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MONITORING IRRIGATION GROUNDWATER QUALITY USING CHEMICAL AND INTERPOLATION ANALYSIS

(Chemical and Interpolation Analysis to Monitoring Groundwater Quality Used for Irrigation)

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ABSTRACT

Monitoring and assessment of irrigation groundwater is one of the main challenges for decision-makers, local authorities in terms of determining the chemical and spatial characteristics. This study aims to monitor and assessment of irrigation groundwater quality and its suitability for agricultural purposes in Sugh EL-Chmis District, Libya. For this purpose, the groundwater quality data was collected from 16 agricultural wells. The samples were taken based on the following parameters: pH, EC, TDS, $CaCO_3$, ca, mg, CO_3^{2-}, HCO_3^-, SO_4^{2-}, Cl-, NO_3^-, Ca^{2+}, Mg^{2+}, Na^+ and K+. In addition, the rates of Sodium Adsorption Ratio (SAR), Soluble Sodium Percent (SSP), and Kelly's Ratio (KR) in the groundwater were examined. These data were inserted into the Geographic Information Systems environment; the quality maps of groundwater for each element were prepared using the Inverse Distance Weightage (IDW) module. The results of spatial maps showed that the concentration of the chemical constituents in ground water varies spatially, where shown high contamination along the northern region of the study area, while the southern region was more suitability for irrigation. In fact, and according to SAR value, all of the groundwater samples were an excellent class, on the contrary, the KR value of all the area was unsuitable for irrigation (508.47 km^2). In addition, (453.43 km^2) of the study area was doubtful according to SSP value. Overall, the study area has just (8.08 km^2) of an excellent groundwater quality for irrigation, while (280.53 km^2 and 148.97 km^2) was doubtful and unsuitable for irrigation in the study area.

KEYWORDS: *Monitoring, Groundwater Quality, Irrigation, Interpolation, Chemical.*

1. INTRODUCTION

Groundwater is the main source of water for agricultural, industrial, and domestic uses in many countries. As such, monitoring the chemistry of groundwater is essential in determining its use for irrigation, domestic, and industrial. However, the uncontrolled use of irrigation water results in the waste of water resources and Which may result to find unsuitable groundwater for crops..(Kourgialas et al., 2017), hence monitoring and conserving this important resource is essential for sustaining life on this planet.

Irrigation water quality is defined as the properties of water which could potentially affect human through agriculture. Several researchers have stated that a complete irrigation water quality takes the following factors into consideration: total salinity, water infiltration rate, pH, specific toxic ion concentration, microbial pathogens and excess nutrients (Bauder et al. 2003). Using contaminated wastewater for agricultural activities could have mild to severe physical skin effects, while total salinity of the water could lead to crop yield loss. Similarly, pH and toxic ions could also affect the potential growth of plants, and when combined with total salinity they have the potential to exert an even more complicated and hazardous effects on crop yield. Coliforms present in irrigation water could anchor into raw vegetables and pose great health risk if and when the vegetables are consumed. (Nguyen 2016) proposed several water characteristics, which must be understood to produce a reliable database, for assessing the above-mentioned factors.

Water contains varying types and amounts of dissolved mineral, and these two factors govern the suitableness of water for different uses. In this regard, groundwater is known to contain higher amounts of minerals than surface water (Dhimmar 2014). The quality of groundwater fluctuates as the daily, seasonal and climate factors change.

Chemistry of groundwater often to affected by several factors such as the general geology of the area, the degree of chemical weathering of the various rock types, and the external pollution, including effluents from agricultural return flow, industrial, and domestic activities (Davraz and Özdemir, 2014). Excessive sodium content in water renders it unsuitable for soils containing exchangeable Ca and Mg ions. If the percentage of Na to (Ca + Mg + Na) is considerably above 50 in irrigation waters, soils containing exchangeable calcium and magnesium will take up sodium in exchange for calcium and magnesium causing de-flocculation and impairment of the tilth and permeability of soils10. Groundwater quality can be It can also be affected by natural processes that result in elevated concentrations of certain constituents in the groundwater.

Problems related to the quality of groundwater are widespread and vary in scope and severity. They can be divided into two main categories: those caused by contamination, and those caused by overexploitation. Most problems are as yet unidentified since they are hidden from view below the surface of the ground. Since the flow of groundwater tends to be very slow, the impact of today's action might not become apparent for the next several decades (Ramachandra 2006).

Joseph Holden et al. (2012) examined the effort to balance high aspirations for environmental water quality, with high growth in agricultural production to fulfil the objectives of food security and provide viable livelihoods for farmers. They found that land management is amongst the many factors affecting the quality of the surface and groundwater. They recommended that consideration be given to current issues regarding agriculture-related water quality and how these problems can be mitigated.

Assessing the quality of groundwater is important for the sustainable use of this resource, where it can be affected or degraded as a result of different human activities.(Selvam et al., 2014) however, the groundwater analysis is one of the most important issues in groundwater studies. Recently, the GIS technique has been used to identify and spatial variations of groundwater significantly (Kourgialas et al., 2017).

Libya has depended on groundwater to meet its needs for a long time; it relies on it to meet 95 percent of its water requirements (UNEP, 2010). However, the demand for water continues in various fields. Therefore, many coastal groundwater aquifers are becoming salty due to seawater intrusion. Thus, the depletion of groundwater is a major environmental concern as a result of overuse in agricultural developments (Bindra et al., 2013).

In the study area, valuation of groundwater quality for irrigation is necessary, as the prospect of a change in the quality of groundwater has happened with the population growth and agricultural expansion in the region. Hence, the chemistry study of the groundwater is important in order to find out the suitability of the groundwater for irrigation purposes. The poor quality of the irrigation water may affect crop yields and soil's physical conditions, by contrast, if the water quality is good, the agricultural production will also be good (Reddy, 2013).

The present study monitoring the groundwater based on laboratory investigation and integrates the various databases for mapping the spatial distribution of groundwater parameters in the study area Sugh EL-Chmis using IDW method in GIS.

2. MATERIAL AND METHODS

2.1 Location of the study area:

The area geographically lies between the north latitudes of 32° 26'N and 32° 37'N, and between the east longitudes of 14° 13'E and 14° 26'E' with an estimated land mass of about 508.47 km^2. In fact, this region is one of the oldest agricultural areas in Libya with the best arable soils for agricultural activities. However, the region has been experiencing remarkable changes in the various living areas at a rapid pace.

The study area (SUGH EL - CHMIS) lies to the north-west on the Mediterranean coast, in the north-west of Libya. It is located between the city of Al Khums in the west (120km east of Tripoli) and the city of Zliten in the east (70km west of Misrata), and bordered by the Al Amamra village in the south(Abunnour et al., 2016) (Fig1).

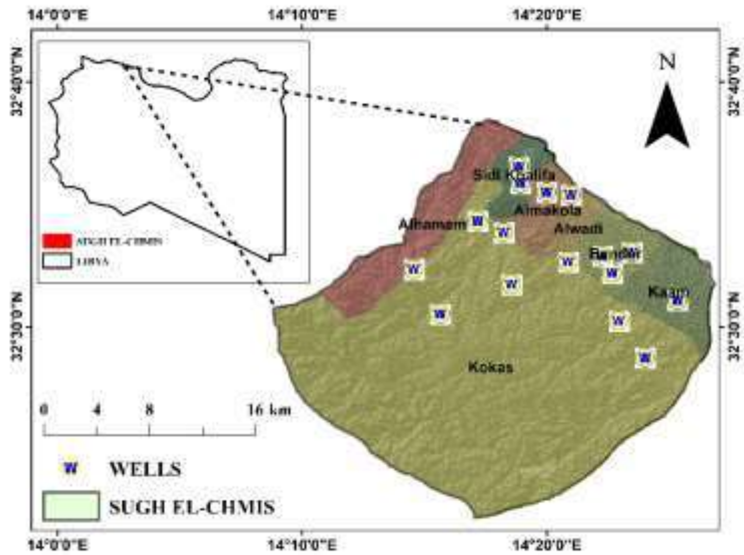


Figure 1: Location of study area

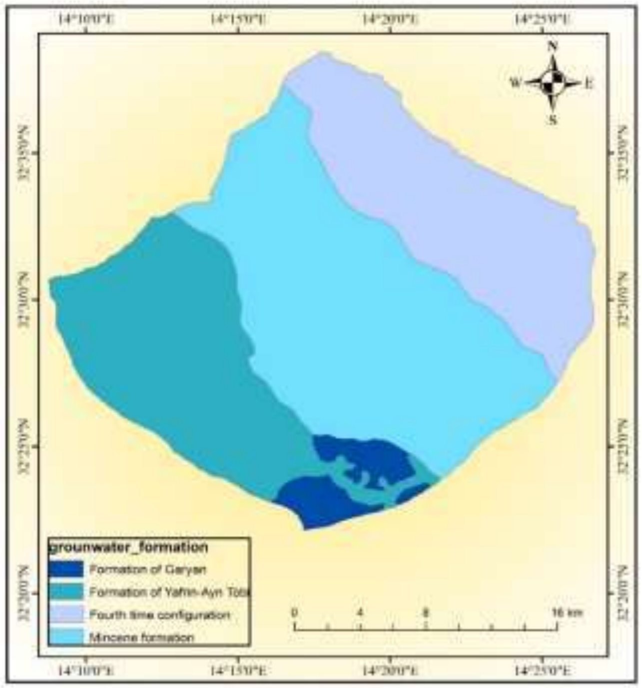
2.2 Underground Water:

Since the ancient times, the underground water plays a great role in human life stability especially in drought time. Currently, the underground water covers a 98% of water needs in the Libya with 80% employed for agricultural purposes (HAMILA, 2001).

The underground water is existed within underground reservoirs including renewable and non-renewable ones. The renewable reservoirs are located in east areas nearby the sea since the quaternary and Miocene ages and enriched by raining over time (HAMILA, 2001). While the non-renewable reservoirs are located in the south areas since the Cretaceous and Alkmbrod Vichy ages (Center, 1975).

The area under the study is characterized by possessing rocks bearing formations full of water since the Cretaceous and chalky age. (Fig2)

Fieger 2: groundwater formations in the study area.



(GEFLI, 1972).

i. Surface Tanker:

It is located on the south part of the sea beach and counts up to 3 km. this tank is a form of Limestone.(Authority, 2002)Its depth is estimated at 15 to 30m and the static level of water is estimated at 10 to 15m.

The tanker's productivity revolves around 15.5 m^3/hour with dissolved salts of 3 to 7 gm/l. This tanker has been overused resulting of high percentage of dissolved salts if compared to other tanks(Authority, 2002).

ii. Mucin Tanker:

It is considered as a limestone with the integration of marl. This tanker extends for 25 km toward the south and its depth varies around 30 to 100m while the water level varies from 50 to 70m. the productivity of this tanker is equal to 20 m^3/hour. On the other hand, the dissolved salts are estimated at 2 to 3gm/l. However, due to the indiscriminate drilling of civilians the consumption of water has exceeded the limits in recent years(Authority, 2002).

iii. Gherian Tanker:

It encompasses the limestone and Dolomite stone. It is highly used in Kaam for agriculture. The depth of this tank varies from 80m to 120m while the static water level is estimated at 5m to 40m. the productivity of this tank amounts to 150 m^3/hour. On the other hand, the dissolved salts around 1.8m to 2.5gm/l.

iv. Ain Tabi Tanker:

It is located in the south and south west areas and used mainly by private farms. Its depths go around 175 to 500m and formed from limestone and marl with some Dolomite. The level of static water varies from 100 to 150m approximately. The productivity of this tanker varies from 40 to 80 m^3/hour with dissolved salts of 2 to 2.5m/l.

v. Sandstone Tanker

The stones of this tanker include sandstone and soft sandy clay with water being exited in depths of 500 to 700m from the surface of the earth (Ramali and Holloway, 2012). The static water level varies from 20 to 25m due to the high depth of this tanker, it is rarely used by civilians and the dissolved salts don't exceed 2.5gm/l with high productivity estimated at 100m^3/hour.

2.3 Data collection from groundwater samples:

The groundwater data for this study was collected from sixteen (16) samples, taken randomly but regularly from the wells used for agriculture in the region ،where the area has been divided into two parts, a northern part (8 wells less than 4.5 km from the sea), and a southern part (8 wells more than 4.5 km), depending on the depths different wells in the region between north and south.by tracking the following lines:

i. In the beginning, searcher coordinated with the farm owners for taking samples of the water during irrigation. These samples were collected on the 6-7th of August 2015, in this season (summer) the irrigation is almost daily. Thus, the water withdrawals from the wells have reached their peak.

ii. Thereafter, the geographical coordinates of the wells during the sample collection were identified by the Global Positioning System (GPS) (Table 1and finger 3).

iii. As a final point, collected samples were kept in plastic bottles (500ml) and given to the Laboratory later to chemical analysis of groundwater samples because it is important to know the specific characteristics of the quality of water for irrigation.

iv. The surface of the study area are varied from one place to another, where it is a narrow plain, inclined surface clearly from the south to the north towards the sea, and punctuated by numerous dry valleys short (finger 3) however, the farms in the south-eastern are much lower than those in the south-west of the region.

Table (1). Information of Wells in the study area

NO. OF WELLS	LOCATION		DISTANCE FROM THE SEA IN KM.	DEPTH OF THE WELL
	N	E		
1	32°35'18.72"	14°21'1.64"	0.9 km	22m
2	32°35'26.00"	14°20'1.88"	1.7 km	31m
3	32°36'30.89"	14°18'51.91"	2.2 km	24m
4	32°32'59.15"	14°23'30.77"	2.35 km	35m
5	32°31'0.56"	14°25'21.82"	2.64 km	40m
6	32°35'48.63"	14°18'57.16"	2.7 km	25m
7	32°32'52.16"	14°22'18.03"	3.6 km	36m
8	32°32'9.59"	14°22'40.70"	4.5 km	45m
9	32°32'37.20"	14°20'52.68"	4.9 km	140m
10	32°33'49.54"	14°18'15.17"	5.8 km	60m
11	32°34'16.30"	14°17'12.24"	7 km	140m
12	32°31'40.73"	14°22'48.60"	7 km	65m
13	32°28'40.41"	14°24'2.15"	7.2 km	85m
14	32°31'42.47"	14°18'33.67"	8.7 km	150m
15	32°33'9.29"	14°13'53.22"	12.1km	143m
16	32°30'29.41"	14°15'39.28"	13.5km	120m

Source; field study 2015.

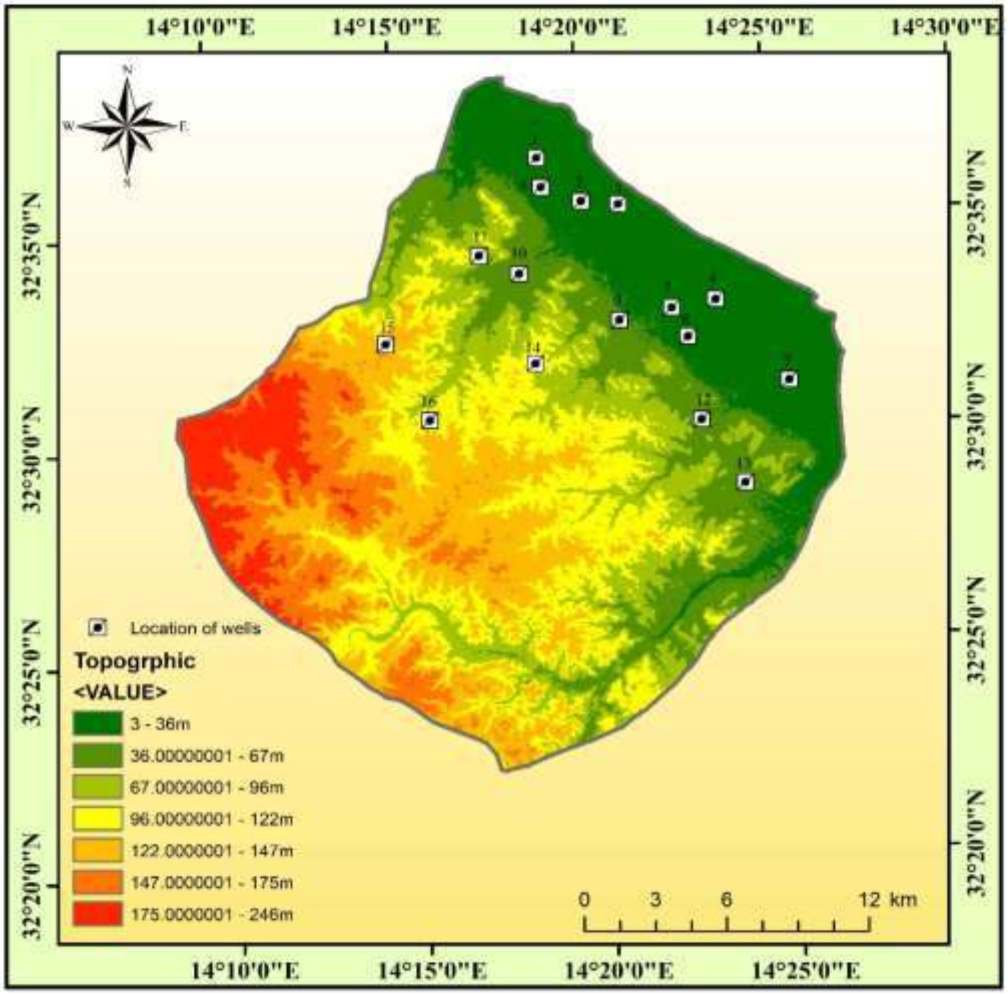


Fig3: location of the wells.

2.4 Chemical analysis of groundwater samples:

In the chemical analysis laboratory for water, the quality of the groundwater in the region was evaluated, whereby the assessment included most of the chemical elements in them, which were represented by pH, conductivity (EC/cm), dissolved solids (TDS mg/l), total hardness ($CaCO_3$ mg/l), calcium hardness (ca mg/l), magnesium hardness (mg mg/l), carbonate (CO_3^{2-} mg/l), bicarbonate (HCO_3^- mg/l), sulfate (SO_4^{2-} mg/l), chloride (Cl- mg/l), nitrate (NO_3^- mg/l), calcium (Ca^{2+} mg/l), magnesium (Mg^{2+} mg/l), sodium (Na^+ mg/l), and potassium (K+ mg/l).

2.5 Water classification for irrigation:

Good groundwater quality used for irrigation is sometimes not available in sufficient to satisfy the crops requirements. However, this study has adopted the following elements and parameters to determine the suitability of groundwater for irrigation. In order to study the quality of groundwater, the chemical data of the samples which collected were assessed in terms of its suitability for irrigation. Moreover, before using Inverse Distance Method (IDW) for producing the groundwater quality maps, the Weights of specific elements validity water for irrigation have been amended. Each class in every thematic map was assigned a weight. Highest weight was assigned to the class that is most suitable for that purpose and the lowest weight was assigned to the class that is least suitable/unsuitable class. (Table 2).

i. Electrical Conductivity.
ii. Total concentration of dissolved salts (TDS);
iii. Acidity degree (pH).
iv. Sodium adsorption's ratio (SAR) (Raghunath, 1987).

$$\mathrm{SAR} = \mathrm{Na}^{+} / \frac{\sqrt{\mathrm{Ca}^{2+}\mathrm{Mg}^{2+}}}{2}$$

Where, SAR = Sodium adsorption ratio Na^{2}+= sodium percentage (MM/L)

Where, the concentrations of Ca+2, Mg+2 and Na+ are expressed in milliequivalents per litre.

vi. Kelly's Ratio is calculated using the equation (Kelly's 1963) shown below. Sodium is measured against *Ca+2*, and Mg+2 is used to calculate Kelly's ratio. The formula used in the estimation of Kelley's ratio is expressed as:

$$\mathrm{KR} = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$$

Where, all the ionic concentrations are expressed in meq/L.

Ca^{2}(2+) =calcium percentage (MM/L) Mg^{2}(2+) = Magnesium percentage (MM/L).

v. Soluble Sodium Percent (SSP) for groundwater was calculated by the formula,

$$\mathrm{SSP} = \frac{Na \times 100}{Ca^{2+} + Ma^{2+} + Na^{+}}$$

Table.2. Limits of parameter indices for rating groundwater quality and its suitability for irrigation

Weight	Amended Weight	Class	Criteria	
5		Excellent	< 250	
4		good	250-750	
3		medium	750-2250	EC
2		doubtful	2250-4000	
1		unsuitable	>4000	
4	5	Excellent	<10	
3	4	good	10-18	
2		doubtful	18-26	SAR
1		unsuitable	>26	
5		Excellent	< 20	
4		good	20-40	
3		medium	40-60	SSP
2		doubtful	60-80	
1		unsuitable	> 80	
5		Excellent	<500	
4		good	500-1100	
3		medium	1100-2000	TDS
2		doubtful	2000-3200	
1		unsuitable	>3200	
5		Excellent	7	
4		good	6.5 & 7.5	
3		medium	6 & 8	pH
2		doubtful	5.5 & 8.5	
1		Unsuitable	<5.5 &> 8.5	
2	4	good	<1	KR
1		Unsuitable	>1	

Source: modified from(Ordookhani et al., 2012)

2.6 GIS Spatial Integration and Quality Evaluation:

To finding a solution for water resources problems and evaluating water quality, GIS became a valuable tool for determining the extent of water available and suitable for human use. In the present study, ArcGIS 10.2 software was used for spatial integration and irrigation water quality mapping. Based on the irrigation water quality standards, the spatial distributions of major elements (EC, SAR, SSP, TDS, pH and KR) were integrated with the help of the Inverse Distance Weightage IDW module available in the GIS software. Where this tool uses a determined or a selected group of sample points to estimate the output of grid cell value. Furthermore, in the IDW method, the sample points are weighted during interpolation such that the influence of one-point relative to other declines with distance from the unknown point wants to create(Shoeb and Muluken, 2015). (Fig2) illustrated the methodology. In the final step, the raster calculator tool is used to get the final map of the suitability of groundwater for the purpose of irrigation in the region.

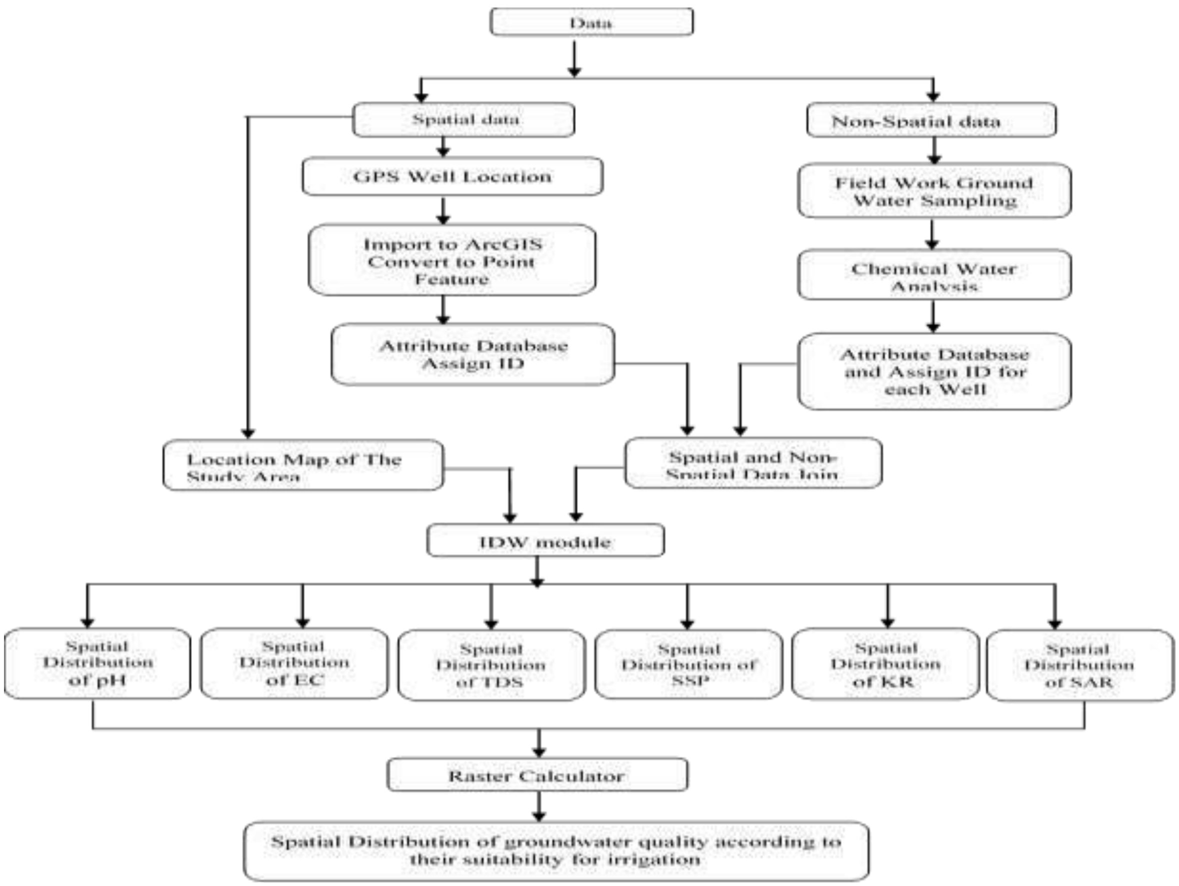


Figure (2). Flow chart showing the methodology adopted for Spatial Distribution of groundwater quality according to its suitability for irrigation mapping.

3: RESULTS AND DISCUSSION

Sixteen groundwater samples were collected from the agricultural wells in the region. These wells differed in their remoteness from the sea coast, as well as in depths. Based on these differences, the results of the chemical analysis were also different. as shown as in the table (3).

Table (3): Results of the chemical analysis of groundwater samples.

Well No	pH	EC	TDS	$CaCO_3$	Ca	Mg	CO_3^{2-}	HCO_3^-	SO_4^{2-}	Cl^-	NO_3^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
1	6.73	12148.59	7775.1	2592.33	1090.98	1501.35	0	227	1378	3400.12	111.1	436.83	364.53	1824	33.48
2	6.47	10210.63	6534.8	2502.25	1201.08	1301.17	0	234	1028	2950.34	108.1	480.91	315.92	1394	23.57
3	6.88	4209.53	2694.1	1050.95	540.49	510.46	0	202	615	970.77	25	216.41	123.94	525.8	15.19
4	6.54	9608.13	6149.2	2232.01	1111	1121.01	0	231	1221	2540.23	86.9	444.84	272.18	1337	16.04
5	6.49	7014.06	4489	1961.76	1020.92	940.85	0	173	1083	1690.12	73	408.78	228.44	814.9	17.78
6	6.86	3530.94	2259.8	840.76	450.41	390.35	0	185	526	790.11	17.2	180.34	94.78	453.5	12.86
7	6.78	9269.69	5932.6	2011.81	1030.93	980.88	0	184	1086	2570.65	62.3	412.78	238.16	1363	15.69
8	6.76	5453.75	3490.4	1391.25	630.57	760.68	0	164	879	1280.45	35.8	252.48	184.69	682.3	11.63
9	7.12	2745.63	1757.2	690.62	320.29	370.33	0	185	445	554.09	14.8	128.24	89.92	330.5	9.63
10	6.97	2869.69	1836.6	690.62	350.32	340.31	0	178	428	620.15	16.5	140.27	82.63	360.8	10.27
11	7.08	3714.22	2377.1	800.72	320.29	480.43	0	175	528	886.76	3.44	128.24	116.65	527.9	11.1
12	6.89	4067.5	2603.2	1050.95	650.59	400.36	0	167	739	830.73	15.7	260.49	97.21	479.9	13.2
13	7.04	4888.13	3128.4	1010.91	410.37	600.54	0	146	822	1100.55	27.3	164.31	145.81	708.6	13.83
14	6.85	2913.13	1864.4	780.7	430.39	350.32	0	189	602	480.5	11.1	172.33	85.06	312.9	11.47
15	7.03	2291.56	1466.6	600.54	210.19	390.35	0	164	289	530.11	21.8	84.16	94.78	275.1	7.62
16	6.97	2869.69	1836.6	690.62	350.32	340.31	0	178	428	620.15	16.5	140.27	82.63	360.8	10.27

3.1 **pH:** For irrigation water, the normal pH range is from 6.5 to 8.4. pH rate outside of the normal range may cause a nutritional imbalance or may contain a toxic ion, where low pH may cause accelerated irrigation system corrosion. Furthermore, pH of above 8.5 is often caused by high carbonate (CO_3^{2-} and bicarbonate (HCO_3^-) concentrations (Hamza, 2012). The High alkaline of water with high carbonate and bicarbonate levels can impact on the plant's uptake of calcium, magnesium, it also tends to precipitate calcium carbonate, which may cause blockages in pipes.(Vincent, 2010)

Based on the results of the chemical analysis of the groundwater in the region, as reflected in Figure 1, we can say that the pH component in the groundwater does not exceed 7.2, and is not less than 6.4. Based on that, the quality of groundwater as judged by previous classifications, demonstrates that the water is good for irrigation uses (see Figure 4).

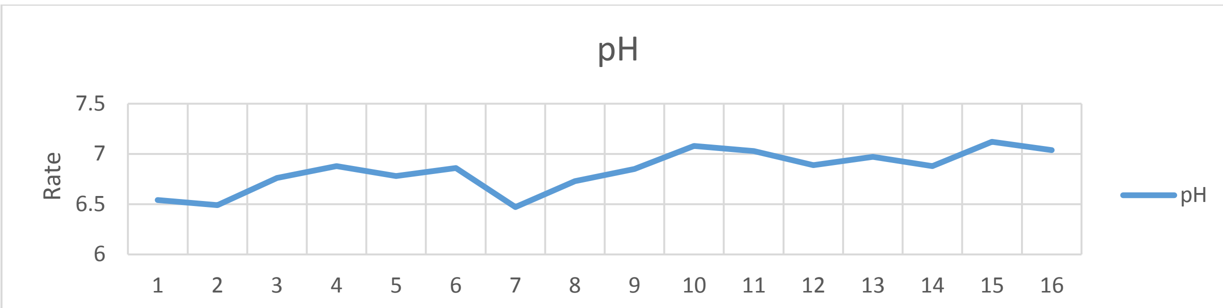


Figure (4). Rate of pH in the groundwater.

3.2 (EC) and (TDS)

From the figures below (5 and 6) that shows the correlation between the EC and TDS in the groundwater, it is found that whenever the EC rate is high, the rate of TDS in the water is high as well (positive correlation) (Iyasele and Idiata, 2015). Moreover, in reference to Table (1) and the agricultural wells, which shows the locations and distance from the sea, it is noted that the more we move away from the coast to the south, the lower the rate of the EC and TDS in the groundwater (inverse relationship).

Furthermore, the table (4) is shown the relationship between dissolved salts in the groundwater and determining suitability for irrigation.

In addition, to the existence of a relationship between the level of depth of the wells and the rate of EC and TDS, the wells that exceeded a depth of 60 m were the least concentrated of these two elements.

It should be noted here that the wells that are pulling water from the aquifer and surface, which range in depth between almost 15-30 m, are the most affected and considered inappropriate for use in the field of agricultural irrigation. It signifies the amount of total dissolved salts (TDS) (Sirajudeen et al., 2014)

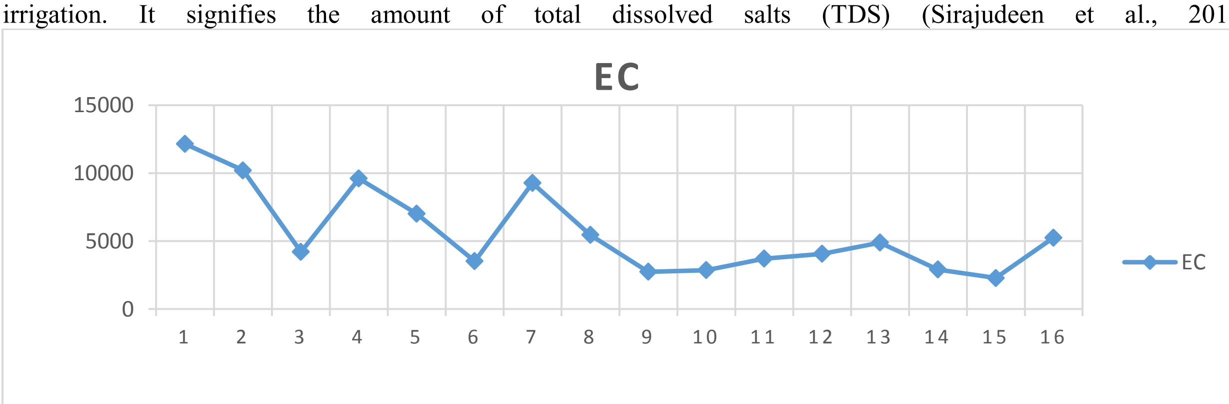


Figure (5): Rate of EC on the groundwater.

Table (4): Water validity for irrigation based on dissolved salts (TDS) mg/L(Aljendil 1978).

Total Dissolved Salts (TDS)	Water validity for irrigation
Less than 500	Complete validity in all lands for all types of plants and trees.
500-1100	Sensitive crops are exempted such as citrus by increasing the water at each irrigation time to eliminate the dissolved salts.
1100-2000	Valid for non-salt sensitive crops by providing the means for extra water dismissal and sufficient water soil washing.
2000- 3200	Suitable for good drainage lands by allowing sufficient time and water in each irrigation and selecting salt resistant crops.
More than 3200	This type of water is not valid for irrigation at all.

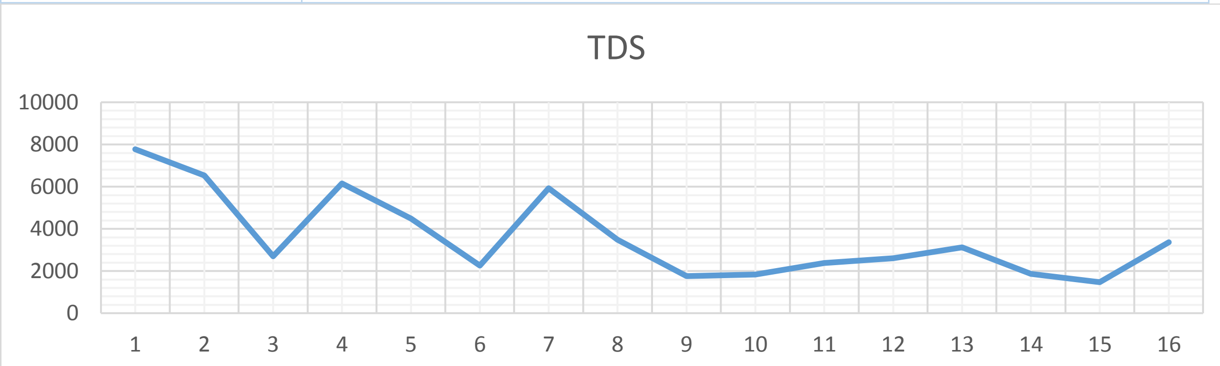


Figure (6): Rate of TDS on the groundwater.

In order to identify the other elements that determine the groundwater quality for irrigation, the equations previously mentioned were applied (SAR, SSP and KR); the following table shows (5) the results of these equations.

Table (5): The results of equations SAR, SSP, and KR

WELL NO.	SAR	SSP	KR	WELL NO.	SAR	SSP	KR
1	2.39	83.25	2.27	9	6.9	60.23	1.51
2	2.19	63.62	1.74	10	7.26	61.81	1.61
3	4.53	60.7	1.54	11	8.8	68.31	2.15
4	5.2	65.09	1.86	12	3.75	57.29	1.34
5	2	56.11	1.27	13	7.36	69.55	2.28
6	5.99	62.24	1.64	14	4.72	54.86	1.21
7	3.21	67.67	2.09	15	8.59	60.58	1.53
8	3.57	60.94	1.56	16	3.79	61.46	1.59

3.3 SAR represents excessive sodium content in water. Hence, the assessment of sodium hazard in water is necessary when considering the suitability for irrigation (Nagaraju et al., 2014)

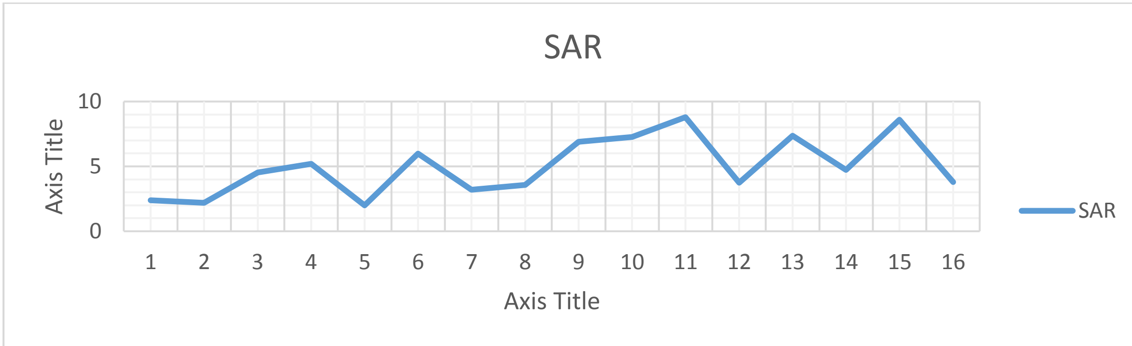


Figure (7): Rate of SAR in groundwater

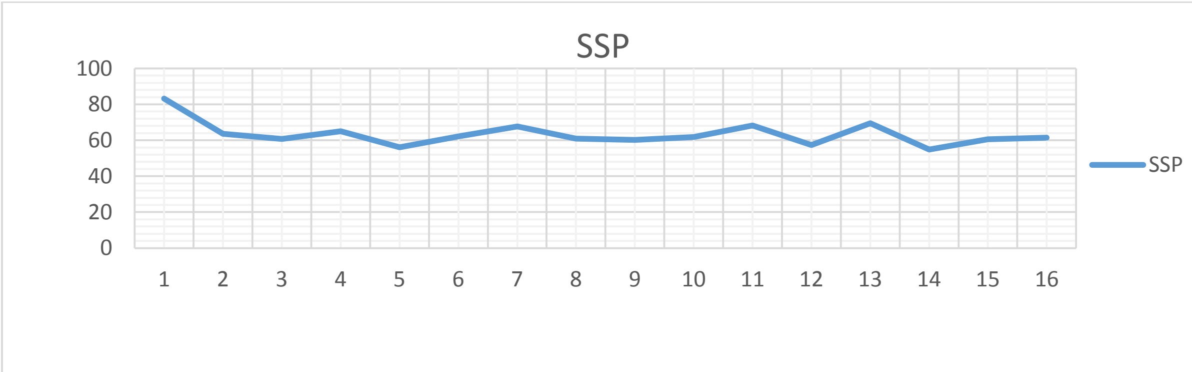
Former figure denotes that the rate of SAR in groundwater is below 10, which means that all the water is considered excellent for agricultural use.(look at the table 6).

Table (6): Sodium adsorption's SAR ratio in water and its impact on soil and crops (mm/liter. (Aljendil, 1978).

Sodium adsorption's ratio	Impact on soil and crops
1-10	Valid for all types of soils; Better to avoid sodium-sensitive crops such as the nucleus of stone fruit
11-18	It causes the increase of the sodium percentage; thus, it suits a few soil textures such as sandy soils.
18-26	Soil may need to be improved if the water has this high sodium percentage in order to exchange other supporting ingredients with sodium.
More than 26	Water is considered useless when the sodium concentration percentage reaches this level, as the dissolved calcium element is unable to use this water.

3.4 **SSP**: Represents soluble sodium percentage in the water. The advised soluble sodium value should not be more than 50; 50 is adequate, which indicates good quality water and if more than 50 the water quality will be unsuitable for irrigation (Deshpande and Aher, 2012).

Based on the outcome of the previous equation, which has been used to determine the ratio of the recoverable soluble sodium in the water, as shown in Table (5) and figure (6), denotes that the groundwater in the region is not suitable for irrigation uses.

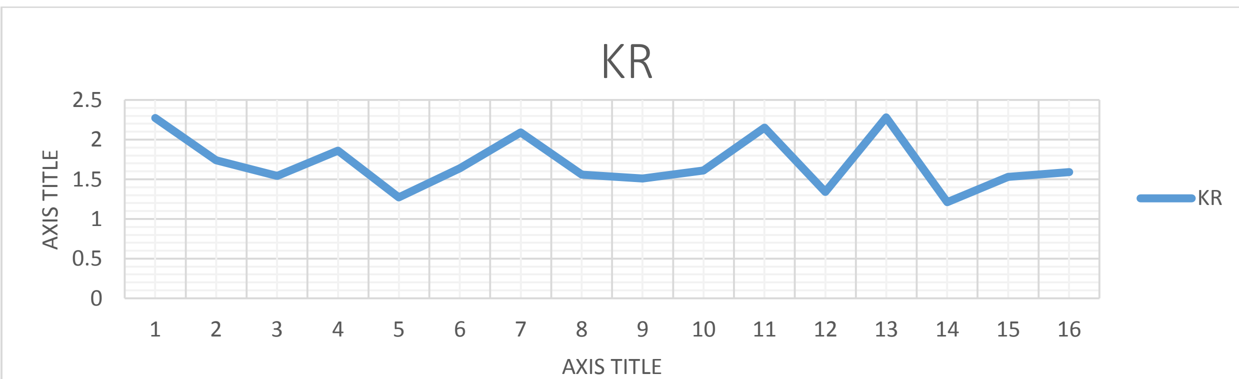


Figure(8): Rate of SSP in groundwater

3.5 **KR**: Determines the hazardous effects of sodium on the water quality for irrigation usage. The computed Kelly's ratio is as follows:

A Kelly's ratio that is less than one is suitable for irrigation, while those with a ratio of more than one are considered unsuitable (Nagaraju et al., 2014, Asiwaju-Bello et al., 2013).

Based on the following figure, clearly all the water samples have exceeded the ratio of 1, which means they are unsuitable for agricultural irrigation.



Figure(9): Rate of KR in groundwater

3.7 GIS and groundwater maps:

After the completion of the previous descriptive analysis data, the mapping of each element of the selected items for validity of water for irrigation, using Moodle IDW in GIS, is conducted.

Depending on the previous classifications shown in Table (2), the following maps in the figures from 8 to 14 has shown the suitable groundwater areas for irrigation usage.

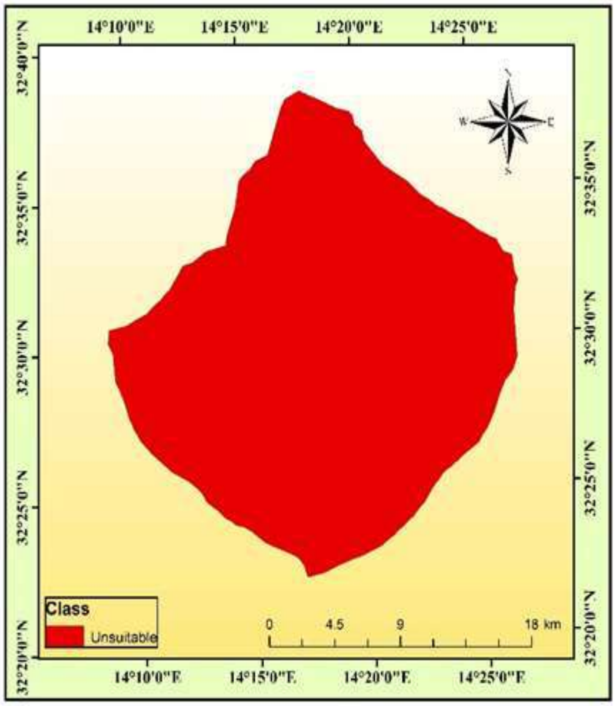


Figure (9): Suitability of water for irrigation, depending of KR in groundwater

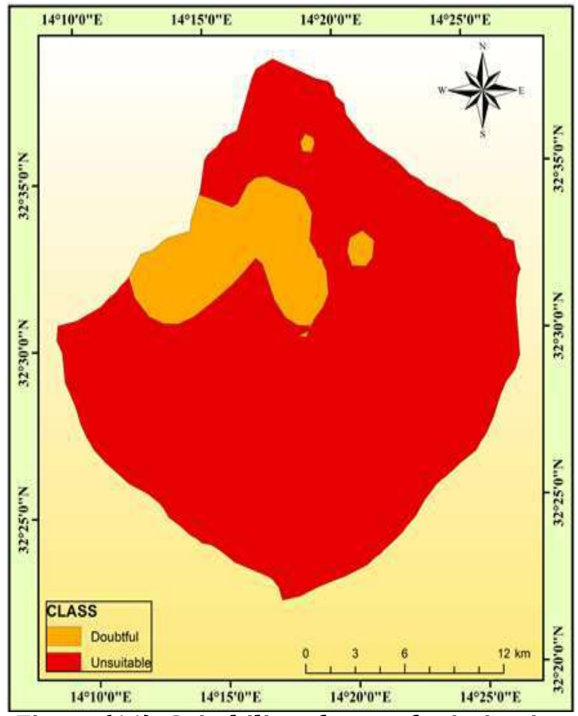


Figure (11): Suitability of water for irrigation, depending of EC in groundwater

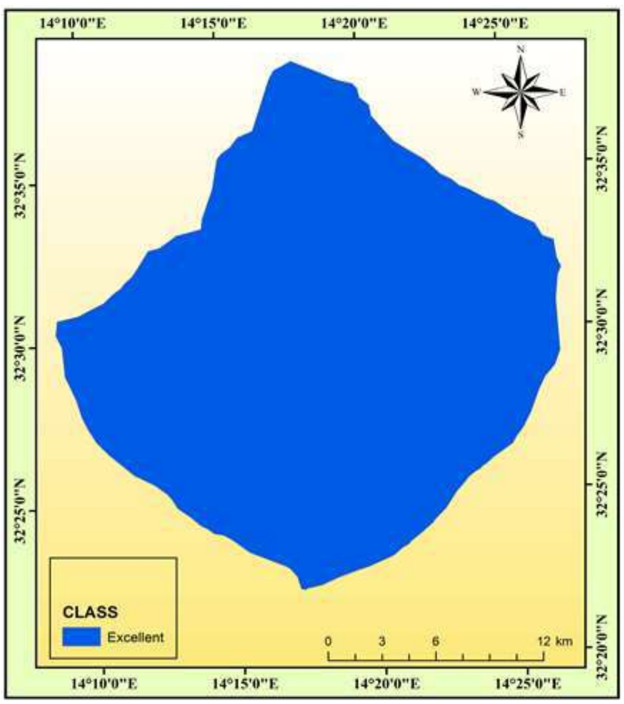


Figure (10): Suitability of water for irrigation, depending of SAR in groundwater

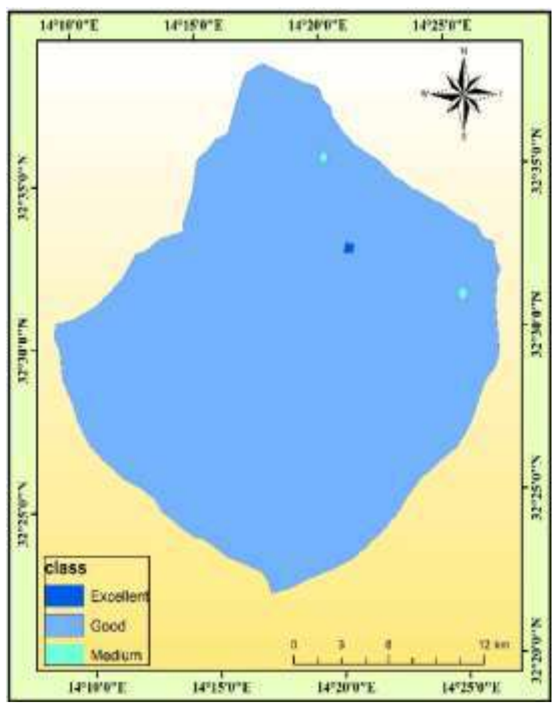


Figure (12): Suitability of water for irrigation, depending of pH in groundwater

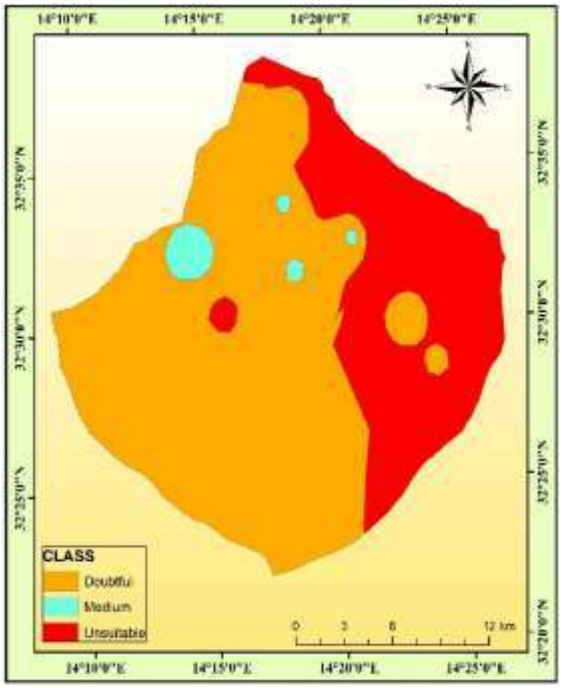


Figure (13): Suitability of water for irrigation, depending of TDS in groundwater

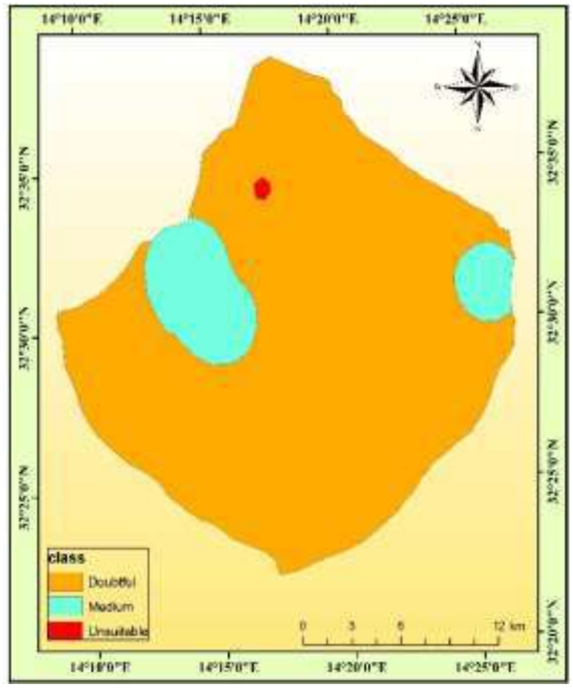


Figure (14): Suitability of water for irrigation, depending of SSP in groundwater

Finally, a raster calculator tool, was used to produce the final map which determines the appropriate irrigation groundwater areas.

Besides, through this map, the area of each element in the set of the water validity of irrigation has been identified in order to conduct comparative studies in the future. table (7), figure (16).

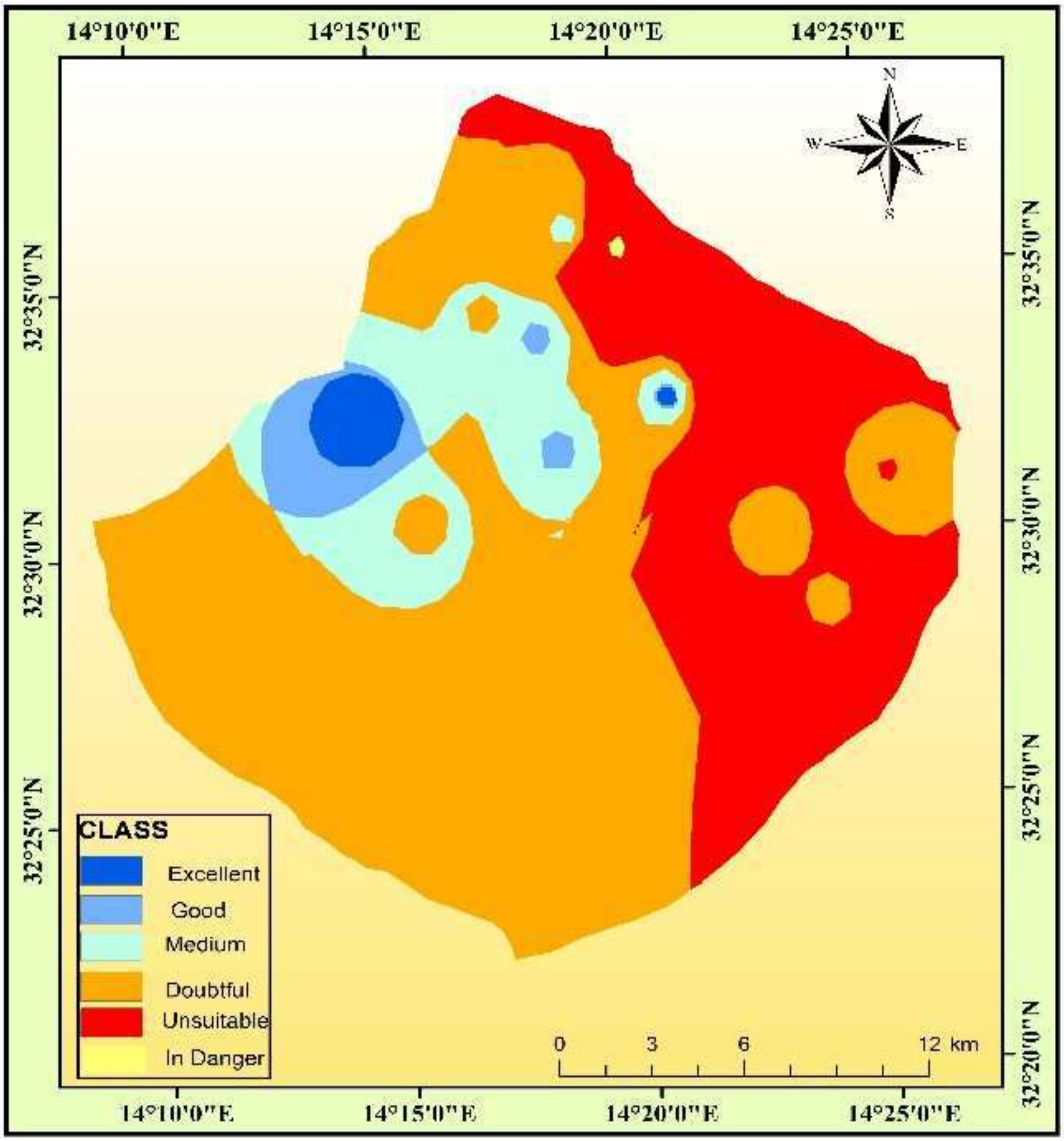


Figure (15): Final suitability groundwater map for irrigation.

Table (7): Groundwater classification and the area represented by each rating in km²

class / value	EC	SAR	SSP	TDS	pH	KR	Irrigation map
Excellent		508.47km^2			0.31 km^2		8.08 km^2
Good					507.55 km^2		14.95 km^2
Medium			54.05km^2	10.16 km^2	0.57 km^2		55.68 km^2
Doubtful	62.62 km^2		453.43 km^2	333.12 km^2			280.53 km^2
Unsuitable	445.82 km^2		1.01 km^2	165.17 km^2		508.47 km^2	148.97 km^2
In Danger							0.26 km^2

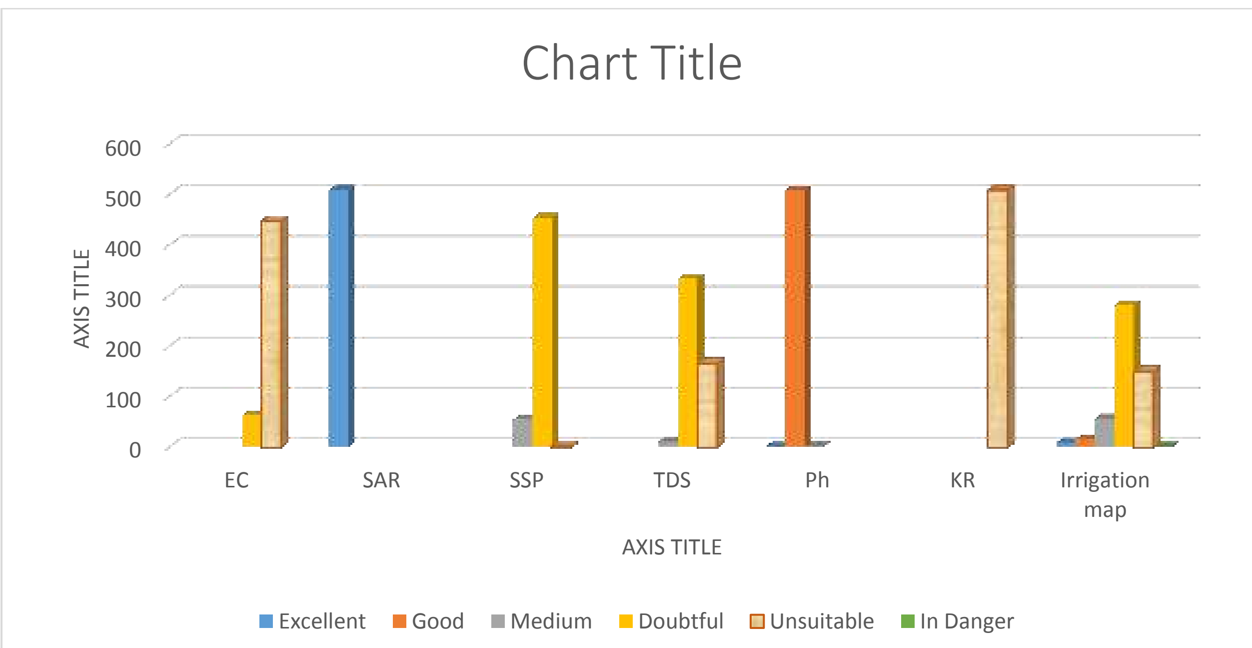


Figure (16): Groundwater classification and the area represented by each rating in km²

4 CONCLUSIONS

The present study has been undertaken to analyse the spatial variation of groundwater quality for irrigation parameters such as EC, pH TDS, SAR, SSP and KR. The chemical analysis was conducted from sixteen groundwater samples in the study area (Sugh EL-Chmis) that has around 508.47km2 on the west north of Libya. The results showed that the water quality for irrigation in the region as a whole varies from one place to another. As can be seen from the final map (Figure 14), that regions close to the seacoast and with a little depth of wells (less than 60m) were unsuitable for irrigation in parameters that are studied as such as, TDS, EC, KR are above maximum permissible limits for the majority of the sample wells in the north.

The regions close to the sea coast and depending on the surface aquifer with a little depth was unsuitable for irrigation. Where the percentage of the area of groundwater unsuitable for irrigation about 29.29% of the total area of the region. However, the groundwater in the southwest is the best suitability water for irrigation (23.03 $km^{2})$; These findings had emerged clearly after the GIS used. Therefore, the current status of groundwater that used for irrigation necessitates for necessary groundwater quality maintain methodologies implementation.

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