International Science and Technology Journal
المجلة الدولية للعلوم والتقنية

Volume 36 العدد
Part 2 المجلد

المجلة الدولية للعلوم والتقنية
International Science and Technology Journal
ISTJ

http://www.doi.org/10.62341/omgq1706

Received	**2025/05/25**	**تم استلام الورقة العلمية في**
Accepted	**2025/06/14**	**تم قبول الورقة العلمية في**
Published	**2025/06/17**	**تم نشر الورقة العلمية في**

Groundwater Quality Assessment in "AL JABAL AL AKHDAR Area", Libya

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Abstract

The present study deals with the area of Al Jabal Al Akhdar (Green Mountain) in Libya in order to evaluate the current status of the groundwater contaminants and their sources in groundwater. Groundwater samples are collected from 10 wells at different locations and analyzed. The physicochemical parameters—including pH, temperature, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), calcium, magnesium, total hardness, sodium, potassium, nitrate, sulfate, iron, manganese, and chloride—were measured using standard methods and compared against World Health Organization (WHO) guidelines.. The obtained results indicate that many of the estimated physico-chemical parameters of samples (1-7) are less than the permissible limits of WHO while, the values of the samples (8, 9 and 10) results exceeds the permissible limits of WHO, reflecting that the wells are contaminated and unfit for human consumption. Similar indicators are obtained by evaluation of the groundwater for irrigation uses. From bacteriolgoical study, for well numbers (8 , 9 and 10) have faecal contamination of groundwater with coliform bacteria because the number of coliforms is highly comparative with the acceptable value while none of other wells were recorded any coliform number.

Keywords: Groundwater, physicochemical and biological parameters, Al Jabal Al Akhdar area, Libya.

http://www.doi.org/10.62341/omgq1706

تقييم جودة المياه الجوفية في منطقة " الجبل الأخضر" ليبيا

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المستخلص

أجريت الدراسة في منطقة (الجبل الأخضر) في ليبيا لتقييم الوضع الراهن للملوثات الكيميائية والفيزيائية ومصادرها في المياه الجوفية. وقد تم تحليل عينات المياه الجوفية التي تم جمعها من 10 آبار في مواقع مختلفة. وقد تم تحليل المعاملات الفيزيائية مثل درجة الحرارة ، ودرجة الحموضة والاوكسجين الذائب والأيصالية والاملاح الذائبة الكلية ، والكيميائية مثل الكالسيوم والمغنيسيوم والعسر الكلي والصوديوم والبوتاسيوم والنترات والكبريتات والحديد والمنغنيز والكلوريد الأساليب القياسية وتقييمها مع معايير منظمة الصحة العالمية . وأظهرت النتائج أن العديد من المعاملات الفيزيائية والكيميائية للآبار (1–7) هي أقل مع الحدود المسموح بها لمنظمة الصحة العالمية . بينما المياه فى الآبار (8 و 9 و 10) هي أعلى من الحدود المسموح بها من منظمة الصحة العالمية بسبب قربها إلى البحر وأشار إلى أن مصادر هذه المياه ملوثة وغير صالحة للاستهلاك البشري . وبلانسبة لصلاحية المياه الجوفية للرى فلقد تم تقدير نسبة ادمصاص الصوديوم وبناء عليه تم تعيينها وتصنفيها من حيث الصلاحية فوجد أن مياه الابار (1 ، 3 و 7) ممتازة لأغراض الرى بينما مياه الابار الأخرى لا تصلح للرى. وقد تم تأكيد تلك النتائج بالتحليل البكتريبولوجى للمياه الجوفية التى استنتج منها ان الابار (8 ، 9 و 10) تحتوى على تلوث بيولوجى نتيجة وجود عدد كبير (22–30 CFU/ml).

الكلمات المفتاحية: مياه الابار، المعاملات البيولوجية والفيزوكيميائية، منطقة الجبل الاخضر، لبيبا

Introduction

Water, a fundamental element for life on Earth, plays a crucial role in many aspects of modern society. Its quality is of paramount importance to the environment, public health and various industries (Benaissa, et al., 2022). Life is not possible on this planet without

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water. It acts as a media for both chemical and biochemical reactions and also as an internal and external medium for several organisms. About 97.2% of water on earth is salty and only 2.8% is present as fresh water from which about 80% constitutes groundwater. Groundwater is highly valued because of certain properties not possessed by surface water (Singh, et al., 2015; Goel, 2000).

Because of the high concentration of certain chemical and physical factors, Libya's groundwater quality is a serious problem that poses a health risk to people (Rashrash, et al., 2015).

The suitable quality of water and its permits for drinking and other localized purposes depend on its physicochemical and microbiological properties (Abd El-Aziz, 2017). According to statistics, drinking water quality is directly linked to 80% of diseases in developing countries. Additionally, dirty and contaminated drinking water is linked to groundwater contamination, which can lead to diseases like cholera, diarrhea, dysentery, and hepatitis. Over 842,000 people worldwide pass away from diarrhea every year (Nnamani, 2018; Jauda, et al., 2021).

Groundwater is considered as one of the purest forms of water available in nature and meets the overall demand of rural and urban population. With the growth of industry the groundwater is made susceptible for contamination due to addition of waste materials. The quality of the groundwater is eroded as a result of factory waste products seeping into the aquifer through rainfall. Around the world, groundwater is utilized for agriculture, industry, domestic consumption, and water supply. In the last few decades, there has been a tremendous increase in the demand for fresh water because of rapid growth of population, unplanned urbanization and industrialization (Kfle, et al., 2019; Joarder et al., 2008).

North East Libya's Al Jabal Al Akhdar (Green Mountain) region has a distinct environment compared to the rest of the nation. Due in large part to its upland nature with a lot of flora and its proximity to the Mediterranean, it is the wettest region in Libya. The water resources in the Al Jabal Al Akhdar region are heavily wasted and abused due to inadequate management and negligence, which led to many negative consequences and water-related problems, e.g. reduction in water supply and deterioration in quality (Hamad, 2012).

Susa, Ras al-Hilal, and Derna are located on the foothills of Al Jabal Al Akhdar, which is home to higher locations like El-Marj, Albayda, and Shahat, Libya's primary tourist destinations. The Risiding

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people's primary activity is agriculture, and they rely significantly on groundwater for home, farming, animals, and potable needs. Groundwater quality testing on a regular basis is necessary to safe guard its long term sustainability (Chapman, and sullivan, 2022; Adak and Purohit, 2003)

The present work attempts to study the physicochemical properties in ground water of Al Jabal Al Akhdar (Green Mountain) area. The results of the study will help in gathering significant data pertaining to the aspects quality status of groundwater of Al Jabal Al Akhdar (Green Mountain). The obtained results may help the ground water conservation managers to improve and restore the groundwater.

Materials and methods

Location of Study Area

The study took place in Al Jabal Al Akhdar area, Libya. Al Jabal Al Akhdar, is a highland in northern-eastern Libya (Figure 1). In its core region, this crescent-shaped ridge rises to a height of over 850 meters above sea level. The northern flank consists of step-like plateau bordered by escarpments. The southern flank dips gently towards a depression extending from Ajdabiya to AI Jaghbub, which is marked by several large sabkhas. To the east and mostly to the west, a coastal plain is well developed between the foot of the first escarpment and the sea. (Pallas, 1978). Geographically, Al Jabal Al Akhdar is located between longitudes °21 31' 00" E and 21° 46' 00 E and latitudes 32° 45' 00" and 32° 53' 00", representing different topographic areas as shown in Table (1).

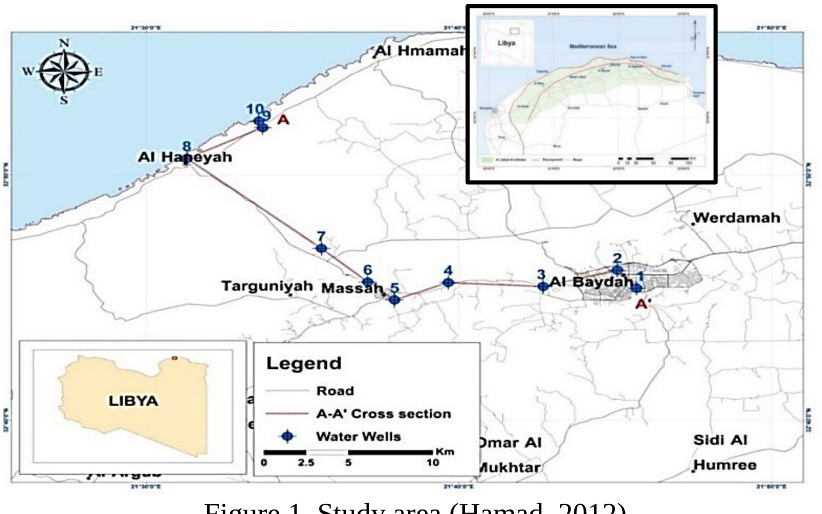

Figure 1. Study area (Hamad, 2012)

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Table 1. Data of groundwater wells, Al Jabal Al Akhder, Libya

Well no	Water bearing formation	Rock type	Depth, m	Ground elevation , m	Location coordinates East	Location coordinates north
1	Eocene - darnah formation	limestone	296	627	21° 45' 41"	32° 45' 23"
2	Eocene - darnah formation	limestone	300	623	21° 45' 40"	32° 46' 70"
3	Eocene - darnah formation	limestone	345	595	21° 42' 42"	32° 45' 27"
4	Eocene - darnah formation	limestone	319	570	21° 39' 40"	32° 45' 37"
5	Eocene - darnah formation	limestone	368	505	21° 37' 57"	32° 44' 54"
6	Oligocene – contact	Marl , clay , limestone	300	495	21° 37' 50"	32° 45' 38"
7	Eocene - darnah formation	limestone	325	310	21° 35' 36"	32° 47' 00"
8	Quaternary	limestone, shale, clay	4.5	6	21° 31' 18"	32° 50' 40"
9	Quaternary	limestone, shale, clay	24	27	21° 33' 44"	32° 51' 55"
10	Quaternary	limestone, shale, clay	24	27	21° 33' 36"	32° 52' 12"

Physico-chemical analysis of groundwater samples

Groundwater samples without any air bubbles were collected in polyethylene bottles as per standard procedure. Samples were analyzed for 17 parameters. Total dissolved solids (TDS), temperature and electrical conductivity (EC) were measured using Hanna auto ranging microprocessor EC/TDS/°C meter, and pH by pH meter mode 370/mv meter Wagtech. Iron, manganese, magnesium, calcium, sodium and potassium were analyzed using Flame Atomic Absorption GBC Scientific Equipment SAVANTAA. The following parameters are estimated using the following methods as indicated in brackets; Dissolved oxygen (DO) (azide modified winkler), Nitrate (cadmium reduction), Total hardness (EDTA titration), Chloride (Sliver nitrate titration), Sulphate (Turbidimetric Method) and Bicarbonate (Titration with HCl and methyl orange indicator).

Bacteriologcal analysis of groundwater samples

Samples are taken in a sterile 250 ml plastic bottle. To fill the bottle, carefully unscrew the cap and place it slightly below the water's surface. 100 ml of each water sample is filtered through a sterile

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membrane that traps bacteria in accordance with the Noble et al. (2003) membrane filter technique. After that, the membrane is aseptically transferred into MacConkey media and cultured for twenty-four hours at 37°C. Coliform density (total coliform colonies per 100 mL) or CFU is the number of resultant coliform colonies that indicate fecal contamination.

Results and discussion

The average value with standard deviation of the physicochemical parameters of water samples in ten places in Al Jabal Al Akhdar are estimated. They are tabulated (Tables 2, 3 & 4). While Table (5) shows the bacterological values of groundwater in ten places in Al Jabal Al Akhdar.

The results in Table (2) indicate variable concentration of calcium from 58.33 to 168 mg/L. Magnesium is supposed to be non-toxic at the normal concentration generally in natural water. The ranges of magnesium hardness change between 8.20-129.75 mg/L. All samples' magnesium values are within the WHO's safe ranges (150 mg/L) (Figure 2).

Large amounts of sodium give a salty taste when combined with chloride. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium concentrations varying from 30.05 to 62.67 mg/L (wells Nos. 1 & 7). They lie under the safe limits of WHO (200 mg/L) while the sodium concentrations of wells (8,9 & 10) are 529.17, 536.67 and 868.57 respectively due to the salt water intrusion from the Mediterranean Sea.

The primary sources of iron in groundwater include naturally occurring rock-forming minerals from mining and industrial waste, as well as corrosion. The high iron percentage imparts a harsh, severe taste to water and a brownish color to laundered garments and plumbing fixtures. Iron concentrations range from 0.2110 to 0.043 ppm (Table 2), according to WHO recommendations (1.0 ppm) (Figure 2).

Table 2. Concentration of cations and heavy metals (mg/L), the groundwater, Al Jabal Al Akhdar, Libya.

Well	Ca	Mg	Na	K	SAR	Fe	Mn
1	58.33± 1.08	29.41± 0.66	35.91± 0.44	1.47± 0.12	0.94± 0.01	0.133± 0.0007	0.017± 0.0001
2	87.00± 0.71	14.08± 0.27	41.17± 0.89	1.63± 0.02	1.06± 0.02	0.042± 0.001	0.005± 0.001

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3	63.00± 1.41	14.80± 0.24	30.05± 0.30	1.00± 0.03	0.88± 0.00	0.0347± 0.003	0.012± 0.008
4	68.00± 1.41	34.68± 0.42	40.02± 0.59	1.29± 0.03	0.97± 0.01	0.0547± 0.004	0.008± 0.004
5	104.33±1 .43	13.05± 0.13	62.67± 1.78	0.65± 0.03	1.53± 0.04	0.0243± 0.004	0.0133± 0.004
6	90.00±0. 71	8.20± 0.34	43.20± 0.75	2.26± 0.08	1.19± 0.01	0.0553± 0.004	0.0087± 0.004
7	87.33±1. 78	19.47± 0.36	49.40± 0.68	1.50± 0.02	1.23± 0.00	0.0883± 0.002	0.0950± 0.001
8	100.67 ± 0.82	102.58± 0.37	529.17± 15.78	35.1± 0.71	8.82± 0.25	0.0350± 0.004	0.0137± 0.002
9	168.00± 0.71	100.33± 1.08	536.67± 2.48	14.6± 0.09	8.04± 0.02	0.2110± 0.008	0.0933± 0.001
10	165.00± 0.71	129.75± 0.31	868.57± 21.36	30.1± 0.39	12.5± 0.12	0.1853± 0.004	0.0163± 0.001
WHO	75	150	200	200	-	1	-

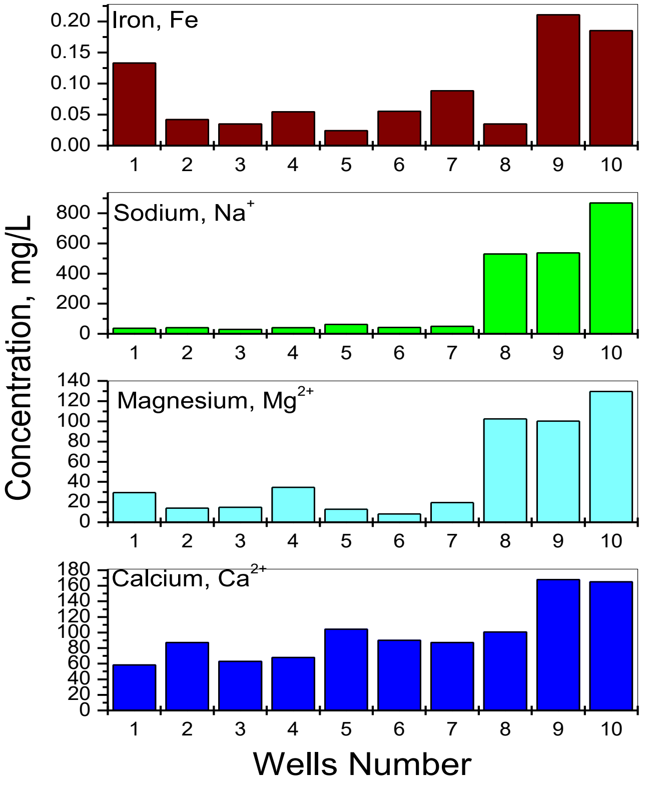

Figure 2. Histograms showing concentrations of cationic elements in the studied wells. Al Jabal Al Akhdar area, Libya

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Table (3) shows the values of anions concentrations in the groundwater of the studied wells. Bicarbonate concentrations change from 190 to 523.33 mg/l.

The nitrate concentration is within the set limit (50 mg/L) by WHO (2022). High nitrate values in groundwater are possibly due to organic and sewage pollution. The groundwater concentration of ntirate increased to (48.33 and 45.67 ppm) in wells 8 & 10 respectively. As the depth of the groundwater table increases, nitrate contamination often decreases (Figure 3).

Chloride concentrations range from 6 mg/L to 15 mg/L in the groundwater of Al Aabal Al Akhdar area (Tardy, 1971). Abundant chlorides in groundwater can indicate seepage from specific kinds of sewage facilities. Human wastes generally is high in chloride content. Once these wastes are deposited in sewage lagoons, chloride often moves to the system of groundwater and because it is not absorbed by soil, chloride can travel great distances. All kinds of water naturally include chloride. Natural water contains chloride due to industry, agriculture, and rocks that are high in chloride. The invasion of household trash and disposals by human activity is the cause of the high content of chloride (Jha and Verma, 2000). Wells 1 and 7 have chloride concentrations between 46.67 and 97.33 mg/L, which is within the WHO's permissible limit of 250 ppm and shows less chloride contamination. In contrast, wells 8 and 10 have chloride concentrations between 840 and 1393 mg/L because of salt water intrusion from the Mediterranean Sea (Fig.3).

Concentrations of sulphate range from 20 to 300 mg/L, falling within the WHO-permissible limits of 500 mg/L. Since seawater contains comparatively significant amounts of sulfate, seawater intrusion may cause sulphate levels in nearby coastal aquifers to rise (Sterrett, 2007).

Table 3. Concentration of some anions (mg/L), the groundwater, Al Jabal AlAkhdar, Libya.

Well	HCO_3^-	$SO4^{2-}$	Cl^-	NO_3^-
1	322.33±1.08	20.00±0.71	57.00±0.70	18.00±0.70
2	308.33±1.08	30.00±0.71	65.33±1.47	24.33±0.41
3	279.00±1.41	20.67±2.94	46.67±1.08	15.67±0.41
4	190.00±1.41	48.00±0.71	62.83±0.89	35.67±0.82
5	291.33±1.08	74.33±1.08	97.33±2.48	20.67±0.41

6	312.00±0.71	32.33±0.41	69.67±0.41	22.00±0.71
7	303.33±0.82	64.67±0.41	77.67±0.74	18.67±0.82
8	379.00±10.42	208.67±0.82	846.33±23.69	48.33±0.41
9	329.33±0.82	222.67±1.78	840.33±3.89	37.67±0.41
10	523.33±1.08	300.00±1.41	1393.00±1.41	45.67±0.82
WHO	-	**250**	**250**	**10**

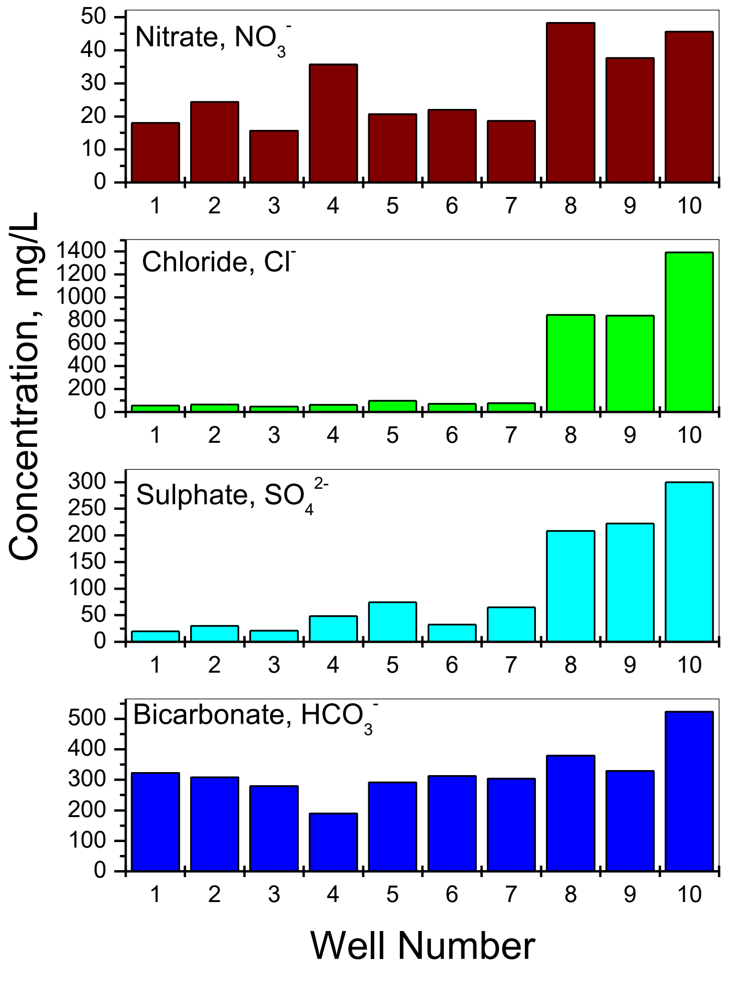

Figure 3. Histograms showing concentrations of anionic elements in the groundwater of the studied wells. Al Jabal Al Akhdra area, Libya.

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The groundwater temperature in the wells under study ranges from 19.23 to 22.17°C (Table 4). While hot water encourages the growth of microorganisms, which can lead to an increase in taste, odor, color, and corrosion issues, cool waters are typically more suitable for drinking (Okoye and Okoye, 2008). Metal corrosion problem are also associated with high temperature especially when the water being more acidic.
Water samples were found to have pH levels ranging from 7.21 to 7.83, which falls within the World Health Organization's (WHO) recommended range of 6.5 to 8.5.
According to European economic community report (Indirabai and George, 2002), the maximum amount of (DO) that can be present in drinking water is 5 parts per million (ppm), and Renn (1970) postulated 6 ppm and above as the standard desirable limit of oxygen for water, but this value varies depending upon water temperature and the partial pressure of oxygen in its gas phase. The DO has the value above 7 mg/L. The combination of oxygen-rich rainwater with groundwater may be the cause of the high oxygen content (Figur 4).
The ability of a fluid to transport an electrical charge is measured by its conductivity, which is directly correlated with the concentration of dissolved chemicals in the water. The higher the overall amount of dissolved substances in the water, the higher the conductivity of the water. Every sample's (EC) was higher than the WHO-established acceptable level of 500 µS/cm. EC is a measure of soil salinity and water quality. As a result, several water samples, like those from wells No. 8, 9, and 10, had comparatively high readings that indicated high salinity. The EC values of 4550.67, 4472.33, and 6301.67 µS/cm, respectively, indicate that the water is highly acceptable for both agricultural and home usage (Goel, 2000).
The dissolved combined content of all inorganic and organic materials in a liquid, whether they are molecular, ionized, or micro-granular, is measured by the term (TDS). Although TDS is not typically regarded as a primary pollutant, its primary usage is in the study of water quality. It is employed as an aggregate indicator of the presence of a wide range of chemical contaminants as well as an indicator of the aesthetic qualities of drinking water. According to the classification by Subba Rao (2017) and WHO, 2022, the groundwater quality ranges from fresh water (TDS < 1000 mg/l) to brackish water (1000 mg/l < TDS < 10,000 mg/l). The total dissolved solids of wells (Nos.1-7) ranges between 452 and 651

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mg/L, indicating fresh water, while it increases in the (8, 9 and 10) wells and changes from (2995 mg/L) to (4152 mg/L) indicating brackish water. It is obvious that TDS also increases from inland to the coast. This is attributed to water-rock interaction or saltwater invasion from the Mediterranean Sea (Figure 4).

Calcium and magnesium are responsible for almost all of the hardness in ordinary water. In addition to alkali metals, all metallic cations contribute to hardness. The range of total hardness is 217.70 to 320.35 mg/l. They fall within the WHO-recommended acceptable limit of 500 mg/L, with the exception of wells Nos. 8, 9, and 10, where the levels vary from 672.90 to 834.00 and 947.23 mg/L, respectively.

Table 4. Physical parameters of the groundwater, Al Jabal Al Akhdar area, Libya*

Well	DO	Temp, °C	TDS	EC, µS/cm	pH	TH
1	7.23± 0.15	19.23± 0.17	506.00± 0.71	718.00± 3.93	7.83± 0.01	264.16± 2.51
2	6.67± 0.08	20.23± 0.18	524.00± 1.41	790.00± 1.41	7.21± 0.01	275.23± 2.86
3	7.30± 0.07	21.23± 0.15	452.00± 1.41	633.33± 2.16	7.64± 0.01	217.70± 3.77
4	9.17± 0.20	19.70± 0.19	540.67± 0.41	818.67± 4.32	7.61± 0.01	313.13± 3.60
5	8.23± 0.11	20.33± 0.29	651.67± 1.08	988.00± 1.41	7.62± 0.02	320.35± 1.62
6	8.37± 0.11	20.30± 0.19	568.00± 1.22	810.67± 1.63	7.32± 0.01	254.83± 5.81
7	8.83± 0.11	22.17± 0.20	516.33± 1.08	735.33± 2.16	7.67± 0.01	301.00± 5.61
8	8.47± 0.11	21.63± 0.39	2995.67± 3.63	4550.67± 9.65	7.81± 0.01	672.90± 2.72
9	7.77± 0.11	21.77± 0.48	2951.67± 1.08	4472.33± 1.78	7.55± 0.01	834.00± 2.83
10	8.33± 0.11	20.83± 0.54	4152.00± 1.22	6301.67± 2.48	7.53± 0.02	947.23± 0.48
WHO	**7.5**	**30-32**	**500**	**500**	**6.5-8.5**	**500**

*All parameters are expressed in mg/L except pH, Temperature (°C) and (Electric conductivity) EC (EC is expressed in **µS/cm**); DO : Dissolved oxygen; TDS: total dissolved solids ; TH: total hardness

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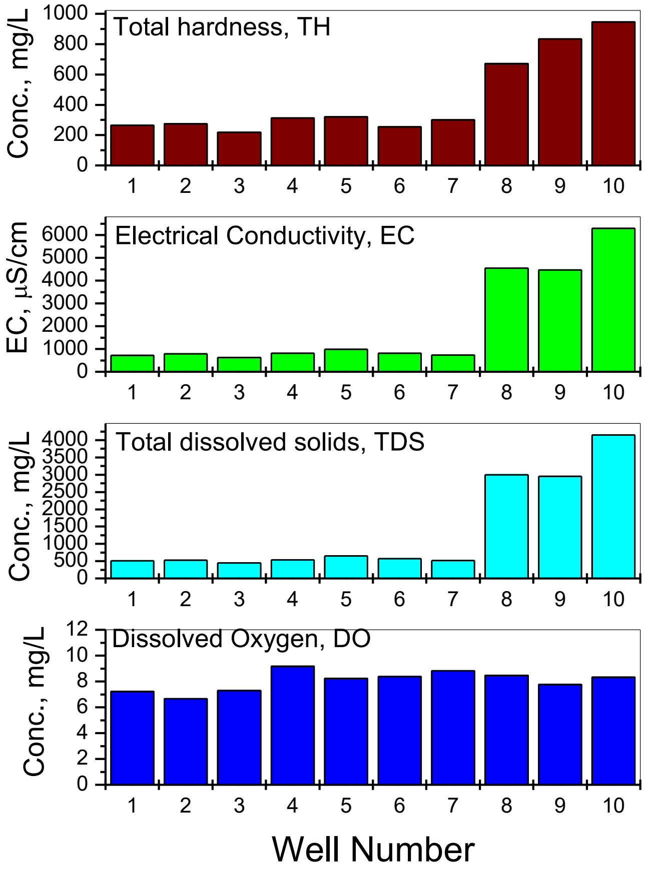

Figure 4. Histograms showing physical parameters of the groundwater, Al Jabal Al Akhdar area, Libya

The Piper diagram **(Piper, 1953)** is used to classify groundwater genetically (Figure 5). The two lower triangles in this diagram represent the milliequivalent distribution of the major anions (Cl^-, SO_4^{2-}, and CO_3^{2-} plus HCO_3^-) and cations (Mg^{++}, Ca^{++}, and Na^+ plus K^+). The diamond-shaped portion above summarizes the dominant cations and anions to show the last water class. The samples in wells (1,4) exhibit a mixed calcium-sodium composition, according to the cation distribution. Calcium makes up the composition of the samples from wells 2, 3, 5, 6, and 7. On the other hand, sodium makes up wells 8 and 10. Bicarbonate type water for samples (wells 1–7) and chloride type water for samples (wells 8–10) are more common in the anion triangle. All of the samples fall within the diamond's upper portion, which denotes a major salinity character. This indicates a source that is becoming more salinized, either as a result of salt water incursion or as a result of salts and evaporating water bearing rocks interacting.

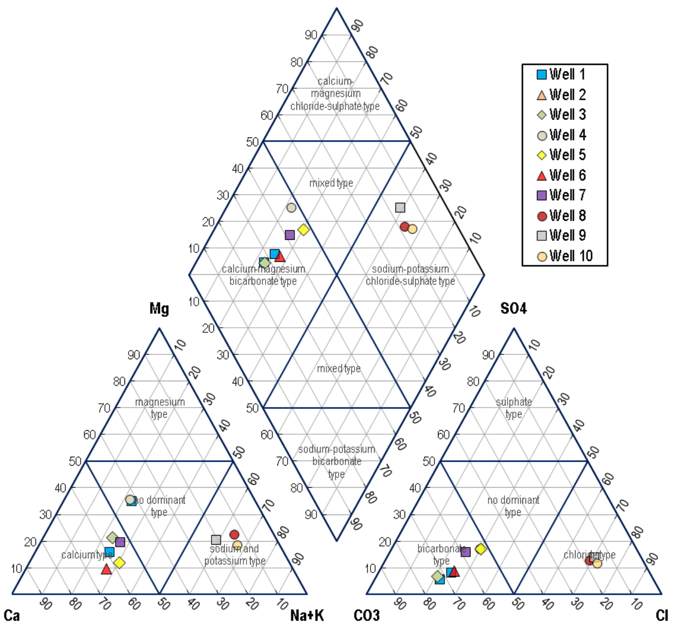

Figure 5. Piper diagram of groundwater samples of the studied wells

Sodium adsorption ratio (SAR)

The sodium adsorption ratio (SAR) values of each water sample were calculated by using Richard (1954) equation:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$$

The amount of salt absorbed by the soil and the SAR values of irrigation water are significantly correlated. The cation-exchange complex may become saturated with sodium if the irrigation water has a high salt content and a low calcium content. The dispersion of clay particles might cause the soil structure to be destroyed. In the wells under study, the computed SAR value varies from 8.82 to 8.04 and 12.50, respectively (wells 8, 9, and 10) and from 0.94 to 1.53

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(wells 1, 7, inclusive) (Table 2). The data is depicted on the salinity diagram (Figure 6), where the alkalinity danger is represented by SAR and the salinity hazard by EC. The C2S1 class, which has a medium salinity hazard and a low sodium hazard, includes the water samples from wells 1, 3, and 7. With a high salinity hazard and a low sodium hazard, the water samples from wells 2, 4, 5, and 6 are classified as C3S1 quality. The C4S3-quality class, which includes samples from wells 8, 9, and 10, has a very high salinity danger and a high sodium hazard.

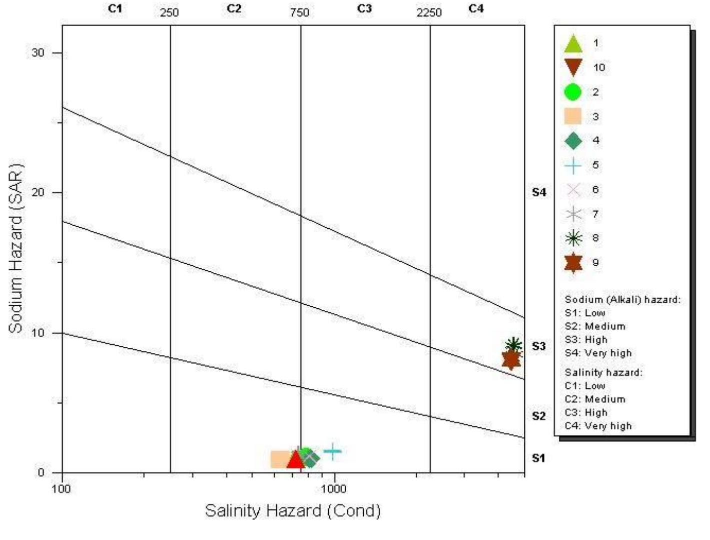

Figure 6. Groundwater classification according to EC and SAR values of the studied wells, Al Jabal Al Akhdar, Libya

The total count of bacteria

The total count of bacteria per ml of sample for to well were ranged from 4 to 19 CFU/ml for well numbers (1, 2, 3, 4, 5 & 6). On the other hand, the count of bacterial colony were 24 , 200 , 163 , 177 CFU/ml for the well numbers (7, 8, 9 & 10) respectively (Table 5) .

The total count of coliforms bacteria

The total count of coliform per 100 ml isolated from 10 well sample were ranged from 22 to 30 CFU/ml for well numbers (8 , 9 and 10) which suggest faecal contamination of groundwater with coliform bacteria because the number of coliforms is highly comparative with

http://www.doi.org/10.62341/omgq1706

the acceptable value due to uncover well's open. None of other wells were recorded any coliform number (Table 5).

Table 5. The total count of bacteria and coliforms isolated from wells in this study.

Well of no	Total count of bacteria per ml of water sample (main)	Coliforms per 100 ml (main)
1	12	0
2	10	0
3	19	0
4	12	0
5	9	0
6	4	0
7	24	0
8	200	30
9	163	22
10	177	25

Conclusions

Since the water's quality dictates its suitability for different uses and because Al Jabal Al Akhdar needs water for irrigation and drinking, it is essential to talk about groundwater evaluation in particular. It appears that the groundwater from wells 1, 7, and more has values below WHO criteria and can be used safely for drinking based on the chemical analysis results collected during the current study and in accordance with WHO standards. However, because wells 8, 9, and 10 are so close to the Mediterranean Sea, their groundwater is unfit for human consumption. Higher levels of salt, nitrate, and TDS contaminate them. The Department of Agriculture's Salinity Laboratory's 1954 Sodium Adsorption Ratio (SAR) guidelines, which assess the appropriateness of water for irrigation, were also taken into account. Wells 1, 3, and 7 have excellent groundwater for irrigation purposes based on the classification of groundwater for irrigation purposes. Other wells supply groundwater that is unsuitable for cultivation. According to a bacteriological research, well numbers 8, 9, and 10 have fecal contamination of groundwater with coliform bacteria since their coliform counts are very comparable to the allowed value, although no coliform counts were found in any of the other wells.

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