

Study of some physicochemical and biological properties of groundwater in Municipality of Al Sahel Al Jabal Al Akhdar

Mohammed Husayan Salih^{1*}, Farag A. ELMabrouk²

¹Department of Civil Engineering, Faculty of Engineering, University of Benghazi, Al-Marj, Libya

²Department of Civil Engineering, Faculty of Engineering, University of Benghazi, Benghazi, Libya

دراسة بعض الخصائص الفيزيائية والكيميائية والبيولوجية للمياه الجوفية في بلدية الساحل بالجبل الأخضر

محمد حسين صالح^{1*}، فرج المبروك²

¹قسم الهندسة المدنية، كلية الهندسة، جامعة بنغازي، المرج، ليبيا

²قسم الهندسة المدنية، كلية الهندسة، جامعة بنغازي، بنغازي، ليبيا

*Corresponding author: mohammed.husayn@uob.edu.ly

Received: July 26, 2026

Accepted: October 06, 2026

Published: October 23, 2026

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract:

This study aimed to evaluate the groundwater quality in some areas of the Al-Sahel Al-Jabal Al-Akhdar region to estimate the extent to which the quality of this water conforms to the Libyan standard specifications for drinking water. Fourteen samples were collected from different sites in the study area. Physical, chemical, and microbial tests were conducted according to the American standard (APHA, 2017), and test results were compared with the Libyan standard specification for drinking water NO. 82 (2015 AD). The results of the physical properties indicate that the temperature, and electrical conductivity were (20.9, 24.1 C0), (708, 1682 μ S/cm), respectively. The test results of the chemical properties showed a good levels of values, such as: pH (7.26 , 7.85), Total dissolved solids (460 , 1093 ppm) except sample (W8) was (1093 ppm), nitrate (0 , 15.67 ppm), and total hardness as CaCO₃ (50 , 450 ppm). Microbial analysis revealed that two of the samples were contaminated with (E.coli) bacteria. The results for the two infected samples were taken from the external tank of the well, not directly from the well itself, because the well pipe runs directly from the well to the tank without a valve at the well inlet. Overall, the structural condition of both structures was very poor.

Keywords: Groundwater, drinking water, water quality.

المخلص:

هدفت هذه الدراسة إلى تقييم المياه الجوفية في بعض مناطق بلدية الساحل الجبل الأخضر، وذلك لتحديد مدى مطابقة جودة هذه المياه للمواصفات القياسية الليبية لمياه الشرب. جُمعت أربع عشرة عينة من آبار مختلفة في بلدية الساحل الجبل الأخضر، وأُجريت لها اختبارات فيزيائية وكيميائية وميكروبية وفقاً للمعيار الأمريكي، وقورنت النتائج المعملية بالمواصفة القياسية الليبية لمياه الشرب رقم 82 لسنة 2015 ميلادي. أظهرت النتائج المعملية للخواص الفيزيائية أن درجة الحرارة والموصلية الكهربائية كانت (20.9، 24.1م0)، (708، 1682 ميكرو سمينز / سم)، على التوالي. بينما أظهرت النتائج المعملية للخواص الكيميائية مستوى جيد من القيم مثل: الرقم الهيدروجيني (7.26، 7.85)، والمواد الصلبة الذائبة الكلية (460، 1093 جزء في المليون) باستثناء العينة (W8) كانت (1093 جزء في المليون)، والنترات (0، 15.67 جزء

في المليون)، والعسر الكلي (50, 450 جزء في المليون). كشف التحليل الميكروبي أن اثنتين من العينات ملوثتان ببكتيريا الإشريكية (*E. coli*). تم أخذ نتائج العينتين المصابتين من الخزان الخارجي للبئر، وليس مباشرة من البئر نفسها، لأن أنبوب البئر يمتد مباشرة من البئر إلى الخزان بدون صمام عند مدخل البئر. بشكل عام، كانت الحالة الهيكلية للخرنين سيئة للغاية.

الكلمات المفتاحية: المياه الجوفية، مياه الشرب، جودة المياه.

Introduction:

Water is one of the most important elements that profoundly influence life. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. Water pollution has become one of the main threats that face humanity today. Increasing everyday activities lead to contamination of water sources including groundwater. This contamination contributes to generating large amounts of polluted water that people cannot use in their daily lives. Contaminated water is generated from many different sources: sewage, petroleum refineries, detergents, pesticides, herbicides, and insecticides [1]. These pollutants can be either physical or chemical. In addition, water is contaminated by pathogens such as bacteria, viruses, and fungi. However, Groundwater is used for domestic and industrial water supply and also for irrigation purposes all over the world. According to World Health Organization (WHO), about 80% of all diseases in human beings are caused by water [2]. Once the groundwater is contaminated, its quality cannot be restored easily [3]. This important water source contains different elements, ions, and compounds according to the earth's geology. For example, nitrate can be a natural constituent, but high concentrations often suggest a source of pollution [4]. Water quality standards are needed to determine whether groundwater of a certain quality is suitable for its intended use. The study aims to evaluate selected characteristics of groundwater in several areas of the Al-Sahel Municipality, Al Jabal Al Akhdar, Libya, to determine the extent to which the quality of this water complies with the Libyan standard specifications for drinking water.

search Problem:

The phenomenon of water pollution and its associated problems has gained significant importance due to rapid population growth, increasing urbanization, and the expansion of human activities. Furthermore, there is a lack of a sustainable development framework to preserve these resources and safeguard the rights of future generations, particularly as the demand for fresh water continues to rise. Groundwater pollution also poses a serious threat to human health and environmental safety. Coupled with rising daily water consumption, inadequate infrastructure, and intensified agricultural and industrial activities which have led to massive water depletion there is an urgent need to assess the water situation in the region.

Literature Review:

Many local studies have been conducted, including the following: the study by [5]. Quality assay measurement of groundwater in Wadijarif, Sirte, Libya. The collected samples were subjected to different analyses, to conduct chemical and bacteriological studies of the study area, Chemical analyses were conducted on those well samples in terms of determining the concentration of main ions (chloride, potassium, sodium, sulfate, carbonate, bicarbonate, silicon, manganese, barium, magnesium, calcium, nitrate, alkalinity, electrical conductivity, acidity, pH and total dissolved solids) and bacteriological analysis. This groundwater is classified as very poor and unsuitable, furthermore, all analyzed samples for bacteriological content classified as contaminated and were classified as unsafe. Results showed that the concentration of (TDS) was higher in wells. TDS increases from south to north, as TDS concentration and other ions increase the closer, we are to the sea, resulting from the seawater intrusion. The study has come to the results that these waters are not suitable for drinking before treatment, because the levels of total dissolved solids and ions are critically high. The wells of fare affected by seawater leakage.

Study researchers [6]. Quality assessment of groundwater resources in the city of Al-Marj, Libya. This study aimed to assess and compare the quality of groundwater in the city of Al-Marj in Libya with the international standard guidelines for drinking water recommended by WHO. An evaluation of the groundwater wells in the study area was conducted. Standard techniques, such as Minitab (v. 16) and ArcGIS (v.10.2), were used for the analysis of the physicochemical and biological parameters of the groundwater samples. An assessment of the calculation of groundwater quality was conducted based on temperature, pH, turbidity, electrical conductivity, total dissolved solids, chloride, sulphate, bicarbonate, total hardness, calcium, potassium, magnesium, ammonia, ammoniacal nitrogen, nitrate, sodium, copper, iron, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total suspended solids, *Escherichia coli*, and total coliform bacteria. Results indicated that most groundwater

wells in the study show higher concentrations of several parameters than the permissible limits for drinking water; thus, the water in these wells is chemically and biologically unsafe for drinking purposes.

This aligns with the study [7]. This study aims to evaluate the suitability of drinking water for some wells in the Qurji and Western Street areas in Tripoli, Libya. Water samples were collected from (7) wells in the targeted area. This study includes some physical and chemical analyzes such as pH, electrical conductivity, TDS, sodium, potassium, chloride, sulfates, and nitrate ions, in addition to bacteriological analyzes such as total number of aerobic bacteria, total coliform bacteria, and *Escherichia coli* bacteria. Results showed that the obtained pH values agreed with the range allowed by the WHO for drinking water, except for well No. 1 where the pH value was 6.24, which is less than the permissible range. Electrical conductivity values ranged from 45.8 to 4280 $\mu\text{S}/\text{cm}$. TDS values range (29.7, 2840 ppm) and Na, K, Cl, SO_4 , NO_3 ions concentration range (1.39, 255.7 ppm), (0.52, 33.77 ppm), (0.9, 5.5 ppm), (1, 99 ppm), and (1.1, 14.7 ppm) respectively. As for bacteriological analyses, the samples were free of bacteria, apart from well No. 4, in which the total Coliform bacteria were more than 5,000 colonies per liter (500 per 100 ml). Thus, a comparison of the results obtained, the water samples studied (except the samples from wells No. 1 and 4) were in conformity with the Libyan standard specification for drinking water and are suitable for human consumption.

Material and methods:

Study area:

The research was conducted in Al-Sahel Al-Jabal Al-Akhdar municipality. The municipality is in the north-eastern part of Libya, on the Mediterranean Sea's coast northeastern Libya and The Mediterranean climate, with hot, dry summers and mild, rainy winters, has an impact on the study area. comprises the following localities, (Bialhadid, Alhamama, Alhunih, Zawiat aleurbub, Qisr libya, Albayada, Tolmitha, Acafnta, Mirad maseud, Bata, and Sayidinuh. Figure (1) shows the distribution of these well locations.



Figure (1): Study area

sample collection:

Fourteen samples were collected from 14 wells from mid-March 2026 AD, as shown in Figure 1, according to the American standard (APHA) [8]. Commonly, 0.33 - liter plastic bottles were used, washed several times with distilled water, filled with the sample, and then sealed tightly. All samples were immediately transported to the physical and chemical analysis laboratory, where all physical and chemical analyses were performed upon arrival. As for the bacteriological analyses, the samples were collected under appropriate sterilization conditions and transported to the laboratory to conduct the necessary analyses within a period not exceeding 5 hours from the collection of the samples. Figure (2) shows some of the water samples used in the study to conduct physical, chemical, and microbial tests in the laboratory.



Figure (2): Water samples

Devices:

The, physical, chemical, and biological parameters were measured using several devices as shown in Table (1).

Table (1): Devices used in tests

Parameter	Devices
EC, TDS	Conductivity meter
pH, T	pH meter
NO ₃ , TH as CaCO ₃	Specter photometer 7500
<i>E. coli</i>	Compact dry and incubator

Results and discussion:

1. **Physical tests:** The temperature and electrical conductivity values ranged between (20.9, 24.1 Co), (708, 1682 $\mu\text{S/cm}$), respectively from the wells. Table (2) shows the results of temperature and electrical conductivity values for the studied samples.

Table (2): Results of temperature and electrical conductivity values

Sample	Sample location	T (C°)	EC ($\mu\text{S/cm}$)
W1	Bialhadid (Alnukhlat)	21.3	1010
W2	Bialhadid (Bufatimat)	22.4	1173
W3	Alhamama (Mibarh)	22.7	834
W4	Alhunih (Almurabiyh)	24.1	1168
W5	Zawiat aleurqub (Alsadra)	20.9	708
W6	Qisr libya (Adfids)	22.1	1074
W7	Albayada (Tis)	22.5	1100
W8	Tolmitha (Alsaahil)	21.9	1682
W9	Acaftan	21.4	817
W10	Mirad maseud (Alzaawih)	23.2	896
W11	Batah (Ain zaghroua)	22.7	1293
W12	Batuh (Qraabirbi)	23.3	1159
W13	Sayidi nuh	24.1	780
W14	Batuh (Khatu dighar)	23.1	934

Electrical conductivity is defined as a measure of the ions (positive and negative) present in water [9]. It represents the electrical conductivity of water, which is directly proportional to the temperature and the total amount of dissolved salts [10]. The standard Libyan specification for drinking water [11],

did not specify the temperature and electrical conductivity value. This study aligns with the study by [6], but it differs from the studies by [5,7]. regarding temperature and conductivity values.

2. **Chemical tests:** Potential hydrogen, total dissolved solids, nitrate, and total hardness as CaCO_3 values ranged between (7.26, 7.85), (460, 1093 ppm), (0, 15.67 ppm), (50, 450 ppm), respectively, from the wells. Table (3) shows the results of potential hydrogen, total dissolved solids, nitrate, and total hardness as CaCO_3 values for the studied samples.

Table (3): Results of pH, total dissolved solids, nitrate, and total hardness values

Sample	Sample location	pH	TDS ppm	NO_3 ppm	TH ppm
W1	Bialhadid (Alnukhlat)	7.40	656	2.95	370
W2	Bialhadid (Bufatimat)	7.41	762	2.57	410
W3	Alhamama (Mibarah)	7.38	542	1.714	330
W4	Alhuni (Almurabiyh)	7.26	759	1.945	270
W5	Zawiat aleurqub (Alsadra)	7.58	460	1.023	450
W6	Qisr libya (Adfids)	7.46	698	1.976	350
W7	Albayada (Tis)	7.43	715	3.85	390
W8	Tolmitha (Alsaahil)	7.47	1093	4.41	390
W9	Acaftan	7.85	531	0	330
W10	Mirad maseud (Alzaawih)	7.62	582	0	440
W11	Batah (Ain zaghroura)	7.47	840	13.33	50
W12	Batuh (Qraabirbi)	7.51	753	15	120
W13	Sayidi nuh	7.35	507	15.67	50
W14	Batuh (Khatu dighar)	7.38	607	15	88

The pH results showed that most water samples were neutral and fell within the limits and standard specifications permitted in Libya for drinking water (6.5, 8.5).

The concentration of total dissolved solids (TDS) is an important indicator of water suitability for various purposes and uses [12]. Dissolved salts affect the physical properties of drinking water, such as taste, hardness, and the tendency to form scale; it is observed from the results most of the samples were below the permissible Libyan limits and standards (1000 ppm), except for sample (W8), where it was (1098 ppm). These results are consistent with the study by [6], but they differ from the findings of [5,7]. These findings differ from those reported by [13], who identified two wells contaminated with nitrate and attributed this contamination to agricultural activities, the shallow depth of the wells, and the hydrological conditions of the area.

The concentration of nitrate in the examined groundwater wells was lower than the Libyan limits and standards for drinking water (45 ppm). The sources of nitrate pollution are septic tanks, animal and human waste, and commercial fertilizers [14]. These results are consistent with the study by [5-7].

The study results showed that hardness values ranged from 50 to 450 ppm, the lowest value was recorded in the water sample from Well (W13), while the highest value was recorded in the water sample from Well (W5). In all samples, hardness levels remained within the permissible limits according to Libyan standards (500 ppm). Consuming very hard water may increase the likelihood of developing urinary tract stones, whereas numerous studies and research have indicated an inverse relationship between water hardness and cardiovascular diseases [15].

3. Biological tests:

Testing for *Escherichia Coli* Bacteria (*E. coli*). The results of the microbiological analysis showed that the samples were free of *Escherichia coli* bacteria except for two samples (W11, W12). Table (4) shows the results of the sample analysis.

The results for the two samples were taken from the external tank of the well, not directly from the well itself. This is because the well pipe runs directly from the well into the tank without a valve at the well inlet. Therefore, the sample was taken from the tap leading out of the external tank. The structural condition of the two tanks was dilapidated and exposed to erosion and reptiles. These results do not align with the studies by [5-7,16].

Table (4): Results of *Escherichia coli* Bacteria

Sample	Sample location	E. coli
W1	Bialhadid (Alnukhlat)	-ve
W2	Bialhadid (Bufatimat)	-ve
W3	Alhamama (Mibarh)	-ve
W4	Alhuni (Almurabiyh)	-ve
W5	Zawiat aleurqub (Alsadra)	-ve
W6	Qisr libya (Adfids)	-ve
W7	Albayada (Tis)	-ve
W8	Tolmitha (Alsaahil)	-ve
W9	Acaftan	-ve
W10	Mirad maseud (Alzaawih)	-ve
W11	Batah (Ain zaghroura)	+ve
W12	Batuh (Qraabirbi)	+ve
W13	Sayidi nuh	-ve
W14	Batuh (Khatu dighar)	-ve

Conclusion and Recommendations:**Conclusion:**

Through this study, which shows fourteen samples of groundwater wells in the Al-Sahel Al-Jabal Al-Akhdar municipality in northeastern Libya, some physical properties were determined, such as temperature, electrical conductivity, as well as some chemical properties such as: (pH, total dissolved solids, total hardness as CaCO₃, nitrates, and biological properties such as *Escherichia Coli* Bacteria and such as comparing the practical results with local and international standard values, the results were as follows:

1. Laboratory results showed that the physical properties were at a good level, while local specifications did not define a standard for them.
2. Laboratory results showed that the chemical properties were within local specifications, with the exception of sample (W8) which exceeded the maximum allowed limit (1000 ppm).
3. Microbial results showed that two of the wells were contaminated with pathogenic *Escherichia coli* bacteria (W11, W12). The results of the two contaminated samples were taken from the external tank of the well, not directly from the well itself. This is because the well pipe runs directly from the well to the tank without a valve at the well inlet.

Recommendations:

Through the laboratory results obtained, the following recommendations were made:

1. The study recommends the importance of establishing a reference laboratory affiliated with the competent regulatory bodies to monitor the quality of drinking water in the Al-Sahel Al-Jabal Al-Akhdar Municipality.
2. Educating consumers through visual, audio and print media about water that is not suitable for human consumption.
3. Establishing a website that includes a database of groundwater wells in the Al-Sahel Al-Jabal Al-Akhdar Municipality, the results of periodic quality tests conducted by the relevant authorities, and any warnings or information about the quality of this water.
4. Inviting researchers to conduct further studies on groundwater in all areas of the Al-Sahel Al-Jabal Al-Akhdar Municipality.
5. It is important to build concrete tanks to dispose of sewage water, so that it does not reach the groundwater and cause its pollution.
6. Monitor agricultural fertilizers and pesticides because they pose a risk to the soil and then to groundwater

References:

1. Chong MN, Jin B, Chow CW, Saint C. Recent developments in photocatalytic water treatment technology: a review. *Water Res.* 2010;44(10):2997-3027.
2. World Health Organization. Guidelines for drinking-water quality. Geneva: World Health Organization; 2002.
3. Awo NF, Chris G, Kwasi AA. Physico-chemical quality of groundwater in Keta South, Ghana. *J Health Environ Res.* 2017;3(3):51-56.
4. Ibede A, Abosith MF, Alemad A, Elkharrim K, Belghyti D. Physicochemical quality of Murzuq groundwater Sabha, Libya. *WIT Trans Ecol Environ.* 2013;178:225-239.
5. Amhamed AF. Quality assay measurements of groundwater in Wadijarif-Sirte-Libya. 2020.

6. Hamad JRJ, Yaacob WZ, Omran A. Quality assessment of groundwater resources in the city of Al-Marj, Libya. *Processes*. 2021;9(1):154.
7. Mayouf K, Sharif A. A study of some chemical and bacteriological properties of groundwater and its suitability for drinking in the Gurji and Western Street areas, Tripoli. *J Pure Appl Sci*. 2024;23(1):120-124.
8. American Public Health Association. Standard methods for the examination of water and wastewater. American Public Health Association; 2017.
9. American Public Health Association. Standard methods for the examination of water and wastewater. 20th ed. Washington (DC): American Public Health Association; 1999.
10. Bachmat Y. Groundwater contamination and control. New York: Marcel Dekker; 1994.
11. Standard Libyan (S.C.L.10). National Center for Specifications and Standards for Drinking Water. First version; 2015.
12. Food and Agriculture Organization of the United Nations. Waste water treatment and use in agriculture. FAO Irrigation and Drainage Paper No. 47. Rome: FAO; 1992.
13. Al-haen M, Al-Haen I, Abdullah Abdullah, Habeeb Abdulqadir, Ahmed Mohamed, Ahmed Alabed. Spatial and seasonal distribution of nitrate and phosphate contamination in groundwater in Wadi Al-Tarfawi, Northeastern Libya. *Alq J Med App Sci*. 2026;9(1):288-294. doi:10.54361/ajmas.269145.
14. Wagh VM, Panaskar DB, Mukate SV, Aamalawar ML, Sahu LU. Nitrate associated health risks from groundwater of Kadava river Basin Nashik, Maharashtra, India. *Hum Ecol Risk Assess*. 2020;26:654-672.
15. Richards LA. Diagnosis and improvement of saline and alkali soils. Washington (DC): US Department of Agriculture; 1954. Agriculture Handbook No. 60.
16. Elbagrmi TM, Al-Haen IA, Amharb AM, Al-Haen MA. Bacteriological assessment of natural spring waters in the Al Jabal Al Akhdar Region, Libya: a field study of biological indicators of fecal contamination and their suitability for human consumption. *North Afr J Sci Publ*. 2026;4(1):327-332.