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Water Quality Assessment of Al-Najaf City Potable Water Network

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ABSTRACT

Water is an essential aspect of life and important in evolution. Recently the potable water quality topic has received much attention. The study aims to determine drinking water quality in Al-Najaf City by collecting samples throughout Al-Najaf city and comparing the results with the Iraqi guidelines (IQS 417) and World Health Organization (WHO) guidelines, as well as to calculate the WQI. Samples were tested in the laboratory between December 2021 and June 2022. The results showed that multiple parameters exceeded the allowable limits during both testing periods; during winter months, the results of TDS and turbidity exceeded the upper limits in multiple locations. Total hardness values also exceeded the limit of 500 ppm for all samples taken in the winter period. For magnesium and calcium, summer measurements were mainly within limits, unlike winter period measurements which mostly exceeded the limits. Residual chlorine tests in winter had higher concentrations, generally ranging from 0.25 to 0.8 mg/l. While During summer, concentrations dropped below the allowable limit in multiple sampling points. The study concluded that the majority of the water samples gathered during the winter months were of poor quality as the total WQI values were between (99-110), while the total WQI values for water samples collected during the summer period were rated as good quality water ranged between (75-81).

Keywords: Water quality, Residual chlorine, WQI

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تقييم جودة المياه لشبكة مياه الشرب في مدينة النجف

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الخلاصة

الماء هو جانب أساسي من جوانب الحياة ويؤدي وظيفة مهمة في التطور. نظرًا للحاجة المتزايدة لاستهلاك المياه، فقد حظي موضوع جودة المياه الصالحة للشرب بالكثير من الاهتمام مؤخرًا. الغرض من هذه الدراسة هو تحديد جودة مياه الشرب في مدينة النجف من خلال جمع عينات متعددة من جميع أنحاء المدينة ومقارنة النتائج مع المعايير العراقية (IQS 417) ومعايير منظمة الصحة العالمية (WHO)، وكذلك لحساب WQI، والذي يوفر قيمة واحدة للتعبير عن الجودة الشاملة بناءً على 8 معايير أساسية لجودة مياه الشرب. تم جمع العينات واختبارها في المختبر خلال الفترة ما بين كانون الاول 2021 وكانون الثاني 2022. وأظهرت نتائج اختبارات المياه أن العديد من المعايير تجاوزت الحدود المسموح بها خلال فترتي الاختبار، حيث تجاوزت الأملاح الذائبة خلال أشهر الشتاء الحد الأعلى البالغ 1000 جزء في المليون في مواقع متعددة. من ناحية أخرى، تجاوزت مستويات العكورة الحد الأعلى في 29 عينة من إجمالي 42 عينة تم اختبارها طوال فصل الشتاء، كما تجاوزت قيم العسرة الكلية حد 500 جزء في المليون لجميع العينات المأخوذة في فصل الشتاء. بالنسبة لعنصري المغنيسيوم والكالسيوم، كانت قياسات عينات الصيف ضمن الحدود بشكل عام على عكس قياسات فترة الشتاء التي تجاوزت الحدود في الغالب. كانت اختبارات الكلور المتبقي خلال فترة الشتاء ذات تراكيز أعلى، تتراوح عمومًا من 0.25 إلى 0.8 ملغم / لتر. بينما خلال فصل الصيف، انخفضت التركيزات عن الحد المسموح به في نقاط متعددة، حيث تراوحت التراكيز بين (0–0.5) ملجم / لتر. توصلت الدراسة إلى أن غالبية عينات المياه التي تم جمعها خلال أشهر الشتاء كانت ذات نوعية رديئة حيث تراوحت قيم WQI الإجمالية بين (99–110) ، بينما كانت قيم WQI الإجمالية لعينات المياه التي تم جمعها خلال فترة الصيف والتي تم تصنيفها على أنها ذات نوعية جيدة بين (75–81).

الكلمات الرئيسية: نوعية المياه، الكلورين المتبقي, مؤشر جودة المياه

1. INTRODUCTION

Everyone should have access to safe drinking water as a basic necessity of life. Human life depends on having access to a sufficient and high-quality water supply to ensure inhabitants' well-being and the growth of several enterprises **(Kefyalew, 2018; Mohammed and Abdulrazzaq, 2021)**. Given the growing water demand, the problem of drinking water quality has recently attracted much attention. Water is a vital component of life and plays a crucial role in evolution. Water contaminants that are hazardous to human health must be eliminated. Minerals, organic chemicals, and disease-causing microbes are examples of pollutants, as are the needs for meeting chemical, biological, and physical quality requirements, allowing water to be safely drunk, cooked with, and used in other household applications **(Vigneswaran et al., 2009)**.

The Water Quality Index (WQI) is a powerful tool in water quality assessment which can be defined as a rating that determines an overall score based on several different water quality criteria taken into consideration **(Ramakrishnaiah et al., 2009; Alwaeli et al., 2021)**. The Iraqi drinking water guidelines (IQS 417) were used to calculate WQI. **(Al-Dulaimi and Younes, 2017)** investigated the safety of drinking water in Baghdad and compared the water from the tap to that sold in bottles. Baghdad was divided into five zones, each with its own water supply, and 40 water specimens was taken from each. The most popular bottled water brands were tested extensively and compared to municipal tap water. Different types of water sources have varying effects on the quality of the tested potable water samples. In some areas, the water's total dissolved solids (TDS) content is too high to be considered drinkable (>600 ppm). Furthermore, sulfate levels in municipal and bottled water were frequently high, between 200 and 330 mg/l. The bottled water met or exceeded WHO guidelines. Hardness, Cl, Pb2+, and microbiological levels were within acceptable parameters in tap and bottled water. In conclusion, the authors emphasized the need for more radiological examinations into the effect of the conflicts on Iraq's water supply. García-Ávila and others conducted a study using the water quality index (WQI) to evaluate and analyze the quality of drinking water in Azogues city **(García-Ávila et al., 2018)**. Thirty samples were taken from different parts of the drinking water distribution system over six months. Turbidity, temperature, electric conductivity, pH, total dissolved solids, calcium and magnesium, alkalinity and chlorides, nitrates, phosphates, and sulfates were all measured. The physical and chemical properties were tested using the appropriate methods. Using the WQI, researchers concluded that all samples had very high water quality levels. The Water Quality Index asserts that the quality of the sample was between good and excellent. **(Jaid et al., 2019)** performed a drinking water quality analysis in Al-Dura, southern Baghdad. The results were compared to Iraqi (IQS) and World Health Organization (WHO) criteria. Researchers developed a water quality index with a single number to describe overall quality based on 12 characteristics measured between November 2016 and February 2017. Between November 2016 and February 2017, twelve sampling stations were selected around the Al-Dura area. Chloride ions, water hardness, turbidity, oxygen concentration, total dissolved solids, alkalinity, electrical conductivity, chlorine, and pH were some of the water quality indicators tested for. Based on the results of the study, the WQI for drinking water falls within the permissible range of 0–25. **(Mahdi et al., 2021)** determined whether or not the groundwater in the Al-Zubair region of southern Iraq is fit for human consumption and drinking. The Water Quality Index, or WQI, was used to analyze the water in the investigated wells using fifteen physiochemical parameters. It is found that the groundwater should not be used for drinking or any other purpose involving human consumption.
This work aims to determine the quality of drinking water in Al-Najaf City by collecting samples throughout Al-Najaf city and comparing the results with the (IQS 417) and (WHO) guidelines, as well as to calculate the WQI, which provides a single value to express overall quality based on 8 parameters that are essential to potable water quality.

2. MATERIALS AND METHODS

2.1 Study Area

Al-Najaf city is located 10 km west of the Euphrates River, 160 km southwest of Baghdad, and 78 km east of Karbala, as shown in **Fig. 1**. Al-Najaf is one of Iraq's most significant provinces, having an area of around 80 km^2, with a fast-developing rate and increasing population.

Figure 1. Location of Al-Najaf city.

2.2 Data Collection

Water samples were collected in a clean 1-litre plastic container and evaluated for water quality parameters. The data were collected in summer and winter seasons. Furthermore, in each season, two months have been chosen for data collection, in summer (May and June) and in the winter, water samples were collected in (December and January). With seven mains providing water to Najaf city, a sample was collected at the endpoint of each main in the morning and evening, with 14 samples collected on each sampling day. **Fig. 2** displays the locations of measurement. Each sample was bottled in three bottles, and the average of test measurements was calculated to ensure the high accuracy of the measurements.

Figure 2. Sampling locations in Al-Najaf city.

2.3 Water Quality Parameters

To assess the potable water quality of Al-Najaf city, the following parameters are chosen: pH, total hardness, turbidity, total dissolved solids, residual chlorine, alkalinity, electrical conductivity, magnesium, and calcium. Measurements were done according to ASTM standards for water testing. The results demonstrated in **Table 1** are compared to local (IQS 417) and international (WHO) guidelines. **(Iraq water Standard, 2001; WHO, 2022)**

Table 1. According to (WHO) and (IQS 417) water quality criteria.

Parameter	IQS 417(2009)	WHO (2022)
pH	6.5-8.5	6.5-8.5
Total dissolved solids (TDS)	1000	1000
Electrical conductivity (EC) μS/cm	1500	1500
Turbidity (NTU)	5	5
Magnesium (ppm)	50	-
Calcium (ppm)	75	-
Total hardness (ppm)	500	500
Alkalinity (ppm)	-	-
The residual chlorine (mg/l)	0.2-0.5	0.2-0.5

2.4 WQI Application

The Iraqi drinking water guidelines (IQS 417) are used to calculate WQI which is applied to obtain a comprehensive assessment of water quality. The WQI is determined using a total of four steps. Firstly, a weight (*wi*) was given to each of the eight parameters (pH, TDS, EC, turbidity, Mg, Ca, total hardness, and residual chlorine) based on the relative weight (Wi) of each parameter in determining the overall water quality that is suitable for human consumption, as shown in **Table 2 (Batabyal and Chakraborty, 2015).**

Table 2. Relative weights of quality parameters **(García-Ávila, et al., 2018)**.

Parameter	IQS 417	Weight (*wi)*	Relative weight (*Wi)*
pH	6.5-8.5	3	0.12
TDS	1000	4	0.16
EC	1500	3	0.12
Turbidity	5	5	0.2
Mg	50	2	0.08
Ca	75	2	0.08
Total hardness	500	2	0.08
Residual chlorine	0.2-0.5	4	0.16
		$\sum wi = 25$	$\sum Wi = 1$

Secondly, the highest possible weight (5) was given to the turbidity because of its considerable influence in determining the water quality. The lowest possible weight (1) was given to magnesium because of the minor importance of its impact. The other parameters like pH, TDS, EC, Ca, total hardness, and residual chlorine were each given a weight between 1 and 5 based on how significant they were considered to be in evaluatinghe water's quality **(García-Ávila et al., 2018)**. In the second step, each parameter's relative weight (Wi) is computed using Eq.(1) **(Abbasnia et al., 2018):**

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (1)$$

where:
W_i is the relative weight,
w_i is the weight of each parameter,
n is the number of parameters.
In the third step, a quality rating scale known as *Qi* is determined for each parameter by first determining its concentration in each water sample, then multiplying that concentration by its respective value in line with the criteria outlined in (IQS 417), and finally multiplying the sum by 100 according to Eq. (2).

$$q_i = \frac{C_i}{S_i}.100 \quad (2)$$

where *qi* represents the quality rating, *Ci* represents the concentration of each parameter in each water sample, and *Si* represents the corresponding IQS 417 drinking water standard for each parameter. In the final step, *SI* is obtained for each chemical parameter, which is then used to determine the WQI using Eq. (3).

$$SIi = WixQi \quad (3)$$

By summing together the values of the component indices for each water sample, we can determine the overall Water Quality Index (WQI) using Eq. (4):

$$WQI = \sum SIi \quad (4)$$

Computed *WQI* values are usually classified into five categories, as shown in **Table 3**.

Table 3. Types of water according to the Water Quality Index (WQI).

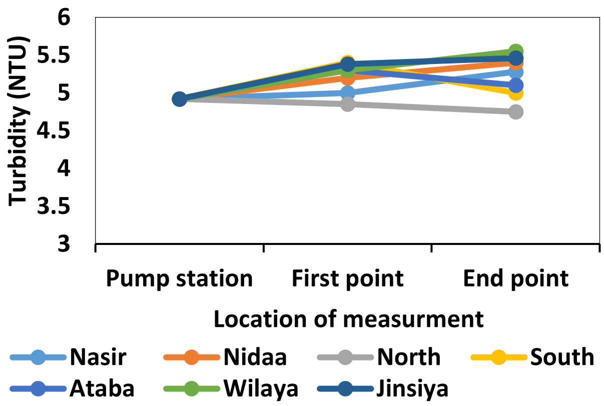
WQI range	Type of water
< 50	Excellent water
50 - 100	Good water
100 - 200	Poor water
200 - 300	Very poor water
> 300	Unfit for drinking

3. RESULTS AND DISCUSSION

3.1 Leakage Detection

A series of specific measurements needed to be done on the network to determine whether there was a leak in any of the main pipes. According to the information presented earlier, the Najaf city network formed of seven main lines. Water samples were taken from three different locations: at the main pumping station, which serves as the starting point for each main line, at the middle point of the line, and at the endpoint. Every measurement was carried out at morning hours. The degree of turbidity correlates directly to the presence of a contaminant in the pipeline **(Nasier and Abdulrazzaq, 2022)**. Samples were analyzed for turbidity to determine whether or not there was contamination of the water in the pipeline. Measurements were undertaken on the 14th of December and the 14th of May. **Fig. 3** shows turbidity measurements.

Results showed that the turbidity values showed no abrupt change of high value, thus indicating that the main lines do not suffer from big leakages. However, small leakage points might exist due to minor changes throughout the network. The starting value for winter at the pump station was (4.92) NTU, and for summer, (4.14) NTU. These values represent the first point for all mains because all main lines are supplied from the same source. The change in turbidity is primarily escalating, with the greatest values recorded for December and May being 5.55 and 4.65, respectively. However, a slight decrease in turbidity value may be observed in some instances. This is because of the complex hydraulic conditions resulting from the system's configuration and the variable water demand, which directly influences turbidity.



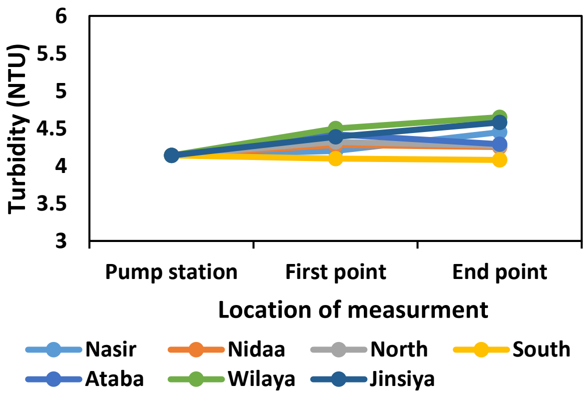


Figure 3. Turbidity measurements were taken on the 14th of December and May.

In addition, turbidity may be affected indirectly by other factors. The flow velocity, which has a direct impact on particle deposition and re-suspension, has a direct influence on the change in turbidity. Additionally, the shear stress exerted on pipe walls influences the change in turbidity **(Pothof and Blokker, 2012; van Summeren and Blokker, 2017)**.

3.2 Quality Parameters Analysis

A comparison between the physical and chemical characteristics of the water samples gained in Najaf city and the requirements set by (IQS 417) and (WHO) is acomplished. The results below are obtained by calculating the average of 3 samples taken at each sampling point for measurement accuracy.

3.2.1 pH

The measured pH values in the morning and evening are presented in **Fig. 4.** The pH levels of all samples fell within the range specified by IQS and WHO (6.5-8.5), and these values exhibited only a slight fluctuation throughout the sampling period.

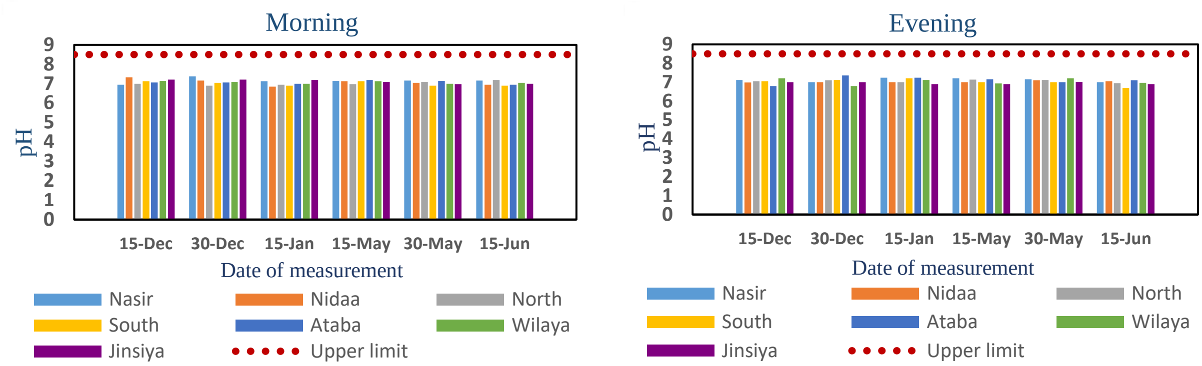


Figure 4. The measured values in the morning and the evening from the 15th of December to the 15th of June.

3.2.2 TDS

Values of TDS showed variation throughout the months of winter and summer, as shown in **Fig. 5**. During summer, all the values for the multiple sampling points were within limits specified by WHO and Iraqi guidelines (maximum of 1000 ppm). While during the months of winter, the results of TDS were higher and exceeded the upper limit of 1000 ppm in multiple locations of the network and reached a maximum concentration of 1045 during January.

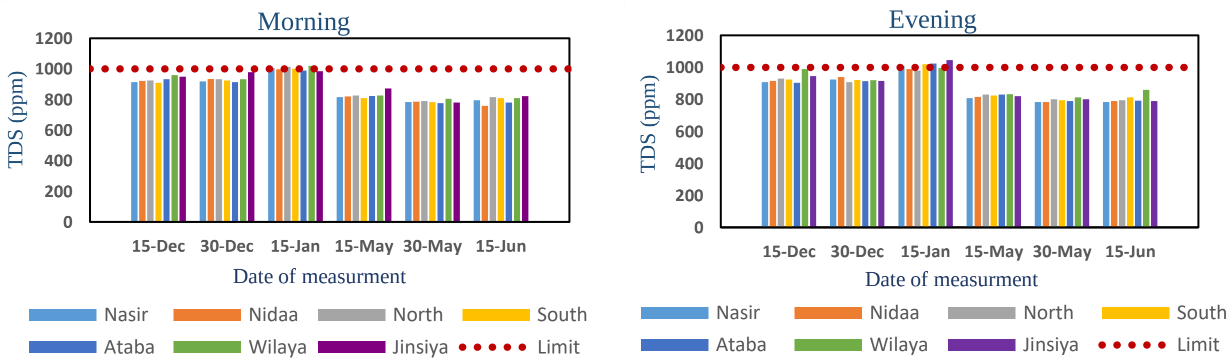


Figure 5. Values of the measured TDS in the morning and the evening from the 15th of December to the 15th of June.

3.2.3 Electrical conductivity

Results showed that EC values were close to the upper limit of (1500 µS/cm) during the winter, as specified by the IQS 417 and WHO guidelines. The main cause is the high value of TDS in water samples. Throughout the winter, EC values were near reaching the upper limit (1500 µS/cm). Measurements grew even more throughout January, reaching a maximum of 1520 µS/cm. EC levels were within the acceptable range during summer, with readings between 1100 and 1300 µS/cm. The measurements taken in the morning and the evening did not significantly differ from one another. The outcomes of the measurements are depicted in **Fig. 6**.

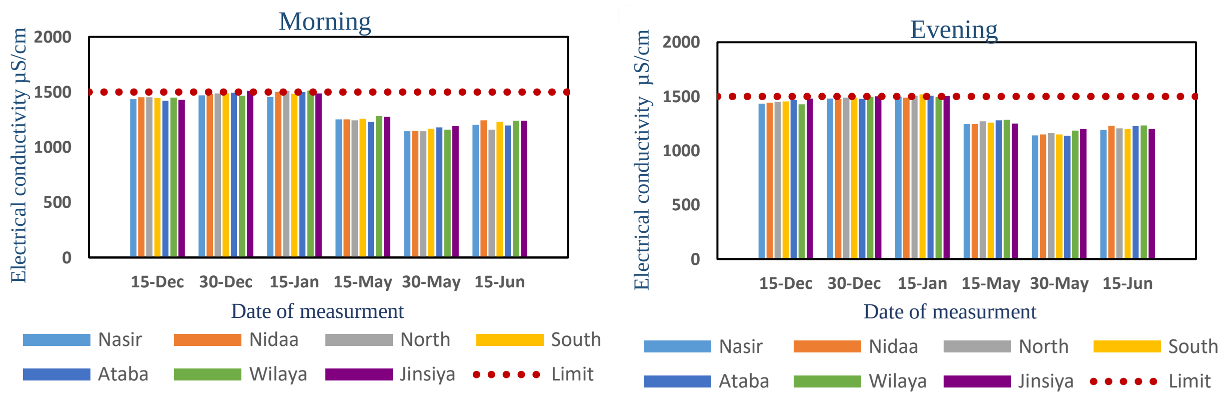


Figure 6. Values of EC measure in the morning and the evening from the 15th of December to the 15th of June.

3.2.4 Turbidity

The results of the turbidity measurement indicated that the water quality throughout the summer months was better, as the turbidity value was within the limit specified by IQS 417 and WHO (below 5 NTU). Even though the values were closer to the upper limit most of the time (4+), the lowest value recorded was 3.57 NTU in June. The turbidity levels, on the other hand, surpassed the upper limit in 29 of the total 42 samples tested throughout the winter season. The highest value achieved was 5.5 NTU, detected on the evening of December 30. **Fig. 7** shows the results of the measurements.

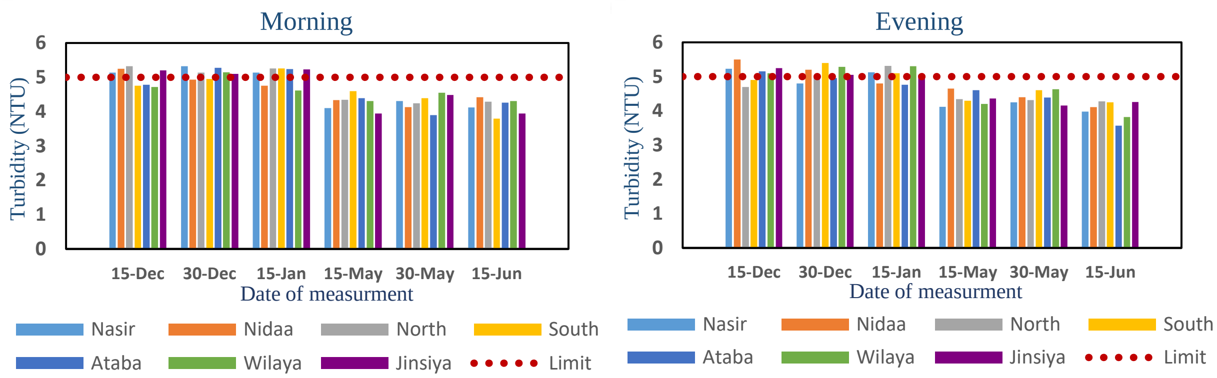


Figure 7. The Measured Turbidity values in the morning and evening from the 15th of December to the 15th of June.

3.2.5 Magnesium

Fig. 8 shows that the variation in magnesium concentration values throughout the winter period exceeded the summer period, with the highest recorded value being (62 ppm) in December. For the winter period, most samples recorded values higher than the (50 ppm) limit as per the (IQS 417) guidelines. The WHO guidelines do not limit magnesium concentrations in potable water. In summer, magnesium concentrations were within the limit with values ranging between (30-41) ppm in May and had a noticeable increase in June, where the values increased to be in the range of (35-48) ppm.

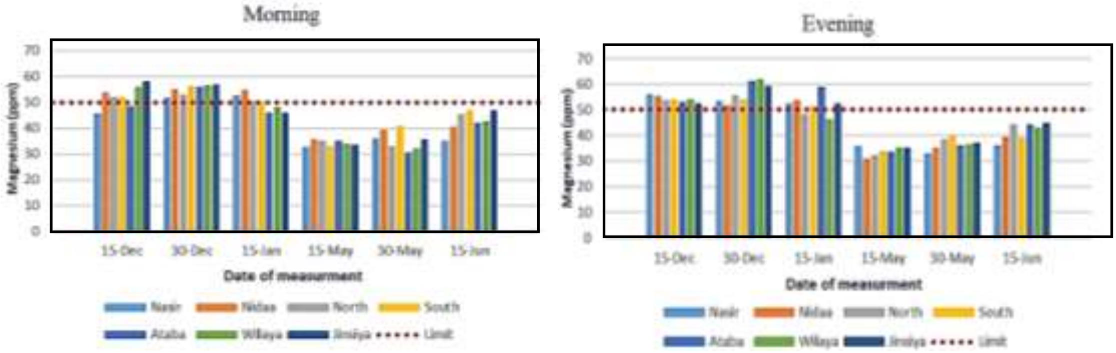


Figure 8. The measured values of Mg in the morning and evening from the 15th of December to the 15th of June.

3.2.6 Calcium

The results of calcium concentration measurements displayed in **Fig. 9** show that during the winter season, levels significantly exceed the maximum limit of (75 ppm) that is prescribed by the (IQS 417) guidelines. For the winter samples, concentrations fell in the region of (100-125) ppm. When looking at the concentrations that were measured on May 15th and May 30th (70-76) ppm, the results were quite close to falling inside the acceptable range. Once more, the concentrations were found to be too high in January, with levels ranging between 75 and 85 ppm. According to WHO, the calcium ion concentration in water must fall within the range of 100–300 mg/l to have a flavor that is agreeable to consumers.

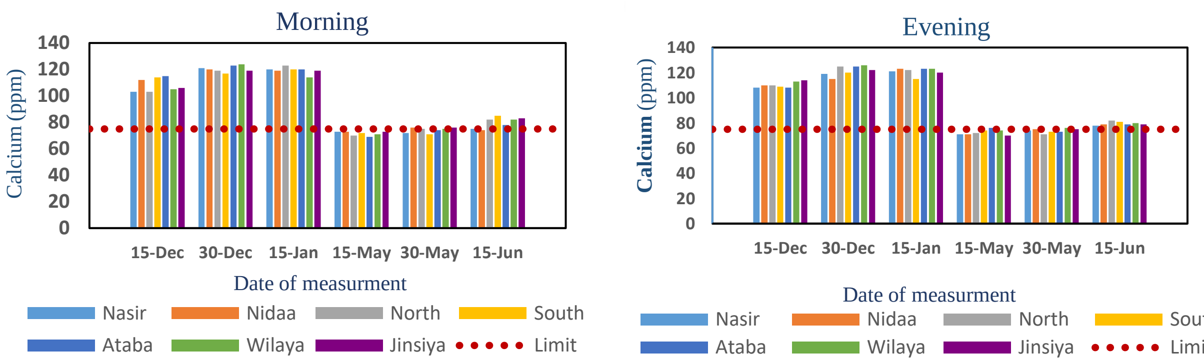


Figure 9. Values of calcium measured in the morning and evening from the 15th of December to the 15th of June.

3.2.7 Total Hardness

The water in the Najaf municipal potable water network has been shown to have a highly hard nature (with a total hardness value of more than 180). Values during the winter period were higher than the allowable limit of (500 ppm) for all samples except two. The (WHO) and the (IQS 417) both agree that the limit of total hardness that should be present in drinking water is 500 ppm. On the other side, the values that are recorded during the summertime are lower than the limit, with the highest observed value being (452 ppm). The high value of total hardness can be attributed, in part, to the water's high calcium and magnesium content. **Fig. 10** shows the recorded values

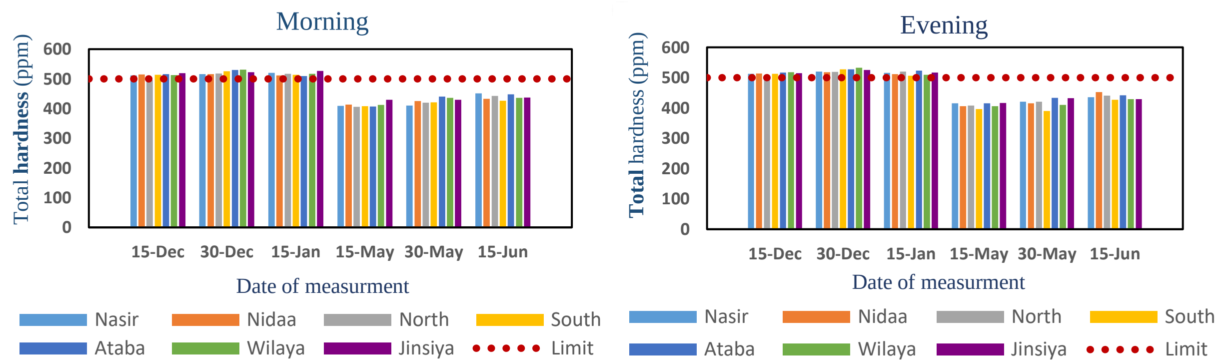


Figure 10. The measured values of total hardness in the morning and evening from the 15th of December to the 15th of June.

3.2.8 Alkalinity

Samples taken in the winter had higher alkalinity levels, reaching a maximum of 144 ppm, while the remaining values ranged from 125 to 140 ppm on the 30th of December and 115 to 130 ppm in January. The lowest figure ever measured for alkalinity was 98 ppm, which occurred during the summer season. Total alkalinity is not limited in any way by WHO or IQS criteria; nevertheless, it is required by a number of other international recommendations to fall within the range of (80-200) ppm, with a desire for a lower number. **Fig. 11** presents the recorded values of alkalinity.

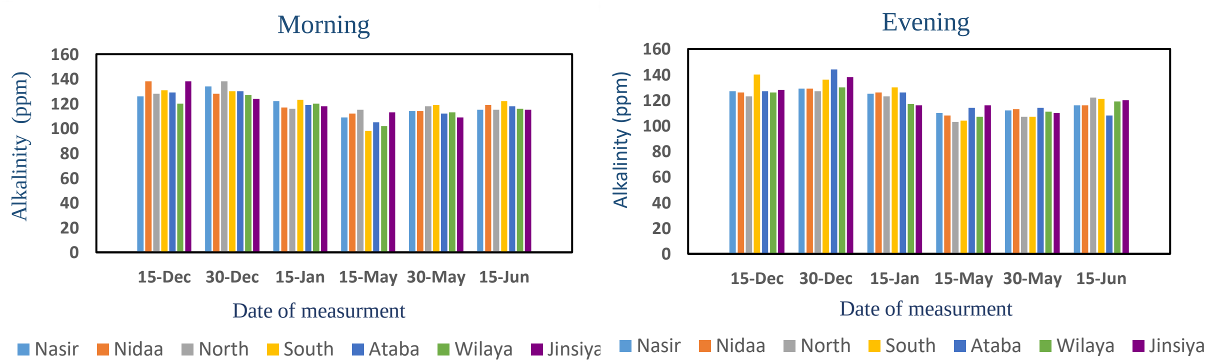


Figure 11. The measured values of alkalinity in the morning and evening from the 15th of December to the 15th of June.

3.2.9 Residual Chlorine

The results of the residual chlorine measurements shown in **Fig. 12** showed significant variance between samples examined in the morning and in the evening, in addition to differences between measurement days, which showed inconsistency in the results. These differences are shown in the figures. During the winter months, residual chlorine values are typically higher than during the summer months. Summer values were above the lower limit specified by WHO and IQS guidelines, which is 0.2mg/L, for most sampling points, with some values being over the upper limit, which is 0.5 mg/L as set by WHO and IQS 417 guidelines. Although some samples dropped below the minimum limit, especially during the evening and reaching 0 mg/L for Al-Wilaya main line on the 15th of May. Values ranged from 0.25 to 0.8 mg/L in winter for both morning and evening samples.
The difference in concentration between sampling points is due to multiple reasons that affect chlorine concentration directly, such as seasonal variation, as chlorine degradation in distribution networks is faster in summer periods **(Casas-Monroy et al., 2019)**. The differences in distance between the supplying point and the areas supplied since the same source point supplies all main lines, inconsistency of chlorine concentrations injected at the source due to injection system malfunctions or inefficient working staff at the station **(Rammadhan et al., 2016)**. Moreover, network pipes age and degradation over time, the presence of leakage and unauthorized connections, and the effect of water age on residual chlorine degradation during lower demand conditions. **(Alsaydalani, 2019; Geng et al., 2022).**

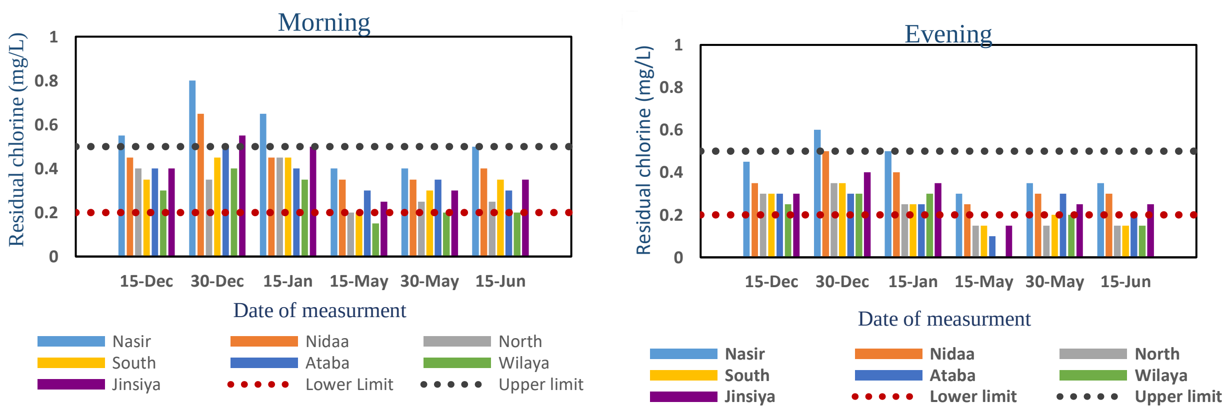


Figure 12. The measured values of residual chlorine in the morning and evening from the 15th of December to the 15th of June.

The difference in the measurements between sampling points for the two seasons is mainly due to the following reasons:
1- The difference in temperature between the two periods affects multiple parameters.
2- The possibility of water contamination due to the presence of pipe cracks.
3- The difference between raw water entering the treatment station.
4- Increased retention time during the winter contributes to quality deterioration.
5- The difference between the degree of water treatment in different periods.

3.3 WQI

The water quality index was applied for two sampling days, the 30th of December and the 30th of May. Average values were calculated for morning and evening measurements in **Table 4**.

Table 4. Average values of measurements taken in the morning and evening on the 30th of December and May.

	pH	TDS	EC	Turbidity	Mg	Ca	Total hardness	Residual chlorine
30th -Dec								
Nasir	7.19	921	1475	5.25	52.25	120	518	0.7
Nidaa	7.04	938	1480.5	5	53.45	117.5	517.5	0.575
North	7.06	927	1493	5.275	54.1	122.5	518	0.35
South	7.085	915	1488.5	5.34	54.8	118.5	526.5	0.4
Ataba	7.205	914	1485.5	5.12	58.5	124	531.5	0.4
Wilaya	7	924.5	1481.5	5.2	59.35	125	531	0.35
Jinsiya	7.1	974	1505	5.08	58	120.5	523	0.475
30th -May								
Nasir	7.155	784.5	1143	4.28	34.5	73	416	0.37
Nidaa	7.057	785	1149.5	4.265	37.15	75.5	422.5	0.325
North	7.11	788.5	1154	4.27	35.7	72.5	420.5	0.2
South	6.95	785.5	1158.5	4.51	40.4	72.5	405.5	0.25
Ataba	7.08	783	1159.5	4.14	33	73.56	437	0.325
Wilaya	7.01	808	1172	4.59	34	75	423	0.2
Jinsiya	7	790	1195	4.32	36.4	75.5	431	0.275

Table 5. Calculated quality rating scale values (*qi*).

	pH	TDS	EC	Turbidity	Mg	Ca	Total hardness	Residual chlorine
30th -Dec								
Nasir	84.55	92.1	97.35	105.0	104.5	159.60	103.6	140
Nidaa	82.79	91.8	98.60	100.0	106.9	156.28	103.5	115
North	83.03	92.7	99.43	105.50	108.2	162.93	103.6	70
South	83.32	91.5	99.13	106.8	109.6	157.61	105.3	80
Ataba	84.73	91.4	98.93	102.4	117.0	164.92	106.3	80
Wilaya	82.32	92.45	98.67	104.0	118.7	166.25	106.2	70
Jinsiya	83.50	97.4	100.23	101.6	116.0	160.27	104.6	95
30th -May								
Nasir	84.14	78.45	76.12	85.6	69.0	97.09	83.2	74
Nidaa	82.99	78.5	76.56	85.3	74.3	100.42	84.5	65
North	83.61	78.85	76.86	85.4	71.4	96.43	84.1	40
South	81.73	78.55	77.16	90.2	80.8	96.43	81.1	50
Ataba	83.26	78.3	77.22	82.8	66.0	97.83	87.4	65
Wilaya	82.44	80.8	78.06	91.8	68.0	99.75	84.6	40
Jinsiya	82.32	79.0	79.59	86.4	72.8	100.42	86.2	55

Then. The quality rating scale (q_i) is calculated for every parameter according to (IQS 417) guidelines, as shown in **Table 5** below. Moreover, **Table 6** demonstrates each parameter's sub-index (SIi) estimation.

Table 6. Estimation of component indices (SIi) for each parameter.

	pH	TDS	EC	Turbidity	Mg	Ca	Total hardness	Residual chlorine
30th -Dec								
Nasir	10.15	14.74	11.68	21.00	8.36	12.77	8.29	22.40
Nidaa	9.93	14.69	11.83	20.00	8.55	12.50	8.28	18.40
North	9.96	14.83	11.93	21.10	8.66	13.03	8.29	11.20
south	10.00	14.64	11.90	21.36	8.77	12.61	8.42	12.80
Ataba	10.17	14.62	11.87	20.48	9.36	13.19	8.50	12.80
Wilaya	9.88	14.79	11.84	20.80	9.50	13.30	8.50	11.20
Jinsiya	10.02	15.58	12.03	20.32	9.28	12.82	8.37	15.20
30th -May								
Nasir	10.10	12.55	9.13	17.12	5.52	7.77	6.66	11.84
Nidaa	9.96	12.56	9.19	17.06	5.94	8.03	6.76	10.40
North	10.03	12.62	9.22	17.08	5.71	7.71	6.73	6.40
south	9.81	12.57	9.26	18.04	6.46	7.71	6.49	8.00
Ataba	9.99	12.53	9.27	16.56	5.28	7.83	6.99	10.40
Wilaya	9.89	12.93	9.37	18.36	5.44	7.98	6.77	6.40
Jinsiya	9.88	12.64	9.55	17.28	5.82	8.03	6.90	8.80

The sum of sub-index estimations represents the calculated total WQI is given in **Table 7.**

Table 7. Summation of the component indices (WQI).

		WQI	Type of water
30th -Dec	Nasir	109.38	Poor water
	Nidaa	104.19	Poor water
	North	99.01	Good water
	south	100.49	Poor water
	Ataba	101.00	Poor water
	Wilaya	99.80	Good water
	Jinsiya	103.62	Poor water
30th -May	Nasir	80.69	Good water
	Nidaa	79.90	Good water
	North	75.51	Good water
	south	78.34	Good water
	Ataba	78.84	Good water
	Wilaya	77.14	Good water
	Jinsiya	78.90	Good water

4. CONCLUSIONS

Water quality tests showed that distributed water quality differed between winter and summer, with the summer period having better overall quality. During the winter, test results showed that the samples exceeded the maximum allowable limits for multiple parameters according to IQS 417 and WHO potable water guidelines. This led to categorising water in this period as poor water in the WQI. Residual chlorine tests showed significant variance between samples examined in the morning and the evening, in addition to differences between measurement days, which showed inconsistent results. The winter period had higher morning and evening sample concentrations ranging from 0.25 to 0.8 mg/l. While During summer, concentrations dropped below the allowable limit in multiple sampling points and days, where concentrations ranged between (0-0.5) mg/l and reached 0 mg/l for the Al-Wilaya main line on the 15th of May.

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