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A Study of Some Specific Properties of the Irrigation Water Quality for Artesian Self-propelled Wells in Wadi Al-shatti Region in Southern Libya

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Abstract

This research was conducted with the purpose of studying some specific properties of irrigation water quality for artesian self-propelled wells in Wadi Shati region in southern Libya, and assessing the quality of chemical water properties and their suitability for irrigation. This study included 10 artesian self-propelled wells where the results showed that all the chemical properties of irrigation water were within the permissible limits of the Food and Agriculture Organization of the United Nations and the American Salinity Laboratory standards. except for potassium (K) that exceeded the permissible limits, where the results showed that the (K) concentration is between 0.51-0.59 meq/L, and the values of electrical conductivity ranged between 917-1035 s/m³µ, while the total dissolved salts were between 587-662 mg/*L*, also the exponent values The pH is between 6.9-7.7, while the sodium (Na) concentration is between 2.48-3.09 meq/*L*, and the calcium (Ca) results ranged between 0.6-0.9 meq/*L*, and the chloride concentration ranged between 4.37 and 4.90 meq/*L*, and these sulphate concentrations were between 1-2.54 meq/*L*, while the bicarbonate concentration ranged between 1.25-1.51 meq/*L*, The results of the basic indicators in irrigation water indicated that the percentage of sodium ranged between 49-59%, and the rate of sodium adsorption ranged between 2.45-3.45 meq/*L*, and the modified sodium adsorption ratio was 3.13-4.07 meq/*L* and the magnesium (Mg) risk ratio 43-67%, Thereby the water studied was classified as highly salty and low in sodium risk.

Keywords

Artesian Wells, Self-propelled, Irrigation Water, Water Quality

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1. Introduction

Libya is among several countries that are undergoing water scarcity with a per capita share of renewable water resources not exceeding 108 m^3/yr. The country relies almost entirely on groundwater which represents 97% of the total volume of water used for agricultural, industrial and domestic purposes. Other resources such as rain water, desalination and treated wastewater contribute the remaining 3%. Domestic water represents 12% of the total water supply in Libya and originates from three main sources, namely the Man-Made River Project (60%), the municipal well fields (30%), and desalination plants (10%).

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Domestic water use is expected to reach 860 Mm^3/yr by the year 2025 compared to 650 Mm3 at present. [1]

Well water is a type of groundwater and a well is a hole drilled or pierced inside the earth's crust until it reaches the saturation range (groundwater). The wells are divided into two main types, ordinary wells which are either hand-excavated and use groundwater close to the surface of the earth or drilled by mechanical means Sophisticated and then called automatic wells and use the most abundant and deeper groundwater, and the other is the automatic emission of water from it due to hydraulic pressure and these are called artesian wells [2, 3].

The quality of irrigation water plays a large role in plant growth and the expected productivity of irrigated lands, where agricultural crops need good quality and sufficient quantity of irrigation water to grow crops and obtain economic production [4, 5], in many regions of the world several agricultural problems results from the water produced as a result of the accumulation of salt in the soil, and the source of these salts is the water. Therefore, a study of the quality of irrigation water determines whether it is suitable for use in that it does not cause the conditions of saline or alkaline soils and the toxicity characteristic of plants and agricultural crops when irrigating [6].

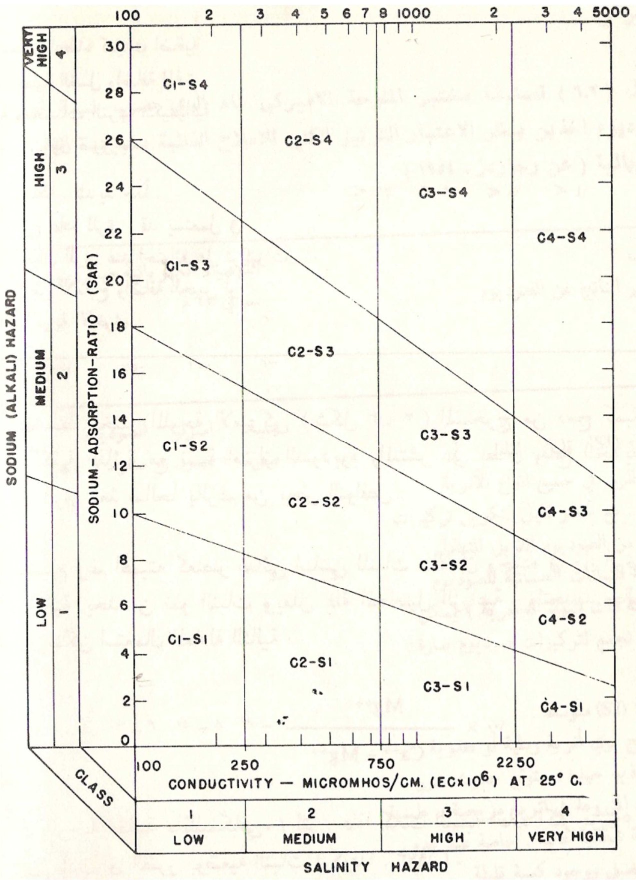

Figure 1. American Salinity Laboratory for Irrigation Water Classification Scheme.

Among the most important factors that determine the quality of irrigation water is the degree of salinity, as the excessive use of water with high salinity in irrigation does not affect the growth of the plant and the amount of production only, but it has a harmful effect on the soil as it turns over time into saline soils, and the continuous monitoring of some concentrations of elements such as sodium (Na), potassium (K), calcium (Ca) and magnesium (Mg), and determining their concentration, is necessary to know the suitability of this water for irrigation [7-9].

This study aims to evaluate some of the specific characteristics of irrigation water quality for artesian self-propelled wells and to determine the suitability of this water for irrigation crops by comparing it with the standards of irrigation water quality for FAO.

2. Experimental

2.1. Sample Collection

The study included Wadi Al-Shati area in south western Libya between latitudes 27º-28º north and longitudes 12º-15º east, where 10 samples were collected from self-propelled groundwater wells that are under study in clean plastic containers with a capacity of 2 litters (three replicates per sample) Physical and chemical analysis were performed on these samples.

2.2. Methods

2.2.1. pH Values

The pH of the water samples were measured immediately after collection using the JENWEY 3310 pH Meter.

2.2.2. Electrical Conductivity and Total Dissolved Salts

Electrical Conductivity (EC) was measured for the samples after collection using the Laboratory type ELE Conductivity Meter 4310, then the Total Soluble Salt concentration (TDS) was calculated mathematically by the electrical conductivity values obtained during the measurement of samples, according to the following equation Eq (1):

$$TDS = EC \times 0.64 \quad (1)$$

2.2.3. Chlorides

Determine the chloride concentration by means of Mohr Titration with silver nitrate (0.0141 M) using potassium chromate as indicator as stated in the American Public Health Association, (A. P. H. A) [10].

2.2.4. Sulphate

Turbidity method was used to measure the sulphate concentration in drinking water samples using the Spectrophotometer PU 8625 UV/Visible apparatus as shown in (A. P. H. A).

2.2.5. Bicarbonates

The bicarbonate and carbonate were calculated by titration of hydrochloric acid (0.02 N) as reported in (A. P. H. A).

2.2.6. Sodium (Na) and Potassium (K)

The sodium and potassium concentration were measured using the Corning 410 Flam photometer as described in (A. P. H. A).

i. The Percentage of Sodium SP%

The Percentage of Sodium SP% was calculated by the following equation Eq (2):

$$SP\% = \frac{\mathrm{Na(meq/L)}}{\mathrm{Ca}+Mg+K+Na(meq/l)}\ X\ 100 \quad (2)$$

ii. The Percentage of Sodium Adsorption (SAR)

The Percentage of Sodium Adsorption (SAR) was calculated by the following equation Eq (3):

$$SAR = \frac{\mathrm{Na(meq/l)}}{\sqrt{\frac{Ca+Mg(meq/l)}{2}}} \quad (3)$$

iii. The Modified Sodium Adsorption Ratio

The Modified Sodium Adsorption Ratio was calculated using this equation:-

$$SAR_{adjt=}SAR\ (1 + 8.7\text{-}PHc) \quad (4)$$

iv. The Remaining Sodium Carbonate RSC

The Remaining Sodium Carbonate RSC has been calculated from the following equation in (m eq/L)

$$RSC=(CO_3 + HCO_3) - (Mg + Ca) \quad (5)$$

2.2.7. Calcium (Ca) and Magnesium (Mg)

Hardness, calcium and magnesium were estimated in water samples titrated by E. D. T. A.

2.2.8. The perc$entage of ma$gnesium Risk

The Magnesium % was calculated using the following equation Eq (6):

$$Mg\ \% = \frac{\mathrm{Mg(meq/L)}}{\mathrm{Ca}+Mg\ (m\ eq/L)}\ x\ 100 \quad (6)$$

3. Result and Discussion

3.1. The pH

The pH values of studied irrigation water samples ranged between 6.9 and 7.7 as shown below in Table 1, These values are considered within the guiding standards of the FAO, which states that the water used for irrigation should not exceed the pH of (6-8.5). (These values are consistent with previous studies that were within the permissible limits such as Kalash et al., 1981, El-Seeaidi, Vogerbrow 1995, Abosathi and Ahmed, 2015) [11-13].

Table. 1. Some physical properties and the concentration of anions and cations for irrigation water for artesian wells.

Well No.	ANIONS (meq/l)			CATIONS (meq/l)				PH	E. C µs/cm
	SO_4^{--}	HCO^-_3	CL^-	K^+	Na^{++}	Mg^{++}	Ca^{++}		
1	1	1.36	4.85	0.51	2.52	1.42	0.7	7.7	933
2	1.52	1.26	4.9	0.54	2.52	1.08	0.6	7.4	938
3	2.25	1.28	4.82	0.51	2.48	1.17	0.65	7.6	918
4	2.1	1.25	4.73	0.54	2.52	1.03	0.7	7.4	922
5	1.6	1.33	4.76	0.54	2.48	0.83	0.9	7.5	917
6	1.85	1.45	4.39	0.54	3.04	0.83	0.75	6.9	1035
7	1.81	1.45	4.37	0.56	3	0.75	0.9	7.4	1006
8	2.1	1.33	4.45	0.56	3.04	0.92	0.8	7.3	1017
9	1.73	1.51	4.56	0.59	3.04	0.67	0.9	7.5	1029
10	2.54	1.33	4.53	0.56	3.09	0.92	0.7	7.3	1029
FAO	20-0	10-0	30-0	--	40-0	5-0	20-0	8.5-6.5	--

3.2. Electrical Conductivity

Electrical conductivity is one of the main indicators of the high or low salinity of the water used in irrigation, and by comparing the results shown in Table 1, the value of electrical conductivity ranges between 917-1035 s/cm³µ in well No. 5 and 6, respectively, and with these results, these are classified Water according to the salinity severity is medium to high risk.

3.3. Total Dissolved Salts TDS

The total TDS of all wells studied were within the guiding standards of the FAO, where the lowest concentration was 587 mg/L was in well No. 3, 5 and the highest concentration was 662 mg/L in well No. 6 as shown below in Table 2, and the total soluble salts are an indication of the concentration of dissolved salts and pollutants that are in the form of substances and compounds dissolved in water as a negative and positive ions or organic substances or salts, acids and alkalis dissolved in water, these results were Within the permissible limits.

Table 2. The values of the basic indicators used to evaluate irrigation water for artesian wells.

Well NO.	RSC	SAR_{adj}	Sp	MgR	SAR	TDS
1	-0.67	3.62	49	67	2.45	597
2	-0.42	3.26	53	64	2.74	601
3	-0.54	3.13	52	64	2.61	587
4	-0.48	2.94	53	60	2.7	590
5	-0.4	3.16	52	48	2.66	587
6	-0.13	4.07	59	53	3.25	662
7	-0.2	3.88	58	45	3.29	644
8	-0.39	3.87	57	53	3.28	651
9	-0.06	4.03	58	43	3.42	659
10	-0.29	4.04	49	57	3.43	659

3.4. Chloride

Through the results obtained for the analysis of well's water in Table 1, the lowest concentration was in wells 4 and 7 and the highest concentration in well No. 2 and the results of chloride in the samples range from 4.37 to 4.90 mmc/*L*. This water is classified as medium in its content of Chloride did not exceed the indicative limits of FAO, which are (0-30 meq/*L*), and this water is suitable for irrigating crops that are well tolerated for chlorine with the appearance of moderate damage to plants less tolerable to chlorine.

3.5. Sulphates

The sulphate concentration indicates that the studied well water has a moderate percentage of sulphate, as its sulphate content ranges between (1-2.54 meq/*L*) as shown in Table 1 and it is within the permissible limits, as the FAO has set the indicative limits of (0-20mg/L).

3.6. Bicarbonate

The concentration of bicarbonate in the studied wells ranges between 1.25-1.51meq/*L*, where it was the lowest value in well No. 4 and the highest value in well No. 9 as shown in table 1.

3.7. Sodium and Potassium

The results obtained from the study found in Table 1 indicate that the irrigation water content of sodium was the lowest 2.48 mm/*L* in well No. 3 and 5 and the maximum concentration of 3.09 mm/*L* in well No. 10, which is within the indicative standards according to FAO ,And it corresponds to other studies being within the permissible limits [10-12].

Also the study showed that the lowest concentration of potassium in the studied samples was in well No. 1 and 3 and reached 0.51 meq/*L* and the highest concentration was in well No. 9 0.59 meq/*L* as shown in Table 1.

3.7.1. The Percentage of Sodium SP%

By calculating the percentage of sodium found in Table 2, the following results were reached: The lowest percentage in well No. 1 was (49%) and the highest percentage in well No. 6 was (59%). When this percentage increases above 50%, it reduces the quality and suitability of this water for irrigation purposes due to the high percentage of sodium, which leads to the possibility of increasing the exposure of land and plants to alkaline damages.

3.7.2. Sodium Adsorption Ratio SAR

The SAR value ranged between 2.45 -3.45mmc/*L* .Thus, the water is classified as suitable for irrigation for all types of lands, as it did not exceed the guiding limits of FAO, which are estimated (0-15 meq/*L*).

3.7.3. Modified Sodium Adsorption Ratio

The results of the modified sodium adsorption ratio, shown in Table 2, ranged between 3.13-4.07 mg/*L* in well 3 and 6, respectively. These ratios make this water do not cause permeability problems according to the Ayersvistot classification to determine the validity of irrigation water, and when comparing the values of each of the adsorption ratio Sodium with modified sodium adsorption ratio and the difference between them It is clear that there is an increase in the values of modified sodium adsorption ratio over the values of sodium adsorption ratio and this means that the water has the ability to precipitate calcium carbonate in the soil [14-16].

3.7.4. The Remaining Sodium Carbonate RSC

The results in Table 2 indicate that all values were negative, and this means the prevalence of calcium and magnesium ions so that there is no room for precipitation of sodium carbonate and this makes it free of sodium carbonate residual, and this water is suitable for irrigation purposes for all types of lands and thus reducing the harmful effect of sodium ion.

3.8. Calcium and Magnesium

The results of calcium estimation in all the samples under study as shown in Table 1 indicated that all well's water is within the guiding standards according to FAO, which is (0-20 mm/m)/*L*, where the least concentration was 0.6 mm/m in well No. 2 and the highest concentration was 0.9 meq/*L* in Well No. 5, 7 and 9.

Also the results obtained for the magnesium concentrations shown in Table 1 showed that the lowest concentration in well No. 9 was 0.67 mm/*L* and the highest concentration in well No. 1 was 1.42 mmc/*L*, and these values make the samples examined within the guiding standards of FAO.

3.9. The Percentage of Magnesium Risk

All concentrations calculated for the magnesium risk referred to in Table 2, which ranged between 43-67% in well 9 and 1 respectively, and it is known that if the magnesium risk ratio exceeds 50%, the water is dangerous for most crops

4. Conclusion

The studied irrigation water was classified according to the American Salinity Laboratory scale. This scale depends on the relationship between the degree of electrical conductivity in (µs/cm³) and the rate of sodium adsorption, where it was found that all studied water samples range between 917-1035 (/s/cm³), that is, they According to this scale, it falls within the high-salinity water (C3). As for SAR, it was found that all school water samples range between 2.45 -3.45 as it is according to this scale located within water (S1), which makes this water classified as C3-S1, which is considered high. Low-sodium salinity, which makes this water not suitable for irrigating sensitive crops, especially citrus fruits, and for irrigating lands that do not have dirt or hard layers that prevent leaching.

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