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Research Article

# Assessment of Physicochemical and Bacteriological Parameters of Bottled Drinking Water Marketed in Gilgit City and its Vicinity

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**Abstract:** This study analyzed physicochemical and bacteriological parameters of packaged water sold in Gilgit city and its vicinity. Samples from source, market, and after the process were collected randomly from three different companies and analyzed from April 2017 to May 2017. Bacteriological parameters include *Escherichia coli* and *Enterococci;* it was further examined with conformity tests. The investigated physical parameters included (pH, Turbidity, Conductivity, Total Dissolved Solids). Some important chemical parameters like Total phosphorous and Total Nitrogen were assessed through a spectrophotometer. The results revealed that the Physicochemical parameters fell within WHO tolerable limits, pH ranged from 7.0 to 8.4, TDS were observed from 260 ppm to 40 ppm, Electrical conductivity was found between 91 µs-510 µs, Turbidity varied from 0.03 NTU to 0.52 NTU. The Total Nitrogen and Total Phosphorus range from 0.09 mg/L to 2.09 mg/L and 95 mg/L to 540 mg/L. The bacteriological parameters were unsatisfactory as some of the samples were contaminated with the *E. coli* and *Enterococci*. The maximum value for *E. coli* was 288 CFU/100 ml, and that of the *Enterococci* was 267 CFU/100 ml, which strongly violates the WHO specifications for bottled drinking water quality. Based on our findings, the Bacteriological examination of some samples is classified under the high-risk category since they are found to be unsafe for drinking. It is recommended there should be strict monitoring and surveillance of bottled water quality; sources should be protected, and awareness should be given to the public regarding its quality.

**Keywords:** Packaged Water, Water Quality, Contamination, Filtered water, Mineral water.

## 1. INTRODUCTION

Water is an important nutrient-free from any harmful calories but still a vital part of the diet [1, 2]. It is essential to carry out all the metabolic processes taking place in the living body. A person with a weight of 60 kg must intake 2 liters of water a day [3]. According to WHO valuation, about 1.1 billion people globally drink contaminated water, and the vast case (88 %) of the diarrheal disease reported across the world is credited to unsafe water, sanitation and hygiene.

Furthermore, around 250 million infections each year result in 10–20 million deaths worldwide due to water-borne diseases. These widespread diseases such as cholera, dysentery, and salmonellosis are mainly due to the lack of safe drinking water and inadequate sanitation, resulting in the deaths of millions of people in developing countries every year. Diarrhea is the primary cause of death of more than 2 million people globally, most of whom are children [4].

The principal sources of water in Gilgit and Baltistan are glacier and snow deposits. The water from these glaciers enters streams after melting, which is further used for many purposes such as agriculture, domestic purposes, and livestock. For drinking and cooking purposes, water is generally stored in the pits and wells. The water supply reduces during the winter season due to a decrease in snow and glacier melting rate. This water again replenishes during the summer season [5].

Because of the growing need for safe drinking water, the world's population has begun to use bottled water. Worldwide, it is estimated that about 89 billion liters of bottled water are used each year [6]. Several scientific procedures and tools have

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been developed to analyze water contaminants. pH, turbidity, conductivity, total suspended solids (TSS), total dissolved solids (TDS), total organic carbon (TOC), and heavy metals are among the tests that are performed. These characteristics can influence the quality of drinking water if their levels exceed the acceptable limits set by the World Health Organization (WHO) and other regulatory authorities [7].

In Gilgit city, the production and consumption of bottled drinking water are increasing gradually. However, continuous surveillance or examination of its quality at retail premises is not being carried out. This may lead to the consumption of low-quality packaged water. There has also been a growing concern about the microbiological quality of the products. The current study's main objective is to analyze the physicochemical and bacterial contamination of bottled drinking water marketed in Gilgit city and its vicinity and to check their compliance with the standard.

## 2. MATERIAL AND METHODS

### 2.1 Study Sites

There are three bottled water companies named Sujo, Seven Spring, and Vividle, which supply bottled drinking water and currently operate in the Gilgit city Metropolitan area shown in Figure 1.

### 2.2 Population and Sampling Methods

A random sampling technique was used to collect samples from the respective companies. 4 samples were taken from each company. 1000ml water sample was taken from the source, after the process, and from the market to evaluate bottled drinking water's physicochemical and bacteriological parameters.

Before sampling, the bottles were autoclaved at 121 °C for 15 min, and caps were appropriately sealed to form no air bubbles inside. The caps were tightened and labeled for identification. These bottles were covered with an aluminum sheet and transferred to plastic bags so that bare hands may not contaminate the water bottles. Samples were transported to the water quality lab within a few hours to investigate the microbiological parameters through membrane filtration technique and chemical contents using a spectrophotometer [7].

### 2.3 Physicochemical Analysis

The physical parameters included pH, Turbidity, Total dissolved solids, and electrical conductivity were determined through pH meter (AD 1020, ADWA), Turbidimeter (TB1, VELF SCIENTIFICA), Conductivity meter (AD3000, ADWA), respectively. Chemical parameters, such as Total Nitrogen and Total Phosphorus, were


**Fig. 1.** Map of the study area representing water samples for examination

determined through a spectrophotometer [8].

### 2.4 Bacteriological Analysis

The microbiological parameters included *E. coli* and *Enterococci*. The Chromogenic (EC X-GLUC Agar) selective media was used to detect Escherichia coli. At the same time, the *Enterococci* were determined by Filtering 100 ml of water from respective samples and culturing it on Slanetz and Bartley agar. The confirmation test for *Enterococci* was done by using Bile Aesculin Azide agar (BEA). The method for bacteriological examination was followed as per the standard procedure for the investigation of water and wastewater [9].

### 2.5 Statistical Analysis

MS Excel 2010 and Statistix 8.1 analyzed the data acquired from the laboratory.

## 3. RESULTS

Results of pH were observed in a range of 8.3 to 7.5. The highest pH was observed in the large market sample 8.3. However, the lowest was observed in the source sample, 7.7. The results of EC in assessed samples showed some differences. The value ranged from 496.67 µs to 165 µs. The maximum value of EC in vividle samples was observed in market large 496.76 µs, whereas the minimum value was recorded in samples after process 165 µs. TDS results in the collected samples showed significant fluctuations at different samples that ranged from 250 ppm to 83 ppm. The value was maximum at source sample 250 ppm, and the minimum value lay at market small 83 ppm. The analyzed results of Turbidity ranged between 0.5100 NTU and 0.040 NTU. It is maximum at market small 0.5100 NTU, while the minimum values were recorded 0.0400 at market large. The total phosphorus ranged between 226 µg/L and 120 µg/L. The highest value was observed in market large 226 mg/L, and the minimum value was observed in after process 95 mg/L. Total nitrogen ranged between 1.5300 mg/L to 0.740 mg/L. The highest value of total nitrogen was observed in the source 1.5300 mg/L, while the minimum values were observed in the samples after the process 0.7400 mg/L. There was no *Enterococci* contamination in the samples after the process, market small and market large, but the value was highest in source 255.00 CFU/100 ml. The highest value of *Enterococci* was observed in the source 8 CFU/100 ml, and there was no contamination in samples after the process, market small and market large. Statistics for the water quality parameters are concise in table 1.

Analyzed results of physicochemical and bacteriological parameters of four samples collected from the Seven Spring bottled Water companies and their comparison were shown in table 2. The pH recorded ranged between 7.8 and 8.00. An overall minor amount of differences were recorded in pH results. The two samples of after process and market small showed the same maximum pH values that are 8.00; likewise, another two samples of source and market largely showed the same minimum values of 7.800, respectively.

EC results in assessed samples also showed

**Table 1.** Physicochemical and Bacteriological results of water analysis from vividle.

| | Vividle | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | pH | EC µs | TDS ppm | Turbidity NTU | Total Phosphorus µg/L | Total Nitrogen mg/L | *E. coli* CFU/ 100 ml | *Enterococci* CFU/100 ml |
| Source | $7.7000^{B}$ | $226.00^{B}$ | $250.00^{A}$ | $0.1200^{B}$ | $170.00^{B}$ | $1.5300^{A}$ | $255.00^{A}$ | $8.0000^{A}$ |
| After Process | $8.2000^{A}$ | $165.00^{C}$ | $132.00^{B}$ | $0.1300^{B}$ | $95.000^{C}$ | $0.7400^{B}$ | $0.0000^{B}$ | $0.0000^{B}$ |
| Market Small | $7.5000^{C}$ | $206.00^{B}$ | $83.000^{C}$ | $0.5100^{A}$ | $101.00^{C}$ | $0.7400^{B}$ | $0.0000^{B}$ | $0.0000^{B}$ |
| Market Large | $8.3000^{A}$ | $496.67^{A}$ | $101.00^{C}$ | $0.0400^{C}$ | $226.00^{A}$ | $0.7500^{B}$ | $0.0000^{B}$ | $0.0000^{B}$ |

**Note:** Source (Point before filter plant), After Process (point after filtration process), Market small (1.5 liters), and Market large (19 liters). Means followed by a different letter(s) in the same column are significantly different from one another at $p \leq 0.05$.

**Table 2.** Physicochemical and Bacteriological results of water analysis from Seven Spring.

| Seven Spring | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | pH | EC µs | TDS ppm | Turbidity NTU | Total Phosphorus µg/L | Total Nitrogen mg/L | *E. coli* CFU/ 100 ml | *Enterococci* CFU/100 ml |
| Source | 7.8$^{A}$ | 101.00$^{C}$ | 50.000$^{C}$ | 0.3267$^{B}$ | 530.00$^{A}$ | 1.8300$^{A}$ | 20.00$^{A}$ | 65.000$^{A}$ |
| After Process | 8.0$^{A}$ | 143.00$^{B}$ | 111.00$^{A}$ | 0.1300$^{C}$ | 114.00$^{D}$ | 0.8800$^{C}$ | 0.0000$^{B}$ | 0.0000$^{B}$ |
| Market Small | 8.0$^{A}$ | 127.40$^{B}$ | 70.000$^{B}$ | 0.4500$^{A}$ | 166.00$^{B}$ | 0.9900$^{B}$ | 0.0000$^{B}$ | 0.0000$^{B}$ |
| Market Large | 7.8$^{A}$ | 218.00$^{A}$ | 63.800$^{BC}$ | 0.2100$^{C}$ | 135.00$^{C}$ | 0.7900$^{D}$ | 0.0000$^{B}$ | 0.0000$^{B}$ |

**Note:** Source (Point before filter plant), After Process (point after filtration process), Market small (1.5 liters), and Market large (19 liters). Means followed by a different letter(s) in the same column are significantly different from one another at LSD ≤ 0.05

big fluctuations at various samples ranging from 218 µs to 101 µs. EC recorded was maximum at market large 218 µs; however, minimum values were recorded in source 101µs. The TDS values also showed fluctuations where the maximum value was 111 ppm in after-process samples, while the minimum value was of source 50 ppm. There were no big fluctuations recorded in the Turbidity. Its value ranged from 0.4500 NTU to 0.1300 NTU. The measured results for Turbidity were maximum at market small 0.4500 NTU. Likewise, the minimum value was 0.1300 NTU after the process.

The total phosphorus of all assessed samples ranged between 530 µg/L to 114 µg/L. The maximum value was 530 µg/L in the source, while the other hand minimum value was 114 µg/L. The values of Total nitrogen fluctuated from point to point and ranged between 1.8300 mg/L to 0.7900 mg/L. It was maximum in source 1.8300 mg/L, and the minimum value was 0.7900 mg/L in market large respectively after the process. *Enterococci* showed a large number of fluctuations in different samples ranging from 0 to 20.00 CFU/100 ml. The *Enterococci* contamination was highest in the source of Seven Spring 20.00 CFU/100 ml while there was no contamination in the after process, market large, and market small samples

In this study, the water samples from Sujo bottled water were assessed for drinking water quality. Results of physicochemical and bacteriological parameters of different samples taken from the Sujo bottled Water Company. There were no big fluctuations recorded in different samples' pH values as it ranged between 8.2 to 7.8. The pH of the assessed samples was maximum at source 8.2, while the three remaining samples showed the same minimum results, that is 7.8. EC values of all the assessed samples ranged from 175 µs to 120 µs. EC was maximum at source 175 µs, and the minimum value was recorded 120 µs in market small. The TDS fluctuations recorded were ranged from 91 ppm to 60 ppm. The maximum value was 91 ppm from the source. However, the minimum value was 60 ppm after the process. Values of Turbidity showed minor variations at different sampling points, ranging from 0.69 NTU to 0.2400 NTU. Turbidity's elevated results were maximum at source 0.69 NTU, and the minimum value recorded was 0.2400 NTU in the market large. Total phosphorus ranged between 422 mg/L to 138 mg/L. The minimum value was 138 mg/L, while the maximum one was 422 mg/L at the source. Total nitrogen also varied at different points. Its value ranged from 1.0900 mg/Lto 0.6400 mg/L. The elevated results for total nitrogen were maximum at the source of 1.0900 mg/L. Likewise; the minimum value was 0.6400 mg/L in the after-process samples. The *E.coli* contamination was highest in the Sujo bottled water company, which ranged from 278 CFU/100 ml to 252 CFU/100 ml. The source was highly contaminated with 278.00 CFU/100 ml. The elevated results for *Enterococci* were maximum at the source 257 CFU/100 ml, but there was no contamination in market small and market large. All the average values of physicochemical and microbiological parameters of Sujo were shown in table 3.

**Table 3.** Physicochemical and Bacteriological parameters of water analysis in Sujo

| | Sujo | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | pH | EC µs | TDS ppm | Turbidity NTU | Total Phosphorus µg/L | Total Nitrogen mg/L | *E. coli* CFU/ 100 ml | *Enterococci* CFU/100ml |
| Source | 8.2$^{A}$ | 175.00$^{A}$ | 91.000$^{A}$ | 0.6900$^{A}$ | 422.00$^{A}$ | 1.0900$^{A}$ | 278.00$^{A}$ | 257.00$^{A}$ |
| After Process | 7.8$^{B}$ | 120.00$^{C}$ | 60.000$^{B}$ | 0.2800$^{C}$ | 138.00$^{D}$ | 0.6400$^{A}$ | 252.00$^{B}$ | 61.000$^{B}$ |
| Market Small | 7.8$^{B}$ | 153.00$^{B}$ | 76.000$^{AB}$ | 0.5300$^{B}$ | 200.00$^{B}$ | 0.9900$^{A}$ | 251.00$^{B}$ | 0.0000$^{C}$ |
| Market Large | 7.8$^{B}$ | 174.00$^{A}$ | 87.000$^{A}$ | 0.2400$^{D}$ | 178.00$^{C}$ | 0.8500$^{A}$ | 0.0000$^{C}$ | 0.0000$^{C}$ |

**Note:** Source (Point before filter plant), After Process (point after filtration process), Market small (1.5 liters), and Market large (19 liters). Means followed by a different letter(s) in the same column are significantly

## 4. DISCUSSION

Water contamination is influencing the lives of many people all over the world as organic and inorganic contamination, as well as a load of fecal matter in natural water, increases. Drinking water poisoning has been identified as one of Pakistan's most serious public health issues. Our study results obtained by the physicochemical and microbiological analysis were different for different water samples taken from three other bottled water companies. The physicochemical parameters were within the WHO standard guidelines of drinking water quality. Still, one company's bacteriological parameters exceeded the WHO limits despite multiple sample drawl and subsequent assessments.

The pH of water is affected by the presence of $CO_2$, organic and inorganic solutes in it. In this study, the pH of all companies such as Vividle, Seven Spring, and Sujo showed small fluctuations. The elevated results for pH ranged between 7 to 8.40. pH recorded at Seven Spring market small sample was minimum 7.0 while the maximum value was recorded as 8.40 in the source of Sujo. The pH range was within the limits prescribed by the World Health Organization. This result is partially in agreement with the finding of Biadglegne [10]. in the Amhara region and further supported by Shittu *et al*. [11] in Abeokuta, Nigeria. Similar results were observed by Budhathoki [12] in Nepal and Allam *et al*. [13] in Dhaka. EC (Electrical Conductivity) ranged between 91 µs/cm to 510 µs/cm. None of the samples cross-permissible limit of WHO standards of drinking water. The maximum value was recorded in the source of vividle, which was 510 µs/cm, and the minimum value was 91 µs/cm in the source of seven spring. This result was in-agreement with Sheikh *et al.* [14] in Kashmir Himalaya, Budhathoki [12] in Nepal.

TDS (total dissolved solids) also showed differences and ranged from 40 ppm to 260 ppm, which falls under the WHO permissible limit prescribed for drinking water. The minimum was 40 ppm in the source of Seven Spring, while the maximum was 260 ppm in Vividle. The current result correlates with the research of bottle drinking of Salehi *et al*. [15] in Iran and Sasikaran *et al*. [16] in the Jaffna peninsula. Water that contains TDS more than 100 ppm. High values of TDS affect the hardness, taste, and corrosive property of water [17].

Turbidity elevated from 0.03 NTU to 0.7 NTU. It was maximum in the source of Sujo 0.7 NTU and minimum in the market large of Vividle that was 0.03 NTU scale. None of the values exceeded permissible limits <5 NTU of WHO standards. Our findings are similar to the findings of Bikram [18]. In Tamdalge tank Kolhapur district Maharashtra India where the value of Turbidity increased <5 NTU. While in our study, no sample crossed the permissible limit set by WHO. The results correlate with the findings of Werkneh *et al*. [19] in Ethiopia. Total phosphate was maximum in the source of Seven Spring 540 mg/L, and the minimum was 85 mg/L in the after process sample of Vividle which falls under the category of WHO. Total nitrogen ranged from 0.09 mg/L to 2.0 mg/L, and the value lies within WHO's limits. Our study contradicts the results of Allam *et al*. [13] in Bangladesh. The bacteriological assessment of water establishes its potability of water. The permissible limit of bacteria set by WHO for drinking water quality is 0 CFU/100 ml. The value of *E. coli* ranged from 0 CFU/100 ml to 288 CFU/100 ml. This value exceeds the limits of WHO. The contamination was maximum in the source of Sujo 288 CFU/100 ml and no contamination in the Seven Spring and Vividle after the process and market samples. The current study agrees with Biadglegne *et al*. [20] and Ali *et al*. [21]. Our study contradicts the study of Warburton *et al*. [22] in Canada. The value of *Enterococci* ranged from 0 CFU/100 ml to 267 CFU/100 ml. The maximum value was calculated in the source of Sujo, while some samples were free from contamination. This range exceeds the standards of WHO. This study is in compliance with the study of Budhathoki [12].

## 5. CONCLUSION AND RECOMMENDATIONS

It is concluded that bottled water is thought to be pure but cannot be relied on blindly. The quality of bottled water was good from a physicochemical aspect. From a bacteriological point of view, 5 samples were contaminated with coliforms, and 7 samples were free from bacterial contamination. It can be concluded that the samples contaminated with coliforms are not fit for human consumption. One reason for contamination may be the inappropriate standard operating procedures peculiar to the container's decontamination and the source water. During the sampling process at the plant, the personnel handling water bottles were devoid of any proper personal protective equipment, especially gloves and masks. Strict rules should be made by the responsible authorities to monitor the bottled water quality regularly. Awareness should be given to the public for either using a disinfectant or boiling water instead of solely relying on bottled water. There should be small microbiological investigative units associated with the bottled water companies.

## 6. CONFLICT OF INTEREST

The authors declared no conflict of interest.

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