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Evaluation of Bacteriological Quality and Physicochemical Parameters of Drinking Water from Water Vending Machines in Dar es Salaam Region, Tanzania

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ABSTRACT

The usage of water from water vending machines has spread in both developed and developing countries. Despite their popularity, various studies documented on low quality of drinking water from water vending machines. The present study aimed to determine physicochemical (pH, electrical conductivity (EC), Total Dissolved Solids (TDS), turbidity, Chloride, Nitrate, Sulphate, Phosphate , Calcium carbonate) and bacteriological (E.coli bacteria and total coliform) parameters of drinking water in selected parts of Dar es Salaam region, Tanzania. Nine water samples from randomly selected water vending machines were collected and tested for physicochemical and bacteriological parameters. The pH, electrical conductivity (EC), and total dissolved solids (TDS) were measured using a multiparameter meter. Turbidity was determined using a turbidimeter, while Nitrate, Chloride, Phosphate, Sulphate, and Calcium carbonate were analyzed using a spectrophotometer. Bacteriological analysis, including E. coli and total coliforms, was conducted using cultural and biochemical methods. The average results of the physicochemical tests were as follows: pH 7.32, electrical conductivity 969 mg/L, total dissolved solids 506 mg/L, turbidity 1.84 NTU, Chloride234.90 mg/L, Nitrate 3.3 mg/L, Sulphate 183 mg/L, phosphate 0.39 mg/L, and calcium carbonate 262 mg/L. Physicochemical results of tested samples were suitable for drinking and met World Health Organization (WHO) and Tanzania Standards guidelines for drinking water. For total coliform count, the majority of water samples (78%) were excellent while for Escherichia coli all samples (100%) were excellent. Therefore, the study concluded that, water from water vending machines is fit for human consumption. In order to safeguard public health, the study recommends public awareness, regular water testing and monitoring its quality.

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1.0 Introduction

Safe drinking water is a fundamental requirement for human life (Javed and Kabeer 2018; Uddin *et al.,* 2018). As the population increases in the world, consumption of drinking water from various water sources also increases (UNESCO 2020). Various researchers documented the increases in water consumption from vending machines, especially in public places, workplaces, and educational institutions (Stoyanov, 2021). Therefore, water vending machines are rapidly gaining popularity in developed and developing countries (Grech and Allman-Farinelli 2015; Stoyanov 2021). Due to its affordability, environmental friendliness, and ability to overcome the problems associated with bottled water disposal and contamination, water from water vending machines is preferred over bottled water (Ramírez-Castillo *et al.,* 2015; Stoyanov 2021). Tanzania's capital and largest city, Dar es Salaam, is not an exception when it comes to the prevalence of water vending machines (Mbwette 2010). The Dar es Salaam region has a hot, dry, tropical climate with high temperatures, with daily averages ranging from 21 to 32°C (Mbwette 2010). Maintaining bodily hydration becomes difficult in such climates, and drinking a lot of water becomes essential, particularly when outdoors (Mbwette 2010). Although per capita bottled water consumption is significant in the Dar es Salaam region, bottled water may not always be affordable by specific sectors of the population, especially those who may have the highest exposure to extreme temperatures and hence be at risk for dehydration (Mtoni *et al.,* 2013). Therefore, many water vending machines were installed to meet the growing demand for potable water to such susceptible sectors of the population.

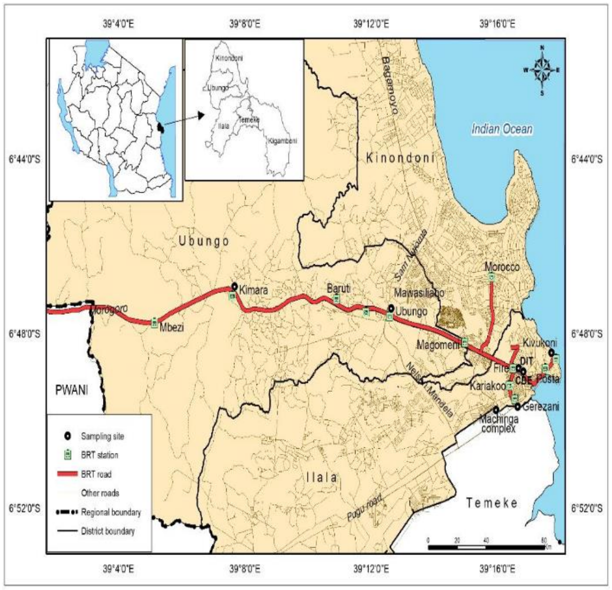
A water vending machine is an automated self-service machine that dispenses water into a container in exchange for a specified price (Ramírez-Castillo *et al.,* 2015). These machines have reverse osmosis or activated carbon filters which help in removing organic and inorganic impurities as well as chlorine taste and odours (Sacchetti *et al.,* 2014; Ramírez-Castillo *et al.,* 2015; Stoyanov, 2021). Although vending machines are equipped with disinfection and purification systems to produce safe water, water quality from vending machines is not guaranteed (WHO 2004; Al Moosa *et al.,* 2015; Wibuloutai *et al.,* 2019). Various studies reported that water from water vending machines can be contaminated by microbes and chemicals through various ways, including during transport, storage and handling before consumption (Akhbarizadeh *et al.,* 2020; Boonhok *et al.,* 2021; Mohammadi *et al.,* 2022). Nevertheless, various studies documented that contaminations of water from water vending machines can be caused by the day-to-day activities in the surrounding area or with heterotrophic bacteria, especially its inner surface or nozzle dispenser (Sacchetti *et al.,* 2014; Wibuloutai *et al.,* 2019).

It was reported by Al Moosa et al. (2015) and Wibuloutai et al. (2019) that water dispensers are a potential way in which waterborne diseases can be transmitted and cause a threat to human health. Total coliform is one of several microorganisms that can contaminate water vending machines, along with *Escherichia coli (E. coli)*, *Faecal streptococci*, *P. aeruginosa*, and *Staphylococcus species* (Ligouri *et al.,* 2010; Moosa *et al.,* 2015; Park *et al.,* 2018; Hile *et al.,* 2020). Waterborne pathogens and their related diseases are a major public health concern worldwide (Ramírez-Castillo *et al.,* 2015). Therefore, water quality assessment from water vending machines is paramount to human health. To the best of my knowledge, evaluation of bacteriological quality and physicochemical parameters of drinking water from water vending machines have not been previously evaluated, quantified, or analysed, especially in Tanzania. The aim of this study was to determine the physicochemical parameters and bacteriological quality of drinking water distributed through water vending machines located in different parts of the Dar es Salaam region, Tanzania.

2.0 Materials and Methods

The present study was conducted in selected parts of the Dar es Salaam region, Tanzania (Figure 1), from June 2024 to December 2024.

Figure 1
The Map of Part of Tanzania Showing the Study Sites of Dar es Salaam Region



2.1 Collection, Preservations and Transportation of Water Samples

A total number of 9 water samples were collected from nine vending machines (one sample from each water vending machine) installed in different parts of the Dar es Salaam region, namely Kimara, Gerezani, Feri, Dar es Salaam Institute of Technology (DIT), Mawasiliano and College of Business Education (CBE). Water samples labelled VA, VB, VC, VD, VE, VF, VG, VH, and VI were collected directly from the nozzle of the vending machines in a pre-sterilised 500 ml bottle and then collected to the Dar es Salaam Institute of Technology laboratory in a cold *box* containing ice blocks. Thereafter, the collected samples were analysed in accordance with standard methods of water analysis as previously documented by Akoto (2007).

2.2 Determination of Physicochemical of Water Samples

Determination of physicochemical parameters was performed using standard methods as recommended by various researchers (WHO 2007; Yuncong and Migliaccio 2011). The pH, electrical conductivity, and total dissolved solids of sampled water were measured by multiparameter (LMMP-30) previously calibrated with buffer solutions and turbidity by turbidimeter (Axiom GMbh). On the other hand, chemical parameters including, Nitrate, Chloride, Phosphate, Sulphate and Calcium Carbonate were determined by using a spectrophotometer. Each of the aforementioned parameters was measured in triplicate, and the mean of each parameter was determined in order to guarantee sample testing accuracy in each measurement. Thereafter, the obtained mean of each parameter was compared with the limits set up by the World Health Organisation (2011) and Tanzania Standard (TZS 789:2008) for drinking water.

2.3 Detection and Enumeration of Bacteria in Water

E. coli bacteria and total coliform were identified culturally and biochemically, as documented in various studies (Bachtarzi *et al.,* 2015; Olowe *et al.,* 2015; UNICEF 2016; Marzan *et al.,* 2017). 100 microlitres of water from each sampling point were added into test tubes containing sterilised 5 ml nutrient broth each and incubated at 37°C overnight for bacteria growth. A glass spreader that had been previously sterilised with 70% alcohol and burnt in a Bunsen burner was then used to spread 100 microlitres of the original sample and various prepared dilutions (10-1, 10-2 and 10-3) from each sample into various petri dishes containing EMB and MacConkey agar media. After spreading, the petri dishes were incubated at 37°C for overnight followed by observing each plate. Thereafter, the most probable number (MPN) method was then used to count the total coliforms.

In order to confirm the presence of coliform bacteria, all tubes showing growths, their broth were taken and streaked onto MacConkey and EMB agar plates. Bacterial colonies were identified using the macromorphology method, which was followed by microscopic examination of several bacterial cells (micromorphology). Additionally, Indole's test was conducted to confirm the presence of *E. coli*, as recommended by Alkhiry (2020).

2.4 Visual Observations

Water vending machines were also evaluated on three aspects, which included the availability of dispensing nozzle covers, overall machine conditions, and surrounding cleanliness, as recommended by Cayemitte *et al.* (2022).

2.5 Statistical Analysis

Descriptive analysis was performed by the Microsoft Excel programme version 10 to summarise results for concentration ranges and means of physicochemical parameters of water samples. Also, the same tool was used for computing the percentages of contaminated water samples for the aim of analysing the bacteriological quality.

3.0 Results

Both physiochemical and bacteriological parameters were used to assess the quality of water samples collected from water vending machines. The physiochemical results of the present study labelled VA, VB, VC, VD, VE, VF, VG, VH and VI were compared with allowable limits for drinking water quality of the Tanzania Standards (TZS 789:2008) and World Health Organisation (WHO 2011). The results of physiochemical and bacteriological parameters were as shown in tables 1, 2 and 3.

3.1 Physical Parameters

The findings revealed that the pH ranged from 6.3 to 8.8 with an average of 7.32 (Table 1). The results showed that one water sample (VI) had a pH higher (8.8) than the reference values of Tanzanian and WHO drinking water regulations (Figure 2). On the other hand, two water samples, namely VA and VD, had a pH slightly lower (6.3 and 6.4) than the TZS (6.5-9.5) and WHO (6.5-8) drinking water standards (Figure 2). However, mean values of water pH fell within the stipulated permissible limit of WHO (6.5-8) and Tanzania (6.5-9.5) for drinking water (Table 1).

The average electrical conductivity measured was 969 µS/cm, with values varying from 854 µS/cm to 1140 µS/cm (Table 1). The mean value of water electrical conductivity was within the acceptable range of WHO (2500 mg/L) and Tanzania (3000 mg/L) for drinking water. The mean TDS of water samples was 506 mg/L, with a range of 445 mg/L to 610 mg/L (Table 1). TDS level in VC water sample was found to be slightly higher (610 mg/L) than the WHO's recommended and maximum permissible levels (Figure 5). The average water sample result, however, was within Tanzania's (1000 mg/L) and WHO's (600 mg/L) permitted level. Additionally, Table 1 shows that the turbidity values from the examined water samples ranged from 0.94 NTU to 2.60 NTU, with a mean of 1.84 NTU. The mean value analysed was within the acceptable range of both WHO (5 NTU) and TZS (5-25 NTU) standards (Table 1).

Table 1

Results for Physical Parameters from Different Sampling Sites (n=9)

Sample ID	**pH**	**Turbidity (NTU)**	**EC (µS/cm)**	**TDS (mg/L)**
VA	6.3	2.54	920	480
VB	7.1	1.92	1056	550
VC	7.3	1.84	1140	610
VD	6.4	0.94	930	495
VE	7.9	2.60	912	490
VF	7.6	2.36	854	477
VG	7.1	1.40	890	445
VH	7.4	1.44	1050	525
VI	8.8	1.50	968	484
Average	7.32	1.84	976	506
WHO Standard/limits	6.5-8	5	2500	600
TZS Standard/limits	6.5-9.5	5-25	3000	1000

Figure 2
pH of Water Samples Tested Compared to the Maximum Standard Value of TZS and WHO Drinking Water Quality

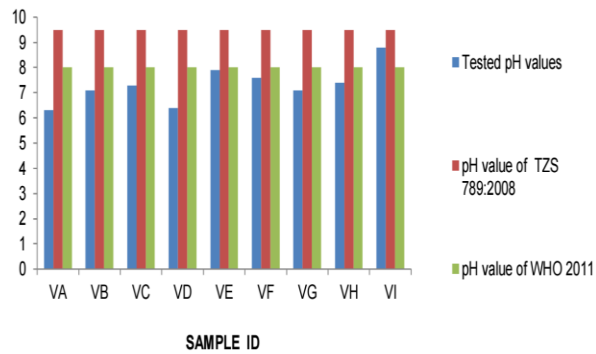


Figure 3
Turbidity of Water Samples Tested Compared to the Maximum Standard Value of TZS and WHO Drinking Water Quality

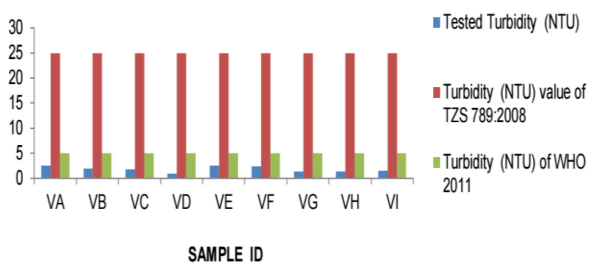


Figure 4
EC of Water Samples Tested Compared to the Maximum Standard Value of TZS and WHO Drinking Water Quality

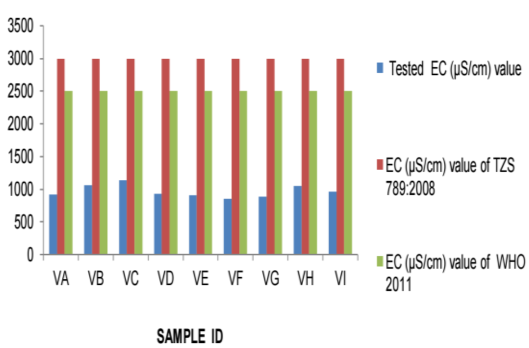
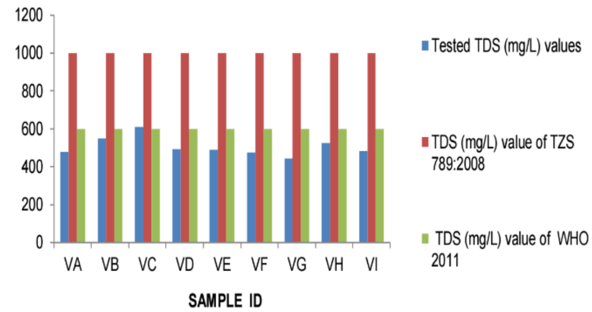


Figure 5
TDS of Water Samples Tested Compared to the Maximum Standard Value of TZS and WHO Drinking Water Quality



3.2 Chemical Parameters

The level of chloride in water samples ranged from 170 mg/L to 340 mg/L with a mean of 234.90 mg/L (Table 2). The level of chloride of one water sample (VD) exceeds WHO and Tanzania permissible limits for drinking water (Figure 6). However, the mean value fell within the acceptable range of WHO (250 mg/L) and Tanzania (250 mg/L) standards. The present results indicated that water samples' Sulphate concentrations ranged from 120 to 230 mg/L, with a mean of 183 mg/L (Table 2). The mean value was within the acceptable limits of TZS (400 mg/L) and WHO (250 mg/L) standards for a drinking purpose. According to Table 2, the amount of phosphate ranged from 0.17 mg/L to 0.49 mg/L, with an average of 0.39 mg/L. The average level was within the WHO (<5 mg/L) and Tanzania (2.2 mg/L) permitted range for drinking water limit. The calcium carbonate (hardness (TH)) of water samples was observed to be in a range of 210 to 340 mg/L with a mean of 262 mg/L (Table 2). However, findings indicated that the calcium carbonate of water sample VI exceeds the reference values of the drinking water regulations of Tanzania (Figure 9).

On the other hand, the water's nitrate levels ranged from 1.96 mg/L to 4.66 mg/L, with a mean of 3.3 mg/L (Table 2). The mean value was within the acceptable range of WHO (<50 mg/L) and Tanzania (45 mg/L) permissible values.

Table 2

Results for Chemical Parameters from Different Sampling Sites (n=9)

Sample ID	CL-(mg/L)	SO_4^{2-}(mgL)	NO_3(mg/L)	PO_4^{3-}(mg/L)	$CaCO_3$mg(mg/L)
VA	245	154	2.34	0.22	230
VB	192	182	1.96	0.38	276
VC	220	200	2.14	0.17	240
VD	340	220	3.30	0.42	230
VE	210	210	4.30	0.54	210
VF	243	189	4.50	0.48	260
VG	310	230	3.22	0.36	289
VH	170	144	3.48	0.47	284
VI	184	120	4.66	0.49	340
WHO	250	250	<50	<5	500
TZS	250	400	45	<5	300

Key: (CL^-) Chloride, (SO_4^{2-}) Sulphate, (NO_3^-) Nitrate, (PO_4^{3-}) Phosphate) and ($CaCO_3$) Calcium Carbonate

Figure 6

Cl- of Water Samples Tested Compared to the Maximum Standard Value of TZS and WHO Drinking Water Quality

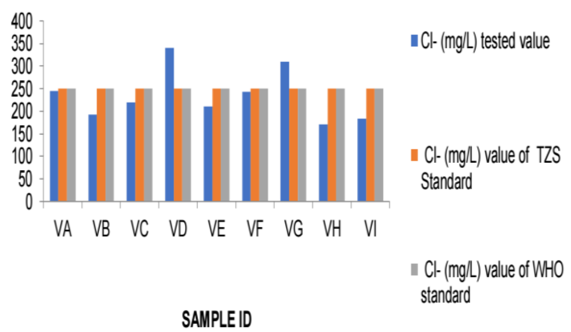


Figure 7

S042- of Water Samples Tested Compared to the Maximum Standard Value of TZS and WHO Drinking Water Quality

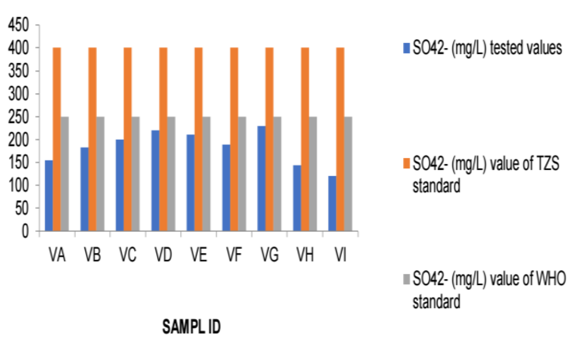


Figure 8

PO43- Of Water Samples Tested Compared to the Maximum Standard Values of TZS and WHO Drinking Water Quality

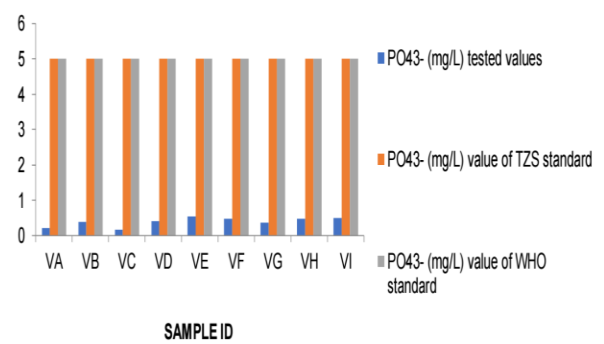


Figure 9

CaCO3 of Water Samples Tested Compared to the Maximum Standard Values of TZS and WHO Drinking Water Quality

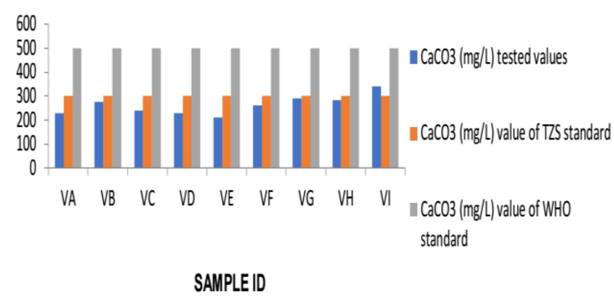
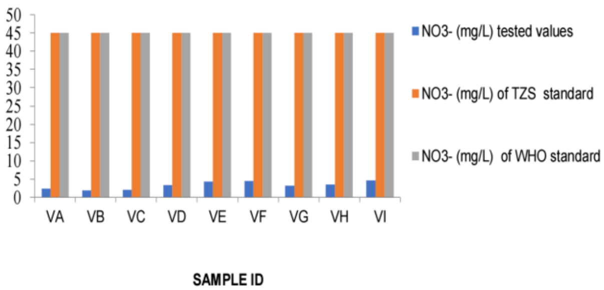


Figure 10

NO3- of Water Samples Tested Compared the Maximum Standard Value of TZS and WHO Drinking Water Quality



3.3 Visual Observations

Visual inspections showed that each water vending machine was equipped with its own dispensing nozzle cover, although three dispensing nozzles were evidenced uncovered by nozzle cover during the sampling process (Figure 11).

Figure 11

Showing Uncovered Dispensing Nozzles at Sampling Point

Three out of nine vending machines were placed beside garbage (Figure 12). On the other hand, unsatisfactorily clean was evidenced from three water vending machines during sample collection.

Figure 12

Garbage Piles nearby Water Vending Machine

3.4 Bacteriological Parameters

Out of nine water samples, two (22%) that were cultured in nutrient broth showed turbidity after being incubated overnight, while seven (78%) of the water samples demonstrate negative results. Two (22%) of the nine water samples were positive for coliforms, while seven (78%) water samples were negative (Table 3). For the case of *E. coli,* all nine water samples (100%) tested negative by indole test analysis.

Table 3

Results of Bacteriological Parameters

Sampling site	*Erscherichia coli* test	Total coliform test	Remarks
VA	-	-	NTC
VB	-	-	NTC
VC	-	+	TC
VD	-	-	NTC
VE	-	-	NTC
VF	-	-	NTC
VG	-	+	TC
VH	-	-	NTC
VI	-	-	NTC

Key: (+) Positive, (-) Negative, (TC) Total Coliform, (NTC) No Total Coliform

For overall water vending machine conditions, all nine were in good conditions, while for machines' surrounding cleanliness criteria, seven machines had clean surroundings, and two were in dirty surroundings. In general, all water vending machines have their own dispensing nozzle cover, which functions to protect the dispensing nozzles from cross-contamination caused by dust, wild animals, etc.

4.0 Discussion

The present study evaluated the quality of drinking water from water vending machines using standard methods. The physicochemical analyses from water vending machines are discussed in relation to standard limits documented by Tanzania (TZS 789:2008) and the WHO (2011) standard for drinking water quality.

The findings revealed that two samples, namely VA and VD, were found to have lower water pH recorded as 6.3 and 6.4 (Figure 2) than that documented by TZS (6.5-9.5) and WHO (6.5-8) standards for drinking waters. The possible explanation of this result could be the absence of the neutralising filters of the machines. This part contains calcium carbonate (limestone), which plays a great role in raising up water pH through synthesising magnesium oxide. This observation is not surprising since the United States Department of Agriculture (2019) documented a low level of water pH caused by the absence of neutralising filters of the vending. Other possible explanations for this observation could be the rapid loss of electrolytes like sodium, calcium, and magnesium during the filtration process, as documented by Tan *et al.* (2016). On the other hand, the higher pH level (8.8) evidenced from sample VI than the reference values of Tanzanian and WHO drinking water regulations (Figure 2). Several other studies reported the higher water pH from vending machines than the WHO's recommended and maximum permissible levels (Mako *et al.,* 2014; Thomas *et al.,* 2023). The possible explanation for the present results could be caused by alkaline substances (calcium carbonate) which are found in neutralising filters, as documented by Mohamed et al. (2014). Various scientific studies have recommended that the upper limit of pH should be at 8.0 for efficient disinfection (Egbimhaulu et al., 2020). Furthermore, it was documented that, as the pH level rises, the disinfecting properties of chlorine decline tremendously at pH 8.5, and there is very little disinfecting power beyond this pH level (Jaeel and Zaalan 2017). Also, it has been reported that, at pH values above 8.5, all strains of *E. coli* are more resistant to free chlorine and that chlorination of water with pH above 8.5 cannot ensure the safety of drinking water (Lantagne and Clasen 2012; Mkwate et al., 2017). Nevertheless, high pH values (above 7.5) may cause pipes to be encrusted with deposits, while low-pH water may cause corrosion of pipe metals, potentially impacting water quality (USGS 2019; Quinete et al., 2021).

The mean value of electrical conductivity of the present study was within the acceptable range of WHO and Tanzania for drinking water. Water conductivity can be influenced by inorganic dissolved particles such as aluminium, cations, calcium, Chloride, iron, magnesium, nitrate, sodium, and sulphates (Ngasala et al., 2019; Leonard, 2022). Additionally, organic compounds like sugar alcohol, oil, and phenols can have an impact on the water conductivity (Ngasala *et al.,* 2019; Leonard 2022).

The results showed that the VC sample had a TDS level higher than the WHO (600 mg/L) drinking water reference value. This finding might be the result of a filtering system or calcification of the building's plumbing that developed as time went on. Similar observations were reported by Thomas *et al.* (2023) that TDS concentrations above the WHO recommendation indicate a problem with the filtration system of premises plumbing that accumulated over time, leading to elevated TDS at the point of use. TDS of less than 100 mg/L of drinking water has been reported to slow down physical development and increase the number of defects in children, while it can induce ulcers, ischaemic heart disease, and hypertension in adults (Roșca *et al.,* 2020). In drinking water, higher levels of TDS cause scaling on water distribution pipelines and impart an undesirable flavour (Moreira *et al.,* 2021; Mortula *et al.,*2021). The level of chloride in the water sample VD exceeds WHO and Tanzania permissible limits for drinking water, as evidenced in the present study (Figure 6). The possible reason for this observation might be the application of chlorine as a disinfectant in the process of purifying water for human use. The same observation was previously documented by various researchers (Richter and de Azevedo Netto 2021).

The findings revealed a lower mean value than that recommended by WHO (5 NTU) and TZS (5-25 NTU). This finding is in agreement with the various researchers who documented the low level of turbidity of groundwater in the Dar es Salaam region (Ngasala *et al.,* 2019; Leonard 2022). Various studies documented different turbidity index for indication of qualities of water, which included iff the water is good (< 1 NTU),fairr (1-5 NTU), or poor(> >5NTU) (WHO 2007;OLantagne and Clasen 2012; Leonard 2022). Furthermore, researchers reported that, as water turbidity increases, the risk to human health also in creases, especially for newborns, the elderly, and people with compromised immune systems such as those with HIV/AIDS, undergoing cancer chemotherapy, or taking organ antirejection drugs (Majeed *et al.,* 2020). There are many possibilities which might explain these observations. One explanation could be that high turbidity can indicate the presence of microorganisms such as bacteria, viruses, and protozoa, which may lead to gastrointestinal illnesses and infections, especially no the aforementioned group of people. These observations agreed with the findings of Leonard (2022),) who reported the occurrence of the aforementioned pathogens due to the high level of turbidity. Moreover, consuming water with high levels of turbidity can lead to nausea, vomiting, diarrhea, and other digestive problems; therefore, it poses ae risk to newborns, the elderly, and people with compromised immune systems such as those withHIV/AIDS,S as documented in various studies (Ngasala *et al.,* 2019; Leonard 2022). Nevertheless, it was reported in various studies that bacteria, viruses, and parasites such as *Giardia* and *Cryptosporidium* can attach themselves to the suspended particles in turbid water and hence interferes with disinfection by shielding contaminants from the disinfectant such as chlorine (Hewett *et al.,* 2020; Latif et al., 2024). Moreover, high levels of turbidity (>5 NTU) are a hurdle for disinfection of drinking water, as they protects microorganisms from the effects of chlorine, stimulate the growth of bacteria, and give rise to a significant chlorine demand (Hewett *et al.,* 2020; Latif *et al.*, 2024). Hence, drinking water with a turbidity range between 5 and 25 NTU does not ensure the safety of drinking water.

One water sample, namely VI,I was found to have higher calcium carbonate than that documented by TZS (300 mg/L) standards for drinking waters (Figure 9). The possible explanation of this result could be the presence of calcium carbonate (limestone) in the neutralising filters of the machines, which plays a great role in raising calcium carbonate, as documented by the United States Department of Agriculture (2019). The high level of alkalinity does not cause health problems, but it can cause aesthetic harm, such as a change in the flavour of the water and the reduced efficiency of electric water heaters (Song *et al.,* 2021; Zhang *et al.,* 2021). .On the other hand, the findings revealed that the Sulphate, nitrate and phosphate analysed were within the acceptable range of both WHO and TZS standards, suggesting that the water was in compliance with regulatory standards. The coliform bacteria were evidenced in two water samples, namely VC and VG. The existence of coliform bacteria in these water samples raises health risks. There are several possible explanations for these observations. One explanation can be caused by unsatisfactory cleanness around water vending machines. Unsatisfactorily clean was evidenced during sample collection, especially where sample VC and VG were collected. This could be caused by the entry of sand and other tiny particles into the water reservoir, which would explain this observation. This result supports the previous conclusion by Liguori *et al.* (2010) and Huang *et al.* (2021)that the main source of water contamination in water vending machines is inadequate cleanliness.

Additionally, the presence of coliform bacteria in water samples VC and VG may be due to high temperatures that may favour the growth and development of microorganisms. According to Moosa *et al.* (2015) and Roy *et al.* (2021), temperature is one of the important factors that could contribute to bacterial development. Coliform bacteria are very likely to occur in an area like the Dar es Salaam region, where high temperatures are typical nearly all year round. The Dar es Salaam region is experiencing high temperatures, with daily averages ranging from 21 to 32°C. The growth of coliform bacteria in these water vending machines was probably significantly influenced by the temperature. This finding is consistent with the observations made by Varga *et al.* (2011), Igbeneghu and Lamikanra (2014), Moosa *et al.* (2015) and Muhammad *et al.* (2020),) who reported the increases of coliform when the temperature is higher than 15°C. Moreover, previous studies reported that coliform increased when the temperature is between 12-30°C (Prest *et al.,* 2016). The growth of coliform may also be influenced by a variety of other parameters, such as pH and total organic carbon (TOC), as reported by Gibert *et al.* (2012). Nevertheless, coliform bacteria evidenced in VC and VG water samples might be caused by vending machine users. The outer surfaces of the faucets of vending machines were not disinfected during sample collections in order to replicate the conditions experienced by machine users. Furthermore, during sample collection, the researcher evidenced uncovered dispensing nozzles. Because the dispensing nozzles were exposed to environmental contaminants, there is a possibility of contaminating the vending machine from various contaminants from the environment, which might lead to the present result. Nevertheless, the present result could be caused by insects like flies coming from garbage piles which were placed near the water vending machine. Garbage piles placed near water vending machines were evidenced at some of the water vending machines during sample collection. Therefore, there is a possibility of free movement of insects like flies from garbage piles to the uncovered dispensing nozzles and hence contaminating water coming from the water vending machine. The findings of the present investigation are in line with the findings by Cayemitte *et al.* (2022),) who reported that flies may play great roles in the contaminations of the water from water dispenser machines. On the other hand, the dispensing nozzles of the remaining vending machines were shielded by nozzle covers, which help to protect them from cross-contamination by dust and wild animals.

5.0 Conclusion

This study found that the mean values of physical and chemical parameters in water vending machines in Dar es Salaam complied with WHO and Tanzania drinking water standards. Bacteriological analysis revealed that 22% of the samples contained total coliforms, while *E. coli* was absent in all samples, indicating excellent microbial quality. These findings suggest that water from vending machines in Dar es Salaam is generally safe for drinking. However, continuous monitoring is recommended to ensure consistent water quality and prevent potential contamination risks.

6.0 Recommendation

To maintain the quality of drinking water dispensed through vending machines across the country, regular cleaning, monitoring, and testing should be conducted by machine owners to ensure compliance with regulations. Emphasis should also be placed on maintaining proper sanitary conditions during water handling, delivery, and storage. Local government authorities should conduct regular analysis and monitoring to ensure water safety. Future research should explore seasonal variations in water quality across different locations and assess the impact of factors such as temperature and filtration systems on drinking water safety.

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9.0 Conflict of Interest

The author declares no conflicts of interest.

10. References

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