Thirst for Knowledge: Exploring Dubai's Water Quality through a Public Health Lens

Dr. Yassen Al Foteih[1], Dr. Rashed Karkain [2], Mr. Salimbabu Abdulla[3], Dr. Zelal Kharaba[4,5]

[1]Associate Professor, College of Humanities, City University Ajman-United Arab Emirates, PO Box 18484, email-alfoteih@gmail.com

[2]CEO/MD, Sustainable Development Research and Training Institute-Dubai-UAE-PO Box-299474

[3]Lab Specialist, Fatima College of Health Sciences, Institute of Applied technology, Ajman-UAE PO Box 3798.

[4]Associate professor, Department of Clinical Pharmacy, College of Pharmacy, Al Ain University, Abu Dhabi Campus, Abu Dhabi 112612, United Arab Emirates

[5]Faculty of Medical Sciences, Newcastle University, Newcastle upon Tyne NE2 4HH, UK

Abstracts: The current study aimed to evaluate the biochemical quality of both bottled water and tap water in the Emirate of Dubai. A total of sixty samples were collected (6 brands x 10 samples each), while an additional 10 samples were taken from the tap water source. The analysis results were then compared to international standards established by IBWA, FDA, USEPA, WHO, and Abu Dhabi's specific standards. The objective was to identify any potential risks or hazards to public health arising from chemical or biological contaminants in the water. The study assessed various parameters, including total alkalinity, total hardness, and heavy metals, all of which were found to fall within international limits. Microbial content was also analyzed and compared to various standards. The results of this analysis demonstrated that the water's composition met the international norms for safe drinking water. To investigate the impact of different sodium concentrations on blood tonicity, a qualitative microscopic assessment was employed. The results revealed that sodium concentrations exceeding 3mg/L rendered the cells hypertonic. Any further increase in sodium concentration beyond this level is directly correlated with increased cell hypertonicity. However, further research is required to delve into other critical aspects of water consumption in the UAE, such as public attitudes toward water and the influence of water pricing on residents' purchasing choices. Public awareness campaigns are essential to rectify misconceptions about both tap water quantity and bottled water quality.

Keywords: Bottled Water, Tap Water Quality, Public health, Microbial Content, Hypertonicity.

1. INTRODUCTION

The consumption of bottled mineral water has seen a global increase [1]. This is largely due to the widespread lack of access to a reliable water supply in people's homes [2]. In 2021, the UAE's population was recorded at 9.99 million, a substantial rise from 69.588 thousand in 1950 (United Arab Emirates and the IMF, n.d.). The average per capita water consumption in the UAE is three times higher than that of EU countries and 82% higher than the global average. Additionally, there is growing concern about the composition of bottled water in the UAE. People often make their choice of bottled water brand without much scrutiny. Bottled waters can contain trace elements and natural substances, some of which may exceed acceptable levels set by various global bodies, including WHO [3]. Furthermore, there is no conclusive evidence that all bottled water brands consistently meet the required mineral compositions and pH levels.

In countries like the United States, Europe, and Canada, water quality is generally regulated by their respective governments or the World Health Organization. These countries conduct regular evaluations and assessments of their water quality [4]. Globally, the production and consumption of bottled water have garnered increased attention [5]. Approximately 90.4% of respondents in a case study of Salento consumed bottled mineral water, with an average consumption of 387.7 liters per capita annually (375.2 liters in PET bottles and 12.5 liters in glass bottles). Public water supply systems were used by 61.5% of respondents, with an average consumption of 169.4 liters per capita annually [6].

Even in places with clean water supplied to every household in major cities, many people in both developing and developed countries prefer bottled drinking water due to concerns about the appearance or water treatment processes such as chlorination in their respective regions [7]. Contamination of tap water can occur at any time due to leaking pipes and pipe corrosion [8]. Dubai is not an exception to the rapid growth of bottled water consumption, even with readily available inexpensive water alternatives [9]. The global increase in bottled water consumption may reflect the perception among the public that bottled water is safer than tap water [10]. However, it's important to note that both chemical and biological contaminants in bottled water can pose risks to human health [11]. For instance, one study found differences in Sb and Br leaching in three bottled water classes and plastic material types [12]. Some studies concluded that 13.0% of the tested samples did not meet Greek standards for human consumption, mainly due to the presence of Total coliforms, P. aeruginosa, or Enterococcus Species. [13]. In contrast, according to another study [14], the concentration of NO3 was found to be between 0.08 and 40 mg L−1, which fell within the prescribed limits of BIS and WHO for all samples. In the UAE, a study revealed that the heterotrophic bacterial count in 21 water samples ranged from 1 to 100 CFU/100 mL, while 12 samples had counts exceeding 200 CFU/100 mL. Only seven household tank water samples had zero heterotrophic counts. However, among the 40 household water tank samples, 22 had zero total coliform bacteria. In 11 samples, total coliform (TC) counts ranged from 2 to 80 CFU/100 mL, while in the remaining 7 samples, TC counts exceeded the countable range (more than 200 CFU/100 mL) [15].

A study conducted by [16] in Bolgatanga, Ghana, focusing on sachet and bottled water brands, found that turbidity, color, total dissolved solids, total hardness, calcium ion, magnesium ion, total iron, chloride ion, nitrate ion, phosphate ion, and sulfate ion in all samples adhered to WHO drinking-water guidelines. However, fluoride ion levels were below the WHO recommended minimum limit of 0.5 mg/L, and a few samples were contaminated with coliform and fecal coliform bacteria. The study concluded that while bottled water exhibited good quality, sachet water suffered from poor quality, primarily due to possible sanitation issues in the area. Another study conducted in Lebanon reported negative growth of fecal coliform, though some samples tested positive for total coliforms and heterotrophic plate count [17]. The quality of bottles is influenced by various factors, including raw materials, manufacturing processes, temperature, storage conditions before and after water filling, and transportation [18]. In this study, we evaluated the chemical and microbiological characteristics of six brands of bottled water and tap water in the Emirate of Dubai. The results were then compared to current global standards for bottled water quality. Additionally, we conducted a qualitative study on Serum Sodium Concentration and Tonicity.

2. MATERIAL AND METHODS

This quantitative study aimed to evaluate the quality of bottled water for human consumption in the Emirate of Dubai. More specifically, it sought to compare the quality of the water against standards established by IBWA, FDA, USEPA, WHO, and Abu Dhabi's regulatory guidelines. The objective was to identify any potential risks or hazards to public health stemming from chemical or biological contaminants in bottled water. To conduct this assessment, samples of bottled water from six different brands, all packaged in plastic containers, were procured from well-known food outlets located in a Fuel Station in Dubai. In addition, a selection of imported bottled water in plastic containers was gathered from Dubai's market for comparison. Stratified sampling was employed for sample selection, with ten bottles from each brand purchased. These samples were handled in a consistent manner from the point of purchase through transportation and storage. Six specific brands of bottled drinking water were chosen for this study, alongside the city's supplied potable water (tap water). A total of 70 samples were collected (10 samples from each brand and 10 samples from tap water) and subjected to physical, chemical, and heavy metals testing.

The samples and analyses were conducted in accordance with various standards, including APHA, ISO 7150-1, DIN 38406, DIN 38409, ISO 6060-1989, ISO 6878-1986, ISO 7890-1-2-1986, EN ISO 26777, DIN 38405 D10. The collection and preservation of samples adhered to the procedures outlined by APHA 1060. Subsequently, the analysis results were compared with the standards set by IBWA, FDA, USEPA, WHO, and Abu Dhabi. In addition to that,

another in vitro examination was carried out to assess the impact of sodium ions on the tonicity of human blood cells. Seven different concentrations of sodium ions, specifically 1mg/L, 3.5mg/L, 6mg/L, 8mg/L, 12mg/L, and 24mg/100ml, were prepared. The hypothesis was that 99% of the added sodium ions would be absorbed by blood cells. To test this, 10µl of a water sample was mixed with 10µl of a human blood sample (from a self-donor, who was a researcher). Following mixing, thin blood films were prepared for microscopic observation under oil immersion at 100X magnification to detect the impact of the sodium ions' tonicity on the blood cells.

3. RESULTS AND DISCUSSIONS

3.1. Assessing Physical, Chemical, and Heavy Metal

In the forthcoming section, the result of all samples analysis is compiled and summarized as demonstrated in table 1 & 2 which includes Physical, Chemical, Heavy Metals as well selected Microbial parameters of Total Coliforms, E. Coli and Enterococcus. We shall make a note that more parameters were tested in the laboratory in addition to those that are listed in selected standards. These extra parameters may be of concern for this study and future studies. In such cases where there are no standards (i.e., conductivity, COD, etc.) the field is left as blank in table 1.

Table 1: Physical and chemical parameters of collected samples in comparison with available global standards and standards within the country.

Bottled Water - Physical &Chemical Parameters												
Parameters	**Standards**					**Brands**						
	IBWA	**FDA**	**USEPA**	**WHO**	**Abu Dhabi**	**A**	**B**	**C**	**D**	**E**	**F**	**Tap water UAE**
Temperature						16	16	17	16	16	17	17
pH	7.5	7.5	7.6	7.5	7.5	8.15	7.47	7.24	7.49	7.41	7.42	7.72
Conductivity (Ms/cm)						287	167.1	254	193.8	207.4	254	330
TDS (at180 C°) mg/l	500	500	500	500	100 - 1000	136.7	156	160	118	78	168	138
Total Solids mg/l	1000	1000	1000	1000	1000	164	164	166	122	110	178	176
Turbidity NTU	0.5	5	0.5	4	4	0.06	0.17	0.03	0.02	0.05	0	0.68
Chemical Oxygen Demand mg/l						4.9999	4.9999	4.9999	4.9999	4.9999	4.9999	4.9999
Sulfate $SO^{4\ mg/l}$	250	250	250	250	250	39.99	39.99	39.99	39.99	67.7	39.99	39.99
Ortho phosphates (PO_4-P) mg/l						0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
Chloride (Cl^-) mg/l	300	300	300	250	250	13.9	2.89	62.19	5.3	<0.5	53.99	73.28
Total Alkalinity mg/l	150	150	150	150	150	149.6	26.4	13.2	96.8	8.8	22	44
Nitrate (NO_3-N) mg/l	1	1	1	50	50	1.06	0.2999	0.2999	0.363	0.2999	0.2999	0.2999
T. Hardness mg/l	200	200	200	500	300	142.4	69.2	79.2	97.2	65.2	88.4	53.6
Free Chlorine mg/l	0.1	0.5	0.5	0.2	0.2	0	0	0	0	0	0	0
Total Chlorine	0.6	1	1	0.5	1	0	0	0	0	0	0	0

Table 2: The presence of heavy metals in collected samples and comparison with available global standards and standards within the country.

Heavy Metals												
Metals	**Standards**					**Brands**						
	IBWA	**FDA**	**USEPA**	**WHO**	**Abu Dhabi**	**A**	**B**	**C**	**D**	**E**	**F**	**Tap water UAE**
Ag mg/l	0.025	0.1	0.1	0.005	NA	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Cd mg/l	0.005	0.005	0.005	0.003	0.003	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Cr mg/l	0.05	0.1	0.1	0.05	0.05	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Cu mg/l	1	1	1	1	1	NIL	NIL	NIL	NIL	NIL	NIL	0.007
Ca mg/l				200	200	46.928	0.954	3.9435	35.285	0.4934	21.34	17.59
K mg/l	8	8	8	8	12	0.455	4.975	0.194	0.234	2.95	4.493	1.14
Mg mg/l					30	9.901	17.29	18.04	5.14	16.37	10.45	4.44
Mn mg/l	0.05	0.05	0.05	0.4	0.4	NIL	NIL	NIL	NIL	NIL	NIL	0.00163
Na mg/l						5.252	0.421	12.63	3.245	9.095	3.789	41.68
Ni mg/l	0.1	0.1	-	0.1	0.07	NIL	0.006	NIL	NIL	NIL	NIL	0.00545
Pb mg/l	0.005	0.005	0.015	0.005	0.01	0.001	NIL	0.001	0.0015	NIL	NIL	0.004
Zn mg/l	5	5	5	5	5	NIL	NIL	NIL	NIL	NIL	NIL	0.00427

3.2 Tonicity of Red Blood Cells in Response to Varying Sodium Concentrations

Sodium levels in the tap water sample were notably higher compared to the other samples, measuring at 41.69 mg/L, with the lowest reading recorded in Brand B at 0.421 mg/L. The water was then tested for its effect on the tonicity of human blood cells. The results showed that a sodium concentration exceeding 3 mg/L caused the cells to become hypertonic. As the sodium concentration increased, the percentage of cells becoming hypertonic also increased proportionally. Sodium levels of 8 mg/L and 12 mg/L resulted in 30% to 40% hypertonicity in the total analyzed blood cells. It became evident that the blood cells shrank in all samples except those with a sodium concentration less than 3 mg/L, which were considered isotonic.

This indicated a clear state of hypertonicity due to excessive sodium in the body cells, which could potentially lead to hypertension. Therefore, it is highly recommended to consume drinking water with very low sodium content, preferably below 3 mg/L.

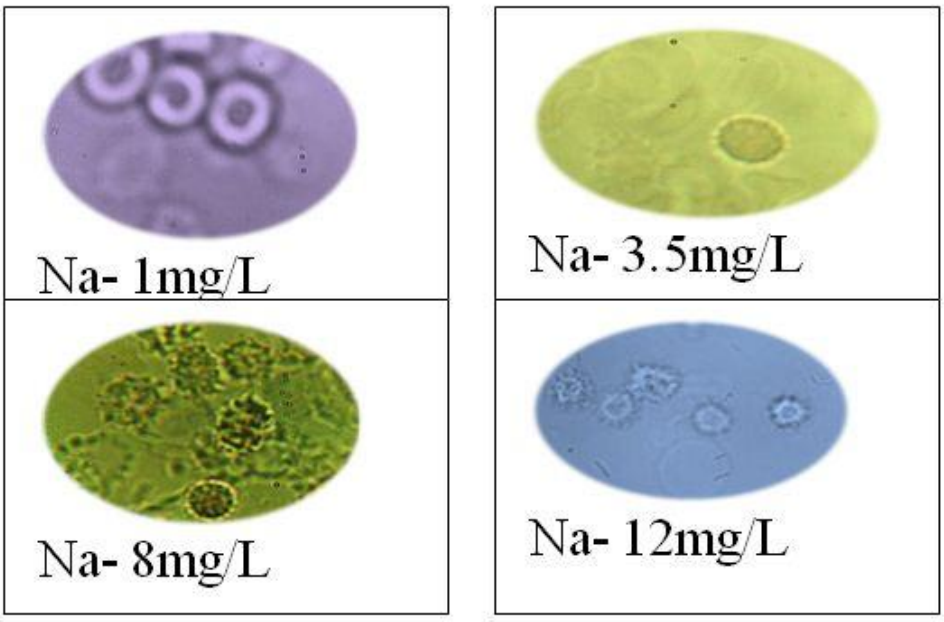

Figure 1. A qualitative microscopic assessment was used to study the impact of different Na concentrations of Blood tonicity.

3.3. Exploring Microbial Content Analysis

An analysis of the microbial content within the samples was performed, and it was assessed against various standards. The established standards were met by our samples, as acceptable limits for both coliforms and enterococcus were adhered to.

Table 3: Assessment of Microbial Content in Sample Analysis Against Selected Standards

PARAMETER	**IBWA**	**FDA**	**USEPA**	**WHO**	**Abu Dhabi**	A	B	C	D	E	F	Tap Water UAE
Total Coliforms MPN/100ml						<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
E. Coli MPN/100ml		<2.2				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
ENTRO COCCUS MPN/100ml						<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

The study's findings reveal that Brand A exhibited a pH level higher than all established standards, measuring at 8.15. Most of the other brands also demonstrated a slightly alkaline pH. According to international standards, the pH should fall within the range of 6.5 to 8.5. The pH values in our samples were well within this range, eliminating the possibility of microbial replication. Total alkalinity was notably high at 149.6 mg/l for Brand A, just below the limit of 150 mg/L set by all selected standards. Brand D also displayed alkalinity at 96.8 mg/L, slightly lower than the selected standards. Brand A stood out with a significantly high total hardness, measuring at 142.4 mg/L, which is close to the standards of IBWA, FDA, and USEPA, set at 200 mg/L. The absence of chemicals or their presence in minimal quantities met the basic requirements demanded by international standards.

Calcium levels in Brand A were higher than in other products, measuring at 46.9 mg/L. However, this value fell below the WHO and Abu Dhabi standards, which are set at 200 mg/L. Brand B and Brand F recorded higher levels of potassium (K) compared to other brands, measuring at 4.97 mg/L and 4.49 mg/L, respectively. Both values remained below the established standards. Only Abu Dhabi has set standards for magnesium (30 mg/L). Although all

products tested positive for magnesium, their levels were below Abu Dhabi's standards. In our sample analysis, pH values were consistently well-maintained in all tested bottled water. This result is in line with the microbial parameter results, which showed no indication of microbial replication. Furthermore, physical and chemical parameters such as total alkalinity and total hardness, as well as heavy metal contents such as calcium, potassium, and magnesium, all conformed to international limits.

CONCLUSIONS

The residents of the UAE as a whole may have some concerns about the suitability of tap water for drinking and perceive bottled water as a safer alternative. The current study demonstrates that the contents of bottled water align with international standards for drinking water. However, notable variations in the composition of bottled water were observed. Remarkably, a sodium ion concentration above 3mg/L leads to a significant alteration in blood tonicity, raising concerns about the chronic consumption of water with high sodium ion levels for domestic uses. While additional research is necessary to delve into various aspects of water consumption in the UAE, including public attitudes towards water relative to those in other countries and the influence of water prices on residents' purchasing choices, it is evident that public campaigns are required to rectify misconceptions regarding both the quantity of tap water and the quality of bottled water.

REFERENCES

[1] Dickie G. Rising bottled water consumption signals safe drinking water goal is under threat, says U.N. think tank | Reuters [Internet]. 2023 [cited 2023 Apr 15]. Available from: https://www.reuters.com/business/environment/rising-bottled-water-consumption-signals-safe-drinking-water-goal-is-under-2023-03-16/

[2] Heidari H, Arabi M, Warziniack T, Sharvelle S. Effects of Urban Development Patterns on Municipal Water Shortage. Front Water [Internet]. 2021;3. Available from: https://www.frontiersin.org/articles/10.3389/frwa.2021.694817

[3] Gautam B. Chemical Evaluation of Trace Elements in Bottled Water. J Healthc Eng. 2020 Dec 3;2020:e8884700.

[4] Qian N. Bottled Water or Tap Water? A Comparative Study of Drinking Water Choices on University Campuses. Water. 2018 Jan;10(1):59.

[5] Parag Y, Elimelech E, Opher T. Bottled Water: An Evidence-Based Overview of Economic Viability, Environmental Impact, and Social Equity. Sustainability. 2023 Jan;15(12):9760.

[6] Gambino I, Bagordo F, Coluccia B, Grassi T, Filippis GD, Piscitelli P, et al. PET-Bottled Water Consumption in View of a Circular Economy: The Case Study of Salento (South Italy). Sustainability. 2020 Jan;12(19):7988.

[7] Sharma S, Bhattacharya A. Drinking water contamination and treatment techniques. Appl Water Sci. 2017 Jun 1;7(3):1043–67.

[8] McFarland ML, Provin TL, Boellstorff DE. Drinking Water Problems: Corrosion. 2021 Jun;

[9] Swan M. The National. 2017 [cited 2023 Aug 16]. Move to bottle-free UAE gathers pace as awareness of alternatives grows. Available from: https://www.thenationalnews.com/uae/environment/move-to-bottle-free-uae-gathers-pace-as-awareness-of-alternatives-grows-1.89057

[10] butler N. Healthline. 2020 [cited 2023 Aug 16]. Tap Water vs. Bottled Water: Which Is Better? Available from: https://www.healthline.com/nutrition/tap-water-vs-bottled-water

[11] Curutiu C, Iordache F, Gurban P, Lazar V, Chifiriuc MC. Main Microbiological Pollutants of Bottled Waters and Beverages. Bottled Packag Water. 2019;403–22.

[12] Filella M, Hennebert P, Okkenhaug G, Turner A. Occurrence and fate of antimony in plastics. J Hazard Mater. 2020 May;390:121764.

[13] Soares AS, Miranda C, Coelho AC, Trindade H. Occurrence of Coliforms and Enterococcus Species in Drinking Water Samples Obtained from Selected Dairy Cattle Farms in Portugal. Agriculture. 2023 Apr;13(4):885.

[14] Verma A, Yadav BK, Singh NB. Hydrochemical monitoring of groundwater quality for drinking and irrigation use in Rapti Basin. SN Appl Sci. 2020 Feb 21;2(3):460.

[15] Khan MA, AlMadani AMAA. Assessment of microbial quality in household water tanks in Dubai, United Arab Emirates. Environ Eng Res. 2017 Mar;22(1):55–60.

[16] Baffour-Awuah E. Sachet Drinking Water in Cape Coast Metropolis, Ghana: Production, Quality and Equipment Maintenance. IIADR [Internet]. 2020 Jan 1 [cited 2023 Aug 16]; Available from: https://www.academia.edu/43879169/Sachet_Drinking_Water_in_Cape_Coast_Metropolis_Ghana_Production_Quality_and_Equipment_Maintenance

[17] Semerjian L. Quality assessment of various bottled waters marketed in Lebanon. Environ Monit Assess. 2010 Feb 1;172:275–85.

[18] Ahmed AT, Emad M, Bkary MA. Impacts of temperature alteration on the drinking water quality stored in plastic bottles. Appl Water Sci. 2021 Sep 24;11(10):167.

[19] Tourenq C, Brook M, Knuteson S, Shuriqi MK, Sawaf M, Perry L. Hydrogeology of Wadi Wurayah, United Arab Emirates, and its importance for biodiversity and local communities. Hydrol Sci J. 2011 Dec 1;56(8):1407–22.

DOI: https://doi.org/10.15379/ijmst.v10i1.2808