Physical and Chemical Analysis of Water Quality at Al-Dur Water Treatment Plant

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Abstract

Background: Water is a fundamental element for sustaining life, playing a crucial role in supporting various organisms. Ensuring the quality of water is vital for public health and safety. This study aimed to examine the water quality at different stages of the Al-Dur Water Treatment Plant and household supplies serviced by the plant from September 2023 to February 2024. Methods: Five water samples were collected from different stages of the treatment process, including raw, sedimentation, alum, treated, and storage tank waters. Additional samples from household supplies were also gathered. Upon arrival at the laboratory, all samples underwent immediate physical and chemical testing. Parameters measured included air and water temperatures, turbidity, electrical conductivity, pH levels, total hardness, total alkalinity, salinity, and total dissolved solids (TDS). Results: During the study period, air temperatures ranged from 12.4°C to 34.4°C, and water temperatures varied between 11.4°C and 28.6°C. Turbidity values ranged from 1.58 NTU to 32.2 NTU, while electrical conductivity values ranged from 412 µS/cm to 585 µS/cm. pH values, predominantly alkaline, ranged from 7.3 to 9.6. Alkalinity values ranged from 40 mg/L to 180 mg/L, and TDS from 210 mg/L to 355 mg/L. Total hardness levels were between 138 mg/L and 338.3 mg/L, aligning with recommended drinking water standards. Conclusion: The findings contribute to a better understanding of the physical and chemical characteristics of water processed by the Al-Dur Water Treatment Plant, which is essential for ensuring water quality and safety in the region. This study aids in evaluating the effectiveness of the treatment processes and maintaining compliance with regulatory standards for potable water supply.

Keywords: Water Quality, Al-Dur Water Treatment Plant, Physical Testing, Chemical Testing, Drinking Water Standards.

Significance | The study of water quality at Al-Dur Water Treatment Plant ensures compliance with standards, safeguarding health and environmental sustainability.

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Introduction

Water is one of the most essential and precious elements on Earth, crucial for the sustenance of various living organisms (Hassan et al., 2015). Water is vital for cell structure, composing 95% of the protein plasma mass of each cell, and is integral to the tissues of humans, animals, and plants. All digestive and metabolic processes Kadham et al. (2024)

occur in an aqueous medium (Bresha & Sharif, 2018). Water sources can be classified into several main categories: rivers, seas, oceans, groundwater, and rainwater Ali et al. (2022). Among these, river water is the most significant as it is the primary source for meeting human needs (Chougule et al., 2009). Many countries worldwide have begun focusing on water conservation and addressing pollution and future water scarcity issues (Varol et al., 2011).

With advancements in various life aspects, developed countries have established different stations for water purification and filtration, ensuring water retains its physical and chemical properties while being free of contaminants, resulting in high-

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quality water (Al-Sultan, 2019). However, most urban areas have faced infrastructural damage, poor maintenance, inadequate services, and weak law enforcement, leading to the accumulation of various waste types, including commercial and industrial waste, in water bodies, causing pollution (Al-Safawi & Assaf, 2018). Contaminated water is a significant cause of disease and high mortality rates, with approximately 25 million people dying annually due to waterborne diseases, according to the World Health Organization (WHO) (Al-Safawi et al., 2018). This study aims to investigate the physical and chemical properties of water from the Al-Dur Water Treatment Plant Shakir et al. (2019).

Materials and Methods

Sample Collection

Samples were collected starting in the morning, covering stages from raw water to household distribution, once monthly on the 15th of each month from September 2023 to the end of February 2024. Samples were collected after allowing the water to run for ten minutes to flush out stagnant, contaminated water. The bottles were filled with minimal air space to preserve the physical and chemical properties during transport, using 2.25-liter polyethylene bottles washed with sample water three times before collection. For measuring biochemical oxygen demand and chemical oxygen demand, 250 ml Winkler bottles were used. Microbiological tests employed narrow-mouthed, sterile glass bottles with a capacity of 200-250 ml. All samples were transported to the laboratory for immediate physical, chemical, and microbiological testing. All glassware used was initially washed with distilled water and dried in an electric oven. Analyses were conducted in laboratories at Tikrit University and the Salah al-Din Water Directorate's Quality Control and Chemical Engineering departments.

Physical Analyses

Air and water temperatures were measured in the field. Air temperature was recorded using a mercury thermometer (0-100°C) placed in the shade at a one-meter height above ground level. Water temperature was measured by immersing a thermometer directly at the sampling site until the reading stabilized, repeating the process for accuracy.

Electrical conductivity (EC) was measured using a HANNA device, with samples immersed in glass containers for one minute until readings stabilized, recorded in μS/cm (APHA, 2003). Turbidity was measured upon sample arrival at the laboratory using a HACH TL2300 HANNA Turbidity Meter, expressed in NTU. COD was determined by adding dichromate to samples in acidic conditions, measured with a spectrophotometer, and quantified in mg/L or ppm based on dichromate consumption (APHA, 2017). BOD5 was measured by incubating opaque bottles at 25°C for five days in a water bath, calculating the difference in dissolved oxygen (DO) to determine BOD5 (APHA, 2005).

Total dissolved solids (TDS) were measured by immersing the HANNA device in water samples, recording readings in mg/L after two minutes (APHA, 2003).

Chemical Analyses

A Germany Lovibond pH meter was used to measure pH, calibrated with buffer solutions (4, 7, 9) before each use. Total alkalinity was determined following APHA (2005) methods

and expressed in mg/L. A 50 ml water sample was taken, and 2 drops of methyl orange were added, turning the solution yellow. The solution was titrated with standardized 0.02 N sulfuric acid until it turned pink. The total alkalinity as CaCO3 was calculated using the formula:

Total Alkalinity (mg/L) = (VH2SO4×1000×MW of CaCO3)Vsample\text{Total Alkalinity (mg/L)} = \frac{(V_{\text{H2SO4}} \times 1000 \times \text{MW of CaCO3})}{V_{\text{sample}}}Total Alkalinity (mg/L)=V sample(VH2SO4×1000×MW of CaCO3)

The total hardness was determined using the Na2EDTA titration method (ASTM, 1984). A 25 ml water sample was taken, 1 ml of buffer solution and a small amount of Eriochrome Black T indicator were added, and the mixture was titrated with 0.02 N Na2EDTA solution until the color changed to blue. The total hardness as CaCO3 was calculated in mg/L.

The study concluded that the physical and chemical properties of water from the Al-Dur Water Treatment Plant generally meet the recommended standards for drinking water, ensuring its safety and suitability for human consumption Abdulqader et al. (2022).

Results

The data in Table 1 illustrates the monthly and site-specific air temperature variations across different stages of water treatment and distribution for the studied station from September 2023 to February 2024. The raw water samples displayed the highest average air temperature (22.7°C), with the highest monthly temperatures recorded in September 2023 (34.4°C) and October 2023 (32.0°C). In contrast, the storage tank samples presented the lowest average air temperature (21.6°C), with the lowest monthly temperature recorded in December 2024 (18.1°C) (Table 1). These variations may be influenced by factors such as ambient air temperature, proximity to heat sources, and duration of exposure to external conditions. The monthly average air temperatures showed a steady decline from 31.2°C in September 2023 to 13.7°C in January 2024, before slightly rising to 16.1°C in February 2024.

Table 2 depicts the monthly and site-specific water temperature variations for the studied station over the same period. Raw water samples registered the highest average water temperature (20.4°C), with the highest monthly temperature of 28.4°C in September 2023.

In comparison, treated water samples had a slightly lower average temperature (19.6°C), with the lowest monthly temperature of 12.7°C in February 2024 (Table 2). These findings highlight the effectiveness of the treatment processes in regulating water temperatures, which is crucial for maintaining water quality and preventing microbial growth. The monthly average water temperatures decreased from 27.6°C in September 2023 to 13.1°C in February 2024, indicating a seasonal influence on water temperatures.

The monthly and site-specific variations in electrical conductivity during the study period are presented in Table 3. The highest average electrical conductivity was observed in the raw water samples (469.5 μS/cm), with a peak in February 2024 (517 μS/cm). In contrast, the distribution 3 samples exhibited the lowest average electrical conductivity (439.5 μS/cm) (Table 3). The treated water samples showed a decrease in electrical conductivity compared to the raw samples, indicating the removal of dissolved ions during the treatment process. The monthly average electrical conductivity values ranged from 418.8 μS/cm in November 2023 to 493.1 μS/cm in February 2024, reflecting seasonal fluctuations in the water's ion content.

As shown in Table 4, the turbidity levels varied significantly across different stages of water treatment and distribution. The storage tank and distribution 4 samples recorded the highest average turbidity (15.70 NTU), with a peak in January 2024 (31.9 NTU for storage tank samples). Conversely, the alum-treated samples displayed the lowest average turbidity (6.46 NTU) (Table 4). This indicates the effectiveness of alum in reducing turbidity levels. The monthly average turbidity levels fluctuated, with the highest values recorded in December 2024 (17.75 NTU) and the lowest in November 2023 (5.307 NTU).

The pH variations during the study period are summarized in Table 5. The distribution 5 samples exhibited the highest average pH (8.85), with a peak in January 2024 (9.6). In contrast, the alum-treated samples had the lowest average pH (6.55) due to the acidic nature of alum. The monthly average pH values ranged from 7.67 in November 2023 to 8.77 in October 2023 (Table 5). These findings suggest that the water treatment processes maintain the pH within a safe range for water consumption.

Table 6 presents the monthly and site-specific total alkalinity variations during the study period. The distribution 1 samples recorded the highest average total alkalinity (129.3 mg/L), with a peak in October 2023 (160 mg/L). In comparison, the storage tank samples showed the lowest average total alkalinity (90.0 mg/L) (Table 6). The monthly average total alkalinity values decreased from 144.4 mg/L in October 2023 to 50.6 mg/L in January 2024, reflecting the impact of treatment processes on alkalinity levels.

The variations in total hardness during the study period are detailed in Table 7. The distribution 5 samples exhibited the highest average total hardness (249.2 mg/L), with a peak in October 2023 (322 mg/L). Conversely, the distribution 1 samples had the lowest average total hardness (201.0 mg/L) (Table 7). The monthly average total hardness values varied from 171.2 mg/L in January 2024 to 276.0 mg/L in November 2023, indicating the influence of seasonal changes on water hardness.

Discussion

The study results indicated that the lowest recorded air temperature was 12.4°C at the raw water station in December Kadham et al. (2023), while the highest recorded value was 34.4°C at the same station in September, as shown in Table 1. The lowest recorded water temperature was 11.4°C at the alum station in February 2024, and the highest was 28.6°C at the second distribution station in September 2023 Meri et al. (2023), as illustrated in Table 2. This variation in temperatures between study stations is attributed to seasonal changes and differences between day and night temperatures (Hussein, 1996; Mustafa, Raja, et al. (2023).

This study agrees with the findings of Alawi and Khamis (2022), which recorded the lowest air temperature as 12.6°C during winter and the highest as 24.7°C, while the lowest water temperature was 11.3°C and the highest was 22.6°C. Similar results were obtained by researchers such as Al-Dulaimi (2021) and Al-Douri (2019), who recorded temperature ranges of 11.5-27.3°C and 10.7-29°C, respectively, while Hakman (2018) recorded a range of 11.0-28.0°C in water Valluru et al. (2023).

The variation in temperature values during the study months is due to Iraq's hot continental climate in summer and cold in winter, with monthly temperature fluctuations (Al-Mundhiri, 2005; Mustafa, Kadham, et al. (2024).

Electrical conductivity is directly proportional to the amount of dissolved substances and their ionic strength, serving as a measure of the quantity and quality of dissolved ions in water (Bhat et al., 2018). It also depends on water temperature, as ions in water conduct electric charges. Hence Hsu et al. (2024), there is a direct relationship between the amount of dissolved salts in water and electrical conductivity (Al-Mundhiri, 2005). In this study, the increase in electrical conductivity values during winter is attributed to soil erosion from riverbanks into the main stream during the rainy season, increasing dissolved salt content in water Yaseen et al. (2023). Thirumulini & Joseph (2009) noted that substances added to water to remove turbidity could increase conductivity values (Ayale, 2018).

This study's results align with Alawi and Khamis (2022), which recorded the highest electrical conductivity in water as 567 μS/cm in February and the lowest as 62 μS/cm in March. The study also aligns with findings from Al-Douri (2019), Ismail (2018), and Al-Nasseri (2019), who recorded the highest conductivity values as

Table 1. Monthly and Site-Specific Air Temperature Variations for the Studied Station (°C)

Sample/Month	Sept 2023	Oct 2023	Nov 2023	Dec 2024	Jan 2024	Feb 2024	Average
Raw	34.4	32.0	25.4	12.4	14.4	17.6	22.7 A
Sedimentation	34.2	31.2	24.2	19.1	13.6	16.7	23.2 A
Alum	31.1	30.9	24.1	18.1	13.4	15.3	22.2 A
Treated	31.1	31.0	23.1	18.2	13.7	13.3	21.7 A
Storage Tank	30.1	30.2	23.2	18.1	13.3	14.4	21.6 A
Distribution 1	30.1	30.1	22.2	18.4	14.3	15.3	21.7 A
Distribution 2	30.4	30.2	22.6	17.9	14.2	17.3	22.1 A
Distribution 3	30.2	30.1	24.1	18.3	13.3	16.3	22.1 A
Distribution 4	30.1	30.3	23.4	17.7	13.2	17.4	22.0 A
Distribution 5	30.1	30.4	23.1	17.5	13.5	17.7	22.1 A
Monthly Average	31.2 a	30.6 a	23.5 b	17.6 c	13.7 d	16.1 c	

Table 2. Monthly and Site-Specific Water Temperature Variations for the Studied Station (°C)

Sample/Month	Sept 2023	Oct 2023	Nov 2023	Dec 2024	Jan 2024	Feb 2024	Average
Raw	28.4	24.5	23.3	18.6	15.2	12.5	20.4 A
Sedimentation	26.7	24.3	23.1	19.0	15.0	12.1	20.0 A
Alum	27.2	24.1	22.1	18.9	15.3	11.4	19.8 A
Treated	26.3	23.6	22.3	17.5	15.3	12.7	19.6 A
Storage Tank	26.1	22.3	22.8	17.9	15.1	12.5	19.5 A
Distribution 1	28.2	22.4	21.9	18.7	14.3	12.5	19.7 A
Distribution 2	28.6	22.1	22.2	17.4	14.5	13.6	19.7 A
Distribution 3	28.3	21.8	23.5	17.2	14.1	14.4	19.8 A
Distribution 4	28.2	21.8	23.6	18.5	13.0	14.6	19.9 A
Distribution 5	28.1	21.1	24.1	19.0	13.5	14.7	20.1 A
Monthly Average	27.6 a	22.8 b	22.9 b	18.3 c	14.5 d	13.1 d	

Table 3. Monthly and Site-Specific Electrical Conductivity Variations During the Study Period (µS/cm)

Sample/Month	**Sept 2023**	**Oct 2023**	**Nov 2023**	**Dec 2024**	**Jan 2024**	**Feb 2024**	**Average**
Raw	480	447	417	471	485	517	469.5 A
Sedimentation	426	439	419	469	457	477	447.8 CD
Alum	430	463	451	454	428	585	468.5 A
Treated	442	435	420	437	431	555	453.3 B
Storage Tank	422	434	415	496	446	465	446.3 CD
Distribution 1	477	427	413	489	443	469	453.0 B
Distribution 2	438	440	402	483	466	470	449.8 BC
Distribution 3	434	433	413	468	412	477	439.5 E
Distribution 4	431	431	409	493	401	459	437.3 E
Distribution 5	418	440	429	476	440	457	443.3 D
Monthly Average	439.8 c	438.9 c	418.8 d	473.6 b	440.9 c	493.1 a	

The study results, as shown in Table 4, recorded the highest turbidity value in water at 32.2 NTU at the second distribution station in January 2024, while the lowest was 1.58 NTU at the first distribution station in February of the same year.

Table 4. Monthly and Site-Specific Turbidity Variations (NTU) in the Studied Station

Sample/Month	Sept 2023	Oct 2023	Nov 2023	Dec 2024	Jan 2024	Feb 2024	Average
Raw	11.4	4.25	9.9	19.3	17.4	3.41	10.94 C
Sedimentation	8.12	5.85	4.65	13.2	10.1	5.44	7.89 D
Alum	5.26	10.5	9.51	5.73	3.58	4.22	6.46 D
Treated	7.43	6.14	4.2	19.7	7.82	5.5	8.46 D
Storage Tank	6.37	5.79	4.15	14.8	31.9	31.2	15.70 A
Distribution 1	9.79	7.46	4.13	25.7	15.4	1.58	10.68 C
Distribution 2	18.5	4.66	4.02	22.1	32.2	3.04	14.09 AB
Distribution 3	23.9	3.46	4.13	25.7	11.9	2.1	11.87 C
Distribution 4	12.4	9.98	4.09	15.4	31.5	20.8	15.70 A
Distribution 5	13.8	14.5	4.29	15.9	13.0	20.4	13.65 B
Monthly Average	11.70 b	7.259 c	5.307 c	17.75 a	17.48 a	9.769 b	

The study results in Table 5 showed that the highest pH value in water was 9.6 at the fourth and fifth distribution stations in December and January of 2024, respectively, while the lowest pH value was 7.3 at the third distribution station in December 2024.

Table 5. Monthly and Site-Specific pH Variations During the Study Period

Sample/Month	Sept 2023	Oct 2023	Nov 2023	Dec 2024	Jan 2024	Feb 2024	Average
Raw	8.2	7.5	7.6	8.2	9.5	8.7	8.28 B
Sedimentation	8.9	8.8	8.2	8.3	9.2	8.5	8.65 A
Alum	8.5	8.7	4.5	4.5	4.9	8.2	6.55 C
Treated	8.4	8.7	8.2	8.3	9.3	7.6	8.42 AB
Storage Tank	8.6	9.1	8.8	9.6	8.9	7.4	8.23 B
Distribution 1	7.6	8.8	8.01	9.1	9.17	8.8	8.58 A
Distribution 2	8.8	8.9	8.0	8.9	9.5	8.4	8.75 A
Distribution 3	8.1	9.1	7.4	7.3	8.7	8.1	8.12 B
Distribution 4	8.8	9.2	8.3	8.5	9.6	8.3	8.78 A
Distribution 5	8.2	8.9	8.7	8.8	9.6	8.9	8.85 A
Monthly Average	8.41 ab	8.77 a	7.67 c	8.05 bc	8.737 a	7.99 bc	

The study results in Table 6 show that the highest alkalinity value in water was 180 mg/L at the first and second distribution stations from September to November 2023, while the lowest alkalinity value was 40 mg/L at the raw water station in January 2024.

Table 6. Monthly and Site-Specific Total Alkalinity Variations (mg/L) During the Study Period

Sample/Month	Sept 2023	Oct 2023	Nov 2023	Dec 2024	Jan 2024	Feb 2024	Average
Raw	120	140	130	60	40	100	98.3 D
Sedimentation	160	120	140	80	45	60	100.8 D
Alum	-	-	-	-	-	-	-
Treated	140	120	160	60	60	80	103.3 CD
Storage Tank	100	140	100	80	60	60	90.0 E
Distribution 1	140	160	180	80	50	166	129.3 A
Distribution 2	180	180	140	60	40	80	113.3 B
Distribution 3	160	160	120	80	60	60	106.7 C
Distribution 4	120	160	140	90	50	60	103.3 CD
Distribution 5	100	120	120	60	50	60	85.0 E
Monthly Average	135.6 b	144.4 a	136.7 b	72.2 d	50.6 e	80.7 c	

The study results in Table 7 show that the highest recorded total hardness value in water was 338.3 mg/L at the sedimentation station in September, while the lowest recorded value was 138 mg/L in December and January.

Table 7. Monthly and Site-Specific Total Hardness Variations (mg/L) During the Study Period

Sample/Month	**Sept 2023**	**Oct 2023**	**Nov 2023**	**Dec 2024**	**Jan 2024**	**Feb 2024**	**Average**
Raw	236.8	299	276	161	138	207	219.6 DE
Sedimentation	338.4	184	322	207	161	276	248.1 A
Alum	-	-	-	-	-	-	-
Treated	188	276	276	184	184	253	226.8 C
Storage Tank	263.2	230	230	161	184	230	216.4 E
Distribution 1	299	148	230	161	161	207	201.0 F
Distribution 2	207	276	276	207	207	238	235.2 B
Distribution 3	276	184	322	138	207	207	222.3 CD
Distribution 4	322	322	230	161	161	253	241.5 B
Distribution 5	253	322	322	184	138	276	249.2 A
Monthly Average	264.8 a	249.0 b	276.0 a	173.8 c	171.2 c	238.6 b	

460, 565, and 579 µS/cm, respectively, during winter Lu et al. (2024). The high turbidity levels in river water during winter are due to rainfall increasing turbidity through surface runoff of soils into the river (Wolde et al., 2020). Turbidity is directly proportional to the amount of rainfall and resulting runoff, and it also depends on river discharge and current speed (Al-Mashhdani et al., 2018).

The reduction in turbidity in water treatment stages depends on sedimentation tanks, filtration quality, and chlorination efficiency Saadh, Avecilla, et al. (2024). It also depends on the amount of alum added, operational efficiency, maintenance quality, and the project's age (Al-Araji, 2003; Nada et al., 2002; Abdul-Aziz, 2015). Our study's results align with Alawi and Khamis (2022), which recorded the highest water turbidity value as 37.1 NTU in February and the lowest as 3.1 NTU in April. These results also align with Yasin (2018), who studied monthly changes in the Tigris River water in Salah Al-Din province Mahmoud et al. (2024). The pH values were generally alkaline, a characteristic of Iraqi waters (Al-Saad et al., 2008). Natural water pH values range from 5 to 8.5, and many Iraqi water bodies have pH values slightly above 7 due to the presence of carbonate and bicarbonate ions (Mouloud et al., 1990). Our study's pH values align with Alawi and Khamis (2022), which recorded the highest pH value as 7.9 in March and the lowest as 7.1 in February and January. These results also align with the studies of Al-Naemi (2017) and Al-Sarraj et al. (2014) on the Tigris River within Mosul city, recording pH ranges of 7.7-8.4 and 6.8-8.0, respectively. The Tigris River's water is suitable as raw water for treatment plants as it falls within the permissible range of 6.5-8.5 for drinking water Saadh, Mustafa, et al. (2024).

The study results in Table 6 show that the highest alkalinity value in water was 180 mg/L at the first and second distribution stations from September to November 2023, while the lowest alkalinity value was 40 mg/L at the raw water station in January 2024. This result is lower than those obtained by Fratam (2018), Al-Sultan (2019), Mahmoud (2021), and Alawi and Khamis (2022), which recorded ranges of 230-146, 221-120, 240-145, and 140-300 mg/L, respectively.

The current study's values increased in autumn, reaching their highest in winter with rainfall and lower temperatures, which enhance the dissolution of carbon dioxide in water. Maintaining moderate alkalinity levels is essential to avoid adverse effects on soil, as high alkalinity values can increase soil acidity and limit nutrient availability (Almuktar et al., 2020).

The study results in Table 7 show that the highest recorded total hardness value in water was 338.3 mg/L at the sedimentation station in September, while the lowest recorded value was 138 mg/L in December and January. These results align with the findings of Al-Sultan (2019), Al-Hamdani (2015), and Al-Sarraj (2013), who recorded total hardness values in the Tigris River within Mosul city ranging from 235-310, 222-382, and 192-294 mg/L, respectively. However, they were lower than those obtained by Alawi and Khamis (2022), which recorded values ranging from 692-292 mg/L. The current study's results did not align with those of Al-Mujamai (2022), who recorded values ranging from 290-90 mg/L.

This discrepancy may be due to the distance the river travels from Mosul to Salah Al-Din, dissolving materials along its course. Al-Sahen (2019) found that total hardness values ranged from 153-177 mg/L in the Tigris River within Salah Al-Din province. The current study's results were lower than those obtained by Al-Saadoun (2021) in his study of the Diyala River, which recorded values ranging from 273.3-1323.3 mg/L. Seasonal variations in total hardness indicate a significant increase during rainy months, raising water levels and dissolved salts from fertilizers added to adjacent agricultural lands, which are washed into the river by runoff. The current study's results align with many studies indicating high total hardness values in Iraqi waters (Al-Samarrai, 2009).

Conclusion

This study's comprehensive analysis of water quality from the Al-Dur Water Treatment Plant, spanning September 2023 to February 2024, indicates that the physical and chemical properties of the water generally meet the recommended standards for drinking water, ensuring its safety and suitability for human consumption. The study observed notable seasonal variations in air and water temperatures, electrical conductivity, turbidity, pH, total alkalinity, and total hardness. These variations can be attributed to factors such as climate conditions, treatment efficiency, and external environmental influences. The results align with previous studies, reinforcing the consistency of the treatment processes. By maintaining parameters within permissible limits, the Al-Dur Water Treatment Plant plays a crucial role in providing safe drinking water to the community, highlighting the importance of continuous monitoring and management of water resources.

Author contributions

B.K.A. conceptualized and developed the methodology. Y.H.O. prepared the original draft and collected data and reviewed and edited the writing. A.K.J.S and B.K.A. analyzed the data and reviewed and edited the writing.

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Competing financial interests

The authors have no conflict of interest.

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