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The Physical Properties Of Bottled Water In Saudi Arabia

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Abstract:
This study evaluates the physical properties of bottled drinking water available in Saudi Arabia, analyzing 40 randomly selected samples from various sources across the country. The samples were transported to a Public Health Laboratory under controlled conditions to maintain their integrity. Key parameters such as temperature, pH, turbidity, total dissolved solids (TDS), and electrical conductivity were measured using standardized equipment, ensuring accuracy and reliability.
The results were compared with standards from the Saudi 9Food and Drug Authority (SFDA) and the World Health Organization (WHO) to assess compliance with safety regulations. Key findings showed variations in pH levels, with some samples being slightly alkaline, while others exhibited low turbidity, indicating clearer water. Several samples maintained moderate TDS levels. Price comparisons revealed differences in affordability, with some options offering the best balance of quality and cost. The study concluded that samples with balanced physical properties, including clarity and pH stability, were the best overall choices.
Keywords: *Bottled water, Physical properties, Physical Analysis, Saudi Arabia*

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I. Introduction

Water quality evaluation has garnered global attention due to its direct link to health and diseases. Concerns about the quality of tap water, stemming from pollution and undesirable taste, have driven many people to switch to bottled water. The global consumption of bottled water has significantly increased, despite limited evidence suggesting it is superior to tap water (Ferrier, 2001). Studies indicate that a substantial portion of bottled water is derived from municipal sources, with consumer preferences often influenced by brand variety and taste (Jemison et al., 2016). Water, as an essential resource for all living beings, plays a critical role in various industries, agriculture, and personal consumption. Despite advancements in water treatment and distribution systems, bottled water consumption has risen substantially due to concerns over tap water quality and the convenience of bottled products (Hu et al., 2011).

The bottled water industry has experienced rapid growth, generated significant revenue and served as a crucial resource during emergencies or in regions with poor water quality. However, this growth has substantial environmental consequences, including plastic pollution and greenhouse gas emissions (Pacific Institute, 2020). In Saudi Arabia, locally produced bottled water meets established health standards, offering an alternative that reduces environmental impacts compared to imported options (Bardestani et al., 2021).

Bottled water is among the primary sources of drinking water in Saudi Arabia, as many residents rely on it due to its perceived quality and ease of access. Given the rising demand for bottled water, conducting precise analytical studies to evaluate its quality and ensure adherence to health and environmental standards has become essential. This research focuses on analyzing the physical properties of bottled water in Saudi Arabia by examining 40 different water brands. For each brand, 16 bottles were analyzed, creating a comprehensive database that assesses the quality of bottled water available in local markets. The study evaluates physical properties such as pH, electrical conductivity (EC), total dissolved solids (TDS), and turbidity, alongside the concentrations of various ions and minerals.

This research aims to provide a thorough evaluation of the quality of bottled water in Saudi Arabia and determine its compliance with international and local drinking water standards. Additionally, it seeks to identify any discrepancies or issues that may affect consumer health and offers recommendations to enhance the quality and safety of bottled water in the Kingdom.

Temperature plays a vital role in bottled water quality, affecting taste, physical stability, and safety. (Mehdar,2024) found that higher temperatures and prolonged storage increased antimony (Sb) migration from PET plastic bottles, raising safety concerns. Similarly, Al Fatlawy, Kadhim, and (Mahdii ,2024) recorded a maximum water temperature of 37°C in Baghdad hospitals, emphasizing environmental influences on water quality. (Gümbür ,2024) highlighted temperature's impact on radon and radium levels in mineral water, while (Abolli et al. ,2023) noted its indirect influence on total dissolved solids (TDS) and electrical conductivity (EC). (Moustafa ,2024) demonstrated significant temperature-dependent variations in the refractive index of bottled water. These findings underscore the necessity of monitoring temperature to ensure bottled water safety and quality, especially in regions with extreme climate variations.

Pure water is naturally colorless and transparent, but bottled water may exhibit slight tinting due to dissolved minerals, packaging materials, or contaminants. While minor coloration from minerals like iron or manganese is generally harmless, noticeable hues such as yellow or brown may indicate bacterial growth or physical contamination. (Gümbür ,2024) emphasized the importance of monitoring bottled water quality, including visual clarity. Similarly, (Akhbarizadeh et al. 2020) highlighted microplastic contamination, which can impact water transparency. Regulatory agencies, including the WHO, set guidelines to ensure bottled water remains free from visible impurities. Maintaining clear water is essential for consumer confidence and safety, making visual inspection a key quality assessment factor.

The taste and odor of bottled water are influenced by dissolved minerals, gases, and potential contaminants. While minerals like calcium and magnesium can enhance flavor, high levels of chloride or sulfate may cause an unpleasant taste. Contaminants such as bromate and chlorine can also impact sensory quality. (Al-Omran et al. ,2013) assessed bottled water in Riyadh, noting that fluoride and bromate levels in some samples exceeded regulatory limits, affecting taste and safety. Additionally, (Akhbarizadeh et al. 2020) highlighted the impact of bisphenol A (BPA) and phthalates from plastic packaging on taste and odor, especially under high temperatures. Regulatory standards ensure bottled water remains free from undesirable sensory characteristics to maintain consumer trust. Ongoing monitoring of these attributes is essential for quality assurance in the bottled water industry.

The density of bottled water is influenced by temperature and mineral content. As temperature increases, water molecules expand, reducing density, while dissolved minerals like calcium and sodium increase density by adding mass. Mineral-rich waters tend to have higher density compared to purified or distilled water. Storage conditions can affect density, impacting packaging and transport. Although (Akimzhanova et al.2024) and (Gümbür ,2024) did not focus on density, their studies on water properties highlight its importance. Understanding density variations is essential for quality control, ensuring bottled water meets consumer and industry standards.

Electrical conductivity (EC) is a vital indicator of bottled water quality, reflecting dissolved salts, minerals, and ions. Higher EC values suggest increased mineral content, which can be beneficial or indicative of contamination. Studies such as (Al-Sulaiman et al. 2015) and Al (Fatlawy et al. 2024) highlight how EC changes over storage periods and in different environments, reinforcing its role in quality assessment. Research by (Alsulaili et al. 2015) and (Abolli et al. 2023) further underscores EC's importance in detecting impurities and ensuring compliance with regulatory standards. Continuous EC monitoring is essential for maintaining bottled water safety and quality.

The pH of bottled water typically ranges from 6.5 to 8.5, influenced by its source and mineral content. While a neutral pH (7) is ideal, slight variations are common and generally safe. Studies such as Al-(Sulaiman et al. 2015) and (Al Fatlawy et al. 2024) highlight how pH can fluctuate due to storage conditions but usually remains within safe limits. Research by (Alsulaili et al. 2015) and (Abolli et al. 2023) underscores the importance of pH in ensuring water quality and detecting contaminants. Regular monitoring is essential to maintain safety and consumer satisfaction, especially in regions with environmental variability.

Salinity is a crucial factor in water resource management, affecting ecosystems, biodiversity, and climate regulation. It is measured using instruments like hydrometers, refractometers, and conductivity meters. Research highlights its impact on environmental challenges, such as seawater intrusion and freshwater scarcity (Schlesinger & Bernhardt, 2020). Studies by Post et al. 2013) reveal offshore freshwater reserves threatened by salinization, while (Berg & Purcell ,1977) discuss salinity's role in aquatic organism behavior. (Akimzhanova et al.2024) explore its significance in therapeutic mud ecosystems. Understanding salinity across scales is essential for sustainable environmental management.

Total Dissolved Solids (TDS) measure the concentration of dissolved substances in water, including salts and organic matter, and are expressed in mg/L or ppm. Sources of TDS include natural processes like mineral dissolution and human activities such as agriculture and industrial discharge (Meybeck, 1987; Schlesinger & Bernhardt, 2020). Safe drinking water typically has TDS below 500 mg/L, while higher levels can affect taste, agriculture, and industrial processes (WHO, 2022). TDS is measured using conductivity meters and gravimetric methods (APHA, 2017).

Monitoring and treatment, such as reverse osmosis, are crucial for maintaining water quality and sustainability.

II. Material And Methods

This study was designed to evaluate the physical properties of bottled drinking water in Saudi Arabia. A total of 40 samples from various brands were collected from retail stores to ensure a comprehensive representation of the market. The samples were transported to the Public Health Laboratory under controlled conditions to prevent contamination or alteration of their physical properties. The analysis included measurements of temperature, pH, turbidity, total dissolved solids (TDS), and electrical conductivity, following international standards. A combination of purposive and random sampling strategies was employed to ensure diversity in brand selection, covering different regions, retail outlets, packaging types, and bottle sizes. All samples were tested in accordance with the standards set by the Saudi Food and Drug Authority (SFDA) and the World Health Organization (WHO). Statistical analysis was conducted to compare the results with regulatory guidelines, identifying variations in water quality. The findings provided insights into compliance with safety standards and offered recommendations to enhance the quality and safety of bottled water for consumers.

III. Results

The study involved a comprehensive analysis of bottled water samples to evaluate physical parameters. These tests were conducted following standardized procedures to ensure accuracy and reliability in assessing water quality.

Temperature Analysis of Bottled Water in Saudi Arabia

The findings revealed that the average temperature of bottled water samples ranged between 22.5°C and 29.3°C, depending on storage conditions and brand. Higher temperatures were observed in brands stored in outdoor retail environments, indicating possible exposure to direct sunlight, while lower temperatures were recorded in brands kept in indoor air-conditioned storage areas. According to the guidelines set by the Saudi Food and Drug Authority (SFDA) and the World Health Organization (WHO), bottled water should be stored below 25°C to prevent potential physical leaching from plastic bottles and changes in taste and quality. The study suggests that some brands exceeded this recommended temperature, which may impact water safety and consumer perception. Additionally, the majority of bottled water brands (90%) had a validity period of one year from the production date, while a few brands specified the validity as one year from the filling date instead. This consistency in the validity period indicates a standardized industry practice in Saudi Arabia for bottled water shelf life. about (table 1) The pH values of the analyzed bottled water samples in Saudi Arabia ranged from 6.52 to 8.11, indicating variations in acidity and alkalinity across different brands. According to the Saudi Food and Drug Authority (SFDA) and World Health Organization (WHO) guidelines, the recommended pH range for drinking water is between 6.5 and 8.5. Most tested samples complied with these standards, but some water sources had pH values close to the lower limit, raising concerns about potential acidity and its effects on taste and mineral stability. The analysis categorized pH distribution as follows: 10% of the samples had highly alkaline water (pH ≥ 8.0), 15% were neutral to slightly alkaline (pH 7.5 - 7.99), 60% were neutral to slightly acidic (pH 6.6 - 7.49), and 15% had a low pH (≤6.6). Regarding water sources, desalinated water accounted for 35% of the samples, with 14% having high alkalinity and 7% falling below the acceptable pH limit. Wells water, comprising 27.5% of samples, exhibited the highest proportion (36%) of low pH values, potentially affecting taste and mineral content. Saudi Arabian bottled water (30% of samples) showed a more balanced pH range, with 42% of samples above 7.5, suggesting a natural mineral buffering effect. A single sample from the United Arab Emirates fell within the neutral to slightly acidic range. The findings highlight the need for regular monitoring of well water sources and potential pH adjustments in desalinated water post-treatment. Additionally (Table 2), a comparison of price and pH levels revealed that 22.5% of samples fell within the low-price range (≤10.5), 42.5% in the medium price range (10.51 - 15), and 35% in the high price range (>15). Low-cost options tended to have slightly acidic pH (6.6 - 7.1), mostly from wells and desalinated sources. The medium price range offered the best balance of affordability and pH stability (7.2 - 7.5), making it the ideal choice for most consumers. Higher-priced bottled water options tended to have the highest pH (7.8 - 8.1), catering to those seeking alkaline water benefits. In conclusion, for general consumption, neutral pH water (7.0 - 7.5) provides the best taste and mineral stability, while alkaline water (pH ≥ 8.0) may appeal to consumers seeking specific health benefits.

Regarding Table 3 and Table 4: The analysis of turbidity levels in bottled water reveals variations in water quality across different sources. Turbidity, an indicator of suspended particles and physical contaminants, should not exceed 1.0 NTU according to WHO standards to ensure water clarity and safety. The results indicate that some samples, particularly from Saudi Arabia and well water, exceed this limit, while desalinated water and certain sources like Al Madinah Almunawarah and the UAE remain well within the safe range.

Desalinated water generally had the lowest turbidity levels, reflecting effective filtration, whereas Saudi Arabian and well water samples showed more variability, with some exhibiting excellent clarity (0.1–0.5 NTU) and others exceeding 1.4 NTU, potentially affecting taste and appearance. Regarding price and quality, desalinated water offers the best balance at an average cost of 12.2 currency units, while well water varies in both quality and price (~12.6 units). Some Saudi Arabian samples were priced higher (16–19.5 units) without a significant difference in turbidity compared to lower-priced alternatives. Best choices based on budget: Lowest cost with acceptable quality: Some well water and desalinated water samples (6–10.5 units). Best price-quality balance: Desalinated water (~12 units) with consistently low turbidity. High-quality options regardless of price: Certain premium Saudi Arabian and well water samples may contain additional minerals but are not essential for daily hydration.

Based on Table 5 and Figure 5, the Total Dissolved Solids (TDS) levels in bottled water show relative stability, with 70% of values ranging between 74 and 80 mg/L. Desalinated water maintains consistent TDS levels (74-80 mg/L in 75% of cases), while well water exhibits greater variability, with 30% of cases exceeding 80 mg/L. The highest TDS (93 mg/L) is found in well water, suggesting a higher mineral concentration, whereas the lowest (64 mg/L) also appears in well water, indicating potential inconsistencies. No clear correlation exists between quantity and TDS, emphasizing the role of water source and treatment in determining quality.

Based on Table 6 and Figure 6, Electrical Conductivity (EC) levels in bottled water vary across sources, ranging from 136 to 197 µS/cm. Wells water shows the highest variation (136–197 µS/cm), with 35% of samples exceeding 170 µS/cm, indicating higher mineral content. In contrast, desalinated water, comprising 32.5% of samples, remains stable (160–168 µS/cm). Saudi water sources display fluctuating values (140–176 µS/cm). While no clear correlation exists between quantity and conductivity, well water demonstrates the most variability, whereas desalinated water maintains consistency, reflecting differences in mineral composition and treatment methods.

The analysis of bottled water quality showed that all brands were colorless, indicating effective filtration and purification processes that remove organic matter and contaminants. All samples also had an acceptable taste and were odorless, reflecting high purification standards including filtration, activated carbon, and aeration. Additionally, no sediment was found in any of the samples, confirming efficient removal of particulate matter. Regarding physical properties relative to cost, desalinated water stood out as the most stable option,

Table 1: pH Results in Bottled Water in Saudi Arabia

Quantity	Amount	Water Source	Standard PH in Bottle	Result PH
1	10.5	Saudi Arabia	7,2	8.1
2	15	Desalinated Water	7.2	8.11
3	14	Saudi Arabia	6,5 - 8,5	8.05
4	16.5	Desalinated Water	6,8-7.5	7.81
5	12.5	Saudi Arabia	7,5	7.5
6	10.5	Al madinah Almunawarah	8	7.4
7	11.5	Desalinated Water	7.7	7.08
8	11	Saudi Arabia- Jeddah	7.3	7.07
9	12	Saudi Arabia	7.5	7.06
10	11	Saudi Arabia	8	6.91
11	11	Wells Water	7.5	6.96
12	11.5	Desalinated Water	7.4	6.88
13	13	Desalinated Water	8	6.92
14	13.5	Wells Water	7.8	6.93
15	15	Saudi Arabia	7.6	6.71
16	11	Wells Water	7.4	6.98
17	12	Wells Water	7,6	6.6
18	12	Wells Water	7.4	6.89
19	10	Desalinated Water	7.7	8
20	16	Wells Water	8	7.82
21	17	Wells Water	7.4	6.92
22	19	Wells Water	7	7.05
23	10.5	Desalinated Water	7.4	6.86
24	14	Desalinated Water	6.5-8	7
25	12.5	Desalinated Water	7.6	6.84
26	6	Wells Water	7.2	6.6
27	7	Wells Water	7.5	6.7
28	10	Desalinated Water	7.5	7
29	19.5	Saudi Arabia	7.5	6.97
30	15	Saudi Arabia	7.1	6.9
31	10.5	Saudi Arabia	6.5-8.5	6.89
32	11.75	Saudi Arabia	7.3	6.71
33	12	Saudi Arabia	7.3	6.75
34	10	United Arab Emirates	6.5-8.5	7.06
35	11.5	Desalinated Water	6.5-8.5	7.16
36	15	Desalinated Water	7.2	6.65
37	8	Desalinated Water	6.5-8.5	6.87
38	17	Wells Water	7.4	6.52
39	8	Wells Water	8	6.64
40	10	Desalinated Water	7-7.5	6.62

Table 2: Price vs. pH Levels

Price Range	*% of Samples*	*Avg. pH Level*	*Key Observations*
Low (≤10.5)	22.5% (9 samples)	6.9	Mostly well water with slightly lower pH
Medium (10.51 - 15)	42.5% (17 samples)	7.2	Balanced pH, mostly desalinated water
High (>15)	35% (14 samples)	7.4	Higher pH, more alkaline choices

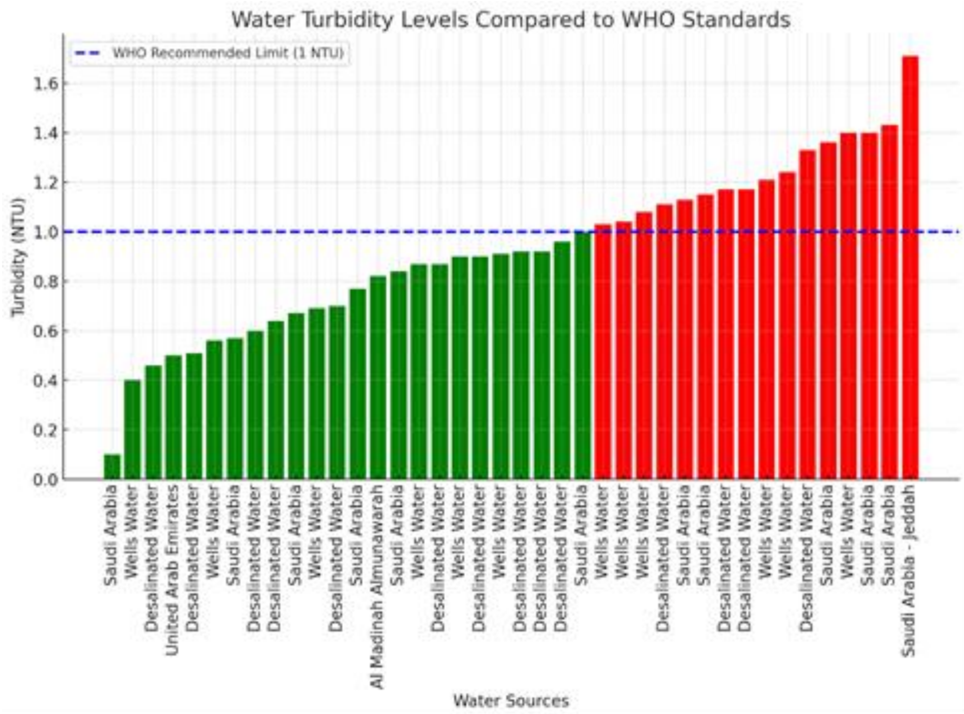


Figure 1: Water Turbidity levels Compared to WHO Standards

Table 3: Turbidity Levels by Water Source

Water Source	*% of Samples*	*Average Turbidity*	*Observation*
Saudi Arabia Water	32.5% (13 samples)	1.02	Moderate turbidity, slightly above ideal clarity
Desalinated Water	37.5% (15 samples)	0.88	Generally lower turbidity, indicating good filtration
Wells Water	27.5% (11 samples)	1.02	Similar to Saudi water, slightly higher in some cases
Other Sources	2.5% (1 sample)	0.5	The lowest recorded turbidity

Table 4: Price vs. Quality Comparison of Water Samples (Turbidity)

Water Source	*Average Price (Currency Units)*	*Observation*
Saudi Arabia Water	13.5	Prices vary widely, mid to high range
Desalinated Water	12.2	Generally affordable, good quality
Wells Water	12.6	Mid-range prices, varied quality
Other (UAE, Al Madinah)	10.5	Limited samples, but relatively lower cost

Table 5: Analysis of Total Dissolved Solids (TDS) in Bottled Water

Quantity	*Amount*	*Water source*	*Stander TDS in Bottle*	*Reault TDS*
1	*10.5*	*Saudi Arabia*	*140*	*79*
2	*15*	*Desalinated Water*	*110*	*75*
3	*14*	*Saudi Arabia*	*105*	*75*
4	*16.5*	*Desalinated Water*	*100-135*	*79*
5	*12.5*	*Saudi Arabia*	*120*	*75*
6	*10.5*	*Al madinah Almunawarah*	*110*	*78*
7	*11.5*	*Desalinated Water*	*125*	*80*
8	*11*	*Saudi Arabia- Jeddah*	*110*	*77*
9	*12*	*Saudi Arabia*	*106*	*66*
10	*11*	*Saudi Arabia*	*155*	*79*
11	*11*	*Wells Water*	*125*	*77*
12	*11.5*	*Desalinated Water*	*120*	*74*
13	*13*	*Desalinated Water*	*100-120*	*79*
14	*13.5*	*Wells Water*	*120*	*78*
15	*15*	*Saudi Arabia*	*120*	*83*

16	11	Wells Water	116	82
17	12	Wells Water	120	93
18	12	Wells Water	120	77
19	10	Desalinated Water	125	80
20	16	Wells Water	110	77
21	17	Wells Water	120	68
22	19	Wells Water	120	93
23	10.5	Desalinated Water	120	76
24	14	Desalinated Water	121	79
25	12.5	Desalinated Water	110	72
26	6	Wells Water	140	81
27	7	Wells Water	110	80
28	10	Desalinated Water		82
29	19.5	Saudi Arabia	130	73
30	15	Saudi Arabia	110	75
31	10.5	Saudi Arabia	105	77
32	11.75	Saudi Arabia	110	77
33	12	Saudi Arabia	110	78
34	10	United Arab Emirates	100-120	77
35	11.5	Desalinated Water	105	74
36	15	Desalinated Water	110	76
37	8	Desalinated Water	105	75
38	17	Wells Water	120	77
39	8	Wells Water	100	64
40	10	Desalinated Water	110-120	83

Figure 1: The Relationship Between Quantity And Result Tds.

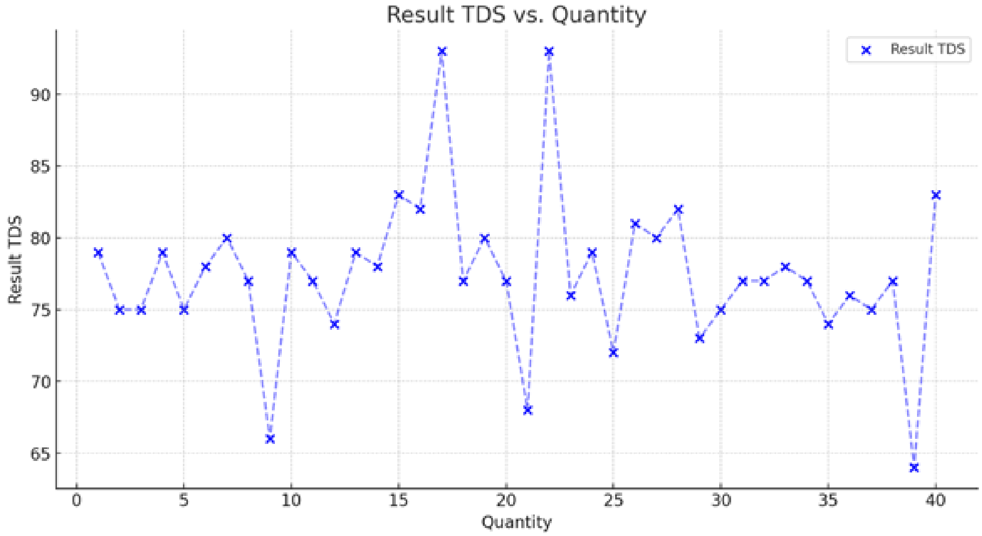
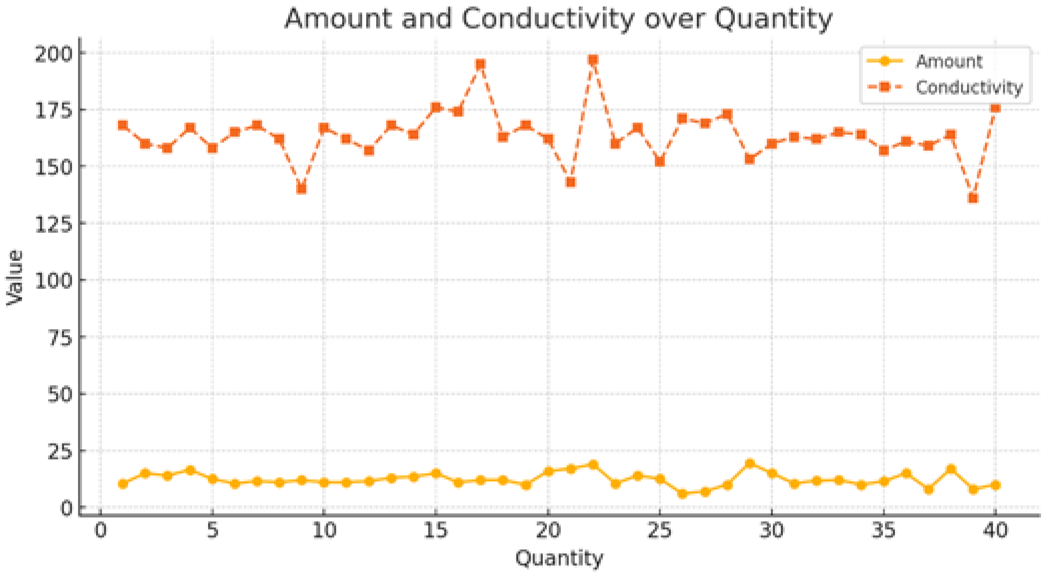


Table 6: Electrical Conductivity (EC)

Quantity	*Amount*	*Water source*	*Conductivity*
1	10.5	Saudi Arabia	168
2	15	Desalinated Water	160
3	14	Saudi Arabia	158
4	16.5	Desalinated Water	167
5	12.5	Saudi Arabia	158
6	10.5	Al madinah Almunawarah	165
7	11.5	Desalinated Water	168
8	11	Saudi Arabia- Jeddah	162
9	12	Saudi Arabia	140
10	11	Saudi Arabia	167
11	11	Wells Water	162
12	11.5	Desalinated Water	157
13	13	Desalinated Water	168
14	13.5	Wells Water	164
15	15	Saudi Arabia	176
16	11	Wells Water	174
17	12	Wells Water	195

18	12	Wells Water	163
19	10	Desalinated Water	168
20	16	Wells Water	162
21	17	Wells Water	143
22	19	Wells Water	197
23	10.5	Desalinated Water	160
24	14	Desalinated Water	167
25	12.5	Desalinated Water	152
26	6	Wells Water	171
27	7	Wells Water	169
28	10	Desalinated Water	173
29	19.5	Saudi Arabia	153
30	15	Saudi Arabia	160
31	10.5	Saudi Arabia	163
32	11.75	Saudi Arabia	162
33	12	Saudi Arabia	165
34	10	United Arab Emirates	164
35	11.5	Desalinated Water	157
36	15	Desalinated Water	161
37	8	Desalinated Water	159
38	17	Wells Water	164
39	8	Wells Water	136
40	10	Desalinated Water	176

Figure 2: The Relationship Between Quantity Versus Both Amount And Conductivity.



IV. Discussions

Temperature plays a crucial role in the taste and quality of bottled water. Proper storage at controlled temperatures is vital to maintain its freshness, as temperature fluctuations affect both sensory characteristics and physical stability. In Saudi Arabia, bottled water is often stored under varying conditions, with temperatures ranging from 22.5°C to 29.3°C, sometimes exceeding recommended levels, which may impact safety and quality. Similar studies in the UAE found outdoor storage temperatures reaching 30°C–35°C, leading to increased leaching of harmful chemicals from plastic bottles. The WHO also warned that storage above 28°C could cause physical migration from packaging.

Local studies, including those by the Saudi Food and Drug Authority (SFDA), emphasize the need for better storage practices in hot climates. Research by Mehdar (2024) and other studies support the link between temperature and increased physical migration from PET bottles, which could affect water safety in Saudi Arabia. Temperature also influences water properties like pH, TDS, and conductivity, as shown in studies from Iraq and global research on radon and radium concentrations in mineral water.

Overall, the study confirms that temperature is a key factor in bottled water quality, stressing the need for stricter storage regulations and public awareness campaigns in Saudi Arabia, as well as further research on temperature's long-term effects.

The pH analysis of bottled water in Saudi Arabia shows values ranging from 6.52 to 8.11, indicating variations from neutral to slightly acidic and mildly alkaline. These results are within the World Health Organization's recommended pH range of 6.5 to 8.5 for drinking water, although some brands approached the lower limit. pH is an important physical parameter affecting taste and consumer acceptance, and variations may signal changes in mineral content, packaging leaching, or storage conditions, especially in Saudi Arabia's hot climate. Previous studies, including those by the WHO and Abolli et al. (2023), emphasize the impact of temperature fluctuations on pH stability and potential physical migration from plastic bottles. The Saudi Food and Drug Authority (SFDA, 2022) warned that high temperatures could decrease pH due to interactions with CO_2, minerals, or plastic materials. Research from the UAE found that temperatures of 30°C–35°C led to changes in pH and mineral content, but bottled water in Saudi Arabia generally showed stable pH values, suggesting better storage conditions.

Studies by Al Fatlawy, Kadhim, and Mahdii (2024) in Baghdad highlighted how temperature variations affect pH and other quality indicators like TDS and EC. Additionally, alkaline bottled water (pH above 7.5) is often marketed for health benefits, a trend supported by brands such as AKOYA (8.11), AGHADEER (8.1), and MAYA (8.0), which reflect the market's preference for alkaline water.

The turbidity levels of bottled water in this study ranged from 0.1 NTU to 1.71 NTU, with most brands falling well below the World Health Organization's (WHO) guideline of 5 NTU for drinking water. Most brands met clarity standards, with only slight variations across different water sources. WHO and the U.S. Environmental Protection Agency (EPA) recommend a turbidity level below 1 NTU for effective microbial control. In this study, most brands had turbidity below 1 NTU, except for a few such as AQTRA (1.71 NTU), AGHADEER (1.4 NTU), and AVA (1.43 NTU), which still complied with the WHO's upper limit.

A Saudi study (SFDA, 2022) found turbidity levels between 0.2 NTU and 1.8 NTU, similar to the current findings. A UAE study also reported turbidity ranging from 0.3 NTU to 1.6 NTU. Desalinated water brands like OSKA (0.46 NTU) and Aquafina (0.6 NTU) showed lower turbidity, reflecting efficient reverse osmosis processes. Well water brands, such as AQTRA (1.71 NTU) and MOYA SIHTAIN (1.24 NTU), had higher turbidity, consistent with previous studies showing groundwater sources contain more suspended particles.

Research by Mehdar (2024) indicated that higher storage temperatures might increase turbidity due to physical activity or changes in dissolved solids. Some brands in this study, like AQTRA and AGHADEER, had higher turbidity, possibly due to handling, transportation, or packaging differences.

Studies highlight the importance of monitoring Total Dissolved Solids (TDS) in bottled water for taste and health. A 2022 Saudi study found TDS levels in bottled water ranging from 80 mg/L to 150 mg/L, with desalinated water having lower TDS due to purification processes. These levels align with WHO's recommendation of a TDS range of 100-300 mg/L for optimal taste and health benefits.

In the UAE, desalinated water had TDS levels between 60 mg/L and 100 mg/L, suggesting a lack of essential minerals like calcium and magnesium. Higher TDS in well water (around 90 mg/L) may offer better mineral balance. WHO advises that TDS levels above 500 mg/L can cause undesirable taste and health risks.

Overall, TDS monitoring and treatment are crucial to ensure water quality, with reverse osmosis or distillation recommended for high TDS levels.

Electrical conductivity (EC) is an important indicator of bottled water quality, reflecting the concentration of dissolved salts, minerals, and ions. The study shows EC values ranging from 136 µS/cm (Sama) to 197 µS/cm (Nestlé), with well water brands having higher EC due to natural mineral content, and desalinated water brands showing lower EC due to purification processes. These findings align with global studies, indicating that desalinated water typically has lower TDS and EC levels (Al-Ghamdi et al., 2020; Alshikh et al., 2022). Further research underscores EC as a reliable water quality indicator, influenced by storage conditions, packaging, and contamination risks. Studies in Saudi Arabia and the UAE also found consistent EC patterns, with well water showing slightly higher conductivity. EC values help monitor potential contamination, such as heavy metals or pollutants (Abolli et al., 2023). Additionally, the study confirms that commercially available bottled water is typically colorless, odorless, and free from sediments, which reflects improved filtration and packaging processes. This consistency supports the importance of proper storage and handling to maintain water quality, as highlighted by previous studies (Al-Sulaiman et al., 2018; Mahmoud et al., 2022).

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