The Scientific Journal of University of Benghazi

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Using The Irrigation Water Quality Index to Evaluate of Some Water Resources in Al-Abyar-Ghut Al-Sultan Area NE Libya.

Idris Basher Imneisi [1*] Salih Abrahim Albadri [2]

1 Department of Plant Production, Faculty of Agriculture, Benghazi University- Libya.
2 Department of Water Technology in The Higher Institute for Agricultural Techniques EL- Marj – Libya.

Received: 21 / 05 / 2021; Accepted: 10 / 07 / 2021

الملخص:

في المناطق الجافة وشبه الجافة حول العالم، تعتبر جودة المياه وكمياتها ضرورية في النظم الزراعية. هدفت هذه الدراسة إلى تقييم جودة مياه الري في منطقة الأبيار (غوط السلطان) للأغراض الزراعية باستخدام مؤشر جودة مياه الري (IWQI). خلال موسم الأمطار، تم جمع 33 عينة مياه من 11 بئراً حكومياً في منطقة غوط السلطان بمتوسط 3 عينات لكل بئر (من يناير إلى مارس 2021). نتيجة لذلك، تم حساب مؤشر جودة مياه الري (IWQI) باستخدام قيم التوصيل الكهربائي (EC) (ومعدل ادمصاص الصوديوم (SAR) وتركيز الصوديوم (Na) وتركيز الكلوريد (Cl) وتركيز الكربونات (HCO3). صُنف مؤشر جودة مياه الري (IWQI) في منطقة الدراسة على أنه ذو جودة متوسطة لاستخدام مياه الري (63.5٪). استخدمت الدراسة الحالية مؤشر جودة مياه الري لتحديد جودة العديد من مصادر المياه الري. اقترحت هذه الدراسة أن جودة مياه الري يمكن أن تعتمد على ظروف التربة والمحاصيل في إدارة جودة مياه الري.

الكلمات المفتاحية:

منطقة الابيار، معامل جودة مياه الري، SAR، ليبيا.

Abstract

In arid and semi-arid regions around the world, water quality and quantity are essential in agricultural systems. This study aimed to evaluate the quality of irrigation water in Al-Abyar area (Ghout Al-Sultan) for agricultural purposes using the Irrigation Water Quality Index (IWQI). During the rainy season, thirty-three water samples were collected from 11 government wells in the Ghout al-Sultan area with an average of 3 samples per well from January to March 2021. As a result, the irrigation water quality index (IWQI) was calculated using the values of electrical Conductivity (EC) , Sodium Adsorption Rate (SAR), Sodium (Na), Chloride (Cl), and Bicarbonate (HCO_3). The irrigation water quality index (IWQI) was classified in the study area as having medium quality for irrigation water use (63. 5%). The current study demonstrated determination of the quality of some water sources in this area using an irrigation water quality index. It suggests that the irrigation water quality of the study area can depending on soil and crop conditions in the field of irrigation water quality management.

Keywords: Al-Abyar region; Irrigation water quality index; SAR, Libya.

1. INTRODUCTION

The recent water crisis has brought about a number of issues in the production of sufficient quantities of water for living all over the world. The management of natural resources has a most important effect on world food security and stability. Irrigated agricultural fields now provide approximately 40% of all world resource [(1)]. FAO's irrigation water recommendations are functional and have been successfully used in general irrigated agriculture for evaluating common constituents in surface water, groundwater, drainage water, sewage effluent, and wastewater. When evaluating irrigation water, the chemical and physical characteristics of the water are emphasized, with few other factors considered significant [(2)]. As a general rule, irrigation water sources should not be tested for trace elements unless there is a reason to believe they are dangerous. Trace elements are almost always found in high concentrations as a result of human activities, especially wastewater disposal. Trace elements should be verified in every wastewater project [(2)]. Groundwater is the main source for drinking, irrigation and other purposes, especially in arid and semi-arid areas. In general, ground water is the main source of the water resources in Libya since it constitutes 98% of the available water resource [(3)]. The agriculture sector is the largest consumer of water, especially in the Mediterranean arid and semi-arid regions, where irrigation water represents from 50% up to almost 90% of total used water [(4, 5)]. Accordingly, water quality is a critical factor for utilizing this water for sustainable development. As a result, classical water quality assessment can be described as an examination of the biological, chemical, and physical properties of water in order to determine natural quality, human health impacts, and desired uses [(6)]. The quality of irrigation water is usually defined in terms of total dissolved solids, main cations and anions. The three most common problems associated with poor water quality around the world are salinity, decreased permeability and increased toxicity of specific ions [(7)]. The water quality index provides a single number (such as grade) to indicate the overall water quality at a specific location and time based on several water quality parameters. It is a tool that provides meaningful water quality data collection, useful for both technical and non-technical personnel who are interested in

*Correspondence:

Idris Basher Imneisi
idris.imneisi@uob.edu.ly.

water Quality results [6, 8]. WQIs are simpler and faster to understand for the general public than a large amount of different environmental data contained in papers. As a result, they can be extremely beneficial in the management of water resources and watersheds [9, 10]. For this reason, the aim of the present work is to evaluate the existing water quality, through the assessment of some selected water quality variables as (some parameters as calcium (Ca), magnesium (Mg), chloride (Cl), electric conductivity (EC) and calculation of sodium adsorption ratio (SAR) of water source Al-Abyar Region (Ghut Al-Sultan). so as to appreciate and explain its suitability for irrigation water by irrigation water quality index. Based on water quality data in the Ghut Al-Sultan region, the Irrigation Water Quality Index (IWQI) technique was used to assess the irrigation water quality. This IWQI aims to assist decision-makers in reporting spatial water quality variations.

2. MATERIAL AND METHODOLOGY.

2.1. The Study Area.

The study area is located near Al-Abyar city, about 62km east of Benghazi city, its population is nearly 45,000 inhabitants, surround by an agricultural lands and forests, many water wells being drilled for agriculture and municipal uses.

The study area geographically lies at N 32 07’ and E 020 31’ as shown in Fig 1. The maximum and minimum elevation is 233 m and 243 m above MSL. The study area covers 11 wells of Ghut al-Sultan wells for drinking water as shown in Fig 1. There are 11 sampling location named as well 1, well 2 up to well 11 on the Gout al-sultan at Al-Abyar municipality.

2.2. Sampling and Analysis.

During the rainy season, thirty-three water samples were taken from 11 wells in Ghut Al-Sultan, averaging 3 samples per well (January to March 2021). The water samples were collected in one-liter polyethylene bottles after being washed twice with sample water to prevent contamination, and then processed and transported to the laboratory for analysis of EC, pH, TDS, and major cations and anions in order to calculate SAR.

2.3. Physic-Chemical Analysis of Water Samples.

Electrical conductivity (EC), pH, temperature (T) were measured locally by (HQ40d Portable pH, Conductivity) field instruments (Hach Company). Sodium (Na^{+}), Calcium (Ca^{++}), Magnesium (Mg^{++}), bicarbonate (HCO_3) were determined using a HACH-DR 6000 UV-Vis Spectrophotometer and flam photometer.

Figure 1. The Ghut Al-Sultan Wells for Drinking Water and Agriculture Use.

2.4. Technique of Calculation Sodium Adsorption Ratio (SAR).

The sodium hazard is usually expressed as a ratio of sodium adsorption (SAR). The ratio of sodium (Na^{+}) to calcium (Ca^{++}) and magnesium (Mg^{++}) ions in a sample is measured using this index. Calcium causes soil particles to flocculate (stick together), while sodium causes soil particles to scatter (separate). This dispersed soil will quickly crust, causing problems with water infiltration and permeability [5]. SAR is expressed as follows [11].

$$\mathbf{SAR} = \frac{\mathbf{Na^{+}}}{\sqrt{\left[\frac{\mathbf{Ca^{2+}} + \mathbf{Mg^{2+}}}{\mathbf{2}}\right]}} \quad \dots\dots\dots \mathbf{eq(1)}$$

(Concentrations are in mq/l)

2.5. Technique of Irrigation Water Quality Index (IWQI).

Meireles et. al.,[12] established a method for calculating the groundwater quality index for irrigation (IWQI), which was used in the current study area Al-Abyar Region (Ghut Al-Sultan). Creating the IWQI involves three main steps

2.5.1. **First step**: obtain measurements on individual water quality indicators.

The chosen parameters of groundwater for irrigation purposes in Al-Abyar Region (Ghut Al-Sultan) all through the rainy seasons in 2021 used to be the first step.

2.5.2. **Second step**: transform measurements into **‘‘sub-index’’** values to represent them on a common scale.

- **Computation of Sub Index of Quality Rating (qi).**

According to irrigation water quality parameters proposed by the University of California Committee of Consultants - UCCC and criteria defined by [2], values of (qi) were calculated based on each parameter value, as shown in Table 1.

$$\mathbf{qi} = \mathbf{Qimax} - \left(\frac{\mathbf{Xij} - \mathbf{Xinf}}{\mathbf{Xamp}} * \mathbf{Qiamp}\right) \dots \boldsymbol{eq(2)}$$

where;

Qimax = is the maximal value of qi in each category.

Xij = is the parameter marked value;

Xinf = is the minimal value of the category to the parameter.

Qiamp = is the ampleness of the category.

Xamp = is the ampleness of the category to each parameter. The upper limit was considered the highest value calculated in the physical-chemical and chemical analysis of the water samples in order to calculate Xamp of the last class of each parameter.

Table 1. General Classifications of Irrigation Water Based Upon EC, Na, Mg, Cl, HCO_3 and SAR for Quality Measurement (Qi) Calculation.

Qi	EC µS/cm	Na+ (meq/L)	SAR (meq/L)	CL- (meq/L)	HCO_3 (meq/L)
[85,100]	[200-750)	[2-3)	[2-3)	[1-4)	[1-1.5)
[60,85)	[750-1500)	[3-6)	[3-6)	[4-7)	[1.5-4.5)
[35,60)	[1500-3000)	[6-9)	[6-12)	[7-10)	[4.5-8.5)
[0,35)	More than 3000	More than 9	More than 12	More than 10	More than 8.5

- **Determination of Unit Weight.**

The values of (Wi) were defined according to the parameters values in their studied area and the criteria of [13] listed in Table 3. In relation to this variable, the explain ability of each parameter. Table 2 shows the normalized weights, wi, calculated using Equation 3., the Wi values were normalized such that their sum equals one.

$$\boldsymbol{Wi} = \frac{\boldsymbol{wi}}{\sum_{i=1}^{n} \boldsymbol{wi}} \qquad \dots\dots\dots \boldsymbol{eq}(3)\ .$$

2.5.3. Third step: aggregate the individual sub-index values into an overall IWQI value.

The irrigation water quality index (IWQI) developed in Brazil by[12]. The IWQI is a five-category scale with a range of 0 to 100 points that is measured as follows:

$$\mathbf{IWQ}\boldsymbol{I} = \sum_{\mathbf{i=1}}^{\mathbf{n}} \mathbf{qi\ wi} \qquad \dots\dots\dots \mathbf{eq(4)}$$

Table 2. The Wi Values Were Normalized Such That Their Sum Equals One.

Parameter	wi
Electrical conductivity	0.211
Sodium (Na+)	0.204
Sodium adsorption ratio (SAR)	0.189
Chloride	0.194
Bicarbonate	0.202
Total	1.00

The proposed equation is as follows indicators have been developed in table 3. the range is from 0 to 100. According to the index value, the quality of irrigation water can be classified divided into five categories: very bad (0-25), bad (25-50), medium (50-75), good (75-95) and excellent (95-100). Water conditions corresponding to various IWQIs these values are listed in table 3. indicates that some water quality parameters are be contaminated by man-made or geological pollution. therefore, appropriate measures need to protect or improve quality source water. In this case, the irrigation water is further need to investigate the reasons for the deterioration and pay attention to take appropriate remedial measures. Therefore, the proposed indicators can be used as decisive rules for determining surface and underground irrigation water management groundwater resources.

Table 3. IWQI and Corresponding Class and Status of Water Quality.

Class	IWQI value	Status of water
Very bad	0–25	Unsuitable
Bad	25–50	Management of water quality needed
Medium	50–75	Can be used depending on soil and crop conditions
Good	75–95	Acceptable
Excellent	95–100	Pristine quality

3. RESULTS AND DISCUSSION

Groundwater quality for irrigation purposes was evaluated by calculation the irrigation Water Quality Index (IWQI) for each sample that indicates the influence of individual water quality parameters on the overall water quality. The IWQI has advantages by reflecting the suitability of water for specific use. The proposed index method utilizes five limitation groups that have been mentioned by [2, 13] with few modifications in their classification categories for irrigation water quality assessment.

3.1. Physical and Chemical Parameters

Table 4 the water parameters such as EC, Ca, Mg, Cl, Na, HCO_3 and Sodium adsorption ratio (SAR) are considered for estimation of irrigation water quality index. The descriptive statistics of chemical analyses of groundwater samples collected from rainfall seasons are presented in Table 5.

Table 4. The Average of Water Parameters in Some Water source Al-Abyar Region (Ghut Al-Sultan).

Sample code	EC µS/cm	TDS ppm	PH	Ca (meq/L)	Mg (meq/L)	Cl (meq/L)	Na (meq/L)	HCO_3 (meq/L)	SAR
Well 1	1507	979	8.05	8.3	6.91	0.92	8.21	2.34	2.98
Well2	1651	1073	8.05	9.7	7.83	0.87	9.65	2.72	3.27
Well3	2125	1381	8.01	12.4	9.75	0.7	12.26	3.42	3.69
Well4	1751	1138	8.06	10.25	8	0.98	9.69	2.75	3.20
Well5	1787	1161	8.06	10.4	8.12	0.87	9.95	2.81	3.27
Well6	1524	990	8.36	8.95	7	0.95	8.43	2.39	2.98
Well7	1780	1158	8.35	10.4	8.16	0.84	10.34	2.93	3.40
Well8	1885	1225	8.07	11	8.66	0.9	10.52	2.98	3.36
Well9	2161	1404	8.21	12.6	9.91	0.73	12.13	3.44	3.62
Well10	2379	1546	8.26	13.9	10.91	0.73	13.39	3.8	3.80
Well11	1826	1186	8.09	10.65	8.33	0.7	10.04	2.85	3.25

Table 5. Descriptive Statistics of the Concentration of Water Quality Parameters of Al-Abyar Region (Ghut Al-Sultan).

	N	Min	Max	Mean		Standard Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Total dissolved solid (TDS) mg/l	33	979.00	1549.00	1204.	29.59	170.00
EC (µS/cm)	33	1507.0	2384.41	1854	45.5	261.6
pH	33	8.02	8.38	8.141	.0215	.12348
Calcium Ca (mg/L)	33	23.90	34.80	29.7	.6370	3.6593
Magnesium Mg (mg/L)	33	188.10	308.30	239.5	6.19	35.61
Chloride Cl (mg/L)	33	166.20	277.70	215.	5.52	31.760
Sodium Na (mg/L)	33	83.10	131.70	102.3	2.513	14.43
Bicarbonate HCO_3 (mg/L))	33	143.20	231.90	180.1	4.597	26.412

3.2. Irrigation Water Quality Index

The dominant parameters which play a necessary role in the water first-class for agricultural purposes need to be recognized which are together with EC, Na+, Cl−, and HCO3 and SAR. In the second step, the weight of water quality parameters including: the water quality measurement parameter value (Qi), and the accumulation witness (Wi) have to be determined relying on every individual parameter value and in the end taking account into the standards which have been proposed by(2). Table 6 and Figure 2 illustrate the average irrigation water quality index at all sampling collections.

Table 6. Shows an Average Irrigation Water Quality Index (IWQI) In The Study Area.

Sample code	Wi*Qi of EC	Wi*Qi of Na	Wi*Qi of SAR	Wi*Qi of Cl	Wi*Qi of HCO_3	IWQI
Well 1	11.907	6.324	17.361	18.97	17.015	71.58
Well2	10.894	3.06	16.916	19.07	16.112	66.05
Well3	7.5608	1.087	16.246	19.4	14.448	58.74
Well4	10.191	2.969	16.996	18.85	16.041	65.05
Well5	9.9381	2.38	16.900	19.07	15.898	64.18
Well6	11.787	5.825	17.348	18.91	16.896	70.77
Well7	9.9873	1.496	16.703	19.12	15.613	62.92
Well8	9.2488	1.088	16.764	19.01	15.494	61.60
Well9	7.3076	1.087	16.353	19.34	14.401	58.49
Well10	5.7743	1.087	16.062	19.34	13.545	55.81
Well11	9.6638	2.176	16.912	19.4	15.803	63.95

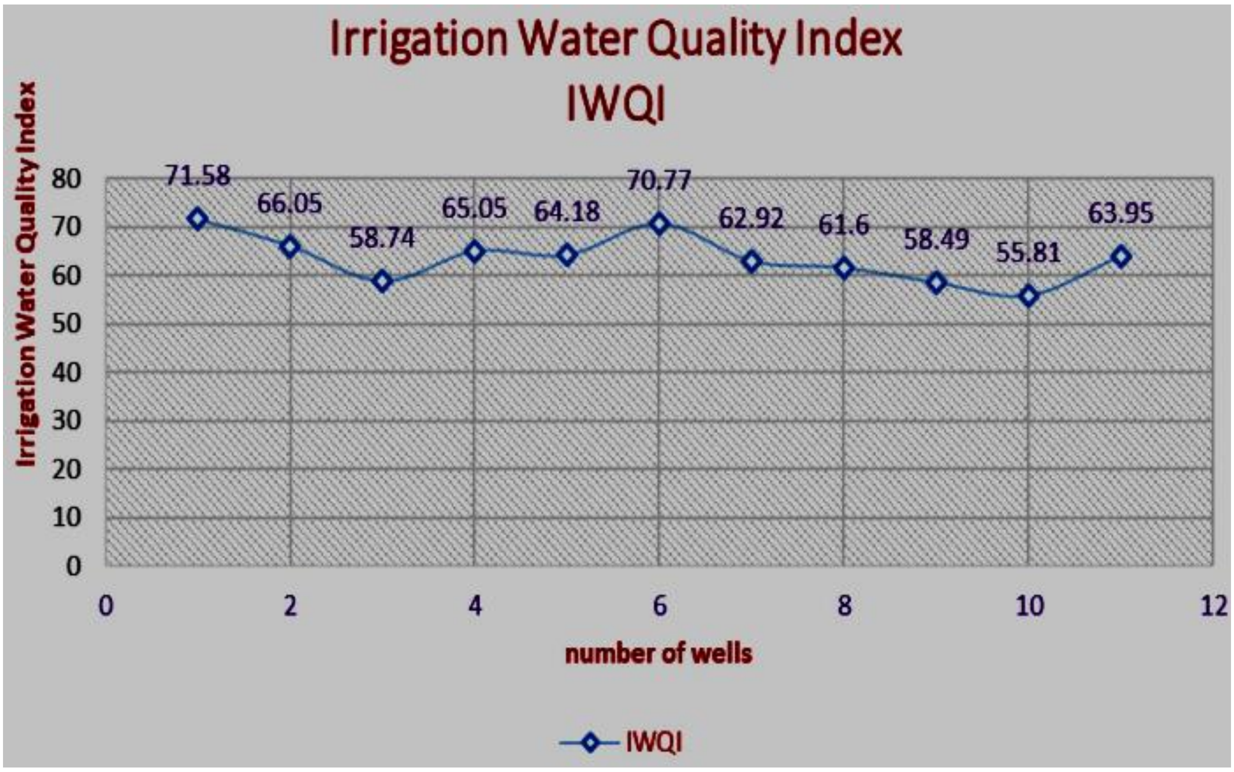

Figure 2. illustrates the average irrigation water quality index(IWQI) for well samples in study area.

4. CONCLUSION

The main objective of this study is to evaluate the irrigation water quality for the Al-Abyar Region (Ghut Al-Sultan) by using Irrigation water quality index (IWQI). The results reveals are:

- (IWQI) methods could be a very effective and efficient tool for summarizing and reporting monitoring data to policy makers in order to understand the state of groundwater quality and to provide the potential for better use in the future.
- The Al-Abyar Region's Irrigation Water Quality Index (IWQI) was created to assess the quality of groundwater for irrigation (Ghut Al-Sultan). To compute the EC, Ca+2, Mg+2, Cl-, Na+1, HCO3-1, and SAR, 11 wells within the research region were analyzed during the wet seasons of 2021. (IQWI).

- IWQI ranged from 55.8% to 71.5% during the rainy season, with an average of 63.56%.
- For the period January to March 2021, the average WQI values for some sources in the Al-Abyar Region (Ghut Al-Sultan) were classified as medium water quality for irrigation water usage (63.5%).
- It suggests that the irrigation water quality of the Study area can be used depending on soil and crop conditions in the field of irrigation water quality management.
- EC concentrations ranged from 1507 µS/cm to 2379 µS/cm during the rainy season, with an average of 1852.36 µS/cm.
- During the rainy season, SAR readings ranged from 2.97 to 3.80 meq/L, with a mean value of 3.34 meq/L.
- The toxicity of water is calculated in terms of sodium ion concentration (Na^{+1}). Sodium concentrations ranged from 189 to 308 mg/L during the rainy season, with a mean of 239.72 mg/L.

This study should be taken into account when designing and implementing strategies for effective groundwater management for irrigation in areas similar to Ghut Al-Sultan.

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