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Assessment of the Water Quality (WHO) of Some Shallow Wells in the Zawia Janzour Area, Eastern Libya, its Suitability for Drinking and Irrigation

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Abstract: The current study was performed to evaluate the water quality of some shallow wells in the Zawiyat Janzour region - eastern Libya during the summer and winter seasons of the year (2022-2023). The study aimed to determine the physical, chemical and microbial characteristics, as well as evaluating their suitability for drinking and irrigation in accordance with international specifications (WHO) and Libyan standard specifications. The obtained results of (electrical conductivity, total dissolved salts, sodium, potassium, calcium, magnesium, bicarbonate, sulfate, chloride and nitrate) showed that they were within the permissible limits for drinking water according to international standard and Libyan specifications in the wells No. (1, 2, 3, 4, 8) in summer and wells No (1, 2, 3, 8) in the winter, out of the total number of12 wells studied whereas the the rest of the wells exceeded safe limits for drinking water during the two seasons. Regarding irrigation water quality using the US Salinity Laboratory (USSL) system, the results showed that the classification of the well water was (C4-S1, C3-S1), meaning in other words that the water is classified from high to very high salinity and is used to irrigate crops that tolerate salinity, with some restrictions. Regarding the risk of sodium the results showed that all well water lies under the first category with little harm. However when classifying irrigation water according to the International Food and Agriculture Organization (FAO) system, it indicated that yiioturns out that the water of most wells during the two seasons falls into (a mild problem, an increase in the problem). Some mathematical indicators for irrigation (SAR - SSP%) were also used and all of these indicators were within safe limits when used for irrigation and are valid for all soils.

Key words: Shallow Wells · Water quality · Drinking Water · Irrigation · WHO · Lib · FAO · USSL · SAR

INTRODUCTION

Water scarcity is considered to be one of the most important problems issues for most regions located within the range of the arid and semi-arid lands face is a lack of water.Rapid population development and an increase in human activity have led to a rise in water demand, which has made the water scarcity issue worse and caused the quality of the water to deteriorate. [1]. Groundwater is one of the major resources that people use for industrial, agricultural and drinking purposes. A large number of aquifers in northern Libya are overused as a result of the heavily increased groundwater-dependent irrigated agriculture [2]. The study area, located in northeastern Libya, is considered to be one of the areas that suffer from water scarcity, especially surface sources, as it is located within the arid and semi-arid areas in which rainfall rates are low and thus the reliance is mainly on desalination of seawater, groundwater and water harvesting [3]. The northern regions of Libya depend mainly on groundwater, which has led to excessive water depletion leading to a decrease in the groundwater level

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and an increase in its salinity, in addition to an increase in soil salinity, making it less suitable for drinking and agriculture [4]. Therefore, The aim of this study is to identify some of the physical and chemical properties of shallow well water in the study area and to determine to what extent these characteristics comply with the standard specifications of the World Health Organization and the Libyan parameters for human use for drinking and agricultural use for irrigation as well as determining whether there are changes in the characteristics of the water between the winter and summer seasons.

MATERIALS AND METHODS

Study Area: The study area is located, a rural village located in the northeast of Libya, which is within the northern administrative borders of the municipality of Bir al-Ashhab, east of the city of Tobruk. Its eastern borders are the Marsa Lak region and its western borders are the Kampot region and its northern borders are the Mediterranean coast. With this geographical location, it is located between. Longitudes 24041' - 24037' East and latitudes 31044' - 32000 North as shown in (Figure 1).

According to the 2023 census, the population of the study area, the municipality of Bir al-Ashhab, is approximately 28,000 people. Its climate is characterized by a Mediterranean climate with hot, dry summers and warm, rainy winters, with an average temperature of 31 degrees Celsius during the summer.

Sample Collection: The study used two distinct seasons to gather samples: the first took place in August 2022 during the summer and the second season took place in February 2023 during the winter. Twelve shallow wells were selected, with depths ranging from 6 to 23 metres and were distributed randomly throughout the study area, as depicted in Figure 2.

Methods of Physical and Chemical Analysis: The pH and electrical conductivity (EC) of water samples were measured using digital conductivity meters immediately after sampling. Water samples were collected from the study area and analyzed in the laboratory for the major ions (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, HCO_3^{-}, CO_3^{-}, SO_4^{--}, Cl^{-}, NO_3^{-}), using the standard methods as suggested by the American Public Health Association [5]. Sodium (Na^{+}) and Potassium (K^{+}) were determined by flame photometer. Total hardness (TH) as $CaCO_3^{-}$, Calcium (Ca^{++}), Carbonate (CO_3^{-}), Bicarbonate (HCO_3^{-}) and Chloride (Cl^{-}) were analyzed by volumetric methods. Sulfates (SO_4^{--}) were estimated using the colorimetric technique.

Calculation of Sodium Percentage and Sodium Adsorption Ratio (SAR): Sodium adsorption rate (SAR) and sodium percentage (Na %) are used in Wilcox and Riverside charts to understand water quality for irrigation purposes. Na % is calculated in relation to the relative proportions of cations present in water using the following formula, with ion concentrations expressed in meq/l: using the following formula:

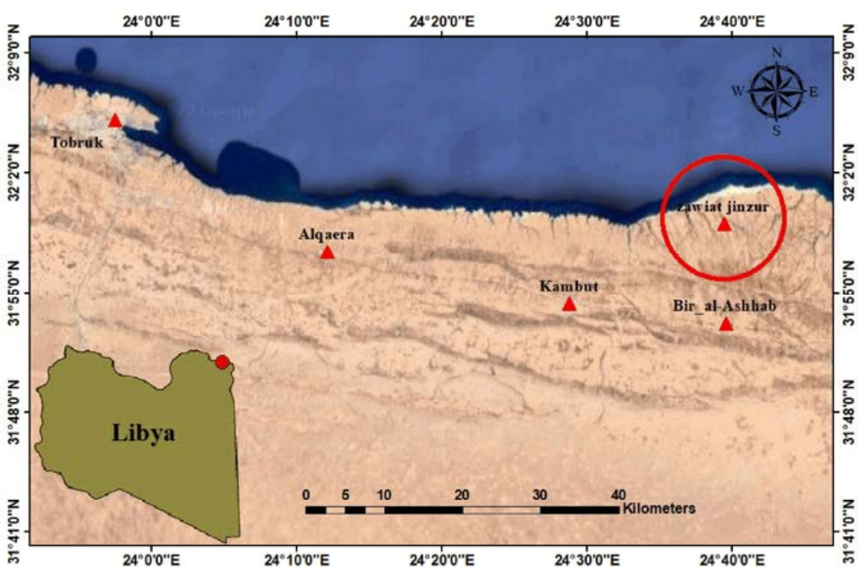

Fig. 1: Geographical location of the study area Source: Arcmap

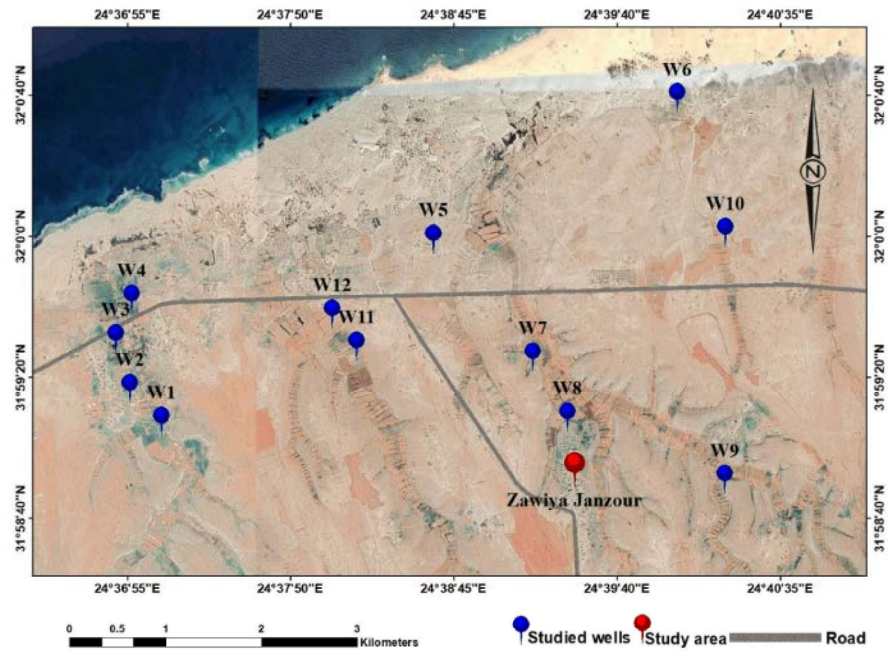

Fig. 2: Locations of wells in the study area. Source: Arc Map

$$\%Na = \frac{Na^{+}}{Na^{+} + K^{+} + Mg^{2} + Ca^{2+}} \times 100 \qquad (1)$$

The SAR is calculated from the ratio of sodium to calcium and magnesium, using the following formula:

$$SAR = \frac{\left[Na^{+}\right]}{\sqrt{\frac{\left[Ca^{+}\right] + \left[Mg^{2+}\right]}{2}}} \qquad (2)$$

There is a close relationship between the irrigation SAR and the extent to which Na+ is absorbed [6]. High concentrations of dissolved ions in water can adversely affect the physicochemical properties of plants and soils, leading to reduced productivity and destruction of soil structure [6, 7].

Statistical Analysis: Statistical Analysis: To analyse the study's data, the descriptive statistical analysis approach was used. Arithmetic averages (highest value, lowest value, general average) and other statistical and mathematical techniques were employed in the analysis using the statistical programme SPSS. Additionally, each item was statistically compared between using the One Way ANOVA test. There is a considerable difference of less than 5% between the two classes.

RESULTS AND DISCUSSION

pH: Data presented in Table 1 indicate that Well No. (4) had the greatest pH value (8.2) in the summer,, while Well No. (12) had the lowest pH value in the winter, resulting in an overall average of 7.4, as indicated in Table (1). According to the The World Health Organisation guidelines and Libyan standard specifications, all of the pH results are within the permissible range for drinking water. Rising pH values in summer could be attributed to the lower rock layers containing mineral oxides accelerate the process of these oxides' dissolution leading to raising in the pH in the summer time [8].

Total Dissolved Salts (TDS): From the same table, TDS values were low in all wells throughout the winter, as illustrated by the map of the regional distribution of TDS in the winter, which is displayed in Figure (3). This ia a result of surface runoff which feeds the wells during the wet season,. However, it can be seen from the map of the summer time Figure (4) the spatial distribution of dissolved salts in there was a significant concentration of total dissolved salts throughout this time. The study area is located in an arid to semi-arid environment and such the rise may be explained by the hot weather, high temperatures and little rainfall [8].

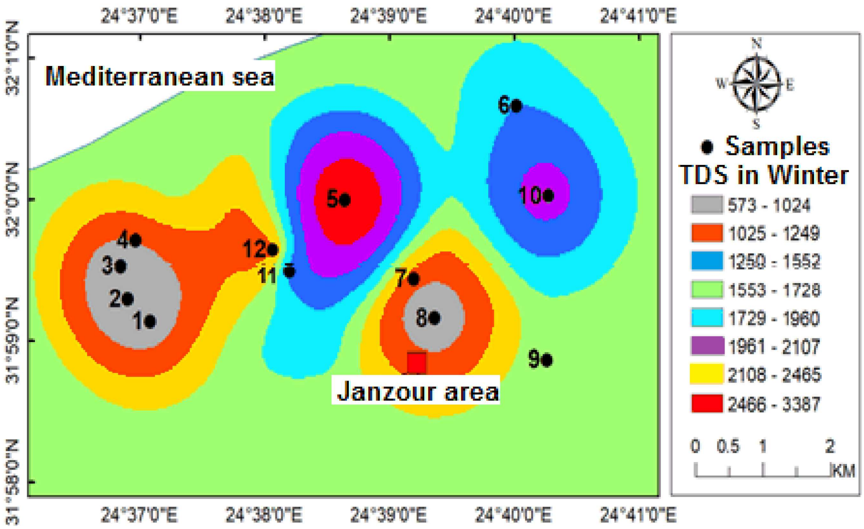

Fig. 3: Spatial distribution map of total dissolved salts for wells in the study area - winter season

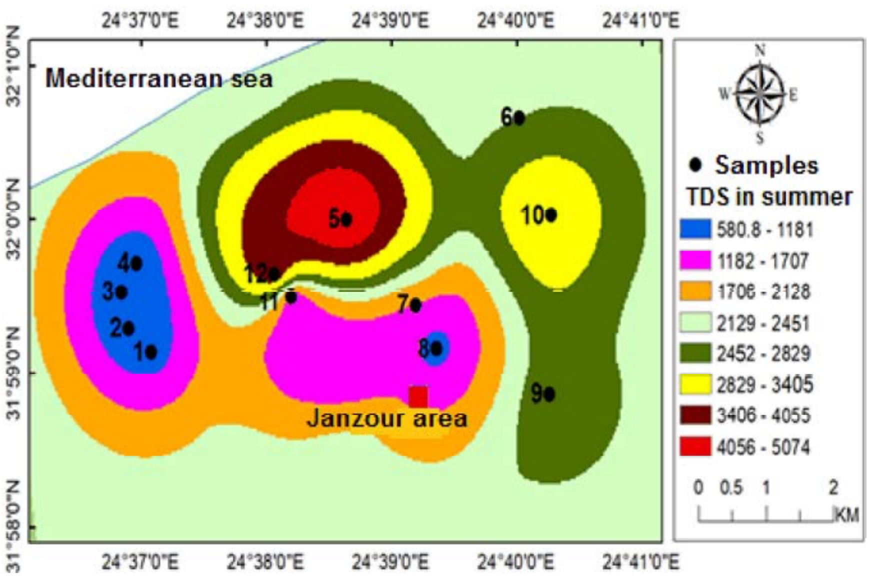

Fig. 4: Spatial distribution map of total dissolved salts for wells in the study area - summer season

Electrical Conductivity (EC): Data in Table (1) illustrates, the findings revealed a wide range of electrical conductivity values. In well No. (5), the maximum value of conductivity (7806 microSiemens/cm2) was recorded in well No. 5 in the summer, while the lowest value (1020 micro Siemens/cm2) was in Well No. 2 in winter season, meanwhile the general mean of all wells was (2891 microSiemens/cm2). Comparing the recorded values of EC with WHO specifications, it is clear that five wells in the summer and six in the winter are within the acceptable limits.The high electrical conductivity values could be attributed to the increase in total dissolved salts (TDS) concentration [9]. In addition, during the summer season, the increase in temperature cause higher evaporation and raise the quantity of salts that seep into the groundwater and raise electrical conductivity [10].

Calcium (Ca): The results in Table (1) show the greatest calcium content value at (586 mg/L) was recorded in summer and the lowest was at 86 mg/L. in winter season with general mean calcium content was 240 mg/L. Comparing these results with the World Health Organization's and Libya's standard criteria it is clear that wells the wells No (1, 2, 3, 4, 8) in the summer and

Table 1: Physical and chemical analyzes of shallow well water during the winter and summer seasons

	PH		EC μ sem/cm^2		TDS ppm		Ca (mg/l)		Mg(mg/l)	
Well No	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1	7.4	7.3	1433.3	1174.7	788.1d	688.7d	118	99	20	15
2	7.5	7.2	1170.3	1020.3	643.7 d	573 d	95	86	18	13
3	7.6	7.4	1234.3	1055.3	678.8 d	612.3 d	103	91	18	14
4	8.2	7.7	1056	1687	580.8 d	1051c	88	138	15	17
5	7.6	7.5	7806	5643	5073.8a	3387.3a	586	485	70	57
6	7.5	7.7	3859	3432.3	2455.3b	1959.7 b	304	283	46	43
7	7.7	7.5	3078	2055.7	1693c	1192b	250	164	40	30
8	7.5	7.3	1770	1142	973.5c	669 d	144	95	27	13
9	7.6	7.4	4231	2794.3	2750b	1652b	350	249	50	28
10	7.6	7.3	5230	3567.3	3399.5b	2104.3a	456	308	54	32
11	7.5	7.5	2490	2249.7	1369.5c	1281b	209	186	40	33
12	7.2	7.1	6020	4187.3	3913a	2463.3a	520	374	56	40
MAX	8.2	7.7	7806	5643	5073	3387	586	485	70	57
MIN	7.2	7.1	1056	1020	580	573	88	86	15	13
AVE	7.5	7.4	3281	2500	2026	1469.4	268	213	37	27
Lib 1992	8.5-6.5		-		1000(mg/l)		200 (mg/l)		150(mg/l)	
1984 WHO	8.5-6.5		μ2300 sem/cm		1000(mg/l)		200 (mg/l)		50 (mg/l)	

Table 2: Physical and chemical analyzes of shallow well water during the winter and summer seasons

	HCO_3 mg/l		SO_4 mg/l		Cl mg/l		NO_3 mg/l		Na (mg/l)		K (mg/l)	
Well No	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1	266	233	171	139	133	13	13	123	185	169	35	21
2	245	163	150	114	120	11	9	98	160	146	32	24
3	236	185	136	145	126	12	11	114	176	165	32	26
4	180	275	137	246	102	10	15	196	151	278	30	22
5	855	608	722	567	902	66	48	597	1556	1125	114	97
6	530	493	387	362	420	38	37	364	650	594	100	82
7	458	321	267	286	320	36	18	204	531	296	59	41
8	290	237	196	128	174	19	10	119	270	150	44	30
9	584	436	421	365	433	37	23	276	676	421	117	62
10	681	534	461	466	536	58	31	374	953	584	88	58
11	396	356	293	331	245	23	20	213	389	323	43	37
12	678	586	480	413	630	51	36	423	1243	768	68	40
MAX	855	608	722	567	902	66	48	597	1556	1125	117	97
MIN	180	163	136	114	102	10	9	98	151	146	30	21
AVE	449	368	318	296	345	31	22	258	578	418	63	45
LIB 1992			400 mg/l		250 mg/l		45 mg/l		200 mg/l		40 mg/l	
WHO 1984	200 mg/l		400 mg/l		250 mg/l		45 mg/l		200 mg/l		20 mg/l	

LIB (1992). Libyan Guidelines for drinking water quality. WHO (1984). Guidelines for drinking water quality. Results in column are mean of three replicates.

wells (1, 2, 3, 4, 7, 8, 11) in the winter are within the permissible limits for drinking water of he World Health Organization's and Libya's standard criteria. criteria, However, the rest wells exceeded the allowable limit. The area's drought as well as a rise in air temperature and evaporation rate might be the cause of the calcium increase. Furthermore, it is possible that highly soluble limestone rocks are a factor in raising the calcium content of water [11]. High calcium content in water is thought to have a major negative influence on human health as it can cause osteoporosis and other conditions.

Magnesium (Mg): The data in Table (1) demonstrate that the concentration of magnesium varies between the wells in the summer and winter, recording the maximum value at 70 mg/L with the summer and the lowest value at 13 mg/L in the winter. Both Wells (5, 10, 12 and 13) in summer and well (5) in the winter were above the required standards for drinking water;The general mean of Mg was 32 mg/L. Comparing the outcomes based on Libyan standard specifications: Throughout the study's two seasons it was found that every well met Libya's requirements for potable water (150 mg/L). The high concentration of magnesium found in certain wells, could be attributed to the earth's geological nature which may be the cause of the fluctuations in magnesium readings observed in these certain wells [11].

Sodium (Na): Data given in Table (2) reveal that the highest Na value recorded in summer (902 mg/L), while the lowest value at (98 mg/L.) was recorded in winter, with an average of 301 mg/L. Comparing these results with the World Health Organization's and Libya's standard criteria it is clear that wells the wells No (1, 2, 3, 4, 8) in both seasons were below the allowable levels for drinking water, but wells (5, 6, 7, 9, 10, 11, 12) were beyond the allowable limit Given that the region has a view of the Mediterranean Sea, it's possible that the interference of shallow well water and saltwater may be the cause of the rise in sodium content [9].

Potassium (K): Based on the data in Table (2), it is clear that the recorded the greatest value, of K which recorded 66 mg/L summer and the the lowest value (9 mg/L) was recorded in winter. The total average of all wells was 26 mg/L. When Comparing these results with the World Health Organization's and Libya's standard criteria it is clear that wells the wells No 1, 2, 3, 4 and 8 in the summer and 1, 2, 3, 4, 7, 8 and 11 in the winter K content was within the acceptable levels for drinking water by the World Health Organisation and the Libyan standard standards. Regarding the remaining wells, their potassium levels exceeded the World Health Organization's recommended levels. This might be attributed to the type and quantity of fertilizers utilized in the research region, the soil's potassium ion concentration and the condition of the parent material that makes up the soil [12].

Sulphur (SO_4): Data in Table (2) show that the greatest sulphate value (722 mg/L), recorded in summer, while winter had the lowest value, recorded at 114 mg/L. The average sulphate value for the year was 307 mg/L. It appears that wells 5, 9, 10 and 12 in the summer and wells 5, 10 and 12 in the winter exceeded these specifications when the results are compared with the World Health Organization's and Libyan standard specifications, while the remaining wells were within allowable bounds. The types of rocks that the water travelled through and the bacterial activity in the soil layers, which is crucial for oxidation processes, might be the cause of the variation in sulphate concentrations in drinking water between wells [13].

Nitrates (NO_3): Based on the data in Table (2), the deneral average concentration of nitrates was 54 mg/L, where the summer season have the greatest value of NO_3 (117 mg/L) and the winter has the lowest value at 21 mg/L. when the drinking water levels Libyan and international standard specifications It appears that wells 1, 2, 3, 4, 8 and 11 are in the summer and that wells 1, 2, 3, 4, 7, 8 and 11) 12) are in the winter were within the 50 mg/L,. This is based on a comparison of the obtained results with the World Health Organization's specifications and the Libyan standard specifications. The increases in nitrate concentration are often unrelated to changes in geological formations. In addition to heavy irrigation, summer time nitrate concentrations rise because of the diffusion of fertilizers ito water, which causes the Methemoglobinemia (blue baby syndrome) by the high concentration of nitrates in irrigation water that is resulted from the nitrogen compounds from fertilizers [14-16].

The higher values of NO_3 reported in winter season could be explained by Abd El Lateef *et al*. when they sampled ground waater at different depths they found that all of the sampling wells showed declining concentrations in NO_3 from April but increasing again from August, reaching similar levels in October to those at the start of the monitoring programme. This could represent an annual rhythm of nitrate leaching following the peak irrigation period, with a lag phase before the nitrate reaches the groundwater [17].

HCO_3 - bicarbonate: Table (2) displays the data indicate that the summer had the highest concentration (855 mg/L) and the winter had the lowest concentration (163 mg/L), with an average of 409 mg/L.. It seemed that wells (2) and (3) in the winter and well (4) in the summer were in accordance with WHO standards when compared to WHO specifications. The bicarbonate concentration levels in the remaining wells, on the other hand, were higher than the WHO drinking water guidelines. The dissolved of carbon dioxide gas in the limestone or dolomite may be responsible for this rise in bicarbonate concentration [18].

(Chloride - CI): Data in Table (2) reveal that the summer months had the greatest chloride content, which was measured at 1556 mg/L. whereas the winter had the lowest number, 146 mg/L, with an average of 489 mg/L overall. The wells (1, 2, 3, 4) in the summer and (1, 2, 3, 8) in the winter were found to be within the allowable limits for drinking water when compared to the World Health Organization's and Libya's standard standards.

Table 3: Sodium Adsorption Ratio (SAR), Dissolved Sodium Percentage (SSP), US Laboratory Salinity System (USSL 1954) and FAO 1985

	SAR		SSP %		USSL 1954		FAO 1985	
Well No	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1	2.23	2.26	42.30%	45.00%	C3-S1	C3-S1	LP	LP
2	2.22	1.93	44.40%	43.10%	C3-S1	C3-S1	LP	LP
3	2.25	2.18	44.00%	45.20%	C3-S1	C3-S1	LP	LP
4	1.97	3.08	42.80%	49.40%	C3-S1	C3-S1	LP	LP
5	6.9	5.03	51.50%	46.20%	C4-S1	C4-S1	LP	LP
6	4.41	3.96	47.70%	45.80%	C4-S1	C4-S1	PI	PI
7	3.7	2.88	45.40%	44.20%	C4-S1	C3-S1	LP	LP
8	2.61	2.24	43.20%	45.90%	C3-S1	C3-S1	LP	LP
9	4.25	3.25	45.40%	43.80%	C4-S1	C4-S1	PI	PI
10	4.65	3.97	44.70%	46.30%	C4-S1	C4-S1	PI	PI
11	3.06	2.83	42.60%	42.40%	C4-S1	C3-S1	LP	LP
12	5.14	4.07	46.10%	44.40%	C4-S1	C4-S1	PI	PI

Results in column are mean of three replicates

(LP) Light or moderate problem (PI) potential problem increase

The remaining wells values were higher than the permissible limits for drinking water. These findings suggest a clear correlation between the sodium, chloride and total dissolved salts in the wells. Seawater interference may be the cause of the elevated chloride content over the allowable limit, particularly in wells close to the shore [19].

Microbial Analysis: The findings demonstrated that there was no bacterial contamination at all in the water of the wells under investigation. This might be because the wells were placed far enough away from sewage tanks and were kept firmly closed to prevent contamination by surface runoff carrying human waste during the rainy season.

Assessment of the Quality of Irrigation Water Percentage of Dissolved Sodium % SSP: Based on the data in Table (3), we can see that the percentage of dissolved sodium had concentration values ranging from 42.3% to 51.5%. Well No. (5) recorded the greatest value, while Well No. (1) was the lowest value. It can be said that It is safe to use as irrigation water in the summer since it stays below the maximum percentage of dissolved sodium, which is 60% [20].

Sodium Adsorption Ratio (SAR): The results presented Table (3) indicate that the (SAR) values varied from 1.93 to 6.90 mEq/L. In the summer, Well No. (5) had the greatest value, while in the winter, Well No. (2) recorded the lowest SAR value. The discrepancy between the values of calcium and magnesium ions in relation to the sodium ion concentration may be the cause of the variance in sodium adsorption values [6]. The American Salinity Laboratory (USSL) defined the SAR values of the water from the tested wells as water acceptable for irrigation (S1) based on a comparison of the results with the worldwide classifications permitted for irrigation [7].

The Proposed Water Irrigation Classification According to the United States Salinity Laboratory (USSL): The results compared to the United States Irrigation Salinity Laboratory (USSL) standards in Table (3) indicated that all values in the summer and winter seasons lies within the categories of (C3 - S1) and (C4 - S1). This indicates that the salinity of the water quality ranges from high to extremely high and improper usage of it might cause the soil to deteriorate and become less productive. Regarding sodium danger, all values were between the first category's low harm. When something is considered It is accepted for most soil irrigation, but using it as drinking water might have negative health impacts [6, 7].

The Guidelines) of the Food and Agriculture Organization (FAO, 1985): It can be noticed from Table (3), that the classification of water according to the electrical conductivity concentration. According to our findings, wells 1, 2, 3, 4, 8, 11 in the summer and 1, 2, 3, 4, 7, 8, 9, 11 in the winter could be classified as mild to moderate problems, while the remaining wells in the summer and winter are classified as the potentiality for increasing problems. Based on the total dissolved salts content, the irrigation water in this system was categorized, showing that wells 1, 2, 3, 4, 7, 8, 11 are in the summer and wells 1, 2, 3, 4, are in the summer and wells (1, 2, 3, 4, 6, 7, 8), 11) In the winter it was located under this category There is no problem when used for irrigation [21].

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