/sulbactam; SXT, trimethoprim/sulfamethoxazole; TZP, piperacillin/tazobactam; Note: All isolates were also susceptible to ampicillin/sulbactam (SAM), cefotaxime (CTX), ceftazidime/avibactam (CZA), imipenem/relebactam (IMIREL), and meropenem/vaborbactam (MEMV).

coliform colonies from bottled water samples C3, C5, D1, L3, and L4 were identified as *Klebsiella pneumoniae*. Four of these isolates exhibited resistance to ampicillin but remained susceptible to all other antibiotics tested (Table 5)

DISCUSSION

According to the GDWQ of WHO (2022), the ideal microbial indicators of water quality are the indigenous microbiota found at high concentrations in the colon of humans and warm-blooded animals. They should also be able to enter natural waters, water bodies, or water distribution systems via fecal contamination and be culturable using simple methods. Thus, the GDWQ and the PNSDW assess microbial quality using bacterial indicators such as HPC, TC, and *Escherichia coli*.

About HPC measurements, it detects microbes that can be grown on general isolation or nonselective media. This may include non-fastidious, rapidly growing bacteria that have long survival times in treated water (WHO, 2022). One use of this microbial indicator is to determine if the water had undergone sufficient treatment, such as filtration or distillation. In this study, all five samples from two brands (C and D) and one sample each from two other brands (G and J) exceeded the numerical limits set for HPC (Table 3). In addition, exceeding the numerical limit for HPC count (500 CFU/mL) was significantly associated with these brands ($p < 0.01$). Although this bottled water was retrieved from a refrigerator, HPC growth might have been enhanced during initial storage at warm temperatures or exposure to sunlight during transport (Duranceau *et al*., 2012). Though their isolation in bottled water did not specifically indicate fecal pollution and risk for gastrointestinal illness, HPC may still indicate the potential presence of opportunistic pathogens (e.g., *Acinetobacter*, *Aeromonas*, *Pseudomonas*, etc.) that may be significant

for immunocompromised populations in ambulatory care or discharged to "home care" (Herath *et al*., 2014; WHO, 2022).

Regarding numerical limits for TC, five bottled water samples that grew presumptive coliforms were all identified as *K. pneumoniae* (Table 3). However, since most coliform members are heterotrophic and are found naturally in water bodies, isolation in bottled water also does not specifically indicate fecal pollution and risk for gastrointestinal illness in the general population, though it may also pose a risk of infection to those who are immunocompromised (Burlakoti *et al*., 2020; Palmares *et al*., 2024, 2025). In the present study, four out of five *K. pneumoniae* isolates were resistant to one out of 21 (4.76%) antibiotics, whereas, in contrast to one study, their isolates were resistant to 6 out of 8 (75%) antibiotics (Al-Fifi *et al*., 2019). Nonetheless, coliforms like *K. pneumoniae* are usually sensitive to disinfectants. Thus, its presence could still indicate that the bottled water might have been contaminated by personnel or the manufacturing facility involved in water treatment, the bottling process, storage, and packing (Curutiu *et al*., 2020; Hamad *et al*., 2022; Mills *et al*., 2018). In the study, not meeting the standards for TC was not significantly associated with the brands ($p = 0.054$). All of the samples were also negative for *E. coli*, which is regarded as the most sensitive indicator of faecal pollution and a risk factor for waterborne diseases (WHO, 2022).

Regarding yeast and moulds, the GDWQ and PNSDW (DOH, 2017; WHO, 2022) have not set numerical limits for drinking water. Therefore, this study utilised the standards of FDA Philippines for non-alcoholic beverages. In this study, at least one sample from each of the nine brands (A, C, D, G, J, M, N, O, and P) has failed to meet the numerical limits for YM count (see Table 3). Two of which (C and D) also did not comply with the numerical limits for TC. Although testing for yeasts and moulds was not required under the PNSDW, their presence also indicates the quality of water treatment and storage. In this study, all five bottled water samples of Brand M exceeded the numerical limits for YM count. This contamination may have resulted from their immersion in crushed "fish" ice, which had a YM count of approximately 650 CFU/mL, during the selling process. Regardless, several fungi that are reported to contaminate bottled drinking water can also potentially cause illnesses. This occurs by producing mycotoxins, which may cause infections (e.g., allergic reactions) in immunocompromised individuals (Ameen *et al*., 2018; Svagzdiene *et al*., 2010). Therefore, the presence of yeast and mould in bottled water is also a potential concern for public health and safety (Babič *et al*., 2017).

Regarding the observed physicochemical characteristics, all the bottled water samples have no visible color. Their turbidity was also below the detection limits of 0.5 NTU. According to GDWQ standards, color and turbidity may indicate the presence of organic matter and microbial contaminants. Additionally, consumers associate colour and turbidity with safety issues or with sources of poor quality and inadequate treatment (De Queiroz *et al*., 2013; Gharibi *et al*., 2018). Nonetheless, no specific health-related threshold regarding color and turbidity has been set for drinking water (WHO, 2022).

As for pH, all samples from five brands (C, E, F, I, and N) have pH below the minimum allowable level of 6.5. According to the GDWQ, an acidic pH ($pH \leq 7$) may lead to corrosion of pipes in water systems, potentially resulting in microbial contamination of drinking water (WHO, 2022). However, of the five brands with a pH of <6.5, only brands C and N have not met the microbial standards. Nonetheless, no specific health-related threshold regarding acidic pH has been set for bottled drinking water (WHO, 2022), except for its association with the erosion of tooth enamel and dentine (Schmidt and Huang, 2022). Concerning chloride, 13 brands have chloride levels of <0.5 ppm, and the other three brands have less than five ppm, way below the MAL of 250 ppm (WHO, 2022). According to GDWQ, elevated chloride concentrations in water can also accelerate the corrosion of metal pipes in the water distribution system, potentially leading to microbial contamination. Nonetheless, no specific health-related threshold for chloride values in drinking water has been established (WHO, 2022).

In summary, 45% (36 out of 80) of the samples were contaminated with fungi and bacteria. Of the 36 samples, 32.5% (26 out of 80) contained fungi and/or bacterial indicators exceeding the standard allowable limits of the GDWQ, PNSDW, and FDA Philippines. This accounts to 15%, 24%, and 6% of the bottled water, not meeting the standards set for HPC, YM, and TC, respectively. Microbial concentrations for HPC and TC positively correlated with each other ($p < 0.01$), whereas the YM concentrations positively correlated with the bottled water's pH and chloride levels ($p < 0.05$). Moreover, the coliform isolated from five of the eighty samples was identified as *K. pneumoniae,* four were resistant to ampicillin but were susceptible to the other twenty tested antibiotics.

Conclusion

The results suggest that some generic bottled water sold by street vendors and sundry stores in Metro Manila may not have undergone sufficient treatment and quality assurance, leading to the distribution of contaminated water. Thus, the government's regulatory agencies must ensure that manufacturers and distributors of bottled water are identified and have maintained the necessary permits, proving their adherence to standards of purification from production, storage, and deliv-

ery to consumers, as post-packaging contamination is also likely, particularly when vendors operate in unsanitary conditions. There should also be continuous examination of water supply network components such as taps, storage tanks, and feeding pipes for the identified water treatment and bottling facilities. Finally, local studies on the population's perception of bottled water quality and their consumption habits may be needed to further educate the public on choosing the right bottled water.

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Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Aguilar-Salazar, A., Martínez-Vázquez, A. V., Aguilera-Arreola, G., de Jesus de Luna-Santillana, E., Cruz-Hernández, M. A., Escobedo-Bonilla, C. M., Lara-Ramírez, E., Sánchez-Sánchez, M., Guerrero, A., Rivera, G.& Bocanegra-Garcia, V. (2023). Prevalence of ESKAPE Bacteria in surface water and wastewater sources: Multidrug resistance and molecular characterization, an Updated review. *Water*, 15(18). https://doi.org/10.3390/w15183200
2. Al-Fifi, Z., Abada, E., Al-Rajab, A. J., Mahdhi, M.& Sharma, M. (2019). Molecular identification of biological contaminants in different drinking water resources of the Jazan region, Saudi Arabia. *Journal of Water and Health*, 17(4), 622–632. https://doi.org/10.2166/wh.2019.019
3. Ameen, F., Albejad, A., Gashgari, R., Murialdo, S.& Al-Sabri, A. (2018). Diversity of fungi in bottled water in Jeddah, Saudi Arabia. *Water Supply*, 18(5), 1664–1673. https://doi.org/10.2166/ws.2017.227
4. Babič, M. N., Gunde-Cimerman, N., Vargha, M., Tischner, Z., Magyar, D., Veríssimo, C., Sabino, R., Viegas, C., Meyer, W.& Brandão, J. (2017). Fungal contaminants in drinking water regulation? A tale of ecology, exposure, purification and clinical relevance. *International Journal of Environmental Research and Public Health*, 14(6). https://doi.org/10.3390/ijerph14060636
5. Bedada, T. L., Dera, F. A., Edicho, R. M., Gebre, S. G., Asefa, Y. B., Sima, W. G., Maheder, R. F., Negassi, T. Y.& Biegna, A. G. (2018). Mycological and bacteriological quality and safety of bottled water in Ethiopia. *The Open Microbiology Journal*, 12(1), 200–208. https://doi.org/10.2174/1874285801812010200
6. Bird, P., Flannery, J., Crowley, E., Agin, J., Goins, D.& Jechorek, R. (2015). Evaluation of the 3M™ Petrifilm™ rapid yeast and mold count plate for the enumeration of yeast and mold in food: Collaborative study, first action 2014.05. *Journal of AOAC International*, 98(3), 767–783. https://doi.org/10.5740/jaoacint.15-006
7. Bonnin, R. A., Bernabeu, S., Emeraud, C., Creton, E., Vanparis, O., Naas, T., Jousset, A. B.& Dortet, L. (2022). Susceptibility of OXA-48-producing Enterobacterales to imipenem/relebactam, meropenem/vaborbactam and ceftazidime/avibactam. *International Journal of Antimicrobial Agents*, 60(4), 106660. https://doi.org/10.1016/j.ijantimicag.2022.106660
8. Burlakoti, N., Ghimire, N., Chhetri, A. B., Rawal, D. S., Pant, B. R., Upadhyaya, J., Bajgai, T. R.& Koirala, N. (2020). Physical, chemical and microbiological characterization of processed drinking water in central Nepal: Current state study. *Journal of Water Sanitation and Hygiene for Development*, 10(1), 157–165. https://doi.org/10.2166/washdev.2020.111
9. CLSI. (2021). M100 Performance standards for antimicrobial susceptibility testing (31st ed.). Clinical laboratory standards institute.
10. Curutiu, C., Iordache, F., Gurban, P., Lazar, V.& Carmen, M. C. (2020). Main microbiological pollutants of bottled water and beverages. In *Bottled and Packaged water,* (pp. 1–9). https://doi.org/https://doi.org/10.1016/B978-0-12-815272-0.00014-3
11. De Queiroz, J. T. M., Heller, L., De França Doria, M., Rosenberg, M. W.& Zhouri, A. (2013). Perceptions of bottled water consumers in three Brazilian Municipalities. *Journal of Water and Health*, 11(3), 520–531. https://doi.org/10.2166/wh.2013.222
12. DOH. (2017). Philippine National Standards for Drinking Water of 2017. In *Administrative-Order-No.-2017-0010* (pp. 1–37).
13. Doria, M. F. (2006). Bottled water versus tap water: Understanding consumer's preferences. *Journal of Water and Health*, 4(2), 271–276. https://doi.org/10.2166/wh.2006.008
14. Duranceau, S. J., Emerson, H. P.& Wilder, R. J. (2012). Impact of bottled water storage duration and location on bacteriological quality. *International Journal of Environmental Health Research*, 22(6), 543–559. https://doi.org/10.1080/09603123.2012.677999
15. FDA. (2018). Antimicrobials sold or distributed for use in food-producing animals. *US FDA for Veterinary Med.*, 2 (December 2019), 227–249.
16. Gharibi, E., Ghalit, M., Taupin, J. D., Patris, N.& Kouotou, D. (2018). Assessment of the quality of Moroccan bottled water by application of quality indices. *Journal of Water Supply: Research and Technology - AQUA*, 67(6), 576–585. https://doi.org/10.2166/aqua.2018.022
17. Hamad, A. A., Sharaf, M., Hamza, M. A., Selim, S., Hetta, H. F.& El-Kazzaz, W. (2022). Investigation of the Bacterial contamination and antibiotic susceptibility profile of bacteria isolated from bottled drinking water. *Microbiology Spectrum*, 10(1), 1–7. https://doi.org/10.1128/spectrum.01516-21
18. Herath, A. T., Abayasekara, C. L., Chandrajith, R.& Adikaram, N. K. B. (2014). Pseudomonas aeruginosa in bottled drinking water in Sri Lanka: A potential health hazard. *Water Science and Technology: Water Supply*, 14(6), 1045–1050. https://doi.org/10.2166/ws.2014.057
19. Mills, K., Golden, J., Bilinski, A., Beckman, A. L., McDan-

iel, K., Harding, A. S., France, A., Tobar, H. N.& Vecitis, C. (2018). Bacterial contamination of reusable bottled drinking water in Ecuador. *Journal of Water Sanitation and Hygiene for Development*, 8(1), 81–89. https://doi.org/10.2166/washdev.2017.064

20. Momtaz, H., Dehkordi, F. S., Rahimi, E.& Asgarifar, A. (2013). Detection of *Escherichia coli, Salmonella* species, and *Vibrio cholerae* in tap water and bottled drinking water in Isfahan, Iran. *BMC Public Health*, 13(1). https://doi.org/10.1186/1471-2458-13-556
21. Palmares, A. J., Rongalirios, J. J., Santos, M., Siggaoat, M. J., Sucgang, P. L., Tipa, N. N., Torres, J. C. A., Vasquez, C. A., Viernes, A. M.& Gellecanao, F. (2024). The antibiotic resistance profile of *Escherichia coli* from selected estuaries in the City of Manila, Philippines. *Asian Journal of Water, Environment and Pollution*, 21(6), 15–22. https://doi.org/DOI 10.3233/AJW240068
22. Palmares, A. J., Tacsagon, K. J., Taopo, F. C., Taroma, X., Toledo, S., Torres, I. S., Ventura, J. R., Villanueva, A. M., Yamat, L. G.& Gellecanao, F. (2025). Antibiotic resistance profile of *Escherichia coli* from Marikina River in the Philippines: Environmental and public health implications. *Journal of Applied and Natural Science*, 17(2), 614–621. https://doi.org/https://doi.org/10.31018/jans.v17i2.6552
23. Pant, N. D., Poudyal, N.& Bhattacharya, S. K. (2016). Bacteriological quality of bottled drinking water versus municipal tap water in Dharan municipality, Nepal. *Journal of Health, Population, and Nutrition*, 35(1), 17. https://doi.org/10.1186/s41043-016-0054-0
24. Puspita, T., Dharmayanti, I., Tjandrarini, D. H., Zahra, Z., Anwar, A., Irianto, J., Rachmat, B.& Yunianto, A. (2023). Packaged drinking water in Indonesia: The determinants of household in the selection and management process. *Journal of Water Sanitation and Hygiene for Development*, 13(7), 508–519. https://doi.org/10.2166/washdev.2023.050
25. Schmidt, J.& Huang, B. (2022). The pH of bottled water commercially available in Australia and its implications for oral health. *Journal of Water and Health*, 20(5), 871–876. https://doi.org/10.2166/wh.2022.070
26. Schraft, H.& Watterworth, L. A. (2005). Enumeration of heterotrophs, fecal coliforms and Escherichia coli in water: Comparison of 3M^{TM} Petrifilm^{TM} plates with standard plating procedures. *Journal of Microbiological Methods*, 60(3), 335–342. https://doi.org/10.1016/j.mimet.2004.10.008
27. Svagzdiene, R., Lau, R.& Page, R. A. (2010). Microbiological quality of bottled water brands sold in retail outlets in New Zealand. *Water Science and Technology: Water Supply*, 10(5), 689–699. https://doi.org/10.2166/ws.2010.384
28. Tabar, S. A. M. M., Brewis, A.& Sohrabi, M. (2023). Status, social norms, or safety? understanding intended and reported bottled water use in Urban Mashhad, Iran. *Journal of Water and Health*, 21(1), 81–93. https://doi.org/10.2166/wh.2022.319
29. Thermo Fisher Scientific. (2018). Thermo Scientific Sensititre Plate Guide for Antimicrobial Susceptibility Testing.
30. Traoré, O., Ouédraogo, N., Dembélé, R., Kpoda, D. S., Setsoafia Saba, C. K., Ouindgueta Bonkoungou, I. J.& Barro, N. (2023). Physicochemical and bacteriological quality and safety of packaged drinking water in Ouagadougou, Burkina Faso. *Water Supply*, 23(10), 4346–4356. https://doi.org/10.2166/ws.2023.249
31. Walter, C. T., Kooy, M.& Prabaharyaka, I. (2017). The role of bottled drinking water in achieving sdg 6.1: An analysis of affordability and equity from Jakarta, Indonesia. *Journal of Water Sanitation and Hygiene for Development*, 7(4), 642–650. https://doi.org/10.2166/washdev.2017.046
32. WHO. (2022). Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda. World Health Organization.