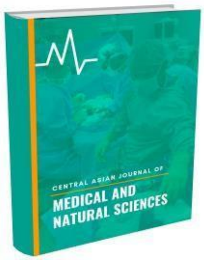

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Article

Using Water Quality Index to Assessment of Ground Water Quality for Drinking Uses in Tuzkhurmatu City, Iraq

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Abstract: A criteria for assessing the quality of water and determining its suitability for varies uses is the Water Quality Index. For examining the general chemical properties of water quality, the Water Quality Index (WQI) is a crucial and effective instrument. 16 groundwater samples, in total, were gathered and their principal cations and anions were examined used at Tuzkhurmatu city in Salah Aldeen governorate, Iraq. 12 parameters including: sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), chloride (Cl), bicarbonate (HCO3), sulfate (SO4), nitrate (NO3), pH, total dissolved solids (TDS), electrical conductivity (EC) has been used to applied WQI . The computed WQI values varied from 56.73 (sample 2) to 1072.69 (sample 4). Calculated WQI results showed four classes: unsuitable water in samples (1, 4, 10) with the percentage of 18.7%, very poor water in samples (11, 14) with the percentage of 12.5%, poor water in samples (5, 6, 8, 9, 12, 13, 15, 16) with the percentage of 50% and good water in samples (2, 3, 7) with the percentage 18.7%. TDS values ranged between 436 and 20780 mg/l, most of ground water samples classified as brackish water, saline water and fresh water. EC values ranged between 620 and 26250 (µs/cm), most of groundwater samples categorized as excessively mineralized water. TH values ranged between 310.83 and 7556.92 (mg/l), all ground water samples categorized as vary hard water. To ascertain if the groundwater samples were suitable for drinking purpose, the TDS, EC and TH results of groundwater samples were compared with the world health organization (WHO) and Iraq quality standard (IQS) to determine its suitability for drinking purpose indicate to the all ground water samples exceeded permissible limits aimed at drinking water value except samples (2,3,5,7) are not exceeded permissible limits. It was clear from the water quality assessment that the most of Tuzkhurmatu city ground water was unsuitable for drinking. The findings of this research indicate to decrease the groundwater quality this might be as a result for anthropogenic activities around the sampling area mainly sewer waste water contamination sources within water samples from the studied area.

Keywords: Groundwater, Water Quality Index, Drinking Water, Chemical Characteristics, Tuzkhurmatu City

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1. Introduction

The most important element of the profound life is water [1]. Still many factors affecting the quality of groundwater, such as agricultural activities (pesticides and fertilizers), besides industrial wastes, geological formation, land use practices, the rainfall patterns and rate of infiltration [2]. Urbanization and accelerating increase of populations have increased the demand on resources of water especially groundwater and this may cause serious problems for the environment in the last few decades [3]. The main factors controllers on the groundwater chemistry are generally the geological characters, and some of these factors are (surrounding areas, the flow direction of groundwater , the severity of chemical weathering of the rock , and the interactivity between water and rock throughout the recharge season) [4], [5], [6],[7], [8].

Physicochemical parameters assisted the researchers to have a general idea about likely contaminants and this can be assessed by evaluating the parameters rates compared with the standard rates, [9], [10]. And for indicating the permissible parameter, water quality index (WQI) referred to the general quality of water for specific location and time [11].

Iraq is one of the countries that may deal with decreasing of water level of Tigris and Euphrates rivers, and this problem originated from outboard activities. This may effect in a negative way on Iraq share for human drinking water. An evaluation of groundwater quality for drinking uses was needed for Tuzkhurmatu city an exemplary case study in Iraq that is currently undergoing some economic development. A criterion to assessing the quality of water and determining its suitability for different uses is the water quality index. And it is among the most effective means of informing concerned individuals and decision-makers about water quality. It, thus, it becomes a crucial parameter for managing and evaluating surface and groundwater [12].

This research involved studying the hydrochemistry of the groundwater and assessing its quality by analyzing some related chemical elements and classify these parameters according to the suitability for drinking purposes. In May 2018, 16 groundwater samples were taken from wells and examined for cations (Na+, Ca2+, Mg2+, K+), and anions (SO42−, Cl−, NO3−) beside evaluating some physical characteristics including total dissolved solid (TDS), pH, electrical conductivity (EC). This study conducted in Tuzkhurmatu city in Salah Al-Den Governorate between (Latitude: 34º 36' 00'' N - 34º 56' 30'' N) and (Longitude: 44º 28' 30'' E- 44º 46' 00'' E) (Figure 1).

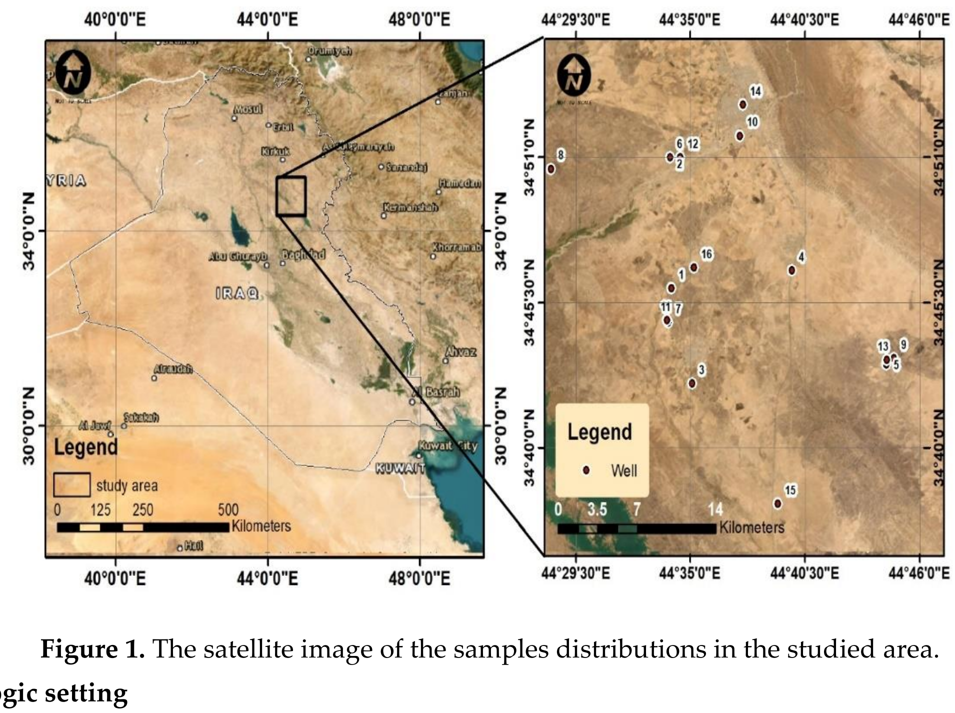

Figure 1. The satellite image of the samples distributions in the studied area.

Geologic setting

Generally, Quaternary deposits are covering more than most of the study area. Pre-quaternary deposits, belong to Tertiary (Middle Miocene-Pliocene) and are represented by Fatha, Injana, Mukdadiyah and Bai Hassan Formations. Middle Fars Formation (transition zone) has been added to the Fatha Formation. The wells of ground water in the studied area were partially penetrating Bai Hassan formation at varying depths. The top and main hydrogeological productive aquifer in the research region is thus represented by this Formation. It is regarded as a significant sandstone aquifer with the Quaternary deposit gravel on the top and the Mukdadiyah formation beneath [13] Figure 2.

Structurally, the research area belongs to the Foothill Zone of the Unstable Shelf of Nubio - Arabian Platform and Mesopotamian Zone. Tectonically, it partially belongs to Tigris and Hemreen - Makhul subzones [14], [15]. Herein Gilabat and Pulkhana anticlines are the majority structural elements. The region is highly effected by structures and morpho¬logy, and covered by thick Quaternary deposits, derived from existing mountains and far area too, dissected by very comp¬licated systems of drainage. Moreover the study area is inform of vast plains interrupted by long and narrow mountain ranges, acting as an influent areas with their crustal lines represen¬ting major divide lines of different basins.

The main sources of water is the rain beside the existing rivers. The yearly rainfall occurs between November and April and the climate effected on amount of water and changing of ground water level [16]. The majority of the rocks are porous and permeable (has good infiltration capacity) except the claystone's. Aquifers are represented by Al-Fatha alluvial fan, floodplain deposits and discontinuous lenticular and commonly elongated bodies of variably sorted sand and gravels beside the Miocene rocks. Main sources of water are hand dug wells, artesian wells, springs and direct precipitation beside the rivers. The quantity of the water is good, especially at both sides of the Tigris River.

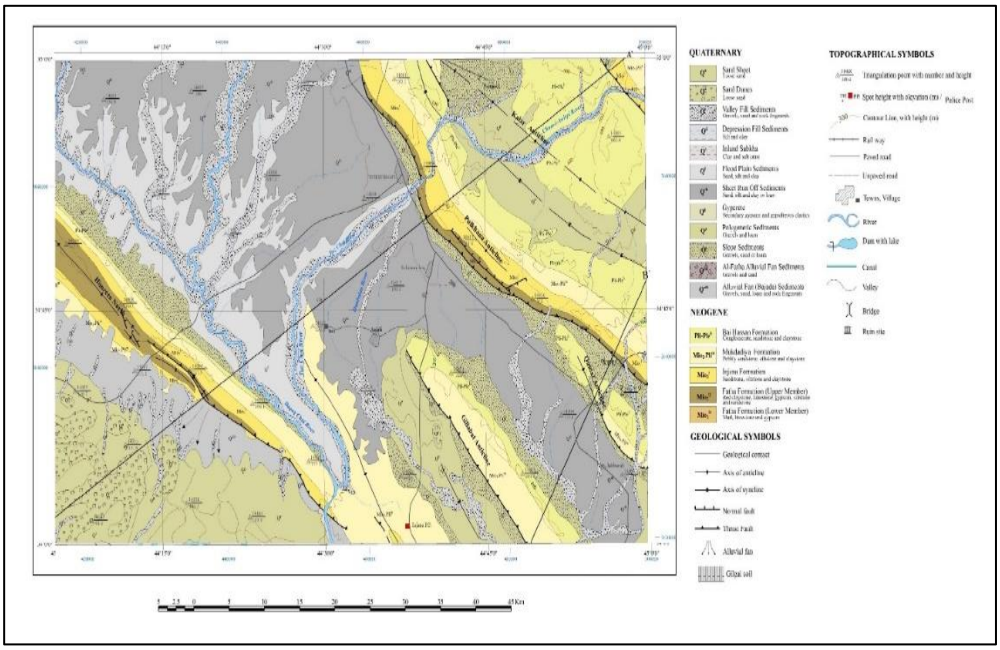

Figure 2. The geological map of the studied region.

2. Materials and Methods

16 groundwater samples used in this study from different locations during May 2018 to examine the quality of groundwater for drinking uses. The groundwater samples examined 12 parameters including: electrical conductivity (EC), pH, total dissolved solids (TDS), sodium (Na), magnesium (Mg), calcium (Ca), potassium (K), sulfate (SO4), bicarbonate (HCO3), chloride (Cl), nitrate (NO3), TDS, pH and EC were measured separately in the field using transportable multi-meters (Trans ISO 9002), while the rest of the parameters and following standard protocols were analyzed in the laboratory recommended by APHA [17] Table 1.

Basic parameters for calculating Water Quality Index (WQI) according to the drinking water quality requirements by Iraqi standard [18].

Table 1. Physiochemical properties of samples in the study area.

well no.	PH	EC (μS/cm)	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	HCO_3 (mg/l)	SO_4 (mg/l)	Cl (mg/l)	NO_3 (mg/l)	T H (mg/l)
1	7.5	16400	13660	592	605	3220	3	101	4984	3692	6	4026.99
2	6.6	620	436	88	20	38	2	110	182	21	24	310.83
3	7.7	660	478	120	5	41	2	207	180	18	3	332.21
4	6.6	26250	20780	1280	488	5474	4	79	4080	9230	6	5332.28
5	7.5	1023	764	108	66	69	1	220	278	121	6	552.06
6	6.8	3380	2692	460	115	225	3	67	1622	120	6	1667.84
7	8.3	730	520	60	41	60	2	171	192	64	6	324.53
8	7.8	2000	1383	112	102	207	2	207	638	213	6	710.59
9	7.8	3140	2275	448	117	78	3	73	1296	199	3	1644.91
10	8.1	14400	9216	2200	448	1357	3	142	924	1289	12	7556.92
11	7.8	3530	2272	448	198	481	3	200	507	412	12	1978.22
12	7.8	2440	1896	360	183	394	2	200	498	234	12	1687.96
13	7.8	3140	2040	400	194	409	2	198	491	308	12	1837.11
14	7.4	3940	2521	296	110	372	2	306	845	536	2	1221.36
15	7.4	2560	1638	148	84	264	2	317	374	489	2	730.016
16	7.4	4470	2861	189	42	391	2	202	721	408	408	663.66

The (WQI) calculation by following the steps using the weighted arithmetic index method [19].

Assigned the specific weights for the parameters based on their relative significance in the overall quality of the drinking water as shown in Table 2. he following formula has been used to calculate the relative weight (Wr).

$Wr = Wi / \sum_{n=1}^{n} wi$ .... (1)

Where wi is the weight of each parameter and n is the number of parameters. Wr is the relative weight. Table 2 illustrate the Wr values of each parameters.

Determine each parameter's quality rating scale (qi), which is determined by dividing its concentration in each water sample by the corresponding standard in accordance with the rules, and multiplying the result by 100 which is illustrate in Table 2.

$qi = (Ci / Si) * 100$ ....(2)

Where Si is the Iraqi drinking water standard for each parameter in mg/L according to the guidelines of the [18] and qi is the quality rating. Ci is the concentration of each parameter in each water sample in mg/L.

Calculated SIi for each chemical parameter using the following equation:

$SIi = Wr * qi$ …..(3)

Lastly, use the formula below to calculate WQI for each chemical parameter.

$WQI = \Sigma SIi$ …..(4)

Table 2. The relative weight for each parameter.

Parameter (mg/l)	Iraqi Standard (Si) (2009)	Weight (Wi)	Relative weight (Wr)
PH	6.5-8.5	4	0.129
TDS	1000	5	0.161
TH	500	2	0.064
Ca^{++}	150	2	0.064
Mg^{++}	100	2	0.064
Na^{+}	200	2	0.064
K^{+}	12	2	0.064
Cl^{-}	350	3	0.096
SO_4^{--}	400	4	0.129
NO_3	50	5	0.161
Total		∑W=31	0.996

The WQI value of the sample is represented by the total of the Sli that was calculated using formula (3) above. Table 3 lists the WQI and Sli values. The values of calculated WQI are categorized in to five class, "excellent water" to "unsuitable water" of drinking water after [20].

Table 3. The values of Sli and WQI for each parameter.

Sa. No.	*Sli* PH	*Sli* TDS	*Sli* TH	*Sli* Ca^{+2}	*Sli* Mg^{+2}	*Sli* Na^{+1}	*Sli* K^{+1}	*Sli* Cl^{-1}	*Sli* SO_4^{-2}	*Sli* NO_3^{-}	∑*Sli* = WQI
1	4.3	219.92	51.54	25.25	38.72	103.04	1.6	101.26	160.73	32.52	738.90
2	-3.44	7.01	3.97	3.75	1.28	1.21	1.06	0.57	5.86	35.42	56.73
3	6.02	7.69	4.25	5.12	0.32	1.31	1.06	0.49	5.80	66.65	98.73
4	-3.44	334.55	68.25	54.61	31.23	175.16	2.13	253.16	131.58	25.43	1072.69
5	4.3	12.30	7.06	4.60	4.22	2.20	0.53	3.31	8.96	70.84	118.35
6	-1.72	43.34	21.34	19.62	7.36	7.2	1.6	3.29	52.30	21.57	175.92
7	11.18	8.37	4.15	2.56	2.62	1.92	1.06	1.75	6.19	55.06	94.88
8	6.88	22.26	9.09	4.77	6.52	6.62	1.06	5.84	20.57	66.65	150.30
9	6.88	36.62	21.05	19.11	7.48	2.49	1.6	5.45	41.79	23.50	166.01
10	9.46	148.37	96.72	93.86	28.67	43.42	1.6	35.35	29.79	45.72	532.99
11	6.88	36.57	25.32	19.11	12.67	15.39	1.6	11.30	16.35	64.4	209.60
12	6.88	30.52	21.6	15.36	11.71	12.60	1.06	6.41	16.06	64.4	186.63
13	6.88	32.84	23.51	17.06	12.41	13.08	1.06	8.44	15.83	63.75	194.91
14	3.44	40.58	15.63	12.62	7.04	11.90	1.06	14.70	27.25	98.53	232.78
15	3.44	26.37	9.34	6.31	5.37	8.44	1.06	13.41	12.06	102.07	187.90
16	3.44	46.06	8.49	8.06	2.68	12.51	1.06	11.19	23.25	65.04	181.80

3. Results

The most effective method for assessing the overall quality of water resources is the WQI [21]. The ions concentration were originally resulting by dissolved minerals in addition water percolation through soil and human activities which is reflected as a main source of ground water deterioration. Major ions and physicochemical results of groundwater samples in Table (1) used to calculating WQI of the samples from research area. The WQI values of the ground water samples calculated were shown in tables (2 and 3). The computed WQI values varied from 56.73 (sample 2) to 1072.69 (sample 4). Calculated WQI values categorized into five types [22] in Table (4).

Table 4. WQI for groundwater samples of Tuzkhirmatu city.

Sample no.	Water value	Water quality classification	The percentage of samples
---	< 50	Excellent water	----
2, 3, 7	50 -100	Good water	18.7 %
5, 6, 8, 9, 12, 13, 15, 16	100 – 200	Poor water	50 %
11, 14	200 -300	Very poor water	12.5 %
1, 4, 10	>300	Unsuitable water	18.7 %

The percentage of ground water samples that showed in table 4, accordingly 18.7% of samples fell into the "good water" class, 50 % of samples fell into the "poor water" class, 12.5 % of samples fell into the "very poor water" class and 18.7 % of samples fell into the "unsuitable water" class Figure 3

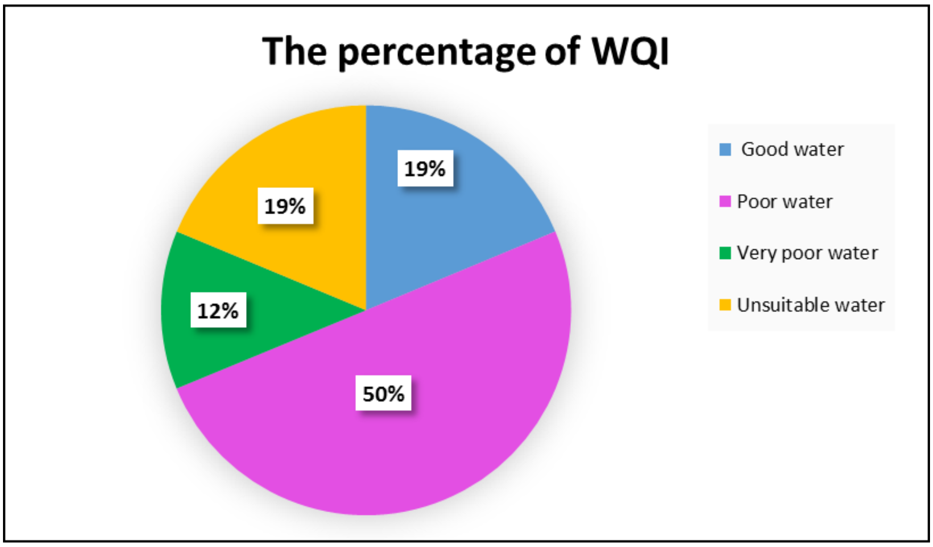

Figure 3. The percentage of WQI for the all samples in the research area.

The TDS values ranged between 436 and 20780 mg/l, most of ground water samples classified as brackish water, saline water and fresh water according to [23] Table (5).

Table 5. Ground water samples classified using TDS parameter after.

Samples No.	Classification of water depending on TDS
2,3,5,7	Fresh water
6,8,9,11,12,13,14,15,16	Brackish water
10	Salty water
1,4	Saline water

The EC concentration ranged between 620 and 26250 (µs/cm). According to [24], the most of groundwater samples are categorized as excessively mineralized water Table (6).

Table 6. Ground water samples classified using EC parameter after [24].

Samples No.	Classification of water
2,3,7	Highly mineralized water

1,4,5,6,8,9,10,11,12,13,14,15,16	Excessively mineralized water

The TH concentration ranged between 310.83 and 7556.92 (mg/l), all ground water samples classified as vary hard water according to.

The TDS, EC and TH results of groundwater samples are compared with the IQS and WHO to ascertain its suitability for drinking purpose. Table (7) shown that the samples of ground water exceeded permissible limits aimed at drinking water value set by IQS and WHO [25] except samples (2,3,5,7) are not exceeded permissible limits.

Table 7. The standards of drinking water comparing with groundwater samples.

Parameters	IQS (2009)	WHO (2011)	Exceeding limits	Samples of groundwater
TDS (mg/l)	1000	1000	Exceed	All samples except (2,3,5,7)
			Not exceed	2,3,5,7
EC (μs/cm)	1500	1530	Exceed	All samples except (2,3,5,7)
			Not exceed	2,3,5,7
TH (mg/l)	500	---	Exceed	All samples except (2,3,7)
			Not exceed	2,3,7

4. Discussion

Quality of Samples tested for groundwater in the studied region, is within good water to unsuitable water regarding drinking purposes. While, poor water class found in the most samples. The results of this research compared with the results of paper that all samples are excellent and good water indicate to decrease the groundwater quality this might be as a result for anthropogenic activities around the sampling area mainly sewer waste water contamination sources within water samples from the study area.

5. Conclusion

Water Quality Index technique used in this study for evaluating groundwater quality in Tuzkhurmatu city for drinking usages, results showed four classes: unsuitable water in samples (1, 4, 10) with the percentage of 18.7%, very poor water in samples (11, 14) with the percentage of 12.5%, poor water in samples (5, 6, 8, 9, 12, 13, 15, 16) with the percentage of 50% and good water in samples (2, 3, 7) with the percentage of 18.7%.

Most of ground water samples classified as brackish water, saline water and fresh water according TDS values, very hard water according to TH values and classified as excessively mineralized water according to EC values. The TDS, EC and TH results of groundwater samples were compared with the world health organization (WHO) and Iraq quality standard (IQS) to ascertain its suitability for drinking uses, which indicate to the all ground water samples exceeded permissible limits aimed at drinking water value except samples (2,3,5,7) are not exceeded permissible limits. It was clear from the water quality examination that the most of Tuzkhurmatu city groundwater were unsuitable for drinking.

REFERENCES

[1] S. P. Gordé and M. V. Jadhav, "Assessment of water quality parameters: a review," *Journal of Engineering Research and Applications*, vol. 3, no. 6, pp. 2029-2035, 2013.

[2] W. E. Federation and American Public Health Association, *Standard methods for the examination of water and wastewater*, 20th ed. Washington, DC, USA: American Public Health Association, 2005.

[3] O. Altansukh and G. Davaa, "Application of Index Analysis to Evaluate the Water Quality of the Tuul River in Mongolia," *Journal of Water Resources and Protection*, vol. 3, no. 6, pp. 398-414, 2011. [Online]. Available: http://dx.doi.org/10.4236/jwarp.2011.36050

[4] R. C. Ferrier et al., "Water Quality of Scottish Rivers: Spatial and Temporal Trends," *The Science of the Total Environment*, vol. 265, no. 1-3, pp. 327-342, 2001. [Online]. Available: http://dx.doi.org/10.1016/S0048-9697(00)00674-4

[5] C. Neal et al., "Water Quality of Treated Sewage Effluent in a Rural Area of the Upper Thames Basin, Southern England and the Impacts of Such Effluents on Riverine Phosphorus Concentrations," *Journal of Hydrology*, vol. 304, no. 1-4, pp. 103-117, 2005. [Online]. Available: http://dx.doi.org/10.1016/j.jhydrol.2004.07.025

[6] H. P. Jarvie, C. Neal, and P. J. A. Withers, "Sew-Age Effluent Phosphorus: A Greater Risk to River Eutrophication than Agricultural Phosphorus?" *Science of the Total Environmental*, vol. 360, no. 1-3, pp. 246-253, 2006. [Online]. Available: http://dx.doi.org/10.1016/j.scitotenv.2005.08.038

[7] A. M. Rabee, B. M. Abdul-Kareem, and A. S. Al-Dhamin, "Seasonal Variations of Some Ecological Parameters in Tigris River Water at Baghdad Region, Iraq," *Journal of Water Resource and Protection*, vol. 3, no. 4, pp. 262-267, 2011. [Online]. Available: http://dx.doi.org/10.4236/jwarp.2011.34033

[8] G. Burnham, R. Lafta, S. Doocy, and L. Roberts, "Mortality after the 2003 Invasion of Iraq: A Cross-Sectional Cluster Sample Survey," *Lancet*, vol. 368, no. 9545, pp. 1421-1428, 2006.

[9] APHA, *Standard Methods for Examination of Water and Wastewater*, 20th ed. Washington, DC, USA: American Public Health Association, 1998.

[10] V. P. Singh and M. Fiorentino, *Geographic Information System in Hydrology*, Dordrecht, Netherlands: Kluwer Academic Publishers, 1996.

[11] Y. Saeedrashed and A. Guven, "Estimation of Geomorphological Parameters of Lower Zab River-Basin by Using GIS-Based Remotely Sensed Image," *Water Resources Management*, vol. 27, no. 1, pp. 209-219, 2013. [Online]. Available: http://dx.doi.org/10.1007/s11269-012-0179-x

[12] S. Al-Hasnawi, "Groundwater quality index for Dammam formation in Al-Najaf area," Ph.D. thesis, College of Science, University of Baghdad, 2013.

[13] A. A. Rashid, M. A. Al-Dabbas, and W. H. Kadhim, "Assessment of Groundwater Quality for Drinking in Tuzkhurmatu Area, Salahadden Governorate – Iraq," *Iraqi Journal of Science*, vol. 39, no. 2, pp. 91-103, 2016.

[14] S. Z. Jassim and J. C. Goff, *Geology of Iraq*, Brno, Czech Republic: Dolin, 2006.

[15] A. M. Barwary and N. A. Slewa, "Geological Map of Samarra Quadrangle, sheet NI-38-6, Scale 1:250,000," 3rd ed. Baghdad: GEOSURV, 2014.

[16] S. A. Al-Qaraghuli, A. A. Hassan, R. A. Albaldawi, and O. K. Abd, "The Effect of Climate Changes on The Fluctuation of The Water Level of Al-Razzaza Lake, Iraq," *Iraqi Geological Journal*, vol. 62, no. 11, pp. 4464-4474, 2021.

[17] APHA, *Standard Method for the Examination of Water and Wastewater*, 21st ed. Washington, DC, USA: American Public Health Association, 2005.

[18] IQS, "Iraqi standard of drinking water," No. 417, modification No. 2, 2009.

[19] R. M. Brown, N. J. McCeiland, and R. A. Deininger, "Water quality index-do we dare?," *Water Sewage Works*, vol. 117, no. 10, pp. 339-343, 1970.

[20] C. R. Ramakrishnalah, C. S. Sadas hivalah, and G. Ranganna, "Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka state, India," *E Journal of Chemistry*, vol. 6, no. 2, pp. 523-530, 2009.

[21] M. Ketata, M. Gueddari, and R. Bouhlila, "Use of geographical information system and water quality index to assess groundwater quality in El Khairat deep aquifer (Enfidha, Central East Tunisia)," *Arabian Journal of Geosciences*, vol. 5, no. 6, pp. 1379–1390, 2011.

[22] C. R. Ramakrishniah, C. S. Sadashivaiah, and G. Ranganna, "Assessment of Water Quality Index for the Groundwater in Tumkur Taluk," *E-Journal of Chemistry*, vol. 6, no. 2, pp. 523-530, 2009.

[23] D. K. Todd, *Groundwater Hydrology*, 3rd ed. New York: John Wiley and Sons, 2007, p. 535.

[24] M. Detay, *Water Wells-Implementation, Maintenance and Restoration*, London: John Wiley and Sons, 1997, p. 379.

[25] WHO, *Guidelines for drinking-water quality*, 4th ed. Geneva, Switzerland: World Health Organization, 2011, p. 564.