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Evaluation of the Drinking and Irrigation Quality of Groundwater in Basrah, Iraq

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ABSTRACT

This study assessed the quality of groundwater in south of Basrah governorate from three regions (Zubair, Safwan and um-Qaser), as well as its expediency for drinking purposes and irrigation. Fifty groundwater specimens from various locations were, whereas their physical and chemical parameters were assessed. The WQI was used to measure overall water quality, and the results were displayed using GIS. The calculation of the Water Quality Index (WQI) took twelve physiochemical parameters into account, including pH, EC, TDS, TH, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SO_4^{-2}, Cl^{-}, HCO_3^{-} and NO_3^{-}. The groundwater in Basrah was found to be of generally low quality, with significant levels of salinity, hardness, and TDS. The groundwater in the research region was not fit for human consumption, according to (WHO, 2011) standards for drinking water. Applying WQI revealed that, with the exception of two wells, the ground water in the research area was classed as very poor-unsuitable type. The GIS analysis assisted in identifying the places with the best water quality and those with the most serious issues. The groundwater of research region was used for irrigation purposes. The indices considered included SAR, SSP AND MH%. The groundwater from the study area is generally in good condition and may be utilized for irrigation, as shown by the estimated water indices when compared to the accepted standards.

Keywords: Basra, WQI, GIS, groundwater, irrigation.

INTRODUCTION

Freshwater supplies are running out globally due to population increase and industrialization. Due to the deterioration of its freshwater source during the past 20 years, Iraq has experienced a global water shortage (Euphrates and Tigris) (Alwan et al., 2019). The numerous dams that Iraq's neighbors have constructed at the headwaters of the Euphrates and Tigris rivers are one of the primary reasons for their decrease. This occurred when the country's water resource management lacked scientific planning, infrastructure, and a significant population increase. Iraq position in the Mena region, one of the most vulnerable places to climate change, dramatically influences water shortages (increasing evaporation, poor rainfall, increased sea level, and drought). Because of these factors, Iraq's freshwater resources are no longer sufficient to satisfy all requirements. Many adverse effects, including increased unemployment, poverty, food insecurity, and hunger, were caused by the repercussions, adversely affecting the energy, tourism, industry, and agricultural sectors. In recent years, groundwater has increasingly replaced surface water as a significant natural supply. Groundwater has various benefits that make it more useful relative to surface water. The quality is better, less prone to contamination, and less susceptible to seasonal and long-term changes. Besides, groundwater may occur in the areas where it is uncommon to find surface water because of its wider dispersion than surface water (Mahdi et al., 2021).

When the acceptable limit is exceeded for a concentration of organic and inorganic substances in water, an impact that is harmful to human health results, groundwater quality deteriorates because of many reasons, including inadequate sewage management, overuse, and filthy conditions in rural areas, as well as increased fertilizer usage, inadequate water planning, and the failure to implement planning measures. A thorough evaluation of groundwater quality is required to make the best possible use of the available groundwater over the long term and to satisfy the growing demand for water (Salman Dawood et al., 2018).

Water Quality Index (WQI) is important for tracking and evaluating groundwater quality, in order to assess if the water is appropriate for drinking, human consumption and other uses or not. It can be used to convey information to decision-makers and relevant individuals because it is a direct, consistent and repeatable unit of measurement (Chauhan et al., 2010; Lateef, 2011; Saleh et al., 2017). The water quality index is a single value that can be employed for many different purposes to understand the quality of water (Dutta et al., 2018).

The index was initially developed by Horton in 1965 to evaluate water quality using the ten most popular water parameters. The traditional approaches to assessing water quality focus on comparing the experimentally acquired results to local or international standards. These methods provide accurate source identification and may be necessary for verifying legal compliance. Nonetheless, a thorough picture of the regional and temporal patterns in the overall water quality is not always possible from them (Debels et al., 2005). WQI has been suggested for usage in various studies to measure water quality (Bordalo et al., 2001; Horton, 1965; Ketata-Rokbani et al., 2011; Lateef, 2011; Saeedi et al., 2010), Moreover, many techniques for computing the WQI have been devised, assessing comparable chemical and physical features in the statistical integration and interpretation of the parameter values (al-hadithi, 2012; Al-Omran et al., 2015; Aly et al., 2015; Krishna Kumar et al., 2014; Magesh & Chandrasekar, 2013; Rao & Nageswararao, 2013).

The major goals of this research were to estimate some of the hydrochemical effects of the groundwater in the study region and evaluate the quality of groundwater by WQI, then compare it to worldwide standards to show that it is safe for drinking and irrigation.

STUDY AREA

Basra governorate is situated in southeast Iraq, gazing out over the Gulf of Arab. It is surrounded by the governorate of Maysan to the North, Iran to the east, the Arabian Gulf and Kuwait to the south, and the governorates of Dhi-Qar and Muthanna to the west. An estimated 19,070 km^2 or 762,800 acres. The study region includes (Zubair, Safwan and um-Qaser), it is part of the Zubair district Iraq/Basrah investigation area extended from 30°10' to 30°32' North and longitudes from 47°25' to 47°56' East (Fig. 1). It is situated in the southwest of Basrah Governorate. It is surrounded by the Abu Al-Khasib and Al-Faw districts on the east and northeast by the Basrah District. It is also bounded on the west and north by the Al-Muthanna Governorate and south by the State of Kuwait. The study region is situated inside the "Dibdibba formation" of the earth, which extends over a significant portion of southern Iraq and a small portion of the country's west. Upper Miocene to Pliocene in age, the Dibdibba Formation is composed of sand, gravel, and white quarts that have been somehow bonded into a hard grit (Abdulameer et al., 2018), which are 30 to 260 meters thick (Dawood et al., 2016). The average

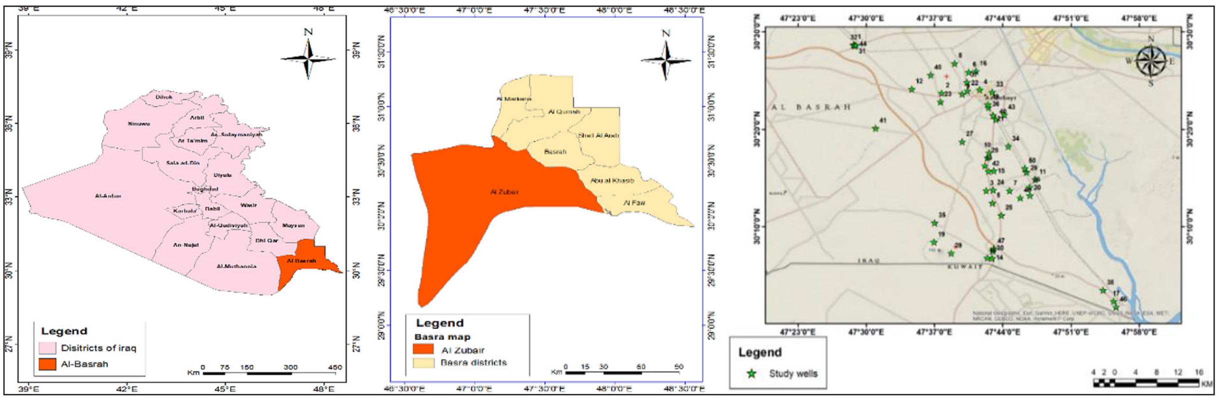

Figure 1. Study area

saturated thickness of the Dibdibba formation, which is characterized by unconfined to semi-confined conditions, is around 14 m (Al-Tememi, 2015). The study location is located in a semi-dry region. The study region has a hot summer climate with minimal precipitation in the winter. The place of study is in a semi-arid region. The research area witnesses hot summers and little precipitation in the winter, as the temperature ranges from 12 to 38 degrees. July is the hottest month in Az Zubair through all the year, with a mean low of 28 °C and high of 46 °C and the coldest month of the year in Az Zubair is January, with an average low of 7 °C and high of 18 °C. About 72.1 mm (2.83 in) of precipitation falls annually.

MATERIAL AND METHODS

Groundwater sampling

Fifty specimens were taken from wells of water in different regions in the Basrah governorate (Zubair, Safwan and um-Qaser), as shown in Figure 1.

A portable electronic device, model SD-300con, was used to test the water samples acidity pH, EC and TDS in the field. Inside the laboratories, specimens were chemically analyzed ($SO4^{2-}$, Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, NO^{3-}, HCO^{3-} and total hardness). In order to assure gathering representative samples, the groundwater samples were collected after ten minutes of pumping. The sample was prepared in the morning using polyethylene bottles with a volume of one liter (Rainwater & Thatcher, 1960) which were preserved in a cool box to maintain the water temperature. The samples were collected and sent to the lab on the same day. The standard technique for assessment of water and wastewater (19th edition) was used to guide the methods of analysis for various parameters (APHA, 1995). Table 1 shows the instruments that were used in the examination

Water quality index

WQI is referred to as a rating system that illustrates the overall effect of each water quality parameter. It is regarded as the greatest method for providing the public with the most straightforward information on water quality (Akter et al., 2016). WQI is able to reduce several water quality factors to a single numerical value by organizing the complicated and enormous volumes of raw data on water quality into logical and simplified categories that indicate the overall water quality state (Latha & Rao, 2010).

The index measuring water quality was created using twelve variables. The WQI calculations utilized the World Health Organization's guideline for drinking water quality as shown in Table 2 (WHO, 2011).

The following procedures were used to calculate WQI: Each of the (12) characteristics (pH, EC, TDS, TH, Ca, Mg^{2+}, Na^+, K^+, SO_4^{2}, HCO_3, Cl, and NO_3) had been given a weight (wi), ranging from (1) to (5), based on its relative importance in the overall quality of water for drinking as presented in Table 2 (Saleh et al., 2017).

Due to their importance in defining water quality, the parameters SO_4^{2-}, NO_3^-, Cl^-, and TDS are given a maximum weight of 5, whereas the parameter K+ is given a minimum weight value of 1 due to its negligible importance (Saleh et al., 2017). The second step was to determine the relative weight using the following equation.

$$Wi = \frac{wi}{\sum_{i=1}^{n} wi} \tag{1}$$

Third step: using the following equation to obtain the quality rating Qi:

$$Qi = \left(\frac{ci}{si}\right) * 100 \tag{2}$$

Finally, compute WQI for each sample (well) using the following formulas:

Table 1. Instruments and analytical methods for chemical analysis

Element and variables	Apparatus and analytical methods
TH as $CaCO_3$, Mg^{+2} and Ca^{+2}	Titration with EDTA (Ethylene Diamine Tetrscitic Acid)
pH, EC, TDS and temperature	Portable meter
K^+, Na^+	Flame photometer
SO_4^{-2}	Turbidity metric method
HCO_3^-	Technicon in volumetric
Cl^-	Titration with $AgNO_3$

Table 2. Water quality standard, assigned and relative weight value

Chemical elements	Drinking guidelines WHO 2011 mg/l	Assigned weight (w_i)	Relative weight Wi
PH	8.5	4	0.10811
EC (μS/cm)	1500	4	0.10811
TDS (mg/l)	1000	5	0.13514
T.H as $CaCO_3$ (mg/l)	500	2	0.05405
Ca^{+2} (mg/l)	200	2	0.05405
Mg^{+2} (mg/l)	150	2	0.05405
Na^+ (mg/l)	400	2	0.05405
K^+ (mg/l)	12	1	0.02703
SO_4 (mg/l)	400	4	0.10811
HCO_3^-	500	3	0.08108
NO_3^- (mg/l)	45	5	0.13514
Cl^- (mg/l)	600	3	0.08108
		∑37	0.999 ≈ 1

Table 3. Water type classification depend on range of WQI (Saleh et al., 2017)

Division	Boundary	Classification of water
I	< 50	Excellent water
II	50.1–100	Good water
III	100.1–200	Poor water
IV	200.1–300	Very poor water
V	>300.1	Water that is unfit for drinking

$$WQI = \sum_{i=1}^{n} (Wi * Qi) \tag{3}$$

The WQI range and kind of water categorization for drinking purposes are shown in Table 3.

Quality of irrigation water

The physicochemical characteristics were transformed from mg/L to meq/L in order to derive the indices. Equation (1) below was used to do this:

$$\text{Conc. (meqL)} = \frac{conc./mgl * valency}{Atomic\ weigh} \tag{4}$$

The major impacts of water quality on soil and plant systems that have an impact on crop output make establishing the appropriateness of irrigation water crucial (Hem, 1985).

Numerous classifications are available to determine if water is suitable for irrigation. They are affected by a variety of factors, like the anions, cations, EC, TDS, pH, sodium adsorption ratio (SAR), soluble sodium percentage (Na%), and magnesium danger (MH percent) (Table 5).

Sodium adsorption ratio (SAR)

Due to unique negative impact of sodium on the physical characteristics of soil, sodium hazard is defined separately from EC, which evaluates all soluble salts in a sample. This index gauges the proportion of sodium (Na^+) to calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions in a sample. High SAR values indicate a salt hazard to soil structure (Mokoena et al., 2020).

SAR values were computed using the formula shown below:

$$SAR = \frac{Na}{\sqrt{(Mg + Ca)/2}} * 100\% \tag{5}$$

The continual use of water with a high SAR led to deterioration in the physical composition of the soil. As a result, soil particles picked up sodium and bonded to them. Afterwards, the soil becomes progressively resistive to water penetration as it dries out, becoming rigid and compact.

Irrigation water was divided into low less than 10 (S1), medium when SAR between 10-18 (S2), high from 18–26 (S3), and extremely high when SAR more than 26 (S4) zones according to SAR values (Turgeon, 2000).

Soluble sodium percentage (SSP)

Because sodium interacts with soil and decreases its permeability, sodium content (Table 5) plays a significant role in categorizing irrigation water. The salt content in irrigation fluids is often expressed as a percentage and may be calculated using the method:

$$SSP = \frac{\text{K} + \text{Na}}{\text{K} + \text{Mg} + \text{Ca} + \text{Na}} \times 100 \quad (6)$$

where: the ion concentrations for K+, Mg+4, Ca+2, and Na+ are measured in (meq/l) units.

Don (1995) and Wilcox (1955) suggested a classification based on Na% in to perfect, good, permissible, dubious and unfitting as shown in Table 7.

Magnesium hazard (MH%)

Mg^{2+} and Ca^{2+} typically exist in balance in the majority of water (Adagba et al., 2022; Hossain et al., 2020). Mg^{2+} and Ca^{2+} do not act identically in the soil system, because magnesium deteriorates soil structure, especially under sodium-dominated and extremely salty conditions (Hem, 1985). High Mg^{2+} concentrations are the result of the replaceable Na^{+} in irrigated soils. Szabolcs (1964) established the index of magnesium danger, a crucial ratio (MH). To calculate the value of MH, the following equation was used:

$$MH = \frac{\text{Mg}}{Mg + \text{Ca}} \times 100 \quad (7)$$

A magnesium index greater than 50 percent would have a detrimental effect on agricultural productivity because the soils would become more alkaline. In contrast, if the MH percent value is less than fifty percent, the water is suitable for consumption and safe for irrigation. MH percent readings of groundwater in the Research area.

RESULT AND DISCUSSION

Physical and chemical properties

Human actions and natural processes have badly impacted the quality of groundwater. On the basis of the requirements established by several authorities, including the drinking water standards released by WHO in 2011, an examination of groundwater quality for drinking establishes its suitability for various purposes.

As presented in Table 4 the average pH of groundwater samples in the research region is 7.3, with values between 6.62 and 8.1 that are essentially constant. All samples apparently met the WHO (2011) criteria of 6.5–8.5 based on their average pH.

The TDS levels in the groundwater of the research area surpass the allowed limit of 1000 mg/L, ranging from 2796 to 13718 mg/L. This shows that human sources significantly harm the groundwater in the studied location. Physical characteristics (Ph and TDS) were mapped geographically for the study area (Figures 2a and 2b). The max and min values in the research area of EC are 21293 μs/cm and 4160 μs/cm, respectively, with an average value is 10534. According to WHO, all samples were over the acceptable level for EC concentration in drinking water (1500). The most prevalent alkaline-earth metal is calcium (Ca), which is an essential component of many common rock minerals. It is an essential part of the solutes in the majority of naturally occurring water and is required to include both animal life and plant. The max and min. value for Ca is 1277 ppm and 340 ppm with an average is 663 ppm. Geographical distribution maps of chemical

Table 4. Physical and chemical measurements of groundwater samples from the research region

Parameters	Max	Min.	Mean	Std. Dev.
PH	8.1	6.62	7.3	0.11
TDS	13.718	2.188	6.740	1.578
EC	21293	4160	10534	2399
Ca	1277	340	663	131
K	259	15	46	30
Na	3996	100	732	368
Mg	951	65	335	139
Cl	4650	381	1668	361
SO_4	4150	530	1421	686
HCO_3	2224	2	448	374
NO_3	26	0.1	9	4.6
TH	7104	1341	3035	851

Note: * All parameters in (ppm) except pH which has no unit, EC (μs/cm).

characteristics (EC and Ca) were produced, as shown in Figures 3a and 3b. In the study region, the potassium concentrations varied from 15 to 259, with an average value of 46. All samples appear to have exceeded the WHO (2011) standard limit of 12 ppm for potassium. The presence of salts is the leading cause of the high sodium level of groundwater. The sodium concentration of samples collected in the study area varied between 100 and 3,996 ppm, with an average value of 732 ppm. In the research region, 48% of samples are below the sodium limit for groundwater is 400 mg/l based on WHO standards, while 52 percent of samples exceeded the limit for drinking purposes. The distribution of potassium and sodium in (ppm) over the research region is shown in Figures 5a and 5b. Magnesium concentrations in groundwater samples range from 65 mg/L to 951 mg/L. The recommended acceptable level of magnesium in drinking water is 150 mg/L (WHO, 2011). The average magnesium content in the study area, 335 mg/L, was higher than allowed. Sodium still slightly outperformed magnesium, however. The average potassium concentration was 46 mg/L during the research period. Regarding the source of such cations, potassium and sodium are the ions that are commonly found in crystalline stones. The mineral potassium is less soluble in natural water. Therefore, clay minerals might

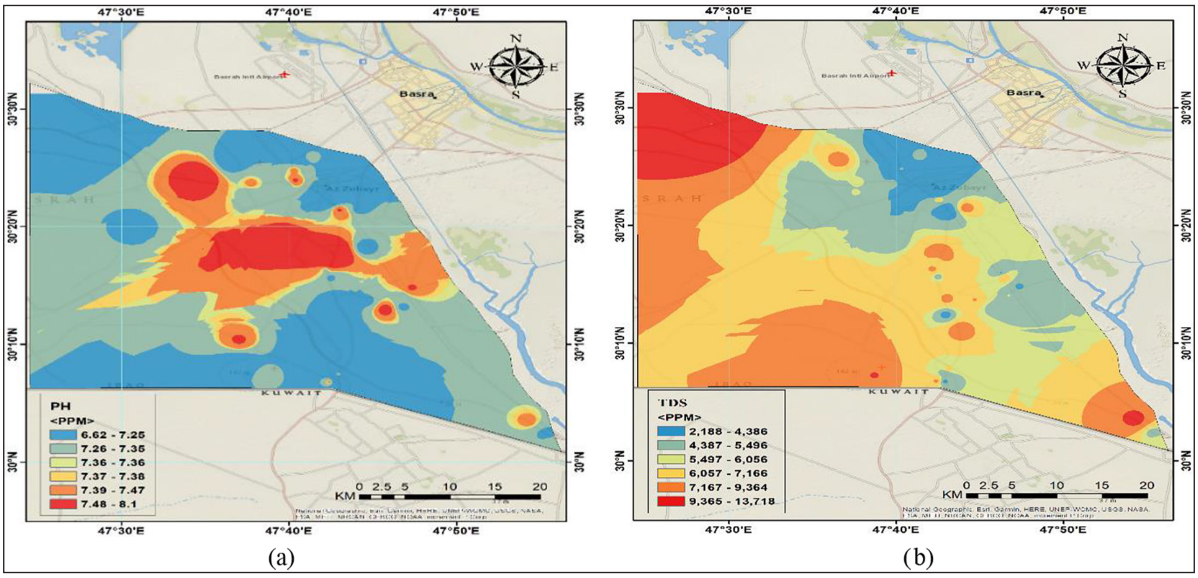

Figure 2. (a) pH and (b) TDS geographical distribution maps of physical characteristics

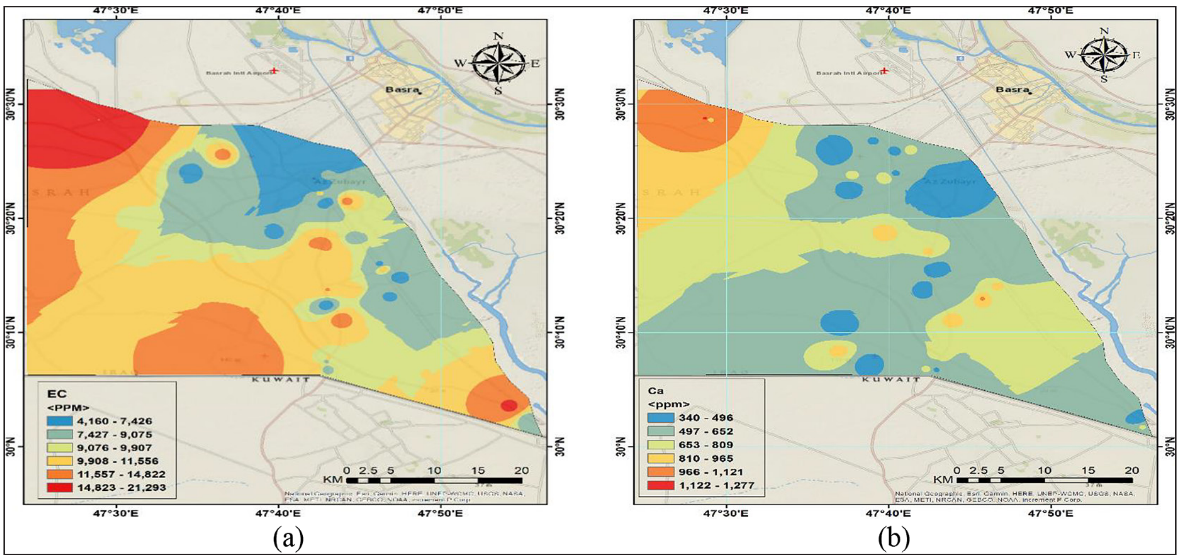

Figure 3. (a) EC and (b) Ca geographical distribution maps of physicochemical characteristics

easily attach it, which is the leading cause of this ion's absence from groundwater.

The chlorine levels in groundwater samples from the research region vary from 381 to 4650 ppm, with an average value of 774 mg/l. According to WHO 2011, the limit of chlorine content for drinking water is 600 ppm.

According to this investigation, the Cl content in all groundwater samples was higher than the set limit except for two samples. Figures 5a and 5b depicts the geographical distribution of Mg and Cl respectively. Sulfate concentration varies from 530 to 4150 ppm, with an average of 1421 ppm and a standard deviation of 686 ppm. Therefore, in the research region, all samples surpassed the limits. The other element that is found in groundwater is HCO_3, where concentration ranges from 2 to 40 ppm. The main sources of bicarbonate are limestone and dolomite. The distribution of SO_4 and HCO_3 in (ppm) over the research region is shown in Figures 6a and 6b. The concentrations of NO_3 in groundwater samples are between 0.1 to 26 ppm, with an average value of 9 ppm. In the study area, all samples met the WHO (2011) criteria of 45 ppm. The last element in the group was the total hardness, where the min and max value is 1341 and 7104 ppm, respectively, with an average value of 3035 ppm. Figures 7a and 7b show the distribution of the area for NO_3 and total hardness in the study region.

Water quality index

It notes that the result of TDS, EC, Ca^{+2}, K^{+}, SO_4^{-2} and TH concentrations exceed the permitted

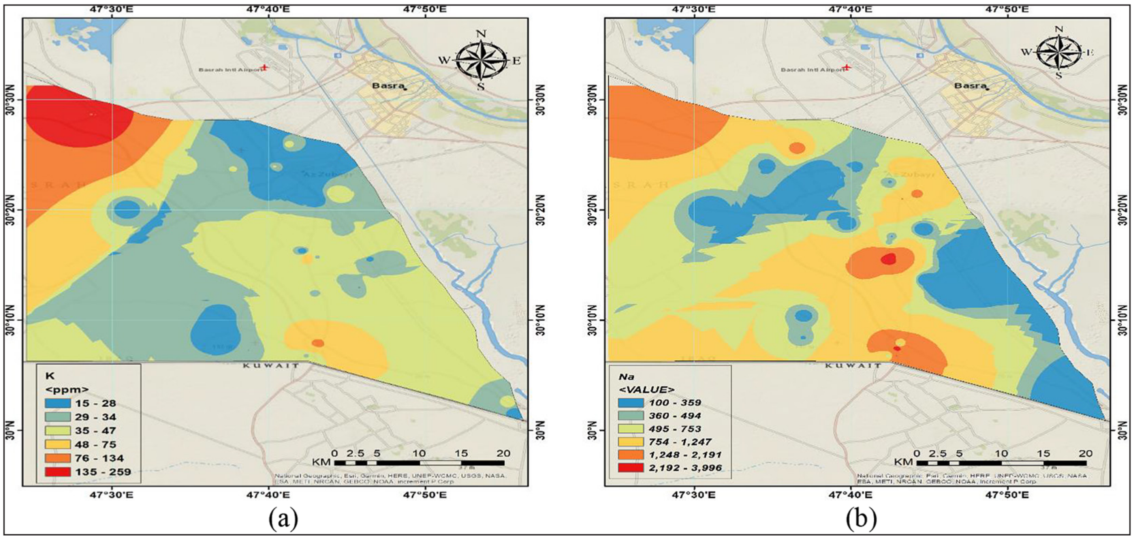

Figure 4. (a) K and (b) Na geographical distribution maps of physical characteristics

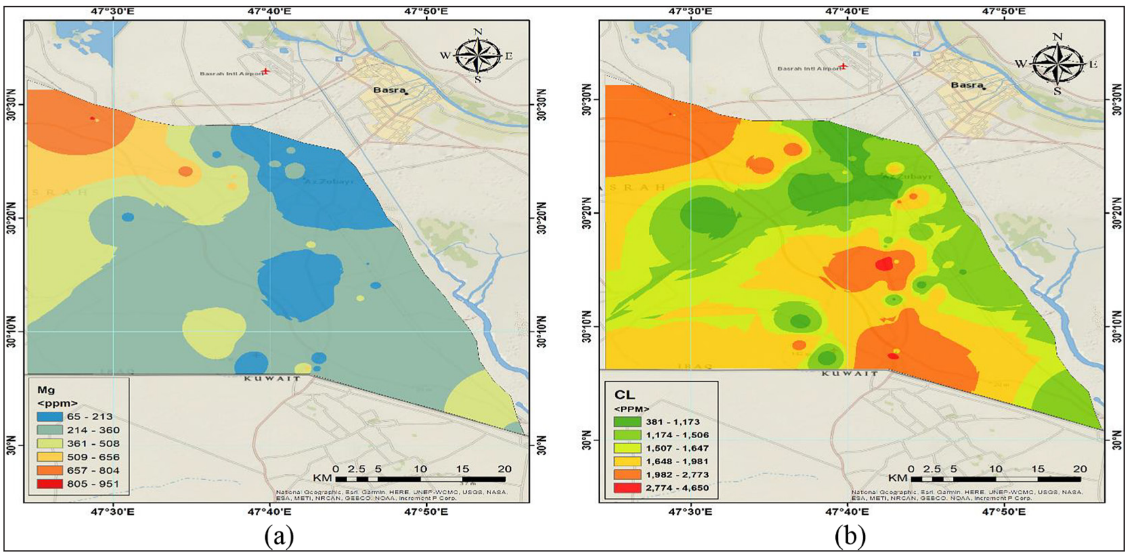

Figure 5. (a) Mg and (b) Cl geographical distribution maps of chemical characteristics

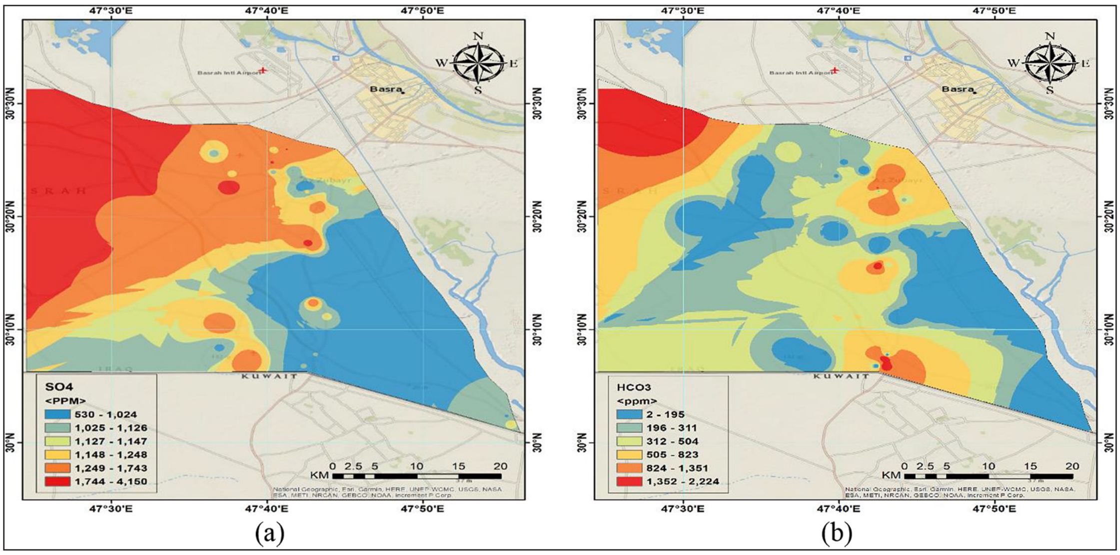

Figure 6. (a) SO_4 and (b) HCO_3 geographical distribution maps of chemical characteristics

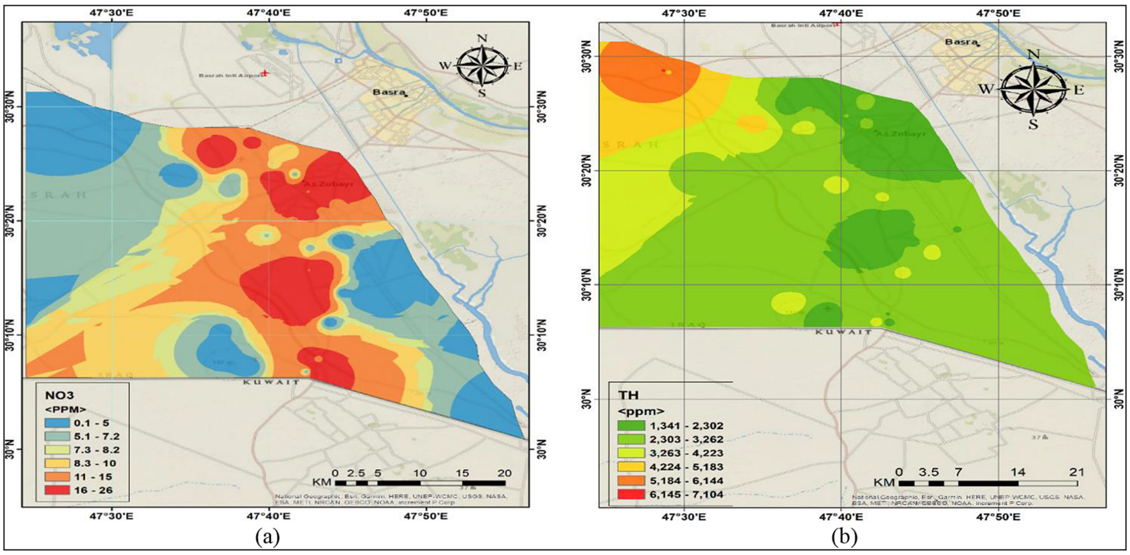

Figure 7. (a) geographical distribution maps of NO_3 and (b) distribution map for TH

limits in all wells. The results of another element (Na^+, Mg^{+2}, Cl^- and HCO_3) exceed the limits in most of the wells; however, pH values lie between maximum and minimum limits in all wells as shown in Table 5 and NO_3^- concentration does not exceed the permitted limits in all wells. Because of the high concentration of chemical parameters, the groundwater in the research region is unfit for direct consumption as human drinking water.

The water quality index is often used for evaluating drinking water. As stated in Table 3, the highest allowable limit for WQI is 300. WQI scores in this research vary from 177.3 to 814.9, with a mean of 353.8. According to Table 5, the groundwater in the study region is categorized as comprising 4% of wells classified as poor water, 42% of wells classified as very poor water, and 54% of wells classed as unfit for drinking purposes, as indicated in Table 5 and Figure 8a and 8b.

Irrigation water quality

SAR, or sodium hazard, is the degree to which the Na^+ of water is replaced by Ca^{2+} and Mg^{2+}, causing deflocculation and soil permeability loss (Egbueri et al., 2021). Due to sodic water usage, SAR predicts soil Na^+ buildup at the cost of Ca^{2+} and Mg^{2+}. The soil permeability is reduced by sodium-rich water, which reduces crop productivity. Crop water availability is affected by a high sodium-calcium-magnesium ratio (Udom et al., 2019).

The SAR values in this research ranged from 0.7 to 39.1 meq/L, with a mean of 6.4 meq/L. This suggests that 74% of the water samples (37

Table 5. WQI and irrigation index values

Well sample	WQI	Division	SAR	SSP%	MH%	Well sample	WQI	Division	SAR	SSP%	MH%
W1	852.31	V	10.1	38.3	55.1	W26	258.40	IV	0.8	8.2	25.9
W2	310.60	V	0.7	6.5	54.0	W27	266.27	IV	1.5	12.2	38.5
W3	318.85	V	12.8	62.6	33.2	W28	304.29	V	2.9	22.7	21.5
W4	220.65	IV	4.2	30.0	48.7	W29	287.34	IV	2.0	16.6	52.8
W5	238.63	IV	9.4	54.5	22.9	W30	461.78	V	28.0	75.2	32.0
W6	176.14	III	5.5	43.5	19.9	W31	689.46	V	9.6	42.1	52.2
W7	273.92	IV	0.9	10.8	41.9	W32	781.40	V	9.9	40.7	53.9
W8	206.23	IV	5.8	42.7	22.2	W33	327.25	V	11.5	58.0	34.6
W9	261.28	IV	3.2	24.6	21.7	W34	242.43	IV	0.9	9.6	38.0
W10	401.80	V	2.5	17.8	46.9	W35	349.09	V	2.2	17.7	67.4
W11	197.75	III	1.0	10.7	42.2	W36	289.01	IV	5.0	39.8	36.1
W12	300.28	V	1.9	12.8	59.3	W37	246.48	IV	3.4	26.4	40.9
W13	337.96	V	14.1	62.3	31.8	W38	386.48	V	1.0	9.5	54.3
W14	382.32	V	22.7	73.0	36.8	W39	342.18	V	10.2	57.9	31.0
W15	314.18	V	15.6	67.9	31.4	W40	324.68	V	13.3	61.9	33.9
W16	278.59	IV	3.5	26.0	34.3	W41	283.87	IV	1.9	16.0	30.3
W17	242.35	IV	1.1	11.4	65.7	W42	480.73	V	39.5	81.9	39.8
W18	354.18	V	3.8	23.4	57.0	W43	357.28	V	14.8	64.8	36.5
W19	357.13	V	2.4	16.8	43.3	W44	545.81	V	8.0	39.0	53.9
W20	226.89	IV	1.2	11.5	37.5	W45	365.03	V	15.9	66.1	48.5
W21	279.13	IV	9.9	57.0	29.5	W46	274.53	IV	1.7	14.3	43.4
W22	211.03	IV	3.0	27.0	40.4	W47	308.74	V	3.6	28.2	31.1
W23	303.38	V	0.9	8.6	72.0	W48	275.92	IV	0.7	6.3	39.1
W24	358.86	V	11.1	54.6	39.1	W49	237.28	IV	3.6	32.6	20.3
W25	378.21	V	5.0	30.2	36.6	W50	212.95	IV	1.8	17.3	

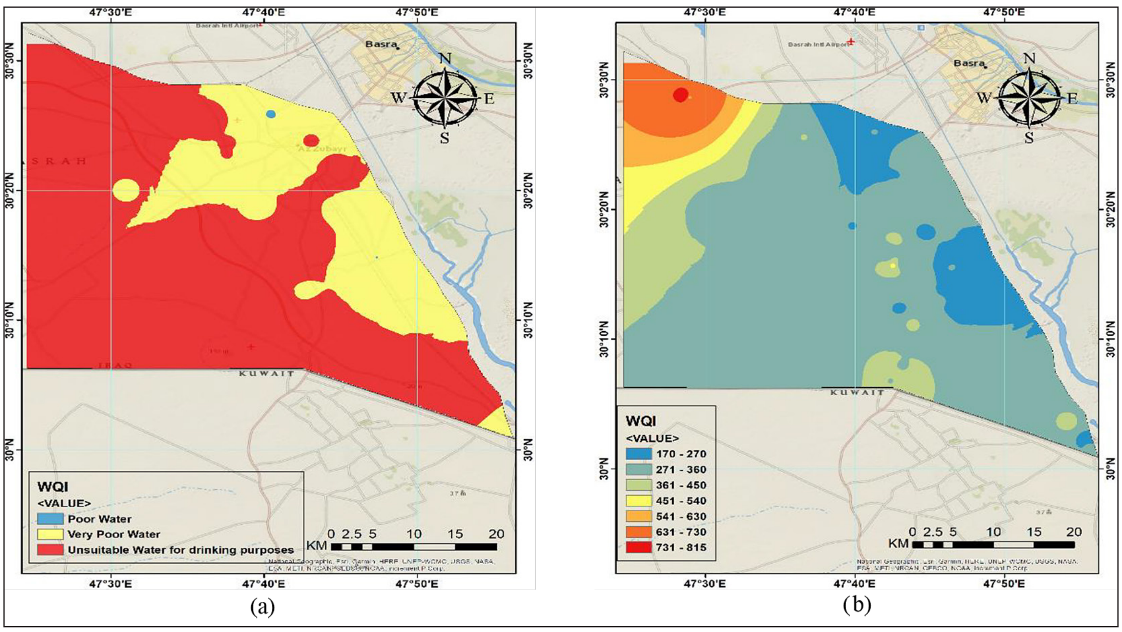

Figure 8. Geographical distribution maps of WQI

samples) were excellent for irrigation and 10% (ten samples) were good, 2% were doubtful (one sample) whereas 4% (two samples) exceeded the limit and were unsuitable for irrigation based on the Sodium Absorption Ratio. According to SAR values (Table 6), most water in the research area is generally acceptable for irrigation, except in small areas that were unsuitable, as shown in Figure 9a.

When water has a high salt concentration, soil is unable to form stable aggregates, which results in a loss of tilt and structure (Kumar et al., 2017). The water-holding capacity of soil decreases in high-sodium waters due to a base-exchange process that drives away calcium and magnesium ions. Soil moisture causes this limitation in aeration and infiltration, but dry soil becomes compact. The sodium concentrations in the study region varied widely, from 6.4% to 81.5%, with average being 31.5%. Nineteen samples (38%) had a value below 20, suggesting superior quality, as shown by the findings. Thirteen samples, or 26%, had values between 20 and 40 percent, which is considered good; nine samples, or 14%, had values between 40 and 60 percent, which is considered acceptable; eight samples, or 16%, had values between 60 and 80 percent, which is considered questionable; and only one sample, or 2%, had a value greater than 80 percent, which is considered unsafe for irrigation purposes as shown in Table 7 and Figure 9b.

Table 6. Irrigation water classification depending on SAR (Turgeon, 2000)

Limits	Status	Percent	Samples number
> 10	Perfect	74%	37
10.1–18	Good	20%	10
18.1–26	Dubious	2%	1
< 26.1	Unsuitable	4%	2

Table 7. Classification of irrigation water by sodium concentration (Wilcox, 1955)

Limits	Status	Percent	Samples number
> 20	Perfect	38%	19
20–40	Good	26%	13
40–60	Permissible	18%	9
60–80	Dubious	16%	8
< 80	Unfitting	2%	1

Table 8. Using magnesium hazards to categorize irrigation water (Raghunath, 2006)

Range	Condition	Percent	Samples No.
< 50	Suitable	76%	38
> 50	Unsuitable	24%	12

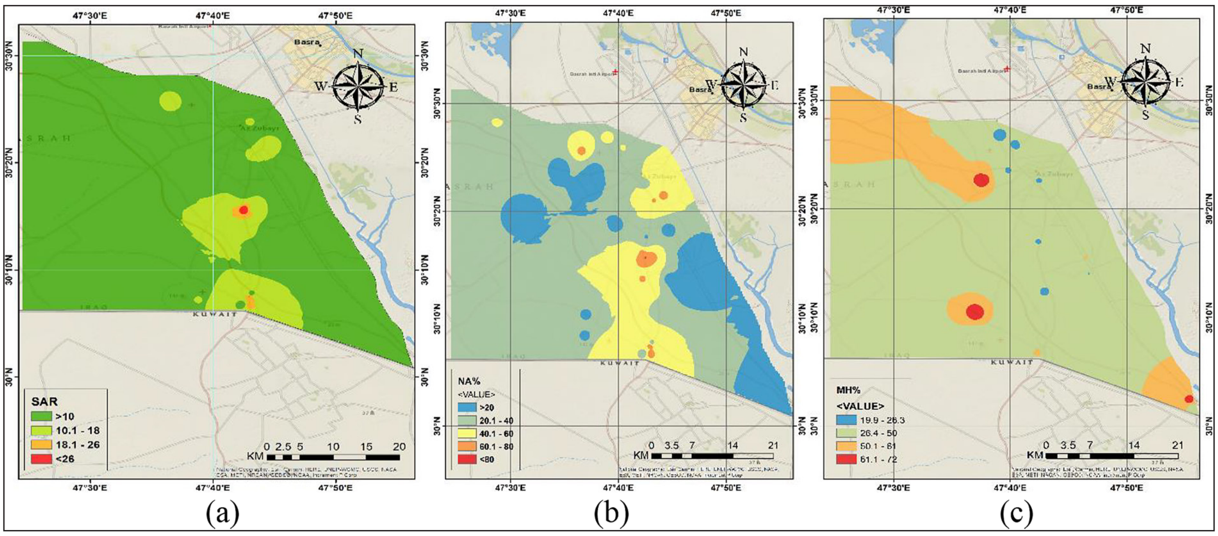

Figure 9. Geographical distribution maps of (a) SAR (b) SSP (c) MH%

In natural streams, calcium and magnesium keep everything in balance A rise in one of these ions might be detrimental for soil since it boosts salinity. Magnesium hazard is a means to measure this danger since irrigation may not be possible with water that contains more than 50% of magnesium. Nine samples, or almost 64% of all samples, had magnesium danger levels below 50%, making them suitable for irrigation water. Table 8 and Figure 9c give the values and distribution maps for MH%, respectively.

CONCLUSIONS

In conclusion, the assessment of groundwater quality in Basrah, Iraq, reveals that the groundwater in the region is contaminated with high levels of pollutants, such as heavy metals and salts, which pose significant health risks to the local population. The main sources of contamination are anthropogenic activities, including urbanization, industrialization, and agricultural practices. The results of the study emphasize the need for urgent action to prevent further contamination of groundwater and to protect the health of the population.

The research demonstrates that the irrigation indices and Gis may be used to effectively assess groundwater quality. Several irrigation indicators were employed, including Sodium adsorption ratio, percentage Sodium, and Magnesium hazard. In order to categorize each sample in accordance with these rules, the values of the irrigation indices were contrasted to accepted benchmarks. The majority of the readings for almost all of the indices were found to be within the Acceptable range, proving that the water quality in the study area is typically good and may be considered as suitable for irrigation. Magnesium hazards were found in several of the materials tested.

Effective groundwater resource management in Basrah requires the formulation and execution of suitable laws and regulations that address pollution sources, encourage sustainable use, and guarantee correct waste disposal. Furthermore, constant evaluation and monitoring of groundwater quality is required to follow changes over time and evaluate the success of management techniques. Overall, the evaluation of groundwater quality in Basrah emphasizes the fundamental need of safeguarding this important resource and assuring its long-term usage for present and future generations.

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