International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18(11s) 2026 pp. 231-236
https://doi.org/10.70917/ijcisim-2026-3751
Article

Groundwater Quality Assessment and Its Effect on Concrete Strength for Sustainable Construction: Babil Governorate, Iraq

Tamar Maitham Al_Asedi[1], Kawthar H. Sh. Aljboury[2], Alaa H. Abdulameer[3], B. Abdulhadi[4], Baneen M. H. Al-Khafaji[5], Fatima Muslim[6], Haneen Fadhil[7], Raghda A. Naser[8], Sabah Mohammed Abd[9], Aqeel Abdulhasan Hussein[10]

[1-10] Building and Construction Techniques Engineering Department, College of Engineering and Engineering Techniques, Al-Mustaqbal University, Hillah, Babylon 51001, Iraq
[1]tamar.maitham.abdulwahabb@uomus.edu.iq , https://orcid.org/0009-0009-5279-2357
[2]kawthar.hussein.shaalan@uomus.edu.iq, [3] Alaa.Hussein.AbdUlameer@uomus.edu.iq , [4]Bareq.a.abdulhadi@uomus.edu.iq
[5]baneen.mohammed.hilal@uomus.edu.iq[6] fatima.muslim.hadi@uomus.edu.iq
[7]haneen.fadhil.kadhim@uomus.edu.iq[8]raghda.ali.naser@uomus.edu.iq[9]sabah.mohammed@uomus.edu.iq , [10] aqeelabdulhassan@uomus.edu.iq

Abstract: Potable water can also be used for construction. This study will examine the physicochemical characteristics of water sources and how they impact specific mechanical properties of concrete because water is necessary for both sustainable development and the completion of construction projects. The main source of water in this area is groundwater. For the purpose of gathering samples, five different locations were surveyed. The World Health Organization's (WHO) established protocols were used to analyze the samples' physicochemical characteristics. We evaluated the concrete samples' compressive, flexural, and split tensile strengths after combining them with water. The quantities discovered in the groundwater samples are within what the World Health Organization deems to be safe levels, according to the results of the quality tests. Water samples from the five locations where the concrete was mixed may play a part in creating high-quality concrete, according to statistics on compressive, flexural, and split tensile strength. Because of this, everyone who works in the construction business must keep using water that is safe for people to drink while mixing concrete.
Keywords: NA

1. Introduction

A "water resource" is any naturally occurring body of water that can be used for more than one purpose. Along with food and shelter, water is one of the most basic things that people need to live and grow. This shows how important it is in many ways. Surface water and groundwater are the two most common and easy-to-get types of water. Because groundwater is more reliable than surface water sources, it is the focus. Groundwater is essential for obtaining water in areas like Iraq that are only partially dry [1]. Many human activities, including manufacturing, require water. Water is an essential component of concrete used in civil engineering because it influences the cement's hydration, workability, strength, and durability. It might get weaker and less potent if the wrong sort of water is utilized [2]. The completed product's mechanical qualities are greatly affected by the water's pH, total dissolved solids, and the quantity of dissolved ions, such as sulfates and chlorides. If there are too many of these chemicals, they can speed up the breakdown of the reinforcing and cause chemical reactions in the cement matrix that you don't want, which can make the concrete weaker. Studies show that concrete mixed with clean water lasts longer than concrete mixed with chemically treated water [3]. Over time and space, geological formations, human activities, and hydrochemical processes all change the quality of groundwater. People in Iraq often make concrete from groundwater without first doing a physicochemical test. This is especially true in the Babil Governorate. This plan puts the long-term safety and stability of concrete buildings in fast-growing, more urban areas at risk. Before groundwater can be used for building projects, studies show that its quality must be checked. Although several studies have examined the effects of groundwater on drinking and irrigation water [4,5], research on the mechanical properties of concrete remains limited. Additionally, the hydrochemical characteristics of Iraqi groundwater may have been exaggerated due to the utilization of diverse environmental and geological contexts in prior studies. Consequently, further investigation is required to explore methodologies for integrating groundwater quality assessments with concrete performance evaluations in specific areas [6]. This study seeks to ascertain the correlation between the mechanical properties of concrete, including its split tensile, flexural, and compressive strengths, and the physicochemical parameters of groundwater sourced from designated locations in Babil Governorate, Iraq. The aim is to promote enduring sustainability in the region's construction practices by evidencing the safety of groundwater for development through scientific data [7,8].

2. Materials and Methods

2.1 Description of the Study Area

Like many other places in Central Iraq, the Babil Governorate is experiencing rapid urbanization and population growth. Its neighbors are Al-Qadisiyah to the south, Wasit to the east, Najaf to the southwest, Karbala to the west, and Baghdad Governorate to the north. Official statistics show that the governorate is home to over two million people and covers an area of about 5,119 km².

Babil Governorate has a semi-arid climate with high summer temperatures and little yearly precipitation. Due to these climatic circumstances, there is a greater reliance on groundwater supplies to meet the demands of building, agriculture, and home use. Babil has seen a discernible increase in housing and infrastructure developments in recent years, which has resulted in a rise in the amount of groundwater needed to produce concrete. As a result, the study's scope was restricted to specific Babil Governorate locales that are representative of places where building is now underway.

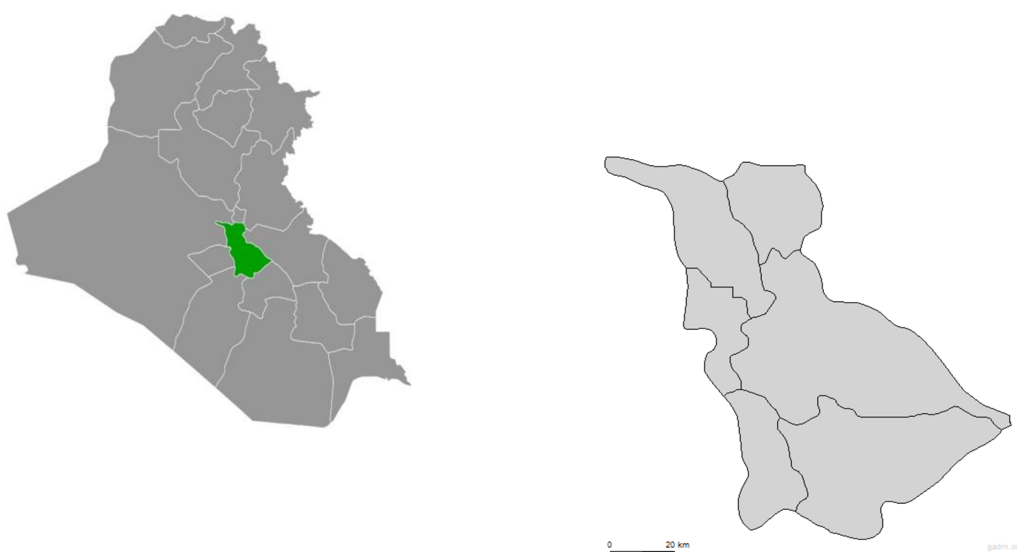

Figure 1. Map of Iraq showing the location of Babil Governorate.

2.2 Collection of Groundwater Samples

Groundwater samples from five chosen locations in the Babil Governorate were analyzed in a lab to provide the primary data for this study. The test locations were chosen to reflect various residential and development zones that mostly obtain their water from groundwater retrieved from boreholes. The physicochemical parameters tested were sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), chloride (Cl), nitrate (NO_3), bicarbonate (HCO_3), sulfate (SO_4), total hardness (TH), total alkalinity (TA), total dissolved solids (TDS), and pH. Secondary data came from the World Health Organization's (WHO) guidelines, which give proposed limits on groundwater quality based on how it would be used.

Two 2-liter plastic bottles were used to collect duplicate groundwater samples from each sampling site for physicochemical testing. To keep the samples from changing in any way, they were maintained in a refrigerator at a temperature below 20 °C until being tested in the lab. Two groundwater samples were also gathered from each area separately so they could be used as mixing water in the making of concrete.

2.3 Laboratory Analysis Procedure (IEEE In-Text Citation)

The first step was to do physicochemical tests to see if the groundwater was safe to drink. Some of the things that were looked at were pH, sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), sulfate (SO_4^{2-}), nitrate (NO_3^-), bicarbonate (HCO_3^-), total hardness (TH), total alkalinity (TA), and total dissolved solids (TDS). The American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation all said that most of these investigations were done using standard methods for testing water [9].

An atomic absorption spectrophotometer was employed to ascertain cation concentrations, whereas a calibrated pH meter was utilized to approximate the pH value. A spectrophotometer was used to detect the amounts of nitrate and sulfate turbidimetrically at wavelengths of 410 nm and 420 nm, respectively, using published methods [9]. As indicated in other studies, the principle of electroneutrality was validated by comparing the total cations and anions expressed in milliequivalents per liter to ensure the accuracy of chemical analyses [10].

Then, the usefulness of groundwater as mixing water for making concrete was tested. Some of the materials that were looked at were ordinary Portland cement, fine aggregate, coarse aggregate, and groundwater samples. The mechanical properties that were looked at were the compressive strength, flexural strength, and split tensile strength of concrete samples. In accordance with BS 1881 – Part 116 (1983) [11], compressive strength tests were conducted.

For every combination made using groundwater from every sample site, two concrete examples were examined. Equation (1) was used to get the compressive strength:

$$Compressive\ Strength = \frac{Average\ failure\ Load\ (N)}{Cross-\ sectional\ Area\ (mm^2)} = \frac{P}{A} \dots\dots\dots\dots\dots\dots (1)$$

Flexural strength tests were performed following **BS 1881 – Part 118 (1983)** [12] and **ASTM C78/C78M-22 (2022)** [13]. The flexural strength, expressed as the modulus of rupture (MOR), was calculated using Equation (2):

$$MOR = \frac{PL}{bd^2} \dots\dots\dots\dots\dots\dots (2)$$

where *b* is the specimen width, *d* is the specimen depth at the point of failure, *L* is the span length, and *P* is the maximum applied load.

A universal testing equipment was used to perform split tensile strength tests in compliance with ASTM C496/C496M-17 (2017) [14]. For every concrete mixture, two cylindrical specimens were examined, and Equation (3) was used to get the split tensile strength:

$$Ft = \frac{2P}{\pi DL} \dots\dots\dots\dots\dots\dots (3)$$

where D is the cylindrical specimen's diameter (mm), L is its length (mm), P is the maximum applied load (N), and f_t is the split tensile strength (MPa).

3. RESULTS AND DISCUSSION

3.1 Presentation of Results

Tables 1 and 2 show the physicochemical analysis results for the five chosen groundwater sampling locations (A–E) in the Babil Governorate, Iraq, as well as the findings of the tests for split tensile strength (STS), flexural strength (FS), and compressive strength (CS) of concrete made using these groundwater samples.

Table 1. Presentation of Results of Physico-Chemical Analysis of the Groundwater Samples

S/No	Location	Sample	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	HCO_3^{-} (mg/L)	Cl^{-} (mg/L)	NO_3^{-} (mg/L)	SO_4^{2-} (mg/L)
1	A	1A	34.7	8.9	24.9	0.4	35	65.8	9.4	57.2
		1B	35.5	9	25.5	0.42	36.5	65.9	9.5	60
		AV	35.1	9	25.2	0.41	35.8	65.9	9.5	58.6
2	B	2A	27.8	8.3	25.3	0.33	48.2	72.3	7.8	64.3
		2B	28.2	8.8	25.2	0.32	49.5	74.6	7.5	65.2
		AV	28	8.6	25.3	0.33	48.9	73.5	7.6	64.8
3	C	3A	34.6	9.3	39.8	0.24	50	75	8.3	70.8
		3B	35.8	9.5	39.1	0.28	50.3	75.9	8.4	72.7
		AV	35.2	9.4	39.5	0.26	50.2	75.5	8.4	71.8
4	D	4A	36.7	8.7	34.6	0.31	56.3	67.7	7.8	68.3
		4B	37.2	7.8	37.2	0.34	54.3	72.2	8.2	70.3
		AV	37	8.3	35.9	0.33	55.3	70	8	69.3
5	E	5A	29.6	7.5	40.3	0.4	48.9	75	7.6	81.2
		5B	30.5	7.6	39.3	0.34	48.2	80	8.5	79.4
		AV	30.1	7.6	39.8	0.37	48.6	77.5	8.1	80.3

Table 2. Presentation of Results of Physico-Chemical Analysis (Contd.), Compressive Strength (CS), Flexural Strength (FS) and Split Tensile Strength (STS)

Location	TA (mg/L $CaCO_3$)	TH (mg/L $CaCO_3$)	TDS (mg/L)	pH	CS (MPa)	FS (MPa)	STS (MPa)
A	54.54	98.33	269.5	7.2	28.03	8.5	5.04
B	52.01	88.2	282.5	7.3	25.14	7.79	4.6
C	52.78	88.9	271.6	7.3	26.1	6.88	5.07
D	50.35	92.51	271.2	7.2	22.81	7.02	4.79
E	50.15	88.63	258.4	6.5	24.73	7.68	5.89

The following items describe the content in Tables 1 and 2: i. The procedures for checking the accuracy of the analysis and calculating the values of Total Alkalinity (TA), Total Hardness (TH) and Total Dissolved Solids (TDS) [9]. ii. The values in the bracket represent WHO Standards. iii. NA implies that no health-based guideline value has been derived. iv. * indicate the taste threshold values.

3.2 Discussion of Results

From the results of the physicochemical analyses of groundwater samples presented in Tables 1 and 2, the pH values of locations A to D indicate near-neutral conditions, which make the water suitable for both domestic and construction purposes, while location E shows slightly acidic conditions but remains within the WHO recommended limits. The total dissolved solids (TDS) values recorded for all sampling locations fall within the WHO acceptable limits.

For the anions, chloride (Cl^-), nitrate (NO_3^-), sulfate (SO_4^{2-}), and bicarbonate (HCO_3^-) concentrations were generally lower than the prescribed threshold levels recommended by WHO standards and are therefore considered acceptable. Likewise, the measured levels for the cations Ca^{2+}, Mg^{2+}, Na^+, and K^+ are within the WHO-mandated ranges.Although total hardness (TH) values were observed in all locations, the values remain within the WHO taste threshold limit, and their presence does not restrict the use of groundwater for construction purposes.

The compressive strength results of concrete produced using groundwater from all selected locations meet the minimum American Concrete Institute (ACI) requirement of **20 MPa** for good quality concrete. The flexural and split tensile strength results are also in good agreement with the performance requirements for sustainable concrete production. So, mixing groundwater from the Babil Governorate sites with concrete cubes could make them stronger overall [15, 16, 17].

4. CONCLUSION

So far, physicochemical tests have been done on groundwater resource samples from the selected sites in Iraq's Babil Governorate. Also included are the results of tests on the concrete's compressive, flexural, and split tensile strengths when mixed with water samples from the specified areas. The groundwater has the right amount of cations and anions, according to the World Health Organization. The World Health Organization also says that the total dissolved solids (TDS) are safe. The analysis of the mechanical properties showed that concrete cubes mixed with groundwater sources had a compressive strength that was equal to or greater than the 20 MPa minimum set by the American Concrete Institute. To ensure that concrete's great mechanical properties last for a long time, a physicochemical test of these water sources is needed.

References

1. G. Lacerda Filho *et al.*, “Physicochemical Analysis of Mixing Water Used in Concrete Production,” *Revista IBRACON de Estruturas e Materiais*, vol. 18, no. 2, 2025, doi: **10.1590/S1983-41952025000200007**.
2. O. M. Ochuko, “Effect of Water Quality on Compressive Strength of Concrete,” *European Scientific Journal*, vol. 15, no. 12, pp. 172–185, 2019, doi: **10.19044/esj.2019.v15n12p172**.
3. W. Kokoszka, “Impact of Water Quality on Concrete Mix and Hardened Concrete Parameters,” *Civil and Environmental Engineering Reports*, vol. 29, no. 3, pp. 174–182, 2019, doi: **10.2478/ceer-2019-0033**.
4. K. C. Nwachukwu, D. A. Okodugha, C. S. Uzoukwu, P. O. Okorie, and B. A. Egbulonu, “Assessment of the Suitability of Water Resources Qualities for Consumption and Construction Purposes,” *International Journal of Advances in Engineering and Management*, vol. 4, no. 3, 2022, doi: **10.35629/5252-0403010112**.
5. Zwain, H. H., AbdUlameer, A. H., Hadi, F. M., Al-Asedi, T. M., Fadhil, H., & Naser, R. A. Spatiotemporal Variations and WQI-Based Assessment of the Euphrates River's Water Quality at Three Stations in Najaf, Iraq2025, *20*(8), 1875-1883. *Journal homepage: http://iieta. org/journals/ijdne*
6. P. Saravanakumar and G. Dhinakaran, “Effect of Acidic Water on Strength, Durability and Corrosion of Concrete,” *African Journal of Engineering Research*, vol. 7, no. 2, pp. 45–52, 2010.
7. ASTM C1602/C1602M-22, *Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete*, ASTM International, 2022.
8. World Health Organization, *Guidelines for Drinking-Water Quality*, 4th ed., Geneva, Switzerland, 2011.
9. APHA, AWWA, and WPCF, *Standard Methods for the Examination of Water and Wastewater*, 21st ed., Washington, DC, USA, 2005.
10. K. C. Nwachukwu, D. A. Okodugha, C. S. Uzoukwu, P. O. Okorie, and B. A. Egbulonu, “Assessment of the suitability of water resources qualities for consumption and construction purposes: A case study of selected towns in Owerri West L.G.A., Imo State, Nigeria,” *International Journal of Advances in Engineering and Management (IJAEM)*, vol. 4, no. 3, 2022.
11. British Standards Institution, *BS 1881-Part 116: Methods of Determination of Compressive Strength of Concrete Cube*, London, UK, 1983.
12. British Standards Institution, *BS 1881-Part 118: Methods of Determination of Flexural Strength of Concrete Cube*, London, UK, 1983.
13. ASTM C78/C78M-22, *Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)*, ASTM International, West Conshohocken, PA, USA, 2022.
14. ASTM C496/C496M-17, *Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens*, ASTM International, West Conshohocken, PA, USA, 2017.

15. AL-FATLAWI, Mohammed, et al. Evaluating Water Infiltration and Runoff: Stretcher Bond vs. 45° Herringbone Patterns in Permeable Interlocking Concrete Pavements. *CivilEng*, 2025, 6.2: 24.
16. Al-Asedi, T. M., & Kadhim, M. J. (2026). Enhancing the Sustainability of Road Projects Using Innovative Soil Stabilization Solutions. *Applied Mechanics and Materials*, *935*, 245-251.
17. Al-Asedi, T. M., Ali, L. H., Al-Dahash, D. F., Al-Fatlawi, M., & Mohammed, O. I. Geotechnical Study of the Soil for a Residential Project in Babil Governorate.