International Journal of Design & Nature and Ecodynamics
Vol. 20, No. 3, March, 2025, pp. 593-599
Journal homepage: http://iieta.org/journals/ijdne

Temporal Variation in Water Quality Assessment Using WQI Methods: A Case Study of Alhussein Water Treatment Plant in Karbala

Ali Hashim Yas[1], Hassanin Abd Ali Alfatlawy[1], Hayder Algretawee[1,2*]

[1] Civil Engineering Department, Engineering College, University of Kerbala, Karbala 56001, Iraq
[2] Water and Hydraulic Structures-Civil Engineering Department, University of Technology, Baghdad 10066, Iraq

Corresponding Author Email: hayder.h@uokerbala.edu.iq

https://doi.org/10.18280/ijdne.200314

Received: 17 September 2024
Revised: 28 February 2025
Accepted: 6 March 2025
Available online: 31 March 2025

Keywords:
water quality index, CCME, weighted arithmetic index, physical and chemical parameters, quality assurance, quality control, temporal variation, Karbala City

ABSTRACT

Surface water quality, particularly in rivers and lakes, has long been deteriorating due to various factors, including anthropogenic and natural activities. Herein, the Alhussein Water Treatment Plant is selected as a case study to assess the quality of treated water pumped to residents in Karbala City. The Weighted Arithmetic Index (WAI) method and the Canadian Council of Ministers of the Environment (CCME) method are used to calculate the Water Quality Index (WQI). The water quality and efficiency of the Alhussein Water Treatment Plant are assessed based on seven chemical and physical parameters: Total Dissolved Solids (TDS), pH, Turbidity, Sulphates (SO_4), Electrical Conductivity (EC), Chloride, and Total Hardness. Four measurement points were selected at different distances from the Alhussein Water Treatment Plant at three different times: 9 am, 1 pm, and 4 pm. Based on the current findings, regarding the measurement time in the early morning (9 am), water quality ranges from good to excellent. Generally, the water quality of the plant is acceptable and can be trusted for various uses, as the average WQI across all measurement sites is 74. This study recommends that investigating the specific sources of pollution is essential for devising targeted mitigation strategies, such as improving wastewater treatment and reducing industrial or agricultural runoff.

1. INTRODUCTION

Although water is an essential component of the ecosystem, the quality of surface water, especially in rivers and lakes, has long been declining due to various factors, including anthropogenic and natural activities [1]. Examples of human activities that strongly affect water quality include farming, mining, livestock production, and the generation and disposal of various types of waste into rivers and lakes without adequate treatment, such as industrial, agricultural, and municipal waste. Additionally, increased sediment runoff and soil erosion due to changes in land use [2-4] and rising heavy metal pollution [5] contribute to water degradation.

Recently, many nations, especially developing nations, have faced tremendous challenges in maintaining water quality levels that meet international standards when attempting to enhance the availability of drinking water in terms of quantity, quality, and cleanliness [6-9]. Even developed countries have been struggling to improve water quality, particularly regarding nutrient enrichment [10], and to enhance the supply of water and wastewater services to an increasing population [11].

The efficiency of a water treatment plant should be assessed by collecting and analyzing large datasets, including water samples collected from outside the plant. Many developed tools can be used to evaluate water quality; one of them is the water quality index (WQI) model. WQI models analyze a wide range of data, both temporally and spatially variation to obtain a single value. Thus, the water quality index can be considered a good indicator of the waterbody quality for surface and groundwater [12-15]. To determine the optimal location for water intake along a river, Bilgin [16] studied the water quality of the Coruh River using the CCME method, which showed that water quality varied between poor and fair. However, this study only used two parameters—sulphate and calcium—at four different measuring points to identify the best location for water intake along the river.

Many researchers focused on the calculation of the water quality index such as Majeed et al. [17] studied the effect of the Tharthar Canal system on the Tigris River relative to the quality of water by adopting a Canadian Water Quality Index (CCME-WQI). The study period was extended to one year. They selected seven parameters to evaluate water quality: temperature, Turbidity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), pH, Phosphate, and Nitrate (NO_3^-). The study concluded that the water quality varied between Tharthr Canal and Tigris River, however, some parameters showed good rank, but the others did not meet high standards of the water quality index. Another study mentioned the water quality of drinking water by selecting four quarters to gather potable water samples during a study period. This study adopted ten chemical parameters to analyze during statistical tests and used the water quality index CCME model. Their results were poor in all quarters [18]. Another study by Jha et al. [19] adopted the British Colombia water quality index through thirteen physical and chemical parameters in seven water treatment plants around the Tigris River in Baghdad. Their results mentioned that the Tigris River water quality was good rank with both raw and treated water. Al-Saadi et al. [20] conducted a study in 2021 using the Meireles water quality index to evaluate groundwater for irrigation purposes. They selected eighty-seven water wells to test chemical and physical parameters. Their results varied between high and severe restrictions for irrigation purposes.

The water quality index usually comprises four steps. First, choosing water quality parameters that be considered to affect the quality. The second step is to read the water quality data for each parameter that has been chosen and convert it to a dimensionless number known as a sub-index. Choosing a weighting factor for the chosen water quality metric is the third step. Fourth, the water quality index's final single value is determined by an aggregation process function that makes use of the sub-indices and weighting factor for the chosen water parameters [21].

Based on the above survey, this study highlights the need for a more comprehensive investigation into the underlying causes of fluctuating water quality at different times of the day. While the previous studies provide a useful assessment of water quality in various water treatment plants based on selected parameters, it does not delve deeply into the specific sources of pollution or the factors contributing to the degradation observed. Additionally, the focus on only some physical and chemical parameters may overlook other critical pollutants or environmental stressors affecting water quality. Therefore, this study aims to assess the water quality management of the Alhussein Water Treatment Plant in southern Karbala by selecting water samples from four sites and analyzing them based on seven physical and chemical parameters at three different periods.

2. STUDY AREA AND METHODOLOGY

Alhussein water treatment plant was selected as a case study to show the quality of water treated, which was pumped to different quarters in the south of Karbala City (Figure 1).

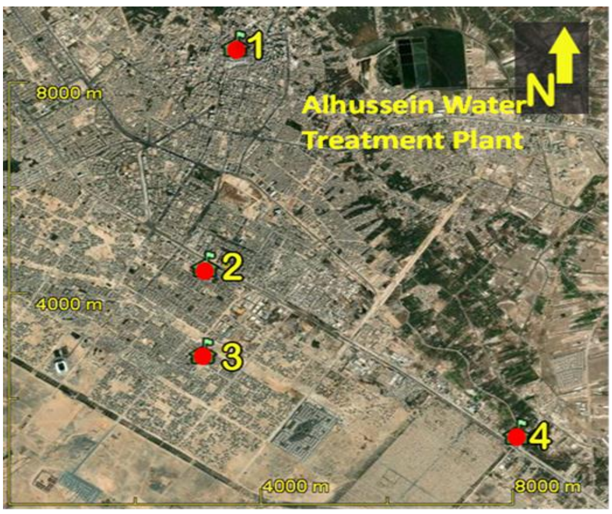

Figure 1. Study area

The water quality and finding efficiency of the Alhussein water treatment plant were studied by choosing seven chemical and physical parameters (pH, Turbidity, TDS, EC, sulfates such as SO_4, chloride, and total hardness). It was sampled on design to control variations in water quality related to peak and off-peak consumptions. Sampling time was determined because saline parameters and pH variations (acidity and alkalinity) have a vital effect on drastic water degradation. Peak hours were selected to reflect the highest water demand, inducing higher contamination levels and fluctuations of parameters, while off-peak hours were selected as a reference point. By applying such an approach, our study enables the identification of overall trends in water quality and the potential impact of water consumption intensity on key indicators. Four measured points were selected at different distances from the Alhussein water treatment plant (Figure 1). The process of choosing samples from the measuring points was selecting four measuring sites, where each measuring point was repeated three times during the day at 9 am, representing peak consumption, 1 pm, representing ordinary consumption, and 4 pm, representing low consumption. This data was collected during one week in May, which has approximately the same weather with a relatively high rate of temperature. Selecting measuring points places within the recent criteria in the literature, as the measuring time is considered the peak periods. To evaluate the water quality of the treated water pumping from Alhussein water treatment, the water quality index by using the CCME Canadian model and the Weighted Arithmetic Index method [22] was used to calculate WQI by using two methods.

2.1 Water quality index using the WQI formula

This model comprises three steps [21]:

i. Calculation of the unit weight (Wn) factors for each parameter using the relation: Wn = k/Sn

$$\text{k} = \frac{1}{{}^{1}/_{S1} + {}^{1}/_{S2} + {}^{1}/_{S3} + \cdots + {}^{1}/_{Sn}} = \frac{1}{\sum \text{Sn}} \tag{1}$$

Sn = Standard desirable value of the nth parameter.

On summation of all selected parameter unit weight factors, k = 1 (unity).

ii. Calculate the sub-index (Qn) value by using the formula:

$$\text{Qn} = \frac{[(Vn - Vo)]}{[(Sn - Vo)]} * 100 \tag{2}$$

where,

Vn = Mean concentration of the n^{th} parameters.

Sn = Standard desirable value of the n^{th} parameters.

Vo = Actual values of the parameters in Pure water (generally Vo = 0 for most parameters except pH).

$$\text{QpH} = \frac{[(VpH - 7)]}{[(8.5 - 7)]} * 100 \tag{3}$$

iii. Combining step (i) and step (ii), WQI is calculated as follows:

$$\text{Overall WQI} = \frac{\sum WnQn}{\sum Wn} \tag{4}$$

2.2 Water quality index using CCME

This method of water quality index was developed by ministers of the environment. This method contains guidelines for assessing water quality. Several water quality index methods have been developed and employed in water quality assessment, and the CCME water quality index is one of many methods. Many researchers from across the world have implemented the CCME water quality index. Like any other water quality index method, the purpose of CCME is to convert the water analytical data into a single data of value which will finally represent the overall water quality of an area study, however, before arriving at that single value data. In the CCME water quality index, we have to first calculate the value of these three elements: (F1) means scope, (F2) means frequency, and (F3) means amplitude. Thus, the formulas and steps for calculating CCME WQI are as follows:

1) Calculating the scope value (F1 value)

$$\mathrm{F1} = \frac{\text{Number of failed variables}}{\text{Total number of variables}} \times 100 \tag{5}$$

2) Calculating the frequency value (F2 value)

$$\mathrm{F2} = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \times 100 \tag{6}$$

3) Calculating the amplitude value (F3 value)

This step comprises three sub-steps:

i. When the test value must not exceed the objective:

$$\mathrm{Excursion}_i = \frac{\text{Failed test value}_i}{\text{Objective}_i} - 1 \tag{7}$$

Eq. (8) is used where the test value must remain above the objective:

$$\mathrm{Excursion}_i = \frac{\text{Objective}_i}{\text{Failed test value}_i} - 1 \tag{8}$$

ii. Calculation nse:

$$nse = \frac{\sum_{i=1}^{n} excursion_i}{Total\ number\ of\ tests} - 1 \tag{9}$$

iii. Calculation F3:

$$\mathrm{F3} = \frac{\mathrm{nse}}{0.01\mathrm{nse}+0.01} \tag{10}$$

Then calculate the water quality index:

$$\mathrm{CCME\ WQI} = 100 - \left[\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732}\right] \tag{11}$$

3. RESULTS AND DISCUSSION

3.1 Temporal and spatial variation analysis of WQI

By collecting the necessary data, two water quality index methods were achieved. This first method classifies the quality of water from Excellent to Unfit for consumption as shown in Table 1.

Table 1. WQI developed by Brown et al. [22]

Water Quality Index	Water Quality Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
> 100	Unfit for consumption

As mentioned above, measurements were recorded at three different times: 9 am, 1 pm, and 4 pm. The water quality index (WQI) was calculated (see Table 2) for individual sites as well as for all sites combined.

Table 2. The findings of measuring sites 1, 2, 3, and 4 and all sites

	Measuring Site 1	
Time	**WQI**	**Result**
9 am	27	Good
1 pm	77	Very poor
4 pm	39	Good
	Measuring Site 2	
9 am	29	Good
1 pm	72	Poor
4 pm	53	Poor
	Measuring Site 3	
9 am	43	Good
1 pm	75	Poor
4 pm	37	Good
	Measuring Site 4	
9 am	25	Excellent
1 pm	55	Poor
4 pm	39	Good
	All Measuring Sites	
Average	55	Poor

The results of this method were that water quality varied between very poor to excellent, however, most findings are within the standards at all measuring times within the four sites. In measuring site number one, water quality was good, but the quality of water was degraded to very poor at 1 pm. Similarly, water quality at measuring site number two dropped from good at 9 am to poor at both 1 pm and 4 pm. On the other side, water quality was improved at both measuring sites three and four, particularly at 4 pm with good quality. At measuring time 1 pm, water quality was poor to very poor degree of temperature at midday always higher than other times during the day and night. therefore, increasing the temperature of water always causes the degrading of water quality.

The effect of measuring time on the water quality index can be shown in Figures 2-5. The findings of this study highlight significant temporal and spatial variations in water quality across the four measuring sites, with results ranging from "very poor" to "excellent" depending on the time of measurement. Despite these fluctuations, it is noteworthy that the overall water quality remained within acceptable standards at all times, indicating that the water sources, although subject to some degradation, did not fall below regulatory safety thresholds.

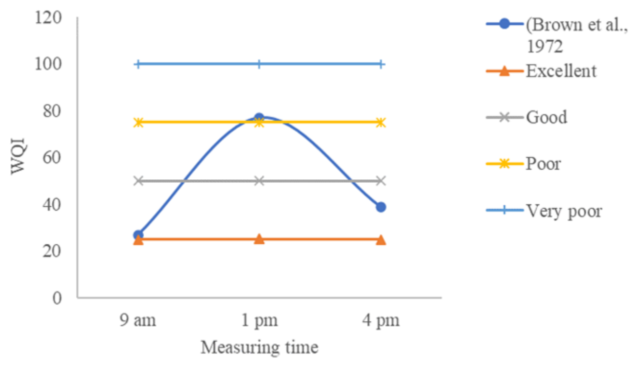

Figure 2. WQI for all times on measuring site number 1

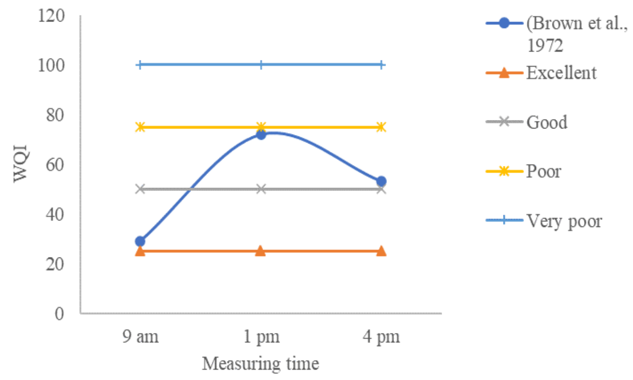

Figure 3. WQI for all times on measuring site number 2

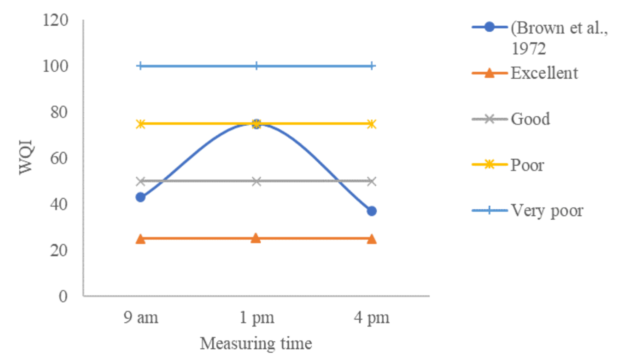

Figure 4. Water quality index for all times on measuring site number 3

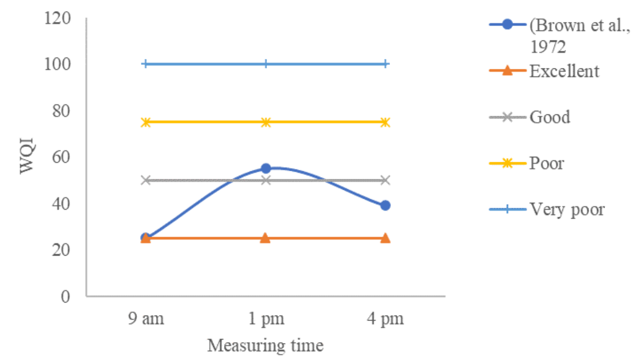

Figure 5. WQI for all times on measuring site number 4

We also measured water quality at the first measuring site; initially, it was "good," but by 1 pm, the result was "very poor." Such a degradation could have been a result of the following; human interference in the form of increased human traffic or other factors like runoff from agricultural and or industrial lands. The decline is just as well timed to be diurnal such that the higher temperatures when the process was probably active during the day or increased use of water accelerated this decline. An additional exploration of trends in the local land use and discharge volume might help understand this decrease even more, especially at around 12:00 local time.

Likewise, the evaluation of water quality at Site 2 showed a downward trend where it was rated 'good at 9 am' and 'poor at 1 pm' and 'poor at 4 pm.' This trend could explain the existence of permanent pollutants that are deposited or reach higher concentrations during the day. The progressive increase of the bad quality water at this site made the author suggest that pollution sources may be active during the time from activities of urban areas or avenues of transport. The decline in quality as a function of the time of day indicates some form of anthropogenic activity or other related natural occurrence such as evaporation and dilution capacity of the water body.

While water quality at measuring sites 3 and 4 have improved from the initial reading, the most favorable result was observed again at 4 pm. Such improvement could also be due to the natural biological systems that include an increase in aeration or dilution resulting from other factors such as tidal currents or changes in the water circulation. Or, it may recommend lower contributions of pollution inputs during the afternoon. These results are particularly encouraging as they indicate that under certain conditions, certain zones continue cleaning themselves and thus can be saved. Further research could concern the analysis of mechanisms that contribute to this improvement as such findings may be useful for optimizing WQM in similar conditions.

Fluctuations within the temporal scales in all the sites suggest that natural and man-made factors contribute significantly to the changes in watersheds and water ecosystems. The decline that was observed earlier in the day in some stations may be attributed to a higher intensity of industrial effluent discharge and/or enhanced agricultural soil erosion during working days. On the other hand, the increase at a later time may suggest that there is some degree of self-cleaning based on the finding that water bodies can occasionally recover depending on the level of pollution or human interference. The studies in diurnal patterns also indicate that temporal changes should be given more attention when doing water quality measurements as the results obtained from the samples at different times of the day are quite different. The observed fluctuations also pointed to the need for constant surveillance as well as the use of timely data to facilitate the proper evaluation of water quality and determine if there is a need for interference during a certain period.

Consequently, the results indicate a strong importance on the site-specific and temporal basis of the water quality interventions that require specific attention. In some areas such as Measuring Site 1, there was evidence of a very high decline in the quality of the water, and measures such as increased regulation of sources of pollutants, increased wastewater treatment, or better control and management of stormwater may be needed to help arrest the decline of quality of water in the area. Conversely, the improvement observed at measuring Sites 3 and 4 suggests that natural or engineered interventions that enhance water body resilience could be explored and potentially replicated in more vulnerable areas.

These findings will be of great help in improving the operation and management of water treatment plants. Hence, by determining the significant factors responsible for variations in water quality, the treatment processes can be fine-tuned for better efficiency, especially during the cycles of high consumption when degradation threats are at their maximum. Moreover, the outcomes of this study could be used as a guide for similar facilities around the world to adopt proactive measures like adaptive treatment strategies and online monitors for overall water quality management and sustainable water supply systems.

3.2 WQI evaluation using the CCME method

This method comprises five categories to describe the water quality (Table 3). The findings of this method were similar to the method used by Brown et al. [22]. All results of this method are shown in Table 4.

Table 3. Details of water quality index

WQI Number	Ranking	Specification
95-100	Excellent	Water quality (WQ) is assured with no significant threat; water condition is close to natural and pristine levels.
80-94	Good	WQ is assured with a minor level of threat; water conditions are always within the expected level.
65-79	Fair	WQ is usually ensured but sometimes impaired or threatened; water quality is sometimes not up to the desired levels.
45-64	Marginal	WQ is often impaired or threatened; water conditions often deviate from desirable or natural levels.
0-44	Poor	WQ is always impaired or threatened, and water conditions are always far from the natural/desirable levels.

Table 4. Results of measuring points 1, 2, 3, and 4 and all sites

	Measuring Site 1	
Time	**WQI**	**Result**
9 am	82	Good
1 pm	85	Good
4 pm	86	Good
All times	82	Good
	Measuring Site 2	
9 am	82	Good
1 pm	85	Good
4 pm	72	Fair
All times	75	Fair
	Measuring Site 3	
9 am	82	Good
1 pm	84	Good
4 pm	81	Fair
All times	75	Fair
	Measuring Site 4	
9 am	72	Fair
1 pm	83	Good
4 pm	71	Fair
All times	71	Fair
	All Measuring Sites	
Average	74	Fair

The effect of measuring time on the water quality index can be shown in Figures 6, 7, 8, and 9.

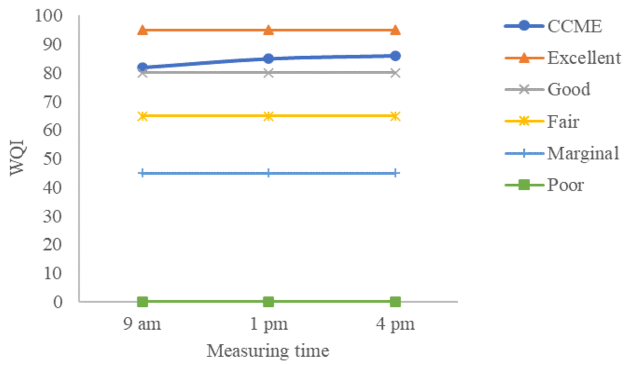

Figure 6. WQI for all times on measuring site number 1

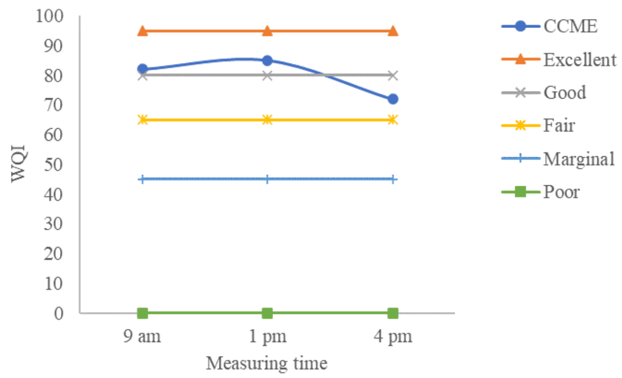

Figure 7. WQI for all times on measuring site number 2

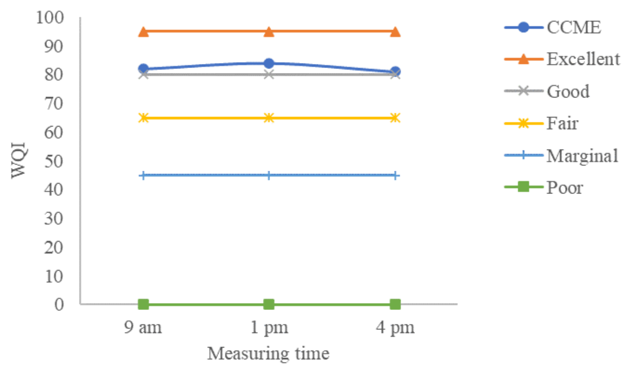

Figure 8. WQI for all times on measuring site number 3

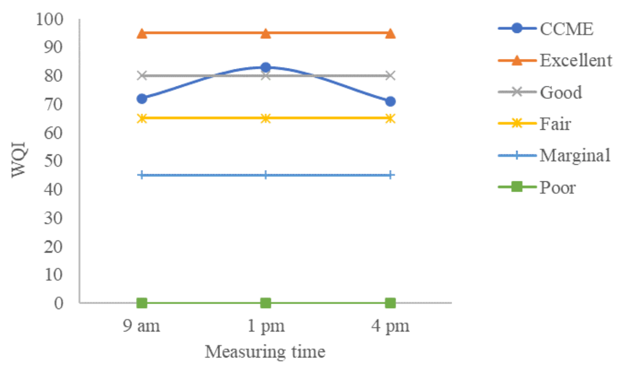

Figure 9. WQI for all times on measuring site number 4

The WQI evaluation using the CCME method for four different measuring sites reveals varying levels of water quality across different times of the day. At measuring site 1, the WQI consistently falls within the "Good" category (ranging from 82 to 86), indicating that the WQ is mostly protected with minimal levels of threat, and water conditions are mostly within the desirable level. This suggests that site 1 experiences minimal water quality issues and remains close to optimal conditions throughout the day.

In contrast, measuring sites 2, 3, and 4 show more fluctuation in water quality. For site 2, while the WQI is "Good" during the earlier hours (82 and 85 at 9 am and 1 pm), it drops to "Fair" (72) in the late afternoon. This decline points to occasional threats or impairments that may be time-dependent, potentially linked to specific daily activities or environmental factors that cause the water quality to depart from its desirable level later in the day. The overall rating for site 2 is "Fair," with an average WQI of 75, reinforcing that while the water quality is usually protected, there are periods of impairment.

Similarly, at measuring site 3, the WQI shows a slight decline from "Good" (82 and 84) to "Fair" (81) later in the day, which mirrors the trend observed at site 2. The average WQI for site 3 is also in the "Fair" category, suggesting that site 3 experiences intermittent threats to water quality throughout the day. By discussing these findings, water quality was good at most measuring times during all measuring points, however, the water quality at measuring time at 4 pm was less than at other times because increasing of water temperature which negatively affects the water quality.

Measuring site 4 presents the most variability, with a WQI of 72 (Fair) in the morning, an improvement to 83 (Good) at 1 pm, followed by a decline to 71 (Fair) later in the day. The consistent fluctuation in WQI, resulting in an overall "Fair" rating, indicates that water quality at site 4 is frequently threatened, with conditions often departing from desirable levels.

The average WQI across all measuring sites is 74, placing the overall water quality in the "Fair" category. This implies that though there is a check on Water Quality in most of the sites, there is periodical vulnerability or momentary threats to sites occasionally. There are still variations of 'Good' and 'Fair' predictability that may indicate environment or anthropogenic-induced pollution of water sources during some times of the day which might be the basic reasons for the need for constant monitoring and intervention on these sites to enhance predictability and water quality. These findings will give management and operation staff the precise temporal and spatial case that is needed to develop the water quality at the worst measurement point/s.

4. CONCLUSIONS

The water quality of the Alhussein water treatment plant was assessed three times a day in this study using two water quality indices: The WQI model by Brown et al. [22] and the CCME WQI method. The data analysis designated conspicuous changes in the quality of the water samples throughout observation with the ratio of quality ranging from excellent to poor depending on the time of sampling. The water was generally good in the morning around 9 am while in the middle of the day around 1 pm, the quality of the water had slightly reduced and was poor or very poor in the various areas. Although the water quality significantly rose in the evening to classes ranging from good to fairly good by 4:00 pm, they point to specific variations that may be associated with existent environmental factors like enhanced people interference, runoff or effused industrial pollutants during the high traffic period. However, analyzing the results obtained in the process of research of the Alhussein treatment plant water showed that its overall quality is rather acceptable for domestic use, although certain fluctuations in the content of most of the analyzed sites proved to be rather self-resistant and capable of self-recovery, provided certain optimize conditions were created for it. Study results are water quality is good at the morning and then gradually degraded during the rest hours till night. therefore, treatment staff should improve it at these critical points, and another treatment plant should investigate the water quality at the mentioned spatial and temporal parameters.

Based on the research presented in this paper, several recommendations of what needs to be done in the future can be made to improve water quality management and monitoring. First, a method of real-time monitoring of water quality at least in the river section with increased contamination rates should be used to monitor fluctuations in water quality at different times of the day and seasons. This would afford a much better picture of the temporal shifts and enable early interventions to be made as soon as possible. Second, collecting broader information about certain sources of pollution and more notably at the time of the most rapid degradation would be crucial to developing proper measures, for instance, enhancing wastewater treatment, minimizing industrial or agricultural discharges, etc. Finally, more studies on the remediation processes found in some treatment plants could help in the fabrication of similar techniques that could be applied to more sensitive treatment plants to improve the amount of water quality as well as the sustainability of the treatment work. Based on the results and conclusions of this study, we recommend choosing a similar water treatment plant in another governorate and checking water quality at the same temporal and spatial factors.

REFERENCES

[1] Algretawee, H., Alshama, G. (2021). Modeling of evapotranspiration (ETo) in a medium urban park within a megacity by using artificial neural network (ANN) model. Periodica Polytechnica Civil Engineering, 65(4): 1260-1268. https://doi.org/10.3311/PPci.18187

[2] Lobato, T.C., Hauser-Davis, R.A., Oliveira, T.F., Silveira, A.M., Silva, H.A.N., Tavares, M.R.M., Saraiva, A.C.F. (2015). Construction of a novel water quality index and quality indicator for reservoir water quality evaluation: A case study in the Amazon region. Journal of Hydrology, 522: 674-683. https://doi.org/10.1016/j.jhydrol.2015.01.021

[3] Alshammari, M., Al Juboury, M.F., Al-Gretawee, H.H. (2020). A comparison of two methods of the environmental treatment for water wells: Case study in Kufa City-Iraq. IOP Conference Series: Materials Science and Engineering, 871(1): 012008. https://doi.org/10.1088/1757-899X/871/1/012008

[4] Al-Shammari, M.H.J., Algretawee, H., Al-Aboodi, A.H. (2020). Using eight crops to show the correlation between paucity irrigation and yield reduction of Al-

Hussainiyah irrigation project in Karbala, Iraq. Journal of Engineering, 2020(1): 4672843. https://doi.org/10.1155/2020/4672843
[5] Sánchez, E., Colmenarejo, M.F., Vicente, J., Rubio, A., García, M.G., Travieso, L., Borja, R. (2007). Use of the water quality index and dissolved oxygen deficit as simple indicators of watersheds pollution. Ecological Indicators, 7(2): 315-328. https://doi.org/10.1016/j.ecolind.2006.02.005
[6] Carvalho, L., Cortes, R., Bordalo, A.A. (2011). Evaluation of the ecological status of an impaired watershed by using a multi-index approach. Environmental Monitoring and Assessment, 174: 493-508. https://doi.org/10.1007/s10661-010-1473-9
[7] Debels, P., Figueroa, R., Urrutia, R., Barra, R., Niell, X. (2005). Evaluation of water quality in the Chillán River (Central Chile) using physicochemical parameters and a modified water quality index. Environmental Monitoring and Assessment, 110: 301-322. https://doi.org/10.1007/s10661-005-8064-1
[8] Kannel, P.R., Lee, S., Lee, Y.S., Kanel, S.R., Khan, S.P. (2007). Application of water quality indices and dissolved oxygen as indicators for river water classification and urban impact assessment. Environmental Monitoring and Assessment, 132: 93-110. https://doi.org/10.1007/s10661-006-9505-1
[9] Ortega, D.J., Pérez, D.A., Américo, J.H., De Carvalho, S.L., Segovia, J.A. (2016). Development of index of resilience for surface water in watersheds. Journal of Urban and Environmental Engineering, 10(1): 72-82. https://doi.org/10.4090/juee.2016.v10n1.007282
[10] Gitau, M. W., Chen, J., Ma, Z. (2016). Water quality indices as tools for decision making and management. Water Resources Management, 30: 2591-2610. https://doi.org/10.1007/s11269-016-1311-0
[11] Algretawee, H., Rayburg, S., Neave, M. (2023). Investigating the effect of spatiotemporal, wind speed and wind direction on precipitation magnitudes within an urban area. Water Science & Technology, 87(10): 2474-2489. https://doi.org/10.2166/wst.2023.141
[12] Rasooly, S.S., Anwer, M. (2023). Assessment of Drinking water quality and the efficiency of the two water treatment plants in UP, India. Journal of Mechanical, Civil and Industrial Engineering, 4(1): 1-8. https://doi.org/10.32996/jmcie
[13] Pant, M., Purohit, V. (2019). A tap water quality assessment of seven places in Dehradun. International Journal of Engineering Research and Technology, 8(5): 655-658.
[14] Mangi, S.A., Sohu, S., Soomro, F.A., Abdullah, A.H., Nagapan, S. (2017). Assessment of Physicochemical parameters for the drinking water quality in the vicinity of Nawabshah City, Sindh, Pakistan. Engineering Science and Technology International Research Journal, 1(1): 10-14.
[15] Pawari, M.J., Gawande, S.M. (2017). Assessment of water quality parameters: A review. International Journal of Engineering Research, 6(3): 1427-1431. https://www.ijsr.net/archive/v4i7/SUB156716.pdf.
[16] Bilgin, A. (2018). Evaluation of surface water quality by using Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) method and discriminant analysis method: A case study Coruh River Basin. Environmental Monitoring and Assessment, 190: 554. https://doi.org/10.1007/s10661-018-6927-5
[17] Majeed, O.S., Nashaat, M.R., Al-Azawi, A.J.M., Drira, Z. (2023). Application of the Canadian water quality index (CCME-WQI) for aquatic life to assess the effect of Tharthar water upon the quality of the Tigris water, northern Baghdad City, Iraq. Ibn Al-Haitham Journal for Pure and Applied Sciences, 36(4): 21-31.
[18] Eassa, A.M., Mahmood, A.A. (2012). An assessment of the treated water quality for some drinking water supplies at Basrah. Journal of Basrah Researches (Sciences), 38(3): 95-105.
[19] Jha, D.K., Devi, M.P., Vidyalakshmi, R., Brindha, B., Vinithkumar, N.V., Kirubagaran, R. (2015). Water quality assessment using water quality index and geographical information system methods in the coastal waters of Andaman Sea, India. Marine Pollution Bulletin, 100(1): 555-561. https://doi.org/10.1016/j.marpolbul.2015.08.032
[20] Al-Saadi, R.J.M., Mutasher, A.K.A., Al-Awadi, A.T. (2021). New regression model for estimating irrigation water quality index. International Journal of Design & Nature and Ecodynamics, 16(2): 127-134. https://doi.org/10.18280/ijdne.160202
[21] Sun, W., Xia, C., Xu, M., Guo, J., Sun, G. (2016). Application of modified water quality indices as indicators to assess the spatial and temporal trends of water quality in the Dongjiang River. Ecological Indicators, 66: 306-312. https://doi.org/10.1016/j.ecolind.2016.01.054
[22] Brown, R.M., McClelland, N.I., Deininger, R.A., Tozer, R.G. (1970). A water quality index-do we dare. Water and Sewage Works, 117(10): 339-343.

NOMENCLATURE

WQI	Water quality index
CCME	Canadian Council of Ministers of the Environment
TDS	Total dissolved solids
pH	Potential of Hydrogen
SO_4	Sulphate
EC	Electricity Conductivity
DO	Dissolved Oxygen
NO_3^-	Nitrate