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Assessment of Ground Water Quality for Drinking Purpose through WQI in Surman (Zakry Locality), Libya.

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Abstract

Water is essential for human being use and livelihoods ecosystem functioning and services, and the survival of all living species. Water Quality Indices aim at giving a single value to water quality of a source reducing numerous parameters into a simpler expression and enabling easy interpretation of monitoring data. Standard water quality model was used to assess the groundwater quality for drinking purposes in Surman (Zakry locality), Libya. Ten samples from different sites were collected and analyzed for understanding the hydrochemical characteristics and the suitability for drinking purposes. Ten parameter were considered for calculating the water quality index, these are calcium, magnesium, sodium, potassium, chloride, bicarbonate, sulfate, pH, total dissolved solids and total hardness. The results obtained from the water quality index were calculated, and found to be within the observed parameters which ranges from 35.69 to 66.05. The total dissolved solids (TDS) were in the majority of samples higher than the permissible limit. The pH values tend slightly toward the acidic range.

Keywords: WQI, drinking purposes, Groundwater quality, moderate, Surman.

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تقييم جودة المياه الجوفية لأغراض الشرب من خلال مؤشر جودة المياه في محلة زكري صرمان، ليبيا

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الملخـــــــص

تعتبر المياه ضرورية لحاجة الإنسان وصحته ورفاهه وسبل عيشه وأداء النظم الإيكولوجية وخدماتها، وبقاء جميع الأنواع الحية. تهدف مؤشرات جودة المياه إلى إعطاء قيمة واحدة لجودة المياه وتقليل عدد المتغيرات، مما يتيح تفسير أسهل للبيانات. تم استخدام مؤشر جودة المياه الحسابي لتقييم جودة المياه الجوفية لأغراض الشرب في مدينة في صرمان (محلة زكري)، ليبيا. تم تجميع وتحليل عشرة عينات من مواقع مختلفة لفهم الخصائص الهيدروكيميائية ومدى ملاءمتها لأغراض الشرب. تم اختيار عشر متغيرات لحساب مؤشر جودة مياه الشرب وهي الكالسيوم، المغنيسيوم، الصوديوم، والبوتاسيوم، الكلوريد، البيكربونات، الكبريات، الأس الهيدروجيني، المواد الصلبة الذائبة الكلية والعسر الكلي. تراوحت قيم النتائج التي تم الحصول عليها لمؤشر جودة المياه المحسوبة للمتغيرات المرصودة من 35.69 إلى 66.05. أظهرت غالبية العينات ارتفاع قيمة المواد الصلبة الذائبة الكلية وايضا قيم الرقم الهيدروجيني تميل قليلاً نحو المجال الحمضي.

الكلمات المفتاحية: مؤشر جودة المياه الحسابي، أغراض الشرب، جودة المياه الجوفية، معتدلة، صرمان.

Introduction

The groundwater is the main source of water supply for drinking and irrigation in arid and semi-arid regions. Quality of groundwater depends mainly on the geochemistry of the soil and rocks. Usually, the chemistry of groundwater is heterogeneous and it is driven by flow, geochemical processes, evapotrans-piration, and potential sources of pollution [1, 2]. The Water quality is characterized based on water parameters (physical, chemical, and microbiological), the human health is at risk if those values exceed standard limits [3, 4].

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Understanding the chemical characteristics of groundwater and its influencing factors is critical to the protection and management of groundwater resources and the sustainable use of groundwater. Using a feasible and effective drinking water quality assessment method is critical to achieve reliable results, facilitating wise decision-making [5]. Water quality index (WQI) is considered as the most effective technique to assess the quality of water. Initially, water quality index (WQI) was developed by Horton (1965) [6] in the United States by selecting 10 most commonly used water quality variables, like dissolved oxygen, pH, coliforms, specific conductance, alkalinity and chloride. A new WQI similar to Horton's index has also been developed by the group of Brown in 1970 [7], which was based on weights to individual parameter. WQI has the capability to reduce the bulk of the information into a single value to express the data in a simplified and logical form. It takes information from a number of sources and combines them to develop an overall status of a water system. They increase the understanding ability of highlighted water quality issues by the policy makers as well as for the general public as users of the water resources [8-13]. Commonly, water quality index (WQI) is based on the following four steps: - selection of the parameters, - determination of the quality function for each parameter, - calculation of the parameter weighting values and - aggregation through mathematical equation [14-20].
The aim of this study was to evaluate the groundwater resources for drinking purpose in in Zakry locality Surman, Libya using weighted arithmetic water quality index (WAWQI) based on some chemical and physical parameters.

Materials and Methods

The study area is located in the north western part of Libya in Surman (Zakry locality) between the following latitudes and Longitude in Table 1 and showed in Figure 1:

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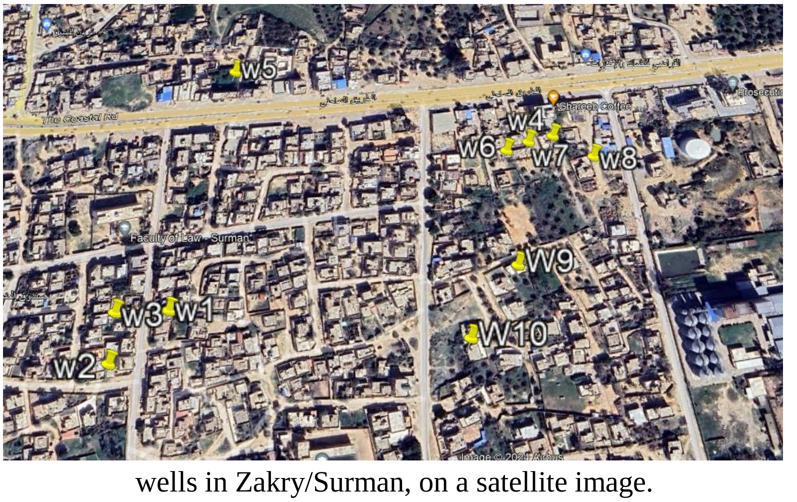
Table 1. Different Locations of the study area.

Well	Latitudes	Longitude
W1	32°45'14.29"N	12°34'52.45"E
W2	32°45'12.21"N	12°34'50.35"E
W3	32°45'14.22"N	12°34'50.14"E
W4	32°45'21.83"N	12°35'8.06"E
W5	32°45'25.51"N	12°34'53.42"E
W6	32°45'21.39"N	12°35'7.01"E
W7	32°45'22.15"N	12°35'9.23"E
W8	32°45'21.17"N	12°35'11.14"E
W9	32°45'16.25"N	12°35'7.54"E
W10	32°45'13.26"N	12°35'5.52"E

Figure 1. Location of the study area, showing the Ten sampled water



wells in Zakry/Surman, on a satellite image.

The collected ten groundwater samples were selected randomly from both private and public water wells. At each borehole location, the sample bottles were washed and rinsed thoroughly with the sample water before being sampled. The boreholes were pumped for about 5 minutes to ensure stable conditions before samples were collected. The water samples were analyzed by the Libyan Center for Studies and Research in Environmental Science and Technology Brak Alshatti. Various selected water parameters including pH, total dissolved solids (TDS), concentration of cations such as Calcium, Magnesium, Sodium and Potassium and concentration of anions such as Chloride, Bicarbonate and Sulfate. The concentration of Sodium and Potassium were measured using Flame photometer. The total hardness Calcium and Magnesium were determined by EDTA titrimetric method. The concentration of Chloride was determined with silver nitrate titration. The concentrations of Bicarbonate were determined by sulfuric acid. Whereas, the concentrations of Sulfate were determined using spectro-photometer. The Salinity refers to the amount of total dissolved solids (TDS) in the water and is frequently measured by electrical conductivity (EC). Waters with higher TDS concentrations will be relatively conductive. The general formula adopted to calculate TDS [21] is

$$TDS\left(\frac{mg}{L}\right) = 0.64 \cdot EC\left[\frac{\mu S}{cm}\right] \ldots\ldots\ldots \quad (1)$$

The statistical parameters and the major ion-concentrations (mg/L) in capering with the Libyan standard [4], are tabulated in Table 2.

Table 2. Chemical analysis of Groundwater in (mg/L)

Well	pH	TDS	Ca^{2+}	Na^{+}	Mg^{2+}	K^{+}	HCO_3^{-}	Cl^{-}	TH	SO_4^{2-}
limit	7.5	1000	200	200	150	40	200	250	500	250
1	6.63	1354.24	22.40	207.20	10.56	15.23	5.12	34.79	100.00	20.50
2	6.63	1352.96	18.20	213.33	5.20	13.33	5.20	44.73	36.00	12.83
3	6.60	388.56	14.40	202.50	0.96	12.38	6.24	59.64	40.00	3.13
4	6.72	1509.95	9.60	200.00	12.96	11.19	4.16	54.67	36.00	0.80
5	6.51	1784.77	12.00	294.35	1.44	18.09	4.64	59.91	69.93	12.49
6	6.66	1152.00	24.06	190.54	4.86	11.80	6.35	45.50	80.08	12.01
7	6.68	1248.00	18.45	195.50	3.89	12.50	5.73	49.98	62.06	7.69
8	6.62	1312.00	9.62	201.50	9.72	14.60	4.65	49.63	63.91	13.93
9	6.61	1356.80	18.20	198.50	170.10	13.50	6.50	50.50	64.10	11.80
10	6.63	1184.00	14.36	210.10	23.81	12.70	5.70	52.40	66.80	10.20

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- **Water quality index**

The assessment of the water quality is difficult simply from elemental concentrations of various water quality parameters. Thus, water quality indices are applied to evaluate water quality through reducing numerous parameters into a simple mathematical expression and enabling easy interpretation of monitoring data [22]. Most of the models employed eight to eleven water quality parameters. In this study, ten (10) important parameters Table (2) were chosen to measures drinking water quality with the application of the following model:

- **Standard water quality model**

The standard water quality model (SWQM) was computed using the 10 various water quality parameters and their relevant Libyan guidelines. According to [23-26], physicochemical parameters were assigned a weight (w_i) from 1 to 5 depending upon their significance in water quality evaluation for human health. In this study, the highest weight of 5 was assigned to nitrates because of its higher impact on human health. To calculate SWQM, three steps were followed [24]:

- Relative weight (W_i) was computed using equation (2)
-

$$W_i = \frac{w_i}{\sum w_i} \dots\dots\dots\dots\dots\dots\dots\dots (2)$$

- Quality rating (Q_i) for each of the observed parameters was calculated using equation (3).
-

$$Q_i = \left[\frac{V_n}{S_s}\right] \cdot 100 \dots.\dots\dots.. (3)$$

where Q_i represents the quality rating, V_n is the concentration of each chemical parameter in each sample (mg/L), and S_n refers to the standard limit for each chemical parameter (mg/L) according to the guidelines of the Libyan standard.

- The Standard water quality model (WQI) was calculated using equation (4).

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$$SWQI = \sum_{i}^{10} (W_i \cdot Q_i) \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Based on the water quality index, the water quality rating is classified into five categories, Table (3) [22].

Table 3. Water quality rating.

WQI	Rating
< 50	excellent
50 – <100	good
100 – < 200	poor
200 – < 300	very poor
≥ 300	unfit

Results and Discussion

The statistical summary of observed concentrations of various parameters in the sampled groundwater with their standards is described in Table 2. Water samples collected from ten different locations in Zakry locality in Surman, Libya were tested to determine the Water quality. Different levels of water quality rating and their respective water quality condition were given in Table 3. The parameters were assigned a weight (w_i) from 1 to 5 depending upon their significance in water quality evaluation for human health. Table (4) presents analyzed physicochemical parameters and their respective assigned, the highest weight of 5 was assigned to the total dissolved solids. The summations of all weights $\sum w_i$ were 30. Calculation for Well 1 as an example, the unit relative weight W_i and the quality rating scale Q_i for each parameter were calculated using equation (2 and 3) respectively and summarized in Table 4.

Table 4. Calculation of WQI, for well 1 as an example.

par.	S_i	V_i	w_i	W_i	Q_i	$W_i \cdot Q_i$
pH	7.5	6.62	4	0.1333	88.27	11.77
TDS	1000	1354.24	5	0.1667	135.42	22.57
Ca^{++}	200	22.4	2	0.0667	11.20	0.75
Na^{+}	200	207.2	3	0.1000	103.60	10.36
Mg^{++}	150	10.56	3	0.1000	7.04	0.70

K^+	40	15.23	4	0.1333	38.08	5.08
HCO_3^-	200	5.12	2	0.0667	2.56	0.17
Cl^-	250	34.79	2	0.0667	13.92	0.93
HD	500	100	3	0.1000	20.00	2.00
SO_4^{--}	250	20.5	2	0.0667	8.20	0.55
					WQI	54.87

Analog calculations for all other wells for, WAWQI are summarized in the Table 5 and depicted in Figure 2.

Table 5. Calculation of SWQI, for all wells.

Well	WQI	Rating
1	54.87	Good
2	52.83	Good
3	35.69	Excellent
4	54.36	Good
5	66.05	Good
6	48.97	Excellent
7	50.46	Good
8	52.67	Good
9	63.90	Good
10	51.52	Good

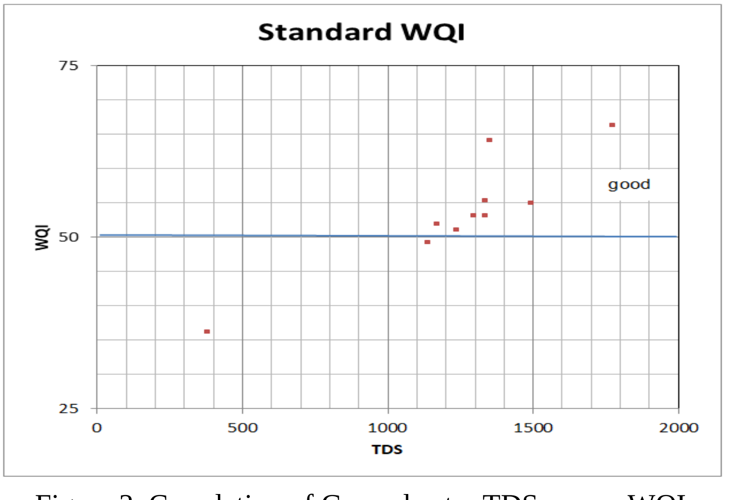

Figure 2. Correlation of Groundwater TDS versus WQI.

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All the values obtained for the ten parameters (Table 2) used for WQI were within permissible limits except the total dissolved solids (TDS) values which were above the Libyan Standard permissible limits. The pH values tend slightly toward the acidic range. Analysis of drinking water quality by WQI showed that the majority of samples were good water quality (50 - < 100), only two (2) samples were excellent (< 50).

Conclusions

The groundwater quality in Zakry locality in Surman, NW Libya were evaluated for their chemical composition and suitability for drinking purpose using the standard water quality index (WQI). Ten (10) water samples from different locations were collected and analyzed for various physico-chemical parameters. The majority of the results obtained described the quality of groundwater in the study area as good according to the water quality rating of the used model. The total dissolved solids (TDS) were in the majority of samples higher than the permissible limit. The pH values tend slightly toward the acidic range.

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