How to Cite:
Deidan, M. T. A., & AbdelQader, R. S. (2022). Assessment of the quality and coefficient of treatment water quality of Hawija district using the Water Quality Index (WIQ). *International Journal of Health Sciences*, *6*(S9), 2718–2727. https://doi.org/10.53730/ijhs.v6nS9.13025

Assessment of the quality and coefficient of treatment water quality of Hawija district using the Water Quality Index (WIQ)

Muhannad Taha Ahmed Deidan
Department of Bioloagy, College of Education for Pure Sciences, University of Kirkuk
Email: ma2290339@gmail.com

Rushdi Sabah AbdelQader
Department of Bioloagy, College of Education for Pure Sciences, University of Kirkuk
Email: rushdisabah@uokirkuk.edu.iq

Abstract---This study used the weighted mathematical model to assess the quality of water produced from the desalination station of Hawija district from 3 sites of the raw water source and 7 sites from the treatment station and the distribution network). The study was conducted from November 2021 to April 2022. The first group of the plantations or cites includes feeding streams which are cites 1 and 2. The 7 sites were divided into two groups. The second group included the sites inside the station which were 3, 4, and 5. The values of the water quality coefficient varied in relation to the stages of water desalination. These values in cites 3 and 4 were poor because they reflected the beginning of the treatment stages of the water in the treatment plant, while the water quality factor in site 5 became excellent indicating the beginning of the stages of water treatment in this site. The third group which included cites 6, 7 and 9 represented the distribution grid in the district where the water quality was excellent. As for site 8, the water quality factor was good, and this site was the Al-Nida neighborhood in the distribution grid. The reason for the low water quality in this site is because distribution grid pipes in this site were old. Turbidity and bacteria increased in the sites under consideration for the study of the water of the canal feeding the desalination station the current study showed that the station works with high efficiency in the water desalination.

***Keywords*---**Water quality, Hawija, Water Quality Index, Physical factors, Turbidity.

Manuscript submitted: 9 May 2022, Manuscript revised: 18 July 2022, Accepted for publication: 27 August 2022

Introduction

The demand for water has increased in the past decades due to population growth and industrial and agricultural activity, especially in the developing countries. In addition, the quantity and quality of surface water have been greatly affected, which negatively affects the health of humans, animals and plants. Unscientific use of agricultural pesticides and fertilizers, and the neglect of proper methods of waste disposal in the urban area led to a degrading quality of surface water(Al-Hamdani, Kaplan, & Al-Saffawi, 2021; Al-Mashhadany, 2021). Therefore, studies must focus continuously on monitoring water quality and investigate the causes of pollution to take the necessary measures to reduce the pollution problems of the aquatic environment.

The water quality index (WQI) was first proposed by Horten in 1965(Ramadhan, Al-Saffawi, & Al-Mashhdany, 2018). The WQI shows that the overlapping effects of the studied standards that are used to determine water quality and WQI is considered one of the most widely used methods for controlling surface water pollution(Devojee, Nagababu, Kumar, Nandini, & Hemakumar, 2018). The water quality coefficient gives one value instead of tens of data that confuse the reader, and this value or number is understood by specialists and non-specialists from the general public to understand water quality(Howladar, Al Numanbakth, & Faruque, 2018). Because of the lack of 100% unpolluted water, there was a need to use purification stations, which filter water before it reaches consumers. These stations differ in many characteristics such as geographical location, production capacity, and materials used in purification and filtering in terms of quality and quantity, which affect the efficiency and operation of the station in the production of potable water(Abdul-Baqi, 2020). Also, one of the most important risks facing humans is the deterioration of the quality of drinking water resulting from the inefficiency of drinking water treatment processes because the filtration plants are old, and the distribution grids deteriorate. These defects reduce the quality of water, which increases the possibility of water pollution by pathogens that negatively affect the health of the consumers causing many serious injuries that may lead to death(A.-A. Y. Al-Saffawi, 2019).

The current study uses the weighted mathematical model of water quality to assess the quality of water produced from the treatment plant of Hawija district, Kirkuk governorate, and its suitability for drinking and domestic uses.

Materials and working methods

The study has divided 10 sites into three groups within the study area in Hawija district \ Kirkuk governorate. The first sites were distributed on each of the feeding channel (within the district of Hawija), on the Hawija water purification project and the drinking water distribution grid in the residential neighborhoods of the district. Sites 1 and 2 represented raw water before treatment. Second, site 3 represents the three basins of sedimentation. In addition, site 4 depicted the ten filters. Site 5 is the site of the collection basin. Third, site 6 is the pushing pumps, except for the distribution grid. Sites 7, 8 and 9 are the distribution grid in the district. Site 10, 2 km away from the station, represented raw water in the feeding channel and is located after the station.

Sample Collected

Water samples were collected at a rate of two samples for each site per month from ten sites in the study area starting from November 2021 to April 2022 using clean polyethylene bottles with a capacity of 1 liter that were washed with sample Water samples were collected taking two samples form each cite every month from the ten cites in the study area. The collection started from November 2021 to April 2022 using clean polyethylene bottles with a capacity of 1 liter that were washed with sample water for each site before taking samples. Yet, the samples for bacterial tests were collected in previously sterilized bottles and kept inside a dark container until reaching the laboratory for physical, chemical and bacterial tests according to international standard methods.
(APHA; APHA & WCPE, 2017).

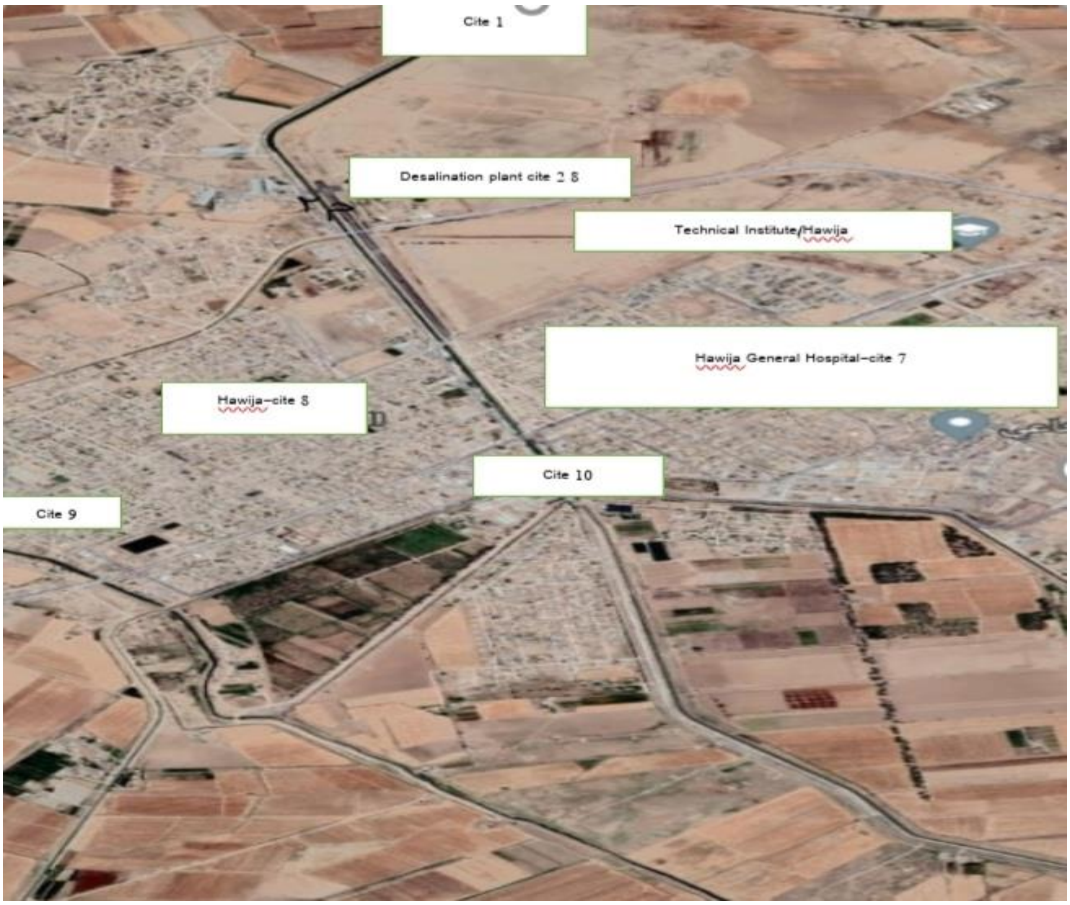

Figure No. (1) A map showing the study area

Water Quality index (WQI)

The weighted mathematical model was used to estimate the water quality of the treatment station of Hawija district, which was referred to by many researchers (Boateng, Opoku, Acquaah, & Akoto, 2016; Howladar et al., 2018;

Ramakrishnaiah, Sadashivaiah, & Ranganna, 2009). The model was applied to fourteen variables as shown in Table No. (1) to calculate the water quality factor, which takes place in the following five stages:

1. First step

The relative weight is calculated according to what is found in the following equation:

$$RWi = \frac{w\,i}{\Sigma_{i=i}^{n} wi} \text{ ....(1)}$$

Since:
RWi: relative weight.
wi: the weight of the adjective.
:Σ(_i=i ^n)wi : The sum of the weights of the adjectives.
2: Second Step
Finding the quality rating (qi) as in the following equation:

$$qi= \frac{Ci}{Si} \times 100 \text{ ....(2)}$$

So:

Ci :The value of the measured attribute.

Si :Standard concentration of the trait and according to international classifications.

Table (1) Standard limits, weight and relative weight for each adjective

Feature	Si. Standard limits	Wi: weight of each feature	RWi: Relative weight
Turb.	5.0	5.0	0.1162790676
T.C	25	2.0	0.0465116279
pH	6.5-8.5	4.0	0.0930232558
Ec25	1400	4.0	0.0930232558
T. Hard.	500	2.0	0.0465116279
T. Alk.	150	2.0	0.0465116279
Na	200	3.0	0.0697674419
K	20	1.0	0.0232558139
SO4	400	3.0	0.0697674419
Cl	250	2.0	0.0465116279
NO3	50	4.0	0.0930232558
PO4	10	1.0	0.0232558139
TP*	10	5.0	0.1162790676
F.C**	0.0	5.0	0.1162790676
	Σ	43	0.9999999840

3: Third Step

The Subindex (SLi) values are calculated as in the following equation:

SLi= Wi × qi........ (3)

4: Fourth Step

The values of the quality coefficient WQI was found out as in the following equation: $WQI= \Sigma SLi$........ (4)

Then the water quality is classified in comparison with Table (3).

Table (3): Classification of water quality according to WQI values(Kamali Maskooni, Naseri-Rad, Berndtsson, & Nakagawa, 2020)

Water quality	WQI
Excellent	50 >
Good	100-50
Poor ردیئة	200-100
Very Poor	300-200
Unsuitable	300 <

5: Five Step

For the purpose of calculating the effect of each criterion on the value of WQI and then judging it, Effective Weight Percentage (Ewi) is calculated and it is calculated by dividing the sub-index Sli by the value of WQI as in the following equation(Ibrahim, 2019; Sahoo & Khaoash, 2020).

$$Ewi= \frac{SLi}{WQI} \times 100........ (5)$$

So, effective weight percentage for each criterion: Ewi

Sub-directory index for each criterion.: SLi

Table (3): Results of percentages of Ewi values affecting the values of water quality index (WQI) for the studied sites

Sites / Param.	1	2	3	4	5	6	7	8	9	10
Turb.	25.45	26.11	8.823	3.816	19.36	19.58	13.27	11.32	17.95	25.24
T.C	0.415	0.416	0.723	0.907	7.887	8.021	4.621	4.202	5.703	0.411
pH	1.260	1.843	2.960	3.666	30,81	30.35	14.41	15.88	21.03	1.910
Ec_{25}	0.746	0.726	1.083	1.366	11.37	11.26	6.412	5.885	7.920	0.695
T. Hard.	0.409	0.401	0.665	0.789	6.608	6.456	3.769	3.416	4.646	0.404
T. Alk.	1.038	1.012	1.599	1.979	16.58	16.31	9.458	8.584	11.39	0.995
Na^+	0.108	0.107	0.167	0.218	1.730	1.623	0.965	0.889	1.245	0.114
K^+	0.039	0.039	0.059	0.072	0.646	0.651	0.351	0.336	0.439	0.045
$SO_4^=$	0.082	0.208	0.328	0.405	3.411	3.398	1.950	1.859	2.405	0.224
Cl^-	0.212	0.079	0.124	0.159	1.364	1.619	0.961	0.931	1.107	0.102
NO_3^-	0.025	0.032	0.036	0.055	0.050	0.424	0.222	0.238	0.423	0.041
PO_4^{-3}	0.009	0.011	0.013	0.018	0.168	0.201	0.133	0.096	0.161	0.017
TPC	27.04	26.54	42.23	42.40	0.000	0.000	49.81	38.81	25.59	26.85

F.C.	43.60	42.47	24.18	44.15	0.000	0.000	0.000	7.534	0.000	42.95

Results and Discussions

Table (4) The results of the analysis and the rates for the water of the studied sites

Sites / Para.	S. limit	1	2	3	4	5	6	7	8	9	10
T.C		9.58	9.8	10.7	10.7	11.1	11.4	11.4	11.5	11.6	9.58
Turbidity		47.1	49.17	10.47	3.6	2.18	2.23	2.62	2.48	2.92	47
PH		7.32	7.38	7.45	7.35	7.37	7.33	7.33	7.39	7.27	7.56
E.C		483	479	449	451	448	448	443	451	451	453
A.L.K		144	143	142	140	140	139	140	141	139	139
T.H		189	189	187	186	186	186	186	187	189	188
T.D.S		263	264	259	261	263	258	262	265	263	262
Cl		19	18.7	18.3	18.7	19.2	23	23.7	25.5	22.5	23.8
SO4		53.2	52.3	51.8	51	51.2	51.5	51.3	54.3	52.2	55.5
Na		13.3	13.5	13.2	13.7	13	12.3	12.7	13	13.5	14.2
K		1.43	1.45	1.40	1.37	1.45	1.48	1.38	1.47	1.43	1683
NO_3		0.58	0.73	0.54	0.65	0.67	0.6	0.55	0.65	0.86	0.95
PO_4		0.17	0.2	0.16	0.17	0.19	0.23	0.26	0.21	0.26	0.31
F, C		16	16	11.3	8.33	0	0	0	0.33	0	16
E.Coli		>16	>16	10.8	4.33	0	0	0	0.0	0	12.5
TPC		>100	>100	100	80	0	0	17.7	17	8.33	>100

1- Physical factors

Turbidity is expressed as the optical property of scattering light through a water sample(Zhang et al., 2012). Also, the high levels of turbidity in the sites(Al-Hamdani et al., 2021; Al-Mashhadany, 2021; Ramadhan et al., 2018; Ramakrishnaiah et al., 2009) is the fact that these sites represent raw water before being treated in the purification plant, and their rates ranged between (3.6-49.17) turbidity as the above table shows. This water was classified as not potable as table (5) shows due to the high concentrations of turbidity in these locations. So it represents the raw water and the beginning of the work of the purification plant(Talai & Al-Shouna, 2012). This is confirmed by the percentage of the effective values of Ewi in Table (3), where the effect ratio for turbidity ranged (25.45) (Organization & WHO., 2004).

2- Chemical factors

The pH is a good indicator of the amount of acid and alkaline balance in the water, and the surface water is moderate compared to the groundwater that has high values (9). The results of the study shown in Table (4) indicate that it was between (7.26-7.56). It is known that Iraqi surface water is rich in bicarbonate and carbonate salts(Talai & Al-Shouna, 2012). The total alkalinity in water belongs to the bicarbonate ions, which results shown in Table (4) were between (139-144) mg/L, which were within the Iraqi and international specifications(A.

Al-Saffawi, 2018). However, the hardness ranged between (186-189) mg/L, where the lowest hardness values were in the locations (9,8,7,6,5), which represented the work of the filtration station as shown in Table (4). The sodium ion is one of the main positive ions in natural waters, as well as in rocks containing halite (A. Al-Saffawi, 2018). The values of sodium ranged between (12.7-14.2) mg / liter as shown in Table (4) and these differences are due to the geological differences through which the water passes and the melting of salts and weathering processes(Al-Safawi, Ali, & Kannah, 2008). The chloride ion rates ranged between (18.3-25.5) mg/L. Also, the sulfate levels was between (51-55.5) mg / liter as shown in Table (4) and that the high levels of sulfate in the water gives it bitter taste when combined with the magnesium ion causes diarrhea (WHO, 2011). The reason for the presence of sulfates in the water is due to the nature of the soil rivers, as well as the processes of biological decomposition of protein materials by sulfur bacteria. As for the phosphorous ion, its rates ranged between (0.2-0.31) μg/l, and the reason for the decrease in phosphorous ions in the water is the tendency of phosphorus to adsorb with soil and organic matter in the form of calcium phosphate (A. Al-Saffawi, 2018). Nitrogen concentrations ranged from (0.6-0.95) micrograms / liter, and the risk of high nitrates in the water is that it causes diseases such as blue baby disease(Alwan, 2017). All the studied variables are within the appropriate limits for all uses.

3: Bacterial factors

Bacteria are one of the important indicators to identify the degree of water pollution. The results shown in Table (4) indicate that the total number of bacteria ranged from 0 to 100 cells/100 ml. The presence of E.Coli and E.Coli bacteria in water is a clear evidence of water contamination with feces. Through it, it is possible to detect a recent fecal contamination of water(WHO, 2011) as their numbers ranged from 0-16, 0-16 cells / 100 ml, and this reflects the pollution of water.

Assessment of water quality for drinking and daily use

The weighted mathematical model has been applied on 14 criteria to assess the water quality of the Hawija district station, Kirkuk governorate. The results shown in Table (5) show that the sites (10,4,3,2,1) has poor quality of water which changed from the type of very poor water to unfit water. The reason for this deterioration in water quality is mainly due to the high levels of turbidity and bacterial contamination, whose rates in these sites ranged between (3.6-49.17) turbidity units. The total number of bacteria, colon bacteria and fecal coliform bacteria ranged (<80-100), 8.33-16,4.33-16<) cells/100 ml, as these sites represented the raw water before it was treated in the station. The cites in the station (9,7,6,5), the beginning of the water treatment had excellent water quality. As for site 8, the weighted model showed that the water quality in this site is good, which represents the distribution network in Al-Nadaa district, because the pipes are old and worn out in this site. When a comparison was made between the sites, it was found that the work of the filter station in Hawija district works with high efficiency, as the results appeared in Table (5).

Table (5): Results of sub-index values and water quality index (Qi, Sli & WQI) for the studied sites

Sites / Param.		1	2	3	4	5	6	7	8	9	10
Turb.	*Sli*	109.5	114.4	24.30	8.372	5.069	5.174	6.093	5.767	6.791	109.3
	QI	942.0	984	209	72.00	43.60	44.50	52.40	49.60	58.40	940
T.C	*Sli*	1.783	1.823	1.991	1.991	2.065	2.121	2.121	2.140	2.158	1.782
	QI	38.30	39.2	42.8	42.80	44.40	45.60	45.60	46.00	46.40	38.32
pH	*Sli*	5.427	8.074	8.153	8.044	8.066	8.022	7.989	8.088	7.956	8.274
	QI	86.11	86.8	87.6	86.47	86.71	86.24	85.88	86.94	85.53	88.94
Ec_{25}	*Sli*	3.210	3.182	2.983	2.997	2.977	2.976	2.943	2.997	2.997	3.009
	QI	34.50	34.2	32.1	32.21	32.00	32.00	31.64	32.21	32.21	32.36
T. Hard.	*Sli*	1.758	1.758	1.832	1.730	1.730	1.730	1.730	1.740	1.758	1.749
	QI	37.80	37.8	39.4	37.20	37.20	37.20	37.20	37.40	37.80	37.60
T. Alk.	*Sli*	4.465	4.434	4.403	4.341	4.341	4.310	4.341	4.372	4.310	4.310
	QI	96.00	95.3	94.7	93.33	93.33	92,67	93.33	94.00	92.67	92.67
Na^+	*Sli*	0.464	0.471	0.461	0.478	0.453	0.429	0.443	0.453	0.471	0.495
	QI	6.650	6.75	6.60	6.850	6.500	6.150	6.350	6.500	6.750	7.100
K^+	*Sli*	0.166	0.169	0.163	0.159	0.169	0.172	0.161	0.171	0.166	0.195
	QI	7.150	7.25	7.00	6.850	7.250	7.400	6.900	7.350	7.150	8.400
$SO_4^=$	*Sli*	0.928	0.912	0.903	0.889	0.893	0.898	0.895	0.947	0.910	0.968
	QI	13.30	13.1	13.0	12.75	12.80	12.88	12.83	13.58	13.05	13.88
Cl^-	*Sli*	0.354	0.348	0.341	0.348	0.357	0.428	0.441	0.474	0.419	0.443
	QI	7.600	7.48	7.32	7.480	7.690	9.200	9.480	10.20	9.000	9.520
NO_3^-	*Sli*	0.107	0.140	0.100	0.121	0.125	0.112	0.102	0.121	0.160	0.177
	QI	1.160	1.50	1.08	1.300	1.340	1.200	1.100	1.300	1.720	1.900
PO_4^{-3}	*Sli*	0.040	0.047	0.037	0.040	0.044	0.053	0.061	0.049	0.061	0.072
	QI	1.700	2.00	1.60	1.700	1.900	2.300	2.600	2.100	2.600	3.100
TPC	*Sli*	116.3	116.3	116.3	93.02	0.000	0.000	20.58	19.77	9.686	116.3
	QI	1000	1000	1000	800	0.000	0.000	177	170	83.30	1000
F.C.	*Sli*	186.5	186.1	113.4	96.86	0.000	0.000	0.000	3.837	0.000	186.0
	QI	1600	1600	1130	833	0.000	0.000	0.000	33.00	0.000	1600
WQI	Value	430.1	438.2	275.4	219.4	26.29	26.43	45.9	50.93	37.84	433.1
	Class	Unfit	Unfit	V.P	V.P	Exc.	Exc.	Exc.	Good	Exc.	Unfit

V.P: Very Poor., Exc.: Excellent

References

Abdul-Baqi, M. A.-J. (2020). The reality of water liquefaction stations in the city of Mosul. *Al-Rafidain Engineering Journal.*

Al-Hamdani, A., Kaplan, A., & Al-Saffawi, A. (2021). *Assessment of groundwater quality using CCME water quality index in Caracosh distract, northeastern of Mosul city, Iraq.* Paper presented at the Journal of Physics: Conference Series.

Al-Mashhadany, M. H. S. (2021). *Assessment The Suitable of The Groundwater for Civil uses in Kakhirta Village, Al-Ayadiyah Subdistrict, Iraq.* Paper presented at the Journal of Physics: Conference Series.

Al-Safawi, A. Y., Ali, F. H., & Kannah, A.-M. M. (2008). *Physical and chemical evaluation of some Al-Sharikhan and Al-Kubba wells and their suitability for* *drinking and domestic use.* Paper presented at the the sixth periodic scientific conference of the Dams and Water Resources Research, Mosul.

Al-Saffawi, A.-A. Y. (2019). Water quality of Nimrud district wells southeast of Mosul city for drinking and civil purpose using the Canadian model of water quality. *Pakistan Journal of Analytical & Environmental Chemistry, 20*(1), 75-81.

Al-Saffawi, A. (2018). Assessment of groundwater for irrigation and domestic suitability by using (WQI) in Singiar district eastern of Mosul city. *Iraq. Mesopo. Environ. J*, 75-84.

Alwan, M. D. M. (2017). *Characteristics of drinking water in Khan Yunis Governorate.* (Master). Islamic University, Department of Geography.

APHA, A. WCPE (2017).“. *Stand Method for Examination of water and wastewater American public Health Association,” 23th ed., Washington DC, USA.*

APHA, A., & WCPE. (2017). Stand Method for Examination of water and wastewater American public Health Association. In.

Boateng, T. K., Opoku, F., Acquaah, S. O., & Akoto, O. (2016). Groundwater quality assessment using statistical approach and water quality index in Ejisu-Juaben Municipality, Ghana. *Environmental Earth Sciences, 75*(6), 1-14.

Devojee, B., Nagababu, G., Kumar, M., Nandini, Y., & Hemakumar, H. (2018). Assessment and mapping of irrigation water quality index of Bapatla Mandal, Guntur District, Andhra Pradesh, India. *International Journal of Current Microbiology and Applied Sciences, 7*(1), 1914-1920.

Howladar, M. F., Al Numanbakth, M., & Faruque, M. O. (2018). An application of Water Quality Index (WQI) and multivariate statistics to evaluate the water quality around Maddhapara Granite Mining Industrial Area, Dinajpur, Bangladesh. *Environmental Systems Research, 6*(1), 1-18.

Ibrahim, M. N. (2019). Assessing groundwater quality for drinking purpose in Jordan: application of water quality index. *Journal of Ecological Engineering, 20*(3).

Kamali Maskooni, E., Naseri-Rad, M., Berndtsson, R., & Nakagawa, K. (2020). Use of heavy metal content and modified water quality index to assess groundwater quality in a semiarid area. *Water, 12*(4), 1115.

Organization, W. H., & WHO. (2004). *Guidelines for drinking-water quality* (Vol. 1): world health organization.

Ramadhan, O. M., Al-Saffawi, A., & Al-Mashhdany, M. H. (2018). Assessment of Surface Water Quality for Irrigation using WQI model; A Case Study of Khosar and Tigris Rivers. *Int. J. of Enhanced Res. in Sci., Techn. and Engin, 7*(3), 63-69.

Ramakrishnaiah, C., Sadashivaiah, C., & Ranganna, G. (2009). Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka State, India. *E-Journal of chemistry, 6*(2), 523-530.

Sahoo, S., & Khaoash, S. (2020). Impact assessment of coal mining on groundwater chemistry and its quality from Brajrajnagar coal mining area using indexing models. *Journal of geochemical exploration, 215*, 106559.

Talai, A. Y. A.-S., & Al-Shouna, R. A. A.-R. (2012). *An environmental and bacteriological study of the quality of groundwater in the southeast of the city of Mosul. Proceedings of . 27-28 November 2012.* Paper presented at the the second scientific conference of the Center for Environmental Research and Pollution Control, Mosul.

WHO, G. (2011). Guidelines for drinking-water quality. *World health organization, 216*, 303-304.

Zhang, B., Song, X., Zhang, Y., Han, D., Tang, C., Yu, Y., & Ma, Y. (2012). Hydrochemical characteristics and water quality assessment of surface water and groundwater in Songnen plain, Northeast China. *Water research, 46*(8), 2737-2748.