ORIGINAL ARTICLE

CHEMICAL ANALYSIS OF DIFFERENT BRANDS OF BOTTLED WATER WITH WORLD HEALTH ORGANIZATION (WHO) STANDARDS

Adeela Mustafa, Hasnain Azam, Sarmad Ayaz Khan, Hoor ul Ain, Faryal Gul, Muhammad Awais, Inayatullah

[1]Department of Community Medicine, Khyber Medical College, Peshawar - Pakistan

ABSTRACT

Objective: To assess the quality and compare different brands of bottled drinking water with WHO standards.

Methods: This is a cross-sectional descriptive study conducted in Peshawar, Pakistan in 2022. 14 brands of bottled water were selected randomly by convenient sampling. Brands included were Aqua Divine, Aqua drink, Aqua Green, Aquafina, Nestle mineral water, Aqwah natural, Dasani, Hydrosip, Max 10 water, Muqattar, Truly, Tyrant Aqua, Dua, and Wah water. Two samples of each brand were taken and analyzed for physiochemical parameters, which included color, turbidity, taste, odor, and minerals such as calcium, total solids, nitrates, chloride, and sulphates. Comparison with WHO standards was done using one sample T-test using a one-sample t-test.

Results: According to our results, the pH values obtained were within the WHO range of 6.5-8.5. Chemical parameters such as calcium ranged between 10 mgs/L to 65 mgs/L(WHO level up to 300 mg/L, and Chloride concentration ranged from 20 to 156 mgs/L(WHO standard is 200 mg/L). Total solids were 500mg/L (WHO standard is up to 100mg/L), sulphates were 200 mg/L (WHO standard is up to 500mg/L and nitrates were not detected in any of the samples. Whereas physical properties such as color, odor, and turbidity were normal.

Conclusion: Our study concluded that the bottled drinking water of different brands available in Peshawar city is physiochemically fit for consumption as all the parameters tested were within the permissible limits of WHO.

Keywords: Bottled water, Drinking water, WHO water quality standards, Physiochemical parameters

This article may be cited as: Mustafa A, Azam H, Khan SA, Ain HU, Gul F, Awais M, Inayatullah. Chemical Analysis of different brands of bottled water with World Health Organization (WHO) standards. J Med Sci 2023 April;31(2):153-156

INTRODUCTION

In Nature, all living things depend on water for routine activities. In the microbial world, no microorganism can survive without water. [1] Humans must have access to adequate, safe, and accessible supplies. Increasing access to clean water for drinking can have very positive effects on health. [2] Social development is associated with water through its impacts on health. Lack of safe drinking water is the main cause of ill health in underdeveloped countries. Positive community health and well-being depends on safe water supply. [3]

As per statistics from World Health Organization (WHO 2002), inadequate sanitation and unsafe water contribute to an estimated 1.7 million deaths globally and about 54.2 million disability-adjusted life years (DALYs) annually, with about 80% of children mortality being brought on by diarrhea brought on by consuming tainted water. [4]

With a fast-growing population and increasing urbanization in Pakistan, the need for fresh drinking water is increasing daily. There is no quality monitoring of Bottled water quality in developing nations (e.g., Ethiopia, Pakistan, etc.) for human consumption. In several parts of the country, bottled water plants have been established, indicating a rise in demand. [5] In Pakistan, increased public awareness of clean drinking water has encouraged the usage of bottled water, particularly in metropolitan areas. [6] Pakistan is ranked 80th among 122 countries in terms of drinking water quality. Only 20% of Pakistan's population is said to have availability of clean water to drink. However, the quality and safety of bottled water are in doubt, as many mineral water brands have been found to fall short of WHO and PSQCA criteria in microbiological and chemical tests. [7] The contents of bottled water are not strictly regulated, and the concentration listed on the labels may not be true. According to research conducted in Pakistan, around 52 percent of bottled water was unfit for human consumption. [8] Globally People drink about 13x1010 liters of bottled water during a year. In Pakistan, the use of bottled water increased from 5.9% to 9.5% in recent years. [9] Due to increased demand, there is also increasing concern regarding the quality of bottled mineral water. [10, 11]

Correspondence
Dr. Adeela Mustafa
Department of Community Medicine, Khyber Medical College, Peshawar - Pakistan
Cell: +92-345-2909019
Email: adeelaamir17@gmail.com
Date Received: 28-02-2023
Date Revised: 02-05-2023
Date Accepted: 09-05-2023

WHO had set up a specific concentration range for different chemical ingredients of bottled water, so every brand of bottled water should keep that range in mind to reach the standard and to be in the safe zone in light of health standards.[12, 13] Essential chemicals i.e., Na, Ca, Nitrate, K, etc. are to be at a specific range for better health of human beings. Any concentration of the ingredients greater or less can cause adverse effects on health. [14, 15] We focused on the comparison of the chemical ingredients concentration range of the most popular brands of bottled water according to WHO standards. Our study provided a new set of important information on different brands of bottled water in Peshawar city for health benefits. Our studies will provide people the important information about popular brands of bottled water consumed by them, and to choose those brands of water which are according to WHO standards.

MATERIALS AND METHODS

A cross-sectional descriptive design was set for the study. The study was approved by the Ethical review board of Khyber Medical College. The bottled water sample was collected from different shops across the city of Peshawar. Chemical analysis was done in the laboratory of the Community Medicine department, at Khyber Medical College. The sample size was calculated using the WHO formula, $N=Z^2 \times P\ [1\text{-}P] \div d^2$. According to this formula, the sample size has to be 245. However, given the lack of many bottled water brands in Peshawar, such a huge sample size was not feasible. Our study included 14 brands, including multinational and local brands, 2 samples for each brand were collected making a total of 28 samples**.** Non-probability convenient sampling technique was used for the collection of samples. Common brands which are commonly used by people were included in the study and unsealed water bottles were excluded. Each sample was 500ml in volume. Special care was taken to pick out samples that were of a fresh batch. Data was analyzed using SPSS software.

RESULTS

Physical Characteristics: The physical characteristics of the water including color, odor, taste, and turbidity were in the normal range according to the WHO standards. Chemical Properties of different brands' bottled Water The chemical properties which were analyzed included Chloride, Nitrate, Total solids, Calcium, and sulfate, and their concentration is shown in Table 1 below: According to PSQCA and WHO standards normal Ranges are:

1. PH.6.5
2. Chloride. 200mgs/L
3. T. Solid. 1000 mgs/L
4. Calcium. 300mg/l
5. Sulphate. 200mgs/L
6. Nitrates. 0.1mgs/L.

Table 1: Physical Properties of Mineral Water

Colour	Physical Parameter	Count	Percentage
	Normal	28	100%
	Abnormal	0	0%
Turbidity	Absent	28	100%
	Present	0	0%
Taste	Normal	28	100%
	Bad	0	0%
Odour	Absent	28	100%
	Present	0	0%

Table 2: Chemical properties of different brands of drinking water

Brands of bottled water	Chloride concentration mg/L	T. SOLIDS Mg/L	NitratesMg/L	Calcium Mg/L	Sulphate Mg/L
Aqua divine	140.00	250.00	Nil	50.00	54.00
Aqua drink	40.00	230.00	Nil	40.00	55.00
Aqua green	85.00	330.00	Nil	55.00	48.00
Aquafina	96.00	190.00	Nil	96.00	64.00
Aqwah natural	156.00	436.00	Nil	14.00	46.00
Dasani	20.00	190.00	Nil	140.00	10.00
Dua	126.00	275.00	Nil	15.00	40.00
Hydrosip	134.00	290.00	Nil	55.00	64.00
Max 10 water	136.00	440.00	Nil	18.00	58.00
Muqattar	140.00	426.00	Nil	50.00	65.00
Nestle pure life	90.00	205.00	Nil	25.00	45.00
Truly	148.00	316.00	Nil	46.00	42.00
Tynant aqua	132.00	320.00	Nil	50.00	63.00
Wah water	105.00	320.00	Nil	15.00	48.00

Table 3: Mean and standard deviation of minerals of all brands

Minerals	Normal range	Mean	Standard deviation
Chloride	200mg/l	104.36	37.74
Total solids	1000mg/l	293.04	83.12
Sulphates	200mg/l	45.07	33.40
Calcium	300mg/l	47.64	13.82

Table 4: One-sample T-test for comparison with WHO standards

Parameters	N	Test value	Std. deviation	Sig (2-tailed	Mean Difference	95% Confidence interval	
						Lower	Upper
PH	28	6.5	.24527	.000	.96429	.8692	1.0594
Chloride	28	200	37.74399	.000	-95.64286	-110.2	-81.00
Calcium	28	300	13.81	.000	-252.3571	-257.7	-246.99
Total Solids	28	l000	83.119	.000	-706.964	-739.1	-674.7

The chemical properties of Our sample were according to PSQCA &WHO standards. Nitrate was not detected in any of the samples. Chloride concentration ranged from 20 to 156 **(**mgs/L) which is lower than 200 mgs/L (WHO standard). It is clear from the result that all the water samples have chloride concentrations within the permissible limit of WHO.

The value of calcium ranged between 10 mgs/L to 65 mg/L. The calcium concentration is less than WHO standard value for calcium (300mgs/L). Sulphate concentration ranged between 10 mgs/L and 140 mgs/L. Sulphate concentration is also within the normal limit according to WHO standard value for Sulphate (200mg/L).

DISCUSSION

The physiochemical characteristics of bottled water were found to be according to WHO standards in our study. A study was conducted in Saudi Arabia in which 21 different brands of locally produced bottled water were collected from a market in Riyadh. The concentrations of Ca, Total solids, and pH value were noted from the labels and then samples were analyzed for concentrations of these minerals in the laboratory. The mean level of Ca and pH was found to be higher than that mentioned on the label whereas the TDS was found to be lower than the mean mentioned on the label. While in our study concentrations mentioned on the label were the same as analyzed in the lab and were within the WHO range. [16]

A study was carried out in Wadi Al-Shati, Libya. Turbidity results ranged from 0.84 to 1.04 NTU, pH values ranged from 5.63 to 7.45, TDS values ranged from 28 to 303 mg/L, calcium values ranged from 0.4-6 mg/L, while chloride concentrations were 1.3 to 45 mg/L, nitrate was only 37 mg/L and sulfate concentrations were 0 to 73 mg/L. All these parameters' values were within the recommended WHO standards except pH. While in our study all the parameters complied with WHO standards. [17]

A study was carried out in Sudan, where the results when matched to drinking water standards set by WHO, the United States Environmental Protection Agency (EPA), the International Bottled Water Association (IBWA), and the Food and Drug Administration (FDA, all results were discovered to be within the appropriate ranges for acceptance as ours. [18]

A study looked into the physical and chemical properties of packed water available in Bangladesh's capital Dhaka. The investigated parameter values were discovered to be in the following ranges: pH (6.11-6.83), EC (38.3-492.1 S/cm), TDS (24.0-296.80 mg/L), DO (5.88-8.76 mg/L), TH (1.5-228.0 mg/L), Cl- (0.23-2.70 mg/L), NO3 - (0.11-2.98 mg/L), SO4 2- (0.04-111 mg/L), Fe2+ (2.25- The results showed that all other parameter values were quite low and appeared to be within the WHO and Bangladesh Drinking Water Quality Standard (BDWQS) limit. This study's results were within alignment with our study's results. [19]

A study conducted in Lahore, Pakistan, compared various bottled water available in Lahore for commercial use. The results revealed a significant difference in quality. Data analysis revealed pH ranges of 7.35-7.95, turbidity 2.14-2.48 NTU, TDS 84-183 mg/L, calcium 16-40 mg/L, chloride 35-95 mg/L, sulphates 22–120 mg/L, nitrates 0.9–3.8 mg/L. Matching our study all the values were in the recommended WHO ranges [(20)]

An important limitation of this study is the small sample size but a large sample size is needed so that all available brands are analyzed.

CONCLUSION

Our study concluded that the bottled drinking water of different brands available in Peshawar city is physiochemically fit for consumption as all the parameters tested were within the permissible limits of WHO.

REFERENCES

1. Ahmad M, Jamal A, Tang X-W, Al-Sughaiyer MA, Al-Ahmadi HM, Ahmad F. Assessing Potable Water Quality and Identifying Areas of Waterborne Diarrheal and Fluorosis Health Risks Using Spatial Interpolation in Peshawar, Pakistan. *Water*. 2020; 12(8):2163
2. World Health Organization. W.H.O Guidelines for Drinking-Water Quality: First Addendum to the Fourth Edition; World Health Organization: Geneva, Switzerland, 2017.
3. Bartram, J.; Brocklehurst, C.; Fisher, M.B.; Luyendijk, R.; Hossain, R.; Wardlaw, T.; Gordon, B. Global monitoring of water supply and sanitation: History, methods and future challenges. Int. J. Environ. Res. Public Health 2014, 11, 8137–8165
4. Bech, J. Soil contamination and human health: part 2. Environ Geochem Health 42, 2287–2292 (2020)
5. Mohsin M, Safdar S, Nasar-u-Minallah M, Riaz O, Khan AA. Use and quality of bottled water in Bahawalpur City, Pakistan: An overview. International Journal of Economic and Environmental Geology. 2019 Sep 4;10(2):112-7.
6. Nazir MA, Yasar A, Bashir MA, Siyal SH, Najam T, Javed MS, Ahmad K, Hussain S, Anjum S, Hussain E, Shah SS. Quality assessment of the noncarbonated-bottled drinking water: comparison of their treatment techniques. International journal of environmental analytical chemistry. 2020 Nov 23:1-2.
7. Bibi S. Safe drinking water in Pakistan. Pakistan Journal of Medical Research. 2018 Apr 1;57(2):48-9.
8. Khan NB, Chohan AN. Accuracy of bottled drinking water label content. Environmental monitoring and assessment. 2010 Jul;166(1):169-76.
9. Samadi, M.T., Rahmani, A.R., Sedehi M. & Sonboli, N., 2009. Evaluation of Chemical Quality in 17 Brands of Iranian Bottled Drinking Waters. J. Res. Health Sci. 9: 25-31
10. Aliabadi, N.; Pham, H.; Curns, A.T.; Rha, B.; Tate, J.E.; Parashar, U.D. Diarrhea-Associated Mortality in Children Less Than 5 Years of Age in the United States, 2005–2016. Pediatric Infect. Dis. J. 2019
11. Daud, M.K.; Nafees, M.; Ali, S.; Rizwan, M.; Bajwa, R.A.; Shakoor, M.B.; Arshad, M.U.; Chatha, S.A.S.; Deeba, F.; Murad, W.; et al. Drinking Water Quality Status and Contamination in Pakistan. BioMed. Res. Int. 2017, 2017, 7908183
12. Zabed, H.; Suely, A.; Faruq, G.; Sahu, J.N. Water quality assessment of an unusual ritual well in Bangladesh and impact of mass bathing on this quality. Sci. Total Environ. 2014, 472, 363–369.
13. Felipe-Sotelo M, Henshall-Bell ER, Evans ND, Read D. Comparison of the chemical composition of British and Continental European bottled waters by multivariate analysis. Journal of Food Composition and Analysis. 2015 May 1;39:33-42.
14. Mahmood S, Kazmi ST, Ali SS. Comparison of drinking water bottles of different countries along with Zamzam Water, Pakistan. Earth Sciences Pakistan (ESP). 2018;2(1):5-1
15. Adekunle FF, Similoluwa FA, Kolawole OA, Adewale AS. Quality assessment of some bottled water produced in Okitipupa, Ondo state, Nigeria. French-Ukrainian Journal of Chemistry. 2020 Jul 1;8(1):108-16.
16. Khan NB, Chohan AN. Accuracy of bottled drinking water label content. Environmental monitoring and assessment. 2010 Jul;166(1):169-76.
17. Ali MA, Elgerbi AM, Emhemmad EJ, Amhimmid WK. Assessment of Some Physico-chemical and Bacteriological Properties of Bottled Drinking Water in the Wadi Al-Shati Area Southern of Libya. Assessment. 2020 Dec;7(6):06-11.
18. Ezeldin M. Some Physicochemical Charactistics of Bottled Drinking Water Samples. Am. J. Chem. 2016;6:12-7.
19. Alam MF, Dafader NC, Sultana S, Rahman N, Taheri T. Physico-chemical analysis of the bottled drinking water available in the Dhaka City of Bangladesh. Journal of materials and environmental science. 2017;8(6):2076-83.
20. Nazir MA, Yasar A, Bashir MA, Siyal SH, Najam T, Javed MS, Ahmad K, Hussain S, Anjum S, Hussain E, Shah SS. Quality assessment of the noncarbonated-bottled drinking water: comparison of their treatment techniques. International journal of environmental analytical chemistry. 2020 Nov 23:1-2.

CONFLICT OF INTEREST: Authors declare no conflict of interest

GRANT SUPPORT AND FINANCIAL DISCLOSURE: NIL

AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under

Mustafa A:	Main Idea, Research proposal
Azam H:	Data Collection and writing
Khan SA:	Review and proofreading
Ain HU:	Data Collection
Gul F:	Review and proofreading
Awais M:	Data Collection
Inayatullah:	Data Collection

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.