






Spatial–Temporal Water Quality Assessment of the Al-Gharraf River (Southern Iraq) Using the Arithmetic Weighted Water Quality Index During 2024–2025

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ABSTRACT

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Al-Gharraf River, Arithmetic Weighted Water Quality Index, Iraq, nutrients, spatial–temporal variation, water pollution, water quality assessment, Water Quality Index

The Al-Gharraf River is a vital water resource in southern Iraq, particularly in Wasit and Dhi-Qar Governorates, supporting domestic and agricultural uses. This study aims to comprehensively assess the spatiotemporal variations of water quality in the Al-Gharraf River using the Arithmetic Weighted Water Quality Index (AW-WQI) for drinking purposes during December 2024 to November 2025. A total of 240 water samples were collected from 20 monitoring stations along the river through monthly sampling over one year. The AW-WQI was calculated based on key physicochemical and biological parameters, including pH, total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD₅), sulfate (SO₄²⁻), nitrate (NO₃⁻), phosphate (PO₄³⁻), and lead (Pb²⁺), using standard limits adopted from Iraqi and international guidelines (WHO and USEPA). The results revealed significant spatial and temporal variations in water quality. Water quality was generally good in upstream sections during periods of higher discharge (AW-WQI: 25–50), while it deteriorated during the dry season in downstream areas, exceeding 100 and reaching a maximum of 338 at Al-Nasr station in November. This deterioration was strongly associated with reduced river discharge and increased pollutant loads from untreated domestic wastewater, agricultural runoff, industrial effluents, and fish-farming activities.

1. INTRODUCTION

Surface water is a renewable resource continuously replenished through the hydrological cycle; however, human activities such as excessive abstraction, pollution, and land-use changes can significantly degrade its quality and accessibility [1, 2]. The quality of freshwater is crucial for determining its suitability for various uses and for maintaining the health of associated ecosystems [3]. Contamination from stormwater runoff, agricultural practices, industrial effluents, and untreated domestic wastewater poses a major threat to surface water systems, adversely affecting both human health and aquatic environments [4, 5]. Moreover, increasing pressures resulting from population increase, climatic variability, and competing water demands further exacerbate water quality deterioration [6].

The Al-Gharraf River is one of the most crucial water resources in southern Iraq, particularly in Wasit and Dhi-Qar Governorates. It originates from the Kut Barrage and traverses southwest between the Tigris and Euphrates Rivers over a distance of approximately 230 km until it reaches the marshes of Nasiriyah [7]. Along its course, the river passes through many urban and agricultural regions, such as Al-Mufaqqiyah, Al-Hayy, Al-Fajr, Qalat Sukkar, Al-Rifai, and Al-Nasr, which expose it to multiple sources of pollution and hydrological alterations (Figure 1) [7].

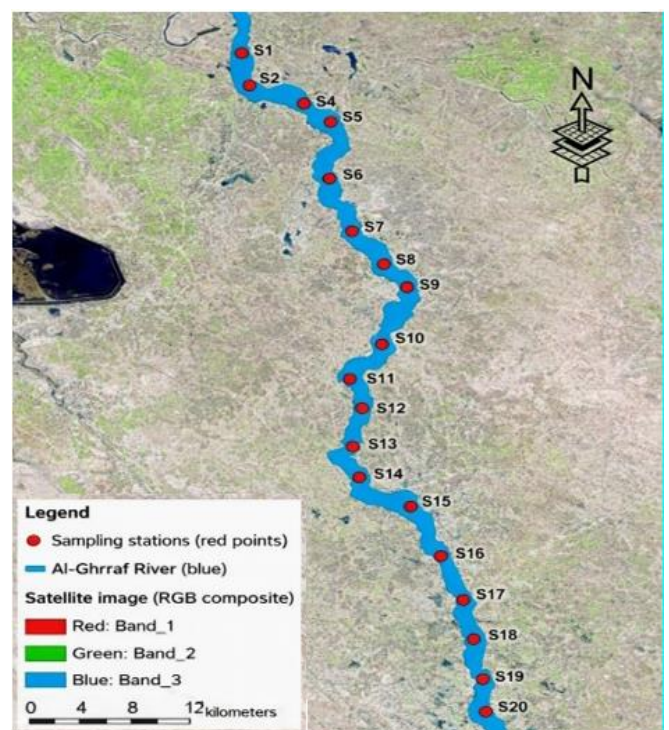


Figure 1. Al-Gharraf River and sampling locations

Prior research on the Al-Gharraf River can be broadly classified into two main categories: hydrological and hydraulic investigations, and water quality and pollution studies. Hydrological and hydraulic studies have focused on flow characteristics, discharge behavior, and river modeling. Daham et al. [8] simulated the upper section of the Al-Gharraf River using one- and two-dimensional HEC-RAS models and demonstrated that the two-dimensional model offers a more accurate representation of water levels and flow velocities. Additional research has examined the hydrological characteristics of the river, highlighting the relationships between discharge, water levels, and basin properties, as well as the influence of hydraulic structures on river regulation [9].

Conversely, water quality and pollution studies have investigated the physicochemical and biological properties of the river. Hamza [10] reported increasing salinity and pollutant concentrations over time, indicating a progressive decline in water quality. Al-Seedi and Al-Aubody [11] determined that the river water could be suitable for certain uses under specific conditions. However, Al-Mayah and Al-Azzawi [12] emphasized substantial water quality deterioration, particularly during low-flow periods, due to untreated domestic wastewater, agricultural runoff, and industrial discharges. Additionally, Jabbar [7] investigated the effects of wastewater discharge on the Al-Gharraf River within the Al-Hayy district, demonstrating significant variations in the physical, chemical, and bacteriological characteristics of the river. Furthermore, research using the Water Quality Index (WQI) indicated that water quality in several sections of the river is frequently classified as poor or unsuitable for drinking [13, 14].

Despite these efforts, there remains a need for a comprehensive assessment that integrates spatial and temporal changes in water quality via a unified and systematic approach. The current study aims to evaluate the spatial and temporal variation of water quality in the Al-Gharraf River using the Arithmetic Weighted Water Quality Index (AW-WQI) for drinking water assessment. In addition, the study aims to identify the main sources of pollution and evaluate the combined effects of anthropogenic activities and hydrological conditions on water quality, with the aim of supporting effective water resource management and promoting river sustainability.

2. MATERIALS AND METHODS

Water samples were collected monthly from 20 monitoring stations along the Al-Gharraf River throughout a one-year period from December 2024 to November 2025. A cumulative total of 240 samples was obtained (20 stations × 12 months). At each location, one sample was collected per month, and no field or laboratory replication was performed. This sampling design allowed for capturing spatial and temporal fluctuations in water quality under both low-flow (dry season) and high-flow (rainy season) conditions. The locations and geographic coordinates of all sampling stations are listed in Table 1.

In addition to the sampling design, water samples were obtained from depths ranging between 15 and 25 cm below the water surface using pre-cleaned polyethylene bottles to avoid contamination. For dissolved oxygen (DO) analysis, Winkler glass bottles (125 mL capacity) were used to ensure precise preservation. Immediately after collection, samples were tightly sealed and stored in a chilled container with crushed ice,

then transported to the laboratory for subsequent analysis.

The water quality assessment was predicated on nine principal physicochemical parameters, including pH, total dissolved solids (TDS), total suspended solids (TSS), DO, biochemical oxygen demand (BOD₅), sulfate (SO₄²⁻), nitrate (NO₃⁻), phosphate (PO₄³⁻), and lead (Pb²⁺).

Table 1. Sampling stations and their geographic coordinates

Station No.	Name of Station	Longitude (E)	Latitude (N)
St.1	Ent. Kut	45.810	32.503
St.2	End Kut	45.843	32.419
St.3	Ent. Al-Mwafaqya	45.920	32.393
St.4	End Al-Mwafaqya	45.930	32.302
St.5	Ent. Al-Hayy	45.955	32.220
St.6	Mid Al-Hayy	46.032	32.156
St.7	End Al-Hayy	46.001	32.090
St.8	Ent. Al-Fajr	45.969	31.989
St.9	End Al-Fajr	45.972	31.901
St.10	Ent. Qalat Sukar	46.055	31.865
St.11	End Qalat Sukar	46.090	31.788
St.12	Ent. Al-Rifai	46.090	31.702
St.13	Mid. Al Rifai	46.099	31.657
St.14	End Al-Rifai	46.107	31.611
St.15	Ent. Al Naser	46.122	31.522
St.16	Mid Al-Naser	46.145	31.482
St.17	End Al-Naser	46.164	31.451
St.18	Ent. Al Shatrah	46.196	31.390
St.19	Mid Al-Shatrah	46.213	31.321
St.20	End Al-Shatrah	46.220	31.228



Figure 2. Field sampling procedure

pH, DO, and TDS were determined in situ using calibrated field instruments. TSS was determined using the gravimetric method, while sulfate, nitrate, and phosphate were analyzed according to standard laboratory protocols established by the study [15]. Lead (Pb²⁺) concentrations were measured using standard analytical techniques. BOD₅ was determined based on DO depletion after incubation at 20 °C for five days in accordance with the study [15]. The overall field sampling procedure, preservation of the sample, and in-situ

measurements are illustrated in shown Figure 2, which presents sample preparation, field collecting, and measurement processes. A comprehensive quality assurance and quality control (QA/QC) protocol was implemented throughout the study to ensure the reliability and accuracy of the analytical results. All field instruments employed for in-situ measurements (pH, DO, and TDS) were calibrated prior to each sampling campaign according to the manufacturer's specifications. Laboratory analyses were conducted in accordance with standard methodologies [15]. Field and laboratory blanks were employed to identify potential contamination during sampling and analysis. Samples were analyzed in duplicate to assess analytical precision. The method detection limits (MDL) for all parameters were taken into account during analysis, and all measured concentrations were above the detection limits. Analytical precision was evaluated through relative standard deviation (RSD), which remained within acceptable limits (typically below 10%). All procedures were carried out under regulated laboratory conditions to ensure consistency and reproducibility of the results.

To evaluate overall water quality, the AW-WQI was applied, which integrates multiple parameters into a singular dimensionless number, as proposed by Brown et al. [16] and further developed in subsequent studies [14, 17]. Similar approaches have also been used by studies [5, 18-20]. The standard allowable values (V_s) and ideal values (V_i) used in the WQI calculations were approved from the recommended Iraqi and international water quality standards presented in Table 2. The standard permissible values (V_s) were adopted from Iraqi water quality standards (ICS No. 417/2001) and supplemented by relevant international guidelines (WHO and USEPA) where necessary. The standard permissible value (V_s) for DO is established at 5 mg/L according to Iraqi and international water quality standards. The optimal value (V_i) was established at 14 mg/L, denoting the theoretical saturation concentration of DO in water under standard conditions. This value has been extensively utilized in traditional WQI formulations to establish a reliable benchmark for assessing oxygen deviation.

Table 2. Recommended Iraqi and international standards for the water quality parameter

Water Quality Parameters	Unit	V Standard for Water Uses	V Ideal
pH	-	6.5–8.5*	7
TDS	mg/L	1000*	0
TSS	mg/L	25*	0
DO	mg/L	>5*	14
BOD5	mg/L	<5*	0
SO ₄	mg/L	250*	0
NO ₃ ⁻	mg/L	45*	0
PO ₄	mg/L	0.4*	0
Pb	ppm	0.01*	0

- Unknown Criteria.

*Iraqi Criteria and Standards of water's chemical limits, ICS:13.060.20 number 417/2001, first update 2001.

It is recognized that actual DO saturation levels in natural waters, especially in high-temperature areas, may be inferior to this theoretical value. The application of $V_i = 14$ mg/L guarantees alignment with recognized WQI methodologies and facilitates comparative analysis across various studies. For parameters included in the drinking water assessment, the corresponding drinking-water standards were used. For

parameters such as pH and DO, ideal values were taken as 7 and 14 mg/L, respectively, while for the remaining parameters, the ideal value was assumed to be zero. The water quality classification according to the WQI scale is shown in Table 3.

Table 3. Water Quality Index (WQI) scale for drinking water [14]

Water Quality Scale	Quality of Water
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very poor
100 and above	Unsuitable for drinking

The WQI was calculated using the following equations, adopted from [14, 16]:

$$WQI = \sum(Q_i \times W_i) / \sum W_i \quad (1)$$

where,

WQI is the overall Water Quality Index.

Q_i is the quality rating of the i^{th} water quality parameter.

W_i is the relative weight of the i^{th} water quality parameter.

Σ is the Summation of all selected water quality parameters.

$$Q_i = 100 (V_m - V_i) / (V_s - V_i) \quad (2)$$

where,

Q_i is the quality rating of the i^{th} parameter.

V_m is the measured value of the water quality parameter obtained from laboratory analysis.

V_i is the ideal value of the parameter.

V_s is the standard permissible value of the parameter according to WHO guidelines.

$$W_i = (1/V_s) \quad (3)$$

where,

W_i is the relative weight of the i^{th} water quality parameter.

V_s is the standard permissible value of the i^{th} parameter according to WHO guidelines.

3. RESULTS

The AW-WQI values, calculated by nine physicochemical parameters, demonstrate significant spatial and temporal heterogeneity in water quality along the Al-Gharraf River. For clarity, the detailed monthly datasets are included in the Supplementary Material, while the main text summarizes the dominant patterns and key observations.

A heatmap of AW-WQI values was created in order to offer a thorough visualization of these temporal and spatial variations (Figure 3). The detailed monthly AW-WQI values for all monitoring stations are presented in Tables A1-A12 in the Appendix. The months of the study period are displayed along the horizontal axis in this representation, and monitoring stations are positioned along the vertical axis. The water quality classification, which ranges from good to unsuitable conditions, is reflected in the color gradient. The heatmap clearly illustrates the increasing decline in water quality from upstream to downstream stations, as well as the significant rise in AW-WQI values during the dry season.

Station	Name	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
St.1	Ent. Kut	Good	Good	Good	Good	Good	Good	Poor	Poor	Very Poor	Very Poor	Poor	Very Poor
St.2	End Kut	Unsuitable	Very Poor	Very Poor	Poor	Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.3	Ent. Al-Muwaffaqiya	Poor	Poor	Poor	Good	Good	Poor	Poor	Poor	Very Poor	Very Poor	Very Poor	Very Poor
St.4	End Al-Muwaffaqiya	Unsuitable	Unsuitable	Very Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.5	Ent. Al-Hayy	Very Poor	Poor	Poor	Good	Good	Poor	Very Poor	Poor	Very Poor	Very Poor	Very Poor	Very Poor
St.6	Mid Al-Hayy	Unsuitable	Unsuitable	Unsuitable	Very Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.7	End Al-Hayy	Unsuitable	Unsuitable	Very Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.8	Ent. Al-Fajr	Very Poor	Very Poor	Poor	Poor	Poor	Poor	Very Poor	Very Poor	Unsuitable	Very Poor	Very Poor	Very Poor
St.9	End Al-Fajr	Unsuitable	Unsuitable	Unsuitable	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.10	Ent. Qalat Sukar	Very Poor	Very Poor	Very Poor	Poor	Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Very Poor	Very Poor
St.11	End Qalat Sukar	Unsuitable	Unsuitable	Unsuitable	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.12	Ent. Al-Rifai	Very Poor	Very Poor	Very Poor	Very Poor	Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Very Poor	Very Poor
St.13	Mid. Al Rifai	Unsuitable	Unsuitable	Unsuitable	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.14	End Al-Rifai	Unsuitable	Unsuitable	Unsuitable	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.15	Ent. Al Naser	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Very Poor	Very Poor
St.16	Mid Al-Naser	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.17	End Al-Naser	Unsuitable	Unsuitable	Unsuitable	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.18	Ent. Al-Shatrah	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.19	Mid Al-Shatrah	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
St.20	End Al-Shatrah	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable

Figure 3. Heatmap of AW-WQI values along the Al-Gharraf River throughout the study period

3.1 Spatial variation

A distinct spatial gradient in water quality is observed along the river course, with relatively lower AW-WQI values at upstream stations and progressively higher values toward downstream locations.

At Kut Entrance Station (St.1), the AW-WQI values ranged approximately between 35 and 60 over the study period. The station was generally classified as Good to Poor, particularly during the months from December to May, when the values consistently fell within the lower range.

At Kut End Station (St.2), a significant increase in AW-WQI values was recorded compared to St.1. The values ranged approximately between 80 and 140, placing this station predominantly within the Very Poor and Unsuitable classifications for the majority of the months.

At the Al-Muwaffaqiya stations (St.3 and St.4), a contrast between the entrance and end stations was evident. The entrance station (St.3) showed moderate values, typically within the Good to Poor range, whereas the end station (St.4) exhibited higher AW-WQI values, often above 100.

In the central segment of the river, specifically at Al-Hayy stations (St.5–St.7), AW-WQI levels escalated significantly. The midstream station (St.6) consistently recorded higher

values than the entrance station, with many months exceeding the threshold of 100.

Further downstream, at Al-Fajr, Qalat Sukar, Al-Rifai, Al-Naser, and Al-Shatrah stations (St.8–St.20), AW-WQI values showed a significant rise. These stations were predominantly classified as Very Poor and Unsuitable, particularly during the dry season.

The maximum AW-WQI values were recorded at downstream stations, particularly at End Al-Naser (St.17) and End Al-Shatrah (St.20), where values exceeded 250 and reached peak values above 300 during late summer.

3.2 Temporal (seasonal) variation

The AW-WQI results showed distinct temporal fluctuations during the research period.

During the winter season (December–February), most upstream and midstream stations recorded relatively lower AW-WQI values, generally within the Good to Poor range. However, downstream stations still exhibited elevated values during this timeframe.

During the spring season (March–May), AW-WQI values remained relatively stable at upstream stations, although moderate increases were observed at midstream and downstream stations.

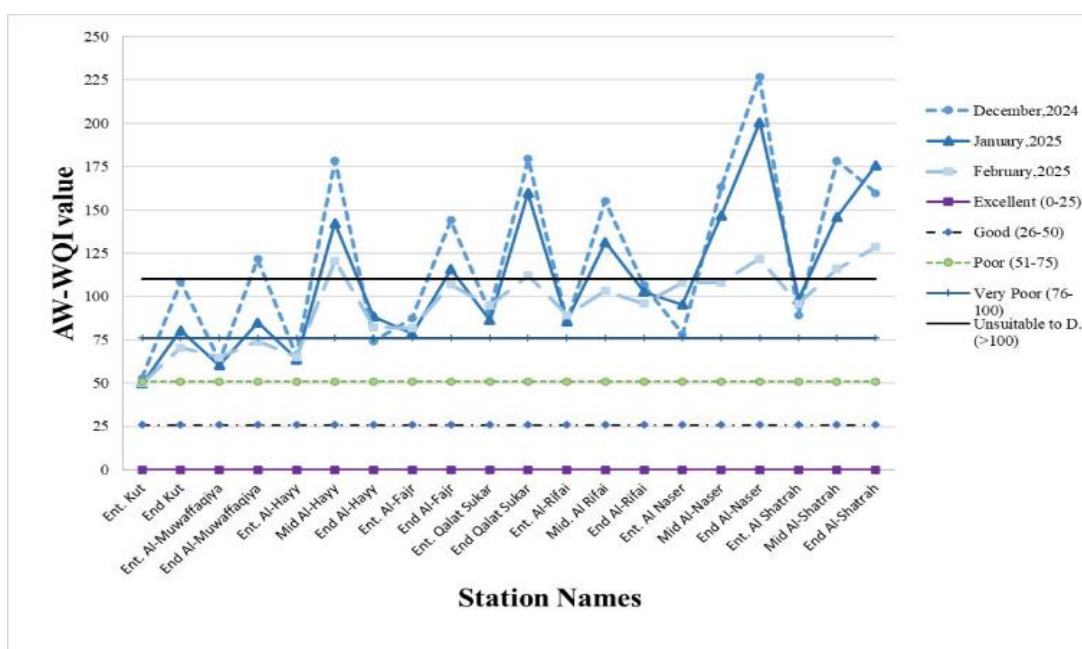


Figure 4. Water quality index (WQI) for drinking uses along the Al-Gharraf River (December 2024–February 2025)

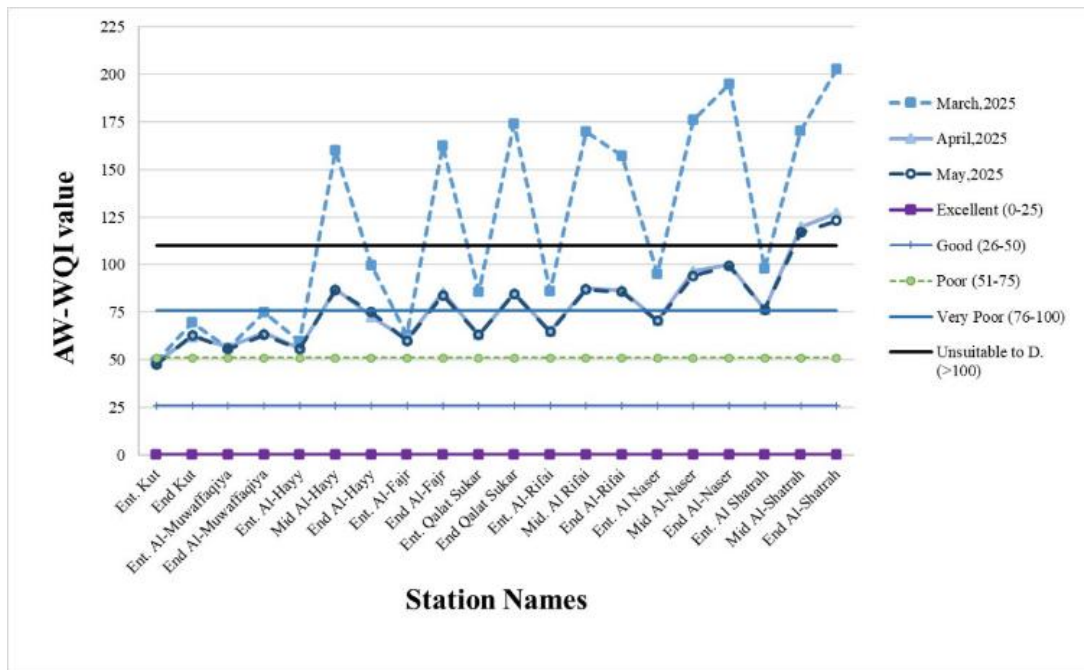


Figure 5. Water quality index (WQI) for drinking uses along the Al-Gharraf River (March–May 2025)

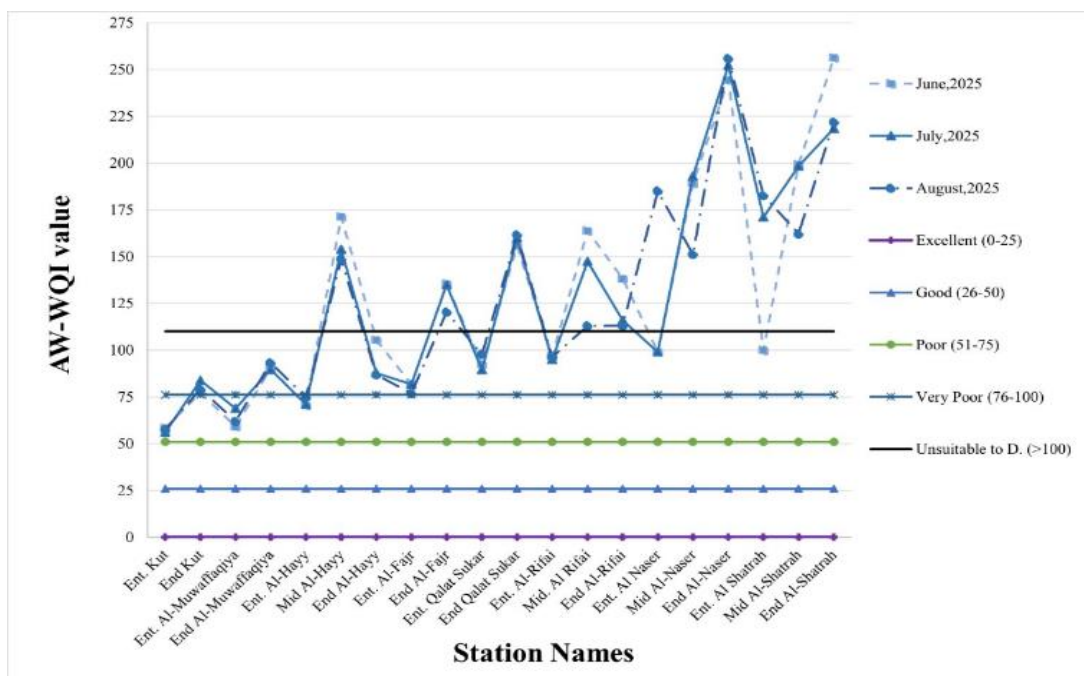


Figure 6. Water quality index (WQI) for drinking uses along the Al-Gharraf River (June–August 2025)

Conversely, during the summer season (June–August), a significant increase in AW-WQI values was observed across nearly all stations. Most stations shifted into the Very Poor and Unsuitable categories, with some stations exceeding 150 and reaching higher values.

The highest AW-WQI values were noted during late summer and early autumn (August–September), where peak values exceeding 300 were recorded at several downstream stations.

In autumn (September–November), AW-WQI levels were elevated at most sites, especially in downstream areas, with minimal improvement seen.

Figures 4-7 show the WQI for drinking, uses according to AW-WQI for the twenty stations along the Al-Gharraf River

during the period from December, 2024 to November, 2025.

3.3 Overall patterns

Overall, the results indicate that:

AW-WQI values exhibit a progressive increase from upstream to downstream stations

Downstream stations consistently record higher values compared to upstream stations

Water quality is often better during winter and spring

Significant deterioration occurs during summer and early autumn

Maximum AW-WQI values are concentrated in the lower reaches of the river.

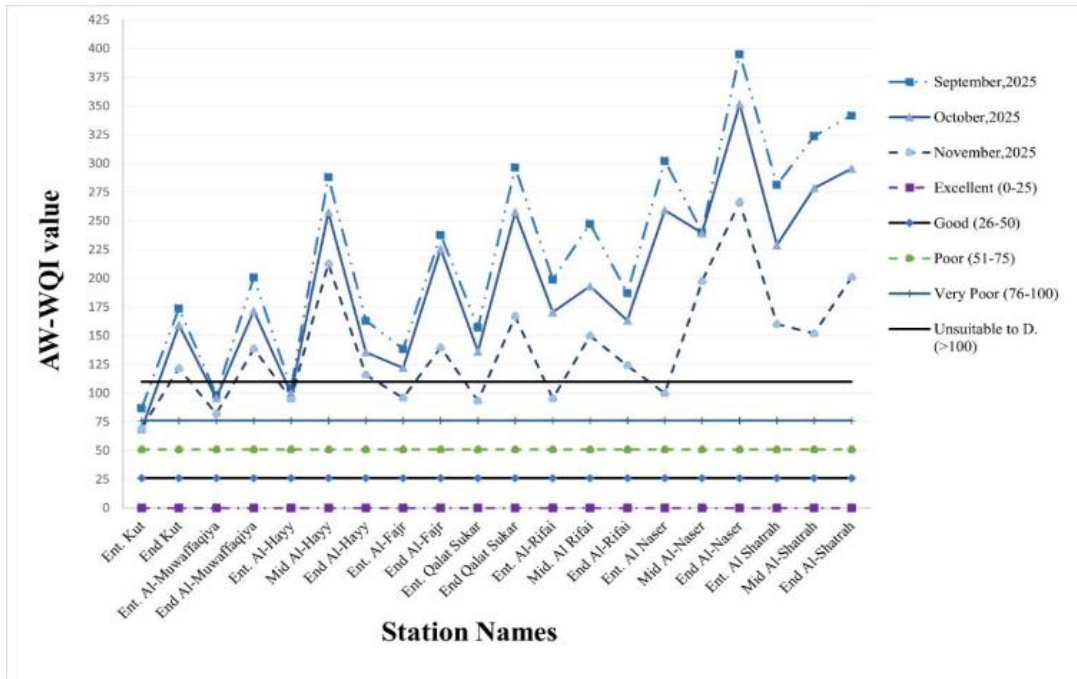


Figure 7. Water quality index (WQI) for drinking uses along the Al-Gharraf River (September–November 2025)

4. DISCUSSION

The results of the present study indicate a clear spatial and temporal variation in water quality along the Al-Gharraf River, as demonstrated by the AW-WQI values. These variations are shaped by the combined effects of hydrological conditions and human activities along the river course.

From a spatial viewpoint, water quality shows a progressive deterioration from upstream to downstream stations. Upstream sites, particularly at the entrances of cities, generally exhibit lower AW-WQI values due to relatively limited human impact and better dilution conditions. Conversely, downstream stations record significantly higher values, reflecting the cumulative impact of many pollution sources discharged along the river [3, 4].

The temporal variation further supports this pattern. During the wet season (December–May), water quality conditions improve due to increased water availability, which facilitates dilution and reduces pollutant concentrations. However, during the dry season (June–November), reduced water releases are strongly associated with higher AW-WQI values, as the river’s ability to dilute pollutants decreases, leading to elevated contamination levels across most sites [4, 13].

The deterioration in water quality is strongly associated with several anthropogenic factors, including the discharge of untreated domestic wastewater, industrial discharges, and agricultural runoff containing fertilizers and pesticides. These sources contribute to the increase in organic matter, nutrients, and heavy metals in the river water [7, 12].

A pronounced deterioration is observed in the downstream section, particularly within Dhi-Qar Governorate, as indicated by the higher AW-WQI values recorded at these stations. This deterioration may be attributed to increased anthropogenic activities along the river, including the discharge of untreated wastewater and return flows from agricultural and domestic uses. In Iraq, wastewater treatment facilities are often insufficient or poorly maintained, which further contributes to the deterioration of water quality [21, 22]. These spatial and

temporal patterns are clearly illustrated by the heatmap (Figure 3), which provides a comprehensive visualization of AW-WQI variation along the river. The heatmap highlights the gradual increase in AW-WQI values from upstream to downstream stations, thereby validating the cumulative impact of pollution sources along the river course. Moreover, higher AW-WQI values are consistently recorded during the dry season across most stations, reflecting the strong influence of reduced dilution capacity.

Moreover, a clear pattern is observed within urban areas, where water quality at mid-city stations is generally worse than at upstream entry points. This can be explained by the fact that the river passes through densely populated city centers, where multiple discharge points are concentrated. Consequently, untreated domestic wastewater and other urban pollutants are directly released into the river, leading to a localized increase in pollutant concentrations. The aggregation of these discharges within the central part of the city results in higher AW-WQI values, highlighting the significant impact of urban activities on river water quality.

Overall, the results show that declining water quality deterioration in the Al-Gharraf River is strongly associated with reduced dilution capacity during the dry season and increasing anthropogenic pressures, particularly in densely populated urban areas and downstream sections of the river [14, 17].

5. CONCLUSION

(1) Based on the results of this study, the AW-WQI exhibited notable spatial and temporal variations in water quality along the Al-Gharraf River during 2024–2025.

(2) Water quality was relatively better during the period of water abundance and rainfall (December–May), where several upstream stations, especially at city entrances, recorded values within the good to poor categories.

(3) A noticeable deterioration in water quality was noted

during the dry season, especially in summer and early autumn, where AW-WQI values ranged from poor to very poor and unsuitable for use at most stations.

(4) Stations located within city centers and downstream ends exhibited poorer water quality compared to entrance stations, underscoring the direct impact of urban discharges on the river.

(5) The deterioration in water quality is strongly associated with reduced water releases from the Tigris River, which reduces the dilution capacity of the Al-Gharraf River and contributes to increased pollutant concentrations.

(6) Untreated domestic wastewater, industrial effluents, and agricultural runoff containing fertilizers and pesticides were identified as major contributors to water pollution, particularly in urban and agricultural regions.

(7) The downstream segment of the river, especially within Dhi-Qar Governorate, showed greater deterioration in water quality compared to upstream and midstream sections due to the cumulative impact of pollution sources.

(8) The absence or limited availability of wastewater treatment plants in urban areas along the Al-Gharraf River significantly contributes to the worsening of water quality.

(9) Fish farming practices and uncontrolled agricultural discharges increase organic loads and nutrient concentrations, negatively affecting the river ecosystem.

(10) From a management perspective, priority initiatives should focus on:

- Targeting downstream regions, particularly within Dhi-Qar Governorate, as priority areas for pollution management.
- Controlling key pollutants such as BODs, nutrients (NO_3^- and PO_4^{3-}), and heavy metals (notably Pb^{2+}).
- Reducing direct release of untreated wastewater into the river.
- Implementing wastewater treatment facilities in major urban centers.
- Adopting seasonal management measures, including increasing water releases during the dry season to improve dilution capacity.

REFERENCES

- [1] Fulazzaky, M.A. (2010). Water quality evaluation system to assess the status and the suitability of the Citarum river water to different uses. *Environmental Monitoring and Assessment*, 168(1): 669-684. <https://doi.org/10.1007/s10661-009-1142-z>
- [2] Zhao, P., Tang, X., Tang, J., Wang, C. (2013). Assessing water quality of Three Gorges Reservoir, China, over a five-year period from 2006 to 2011. *Water Resources Management*, 27(13): 4545-4558. <https://doi.org/10.1007/s11269-013-0425-x>
- [3] Pejman, A.H., Bidhendi, G.N., Karbassi, A.R., Mehrdadi, N., Bidhendi, M.E. (2009). Evaluation of spatial and seasonal variations in surface water quality using multivariate statistical techniques. *International Journal of Environmental Science & Technology*, 6(3): 467-476. <https://doi.org/10.1007/BF03326086>
- [4] Varol, M.E.M.E.T., Gökot, B., Bekleyen, A., Şen, B. (2012). Water quality assessment and apportionment of pollution sources of Tigris River (Turkey) using multivariate statistical techniques—A case study. *River Research and Applications*, 28(9): 1428-1438. <https://doi.org/10.1002/rra.1533>
- [5] Yan, T., Shen, S.L., Zhou, A. (2022). Indices and models of surface water quality assessment: Review and perspectives. *Environmental Pollution*, 308: 119611. <https://doi.org/10.1016/j.envpol.2022.119611>
- [6] Uddin, M.G., Nash, S., Rahman, A., Olbert, A.I. (2022). A comprehensive method for improvement of water quality index (WQI) models for coastal water quality assessment. *Water Research*, 219: 118532. <https://doi.org/10.1016/j.watres.2022.118532>
- [7] Jabbar, W.T. (2013). Effect of domestic sewage on water quality of Al-Gharraf River in Al-Haay city. Doctoral dissertation, Master Thesis. College of Science, Baghdad University.
- [8] Daham, M.H., Abed, B.S. (2020). One and two-dimensional hydraulic simulation of a reach in Al-Gharraf River. *Journal of Engineering*, 26(7): 28-44. <https://doi.org/10.31026/j.eng.2020.07.03>
- [9] Hassan, H.A. (2005). Hydrological characteristics of Al-Gharraf River and its relation to the Tigris River at Kut Barrage. Master's Thesis, University of Baghdad, College of Engineering, Baghdad.
- [10] Hamza, Z.A. (2023). Impact of sub-rivers feeding the Shatt Al-Arab River on its water quality. *Water and Environmental Sustainability*, 3(3): 59-64. <https://doi.org/10.52293/WES.3.3.5964>
- [11] Al-Seedi, S.N.N., Al-Auboody, F.J.F. (2011). Ecological study on some physical and chemical properties of Al-Gharraf river water in Thi-Qar governorate. *College of Education Journal*, 4(1): 44-51.
- [12] Al-Mayah, W.T., Al-Azzawi, M.N. (2023). Monthly variations of some physical and chemical properties for Al-Gharraf River one of the main Tigris branches at Al-Haay City. *Journal of Wasit for Science and Medicine*, 7(1): 190-205. <https://doi.org/10.31185/jwsm.339>
- [13] Kükrcer, S., Mutlu, E. (2019). Assessment of surface water quality using water quality index and multivariate statistical analyses in Saraydüzü Dam Lake, Turkey. *Environmental Monitoring and Assessment*, 191(2): 71.
- [14] Tyagi, S., Sharma, B., Singh, P., Dobhal, R. (2013). Water quality assessment in terms of water quality index. *American Journal of Water Resources*, 1(3): 34-38. <https://doi.org/10.12691/ajwr-1-3-3>
- [15] APHA. (2012). Standard Methods for the Examination of Water and Waste Water. 22nd Edition, American Public Health Association, American Water Works Association, Water Environment Federation.
- [16] 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.
- [17] Uddin, M.G., Nash, S., Olbert, A.I. (2021). A review of water quality index models and their use for assessing surface water quality. *Ecological Indicators*, 122: 107218. <https://doi.org/10.1016/j.ecolind.2020.107218>
- [18] Xiao, M., Bao, F., Wang, S., Cui, F. (2016). Water quality assessment of the Huaihe River segment of Bengbu (China) using multivariate statistical techniques. *Water Resources*, 43(1): 166-176. <https://doi.org/10.1134/S0097807816010115>
- [19] Zhao, E., Kuo, Y.M., Chen, N. (2021). Assessment of water quality under various environmental features using a site-specific weighting water quality index. *Science of the Total Environment*, 783: 146868. <https://doi.org/10.1016/j.scitotenv.2021.146868>

[20] Leizou, K.E., Nduka, J.O., Verla, A.W., Wleizou, K.E. (2017). Evaluation of water quality index of the brass river, Bayelsa State, south-south, Nigeria. *International Journal of Research-Granthaalayah*, 5(8): 277-287. <https://doi.org/10.5281/zenodo.894650>

[21] Ewaid, S.H., Abed, S.A. (2017). Water quality assessment of Al-Gharraf River, South of Iraq using multivariate statistical techniques. *Iraqi Journal of Science*, 20(2): 114-122. <https://www.anjs.edu.iq/index.php/anjs/article/view/89/60>.

[22] Al-Ansari, N., Ali, A.A., Knutsson, S. (2014). Present conditions and future challenges of water resources problems in Iraq. *Journal of Water Resource and Protection*, 6(12): 1066-1098. <https://doi.org/10.4236/jwarp.2014.612102>

WQI	Water Quality Index
Qi	Quality rating of the ith parameter
Wi	Relative weight of the ith parameter
Vm	Measured value of parameter, mg/L
Vi	Ideal value of parameter
Vs	Standard permissible value, mg/L
DO	Dissolved oxygen, mg/L
BOD ₅	Biochemical oxygen demand, mg/L
TDS	Total dissolved solids, mg/L
TSS	Total suspended solids, mg/L
SO ₄ ²⁻	Sulfate, mg/L
NO ₃ ⁻	Nitrate, mg/L
PO ₄ ³⁻	Phosphate, mg/L
Pb ²⁺	Lead, mg/L
pH	Potential of hydrogen (dimensionless)

Subscripts

i ith parameter

NOMENCLATURE

Symbol Description

AW-WQI Arithmetic Weighted Water Quality Index

APPENDIX

Table A1. Sensitivity of WQPs that were used to calculate AW-WQI for December 2024

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	85.9	80.0	72.4	55.6	18.6	98.0	12.9	47.5	50.0	5147.3	49.9	Good
St.2	End Kut	83.5	87.5	256.0	48.5	44.0	130.0	23.3	90.0	103.0	10564.7	102.5	Unsuitable
St.3	Ent. Al-Muwaffaqiya	85.9	81.5	112.0	53.8	30.6	99.6	16.7	55.5	72.0	7371.1	71.5	Poor
St.4	End Al-Muwaffaqiya	83.9	88.5	272.0	53.2	50.0	128.8	26.9	93.8	150.0	15277.0	148.2	Unsuitable
St.5	Ent. Al-Hayy	84.7	83.5	236.0	52.6	38.0	110.0	16.0	70.0	80.0	8213.4	79.7	Very Poor
St.6	Mid Al-Hayy	82.5	91.0	384.0	56.2	90.0	146.0	20.7	148.0	205.0	20925.4	203.0	Unsuitable
St.7	End Al-Hayy	84.7	86.5	340.0	49.5	58.0	116.0	18.4	90.0	120.0	12271.0	119.0	Unsuitable
St.8	Ent. Al-Fajr	85.8	84.2	288.0	48.5	44.0	111.2	16.2	80.5	93.0	9542.3	92.6	Very Poor
St.9	End Al-Fajr	84.1	95.0	340.0	51.0	77.6	96.8	22.2	130.0	187.0	19075.2	185.0	Unsuitable
St.10	Ent. Qalat Sukar	84.7	85.0	296.0	49.0	50.4	123.6	20.0	91.8	110.0	11272.1	109.3	Unsuitable
St.11	End Qalat Sukar	83.6	95.2	380.0	54.9	94.0	144.0	30.7	147.5	190.0	19424.9	188.4	Unsuitable
St.12	Ent. Al-Rifai	84.7	89.0	340.0	49.5	64.0	126.4	20.4	91.0	93.0	9574.8	92.9	Very Poor
St.13	Mid Al Rifai	83.5	90.0	356.0	54.9	90.0	136.0	24.7	105.0	125.0	12816.7	124.3	Unsuitable
St.14	End Al-Rifai	83.5	91.0	340.0	51.5	78.0	128.8	19.3	72.5	100.0	10231.6	99.3	Very Poor
St.15	Ent. Al Naser	84.1	96.0	432.0	53.2	91.0	146.0	26.2	105.0	150.0	15319.8	148.6	Unsuitable
St.16	Mid Al-Naser	84.1	93.5	360.0	52.1	77.0	134.0	22.7	97.5	125.0	12795.0	124.1	Unsuitable
St.17	End Al-Naser	82.9	100.1	520.0	58.8	110.0	159.2	32.9	172.5	200.0	20497.0	198.8	Unsuitable
St.18	Ent. Al Shatrah	83.5	92.8	392.0	61.0	84.0	138.0	24.9	100.0	100.0	10305.7	100.0	Very Poor
St.19	Mid Al-Shatrah	83.8	91.8	388.0	61.7	84.6	132.8	22.7	96.8	168.0	17097.6	165.9	Unsuitable
St.20	End Al-Shatrah	82.9	97.4	440.0	62.5	104.0	149.6	31.3	147.3	215.0	21930.2	212.7	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100			∑Wi =103.0848

Table A2. Sensitivity of WQPs that were used to calculate AW-WQI for January 2025

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	85.9	80.0	88.0	49.0	16.0	92.4	12.1	43.3	50.0	5135.5	49.8	Good
St.2	End Kut	83.5	86.5	84.0	52.6	38.0	88.0	20.8	86.5	93.0	9548.5	92.6	Very Poor
St.3	Ent. Al-Muwaffaqiya	84.9	81.1	88.0	49.0	25.4	100.4	15.4	55.0	75.0	7666.7	74.4	Poor

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WIQI	AW-WQI Value	Water Quality Rating
St.4	End Al-Muwaffaqiya	83.3	88.5	128.0	54.9	45.0	108.8	23.7	93.8	150.0	15270.3	148.1	Unsuitable
St.5	Ent. Al-Hayy	83.6	81.1	96.0	49.5	24.4	110.0	16.0	61.3	74.0	7582.5	73.6	Poor
St.6	Mid Al-Hayy	82.5	94.5	216.0	55.6	62.0	96.8	22.7	133.0	196.0	19975.3	193.8	Unsuitable
St.7	End Al-Hayy	84.5	83.5	100.0	49.5	56.0	98.0	19.6	81.3	190.0	19239.1	186.6	Unsuitable
St.8	Ent. Al-Fajr	82.8	83.0	80.0	49.0	44.0	102.0	16.4	80.5	83.0	8533.6	82.8	Very Poor
St.9	End Al-Fajr	82.7	92.0	96.0	54.3	62.0	100.0	21.3	120.5	176.0	17939.1	174.0	Unsuitable
St.10	Ent. Qalat Sukar	84.9	83.0	88.0	50.0	45.4	102.0	18.7	84.8	97.0	9945.4	96.5	Very Poor
St.11	End Qalat Sukar	82.4	95.0	320.0	55.6	51.0	135.2	31.4	125.0	163.0	16657.6	161.6	Unsuitable
St.12	Ent. Al-Rifai	83.5	89.0	264.0	52.1	60.0	118.0	20.0	86.3	80.0	8259.4	80.1	Very Poor
St.13	Mid. Al Rifai	83.3	88.7	240.0	53.8	84.0	122.4	24.0	105.0	125.0	12810.6	124.3	Unsuitable
St.14	End Al-Rifai	83.1	89.0	140.0	51.5	44.8	98.0	18.3	56.8	119.0	12077.4	117.2	Unsuitable
St.15	Ent. Al Naser	82.7	65.0	188.0	53.2	77.0	142.0	23.6	99.0	98.2	10111.9	98.1	Very Poor
St.16	Mid Al-Naser	83.3	90.8	296.0	55.6	76.0	130.0	21.1	93.8	180.0	18283.4	177.4	Unsuitable
St.17	End Al-Naser	89.4	100.5	540.0	61.7	90.0	134.0	27.8	138.8	160.0	16410.6	159.2	Unsuitable
St.18	Ent. Al Shatrah	85.9	94.0	332.0	61.0	81.6	106.0	23.6	85.0	100.0	10265.4	99.6	Very Poor
St.19	Mid Al-Shatrah	83.5	92.0	248.0	63.3	84.0	110.8	19.0	96.5	173.0	17591.4	170.6	Unsuitable
St.20	End Al-Shatrah	83.3	97.0	368.0	62.5	56.6	134.4	24.0	108.0	195.0	19819.5	192.3	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A3. Sensitivity of WQPs that were used to calculate AW-WQI for February 2025

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WIQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	85.9	80.0	96.0	50.0	16.0	91.6	11.8	46.3	48.0	4943.5	48.0	Good
St.2	End Kut	83.5	87.0	80.0	50.5	38.0	102.0	20.5	84.8	83.0	8543.5	82.9	Very Poor
St.3	Ent. Al-Muwaffaqiya	84.9	81.1	92.0	49.0	25.4	100.0	15.2	56.3	70.0	7170.0	69.6	Poor
St.4	End Al-Muwaffaqiya	83.3	89.7	96.0	51.0	47.2	99.2	24.0	92.3	90.0	9264.9	89.9	Very Poor
St.5	Ent. Al-Hayy	84.7	80.0	100.0	49.0	21.8	102.0	15.8	68.5	73.0	7500.2	72.8	Poor
St.6	Mid Al-Hayy	82.8	91.8	104.0	61.8	62.0	104.0	22.7	113.8	112.0	11524.0	111.8	Unsuitable
St.7	End Al-Hayy	84.5	82.0	96.0	52.8	57.0	100.0	19.4	83.3	95.0	9744.8	94.5	Very Poor
St.8	Ent. Al-Fajr	83.5	82.5	92.0	54.9	43.6	100.0	15.4	77.5	75.0	7727.8	75.0	Poor
St.9	End Al-Fajr	83.3	93.5	100.0	55.4	62.0	96.8	19.8	88.3	115.0	11758.8	114.1	Unsuitable
St.10	Ent. Qalat Sukar	84.7	88.4	104.0	50.6	46.8	102.8	18.0	91.3	85.0	8762.6	85.0	Very Poor
St.11	End Qalat Sukar	82.8	94.5	100.0	55.2	57.0	100.8	28.4	106.3	127.0	13002.9	126.1	Unsuitable
St.12	Ent. Al-Rifai	83.9	86.9	92.0	49.8	64.0	100.8	19.6	89.3	89.0	9160.3	88.9	Very Poor
St.13	Mid. Al Rifai	82.8	89.7	96.0	56.2	66.0	108.8	22.0	102.0	138.0	14094.0	136.7	Unsuitable
St.14	End Al-Rifai	83.3	89.3	104.0	53.8	60.0	100.4	18.0	71.3	132.0	13415.7	130.1	Unsuitable
St.15	Ent. Al Naser	82.8	95.5	100.0	56.8	79.6	115.2	22.7	98.8	96.0	9889.0	95.9	Very Poor
St.16	Mid Al-Naser	83.2	92.0	96.0	55.6	62.0	114.0	21.1	80.0	151.0	15338.1	148.8	Unsuitable
St.17	End Al-Naser	81.6	98.4	88.0	61.7	64.0	98.0	23.6	115.5	155.0	15828.0	153.5	Unsuitable
St.18	Ent. Al Shatrah	82.5	91.8	100.0	62.3	62.0	90.0	22.4	102.5	100.0	10295.8	99.9	Very Poor
St.19	Mid Al-Shatrah	83.2	91.5	100.0	59.5	66.0	100.0	18.1	100.0	152.0	15489.8	150.3	Unsuitable
St.20	End Al-Shatrah	81.5	97.5	104.0	62.5	55.0	114.0	22.2	104.5	185.0	18799.5	182.4	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A4. Sensitivity of WQPs that were used to calculate AW-WQI for March 2025

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WIQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	95.3	59.0	96.0	51.0	21.6	64.0	13.1	40.3	36.0	3730.8	36.2	Good
St.2	End Kut	90.4	70.0	248.0	62.4	64.0	100.8	18.1	63.8	75.0	7706.1	74.8	Poor

St.3	Ent. Al-Muwaffaqiya	95.5	65.5	188.0	54.1	43.8	74.0	13.7	46.3	45.0	4654.6	45.2	Good
St.4	End Al-Muwaffaqiya	88.1	85.2	308.0	63.9	71.0	99.2	20.2	72.0	78.0	8030.6	77.9	Very Poor
St.5	Ent. Al-Hayy	95.3	69.8	180.0	57.2	46.4	80.0	15.7	88.8	48.0	5061.7	49.1	Good
St.6	Mid Al-Hayy	84.5	87.6	360.0	65.1	116.6	113.2	22.8	102.5	98.0	10118.0	98.2	Very Poor
St.7	End Al-Hayy	94.2	72.0	242.0	59.2	64.0	90.0	17.5	66.3	90.0	9211.8	89.4	Very Poor
St.8	Ent. Al-Fajr	95.1	69.0	204.0	57.3	50.4	73.6	15.6	53.3	70.0	7174.7	69.6	Poor
St.9	End Al-Fajr	85.9	85.5	333.2	64.1	114.0	104.0	22.2	98.8	95.0	9806.9	95.1	Very Poor
St.10	Ent. Qalat Sukar	92.9	72.0	248.0	63.3	82.0	90.8	18.0	87.5	74.0	7669.5	74.4	Poor
St.11	End Qalat Sukar	84.5	87.1	384.0	69.2	104.0	108.0	26.6	102.5	98.0	10117.3	98.1	Very Poor
St.12	Ent. Al-Rifai	94.8	70.5	276.0	62.2	76.0	82.0	6.1	80.0	78.0	8050.4	78.1	Very Poor
St.13	Mid. Al Rifai	90.6	84.7	304.0	64.1	98.2	116.0	23.2	100.0	100.0	10306.3	100.0	Very Poor
St.14	End Al-Rifai	92.9	74.5	268.0	64.5	89.6	99.6	18.6	83.0	100.0	10260.9	99.5	Very Poor
St.15	Ent. Al Naser	84.5	86.2	334.0	70.1	126.0	122.0	25.9	105.8	85.0	8828.0	85.6	Very Poor
St.16	Mid Al-Naser	91.8	81.5	284.0	65.4	123.4	114.0	19.5	102.5	114.0	11717.1	113.7	Unsuitable
St.17	End Al-Naser	86.9	84.5	292.0	69.4	137.4	126.0	25.1	145.0	97.0	10126.9	98.2	Very Poor
St.18	Ent. Al Shatrah	90.4	85.5	288.0	70.2	138.8	128.0	25.3	103.0	90.0	9322.6	90.4	Very Poor
St.19	Mid Al-Shatrah	89.2	81.5	284.0	63.8	132.4	115.2	20.1	95.5	115.0	11800.8	114.5	Unsuitable
St.20	End Al-Shatrah	84.1	87.1	352.0	71.3	143.6	133.6	31.0	121.5	131.0	13472.0	130.7	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A5. Sensitivity of WQPs that were used to calculate AW-WQI for (April, 2025)

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	94.7	60.0	84.0	52.6	18.0	66.0	13.0	43.0	40.0	4136.7	40.1	Good
St.2	End Kut	84.9	65.0	104.0	62.3	62.0	102.0	17.7	59.3	75.0	7688.0	74.6	Poor
St.3	Ent. Al-Muwaffaqiya	94.9	62.5	100.0	55.1	40.0	67.2	13.7	44.5	48.0	4946.1	48.0	Good
St.4	End Al-Muwaffaqiya	84.0	79.5	104.0	71.0	63.6	104.0	20.1	66.5	77.0	7908.2	76.7	Very Poor
St.5	Ent. Al-Hayy	92.6	60.2	96.0	62.2	44.0	78.8	15.7	64.0	49.0	5096.7	49.4	Good
St.6	Mid Al-Hayy	84.4	85.5	272.0	70.4	73.4	102.0	22.5	102.0	100.0	10305.6	100.0	Very Poor
St.7	End Al-Hayy	93.6	71.3	152.0	62.9	60.0	80.0	16.5	56.0	97.0	9882.4	95.9	Very Poor
St.8	Ent. Al-Fajr	93.6	63.5	136.0	57.8	40.6	70.8	15.4	58.5	72.1	7393.1	71.7	Poor
St.9	End Al-Fajr	84.8	83.8	208.0	67.6	113.0	94.0	22.0	97.0	80.0	8297.9	80.5	Very Poor
St.10	Ent. Qalat Sukar	88.8	70.8	96.0	66.1	84.2	79.2	17.6	88.5	73.5	7616.4	73.9	Poor
St.11	End Qalat Sukar	83.3	85.7	148.0	70.2	119.2	100.8	25.8	10.3	85.0	8580.3	83.2	Very Poor
St.12	Ent. Al-Rifai	91.2	65.0	108.0	65.4	64.2	74.0	17.7	58.8	75.3	7718.6	74.9	Poor
St.13	Mid. Al Rifai	91.8	84.7	140.0	70.1	96.4	104.0	21.9	103.3	98.3	10138.8	98.4	Very Poor
St.14	End Al-Rifai	91.1	72.3	128.0	68.1	83.4	98.0	18.5	62.0	95.0	9702.0	94.1	Very Poor
St.15	Ent. Al Naser	83.3	83.2	124.0	69.2	80.6	102.0	23.9	102.3	80.0	8301.4	80.5	Very Poor
St.16	Mid Al-Naser	89.6	86.5	192.0	70.6	95.6	106.0	21.0	100.0	100.0	10302.4	99.9	Very Poor
St.17	End Al-Naser	86.5	84.3	184.0	71.3	102.4	102.0	31.9	119.0	95.0	9851.0	95.6	Very Poor
St.18	Ent. Al Shatrah	82.6	76.7	288.0	67.1	94.2	100.0	22.7	108.5	90.0	9325.7	90.5	Very Poor
St.19	Mid Al-Shatrah	87.1	87.6	324.0	71.0	104.2	104.0	20.8	103.0	100.0	10316.7	100.1	Unsuitable
St.20	End Al-Shatrah	82.6	84.6	300.0	72.8	136.8	102.0	29.2	108.5	110.0	11336.0	110.0	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A6. Sensitivity of WQPs that were used to calculate AW-WQI for (May, 2025)

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	94.2	58.6	92.0	52.9	16.0	54.4	11.9	27.5	48.0	4897.8	47.5	Good
St.2	End Kut	88.7	62.7	104.0	62.6	60.0	98.0	17.7	68.3	80.0	8210.6	79.6	Very Poor

St.3	Ent. Al-Muwaffaqiya	93.5	58.5	96.0	57.1	32.0	70.8	13.3	62.0	62.0	6388.3	62.0	Poor
St.4	End Al-Muwaffaqiya	85.9	78.6	148.0	70.1	61.8	100.0	19.5	72.3	86.0	8823.9	85.6	Very Poor
St.5	Ent. Al-Hayy	91.8	57.9	100.0	59.1	43.4	80.0	15.4	56.0	60.0	6176.0	59.9	Poor
St.6	Mid Al-Hayy	83.3	88.8	128.0	71.3	64.0	102.0	21.0	100.0	97.0	9992.9	96.9	Very Poor
St.7	End Al-Hayy	92.4	72.5	132.0	64.3	69.0	96.0	16.1	78.0	88.0	9038.6	87.7	Very Poor
St.8	Ent. Al-Fajr	92.6	64.8	96.0	60.1	45.4	63.2	14.8	25.0	75.0	7599.0	73.7	Poor
St.9	End Al-Fajr	83.3	83.7	100.0	70.4	64.4	106.0	21.3	105.8	92.0	9506.1	92.2	Very Poor
St.10	Ent. Qalat Sukar	85.9	71.1	112.0	66.8	61.8	86.0	15.8	72.0	83.4	8561.1	83.0	Very Poor
St.11	End Qalat Sukar	83.3	88.9	108.0	71.3	112.8	106.0	24.8	102.0	93.9	9697.0	94.1	Very Poor
St.12	Ent. Al-Rifai	93.4	67.7	112.0	64.7	51.4	84.0	19.2	62.5	82.0	8395.8	81.4	Very Poor
St.13	Mid. Al Rifai	84.5	84.6	128.0	66.1	77.6	106.4	22.2	101.3	104.0	10697.9	103.8	Unsuitable
St.14	End Al-Rifai	91.9	72.8	108.0	69.4	62.8	78.8	17.7	77.8	100.0	10236.7	99.3	Very Poor
St.15	Ent. Al Naser	82.8	84.8	88.0	71.0	82.4	104.0	24.7	105.3	90.0	9308.1	90.3	Very Poor
St.16	Mid Al-Naser	90.8	81.0	120.0	70.2	61.8	102.0	18.3	96.3	127.0	12983.4	125.9	Unsuitable
St.17	End Al-Naser	81.2	86.8	316.0	79.5	140.4	106.0	34.0	108.8	120.0	12339.3	119.7	Unsuitable
St.18	Ent. Al Shatrah	84.5	80.0	264.0	70.4	108.0	104.0	23.5	76.0	98.0	10047.2	97.5	Very Poor
St.19	Mid Al-Shatrah	82.0	82.0	260.0	73.3	102.4	108.4	21.1	91.3	150.0	15284.3	148.3	Unsuitable
St.20	End Al-Shatrah	82.8	85.5	224.0	73.7	141.6	105.2	29.5	110.5	160.0	16339.2	158.5	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A7. Sensitivity of WQPs that were used to calculate AW-WQI for (June, 2025)

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	96.5	51.2	144.0	70.9	53.4	57.6	10.1	44.5	60.0	6153.7	59.7	Poor
St.2	End Kut	95.9	62.2	216.0	94.7	102.0	91.6	15.2	55.8	93.0	9499.4	92.2	Very Poor
St.3	Ent. Al-Muwaffaqiya	96.5	46.9	92.0	74.3	44.0	66.4	8.7	120.5	72.0	7540.4	73.1	Poor
St.4	End Al-Muwaffaqiya	95.1	58.7	252.0	97.5	86.0	104.0	18.6	102.5	100.0	10315.1	100.1	Unsuitable
St.5	Ent. Al-Hayy	95.5	52.9	184.0	84.2	62.6	82.0	11.7	101.5	78.0	8102.3	78.6	Very Poor
St.6	Mid Al-Hayy	91.3	78.6	308.0	100.0	151.8	109.2	22.1	113.5	143.0	14658.2	142.2	Unsuitable
St.7	End Al-Hayy	95.4	58.7	224.0	82.8	79.6	86.0	13.8	67.8	138.0	14022.7	136.0	Unsuitable
St.8	Ent. Al-Fajr	96.2	50.4	204.0	80.0	58.2	87.2	11.6	104.3	85.0	8808.4	85.4	Very Poor
St.9	End Al-Fajr	94.6	64.2	284.0	99.2	145.0	109.6	21.9	112.0	150.0	15352.3	148.9	Unsuitable
St.10	Ent. Qalat Sukar	95.6	53.8	236.0	78.2	84.2	86.0	14.2	71.3	87.0	8932.0	86.6	Very Poor
St.11	End Qalat Sukar	91.8	63.9	360.0	105.9	162.0	116.4	24.6	123.8	137.0	14089.2	136.7	Unsuitable
St.12	Ent. Al-Rifai	95.3	58.0	260.0	96.2	103.6	84.0	12.8	86.5	96.0	9878.5	95.8	Very Poor
St.13	Mid. Al Rifai	94.8	62.5	288.0	98.8	130.8	118.8	20.0	105.3	120.0	12332.7	119.6	Unsuitable
St.14	End Al-Rifai	95.1	61.5	264.0	97.7	126.6	95.2	11.6	95.3	101.0	10405.4	100.9	Unsuitable
St.15	Ent. Al Naser	91.1	62.5	348.0	106.8	161.6	117.6	22.8	132.3	98.0	10210.0	99.0	Very Poor
St.16	Mid Al-Naser	83.5	67.5	276.0	98.4	106.4	98.0	15.6	89.8	164.0	16687.0	161.9	Unsuitable
St.17	End Al-Naser	86.4	71.2	424.0	138.9	182.0	137.6	33.6	171.3	130.0	13520.8	131.2	Unsuitable
St.18	Ent. Al Shatrah	88.8	61.1	228.0	119.0	122.4	109.6	22.5	121.5	80.0	8372.6	81.2	Very Poor
St.19	Mid Al-Shatrah	93.8	67.5	340.0	125.0	136.6	108.0	19.5	82.0	190.0	19282.9	187.1	Unsuitable
St.20	End Al-Shatrah	88.6	68.2	368.0	131.6	173.4	128.8	25.4	140.5	164.0	16838.5	163.3	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A8. Sensitivity of WQPs that were used to calculate AW-WQI for (July, 2025)

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	96.5	48.5	104.0	71.3	42.0	44.8	7.2	38.8	68.0	6935.4	67.3	Poor
St.2	End Kut	95.1	55.5	192.0	94.3	65.6	76.8	14.3	73.3	99.0	10134.7	98.3	Very Poor

St.3	Ent. Al-Muwaffaqiya	95.5	48.8	136.0	81.2	41.6	54.0	8.9	63.8	73.0	7501.1	72.8	Poor
St.4	End Al-Muwaffaqiya	95.3	58.8	172.0	96.2	87.4	100.8	18.4	100.3	107.0	11006.3	106.8	Unsuitable
St.5	Ent. Al-Hayy	94.9	52.0	124.0	81.4	56.0	72.0	11.8	68.5	74.6	7675.5	74.5	Poor
St.6	Mid Al-Hayy	83.9	68.8	220.0	101.2	163.0	102.4	20.8	104.3	124.0	12733.1	123.5	Unsuitable
St.7	End Al-Hayy	95.2	49.7	136.0	82.8	64.0	78.0	12.2	96.3	120.0	12287.2	119.2	Unsuitable
St.8	Ent. Al-Fajr	95.5	49.1	172.0	80.0	46.4	79.6	10.2	76.0	87.0	8934.0	86.7	Very Poor
St.9	End Al-Fajr	88.7	58.8	228.0	98.0	142.8	106.0	20.7	105.3	135.0	13831.8	134.2	Unsuitable
St.10	Ent. Qalat Sukar	94.9	48.9	144.0	81.4	84.2	74.0	11.1	74.8	95.0	9737.5	94.5	Very Poor
St.11	End Qalat Sukar	84.7	61.5	272.0	98.0	153.0	101.6	22.4	123.0	156.0	15979.5	155.0	Unsuitable
St.12	Ent. Al-Rifai	94.6	56.5	168.0	94.0	102.2	75.2	11.1	103.0	99.0	10215.2	99.1	Very Poor
St.13	Mid. Al Rifai	94.0	61.2	252.0	98.0	124.4	105.2	19.4	108.0	175.0	17836.5	173.0	Unsuitable
St.14	End Al-Rifai	94.8	55.0	208.0	96.2	103.6	96.0	11.6	99.3	187.0	19008.2	184.4	Unsuitable
St.15	Ent. Al Naser	85.6	64.9	220.0	101.0	150.4	116.0	22.4	121.8	110.0	11374.6	110.3	Unsuitable
St.16	Mid Al-Naser	91.4	57.9	276.0	102.0	153.4	107.2	16.0	91.3	241.0	24401.8	236.7	Unsuitable
St.17	End Al-Naser	83.3	64.0	280.0	131.9	182.4	128.4	23.2	155.3	207.0	21173.1	205.4	Unsuitable
St.18	Ent. Al Shatrah	88.8	57.1	220.0	104.2	122.0	109.6	19.3	102.8	169.0	17222.3	167.1	Unsuitable
St.19	Mid Al-Shatrah	90.8	57.8	268.0	125.0	144.0	113.2	19.1	113.0	256.0	25958.6	251.8	Unsuitable
St.20	End Al-Shatrah	85.2	62.0	236.0	128.2	177.0	124.0	22.2	121.3	232.0	23584.7	228.8	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A9. Sensitivity of WQPs that were used to calculate AW-WQI for August, 2025

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	96.2	45.8	88.0	69.9	44.2	51.6	6.9	29.3	90.0	9111.2	88.4	Very Poor
St.2	End Kut	94.4	55.7	144.0	92.1	64.0	84.0	14.6	61.5	110.0	11202.5	108.7	Unsuitable
St.3	Ent. Al-Muwaffaqiya	95.1	46.9	100.0	79.0	40.0	58.4	8.7	113.0	95.0	9822.0	95.3	Very Poor
St.4	End Al-Muwaffaqiya	94.6	56.6	152.0	98.0	84.0	102.0	18.0	101.3	120.0	12307.6	119.4	Unsuitable
St.5	Ent. Al-Hayy	93.6	49.4	108.0	80.1	60.0	75.2	10.6	104.5	100.0	10305.2	100.0	Very Poor
St.6	Mid Al-Hayy	89.1	67.6	192.0	104.2	101.6	104.0	21.9	102.0	188.0	19115.3	185.4	Unsuitable
St.7	End Al-Hayy	94.8	62.0	128.0	87.1	71.6	71.6	13.6	72.3	191.0	19329.3	187.5	Unsuitable
St.8	Ent. Al-Fajr	95.1	49.1	104.0	80.9	55.2	58.4	11.6	42.3	124.0	12548.7	121.7	Unsuitable
St.9	End Al-Fajr	87.6	55.4	132.0	97.1	143.6	101.6	20.8	103.0	195.0	19822.1	192.3	Unsuitable
St.10	Ent. Qalat Sukar	92.1	52.0	152.0	77.6	62.0	85.6	14.1	81.8	150.0	15249.9	147.9	Unsuitable
St.11	End Qalat Sukar	87.5	66.4	236.0	102.5	149.8	106.0	21.2	106.3	207.0	21036.8	204.1	Unsuitable
St.12	Ent. Al-Rifai	92.9	55.4	116.0	97.5	77.4	66.0	13.3	86.0	177.0	17966.2	174.3	Unsuitable
St.13	Mid. Al Rifai	92.8	62.2	148.0	105.3	146.0	102.0	21.2	103.8	245.0	24827.4	240.8	Unsuitable
St.14	End Al-Rifai	93.5	66.3	136.0	102.0	126.0	98.0	13.7	77.8	267.0	26957.2	261.5	Unsuitable
St.15	Ent. Al Naser	85.8	63.5	204.0	98.4	146.4	102.4	21.7	111.8	194.0	19747.5	191.6	Unsuitable
St.16	Mid Al-Naser	89.5	68.8	208.0	98.6	102.0	100.4	16.6	85.5	327.0	32973.6	319.9	Unsuitable
St.17	End Al-Naser	84.2	72.8	260.0	111.1	182.0	130.4	27.6	132.5	340.0	34411.4	333.8	Unsuitable
St.18	Ent. Al Shatrah	91.6	61.8	152.0	113.6	122.0	103.6	21.8	95.8	221.0	22404.3	217.3	Unsuitable
St.19	Mid Al-Shatrah	89.5	59.8	128.0	98.0	122.6	100.4	20.4	92.8	279.0	28192.6	273.5	Unsuitable
St.20	End Al-Shatrah	83.3	62.2	256.0	102.5	182.8	130.0	23.6	113.0	324.0	32760.7	317.8	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A10. Sensitivity of WQPs that used to calculate AW-WQI for (September, 2025)

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	84.8	83.4	264.0	46.4	48.6	108.0	18.7	63.5	87.0	8899.2	86.3	Very Poor
St.2	End Kut	83.8	96.5	388.0	53.6	76.2	152.8	30.3	105.8	145.0	14817.1	143.7	Unsuitable

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.3	Ent. Al-Muwaffaqiya	85.4	83.6	308.0	47.4	62.0	108.8	20.3	116.3	95.0	9835.8	95.4	Very Poor
St.4	End Al-Muwaffaqiya	83.3	98.8	580.0	55.5	90.2	159.6	34.4	119.8	161.0	16463.0	159.7	Unsuitable
St.5	Ent. Al-Hayy	84.2	86.0	300.0	49.5	84.4	114.0	22.0	103.0	97.0	10007.2	97.1	Very Poor
St.6	Mid Al-Hayy	82.8	100.8	700.0	65.3	164.6	170.8	41.0	180.8	192.0	19737.3	191.5	Unsuitable
St.7	End Al-Hayy	84.7	92.3	372.0	59.2	95.8	124.0	23.3	123.0	199.0	20264.4	196.6	Unsuitable
St.8	Ent. Al-Fajr	84.4	85.9	312.0	50.3	73.6	116.4	21.6	110.3	99.0	10223.8	99.2	Very Poor
St.9	End Al-Fajr	82.7	100.3	624.0	60.6	150.2	172.4	40.7	177.8	205.0	21022.9	203.9	Unsuitable
St.10	Ent. Qalat Sukar	83.6	88.9	444.0	52.4	97.0	138.0	30.7	99.3	147.3	15036.9	145.9	Unsuitable
St.11	End Qalat Sukar	82.5	102.1	712.0	63.4	164.6	174.4	45.6	181.3	164.9	17028.7	165.2	Unsuitable
St.12	Ent. Al-Rifai	84.2	89.1	380.0	53.9	108.2	144.8	26.0	112.8	158.0	16140.7	156.6	Unsuitable
St.13	Mid. Al Rifai	82.9	98.0	572.0	62.4	156.8	167.6	40.2	158.0	210.0	21473.1	208.3	Unsuitable
St.14	End Al-Rifai	83.6	96.5	376.0	58.5	117.0	154.4	27.1	109.5	258.0	26135.0	253.5	Unsuitable
St.15	Ent. Al Naser	81.6	98.7	644.0	61.1	162.0	176.8	50.0	196.0	192.0	19771.9	191.8	Unsuitable
St.16	Mid Al-Naser	81.5	101.8	508.0	66.7	164.8	164.0	45.0	135.3	284.0	28816.1	279.5	Unsuitable
St.17	End Al-Naser	76.6	106.8	820.0	72.6	184.4	191.6	77.8	243.5	328.0	33504.6	325.0	Unsuitable
St.18	Ent. Al Shatrah	82.5	92.0	500.0	63.9	137.8	157.6	46.9	193.0	200.0	20554.3	199.4	Unsuitable
St.19	Mid Al-Shatrah	79.8	103.3	624.0	70.4	179.0	184.8	61.8	203.8	309.0	31495.8	305.5	Unsuitable
St.20	End Al-Shatrah	76.6	106.2	692.0	72.5	178.0	184.8	62.4	208.3	332.0	33809.6	328.0	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A11. Sensitivity of WQPs that used to calculate AW-WQI for (October, 2025)

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm	SUM WQI	AW-WQI Value	Water Quality Rating
St.1	Ent. Kut	83.9	77.8	84.0	49.5	45.4	102.0	16.9	57.5	70.0	7176.8	69.6	Poor
St.2	End Kut	82.5	96.5	260.0	56.8	84.0	142.0	31.1	105.3	120.0	12312.7	119.4	Unsuitable
St.3	Ent. Al-Muwaffaqiya	83.8	85.5	216.0	49.5	50.4	100.0	20.0	65.3	78.0	8002.5	77.6	Very Poor
St.4	End Al-Muwaffaqiya	82.4	97.7	288.0	61.4	103.2	158.4	34.4	117.3	132.0	13548.8	131.4	Unsuitable
St.5	Ent. Al-Hayy	83.3	86.2	232.0	49.5	50.8	100.0	22.7	102.5	84.9	8786.4	85.2	Very Poor
St.6	Mid Al-Hayy	81.2	100.7	628.0	61.7	130.8	158.4	40.2	100.0	148.0	15124.8	146.7	Unsuitable
St.7	End Al-Hayy	82.7	91.0	216.0	55.6	84.6	102.0	27.3	94.3	163.0	16583.1	160.9	Unsuitable
St.8	Ent. Al-Fajr	83.1	86.2	232.0	51.9	65.0	102.4	22.4	105.5	88.7	9177.2	89.0	Very Poor
St.9	End Al-Fajr	82.4	99.0	468.0	59.4	162.0	188.8	42.2	196.0	175.0	18064.5	175.2	Unsuitable
St.10	Ent. Qalat Sukar	83.1	87.7	292.0	56.7	84.0	128.8	31.3	98.0	95.0	9795.9	95.0	Very Poor
St.11	End Qalat Sukar	78.8	105.0	528.0	62.7	169.0	164.8	48.9	108.3	185.0	18849.2	182.9	Unsuitable
St.12	Ent. Al-Rifai	82.4	89.4	256.0	56.7	116.8	136.8	26.3	108.8	98.2	10147.7	98.4	Very Poor
St.13	Mid. Al Rifai	81.4	95.0	380.0	70.2	162.0	168.0	40.4	154.5	198.0	20259.1	196.5	Unsuitable
St.14	End Al-Rifai	83.5	94.6	308.0	58.8	102.2	142.0	26.7	104.0	230.0	23315.6	226.2	Unsuitable
St.15	Ent. Al Naser	78.8	97.1	672.0	62.7	154.4	158.0	45.6	152.5	98.0	10262.6	99.6	Very Poor
St.16	Mid Al-Naser	83.1	101.1	576.0	64.1	162.4	172.8	46.7	145.8	298.0	30244.3	293.4	Unsuitable
St.17	End Al-Naser	76.5	106.3	712.0	76.5	182.0	188.4	64.4	246.3	310.0	31707.1	307.6	Unsuitable
St.18	Ent. Al Shatrah	82.8	95.8	408.0	62.4	132.2	146.0	41.1	130.5	255.9	25982.8	252.1	Unsuitable
St.19	Mid Al-Shatrah	77.6	104.8	648.0	69.4	173.0	149.2	43.3	162.0	290.0	29490.2	286.1	Unsuitable
St.20	End Al-Shatrah	76.7	105.0	508.0	71.3	175.0	168.0	53.3	203.0	309.0	31488.1	305.5	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		

Table A12. Sensitivity of WQPs that used to calculate AW-WQI for November 2025

ID	Name of Station	pH	TDS mg/L	TSS mg/L	DO mg/L	QI					SUM WQI	AW- WQI Value	Water Quality Rating
						BOD5 mg/L	SO ₄ mg/L	NO ₃	PO ₄ mg/L	Pb ²⁺ ppm			
St.1	Ent. Kut	83.9	77.8	84.0	49.5	45.4	102.0	16.9	57.5	77.0	7876.8	76.4	Very Poor
St.2	End Kut	82.5	96.5	260.0	56.8	84.0	142.0	31.1	105.3	130.0	13312.7	129.1	Unsuitable
St.3	Ent. Al- Muwaffaqiya	83.8	85.5	216.0	49.5	50.4	100.0	20.0	65.3	88.0	9002.5	87.3	Very Poor
St.4	End Al- Muwaffaqiya	82.4	97.7	288.0	61.4	103.2	158.4	34.4	117.3	150.0	15348.8	148.9	Unsuitable
St.5	Ent. Al-Hayy	83.3	86.2	232.0	49.5	50.8	100.0	22.7	102.5	88.0	9096.4	88.2	Very Poor
St.6	Mid Al-Hayy	81.2	100.7	628.0	61.7	130.8	158.4	40.2	100.0	188.0	19124.8	185.5	Unsuitable
St.7	End Al-Hayy	82.7	91.0	216.0	55.6	84.6	102.0	27.3	94.3	163.0	16583.1	160.9	Unsuitable
St.8	Ent. Al-Fajr	83.1	86.2	232.0	51.9	65.0	102.4	22.4	105.5	88.7	9177.2	89.0	Very Poor
St.9	End Al-Fajr	82.4	99.0	468.0	59.4	162.0	188.8	42.2	196.0	175.0	18064.5	175.2	Unsuitable
St.10	Ent. Qalat Sukar	83.1	87.7	292.0	56.7	84.0	128.8	31.3	98.0	95.0	9795.9	95.0	Very Poor
St.11	End Qalat Sukar	78.8	105.0	528.0	62.7	169.0	164.8	48.9	108.3	185.0	18849.2	182.9	Unsuitable
St.12	Ent. Al-Rifai	82.4	89.4	256.0	56.7	116.8	136.8	26.3	108.8	98.9	10217.7	99.1	Very Poor
St.13	Mid. Al Rifai	81.4	95.0	380.0	70.2	162.0	168.0	40.4	154.5	198.0	20259.1	196.5	Unsuitable
St.14	End Al-Rifai	83.5	94.6	308.0	58.8	102.2	142.0	26.7	104.0	230.0	23315.6	226.2	Unsuitable
St.15	Ent. Al Naser	78.8	97.1	672.0	62.7	154.4	158.0	45.6	152.5	100.0	10462.6	101.5	Unsuitable
St.16	Mid Al-Naser	83.1	101.1	576.0	64.1	162.4	172.8	46.7	145.8	344.0	34844.3	338.0	Unsuitable
St.17	End Al-Naser	76.5	106.3	712.0	76.5	182.0	188.4	64.4	246.3	310.0	31707.1	307.6	Unsuitable
St.18	Ent. Al Shatrah	82.8	95.8	408.0	62.4	132.2	146.0	41.1	130.5	267.9	27182.8	263.7	Unsuitable
St.19	Mid Al-Shatrah	77.6	104.8	648.0	69.4	173.0	149.2	43.3	162.0	290.0	29490.2	286.1	Unsuitable
St.20	End Al-Shatrah	76.7	105.0	508.0	71.3	175.0	168.0	53.3	203.0	323.0	32888.1	319.0	Unsuitable
	Wi	0.1176	0.001	0.04	0.2	0.2	0.004	0.0222	2.5	100	$\sum Wi = 103.0848$		