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Comparative Analysis of Bottled Mineral Water and Municipal Tap Water Samples from Different Parts of Hyderabad

Research Article

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Abstract

Recently, the consumption of bottled water has increased significantly, even though the quality of tap water is considered excellent, which contributes to plastic pollution. Moreover, it is recommended worldwide to reduce the use of plastic, as its consumption is increasing at an alarming rate. Therefore, this study aims to make a comparison between tap water and bottled water and to show the reasons for choosing bottled water, which is less convenient and often more expensive than tap water. In this study, a total of 20 samples were collected from different parts of Hyderabad and analyzed for bacteriological quality using MPN method and heterotrophic plate count method. Other factors like pH, electrical conductivity (EC) and TDS value were also checked. For bottled water samples, pH was in the acidic range in most cases, which is not good for health, while for tap water it was within the permissible limits, i.e., in the neutral range. The TDS value was very low in most samples of bottled water, while in tap water samples it was in the acceptable range. The number of viable bacteria ranged from 1160 to 9500 CFU for the different bottled water samples and from 1400 (T20) to 10170 CFU (T19) for the tap water samples. The MPN index was zero for all bottled water samples, indicating that they did not contain coliform bacteria or indicator organisms. In the tap water samples, the highest MPN count (17) was found in samples T3, T6, T12, T19, and T13, while the other samples had varying degrees of *E. coli* contamination. In this study, we isolated *Pseudomonas* from the bottled water samples of B16 and *Staphylococcus* from samples B5, B7, B11, and B14. There is a possibility that these microbes may cause opportunistic infections in immunocompromised individuals. Similarly, *E. coli* was isolated from samples of T3, T5, and T6. *Staphylococci* were isolated from samples of T9, T14, T16 and *Pseudomonas* from T16 and T17.

Keywords: Muicipal tap water; Bottled mineral water; Coliform bacteria; Heterotrophic plate count; IM ViC; Most probable number

Abbreviations

WHO- World health organization; CFU- colony forming unit; HPC- heterotrophic plate count; MPN- most probable number; EC- electric conductivity; TDS- total dissolved solids; SDGs- sustainable development goals; CAGR- compound annual growth rate; POE- point of entry systems; POU- point of use; BIS- bureau of Indian standards; APHA- American public health organization; IBWA- international bottled water association

Introduction

Safe drinking water is vital to human life. It is generally believed that bottled mineral water is safe for humans. For long-distance travelers, it is the only source of reliable drinking water. However, several studies have shown that bottled mineral water does not always meet the required standards. Access to quality drinking water and sanitation for all is an important public health and development issue identified in the sixth goal of the Sustainable Development Goals (SDGs) and supported by all nations worldwide. However, over 771 million people worldwide still lack access to improved sources of drinking water sources [1].

The usage rate of bottled mineral drinking water is around 27% in some parts of Asia [2]. In terms of bottled mineral water consumption, India is among the top ten countries in the world. Bottled mineral water companies are one of the fastest growing industries and currently there are more than 3400 bottling plants in India, half of which are in the southern regions of India [3]. Most of the bottled water passed off as mineral water in India, however, is filtered, boiled, or purified by other means such as chlorination, deionization, and reverse osmosis. A better description of bottled drinking water sold in India, therefore, would be "purified bottled water". The non-existence of strict norms on bottled drinking water in India has led to the mushrooming of many small-scale units producing bottled water under different brand names [4]. However, as the demand has increased, serious concerns about the quality and safety of the water have also arisen. The chemical and microbiological quality of bottled mineral water has been found to violate national standards by some manufacturers [5]. Studies conducted in India and other parts of the world have found that bottled water was contaminated with pathogens at various stages of its production [6]. Consumption of contaminated water has led to frequent outbreaks of waterborne diseases such as cholera, typhoid, and hepatitis A and E in India [7].

The production facilities of most companies producing bottled mineral water in India are located in unhygienic places such as agricultural fields or estates. Most companies use bore wells as a source of water. Here, water is pumped from a depth of 80 to 500 feet underground [8]. The less likely sources of packaged water are from public drinking water systems such as municipal water supplies [9]. Therefore, regular monitoring of packaged drinking water such as bottled mineral water is very important. It serves the dual purpose of monitoring the standards of bottled mineral water producers and providing a quality assurance to consumers. The present study was therefore conducted to assess the bacteriological and physical quality of bottled mineral water marketed in the major transit areas of Hyderabad and whether it meets national standards. Along with that municipal tap water samples from different parts of Hyderabad were also analysed and compared with the quality of bottled drinking water.

Review of Literature

The largest beverage market in the world is the bottled mineral water market. The global bottled mineral water market was valued at USD 283.01 billion in 2021 and is expected to grow at a compound annual growth rate (CAGR) of 6.7% from 2022 to 2030. Increasing concerns about various health issues such as gastrointestinal diseases caused by consumption of contaminated water is leading to increased demand for clean and hygienically packaged options [10]. The overall recycling rate for bottles was 27.2% in 2020 [11]. Bottled mineral water is also subject to several criticisms. First, there are no longer significant quality differences between bottled mineral and municipal tap water in many water supply systems. Modern water treatment systems can eliminate the organoleptic impairments that were once common. In fact, blind tests show that consumers do not perceive significant differences between the two waters when they are simply treated [12]. In this context, it is important to consider that a significant portion of bottled mineral water is, in some cases, nothing more than municipal tap water that has been treated to meet chemical, microbiological, and radiological safety requirements applicable to bottled mineral water [13]. Second, the cost of delivery, including energy and packaging [14], is another major issue with bottled mineral water, which is between 240 and 10,000 times more expensive per liter than municipal tap water [15]. Third, plastic waste, most of which ends up in landfills or contributes to the concentration of microplastics in the oceans [16], is another important issue. The environmental costs of bottled water, including those related to energy demand, embedded CO_2 emissions, or waste production, are reported to be 100 times higher than municipal tap water [17]. Fourth, environmental and human health concerns associated with bottled mineral water are also increasing, particularly in the context of plastic bottles and exacerbated by current concerns about microplastics in water. A recent U.S. study concluded that consumers of bottled mineral water could invest up to 90,000 plastic particles in their water each year, compared to 4,000 for those who drink tap water [18]. However, a recent report by the World Health Organization (WHO) concluded that there were no significant health risks, but again cautioned that further research was needed [19]. Leaching of other chemicals such as BPA or antimony into bottled water also remains an important issue.

As mentioned in the introduction, a second strategy for addressing drinking water quality problems is to use a variety of water treatment systems for domestic use. These systems are divided into two main categories: Point-of-Entry systems (POE), which are installed at the entrance of water into the household (e.g., water softeners, disinfection devices, etc.), and Point-of-Use (POU) systems, which can be installed directly into one of the water sources available in the household (reverse osmosis, activated carbon filters, etc.) [20]. POU systems have lower capacity and higher operating costs but are cheaper and easier to install than POE. Of all these systems, jugs or bottles dominate the market in terms of sales and value. The success of bottles can be attributed to their low cost and the fact that they do not require installation Markets. Point-of-use water treatment systems market by equipment [21].

Bottled mineral water manufacturers must obtain ISI certification from the Bureau of Indian Standards (BIS). The BIS tests water samples from these systems at an independent laboratory. Only if the samples are found to be safe does the plant receive official confirmation and a license number [9,22,23].

The various treatment processes for factory-packaged drinking water are decantation, sand filtration, silver ionization, ion exchange, and reverse osmosis. Among chemical disinfectants, free chlorine is most used for water treatment. Tanks are visually inspected for suspended solids and leaks using an illuminated screen [9].

Despite all these protective measures, the presence of impurities in the bottled mineral water indicates that the treatment process in the plants is not effective [8]. Therefore, it was necessary to verify the quality of the bottled mineral water available at this site.

Materials & Methods

Study Area and Sample Collection

This project is carried out in Hyderabad, Telangana State.

Collection of Samples

A total of 20 samples of bottled mineral water samples (20

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brands) and 20 municipal tap water samples were collected from different parts of Hyderabad. The bottled mineral water samples were checked for good condition with intact caps and protective seals before purchase. The date of manufacture and batch numbers were documented. Municipal tap water samples were collected in sterile containers. They were taken to the laboratory and analyzed for total bacterial load and the presence of bacterial indicators of drinking water quality. For the purposes of this study, the bottled mineral water brands were coded B1- B20 and the municipal tap water samples were coded T1-T20. Samples were stored at 4°C until further analysis, and water quality parameter analysis was performed according to the standard methods of Martel et al. (2006) [24], APHA (2012) [25], and IBWA (2012) [26]. Inoculations into selective media were performed within 24 hours of water sample collection (Figure 1).

The samples were examined individually. They were subjected to chemical and bacteriological examination. The analytical procedure was carried out according to the standard methods for the analysis of water and wastewater [26].

Chemical Parameters

pH and Conductivity (EC): The pH is measured with a pH meter and EC with a digital electrical conductivity meter, which provides the direct value of pH and EC according to the instructions of the American Public Health Organization (APHA, 2012) [25].

Total Dissolved Solids (TDS): Total dissolved solids are determined using a digital pocket TDS meter. Premium and routine bench top instruments allow measurement of Electrical conductivity (μS/cm, mS/cm) and TDS (mg/L).

Microbiological parameters

Total heterotrophic plate count (HPC), most probable number of coliform bacteria and IMViC test for differentiation of coliform bacteria were also determined in 20 municipal tap water samples and 20 bottled mineral water samples.

Determination of total heterotrophic bacteria

Heterotrophic bacteria were counted by both serial dilution and pour plate technique (HPC). Serial 10-fold dilutions were performed in sterile water, and 1 ml of each dilution was aseptically placed in sterile Petri dishes in triplicate. Then 20 ml of agar cooled to 45°C was added to each of the plates and mixed thoroughly. The mixture was allowed to solidify, and the plates were incubated at 37°C for 24-72 hours. The number of bacterial colonies were counted and expressed as CFU (colony forming units) per milliliter. Heterotrophic plate count (HPC) was determined using the pour plate technique as described in Standard Methods (APHA, 2005) [25].

MPN test

The purity of drinking water with respect to bacterial contaminants

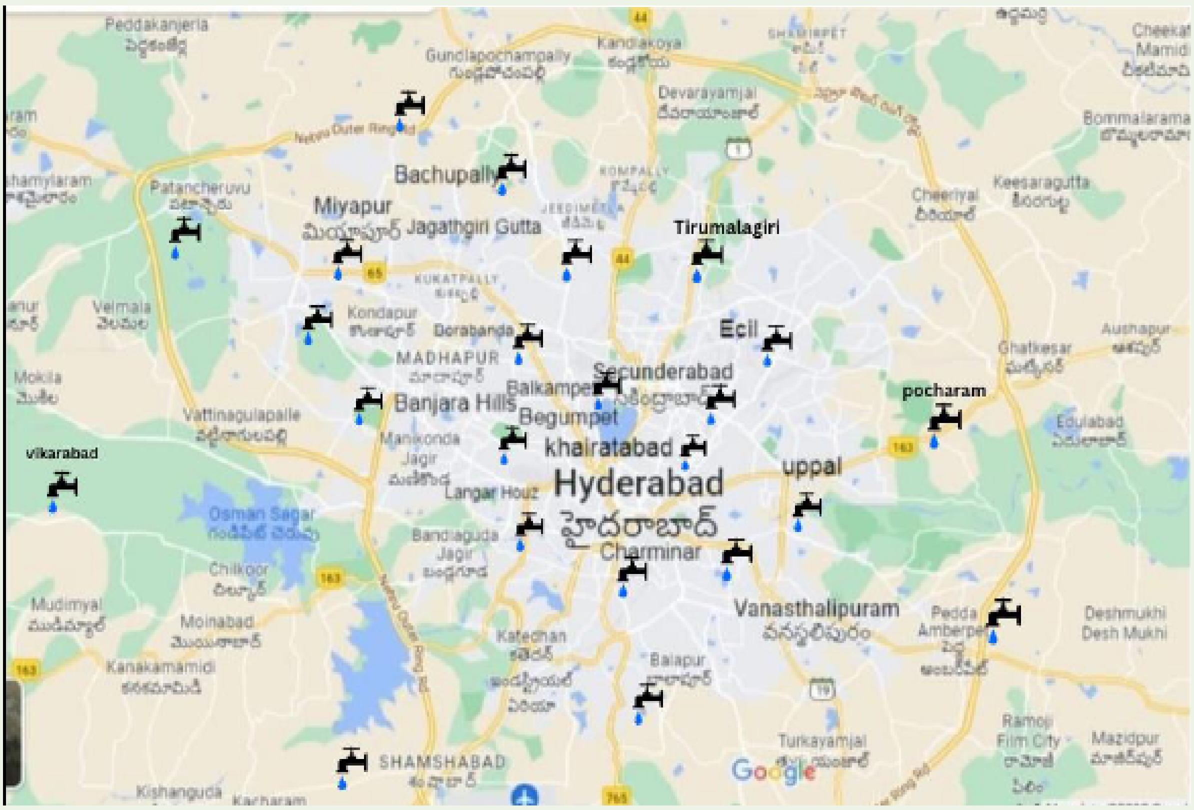

Figure 1: Municipal tap water collection sites.

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is evaluated by testing for the presence of coliform bacteria, as they are considered indicator organisms for fecal contamination. The coliform bacteria in the water sample were determined using the MPN (Most Probable Number) test or the multiple tube fermentation tests. This test is performed sequentially in 3 steps:

1) Presumptive coliform test:

This test detects coliforms in water samples. In this test, lactose fermentation tubes (Mac-Conkey broth) are inoculated with water samples and checked for production of acid and gas from lactose fermentation within 48 hours in any of the tubes is the presumptive detection of coliforms in the water sample.

(a) 10 mL of the water sample was inoculated into each of the 3 tubes with 10 mL of the double strength of Mac-Conkey broth.

(b) 1 mL of the water sample was inoculated into each of the 3 tubes with 9 mL of single strength Mac-Conkey broth.

(c) 0.1 mL of the water sample was inoculated into each of the 3 tubes containing 9.9 mL of the single strength Mac-Conkey broth.

All inoculated tubes were incubated at 37˚C for 24 hours. After incubation, the tubes that had produced gas were counted. The tubes with negative results were incubated for another 24 hours at 37˚C. The tubes that showed gas production were further inoculated for the confirmatory test.

2) **Confirmed coliform test:**

This test is used to confirm the presence of coliforms and to determine the MPN level in the water sample. In this test, water samples from all positive tubes were inoculated with Mac-Conkey broth into two sets of tubes containing Brilliant Green Lactose Bile Salt (BGLB) broth and one set was incubated at 37˚C for 24-48 hours for total coliforms and another set was incubated at 44˚C in a water bath for 24 hours for fecal coliforms. Positively confirmed tubes were used to determine MPN/100ml by the statistical method (MPN table).

3) Completed coliform test:

This test is used to determine the presence of total coliforms as MPN/100ml in a water sample. A positive tube from the confirmatory test was streaked onto a plate of EMB agar and incubated at 37˚C for 24 hours. After 24 hours, colonies with typical growth (dark center with greenish metallic sheen) and atypical growth were transferred to Nutrient agar and Mac Conkey Broth and incubated for 24 hours at 37˚C. By Gram staining, the presence of total coliform and fecal coliform bacteria was further confirmed [27].

IMViC tests:

Different colonies (10) from samples of bottled mineral and municipal tap water were selected based on their morphology. These organisms were subjected to IMViC tests for identification [25].

Results

For convenience, different water samples were given coding i.e., from B1 to B20 for bottled mineral water samples and T1 to T20 for Municipal tap water samples. The details of the same were given in table 1 and table 2.

As mentioned in the methodology, 20 samples of bottled mineral water were collected from different retail outlets in different parts of Hyderabad. Out of these 20 samples, 9 were from local brands, 5 from national brands and 6 from international brands. The collected samples were checked for formal data such as batch number, manufacturing period, expiry date, added minerals, manufacturer etc. It was found that in 3 samples the batch number was not indicated. In 7 samples, the expiry was more than 6 months after the manufacturing date and in 11 samples it was within 6 months. In the 2 other samples the expiry date was not indicated (Table 3).

Table 1: Coding of Bottled Mineral water samples.

S.No.	Sample	Code
1	Kinley	B1
2	Bisleri	B2
3	Tata	B3
4	Bailley	B4
5	Aqua fina	B5
6	Smart Water	B6
7	Himalayan	B7
8	Bindu	B8
9	Oxygem	B9
10	Black water	B10
11	Qua	B11
12	Evian	B12
13	Jonny Fresh	B13
14	Sun Rich	B14
15	Oxy rich	B15
16	Kenvey	B16
17	Aqua Drop	B17
18	Platinum	B18
19	Cottage	B19
20	Hydra 8	B20

Table 2: Coding of Tap water samples.

S. No	Sample	Code
1	KPHB	T1
2	Manikonda	T2
3	Jeedimetla	T3
4	Amberpet	T4
5	Khairtabad	T5
6	Bachupally	T6
7	Uppal	T7
8	Langerhouz	T8
9	Jagadgiri Gutta	T9
10	Borabanda	T10
11	Charminar	T11
12	Thirumalgiri	T12
13	Shamshabad	T13
14	Pocharam	T14
15	Vikarabad	T15
16	Patancheru	T16
17	Balapur	T17
18	Begumpet	T18
19	Kondapur	T19
20	Banjara hills	T20

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Table 3: Formal printed information on water bottles.

S. No	Parameter	Mentioned	Not mentioned
1.	Batch number	17	03
2.	Period of expiry	07 (beyond 6 months) 11 (within 6 months)	02
3.	Manufacture date	19	01
4.	Added minerals	9	11

Physicochemical parameters

Standard methods were used for the analysis of physicochemical water quality parameters. Parameters analyzed were pH, total dissolved solids (TDS), Electrical conductivity [28].

pH

pH is an extremely important variable because it determines the solubility of most metals and because most microorganisms can survive within a narrow pH range. Proper chemical treatment of water, including disinfection, requires control of pH. The pH values obtained are within the WHO standards of 6.5to 8.5. pH has no direct adverse effect on health [29]. Waters with pH below 4 have an acidic taste and above 8.5 have an alkaline-bitter taste. A high pH leads to the formation of Trihalomethanes, which are toxic [30]. At pH below 6.5, corrosion in the pipes starts, releasing toxic metals such as Zn, Pb, Cd, and Cu, etc. Of the total 20 samples analyzed, the lowest pH of 4.4 was found in sample B3 and the highest value of 6.49 was found in sample B11 (Figure 2). This shows that all 20 bottled mineral water samples are not within the prescribed range, with only the sample showing the highest value being closer to the prescribed range, at 6.5. This is significant in that drinking water with a neutral pH is preferred for the effective functioning of our bodies.

In the 20 samples of municipal tap water tested, 12 samples had their pH in the prescribed range, i.e., above 6.5, while sample T13 had the lowest pH of 5.78 and the highest pH of 6.79 was recorded in sample T17 (Figure 3).

When comparing bottled mineral water and municipal tap water, many municipal taps water samples showed pH in the prescribed range, while none of the bottled mineral water samples showed pH in the required range (Figure 4).

According to Dehghani Mohsen et al. in their study in Iran, a mean pH of 7.5 was found in the range of 7.1 to 8.2 in bottled mineral water samples [31]. According to Jersey et al (2019), the average pH of municipal tap water was 6.595 and bottled mineral water was 6.55. Low pH increases the dissolution/absorption of toxic substances [32,33]. Prolonged consumption of this water can lead to hyperacidity, which health experts believe can lead to cancer or cardiovascular damage, including constriction of blood vessels and reduction of oxygen supply, even at low levels.

Electrical conductivity

Pure water is not a good conductor of electric current but is a good insulator. With the increasing concentration of ions in water, the electrical conductivity increases. In general, the number of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) measures the ionic process of a solution that enables it to conduct electricity.

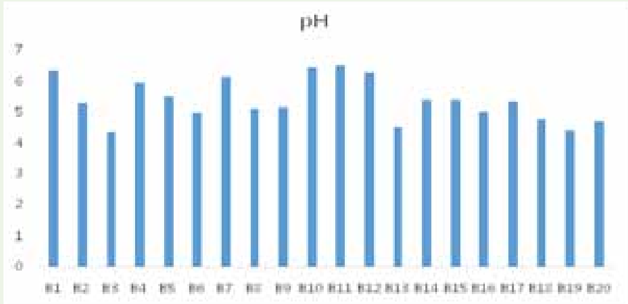

Figure 2: pH in bottled mineral water.

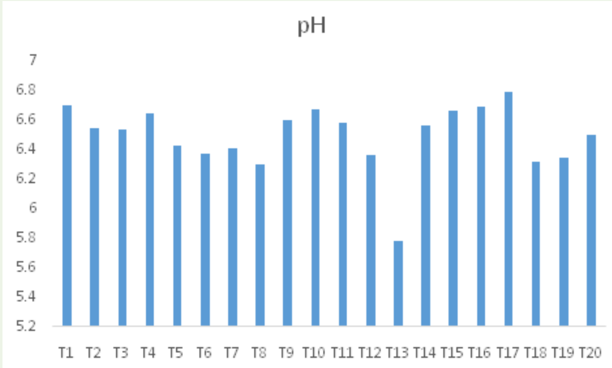

Figure 3: pH in municipal tap water.

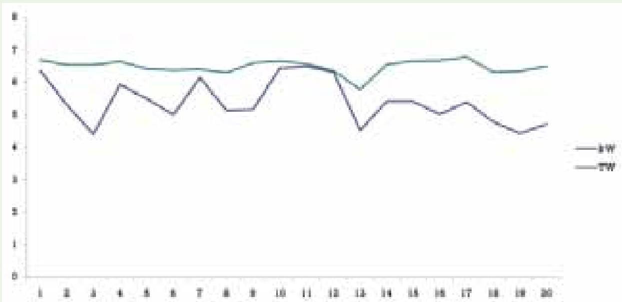

Figure 4: Comparison of pH of bottled mineral water and municipal tap water.

Pure water is not a good conductor of electric current, but rather a good insulator, and increasing the concentration of ions increases the electrical conductivity of water [34], however, a high concentration of electrical conductivity has no medical effects (SON, 2007) [35]. Typical values of conductivity for drinking water range from 50 μS/cm to 1500 μS/cm [36]. According to Reda 2016, the permissible limit for electrical conductivity (EC) is 300 μS cm-1 or 0.3 mS cm-1 [37]. The values of conductivity for our samples ranged from a minimum of 0.06 ms/cm for samples of B3, B16 and a maximum of 0.19 ms/cm for B7 (Figure 5).

The electrical conductivity for the municipal tap water samples also ranged from 0.11 to 1.05 ms/cm. The lowest value was found in sample T13 and the highest in sample T15 (Figure 6). These values

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clearly show that the samples of bottled mineral and municipal tap water are within the prescribed limit (Figure 7).

According to Marjan and Aliakbar (2022), the EC values for bottled mineral water ranged from 0.105 mS (105 mS) to 0.473 mS (473 mS). For municipal tap water samples, the EC values ranged from 0.478 mS (478 mS) to 0.872 mS (872 mS) [38].

In another study by Uddin, M.R et. al (2021), the values of EC for bottled mineral water ranged from 7.12 mS to 433.8 mS [39].

Total Dissolved Solids (TDS): TDS affects water quality in different ways. Excessive TDS gives the water a bad taste due to mineralization of various salts. A dissolved solid of more than 2000 mg/l has a laxative effect [40,41]. This is due to magnesium sulphate along with some sodium sulphate. Sodium components affect cardiac part and women with pregnancy related toxemia [42]. According to the Bureau of Indian Standards (BIS), the upper limit for TDS content in water is 500 ppm. However, the TDS level recommended by WHO is 300 ppm [42,43]. According to one report [44], minerals such as sodium, calcium, magnesium, etc. may be absent at 0-250 ppm. In our study, we found that bottled mineral water had a TDS value of 5 in B5 and 294 in B12 (Figure 8). In municipal tap water samples, on the other hand, the lowest value of 218 was found in sample T2 and the highest of 634 in sample T16 (Figure 9). Based on these data, we could conclude that bottled mineral water samples have lower TDS value than municipal tap water samples (Figure 10). Although no clear health symptoms are reported due to consumption of low TDS, Lee T. Rozelle (1996) states that it can be corrosive and lead to some minor health problems [45].

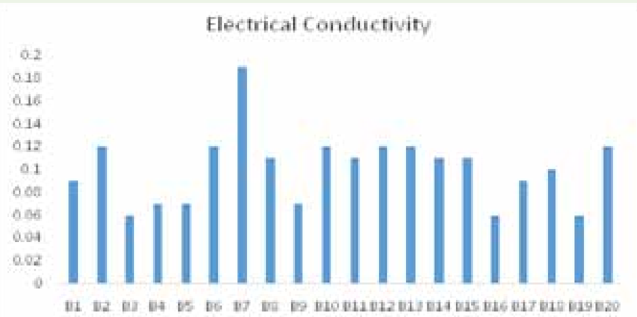

Figure 5: Electrical conductivity of Bottled Mineral water.

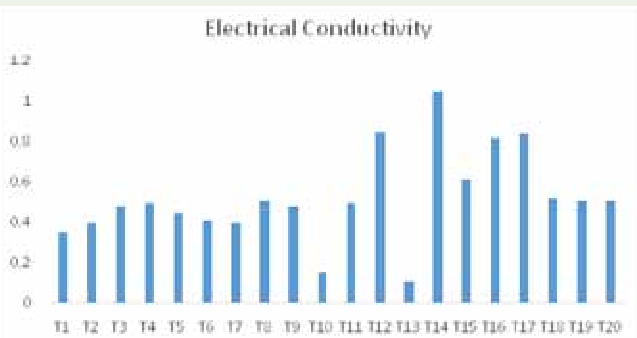

Figure 6: Electrical conductivity of municipaltap water.

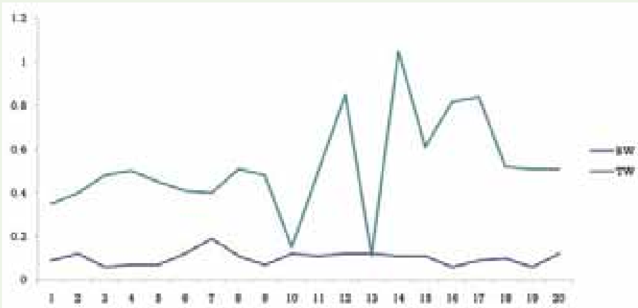

Figure 7: Comparison of EC of bottled mineral water and municipal tap water.

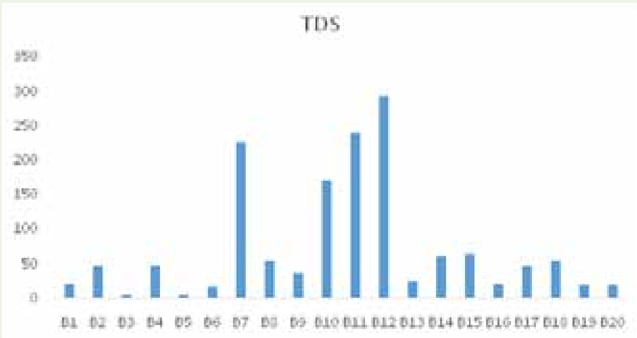

Figure 8: TDS of bottled mineral water.

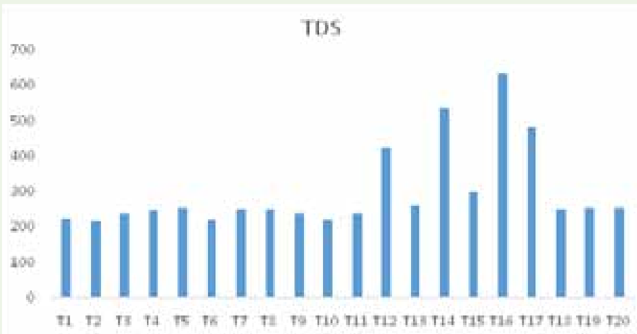

Figure 9: TDS of municipal Tap water.

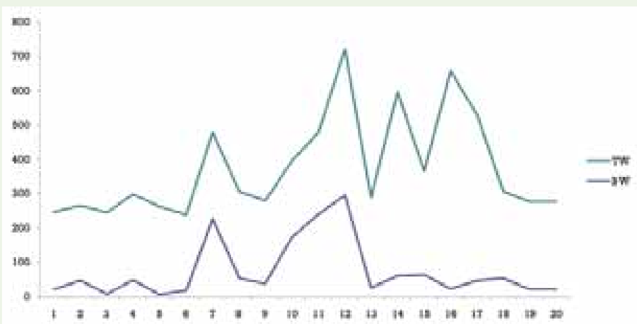

Figure 10: Comparison of TDS of bottled mineral water and municipal tap water.

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Ndinwa et al. (2012) recorded values ranging from 2.47 to 62.3 mg/l in bottled mineral water samples in Delta State, Nigeria [46], while Ajayi et al (2008) recorded high values ranging from 78.0 to 180 mg/l in Ibadan, Nigeria [47]. The total dissolved solids content of drinking water varies from 20 mg/l to 1000 mg/l and consists mainly of inorganic salts, some organic substances, and dissolved gases [35]. The palatability of water with a TDS content of less than 600 mg/liter is generally considered good; when the TDS content exceeds 1000 mg/liter, the drinking water becomes distinctly and increasingly unpalatable (WHO, 2011) [48].

Heterotrophic plate count

The World Health Organization (WHO) recommends that drinking water should have less than 20 CFU/ml of heterotrophic bacteria, excluding coliform bacteria, fecal coliform bacteria, *E. coli*, *Enterococci*, and *P. aeruginosa* [49]. In our results, we found that the CFU for heterotrophic bacteria in bottled mineral water ranges from 1160 to 9500 CFU/ml. in sample B13, 1160 and in sample B5, the highest value of 9500 CFU/ml was found (Figure 11). In Municipal tap water samples, the HPC range is from 1200 in T10 to 13550 CFU/ml in sample T16 (Figure 12). This is of concern as the live cells in the water samples exceed the limit recommended by WHO. Consumption of such bottled mineral water may also have a negative impact on immunocompromised patients. In terms of HPC, there is not much difference between bottled mineral and municipal tap water samples (Figure 13). In municipal tap water, the number was relatively high, which could be due to the distance the water travels from the purification point to the consumer. Bacteria in bottled mineral water may originate from a natural water source or be introduced during the bottling process [50]. Rapid growth of bacteria prior to bottled mineral water may be due to increased surface area, increased temperature during storage, and trace nutrients during storage [51].

In B16 sample, MPN index was 4 indicating the presence of *E. coli* in the sample. For all other bottled mineral water samples, the MPN index was less than 2, assuring the absence of *E. coli*.

In municipal tap water samples, T1, T3, T5, T6, T10, T12, T13, T16 and T19 shows the MPN index more than 2. It shows 45% of the samples were contaminated with the presence of *E. coli* and hence with sewage water.

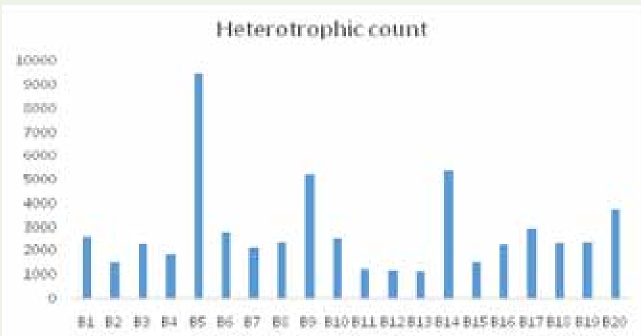

Figure 11: Heterotrophic count of bottled mineral water.

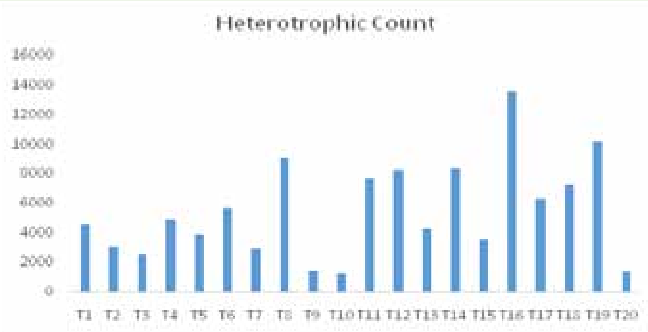

Figure 12: Heterotrophic count of municipal tap water.

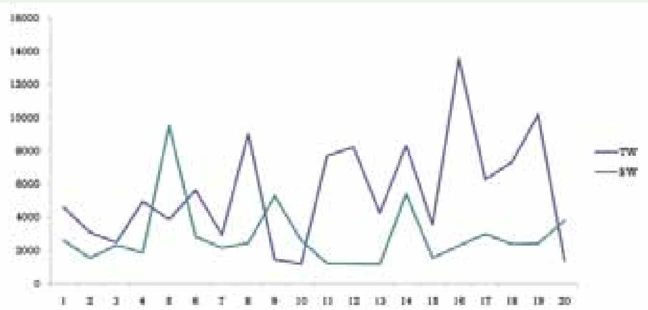

Figure 13: Comparison of Heterotrophic count in bottled mineral water and municipal tap water.

Table 4: MPN of Bottled mineral water samples.

S. No	SAMPLE	Presumptive Test	MPN count per 100 ml of sample
1	B1	0:0:0	<2
2	B2	0:0:0	<2
3	B3	0:0:0	<2
4	B4	0:0:0	<2
5	B5	0:0:0	<2
6	B6	0:0:0	<2
7	B7	0:0:0	<2
8	B8	0:0:0	<2
9	B9	0:0:0	<2
10	B10	0:0:0	<2
11	B11	0:0:0	<2
12	B12	0.0.0	<2
13	B13	0.0.0	<2
14	B14	0.0.0	<2
15	B15	0.0.0	<2
16	B16	1.1.0	4
17	B17	0.0.0	<2
18	B18	0.0.0	<2
19	B19	0.0.0	<2
20	B20	0.0.0	<2

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MPN was negative for all bottled mineral water samples showing absence of *E. coli* in the given samples (Table 4). For municipal tap water samples, MPN was in the range of <2 to 17. Out of 20 samples, in 55% samples, MPN was <2 showing absence of *E. coli*. In remaining samples, highest MPN value i.e., of 17 cells / was observed in 20% of samples (Table 5). MPN was very high in municipal tap water samples when compared to bottled mineral water samples (Figure 14).

Escherichia coli was detected in 5 out of 19 bottled mineral water samples by SeinnSandar May Phyo et al. (2019) [52]. According to a report in Deccan Chronicle, *Escherichia coli* bacteria were found in Alwal and Saroor Nagar drinking water at the rate of 1,600 per 100 ml of water in a water quality report by the Institute of Health Systems for March 2016. A similar result was also reported by Rasheed et al, 2009 [53].

IMViC

Based on colony morphology, 10 bacteria were identified and subjected to IMViC test. Based on the IMViC results, we confirmed that *Pseudomonas* was present in sample B16 and *Staphylococcus* was present in samples B5, B7, B11 and B14. In municipal tap water, however, *E. coli* was present in samples T3, T5, and T6. Similarly, *Staphylococcus* was detected in samples T9, T14 and T16. *Pseudomonas* was present in samples T16 and T17 (Table 6). *Pseudomonas aeruginosa* has been shown to be a persistent contaminant of aquatic plants [54]. This organism is an opportunistic pathogen whose ingestion can cause infections in immunocompromised individuals [55]. *Pseudomonas aeruginosa* is also known for its resistance to many antimicrobial agents, which complicates the treatment of infections caused by this organism. For this reason, testing for the presence of *Pseudomonas* species in drinking water has been proposed as a means of monitoring the hygienic quality of drinking water [48]. *Staphylococcus aureus* is an indicator of poor hygiene practices in bottled mineral water and was likely introduced into samples by personnel involved in water treatment [48]. The presence of *Staphylococcus aureus* in the water samples suggests that the bottled mineral water samples in this study were contaminated not only by the factory environment but also by the people who met any part of the bottling process [56]. A likely source of this bacterial contamination is the use of bare hands during the various stages of bottled water production.

Table 5: MPN of municipal tap water samples.

S. No	SAMPLE	10	MPN count per 100 ml of sample
1	T1	3.0.0	8
2	T2	0.0.0	<2
3	T3	3.2.1	17
4	T4	0.0.0	<2
5	T5	2.2.0	9
6	T6	3.2.1	17
7	T7	0.0.0	<2
8	T8	0.0.0	<2
9	T9	0.0.0	<2
10	T10	3.0.0	8
11	T11	0.0.0	<2
12	T12	3.2.1	17
13	T13	3.1.1	14
14	T14	0.0.0	<2
15	T15	0.0.0	<2
16	T16	1.1.0	4
17	T17	0.0.0	<2
18	T18	0.0.0	<2
19	T19	3.2.1	17
20	T20	0.0.0	<2

Table 6: IMViC results of selected isolates.

S. No	INDOLE	METHYL RED	VOGES PROSKAUER	CITRATE	Organism
1.	+	+	-	-	*E. coli*
2.	-	+	+	+	*Staphylococcus*
3.	-	-	-	+	*Pseudomonas*
4.	-	-	+	+	*Bacillus*
5.	-	-	+	+	*Klebsiella*
6.	-	+	-	-	*Salmonella*
7.	+	-	+	+	*Vibrio*
8.	-	+	+	+	*Staphylococcus*
9.	-	+	-	-	*Salmonella*
10	+	-	-	-	*E. coli*

Conclusion

Recently, plastic pollution of land and water has become a worldwide problem, to which bottled water also contributes. To address this problem, this study was conducted that could raise awareness to reduce the use of bottled water and regain confidence in tap water. In our studies, it was found that bottled mineral water from reputable companies such as B2, B1, etc. is considered safer than that from small companies such as B16, B7, B5, and B11. Nowadays, there is a trend in the market to produce bottles that look like branded bottles. This confuses customers and makes them victims of adulteration. In terms of pH, EC, and TDS, tap water is better than bottled water samples. The Heterotrophic count is also very high and not within the recommended limits for bottled water samples. The only positive factor observed with bottled water is the absence of coliforms but at the same time other microorganisms such as Pseudomonas and Staphylococcus have been isolated from bottled water, which can cause opportunistic infections in consumers. It is best to consume boiled, municipal treated water or use regular bacterial filters instead of reverse osmosis purification systems. The disadvantage of reverse osmosis purification systems is high water loss along with loss of minerals, change in pH, etc.

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References

1. WHO/UNICEF JMP (2021) Progress on household drinking water, sanitation and hygiene 2000-2020: Five years into the SDGs.
2. Beverage Marketing Corporation of New York, May 2017
3. Bottled water India, “The Indian bottled water market: unveiling its thirst. IKON marketing consultants India”
4. Mahajan RK, Walia TPS, Lark BS, Sumanjit (2006) Analysis of physical and

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chemical parameters of bottled drinking water. Int J Environ Health Res 16: 89-98.

5. Kean E, Walker LT, Ogutu S, Shackleford L, Verghese M (2005) Chemical and microbial contaminants in bottled water from Northern Alabama," in Presentation at the 2005 Institute of Food Technologists Meeting, New Orleans, LA, USA, July 2005.

6. Gangil R, Tripathi R, Patyal A, Dutta P, Mathur KN (2013) Bacteriological evaluation of packaged bottled water sold at Jaipur city and its public health significance, Veterinary World 5: 27-30.

7. "Incidence of water borne diseases in states of India. Quality of water and water related diseases in urban areas," September 2018

8. Agrawal A, Pandey RS, Sharma B (2010) Water pollution with special reference to pesticide contamination in India. J Water Resource Protect 2: 432-448.

9. Bureau of Indian Standards (2005) Manual for Packaged Drinking Water, Bureau of Indian Standards, New Delhi, India, 2005.

10. Bottled Water Market Size & Share Report, 2022-2030.

11. World recycling facts for 2022: Plastic, paper and more | World Economic Forum (weforum.org).

12. Teillet E, Urbano C, Cordelle S, Schlich P (2010) Consumer perception and preference of bottled and tapwater. J Sens Stud 25: 463-480.

13. Jain B, Singh AK, Hasan Suan AB (2019) The world around bottled water. In Bottled and Packaged Water. Volume 4: The Science of Beverages; Grumezescu AM, Holban AM, Eds.; Woodhead Publishing: Kidlington, UK.

14. Jain B, Singh AK, Hasan Suan AB (2019) The world around bottled water. In Bottled and Packaged Water. Volume 4: The Science of Beverages; Grumezescu AM, Holban AM, Eds.; Woodhead Publishing: Kidlington, UK.

15. Font-Ribera L, Colomer Cotta J, Gómez-Gutiérrez A, Villanueva CM (2017) Trihalomethane concentrations in tap water as determinant of bottled water use in the city of Barcelona. J Environ Sci 58: 77-82.

16. Avio CG, Gorbi S, Regoli F (2017) Plastics and microplastics in the oceans: From emerging pollutants to emerged threat. Mar Environ Res 128: 2-11.

17. Parag Y, Roberts JA (2009) battle against the bottles: Building, claiming, and regaining tap-water trustworthiness. Soc Nat Resour 22: 625-636.

18. Cox KD, Covernton GA, Davies HL, Dower JF, Juanes F, et al. (2019) Human consumption of Microplastics. Environ Sci Technol 53: 7068-7074.

19. World Health Organization (2019) Microplastics in Drinking Water; WHO: Geneva, Switzerland.

20. EPA (2006) Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems. EPA 815-R-06-010; April 2006.

21. (Tabletop, Faucet-mounted, Countertop, Under-the-sink) Technology (RO, Ultrafiltration, Distillation, Disinfection, Filtration), Application (Residential, Non-residential), & Region-Forecast to 2023.

22. Centre for Science and Environment (2003) Analysis of Pesticide Residues in Bottled Water. New Delhi, India.

23. "ISI mineral water plant. Indiamart," September 2018.

24. Martel K, Kirmeyer G, Hanson A, Steven M, Mullenger J, et al. (2006) Application of HACCP for Distribution System Protection: High-Quality Water, Awwa Research Foundation (AwwRF) and U.S. Environmental Protection Agenc (EPA). Published by: Awwa Research Foundation (AwwRF) and American Water Works Association IWA Publishing.

25. APHA, AWWA, WEF (2012) Standard Methods for examination of water and wastewater. 22nd ed. Washington: American Public Health Association, pp: 1360.

26. IBWA, International Bottled Water Association (2012) Bottled Water Code of Practice.

27. Bergey DH, Noel RK, John GH (1984) Bergey's manual of systematic bacteriology. Baltimore, MD: Williams & Wilkins.

28. Clesceri LS, et al. (1998) "Standard Methods for the Examination of Water and Waste Water," American Public Health Association, Washington DC.

29. Haile Reda A (2016) Physico-Chemical Analysis of Drinking Water Quality of Arbaminch Town. J Environ Anal Toxicol 6: 356.

30. Garzon P, Eisenberg MJ (1998) Variation in the mineral content of commercially available bottled waters: implications for health and disease. Am J Med 105: 125-130.

31. Dehghani M, Nazemi S, Hajer S, Pyrasteh N (2016) Quality Assessment of 30 various brands of bottled drinking waters In Iran. Environ Protect Eng 42: 65-73.

32. Carbonel JES, Gomez RA, Unlayao JC, de la Cruz J (2019) comparative study on the drinking water quality of tap water, bottled water and water from water dispenser in mapúa university, philippines.

33. Afiukwa J, Eboatu A (2013) Analysis of spring water quality in Ebonyi South Zone and its health impact. Am J Sci Industrial Res 4: 231-237.

34. Mohammed B, Gabel M, Karlsson LM (2013) Nutritive values of the drought tolerant food and fodder crop enset. Afr J Agric Sci 8: 2326-2333.

35. SON (2007) Nigerian Standard for Drinking Water Quality. Sttandard Organization Nigeria (SON).

36. Radojevic M, Bashkin VN (1999) Practical Environmental Analysis (645 p.). Science Park, Cambridge, UK: Royal School of Chemistry, Thomas Graham House.

37. Reda AH (2016) Physico-Chemical Analysis of Drinking Water Quality of Arbaminch Town. J Environ Anal Toxicol 6: 356.

38. Ghanbarian M, Roudbari A, Nazemi S, Javid A-B (2022) A comparative study of various parameters of drinking water quality in Shahroud city, Iran: tap water, well water and bottled water. Water Policy 1 June 24: 867-877.

39. Uddin MR, Khandaker MU, Abedin MJ, Akter N, Jamal M, et al. (2021) Quality Assessment of Bottled and Unbottled Drinking Water in Bangladesh. Water 13: 2026.

40. Kumarswami N (1991) An approach towards assessment of dug well water quality by physico-chemical characteristics-a case study. Poll Res 10: 13-20.

41. Dhembere AJ, Pandhe GM, Singh CR (1998) Groundwater characteristics and their significance with special reference to public health in Pravaraarea, Maharastra. Poll Res 17: 87-90.

42. Train E (1979) USEPA, United State Environmental Protection Agency, Washington D.C. Source: Quality Criteria for water by Russel, USEPA, Washington DC

43. [https://www.kent.co.in/blog/what-are-total-dissolved-solids-tds-how-to-reduce-them/#:~:text=According%20to%20the%20Bureau%20of,%2C%20however%2C%20is%20300%20ppm.]

44. (Does Low TDS Water Have Side Effects? Find Out (waterdefense.org)

45. Rozelle LT (1996) Huamn health effects due to consumption of low TDS water. Membrane J 6: 189-195.

46. Ndinwa CCG, Chukumah OC and Edafe EA (2012) Physico-chemical and Bacteriological Characteristics of Bottled and Sachet Brand of packaged Water in Warri and Abraka, Southern Nigeria. J Environ Manage Safety 3: 145-160.

47. Ajayi FT, Babayemi OJ, Taiwo AA (2008) Effects of supplementation of *Panicum maximum* with four herbaceous forage legumes on performance, nutrient digestibility, and nitrogen balance in West African dwarf goats. Anim Sci J 79: 673-679.

48. WHO (2011) Guidelines for Drinking-Water Quality. Fourth edition.

49. Khatoon A, Pirzada ZA (2010) Bacteriological quality of bottled water brands in Karachi, Pakistan.

50. 7-EEC (2009) Directive 2009/54/EC of the European Parliament and of the Council of 18 June 2009 on the exploitation and marketing of natural mineral waters.

51. Venieri D, Vantarakis A, Komninou G, Papapetropoulou M (2006) Microbiological evaluation of bottled non-carbonated water from domestic brands in Greece. Int J Food Microbiol 107: 68.

52. May Phyo SS, Yu SS, Saing KM (2019) Bacteriological Examination of Bottled Drinking Water by MPN Method. Saudi Journal of Biological Sciences 4: 227-232.

53. Khan A, Kazmi SU, Rasheed F (2009) Bacteriological Analysis, Antimicrobial Susceptibility and Detection of 16S rRNA gene of Helicobacter pylori by PCR in Drinking Water Samples of Earthquake Affected Areas and Other Parts of Pakistan. Malaysian J Microbiol 5: 123-127.

54. Morais PV, Mesquita C, Andrade J-L, da Costa MS (1997) Investigation of persistent colonization by *Pseudomonas aeruginosa* - like strains in a spring water bottling plant. App Environ Microbiol 63: 851-856.

55. Environment Agency, UK (2002): The Microbiology of Drinking Water - Part 1 –Water Quality and Public Health.

56. Hunter PR (1993) The microbiology of bottled natural mineral water. J Appl Bacteriol 74: 345-352.

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