Assessment of groundwater quality using (WQI) in Gleewkhan village northeastern of Iraq

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ABSTRACT

The present study is aimed at assessing the water quality index (WQI) for the groundwater of Gleewkhan village, Al-Hamdannia district south eastern of Mosul City. Iraq. This has been determined by collecting 48 groundwater samples from eight deep wells and subjecting the samples to a comprehensive physicochemical and biological analysis. For calculating the WQI, the following 13 parameters have been considered: pH, total hardness, total dissolved solids, calcium, magnesium, chloride, sulphate, nitrate, and phosphate, TPC, Fecal coliform and *E. coli*. The WQI for these samples ranges from 498 to 1633, which classified into un suitable categories for drinking purposes. The high value of WQI has been found to be mainly from the higher values of Total Bacteria and Fecal Coliform in the groundwater which reached to1598×10^{4}cells. ml^{-1} and 1100×10^3 cells.100ml^{-1} respectively. The analysis reveals that the groundwater of the Gleewkhan village needs some degree of treatment before consumption.

Keywords: Groundwater, Gleewkhan village, water quality index, water quality.

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INTRODUCTION

Water resource becomes more and more demanding in everyday life, based on the population growth, the production rate of food stocks and in the evolving industry. The most important fresh water source in the world, based on stability and importance, is the groundwater or subterranean waters[1, 2]It has become a necessity to protect the ground water resources against pollution (natural or anthropic), because they could have negative effects on the human health. The sad fact is that pollution of drinking water is a problem for about half of the world’s population. Each year there are about 250 million cases of water-related diseases, with roughly 5–10 million deaths. Diseases caused by the ingestion of water contaminated with pathogenic bacteria, viruses, or parasites include: Cholera, Typhoid, dysentery and other diarrheal diseases,in the developing countries 1.8 million people, especially children die every day, because of the contaminated groundwater[3, 4]. The most widely spread danger associated with drinking water is the direct or indirect contamination by human and animal fecal matter, chemical, municipal, domestic and agricultural dischargeetc.

Availability of clean water is going to be the greatest constraint for human health. Keeping this into consideration an attempt was made to evaluate the Physicochemical and biological Characteristics of groundwater to determine whether the water is fit for human consumption or not[5]. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source therefore it becomes very important to regularly monitor the quality of groundwater and to device ways and means to protect it[3].

Water resources in Iraq, especially in the last two decades have also suffered of remarkable stress in terms of water quantity due to different reasons such as the dams built on Tigris and Euphrates in the riparian countries, the global climatic changes and the local severe decrease of the annual precipitation rates and improper planning of water uses inside Iraq[6]. Water quality is certainly affected by the quantity and quality of supplies coming from different sources.

Therefore, overall national planning and resource management in respect to water with emphasis on allocation of priorities among the different uses is necessary. It is not surprising that, due to the above factors, studying water quality is so much important to be carried out in order to keep our awareness and understanding of our environment.

Water quality index has been successfully applied to assess the quality of groundwater in the recent years due to its serves the understanding of water quality issues by integrating complex data and generating a score that describes water quality status[7,8].The objective of the present work is to apply WQI to assess suitability of groundwater for drinking proposes in Gleewkhan village, Al-Hamdannia district. Iraq.

MATERIAL AND METHODS

Study site: The study was conducted on ground water of Gleewkhan village, Al-Hamdannia district southeastern of Mosul City. Iraq. It is located between 36°17´7.9" and 36°17´18.7" North Latitude and 43°14´27.6" and 43°14´40.2" East Longitude (Fig. 1), and has an elevation of about 320 m above sea level[9]. The geological formation in it is Al-Fatha (Lower Fars) which consisting mainly of gypsum, anhydrite, evaporated salts, limestone and marl etc.[10].Therefore, the water well be contains high concentration of sulfur compounds as sulfate, sulphite which combined with other cations as Sodium, Calcium and Magnesium[11].

Methodology: In present investigation forty eight water samples taken from 8 different deep wells (depth more than 30 m)were collected through a period from

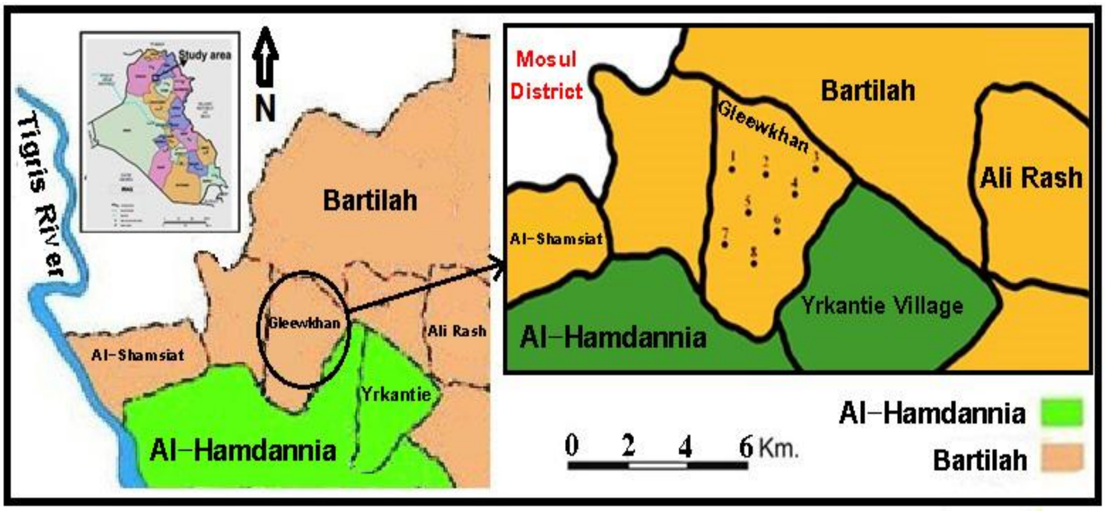

Figure 1: Map of the southern part of Iraq (Nineveh governorate) showing the studied wells.

May to Join 2014 (twice replicates a month) in polythene bottles which were cleaned with distilled water; followed by rinsing the sample container with the sample before it is filled[3]. Each of the groundwater samples was analyzed for 14 parameters such as Temperature, pH, TDS, total hardness, calcium, magnesium , total alkalinity, chloride, sulphate, phosphate, nitrate, TPC, Fecal coliform and *E.coli* were determined by using standard procedures recommended by APHA[12].

Calculation water quality index:

WQI, a technique of rating water quality, is an effective tool to assess spatial and temporal changes in ground water quality and communicate information on the quality of water to the concerned citizens and policy makers[13,14]. WQI is defined as a rating reflecting the composite influence of different water quality parameters, which is calculated from the point of view of the suitability of groundwater for human consumption. It is one of the most effective tools to monitor the surface as well as groundwater pollution and can be used efficiently in the implementation of water quality upgrading programs. The objective of an index is to turn multifaceted water quality data into simple information that is comprehensible and useable by the public. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics. For computing WQI fourth steps are followed[15, 16]:

In the first step, each of the all parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes. The maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment. Magnesium which is given the minimum weight of 1 as magnesium by itself may not be harmful[17](Table 1).

Table (1): Standard permissible Value (Si),weight and Relative Weight (Wi) of each parameters. (*WHO, 2004).			
parameter	Si*	Weight (wi)	Wi
pH	6.5 – 8.5	5	0.1162790
TDS	1400	4	0.0930230
T. Alkalinity	150	2	0.0465116
T. Hardness	500	3	0.0697674
Ca^{+2}	200	2	0.0465116
Mg^{+2}	150	1	0.0232558
Cl^{-1}	250	3	0.0697674
SO_4^{-2}	400	4	0.0930230
NO_3^{-1}	45	5	0.1162790
PO_4^{-3}	1.0	3	0.0697674
TPC	10	5	0.1162790
F. Coliform	0.0	5	0.1162790
Total		Σ wi = 43	0.9999999

In the second step, the relative weight (Wi) is computed from the following equation[15]:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad (1)$$

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters.

In the third step, a quality rating scale (Qi) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines of WHO[18] and then multiplied by 100:

$$Qi = (Ci / Si) \times 100 \qquad (2)$$

Where Qi is the quality rating, Ci is the concentration of each parameter in each water sample in mg/L, and Si is the WHO drinking water standard for each chemical parameter in mg/L according to the guidelines of WHO[18] (Table 1).

In the fourth step, the SI is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation:

$$SIi = Wi \times Qi \quad (3)$$

SIi is the sub index of i^{th} parameter and Qi is the rating based on concentration of i^{th} parameter.

The overall water quality index (WQI) was calculated by adding together each sub index values of each groundwater samples as follows:

$$WQI = \Sigma SIi \quad (4)$$

The computed WQI values are usually classified into five categories (Table 2) for drinking purposes[19].

Table 2: WQI based Classification of drinking water.					
WQI Values	<50	50-100	100-200	200-300	> 300
Class	I	II	III	IV	V
Category	Excellent	Good	Poor	Very Poor	Unsuitable

RESULTS AND DISCUSSION

The values of physicochemical and Bacterial parameters of 48 samples are given in (Table 3 and 4). Temperature is an important water quality parameter due to its influence on other parameters. Temperature affects the solubility and, consequently, the availability of gases such as oxygen in water[11]; it also affects the toxicity of some chemicals in water systems, the groundwater usually have slight variability in its temperature or Homothermal[13]. In this study, the temperature values ranged between 20 to 24 °C which fall below the recommended values of 30°C to 35°C of WHO[18].The pH value of natural water changes due to biological activity and contamination. It is one of the most important indicator of the water quality[17].

The pH of drinking water is normally between 6.5 to 8.5[18]. In the present study pH values ranged from 6.02 at well 2 to 7.86 at well 8.The slight acidic of some of the samples in both wells (4 and 5) may be due to the presence of dissolved carbon dioxide and organic acids in the groundwater[3, 8], however, the pH values of the samples under the study are well within the limits prescribed by Word Health Organization (WHO)[18] for various uses of water including drinking and other domestic supplies.

Table 3: Variations of the physiochemical and bacterial analysis results parameters of the groundwater at Gleewkhan village.(mg.L^{-1})

Well No		Temp .°C	pH	TDS	T.H	T.alk .	Ca^{+2}	Mg^{+2}	Cl^-	$SO_4^=$	NO_3^-	PO_4^{-3}	TPC *	F.Colf. **	*E. Coli** *
1	*Min.* *Max.* *mean* *Sd ±*	22 24 23 0.82	7.06 7.59 7.31 0.17 6	1568 2605 1918 365	900 129 0 108 5 149	400 470 427 24	136 400 212 93	66 165 113 42	125 260 180 47	240 700 533 144	10.6 9 10.8 7 10.7 6 0.05 5	0.24 0 0.90 0 0.42 4 0.24 5	30.0 904 324 410	0.0 3.0 0.5 1.12	0.0 3.0 0.5 1.1
2	*Min.* *Max.* *mean* *Sd ±*	20 22 21 0.82	7.23 7.73 7.42 0.22 2	1408 2010 1686 365	550 107 0 762 175	270 420 326 59	96 180 163 40	74 158 102 34	100 190 151 40	150 346 246 63	10.5 9 10.7 3 10.7 0 0.05	0.10 0 0.28 0 0.15 0 0.06 0	132 955 503 374	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0
3	*Min.* *Max.* *mean* *Sd ±*	22 23 *22.7* *0.47*	7.37 7.66 7.51 0.10 1	1619 1720 1663 330	710 120 0 892 172	120 270 158 31	172 360 234 68	65 82 74 29	92 360 207 99	230 620 406 150	6.86 0 10.7 0 8.04 0 1.26 0	0.09 0 0.29 0 0.16 8 0.07 8	416 615 488 90.3	70 240 74 97	4.0 240 74 97
4	*Min.* *Max.* *mean* *Sd±*	20 22 21 0.82	7.08 7.49 7.11 0.17 3	1152 1876 1508 268	680 132 0 892 172	310 480 385 56	204 352 249 52	42 151 83 22	125 235 174 41	159 430 294 93	10.7 8 10.9 7 10.8 6 0.06 6	0.25 1.90 0.86 0.58	195 922 480 276	21 1100 406 437	21 1100 406 437
Standard limit		27	6.5- 8.5	1000	500	150	200	150	250	400	45	1.0	10	0.0	0.0

Temp: Temperature, TDS: Total Dissolved Solid., T. H: Total Hardness., Ca: calcium., Mg: magnesium., Cl: chloride., SO_4: sulfate., NO_3:nitrate

PO_4: phosphate, TPC: Total Plate Count (*×10^3 Cells. ml^{-1})., F. C.: Fecal Coliform and *E. coli: Escherichia coli*(** ×10^3 Cells. 100 ml^{-1})

Table 4: Variations of the physiochemical and bacterial analysis results parameters of the groundwater at Gleewkhan village.(mg.L^{-1})

Well No		Temp .C°	pH	TDS	T. H	T.alk.	Ca^{+2}	Mg^{+2}	Cl^-	$SO_4^=$	NO_3^-	PO_4^{-3}	TPC *	F.Colf. **	*E. Coli***
5	*Min.*	20	6,02	1344	600	250	92	72	110	418	10.50	0.110	76.0	0.0	0.0
	Max.	22	7.67	2287	1730	470	536	142	165	460	10.76	0.300	839	0.0	0.0
	mean	21.3	7.43	1686	1036	344	307	96	126	434	10.64	0.220	367	0.0	0.0
	Sd ±	0.94	0.163	365	474	73	188	28	23	15.7	0.070	0.069	312	0.0	0.0
6	*Min.*	21	7.04	1690	840	340	344	62	95	320	10.72	0.120	10.0	0.0	0.0
	Max.	23	7.54	2977	2060	490	612	127	355	927	10.83	0.350	1100	0.0	0.0
	mean	22	7.25	2223	1268	393	383	86	238	539	10.80	0.200	527	0.0	0.0
	Sd ±	0.82	0.190	446	430	59	130	22	114	187	0.03	0.077	446	0.0	0.0
7	*Min.*	22	6.86	1555	820	250	136	156	110	317	6.930	0.130	408	0.0	0.0
	Max.	23	7.56	2977	2070	330	552	235	250	990	10.70	0.280	784	0.0	0.0
	mean	22.7	7.05	2185	1448	295	357	187	183	535	7.890	0.204	571	0.0	0.0
	Sd ±	0.47	0.261	470	483	31	131	31	57	240	1.300	0.054	159	0.0	0.0
8	*Min.*	21	7.22	1709	1190	270	236	97	250	491	8.200	0.110	268	23	0.0
	Max.	22	7.86	2688	1800	400	408	187	616	1142	10.76	0.320	585	43	0.0
	mean	21.7	7.44	2223	1466	320	333	137	459	804	10.30	0.192	414	11	0.0
	Sd ±	0.47	0.210	387	234	46	64	40	144	270	0.94	0.080	131	17	0.0
Standard limit		27	6.5-8.5	1000	500	150	200	150	250	400	45	1.0	10	0.0	0.0

Temp: Temperature., TDS: Total Dissolved Solid., T. H: Total Hardness., Ca: calcium., Mg: magnesium., Cl: chloride., SO_4: sulfate., NO_3: nitrate.
PO_4: phosphate., TPC: Total Plate Count (*×10^3 Cells. ml^{-1})., F. C.: Fecal Coliform and *E. coli: Escherichia coli* (** ×10^3 Cells. 100 ml^{-1}).

TDS in water is a measure of combined chemicals of all inorganic and organic substances present in water as molecule, ions or micro granular suspended form, the high concentration can cause heart and kidney diseases[17], TDS values were varied from 1433 mg. l^{-1} to 2977 mg. l^{-1} (Table 3,4), all these values are much higher than that of the permissible limit[18].

Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water .Hardness of water mainly depends upon the amount of calcium and magnesium salts[11]. The hardness, Ca and Mg values shown range from 550, 92 & 42 mg. l^{-1} to 2070 mg. l^{-1} respectively. All of T.H and most of (Ca & Mg) values for water sample were found high than the prescribed limit WHO (500, 200, 150 mg. l^{-1}) respectively. This high values may be mainly due to the dissolution and rock weathering of geological formation in the study area (Al-Fatha) which consisting mainly of gypsum, anhydrite, limestone[8].

The main source for groundwater alkalinity is due to weathering of rocks in the geological information. Higher alkalinity value contributes sour and saline taste to water[20]. Although, alkalinity is not harmful to human beings yet the drinking water with less than 150 mg/l is desirable. During present study the minimum average of total alkalinity value recorded was 158 mg.l-1and the maximum recorded was 388 mg. l-1 during the study period. About %91 of these values are much higher than that of the standard permissible limit. The total alkalinity levels of all the water samples are high thus, resisting acidification of the groundwater samples.

Chlorides are widely distributed in nature as salts of sodium, potassium and calcium etc. Cl are leached from various rocks in the geological information and water by weathering[21]. It present in groundwater samples are in the range of 92-459 mg.l^{-1}, The chloride content (%62 of samples) in the study area was found to be well within the permissible levels 250 mg.l^{-1} as per WHO Standards.

The high levels of nitrate in drinking water may cause serious illnesses such as methemoglobinemia or "blue baby syndrome" , cancer risks, CNS birth, Diabetes etc.[22, 23]. Nitrate in the water samples are found to be in a range of 6.86 to 10.87 mg.l^{-1}. All the data satisfy the objective values for drinking water.

Sulphate concentration in collected groundwater samples is ranges from 150-1142 mg.l^{-1} as (%33 of water samples) in the permissible limit of 400 mg.l^{-1} (WHO). Health concerns regarding sulphate in drinking water have been raised because of reports that diarrhea may be associated with the ingestion of water containing high levels of sulphate[8, 24].

In the present study phosphate ranged from 0.10 to 1.90 mg.l^{-1}, which was found (% 95 of sample) to be well within the permissible levels (1.0 mg.l^{-1}) as per WHO[18], the higher concentration may be due to exploit of fertilizers and pesticides by the people of this area. Excess phosphate consumption could lead to the death of consumer[25].

In the other hand the, Bacteriological tests that, are most widely used methods for monitoring the presence of potential pathogens in drinking water, are based on cultivation and enumeration of the Total Bacteria and fecal coliform group including *E. coli* [14]. During present study the minimum average values of total bacteria, Fecal coliform and *E. Coli* recorded were 324×10^4 Cells. 1ml^{-1} , 0.0 and 0.0 $\times10^3$ Cells. 100 ml^{-1} and the maximum recorded were 571×10^4 Cells. 1ml^{-1}, 406 and 406 $\times10^3$ Cells. 100 ml^{-1}respectively.The count of T. Bacteria (% 100), F. coliform (% 27) and E. coli (% 27) for water samples were found higher than the prescribed limit of WHO (10, 0.0, 0.0) cells. l^{-1}. These high values are mainly due to the human or animal wastes contaminate the groundwater.

In this research, the computed WQI ranges from 384 to 752 the minimum value has been recorded from well no.4 while maximum has been recorded from well no. 6. The computed WQI values (Table 5) are classified into class (V) according to (Table 2), they were fall in unsuitable quality category for drinking purpose.

Table (5): Water Quality Index of Groundwater in Study Area.

Well No.	WQI	Class	Water status
1	512	V	Unsuitable for drinking
2	646	V	Unsuitable for drinking
3	635	V	Unsuitable for drinking
4	384	V	Unsuitable for drinking
5	498	V	Unsuitable for drinking
6	703	V	Unsuitable for drinking
7	752	V	Unsuitable for drinking
8	585	V	Unsuitable for drinking

The high values of WQI at these wells has been found to be mainly from the higher values of TDS, T. Hardness, sulphate, T. Bacteria and F. coliform in ground water. All these factors may cause health hazard on long term and can degrade quality of drinking water, therefore, required to be treated for drinking purpose.

CONCLUSION

The observation, we collected and estimated in this present study indicates that, the higher values of WQI of the samples due to the higher values of TDS, T. Hardness, sulphate, T. Bacteria and F. coliform in ground water obtained at different wells distributed in Gleewkhan village will make the groundwater unsuitable for drinking and domestic purpose. When WQI is greater than 300, it implies that the pollutants are above the standard limits. Similarly WQI > 300 these groundwater are unfit for drinking purpose. Finally this research suggest that the ground water having higher parameters values at the study area can be used domestically only after proper treatment methods. Also this will be harmful to the health of the people especially those that depend on untreated groundwater source for drinking purpose.

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