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ORIGINAL ARTICLE

Comparative Analyses of Physiochemical Parameters of Bottled and Tap Water in Lahore City

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ABSTRACT

Objective: Drinking water quality is of great concern because of different water borne diseases and negative impacts on the health of humans. Increased trend of bottled water usage is seen around the world. The purpose of this study was to analyze the physiochemical and bacteriological quality of tap and bottled drinking water and campare their parameters.

Methods: This study is carried out to determine the physicochemical and microbial properties of the bottled and tap water available in the Lahore city of Pakistan.15 different samples of each bottled and tap water were collected from different areas of Lahore. The investigated parameters were mainly total dissolved solid(TDS), dissolved oxygen (DO), total coliform, Pseudomonas, sodium, arsenic, iron, colour and taste using standard analytical techniques available in the laboratory. The data was analyzed by SPSS software.

Results: The results showed that among 15 different bottled water samples, 66.7% samples contain pseudomonas bacteria and 26.7% samples were contaminated with total coliform the other parameters (sodium, arsenic, TDS, iron) were under safe limit whereas 100% of tap water samples were contaminated. Although some parameters of bottled water in Lahore city were within acceptable range, but most of the bottled water was contaminated with total coliform and pseudomonasthatis not safe to the consumers' health and none of tap water sample was safe.

Practical Implication: This study will be made available to readers for the awareness of water quality and its problem concerned. As ill impacts of contaminated water particularly with above mentioned contaminents, include waterborne diseases and other many diseases.

Conclusion: It is concluded from this study that the use of bottled drinking water is based on the assumption that it is pure. In thisstudy, 66.7% of bottled water and 100% of tap water samples were contaminated with total coliform and pseudomonas exceeding WHO standards. The findings of our study also suggest that as compared to tap water, the bottled drinking water may be safer to drink.

Keywords: water, quality, contamination, bottled water, tap water

INTRODUCTION

Drinking water is defined as water “having suitable quality in terms of chemical, physical and bacteriological parameters so it can be safely usedfor drinking and food preparation (WHO, 2004). According to the World Health Organization (WHO), drinking water is safe for consumption only if it does not cause any hazard to health[11]. In developed countries water that is supplied to household, industries and commerce is of drinking water standard whereas the majority of the worldpopulation have no access to safe water and sources are usually contaminated with pathogens and have an unacceptable level of suspended solids, dissolved chemicals and bacterial count and become a major public health problem. Good quality drinking water accessibility and availability is an importantelement in health, food production and also in poverty reduction.However, despite its abundance drinking water of good quality is not readily available and this has serious health implications[2]. More than 80% of deaths around the world are caused by water borne diseases.

Bottled water is any portable water that is prepared, dispersed or accessible for sale which is preserved in a bottle or other container intended for the consumption of human beings[3]. Bottled water has been used for its good taste, convenience, and purity as compared to the tap water. However, over the last few years, bottled water purity has been challenged. A study conducted in Cleveland, Ohio showed that 5% of the bottled water that waspurchased had fluoride according to the standards whereas 100% tap water met this condition. According to Bacterial count results, 100% of the tap water samples had a bacterial count under 3 CFUs/mL whereas it ranges from 0.01–4,900 CFUs/mLin the bottled water [4,5]. Another study was conducted which determined the impact on bottled water of temperature and storage duration and results showed that in bottled water the bacterial growth was markedly higher as comparedto tap water [6]. According to one study in USA eighty-five million, bottled water are consumed every day with more than thirty billion bottles a year[7]. Bottled water that is used by people in developing countries is not free of contamination and germs. The results of a study conducted in Bangladesh on quality of 4 brands of bottled water showed that all 4 brands were unsafe according to accepted health standards[8]. According to another research in developing countries, bottled water is contaminated by bacteria more frequently although it is written on the label that is pure and safe to use[9]. Consumption of bottled water over the last two decades has increased substantially in developing countries and this may be due to the frequent outbreak of different waterborne diseases[10]. WHO reported that everyday approximately 30,000 people die from diseases that are water borne, and most of the people belongs to the developing or least developing countries[11].

People of Pakistan are showing an increasing trend of using bottled water due to unreliable and compromised tap water quality and in expectation of pure and safe water. The mainstream of population in Pakistan is at a risk of hazardous and unhygienic drinking water because of which most of the people have turned to bottled water as an option to the tap and contaminated water [12]. However, bottled water is expensive and not always healthy due to infrequent testing for contamination [1] and with this increasing demand, it seems that in near future majority of people in Pakistan will rely on bottle water. Therefore, it is important to determine the quality of drinking water in Pakistan in order to make sure that it is suitable for use or not. In this study physiochemical and bacteriological quality of tap and bottled drinking water were analyzed and their parameters were compared.

MATERIAL AND METHODS

Study area and sample collections: 15 bottled drinking water samples were collected from different stores located in the Lahore

city. Similarly 15 tap water samples were collected from various locations such as Johor town, Ittefaq town, Mustafa town, Model town and Faisal townin Lahore city as shown in Fig. 1. The samples were collected, labelled and transported to the biotechnology laboratory according to standard guidelines of WHO. For the collection, clean and dry polyethene bottles were used. Before using all the bottles were washed and then rinsed with each water sample and labelled so that they can be easily identified. The collected water samples are shown in

Table 1. After that all bottled and tap water samples were stored in the refrigerator before performing the test. Each sample was analyzed for qualitative microbiological and chemical parameters. For the bacteriological analysis, all the procedures were done with special care in order to prevent any kind of contamination.

Fig. 1: Areas from which tap water wascollected.

Table 1: Brands ofbottled water used in this study.

Brand code	Brand type	Container
1	Aqua Lite Water	Plastic
2	Pure Asia Water	Plastic
3	Atlantis plus water	Plastic
4	Water berry	Plastic
5	Classic plus	Plastic
6	Water Max	Plastic
7	Aqua Oasis	Plastic
8	Jami Water	Plastic
9	Premium Care Water	Plastic
10	Oro Water	Plastic
11	Blue pearl water	Plastic
12	HK Water	Plastic
13	Pharmagen Water	Plastic
14	Peo Right Water	Plastic
15	New Valley water	Plastic

Analyticalinstrumentsandlaboratory analysis: pH of the different tap water samples was measured by an electrometric method. The pH electrode was placed inside the beakers and the pH values were recorded. In order to confirm, 3 readings were taken for each sample. Total coliform counts and pseudomonas were measured by using the standard membrane filtration technique. In this, an appropriate volume of both bottled and tap water sample is filtered during acellulose ester membrane filter (47mm, 0.45µm pore size) which retain the bacteria that are present in the sample. Then the filter was placed on a coliform agar plate and is incubated at 35± 1 °C for 24 hours. Then bacterial colonies grew up on the plates were inspected for the existence of pink colony for Coliform. Citrate test was performed for biochemical analysis as prescribed by APHA[13]. For the determination of sodium and iron present in bottled and tap water samples, Flame Atomic Absorption Spectrophotometer (FAAS) was used. Total dissolved sodium was measured by taking a mixed sample then it was filtered by a cellulose acetate filter paper, the filtrate was evaporated and then dried out to regular weight at 180ºC. The amplify in dish weight represent the TDS. Data was entered in SPSS (Statistical package for social sciences). Before doing analysis data was checked for errors. Arithmetic mean was calculated for different samples and results are then presented in graphs.

RESULTS AND DISCUSSION

Physiochemical and microbiological characteristic of bottled water: There were 15 samples for which different physiochemical and microbial parameters were analyzed according to the WHO guidelines. The parameters which were analyzed are arsenic, sodium, total dissolved solids, total coliform, Pseudomonas,colour and taste. The results of the physiochemical and microbial analysis are shown in

Table 2. Total coliform was detected in 4 samples out of 15 in bottled water, 10 bottled water were detected +ve for Pseudomonasaeroginosa. The results of 4/15 coliform and 10/15 pseudomonas in bottled water suggestedanimproved surveillance system on an urgent basis. Contamination was also found in the bottled water of Europe [14]. These results for microbial contamination in bottled water are comparable to the findings by El-Salam et al.[15] and Kassenga[16]. According to the study carried out by Majumder et al.[17] and Khanikiet al.[18] 100% of the bottled water samples in Bangladesh and Tehran were bacteriological contaminated respectively. Bacterial contamination can be due to the long time storage of the unhygienic bottled water and government body who are liable for ensuring the quality of bottled water are not suitably performing their duties in places with contaminated bottles. The microbial contamination usually depends on the procedures industry use for decontamination [19]. Bacteria may came from the natural resource of water or can be introduce during the bottled water managing [20]. During storage microbial concentration can increase to a high level[21]. The reasons can be due to the increase outsidethearea of the container, the presence of desired nutrients in the container and high temperature[22,23]. Adverse effects of high arsenic concentrations in drinking water are well documented in various studies conducted in West Bengal districts of India [24] and Wisconsin, USA [25]. Fortunately in this study arsenic was not detectable in all 15 brands tested. All the 15 brands of bottled water tested in this study had measurable concentrations of sodium with mean and SD of 16.3±11.3 respectively. As compared to published data on sodium in European bottled mineral water which had a mean concentration of 26.58 mg/L[26] was rather low in these brands. Other parameters such as iron, TDS and pH were also under the standard limits set by WHO (Fig. 2).

Table 2: Physiochemical and a microbial parameter of bottled drinking water.

Parameter tested	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pseudomonas	cfu/250mL	<1	12	5	<1	3	10	10	12	<1	<1	4	25	11	<1	3
Total coliform	cfu/250mL	<1	<1	<1	<1	<1	<1	4	<1	<1	<1	5	5	12	<1	<1
Sodium	mg/L	0.6	ND	ND	21	ND	0.9	15	ND	ND	ND	23	12	26	12	23
Total dissolved solids	mg/L	250	243	231	260	256	232	240	150	184	180	212	200	157	134	210
Arsenic	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Color	Transparent															
Taste	Unobjectionable															
Iron	mg/l	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
pH	8.2	8.1	7.9	8.3	8.2	7.9	8.1	8.0	7.8	8.2	8.1	8.2	8.1	7.9	8.1	7.8

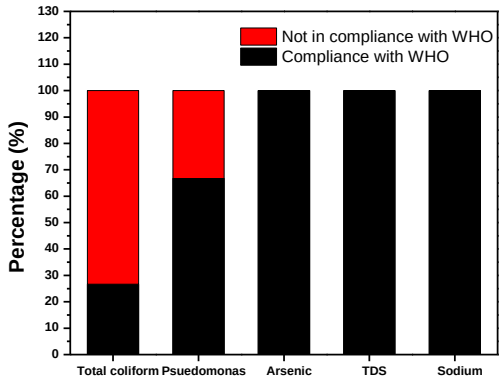

Fig. 2 : Percentage of bottled water samples in compliance with WHO standards.

Physiochemical and microbial quality of tap water: 15 water samples were collected from different areas of Lahore city and analyzed for microbial and physiochemical quality. Results showed that all tap water (100%) were contaminated with total coliform with the value ranged between 15 and 420 (mean 158.9, SD=131.6).The maximum permissible limit regarding faecal coliform according to WHO is (0/100 ml). The results are inconsistent with the study conducted in Islamabad in which all samples contained coliform[19],Kassenga et al. (49.2 %) [16], Chaidez et al. (46 %) [27], Rai et al. (85.7 %) and Yarsin et al. (64 %) [28]. Total dissolved solids were evaluated for the water samples and results showed that 20% of the samples contain TDS above the standard limits and it may be due to the fact that TDS originated from many sources like sewage, industrial wastes and agriculture runoff. The highest value for TDS was 1224mg/L in water and it may be due to the presence of the inorganic compound. Cemented storage tank are also a source of increased level of TDS in water. However, it does not cause any deleterious physiological reactions but if it is present in excessive amount impart undesirable flavor and may also cause scaling on water pipelines.High level of TDS is also found in a study conducted in Rawalpindi with TDS level as high as 1042mg/L in water samples. The results are also consistent with a study conducted by Farooq et.al [29]. High TDS level in drinking water is also found in the capital of Pakistan[30]. All tested sample were in safe limits for sodium with the maximum value of 60mg/L. According to WHO, drinking water pH should be between6.5-8.5. In this study, 26.6% samples that were tested did not meet the WHO requirements with pH range between 8.2-8.5. Similar results were also found in studies conducted by Chaidez et al. [27] and Abed and Alwakeel[31]. All tap water samples (100%) were contaminated with Pseudomonas within a range of 42 -60 CFU/250ml (mean 46.27, SD=5.10). According to WHO drinking water should not contain even a single Pseudomonas

Table 3: Physiochemical and microbial quality of tap water.

No of samples	Total coliform	Arsenic Mg/L	pH	TDS mg/L	Iron mg/L	Sodium mg/L	Pseudomonas
1	94	0.026	8.5	630	0.4	40	43
2	16	0.025	8.3	660	0.6	45	43
3	94	0.01	8.2	665	0.6	60	45
4	95	0.025	9	690	0.6	60	49
5	241	0.025	8.5	665	0.8	42	43
6	210	0.025	8.5	665	0.8	40	43
7	416	0.025	8.3	690	0.8	40	46
8	420	0.01	9	700	0.6	50	48
9	241	0.01	8.2	1165	0.8	45	47
10	94	0.01	8.2	1224	0.6	60	42
11	21	0.025	9	720	0.8	60	44
12	15	0.025	9	1050	0.7	40	43
13	93	0.01	8.5	600	0.8	40	55
14	93	0.01	8.5	650	0.8	45	60
15	241	0.01	8.5	670	0.8	40	43

Table 4: Mean , SD, minimum and maximum values of a different parameter of bottle and tap water samples.

	Mean value		SD		Minimum		Maximum	
	Tap water	Bottled water	Tap water	Bottled water	Tap water	Bottled water	Tap water	Bottled water
Total coliform	158.93	4.8	131.6	3.4	15	1	420	17
Pseudomonas	46.27	12.7	5.10	6.9	42	2	60	43
Arsenic	0.018	-	0.008	-	0.01	0	0.03	0
TDS	762		203		600		1224	
Sodium	47.13	16.3	8.5	11.3	40	0	60	54
Iron	0.7	-	0.13	-	0.4	0	0.8	0
pH	8.5	-	0.31	-	8.2	-	9	-

Comparison between tap and bottle water: The physiochemical and microbial parameters of bottled and tap water are compared according to recommended values established by WHO for drinking water (Table 4). It was found that 100% of tap water was not in compliance with the standards of WHO whereas 66.7% of bottled water was not safe and the difference was significant (<0.05).As shown inFig. 3 bacteriological quality of bottled drinking water is found to be better as comparedto tap water and this result is in agreement with the findings of a study conducted in Islamabad [28] Islam Dhaka [32] and Tanzania [16]. Thetap water poor quality can be caused byimproper treatment methods. No significant difference was seen in the quality of tap and bottled water in India [33] and Saudi Arabia [34]whereas tap water was found to be superior in a study conducted by Abed and Alwakeel in Riyadh, Saudi Arabia [31], and Brazil [19]. It is evident from the literaturethat drinking water quality is a significant problem inSouth Asian countries andother parts of the world like Sudan [35]Makkah al-Mokaarama[36] Egypt [37] and Canada [38].

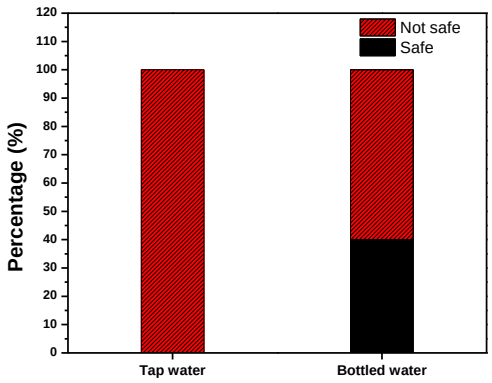

Fig. 3: Comparison of bottled and tap water.

CONCLUSIONS

It is concluded from this study that the use of bottled drinking water is based on the assumption that it is pure. In thisstudy, 66.7% of bottled water and 100% of tap water samples were contaminated with total coliform and pseudomonas exceeding WHO standards. The findings of our study also suggest that as compared to tap water, the bottled drinking water may be safer to drink. On the basis of this study following recommendations are suggested:

People should be guided regarding the drinking water quality by health educators.

Proper monitoring of the treatment of tap as well as bottled drinking water should be done.

Strict action should be taken against all bottled water industry which is not following the standard guidelines of WHO.

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Availability of data and materials: Data will not be shared publicly. The datasets and materials used and/or analyzed during the current study can be made available from the corresponding author on reasonable request

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