Libyan Journal of Medical Research

www.ljmr.ly/ eISSN:2413-6096

Original Article

Assessment of Groundwater Quality from a Chemical and Microbiological Perspective in Selected Domestic Wells in Al-Sarraj, Tripoli

Mohamed Orhuma[1], Ibrahim Greiby E[2] ,Abubaker Abutartour[1], Nour AlShamakhi[2], Lotfia El Majdoub[3], Hajar AlGhariani[1]

1. Libyan Advanced Center for Chemical Analysis, Libyan Authority for Scientific Research

2. Department of Food Science and Technology, Faculty of Agriculture, University of Tripoli

3. Department of Chemistry, Faculty of Science, University of Tripoli

Corresponding Author: ***Abubaker Abutartour***.*Email: abobaker.abase8@aal.ly*

Received:01/09/2025 Accepted:10/10/2025Published:16/10/2025 DOI: https://doi.org/10.54361/LJMR.19.2.40

Abstract

Background: Access to safe drinking water remains a global challenge, particularly in arid regions such as Libya, where groundwater is the primary source of domestic water supply. This study assessed the chemical and microbiological quality of groundwater from selected domestic wells in western Tripoli and compared results with Libyan drinking water standards. Material and Methods: A total of 20 groundwater samples were collected from domestic wells (35–100 m depth) in Al-Sarraj, Janzour, Al-Swani, and Bu Ghubba. Physicochemical parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), major ions, and hardness, were analyzed. Microbiological analyses targeted total coliforms, Escherichia coli, and total bacterial counts. Statistical analysis was performed using ANOVA. **Results:** Most samples exceeded Libyan standards for TDS (>3000 mg/L) and total hardness (>1400 mg/L). Approximately 60% of shallow wells (35–60 m) exhibited the highest contamination rates. E. coli concentrations reached up to 129 CFU/100 mL. Overall, the majority of wells were unsuitable for human consumption. **Conclusions:** Domestic wells in western Tripoli exhibit significant chemical and microbial contamination, rendering them unsafe for drinking water. Urgent interventions, including regular monitoring, enforcement of drilling regulations, and public awareness campaigns, are required.

Keywords: Groundwater; Drinking water; Escherichia coli; Water quality; Microbiological contamination; Libya

How to cite this article: Orhuma, M, Ghariby, I.E, Abutartour, A., AlShamakhi. N, El Majdoub.L, AlGhariani. H: Assessment of Groundwater Quality from a Chemical and Microbiological Perspective in Selected Domestic Wells in Al-Sarraj, Tripoli

Libyan 19-2

Libyan J Med Res. 2025:19-2. 331-337 331

INTRODUCTION

Groundwater represents one of the most important freshwater resources worldwide, serving domestic, agricultural, and industrial purposes. However, it is rarely available in pristine condition. One of the major causes of groundwater contamination is the infiltration of untreated wastewater, particularly in densely populated urban areas, which poses significant public health risks and contributes to the spread of waterborne diseases [2].Libya is among the countries facing severe water scarcity and relies almost entirely on groundwater as its primary water resource. In May 2017, the United Nations Children's Fund (UNICEF) in Libya, in collaboration with the National Center for Disease Control, conducted a nationwide assessment of water and sanitation quality in schools. The study targeted 140 schools, randomly selected across the western, eastern, and southern regions, with a representative subset of 73 schools used for in-depth evaluation. The findings revealed that 67% of schools had only limited access to drinking water (Figure 1), while 95.8% reported inadequate sanitation services. Moreover, coliform bacteria were detected in 46% of water samples, and Escherichia coli was present in 10% of samples. In 52% of schools with E. coli contamination, groundwater wells were the primary drinking water source. The study concluded that the most common causes of microbial contamination were linked to the quality of water sources and inadequate wastewater management practices [3].

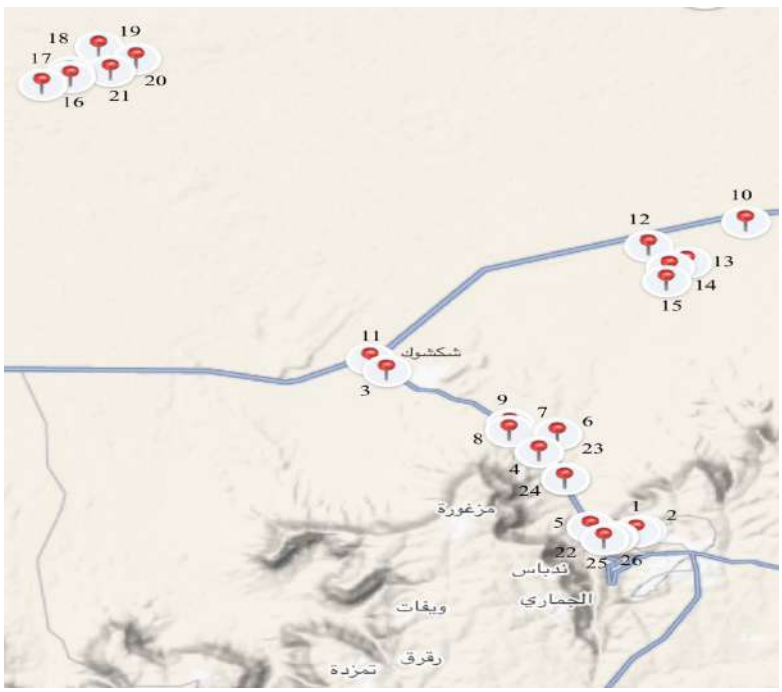

Figure 1: Categories of drinking water sources in schools contaminated with E. coli bacteria [2]

Several studies have highlighted the risks associated with groundwater contamination and its implications for public health. A 2020 study conducted in Yogyakarta, Indonesia, investigated the impact of Escherichia coli contamination in well water and demonstrated a clear association between the presence of E. coli and urinary tract infections among pregnant women who consumed contaminated water [4].In Libya, a study was carried out in Murzuq to evaluate the physicochemical characteristics of drinking water and the effect of well depth on water quality in comparison with the World Health Organization (WHO) and Libyan drinking water standards. A total of 63 samples were collected from shallow wells (<100 m) and deep wells (up to 650 m). The results revealed significant variations in salinity levels depending on well depth [5]. Similarly, Bruce et al. reported that individuals consuming untreated groundwater are at higher risk of contracting waterborne diseases. Another investigation in the United States revealed that nearly half of the wells were contaminated and deemed unsuitable for drinking water. The study estimated that contaminated groundwater causes between 750,000 and 5.9 million cases of illness annually, with an associated mortality rate ranging from 1,400 to 9,400 deaths per year, primarily due to failing or deteriorating sewage systems [2].In western Libya, Mabrouk Al-Arbash conducted an assessment of seven wells in Al-Ajilat to determine their suitability for drinking purposes based on chemical parameters. The findings indicated that pH and bicarbonate concentrations were within acceptable limits; however, total salinity, electrical conductivity, hardness, sulfate, and chloride levels exceeded permissible standards for drinking water [6]. In another study, Zahran Al-Rawashda investigated the sources of groundwater contamination in the Al-Jabal Al-Akhdar region, where rapid population growth, waste generation, and the excessive use of fertilizers and pesticides have accelerated groundwater degradation. Twelve wells were analyzed chemically and microbiologically: 41.7% were uncontaminated due to their distance from pollution sources, 8.3% showed moderate contamination primarily linked to agricultural practices, and approximately 50% were classified as highly contaminated. The latter were mostly located in residential areas lacking adequate wastewater treatment, with both coliform bacteria and chemical concentrations exceeding safe drinking water limits [7].Against this backdrop, the present study seeks to analyze groundwater samples from selected wells in western Tripoli and to compare their quality with the Libyan drinking water standards. The objective is to determine the suitability of these wells for drinking and domestic uses, while simultaneously raising community awareness regarding the safety and sustainability of local groundwater resources.

MATERIAL AND METHODS:

The following parameters were measured: pH, sodium, and potassium concentrations using a flame photometer; electrical conductivity (EC) with a conductivity meter; and total dissolved solids (TDS). Calcium and magnesium ions, as well as total hardness (TH), were determined by titration with 0.01 M EDTA. Chloride concentration was measured using silver nitrate titration with potassium chromate as an indicator, while bicarbonate concentration was determined via titration with standard hydrochloric acid using methyl orange as an indicator. Microbiological analyses were conducted to detect total coliforms, Escherichia coli, and total bacterial count following the procedures outlined in the Libyan National Standard for drinking water.

RESULTS:

The physicochemical analysis of groundwater samples revealed electrical conductivity and total dissolved solids (TDS) levels that frequently exceeded permissible Libyan standards, rendering the water largely unsuitable for drinking. While pH values were within acceptable limits, total hardness was predominantly above the regulatory upper limit. Microbiological assays confirmed widespread contamination, with coliform bacteria and Escherichia coli counts surpassing standard limits, indicating fecal pollution. Furthermore, elemental analysis showed considerable spatial variation in the concentrations of TDS, sodium, calcium, and manganese, with several locations exhibiting elevated levels. Collectively, these findings indicate that the analyzed groundwater is non-compliant with national standards for drinking and domestic use.

Table 1: Mean values of the chemical and physical analysis results of all samples from the study areas

location and number of sample	K	Na	Ca	Mg	TDS	T.H	Ca.H	Mg.H	HCO_3	Cl	pH	El. Cond. (µs/cm)
Al-Sarraj (1)	0.40	56.83	96.00	26.00	1004.00	348.00	240.00	108.00	219.00	326.60	7.19	1366.33
±	0.08	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	253.38

(2)	0.33	35.73	115.30	44.60	842.27	472.00	288.00	184.00	195.20	269.80	7.44	1295.33
±	0.05	0.05	0.00	0.00	1.74	0.00	0.00	0.00	0.00	0.00	0.00	2.36
(3)	0.50	77.83	60.80	148.00	617.03	280.00	152.00	432.00	195.20	127.80	7.34	949.33
±	0.00	0.33	0.00	0.00	3.76	0.00	0.00	0.00	0.00	0.00	0.24	5.79
(4)	0.50	48.77	89.60	50.50	786.03	432.00	224.00	208.00	244.00	312.40	7.43	1209.33
±	0.00	0.49	0.00	0.00	4.94	0.00	0.00	0.00	0.00	0.00	0.01	7.59
(5)	0.43	100.67	99.00	40.70	767.00	416.00	248.00	168.00	195.20	269.80	7.50	1180.00
±	0.05	3.40	0.00	0.00	5.31	0.00	0.00	0.00	0.00	0.00	0.00	8.16
(6)	0.63	84.00	99.00	64.00	789.30	512.00	248.00	264.00	292.80	198.90	7.20	1214.67
±	0.05	3.49	0.00	0.00	8.15	0.00	0.00	0.00	0.00	0.00	0.00	12.66
(7)	0.70	72.33	60.00	34.00	552.20	296.00	152.00	144.00	195.20	170.40	7.60	850.00
±	0.00	1.70	0.00	0.00	8.38	0.00	0.00	0.00	0.00	0.00	0.00	13.49
(8)	0.50	100.83	115.00	42.80	781.63	464.40	288.20	176.40	292.80	213.00	7.23	1202.67
±	0.00	4.40	0.00	0.00	14.04	0.00	0.00	0.00	0.00	0.00	0.02	21.56
(9)	0.40	79.90	109.00	42.70	711.30	448.00	272.00	176.00	219.00	227.20	7.72	1094.33
±	0.00	1.36	0.00	0.00	6.62	0.00	0.00	0.00	0.00	0.00	0.02	10.21
Janzour (1)	1.20	316.47	160.00	83.50	1752.83	744.60	400.00	344.00	390.40	568.00	6.99	2696.67
±	0.00	7.52	0.00	0.00	8.11	0.00	0.00	0.00	0.00	0.00	0.04	12.47
(2)	0.60	106.90	64.00	52.40	827.13	376.00	160.00	216.00	244.00	255.60	7.64	1272.33
±	0.00	1.31	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00	0.03	4.11
Al-Gypsum Gate (1)	0.30	50.07	76.80	591.00	1425.67	784.00	192.00	592.00	146.40	610.60	7.29	2194.33
±	0.00	0.40	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.02	0.47
(2)	0.50	352.17	413.00	46.40	3399.00	1225.00	1032.00	193.00	170.80	1448.60	7.50	5230.00
±	0.08	7.84	0.00	0.00	10.61	0.00	0.00	0.00	0.00	0.00	0.00	16.33
(3)	0.73	674.33	426.00	97.00	2978.67	146.00	1064.00	400.00	195.20	1505.20	7.34	4583.33
±	0.05	4.19	0.00	0.00	12.26	0.00	0.00	0.00	0.00	0.00	0.04	18.86
(4)	0.97	597.00	240.00	155.00	2604.67	1241.00	600.00	641.00	146.40	1320.00	7.64	4007.67
±	0.05	2.45	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.01	0.47
Al-Swani (1)	0.90	303.33	272.00	74.05	2335.67	984.00	680.00	304.80	195.20	1050.80	7.40	3833.33
±	0.00	2.62	0.00	0.00	226.10	0.00	0.00	0.00	0.00	0.00	0.00	12.47
(2)	0.67	107.67	169.00	11.60	1481.67	472.00	424.00	48.00	195.20	553.80	7.24	2280.00
±	0.09	4.19	0.00	0.00	23.23	0.00	0.00	0.00	0.00	0.00	0.02	35.59
(3)	0.50	130.00	70.50	54.00	811.83	400.00	176.00	224.00	195.20	255.60	7.51	1249.00
±	0.00	0.82	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.09	0.82
(4)	0.83	390.33	525.00	85.70	2279.17	960.00	1313.00	0.00	292.80	1079.00	7.77	3506.67
±	0.05	30.58	0.00	0.00	2.95	0.00	0.00	0.00	0.00	0.00	0.05	4.71
(5)	0.40	85.50	112.00	62.10	841.63	536.00	280.00	0.00	170.80	411.80	7.43	1295.33
±	0.00	0.41	0.00	0.00	5.39	0.00	0.00	256.00	0.00	0.00	0.05	7.76

Table 2: Microbiological analysis results of selected samples from the study area

T.count c.f.u/ml	c.f.u/100ml		location and number of sample
	T. coliform	E. coli	
9.0	320.0	2.0	Al-Sarraj (1)
880.0	200.0	0.0	Al-Sarraj (3)
448.0	750.0	110.0	Al-Sarraj (5)
480.0	350.0	129.0	Al-Sarraj (7)
32.0	320.0	1.0	Al-Sarraj (9)
21.0	62.0	0.0	Janzour (2)
15.0	180.0	38.0	Al-Gypsum Gate (1)
2.0	22.0	31.0	Al-Swani (2)
40.0	727.0	0.0	Al-Swani (5)

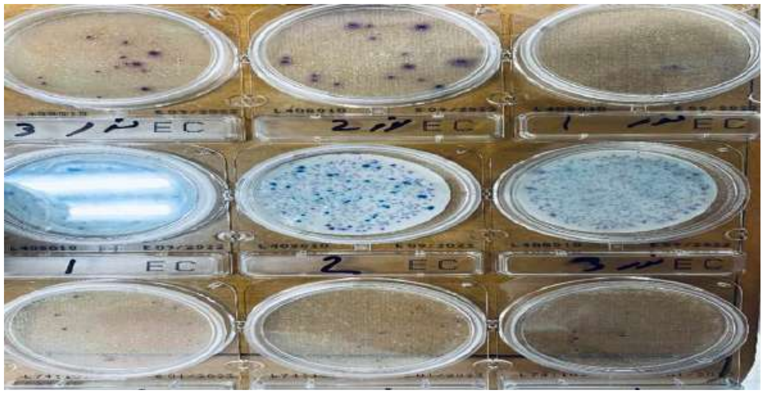

Figure 2: Illustrative image showing the growth of microorganisms on plates from different well samples.

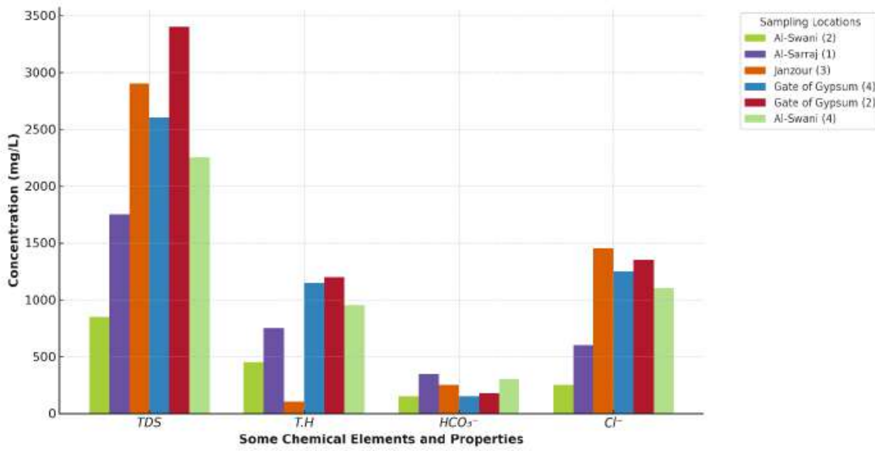

Figure 3. Concentrations of selected mineral elements and chemical properties of groundwater in different study areas.

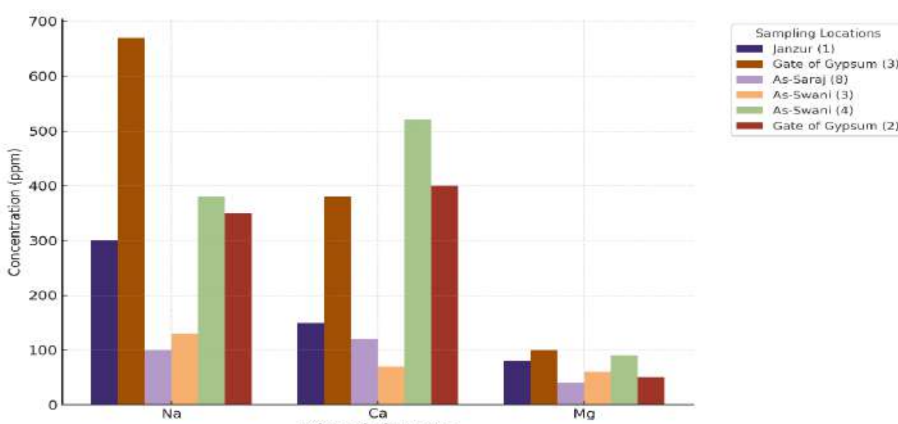

Figure 4. Concentrations of selected mineral elements in groundwater samples from different study areas.

DISCUSSIONS:

The physicochemical characteristics of the water samples are summarized in Table 1. Electrical conductivity values ranged between 800 and 5000 µS/cm, while total dissolved solids (TDS) varied from 500 to 3000 mg/L. The majority of samples exceeded the permissible limits set by the Libyan standards, rendering the water unsuitable and unpalatable for drinking [8]. The measured pH values ranged from 6.9 to 7.7, which fall within the acceptable range. Total hardness values ranged between 280 and 1465 mg/L, with most samples surpassing 400 mg/L, the upper limit specified by the Libyan standard. Excessive hardness not only affects water palatability but also limits its domestic use, as it reduces soap solubility and may contribute to scaling in household systems. Moreover, previous studies have reported a potential correlation between water hardness and cardiovascular diseases [9]. These findings are consistent with earlier research indicating that groundwater salinity (mineral and TDS content) varies with well depth [5]. Furthermore, as reported by Al-Barouni, Libya relies on groundwater for approximately 92.2% of its domestic, industrial, and agricultural needs [10], underscoring the critical importance of protecting and managing this resource. The observed exceedance of key parameters in this study highlights the urgent need for interventions to ensure groundwater safety and sustainability in western Tripoli. Note: Values are expressed as the mean of three replicates for each parameter analyzed per sample. Standard deviations (SD) are provided. Microbiological Analyses As summarized in Table 2, microbiological analyses revealed the presence of coliform bacteria, with values ranging from seven to 750 CFU/100 mL. These levels exceed the permissible limits established by the Libyan drinking water standards. The highest coliform concentration was observed in Al-Sarraj (Sample 5). Similarly, Escherichia coli counts ranged between 2 and 129 CFU/100 mL, with the highest concentration recorded in Al-Sarraj (Sample 7). The detection of E. coli provides clear evidence of contamination from wastewater or animal and bird excreta [4].Total bacterial counts varied substantially among samples, ranging from 2 to 800 CFU/mL, with the highest load observed in Al-Sarraj (Sample 3). Based on these findings, the groundwater samples analyzed in this study are deemed unsuitable for drinking and other domestic purposes, as they fail to comply with the Libyan drinking water standards. These results are consistent with the outcomes of previous studies reporting similar contamination patterns [5].Elemental Concentrations in Groundwater. Figure 3 illustrates the distribution of selected mineral concentrations across the study areas. The highest level of total dissolved solids (TDS) was recorded in Bu Ghubba (Sample 3), reaching approximately 3500 mg/L, while the lowest level was observed in Al-Swani at around 800 mg/L. Bicarbonate (HCO_3^-) concentrations were generally low across most sampling locations, with values below 400 mg/L. This trend is consistent with previous research conducted on wells in northeastern Libya, which reported that groundwater in Al-Bayda and Shahat was suitable for drinking, whereas wells in Derna, Ras Al-Hilal, and Al-Marj showed moderate contamination, and those in Susa were unsuitable for human consumption. Figure 4 presents the distribution of sodium, calcium, and manganese concentrations in the groundwater samples from the study areas. The highest concentrations were approximately 700 mg/L for sodium (Bu Ghubba, Sample 3), 500 mg/L for calcium (Al-Swani, Sample 4), and 100 mg/L for manganese (Bu Ghubba, Sample 3). Among the analyzed elements, manganese exhibited the lowest concentrations across all study locations.

CONCLUSION:

In conclusion, the groundwater in western Tripoli is critically compromised and poses a direct threat to public health. Our analysis definitively shows that the water is chemically unsuitable due to excessive salinity and hardness, and microbiologically unsafe due to severe fecal contamination from inadequate sanitation. This situation demands immediate and decisive action. We urgently call for the implementation of a rigorous and continuous water quality monitoring program, the strict enforcement of well-protection regulations, and significant investment in modern sanitation infrastructure. Furthermore, public awareness campaigns on the dangers of consuming untreated water are essential. Safeguarding this vital resource is not merely an environmental objective but a fundamental public health imperative, crucial for the well-being and sustainable future of the community.

Acknowledgments

The authors acknowledge the Libyan Advanced Center for Chemical Analysis, Tajoura, for providing laboratory facilities and technical support.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

REFERENCES:

1. Macler BA, Merkle JC. Current knowledge on groundwater microbial pathogens and their control. Hydrogeol J. 2000;8(1):29–40.
2. UNICEF. Assessment of water quality, sanitation, and hygiene in Libyan schools. Tripoli (LY): UNICEF and the National Centre for Disease Control; 2017.
3. Setianto YA, Hartono G, Gravitiani E. Effect of polluted well water by bacteria E. coli to urinary tract infections in pregnant women. Pollut Res J. 2021;40(1):12–20.
4. Hamed K, Abdulsalam S. Field study on the quality of drinking water in the Murzuq region. J Appl Sci. 2019;1(1):90–99.
5. Alarbash M, Mabrouk M. Study of groundwater quality and its suitability for drinking from a chemical perspective in the city of Ajilat. J Sci, Univ Al-Zawiya. 2017;1(1):45–52.
6. Alrawashda Z. Groundwater pollution issues in the Green Mountain region. Libyan J Agric Res. 2012;3(2):1369–1415.
7. Alabdali B, Alayeb M, Alzarbi A. Assessment of groundwater quality in the Bercis region, Green Mountain. Libyan J Environ Sci Technol. 2020;11:16–22.
8. Alhaloub R, Nasr M. Estimation of total hardness and some essential elements in bottled drinking water samples in the city of Misrata. [Master's thesis]. Misrata (LY): Libyan Academy; 2014.
9. Albaroni S. Overexploitation of groundwater in Libya. Eng Mag. 1997;1(1):36–37.
10. Nair GA, Bohjuari JA, Al-Mariami MA, Attia FA, El-Toumi FF. Groundwater quality of north-east Libya. J Environ Biol. 2006;27(4):695–700.