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Evaluation of Groundwater Quality in the Settlement Agricultural Project, Ubari Libya

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ABSTRACT

Evaluation of groundwater potential and its quality assessment for drinking and irrigation has recently become a major concern, especially in developing countries. The primary aim of this study is to analyze the quality of groundwater and establish whether they are safe for domestic and agricultural usage. Elven groundwater samples from different sites were collected and analyzed for understanding the Hydrochemical characteristics and the suitability for drinking and irrigation purposes in the settlement agricultural project, Ubari Libya. Elven parameter were considered for calculating the irrigation and drinking water quality indices which are calcium, magnesium, sodium, potassium, chloride, bicarbonate, sulfate, nitrate, pH, total dissolved solids and total hardness. Furthermore, graphical representation such as base exchange indices, meteoric genesis index, chloro-alkaline indices, USSL and Wilcox diagrams were prepared for irrigation water quality. Standard water quality model and synthetic pollution index were used to assess the groundwater quality for drinking purposes in the study area. The calculated parameters; Potential Salinity, Kelly's Ratio, Sodium Adsorption Ratio, and Sodium Percentage show that the majority of the groundwater samples are suitable for irrigation uses. USSLS diagram indicate groundwater quality as moderate salinity and low sodium and water with good quality. Wilcox diagram classify the majority of samples as excellent category. The groundwater samples are categorized as (Na^{+}- SO_4^{2-}) , type and the sources of groundwater are deep meteoric water percolation type. All samples have positive chloro-alkaline indices, indicating a base-exchange reaction. The drinking water quality analysis by the standard water quality model shows that majority of the samples described the groundwater quality in the study area as good to excellent for direct consumption. Based on the Synthetic pollution index, all water samples were identified as moderately polluted. Generally, the groundwater in the study area is good for drinking and irrigation purpose.

تقييم جودة المياه الجوفية في المشروع الزراعي الاستيطاني أوباري ليبيا

وفاء الهادي الذيب أبوبكر مصطفى عمر احمد القايدي

في الآونة الأخيرة أصبح تقييم جودة المياه الجوفية لأغراض الشرب والري مصدر قلق كبير، وخاصة في البلدان النامية. الهدف الأساسي من هذه الدراسة هو تحليل نوعية المياه الجوفية وتحديد ما إذا كانت آمنة للاستخدام المنزلي والزراعي. تم جمع وتحليل إحدى عشرة عينة من المياه الجوفية من مواقع مختلفة لفهم الخصائص الهيدروكيميائية ومدى ملاءمتها لأغراض الشرب والري في المشروع الزراعي الاستيطاني أوباري ليبيا. تم الأخذ في الاعتبار أحد عشر معاملاً لحساب مؤشرات جودة مياه الري والشرب وهي الكالسيوم، المغنيسيوم، الصوديوم، والبوتاسيوم، الكلوريد، البيكربونات، الكبريات، النترات، الأس الهيدروجيني، المواد الصلبة الذائبة الكلية والعسرة الكلية. علاوة على ذلك، تم إعداد مخططات لجودة مياه الري مثل مؤشرات تبادل القاعدة، مؤشر التكوين النيزكي، مؤشرات الكلورو القلوية، مختبر التربة الامريكي و ويلكوكس. تم ايضا استخدام مؤشر التلوث الاصطناعي مؤشر جودة المياه لتقييم جودة المياه الجوفية لأغراض الشرب في منطقة الدراسة. توضح البارامترات المحسوبة أن غالبية عينات المياه

الجوفية مناسبة لاستخدامات الري. الشرب والري. يشير مخطط مختبر التربة الامريكي لان جودة المياه الجوفية معتدلة الملوحة ومنخفضة الصوديوم ومياه ذات نوعية جيدة. يصنف مخطط ويلكوكس غالبية العينات ضمن الفئة الممتازة. تصنف عينات المياه الجوفية إلى نوع (Na^+ - SO_4^{2-}) ومصادر المياه الجوفية هي من نوع المياه النيزكية العميقة. جميع العينات لها مؤشرات كلورو قلوي إيجابي، مما يشير إلى تفاعل تبادل القاعدة. غالبية العينات المتحصل عليها بواسطة مؤشر جودة مياه الشرب وصفت نوعية المياه الجوفية في منطقة الدراسة بأنها جيدة إلى ممتازة للاستهلاك المباشر. تشير النتائج لمؤشر التلوث الاصطناعي الى نسبة تلوث معتدل في جميع العينات. بشكل عام تعتبر المياه الجوفية في منطقة الدراسة صالحة للشرب والري.

INTRODUCTION

Increasing population growth and agricultural activities threaten the groundwater resources has caused in the quality of water and has also raised the level of contamination (Aly et al., 2015; Imran et al., 2023). Groundwater resources in arid and semi-arid regions are under severe pressure due to high temperatures, low and irregular rainfall, and high rates of evaporation and transpiration (Al-Harbi et al., 2010; AlSubih et al., 2021). Several factors affect the quality of groundwater such as the interaction of water with soil and sediments, flow path, rock types and prevailing geochemical conditions such as solubility, redox state, precipitation, filtration, ion exchange, etc. (Corteel et al., 2005; Haroon and Muhammad, 2022; Kumar et al., 2022). The climate and the hydrochemistry of groundwater in desertic aquifers along flow paths in the subsurface, are controlled by various factors such as topography, soil chemistry and interaction of water with aquifer minerals along with internal mixing of chemically different groundwater (Reghunath et al., 2002, Singh et al., 2011). The quality of water is the most important factor affecting lives in the ecosystem. To understand the geochemistry of water and its suitability for domestic and agriculture uses monitoring system generally consists of regular measurements of physicochemical parameters (M.K.N. Kumar et al., 2019; Ismail et al., 2020; Yahong et al., 2020; Mallick et al., 2021; Aldeeb and Aldabusi, 2023). Water suitability of sources for human consumption and irrigation use were described in terms of water quality indices, which often based on the varying types of water quality parameters compared with respective local standards. This study aims to evaluate groundwater quality and its suitability for domestic and irrigation use, in terms of water quality indices by comparing the concentrations of selected parameters.

MATERIALS AND METHODS

Study area is located in the south western side of Libya, in the settlement agricultural projects in the municipality of Ubari between the following latitudes and Longitude: 11 ground water samples were collected from the study area, in the municipality of Ubari Libya. Water samples were analyzed for various parameters which include calcium, magnesium, sodium and potassium; Chloride, bicarbonate, Sulfate and nitrate, electrical conductivity, total dissolved solids. Sodium and potassium were determined using flame photometer. Calcium and magnesium were estimated by EDTA titrimetric method. Chloride was determined by silver nitrate titration and Carbonate and bicarbonate by sulfuric acid. Sulfate and nitrate contents were determined using spectro-photometer. The salinity refers to the amount of total dissolved solids (TDS) in water and is frequently measured by electrical conductivity (EC). Waters with higher TDS concentrations will be relatively conductive. TDS is measured in parts per million or mg/L and EC is measured in micro-Siemens per centimeter (µS/cm). The general formula adopted (Kelly, 1946) to calculate the TDS is

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

The statistical parameters and the major ion-concentrations (meq/L) in capering with the (Libyan standard, 1992), are tabulated in Table (1)

Table (1): Location of the study area.

Well	Latitudes	Longitude
W1	26°36'59.96"N	26°36'59.96"E
W2	26°37'03.80"N	12°43'59.00"E
W3	26°36'59.86"N	12°45'11.74"E
W4	26°36'17.39"N	12°42'59.32"E
W5	26°36'39.19"N	12°43'54.89"E
W6	26°36'28.01"N	12°44'59.79"E
W7	26°35'47.25"N	12°44'52.96"E
W8	26°35'28.71"N	12°42'57.15"E
W9	26°34'37.38"N	12°43'33.30"E
W10	26°33'42.91"N	12°44'56.34"E
W11	26°34'16.77"N	12°45'17.55"E

Table (2): Groundwater chemical analyses in [mg/l].

Well	pH	TDS	Ca^{2+}	Na^{+}	Mg^{2+}	K^{+}	HCO_3^-	NO_3^-	Cl^-	TH	SO_4^{2-}
Limit	7.5	1,000	200	200	150	40	200	45	250	500	250
1	7.30	174.90	7.22	34.96	11.66	5.88	1.83	1.45	64.87	65.87	13.45
2	7.50	173.92	8.02	34.96	8.75	5.88	1.22	1.43	59.91	55.92	11.53
3	7.30	172.62	8.02	36.57	6.80	5.22	1.22	1.68	74.80	47.95	11.05
4	7.80	178.09	16.04	36.57	4.86	5.88	1.83	1.68	49.98	60.03	12.49
5	7.50	155.52	12.03	38.41	9.72	5.88	1.83	1.74	59.91	69.93	12.49
6	7.40	312.36	24.06	45.54	4.86	6.53	1.83	1.32	74.80	80.08	12.01
7	7.20	93.93	18.45	15.00	3.89	5.15	1.22	0.04	49.98	62.06	7.69
8	7.60	173.81	9.62	31.51	9.72	7.18	1.22	1.32	49.63	63.91	13.93
9	8.10	139.70	80.20	131.56	170.1	2.22	1.83	4.51	469.7	897.9	118.2
10	7.40	1600.6	144.36	141.45	23.81	22.22	1.22	3.38	699.8	458.5	102.8
11	7.30	2720.1	224.56	213.21	34.02	33.90	2.44	11.42	924.5	700.9	209.98

RESULTS AND DISCUSSION

In the present study, an attempt was made to determine the suitability of groundwater in the study area for drinking purposes and irrigation use. Analytical results of groundwater samples are presented in Table (2). On the basis of water Physical and chemical Parameters, mathematical computations quality parameters major cations and anions were used to determine water quality indices and some standard diagrams, Table (3).

Table (3): Groundwater indices for irrigation.

	SAR	EC	RSC	KR	Na%	PS	CAI-1	CAI-2	r_1	r_2
W1	1.87	273.3	-1.35	1.15	55.86	1.55	1.91	10.5	-11.96	-12.50
W2	2.03	271.8	-1.14	1.36	59.86	1.45	1.99	11.87	-13.38	-14.00
W3	2.29	269.7	-0.98	1.66	64.23	1.88	1.82	13.83	-16.09	-16.67
W4	2.05	278.3	-1.23	1.33	59.19	1.15	2.23	9.94	-11.54	-12.12
W5	2.00	243	-1.43	1.19	56.53	1.43	2.08	11.04	-12.92	-13.50
W6	2.21	488.1	-1.63	1.24	57.3	1.86	2.02	14.13	-16.36	-17.03
W7	0.83	146.8	-1.26	0.53	38.73	1.25	1.56	12.14	-12.89	-13.71
W8	1.71	271.6	-1.3	1.07	54.83	1.11	2.11	8.92	-9.55	-10.18
W9	1.91	218.3	-18.03	0.32	24.3	10.79	1.44	7.42	-12.65	-12.68
W10	2.87	2500.9	-9.18	0.67	42.31	17.6	1.34	11.95	-12.10	-12.36
W11	3.5	4250.2	-14.04	0.66	42.00	21.71	1.39	7.88	-8.09	-8.29

a) Irrigation Use

1. Kelly's Ratio

(Kelley, 1946) have suggested that the sodium problem in irrigational water could very conveniently be worked out on the basis of the values of Kelley's ratio (KR). The formula used in the estimation of this ratio is expressed as:

$$KR = \frac{Na}{(Ca + Mg)} \ldots\ldots\ldots\ldots(2)$$

Kelly categorized water quality into suitable if KR < 1, marginal, when KR 1-2 and unsuitable if KR > 2. The Kelley's ratio has been calculated for all the water samples of the study area. It varies from 0.32 to 1.66. Around 40% of groundwater samples were suitable for irrigation, the rest were marginal.

2. Potential Salinity

(Doneen, 1954) described that the suitability of water for irrigation is not dependent on the concentrations of soluble salts. Potential salinity (PS) can as calculated as follows:

$$PS = Cl^- + \sqrt{(SO_4^{--})^2} \ldots\ldots\ldots(3)$$

- If PS < 5 water quality is excellent,
- If PS 5-10 water quality is good,
- If PS >10 water is unsuitable for use.

The value of PS in the groundwater samples of the study area ranges from 1.11 to 21.71. majority of the groundwater samples have been classified as excellent and suitable for irrigation, three samples were unsuitable (Table 3).

3. Residual Sodium Carbonate

The residual sodium carbonate (RSC) is used to indicate the alkalinity hazard for soil. RSC levels less than 1.25 meq are considered safe. Waters with RSC of 1.25 - 2.50 meq are within the marginal range (Eaton, 1950). These waters should be used with good irrigation management techniques and soil salinity monitored by laboratory analysis. RSC can be estimated by the formula given below:

$$RSC = HCO_3^- - (Ca^{2+} + Mg^{2+}) \ldots\ldots\ldots(4)$$

In the present study, it was found that all the samples fall into the safe category (Table 3).

4. Base-exchange indices

Two groups of groundwater (Na^+-HCO_3^-) type and (Na^+-SO_4^{2-}) type were used to classify the base-exchange indices r_1 as the following Equation (Gupta *et al*., 2022):

$$r_1 = \frac{Na^+ - Cl^-}{SO_4^{2-}} \ldots\ldots\ldots\ldots\ldots(5)$$

- If r_1 >1: Than groundwater is (Na^+- HCO_3^-) – type.
- If r_1<1: Than groundwater is (Na^+-SO_4^{2-}) type.

The result showed that all samples in the study area have values of r_1 < 1 and are (Na^+-SO_4^{2-}) – type, (Table 3; Figure 1).

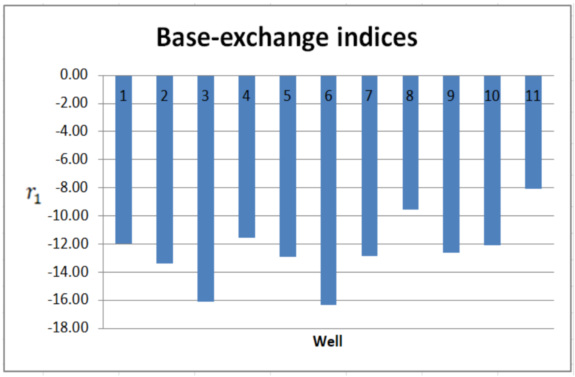

Figure (1): Base-exchange indices r_1.

5. Meteoric genesis index

The Meteoric genesis index r_2 divided groundwater into two categories, deep meteoric water percolation or shallow meteoric water percolation. The Index r_2 can determined using following Equation (Gupta *et al.*, 2022):

$$r_2 = \frac{(K^+ + Na^+) - Cl^-}{SO_4^{2-}} \dots\dots\dots\dots\dots (6)$$

- If $r_2 < 1$: Than groundwater sources are deep meteoric water percolation.
- If $r_2 > 1$: Than groundwater sources are shallow meteoric water percolation.

The obtained results show $r_2 < 1$ and that confirmed a deep meteoric water percolation, (Table 3; Figure 2).

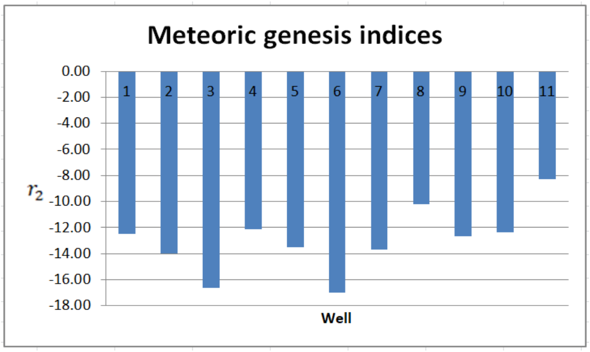

Figure (2): Meteoric genesis index r_2.

6. Chloro-alkaline indices

The chloro-alkaline indices (CAI) are used to evaluate the ion exchange reactions between groundwater and its host rock. The following equations can be used to calculate CAI_1 and CAI_2 (Schoeller 1965; 1977; Liu *et al*. 2015, Mussa and Mjemah, 2023):

$$CAI_1 = \frac{Cl^- - (Na^+ + K^+)}{Cl^-} \dots\dots\dots\dots\dots\dots (7)$$

$$CAI_2 = \frac{Cl^- - (Na^+ + K^+)}{SO_4^{2-} + HCO_3^- + NO_3^-} \dots\dots\dots\dots\dots (8)$$

- Positive values indicate chloro alkaline equilibrium base-exchange reaction, where (K+ and Na+) are exchanged with (Ca2+ and Mg2+).
- Negative values indicate a chloro alkaline disequilibrium base exchange reaction.

The obtained results of all samples show positive CAI indices ratio (Table 2, Figure 3).

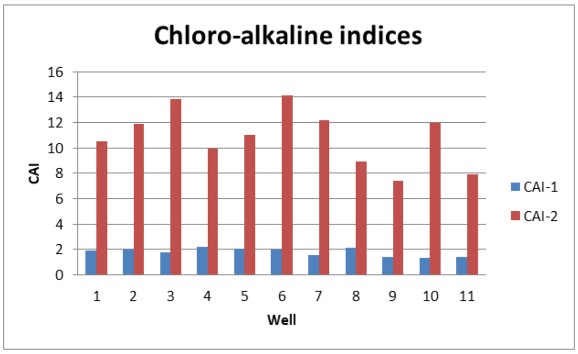

Figure (3): Chloro-alkaline indices.

7. USSLS diagram

The United States Soil Laboratory Staff (**USSLS**) chart is a plot of analytical data of Electrical conductivity (EC) and Sodium Adsorption Ratio (SAR).

- **Electrical conductivity (EC)**

EC is a good measure of salinity hazard to crops as it reflects the TDS in ground water. The total concentration of soluble salts termed as low (C1, EC < 250 µS/cm), medium (C2, 250-750 µS/cm), high (C3, 750-2,250 µS/cm) and very high (C4, >2,250 µS/cm). The electrical conductivity (EC) of the groundwater varies from 146.8 to 4,250.2 µS/cm. The samples show high and very high salinity.

- **Sodium adsorption ratio (SAR)**

SAR is refer to the degree to which usually irrigation water gets in soil by the reactions of Cation ex-change (Manjusree *et* al., 2009). Those reactions making soil impervious and compact, due to the fact that Na^+ taking the place of the adsorbed Ca^{2+} and Mg^{2+}. Calculation of SAR for given water provides a useful index of the sodium hazard of that water for soils and crops. On the basis of SAR (Richard, irrigation water is classified into four categories as: S_1 <10 excellent, S_2 (10-18 good), S_3 (18-26 fair) and S_4 >26 unsuitable. It is formulated as Equation (13):

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \dots\dots\dots\dots\dots\dots\dots\dots (9)$$

The value of SAR in the groundwater samples ranges from 0.83 to 3.5 and have been classified as excellent and suitable for irrigation, Table (3).

USSLS diagram (Figure 4), classifies the water quality into 16 zones to assess irrigation suitability of water. It was observed that the majority of samples were in C2-S1, indicating water of moderate salinity and low sodium and water with good quality.

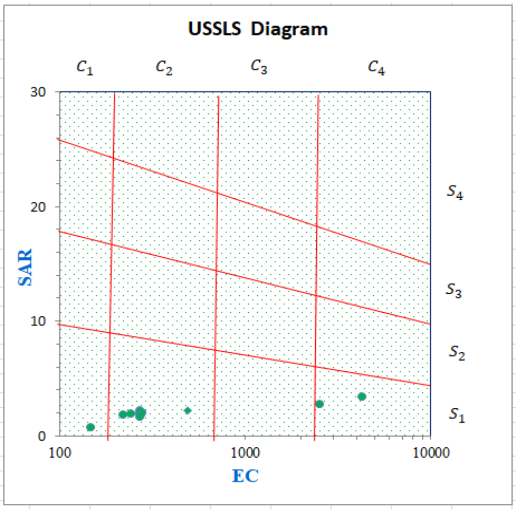

Figure (4): USSLS classification of groundwater.

8. Wilcox diagram

Wilcox's diagram (1955) is adopted for the classification of ground waters for irrigation, wherein the EC is plotted against Na%. The sodium percentage (Na%) is often used as a parameter to evaluate suitability of groundwater quality for irrigation purposes (Wilcox, 1955). The sodium percent is computed with respect to relative proportions of cations present in water using the following formula:

$$Na\% = \frac{Na^{+} + K^{+}}{(Ca^{+} + Mg^{2+} Na^{+} + K^{+})} \cdot 100 \ldots\ldots (10)$$

Water having Na% values 0-20 is considered excellent, 20-40 is good, 40-60 is permissible, and 60-80 is doubtful and above 80 is unsuitable for irrigation use. The calculated values of the sodium percentage Na% in the groundwater of the study area ranged from 24.3 % to 64.23%. Majority samples from the study area are in the permissible category. Data of groundwater samples of the study area are plotted in the Wilcox's diagram (Figure 5). Out of the 11 groundwater samples, 80% of the groundwater samples belong excellent category, except one sample belonging to unsuitable category for irrigation use.

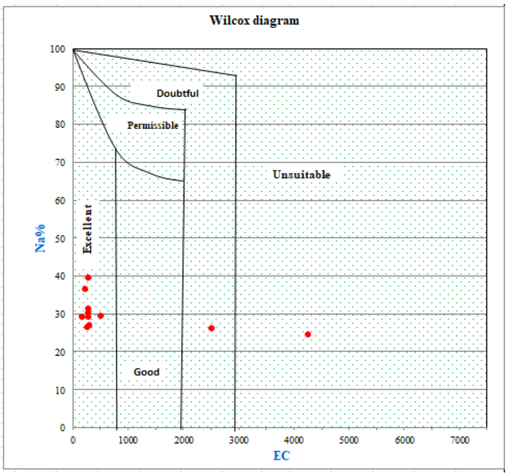

Figure (5): Wilcox diagram relating Na% and EC.

b) Drinking water quality

Assessment of the water quality is difficult simply from elemental concentrations of various water quality parameters. Thus, water quality indices are applied to assess the overall effects of contamination. The water quality index reduces the bulk number of parameters used and provides a single value of multiple water quality parameters into a mathematical equation that rates the health of water quality with number (Brown *et al*., 1970). Most of the models employed eight to eleven water quality parameters. Eleven parameters (Table 2) were used to evaluate drinking water quality with application of the following models.

1. Standard water quality model

The standard water quality model (SWQM) was computed using the 11 various water quality parameters and their relevant Libyan guidelines. To calculate SWQM, three steps were used (Ketata-Rokbani *et al*., 2011):

- Relative weight (W_i):

$$W_i = \frac{w_i}{\sum w_i} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (11)$$

- Quality rating (Q_i) for each parameters:

$$Q_i = \left[\frac{V_n}{S_s}\right] \cdot 100 \ldots\ldots \ldots \ldots \ldots \ldots \ldots (12)$$

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

- The Standard water quality model (SWQM):

$$SWQM = \sum_{i}^{11} (W_i \cdot Q_i) \ldots \ldots \ldots \ldots \ldots (13)$$

2. **Synthetic pollution index**

The Synthetic pollution index (SPI) model (Singh *et al.*, 2014) is used to evaluate the pollution degree of the sampled groundwater. The SPI can calculated using the following equations:

$$SPI = \sum_{n=1}^{11} \frac{V_n}{S_n} \cdot W_n \dots\dots\dots\dots\dots\dots\dots (14)$$

The unit weight $\mathrm{W_n}$ for each water quality parameter is calculated by using the following formula:

$$\mathrm{W_n} = \frac{\mathrm{K}}{\mathrm{S_n}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (15)$$

Where K is the Proportionality constant and can be calculated by using the following equation:

$$\mathrm{K} = \frac{1}{\sum \frac{1}{\mathrm{S_n}}} \dots\dots\dots\dots\dots\dots..\dots\dots\dots (16)$$

Different levels of water quality rating for Synthetic pollution index (SPI) and standard water quality model (SWQM) and their respective water quality condition were given in Table (4).

Table (4): *Water quality rating.*

$SWQM$	Rating [19]		SPI	Rating [20]
Ketata-Rokbani *et al.*, 2011			Shabbir and Ahmad, 2015	
< 50	excellent		< 0.2	suitable
50 – <100	good		0.2 – 0.5	slightly polluted
100 – < 200	poor		0.5 – 1.0	moderately polluted
200 – < 300	very poor		1.0 – 3.0	highly polluted
≥ 300	unfit		> 3.0	unsuitable

For the first Well (1) as example: the standard water quality model (SWQM) equation (13) can calculated using quality rate (Q_i) and unit weight (W_i) for each parameter equation (12 and 11) respectively. The results are summarized in Table (5). According to (Sahu and Sikdar, 2008; Ketata-Rokbani *et al.*, 2011; Shabbir and Ahmad, 2015; Sener *et al.*, 2017), physicochemical parameters were assigned a weight (w_i) from 1 to 5 depending upon their significance in water quality evaluation for human health. The highest weight of 5 was assigned to nitrates because of its higher impact on human health, the sum of w_i is 30. The obtained value for SWQM was 19.58.

Calculation for Well 1 as example for Synthetic pollution index (SPI), the Proportionality constant K for 11 standard parameter S_n:

$$K = \frac{1}{\sum \frac{1}{S_n}} = \frac{1}{0.213222} = 4.68994$$

The SPI equations (14) was calculated using the concentration V_n, the Libyan standard limit S_n and the unit weight W_n equation (15) of each chemical parameter, and summarized in Table (5).

Table (5): Calculation of SPI and SWQM for well 1 as example.

Synthetic pollution index						Standard water quality model			
par.	S_n	V_n	W_n	$\frac{V_n}{S_n} \cdot W_n$		w_i	W_i	Q_i	$W_i \cdot Q_i$
pH	7.5	7.3	0.6253	0.60865		3	0.1000	97.3	9.73
TDS	1000	174.9	0.0047	0.00082		3	0.1000	17.5	1.75
Ca^{++}	200	7.2	0.0234	0.00085		3	0.1000	3.6	0.36
Na^{+}	200	35.0	0.0234	0.00410		2	0.0667	17.5	1.17
Mg^{++}	150	11.7	0.0313	0.00243		2	0.0667	7.8	0.52
K^{+}	40	5.9	0.1172	0.01724		3	0.1000	14.7	1.47
HCO_3^{-}	200	1.8	0.0234	0.00021		1	0.0333	0.9	0.03
NO_3^{-}	45	1.5	0.1042	0.00336		5	0.1667	3.2	0.54
Cl^{-}	250	64.9	0.0188	0.00487		3	0.1000	25.9	2.59
TH	500	65.9	0.0094	0.00124		2	0.0667	13.2	0.88
SO_4^{--}	250	13.5	0.0188	0.00101		3	0.1000	5.4	0.54
SPI				0.65		SWQM			19.6

Analog calculations for all other wells for, SWQM and SPI are summarized in the Table (6) and depicted in Figure (1). The drinking water quality determined by SWQM shows that majority of the groundwater samples has good to excellent quality and can direct used for consumption. Based on the Synthetic pollution index (SPI), all of the water samples were identified as moderately polluted (0.63 – 0.9).

Table (6): Summarized SPI and SWQM for the 11 wells.

Well	SPI	Rating		SWQM	Rating
1	0.65	moderately polluted		19.6	excellent
2	0.66	moderately polluted		19.3	excellent
3	0.64	moderately polluted		19.4	excellent
4	0.69	moderately polluted		19.8	excellent
5	0.66	moderately polluted		19.8	excellent
6	0.66	moderately polluted		22.6	excellent
7	0.63	moderately polluted		16.6	excellent
8	0.67	moderately polluted		19.5	excellent
9	0.81	moderately polluted		65.9	good
10	0.80	moderately polluted		83.9	good
11	0.90	moderately polluted		124.3	poor

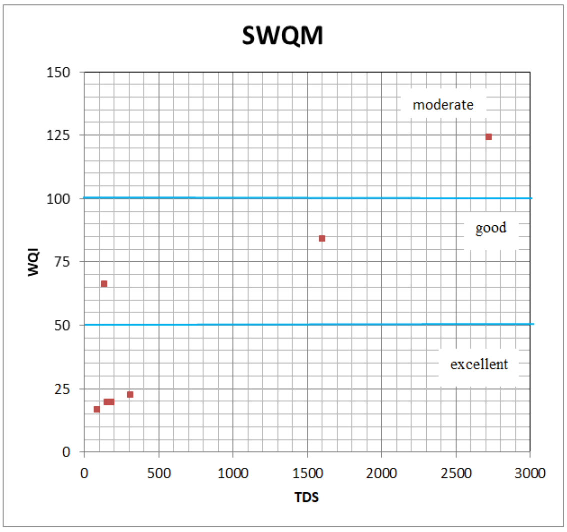

Figure (6): Standard water quality model.

CONCLUSION

Finally, it could be concluded that the water quality of samples in the settlement agricultural project, Ubari Libya is good for drinking and irrigation purpose. The calculated parameters; potential salinity, kelly's ratio and sodium adsorption ratio show that the majority of the groundwater samples is suitable for irrigation uses. The Na% and the resulting Wilcox diagram classify the majority of samples as excellent category. The USSLS chart indicating water of moderate salinity and low sodium and water with good quality. The drinking water quality determined by SWQM shows that majority of the groundwater samples has good to excellent quality and can direct used for consumption. Based on the Synthetic pollution index, all water samples were identified as moderately polluted.

REFERENCES

Aldeeb Wafa (2022); Assessment of Groundwater Salinity and Sodicity for Irrigation in Sabratha, Libya, Libyan Journal of Ecological & Environmental Sciences and Technology (LJEEST), Vol. 4 No. 2 Dec., Pages (27- 32).

Aldeeb Wafa, Aldabusi Bashir (2023); Evaluation of Ground Water Quality for Drinking Purposes in Sabratha, Libya, Scientific Journal for the Faculty of Science-Sirte University Vol. 3, No. 1, DOI: https://doi.org/10.37375/sjfssu.v3i1.102.

Al-Harbi, O.A.; Hussain, G.; Lafouza, O. (2010), Irrigation water quality evaluation of Al-Mendasah groundwater and drainage water, Al-Madenah Al-Monawarah region, Saudi Arabia. *Int. J. Soil Sci*, *5*, 282–300.

AlSubih, M.; Kumari, M.; Mallick, J.; Ramakrishnan, R.; Islam, S.; Singh, C.K. (2021), Time series trend analysis of rainfall in last five decades and its quantification in Aseer Region of Saudi Arabia. *Arab. J. Geosci.* , *14*, 519.

Aly, A.A.; Al-Omran, A.M.; Alharby, M.M (2015), The water quality index and hydrochemical characterization of groundwater resources in Hafar Albatin, Saudi Arabia. *Arab. J. Geosci.*, *8*, 4177–4190.

Brown, R.M., McClelland, N.I., Deininger, R.A. and Tozer, R.G., (1970) "Water quality index-do we dare?", Water Sewage Works, 117(10). 339-343.

Corteel, C.; Dini, A.; Deyhle, AN. (2005), Element and isotope mobility during water-rock interaction processes. *Phys. Chem. Earth* , *30*, 993–996.

Doneen LD (1964) Notes on water quality in agriculture. Published in Water Science and Engineering. Univ. California, Davis USA.

Doneen, L.D. (1954), Salination of Soil by Salts in the Irrigation Water. American Geophysical Union Transactions, 35, 943-950.

Eaton, F.M. (1950), Significance of Carbonates in Irrigation Waters. Soil Science, 69, 123-134. https://doi.org/10.1097/00010694-195002000-00004

Gupta Deepak, Chaudhary Supriya, Singh Anubhuti, Shukla Reetika and Mishra Virendra Kumar (2022), Hydrochemical assessment of groundwater quality in the Narmada River Basin (Central India), Water Supply Vol 23 No 2, 459, https://doi:10.2166/ws.2022.409.

Haroon, H., & Muhammad, S. (2022). Spatial Distribution of Radon Concentrations in Groundwater and Annual Exposure Doses in Mirpur District Pakistan. Groundwater for Sustainable Development, 17, Article ID: 100734. https://doi.org/10.1016/j.gsd.2022.100734

Imran Ud Din, Said Muhammad, Inayat ur Rehman (2023), Groundwater quality assessment for drinking and irrigation purposes in the Hangu District, Pakistan, Journal of Food Composition and Analysis, Volume 115, January, 104919, https://doi.org/10.1016/j.jfca.2022.104919

Ismail AH, Hassan G, Sarhan AH (2020), Hydrochemistry of shallow groundwater and its assessment for drinking and irrigation purposes in Tarmiah district, Baghdad Governorate. Iraq Groundw Sustain Dev 10:100300.

Kelly WP (1946) Permissible composition and concentration for irrigation waters. In: Proceedings of ASC, p: 607.

Ketata-Rokbani M, Gueddari M, and Bouhlila R. (2011), Use of geographical information system and water quality index to assess groundwater quality in El Khairat Deep Aquifer (Enfidha, Tunisian Sahel). Iranica J Energy Environ 2:133–4.

Ketata-Rokbani M, Gueddari M, and Bouhlila R. (2011), Use of geographical information system and water quality index to assess groundwater quality in El Khairat Deep Aquifer (Enfidha, Tunisian Sahel). Iranica J Energy Environ 2:133–44.

Kumar Manish, Kumar Patel Arbind, Sing Ashwin (2022), Anthropogenic dominance on geogenic arsenic problem of the groundwater in the Ganga-Brahmaputra floodplain: A paradox of origin and mobilization, Science of The Total Environment, Volume 807, Part 2, 10 February, 151461, https://doi.org/10.1016/j.scitotenv.2021.151461.

Liu F, Song X, Yang L, Zhang Y, Han D, Ma Y, Bu H (2015) Identifying the origin and geochemical evolution of groundwater using hydrochemistry and stable isotopes in the Subei Lake basin, Ordos energy base, Northwestern China. Hydrol Earth Syst Sci 19(1):551–565. https://doi.org/10.5194/hess-19-551-2015.

M.K.N. Kumar, Kazuhito Sakai, Sho Kimura, Kozue Yuge, M.H.J.P (2019), Gunarathna; Classification of Groundwater Suitability for Irrigation in the Ulagalla Tank Cascade Landscape by GIS and the Analytic Hierarchy Process; Agronomy,9,351; doi:10.3390/agronomy9070351.

Mallick J, Kumar A, Almesfer MK, Alsubih M, Singh CK, Ahmed M, Khan RA (2021) An index-based approach to assess groundwater quality for drinking and irrigation in Asir region of Saudi Arabia. Arab J Geosci 14(3):1–17.

Manjusree, T.M., Joseph, S. and Thomas, J., 2009. Hydrogeochemistry and groundwater quality in the coastal sandy clay aquifers of Alappuzha district, Kerala. Journal of the Geological Society of India, 74(4), p.459.

Mussa, Kassim Ramadhani & Mjemah, Ibrahimu Chikira (2023), Using hydrogeochemical facies and signatures for groundwater characterization and evolution assessment in aquifers with contrasting climate and geology in Tanzania, Applied Water Science, 13, Article number: 201 (2023).

Reghunath, R.; Murthy, T.R.S.; Raghavan, B.R. **(2002),** The utility of multivariate statistical techniques in hydrogeochemical studies: An example from Karnataka, India. *Water Res.* , *36*, 2437–2442.

Sahu P, and Sikdar PK. (2008), Hydrochemical framework of the aquifer in and around East Kolkata Wetlands, West Bengal. India. Environ Geol 55:823–35 Saleem M, Hussain A, and Mahmood G. 2016. Analysis of groundwater quality using water quality index: A Case study of greater Noida (Region), Uttar Pradesh (U.P), India. Cogent Eng 3: 1237927.

Schoeller H (1965), Qualitative evaluation of groundwater resources. In: Methods and techniques of groundwater investigation and development. Water Resources Series No. 33. UNESCO, Paris, pp 44–52.

Schoeller H (1977), Geochemistry of Groundwater. In: Groundwater Studies-An International Guide for Research and Practice. UNESCO, Paris, Ch. 15, 1–18.

Sener S, Sener E, and Davraz A. (2017). Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey). Sci Total Environ 584–585:131–44.

Shabbir R, and Ahmad SS. (2015), Use of geographic information system and water quality index to assess groundwater quality in Rawalpindi and Islamabad. Arab J Sci Eng 40:2033–47

Singh SK, Srivastava PK, Singh D, Han D, Gautam SK, Pandey AC (2014). Modelling groundwater quality over a humid subtropicalregion using numerical indices, earth observation datasets, and X-ray diffraction technique: a case study of Allahabad district, India. Environ Geochem Health Vol. 36, No. 4. DOI: 10.1007/s10653-014-9638-z:157–80.

Singh, C.K.; Rina, K.; Singh, R.P.; Shashtri, S.; Kamal, V.; Mukherjee, S. **(2011),** Geochemical modeling of high fluoride concentration in groundwater of Pokhran area of Rajasthan, India. *Bull. Environ. Contam. Toxicol.* , *86*, 152–158.

Wilcox, LV (1955), Classification and use of irrigation water, US Department of Agriculture Circul. 969: 19.

World Health Organization (WHO). Guideline for drinking water quality. 2012.

Yahong Zhou, Peiyue Li, Leilei Xue, Zihan Dong, Duo Li, (2020), Solute geochemistry and groundwater quality for drinking and irrigation purposes: a case study in Xinle City, North China Geochemistry, Volume 80, Issue 4, 12, 125609.