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Research Article

Assessment of Drinking Water of Al-Abbasia River using Water Quality Index

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Abstract

Water Quality Index (WQI) is one of the most effective indicators assessing the water quality of the surface water. The Water Quality Index was used to determine the quality of raw water used for drinking purposes at the AL-Abbasia River. The water samples were taken from six stations along AL-Abbasia River for during a twenty - month period started from January to October in (2019) to (2020). fifteen parameters of water quality were evaluated including Temperature (C°), Hydrogen power (pH), Total Hardness (T.H), Turbidity (Turb.), Total Dissolved Solid (T.D.S), Chloride (Cl^-), Calcium (Ca^{+2}), Electrical Conductivity (E.C.), Magnesium (Mg^{+2}), Sodium (Na^+), Potassium (K^+), Sulfate (SO_4^{-2}), Total Suspended Solids (T.S.S), Aluminum (Al). Data analysis revealed that some of these parameters exceeded the World Health Organization (WHO) standards such as Total Hardness (T.H), Total Dissolved Solid (T.D.S), Magnesium (Mg^{+2}) and Sulfate (SO_4^{-2}). Other parameters were within the WHO standards. In this thesis three different methods were used to calculate WQI, the WAWQI, CWQI, and Nemerow's Pollution Index. For WAWQI, the computed overall WQI value of all samples and stations along AL-Abbasia River was (64.5) which implies that the water was generally "poor". The computed monthly overall WQI along AL-Abbasia River for all samples and stations was (64.114). The monthly WQI variation ranged to a higher value of (78.42) in February 2019, due to high pollutants and heavy rainfall in this month and a lower value of (53.92) in July 2019 along AL-Abbasia River, and classified as (very poor) in terms of drinking water quality. The annual river water quality index variation along AL-Abbasia River ranged between (64.31) " Poor quality" at the upstream near station (A1) and (64.1) "poor" at the downstream near station (A6) which indicates that the ratio is very close between the river upstream and downstream. The water quality assessment was recorded as "poor" because of the high values of Total Hardness (T.H), sulfate and Total Dissolved Solid (T.D.S) where it exceeded the limits. If we excluded (T.H, sulfate and T.D.S) values from water assessment, the result will be changed from (64.5) to (48.86) and the quality of water will be changed from "Poor" to "Good". According to CWQI, the result calculated by Canadian Water Quality Index method showed that the water quality was fair along the main stream of AL-Abbasia River. The annual average water quality index recorded during the two years was fair in the upstream at station A1 with a value of 74.57 and downstream at station A6 with a value of 61.6. The water quality index during 2019 ranged between fair at A1, A2, and A6 stations and good at A3, A4, and A5 stations with a value ranged between 61.04 at A2 and 82.83 at A3. The water quality index during 2020 year ranged between fair at A1, A2, A3, A4, and A6 stations and marginal at station A5 with values between 77.63 at station A1 and 58.23 at station A5. The Nemerow's Pollution Index is another method used to calculate WQI. This method gives a statistical analysis to show the state of the river water quality for each parameter and each station along the river. When the value of NPI is greater than 1, then this means that there is a high concentration of this parameter, thus increasing the water pollution. The results obtained from this method indicate that high sulfate, T.H, and turbidity concentrations had a significant impact on water quality during the study period. In 2019, The high NPI was recorded for SO_4 and T.H for all stations during the study period, while in 2020, the highest NPI was recorded for T.S.S, SO_4, T.H, T.D.S, Mg, and turbidity.

Keywords: *AL-Abbasia river, drinking water assess, Water Quality Index (WQI), Water quality parameters.*

1. Introduction

Surface water makes up the largest part of the earth's surface like oceans, seas, rivers, lakes, and other. It could be underground water or water vapor in the atmosphere during the hydrologic cycle.

We have surface water that is normally replenished with rain and the earth inevitably converts this water into other forms by evaporation and seepage into the ground. In Iraq surface water is facing increasing problems through the increase in pollutants resulting from population activities such as waste from factories, sewage and agricultural activities.

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These activities are a result of the increase in population growth and with the development that has led to major problems in the quality of the water used, which has raised great concern about water quality.

There are three type of water pollution. Physical pollution that causes watercolor alteration, turbidity, suspended solids, temperature, Chemical contamination, where this form of pollution comes from both organic and inorganic chemicals including heavy metals, which leads to pH changes in water, which increases the toxicity of the water arising from heavy metals and other hazardous chemicals and Biological pollution which is caused by viruses, bacteria, protozoa, and helminths (Mahdi ،W.S.K. 2009).

So, we also have a duty to ensure quality treatment for our climate and the water that we use. Also, Conduct the collection of correct water condition, quantity and quality information as a source for economic and social growth with a view to ensure the preservation of water quality and thus achieve an ecological balance. Water Quality Index (WQI) Considered an important technique for transmitting water quality information to the citizens and decision-makers involved. It is considered one of the important scientific indicators used in many approved researches to assess and management surface water quality around the world (Berman et al. 2010).

In an aquatic environment, There are a variety of physical, chemical and biological factors that influence the consistency of the water. (Sargaonkar and Deshpande 2003). There are a large number of parameters that must be measured together and their relationship to each other, which makes the process somewhat complicated (Boyacioglu 2007) And, There is considerable uncertainty because of both natural and anthropogenic causes. (Simeonov et al. 2002).

The consistency of water has been assessed with respect to its biochemical, chemical and physical parameters. Water quality has been described as an issue that applies directly to human use, including drinking purposes, industrial and agricultural use of water. The importance of the water quality index is to determine the water condition, the percentage of pollution, and to a calculation of the consistency of a surface water. the Water Quality Indexes are one of the simplest ways to assess water quality (Gray 2008). The assessment of water quality in compound parameters can be complex, creating various anxieties in general water quality. It is not easy to evaluate water quality for a large number of parameters with different concentrations.

The traditional old methods of assessing water quality are based on directly comparing parameter values with standard indicators. Water quality indexes are used to minimize the number of details required to represent the actual estimation of water quality. Like other natural streams, the water quality index calculation is based on a variety of physico-chemical and bacteriological characteristics.

For public health purposes and also for aquatic life, water quality is an important factor for health and safety issues, because it is a single number which can be used to define the water quality used for various purposes (Dede, O. T., Telci, I. T., & Aral 2013).

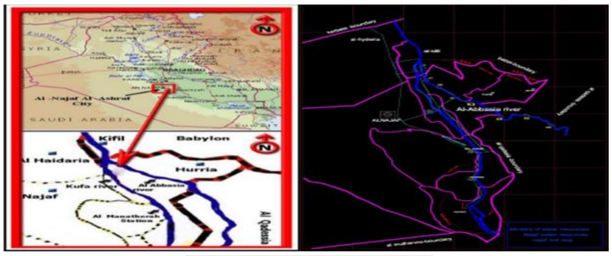

Fig.1: AL-Abbasia river within AL-Najaf city.

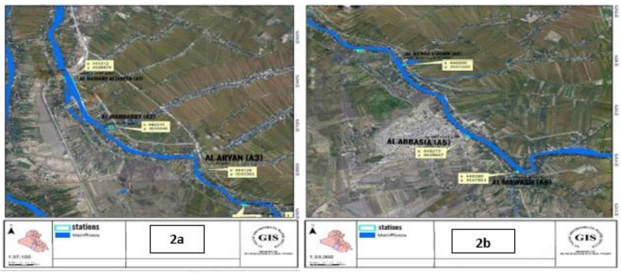

Fig. 2a, 2b: The main stream of AL-Abbasia river.

Fig. 3: Drainage and wastes on river.

2. Study Area and Data Collection

AL-Abbasia is a sub-district belonging to the Kufa district in the Najaf governorate in Iraq and to the south of the capital, Baghdad, and it is considered one of the important areas located in the center of the central Euphrates region, The Euphrates River is located to the east of it, as well as to the northeastern side of Kufa and Najaf, and it is separated from Najaf by an estimated distance of about 14 km. It has a population of more than 96512 people. Its name dates to the Islamic Abbasia Caliphate, and most of its inhabitants are from the Arab tribes. AL-Abbasia district is considered one of the most important districts of which is an agricultural region in which many important crops such as dates, rice, wheat and other important crops are cultivated. Industrial activity in the region is considered very weak, confined to the manufacture of dairy products, milk, and other related products.

One of the most important water projects in this sub-district is the AL-Abbasia dam on the main stream of AL-Abbasia river. This dam organizes irrigation and drainage of the 550,000 dunums irrigated al-Kufa river and AL-Abbasia river.

The length of the Main stream of AL-Abbasia river in AL-Abbasia city is 28 km and enters it after a distance of 8 km from the Shatt Al-Hindiya branching point. The number of the main branches of this coast is 12, while the total length of its reaches 202.16 km and 230.16 km when the main stream of AL-Abbasia is added to it, and one of the most important branches in terms of the length of the main stream is al-Haidari 18 km which irrigate an agricultural area estimated at about 12,000 dunams, and Al-wahhabi stream one of the most important in terms of its length with the branching streams It has a total length of 40.4 km and serves an area of approximate 17,000 dunams. According to water department in Najaf city, the annual drainage rate of the AL-Abbasia river is 121.8 m3/s, and its highest monthly rate is 183.9 m3/s in April, while the lowest monthly rate of drainage of the river reaches 72.1 m3/s in July and August. The Annual intake rate of the river is 3.843 billion m3, while the total area of agricultural land benefiting from the main stream of the AL-Abbasia river and its branches reaches 100,000 dunams. The total length of the Al-Kufa and AL-Abbasia rivers and their branches in the Al-Najaf city are 687.855 km, while the average of their annual water imports reached 7,588 billion m3, and the total agricultural lands benefiting from them and the total of their branches are estimated at 250,000 dunams. 60% of the water of the Al-Hindiya river drains to the of Al-Kufa river, while 40% of the water drains to the AL-Abbasia river, and these two branches (Al-kufa and AL-Abbasia) meet to the north of the Shinafiya district, located in the Qadisiyah city about 8 km. figure 1 shows AL-Abbasia river (Directorate 2020). And figure 4.3a, b shows the main stream of the river.

The climate of Najaf city in summer is hot and dry. Sometimes the temperature reaches to 45 degrees Celsius, and the temperature in winter reaches zero. The temperature along the river different during the season of the year. The temperature of water in AL-Abbasia river range between 15-35 ^{o}C. In AL-Najaf city the accumulated rainfall during the year is 99mm (3.9"). The highest intensity of rain is during January as 30mm, while the rainfall intensity during the summer season is zero. The values of evaporation in Najaf city increase significantly, reaching to their annual total value as 3655.57 mm, due to the high rates of temperatures recorded, as well as the activity of hot dry winds in the months of the summer season. As the rates of evaporation increase dramatically in the summer to reach 548.3, 607.7, 546.9 mm in the months of June, July, and August respectively, which are the months in which the highest rates are recorded, while the decrease evaporation rates to their lowest rates, less than the general rate of 304.62 mm. The rates of evaporation in the months of December, January, February are 88.02, 82.7, and 117.1 mm respectively(Directorate 2020). On the river bank there are many drains and sewage estuaries belonging to the inhabitants on the banks of the river as shown in figure 3. These drains and sewage estuaries effect directly on river pollution. In general, drinking water treatment plants in AL-Abbasia district can be divided into four main sections. These sections are the AL-Abbasia central station (30,000 m3/day), AL-Abbasia north station first canton (21,000 m3/day), AL-Abbasia north station second canton (16,000 m3/day), and AL-Abbasia south station (15,000 m3/day). Each of the four stations includes a number of sub-water projects, where the total number of these sub-projects reaches 23 distributed along the AL-Abbasia River and its branches. The total drinking water supply by these four stations (23 sub-project) estimated by (82,000 m3/day). The amount of water taken from the river is estimated to be (93,300 m3/day) and the percentage of water losses during treatment is estimated by 10%(Salman 2015). Those projects treat, transfer and distribute all of drinking water to residential homes through a wide network of pipes in AL-Abbasia city. There is no specific number for consumption or daily need due to the large number of informal and unlicensed housing units in the area

3. Water Quality Index

The Water Quality Index (WQI) considered the best powerful instruments for transmitting water quality knowledge to residents and policy makers. Therefore, it is considered an important indicator with a high level of accuracy for assessing and examining surface water quality. The water quality index is based on compiling a large number of information in one number and comparing it with the established and applicable standards to facilitate the examination and evaluation process and limit it to one number (Khudair 2013). Horton (1965) first used the index to show the physical and chemical changes that occur in flowing water (Horton 1965). More measurement methods have since been invented to achieve the same Water Quality Index (WQI). This is primarily focused on the various approaches to parameter selection and their effect on the estimation and final value of the indexes. In 1970, Brown and collaborators developed the NFS-WQI index. The Oregon Water Quality Index (OWQI) was introduced by the Environment Department of Oregon in 1970, while Canada introduced the CCME WQI (Canadian Council of Ministers of the Environment Water Quality Index) Index in 1990. The Weighted Arithmetic Water Quality Index (WAWQI) method is another method for calculating the water quality index, which is more suitable than other methods because of its factoring in one key mathematical equation for more quality parameters, as well as its ability to define the quality of surface and underground waters (Călmuc, V., et. al, 2018). A statistical methodology has been used to assess the international quality of the surface waters by using a number of statistical principles (House 1989). The Water Quality Index (WQI) is used to determine water quality by taking into consideration the different criteria on the particular location at which the water is being used

4. Material and methods

All the data of this thesis (Stations, Coordinates (X, Y), Parameters, GIS maps, populations, etc.) was taken from standardization and control department in Al-Najaf city. Data were taken for twenty months from six stations along AL-Abbasia river during (2019-2020 from January to September) period as shown in table 1 below.

Table 1: stations with its details.

Stations	Abbreviation	Coordinates		Distance between stations(km)	Accumulated distance (km)	Treated product water(m3/h)	population per station
		X	Y				
AL-Haidary Aljadeed	A1	441312	3556876	———	0	200	5000
AL-Wahhabby	A2	442311	3555006	2.12	2.12	200	3900
AL-Aryan	A3	444728	3553362	2.923	5.043	200	4000
AL-A'emaa	A4	446866	3551500	2.835	7.878	200	5000
AL-Abbasia	A5	448273	3549047	2.827	10.705	1400	16,000
AL-Mawash	A6	449380	3547851	1.63	12.335	100	3000

three methods were used to calculate the WQI the Weighted Arithmetic Water Quality Index (WAWQI) and Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) and Nemerow's Pollution Index.

A statistical methodology has been used to assess the international quality of the surface waters by using a number of statistical principles(House 1989).

The WQI is used to determine water quality by taking into consideration the different criteria on the particular location at which the water is being used.

The method of calculation of WQI can vary and a range of different methods are available in the literature.

The weighted arithmetic index method (WAM) is most widely calculated parameters of water quality are used in this method (Călmuc, V., Călmuc, M., Țopa, M., Timofti, M., Iticescu, C. and Georgescu 2018).

Many physico-chemical variables used for their possible importance to human use as well as for the analysis of information per each station. These parameters were compared with standard value of drinking water quality recommended by the Standards on the basis of the WQI estimation formula given by (Tiwari, T. N., & Mishra 1985):

$$W_i = \frac{K}{\sum K} \quad (1)$$

Where: - W_i is the unit weight factor and K is proportional constant.

(q_i) the quality rating scale is a number that represents the relative value of that parameter in polluted water in relation to its acceptable standard value and is determined as following:

$$q_i = \frac{V_i - V_o}{S_i - V_o} \times 100 \quad (2)$$

Where:

q_i = quality rating scale for the ith water quality parameter.

Vi = estimate permissible value of the ith parameter.

Vo = Ideal value of the ith parameter pure water.

Si = standard permissible value of ith parameter.

The ideal value for all parameters (Vo) = 0,

The ideal value for pH parameter (Vo) = 7

Overall WQI $= \sum_{i=1}^{i=n} W_i * q_i$ (3)

Table 2: classifications of water quality index (WQI) for surface water for WAWQI method (Tiwari, T. N., & Mishra 1985).

No.	WQI level	Water quality classification
1	0-25	Excellent
2	25-50	Good
3	50-75	poor
4	75-100	Very poor
5	more than 100	Unfit and unsuitable for human uses

While in CWQI three combined factors were used. These factors are F1 (scope), F2 (frequency) and F3 (Amplitude). These factors finally arrange in a mathematical equation to calculate the WQI value given by:

$$WQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right) \quad (4)$$

Scope

Scope is the percentage of failed variables to Total Number of Variables. The mathematical equation for calculation scope given by:

$$F_1 = \left(\frac{\text{Number of Failed Variables}}{\text{Total Number of Variables}} \right) \times 100 \ (5)$$

Frequency

Frequency is the number of Failed Tests to the Total Number of Tests. The mathematical equation for calculation frequency given by:

$$F_2 = \left(\frac{\text{Number of Failed Tests}}{\text{Total Number of Tests}} \right) \times 100 (6)$$

Amplitude

Amplitude is calculated based on the excursion of each failed test relative to its objective. A failed test may either be greater than its objective or less than. The mathematical equation for calculation Amplitude given by:

$$F_3 = \left(\frac{\text{NSE}}{0.01\text{NSE} + 0.01} \right) (7)$$

$$NSE = \frac{\sum \text{Excursions}}{\text{Total number of tests}} \quad (8)$$

$$\text{Excursions} = \frac{\text{FailedTest Value}}{\text{Objective}} - 1 \ (9)$$

Table 3 below includes a classifications of water quality index (WQI) for surface water for CCMEWQI method:

Table 3: Water quality classification based on WQI value for human uses for CWQI(Tyagi et al. 2020).

No	WQI Value	Rating
1	Excellent	95-100
2	Good	80-94
3	Fair	60-79
4	Marginal	45-59
5	Poor	0-44

And according to Nemerow's Pollution Index method the NPI index is used to give a clear assessment of the water quality of each site by making an assessment for each pollutant separately. NPI can be determine by this equation:

$$NPI = \frac{C_i}{L_i} \quad (10)$$

Where,
Ci: - is the ith parameter's discovered concentration, and Li: - is the parameter's permissible limit.

Ci and Li should have the same units and the value of NPI which gives a general indication of the effect of each parameter on water pollution for a given site.

The NPI results will be either ≤ 1 or > 1. If NPI greater than 1, it indicates its presence in surplus amount or concentration and the parameter in question has the ability to pollute the water sources under investigation.

5. Results and Discussion

The result obtained from WAWQI showed the computed overall WQI value of all the samples and stations along AL-Abbasia River was 64.5 which implied that the water was generally "poor" as shown in Table 4 and Fig. 4.

Table 4: Computed overall WQI values of drinking water along AL-Abbasia River.

Parameters	Measured value (Vi)	Standard value (Si)	Ideal value (V10)	Proportional weight (K)	Unit weight factor (wi)	Quality rating (qi)	WQI (wi*qi)
pH	7.7525	6.5-8.5	7	1	0.057	25	1.43
Turb.	3.15	5	0	1	0.057	63	3.59
E.C.	1184.367	2000	0	2	0.1143	59.22	6.77
Alk.	120.97	200	0	1.5	0.0857	60.48	5.18
T.D.S.	753.77	1000	0	2	0.1143	75.4	8.62
T.H	401.88	200	0	1	0.057	200.94	11.45
Ca+2	99.88	150	0	1	0.057	66.9	3.81
Mg+2	38.86	50	0	1	0.057	77.72	4.43
Na+	82.74	200	0	1	0.057	41.37	2.36
K+	4.67	10	0	1	0.057	46.7	2.66
Cl-	126.13	250	0	1	0.057	50.45	2.88
T.S.S.	10.13	25-40	0	2	0.1143	25.33	2.90
SO4	296.58	250	0	1	0.057	118.63	6.76
Al	0.044	0.15	0	1	0.057	29.33	1.67
				17.5	1		64.5077

The computed monthly overall WQI along AL-Abbasia River for all samples and stations was 64.114, which implied that the water was generally "poor" as shown in Table 5. Higher value ranged in the monthly WQI variance 78.42 at February 2019, due to heavy rainfall in this month and lower value 53.92 in July 2019 along AL-Abbasia River, and classified from (very poor for drinking to Poor water quality) as shown in Fig. 5. The annual river water quality index variation along AL-Abbasia River ranged 64.31 " Poor quality" at the upstream near station A1 and 64.1 "poor" at the downstream near station A6 Which indicates that the ratio is very close between upstream and downstream of river as shown in Table 6 and Fig. 6.

According to WAWQI method when parameters value increases the quality rating (qi) will increase and subsequently WQI value will increase and the water quality will decrease. When comparing some of the parameters with the international standard of the WHO, we find that they exceed the maximum limit, but because of the WAWQI method depends on assessing water quality based on a combined set of parameters (this represents one of the defects of this method) so that water quality index value will not be affected greatly.

The water quality assess was “poor” because of the high concentrations of Total Hardness (T.H), sulfate and Total Dissolved Solid (T.D.S) where it exceeded the limits.

If we excluded (T.H, sulfate, and T.D.S) values from water assess, the result will be change from 64.5 to 48.86 and the quality of water will be change from “Poor” to “Good”.

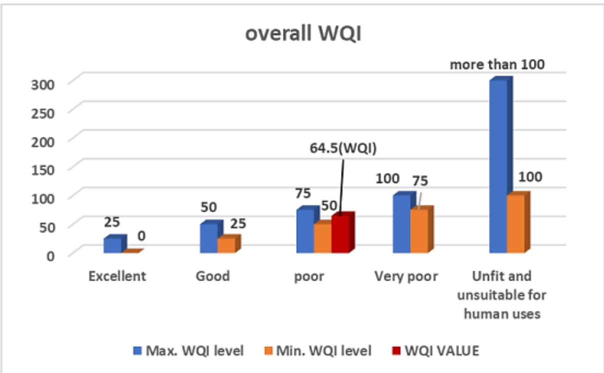

Fig. 4: The overall WQI of drinking water within water quality classification.

Table 5: Monthly WQI along AL-Abbasia River.

Month	WQI	Water Quality Classify
JAN	74.5	poor
FEB	78.42	Very poor
MAR	68.23	poor
APR	67.37	poor
MAY	62.37	poor
JUN	65.84	poor
JUL	53.92	poor
AUG	56.35	poor
SEP	56.76	Poor
OCT	57.38	Poor
Mean	64.114	poor

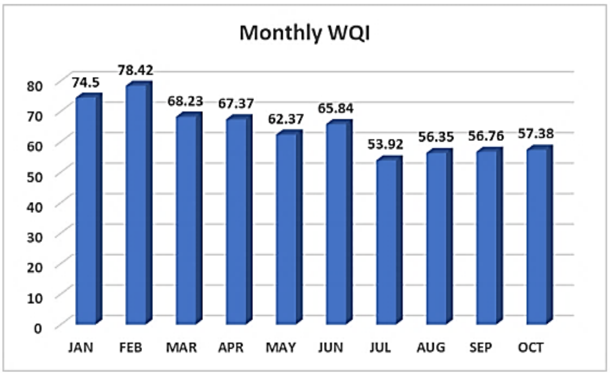

Fig.5: Variation of monthly mean values of WQI of drinking water in AL-Abbasia River.

Table 6: Annual WQI variations for all stations Along AL-Abbasia River.

Station	WQI	Water Quality Classify
A1	64.31	poor
A2	63.23	poor
A3	64.26	poor
A4	65.29	poor
A5	63.6	poor
A6	64.1	poor
Mean	64.1317	poor

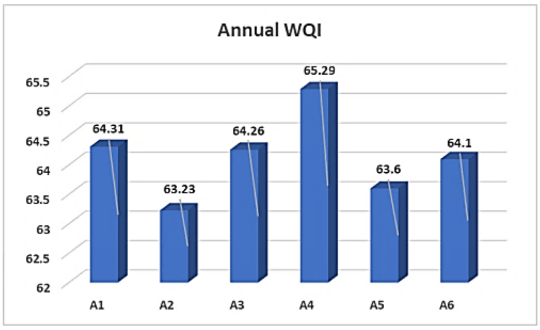

Fig. 6: Variation of annual mean values of WQI of drinking water at all stations along AL-Abbasia River.

The result calculated by Canadian Water Quality Index method showed that the water quality was fair along the main stream of AL-Abbasia river. The annual average water quality index of two years was fair in the upstream at station A1 with value of 74.57 and downstream at station A6 with value of 61.6 as shown in table 7 and figure 7. the water quality index during 2019 year was ranged between fair at A1, A2, and A6 stations and good at A3, A4, and A5 stations with a value ranged between 61.04 at A2 and 82.83 at A3 as shown in table 8. The water quality index during 2020 year was ranged between fair at A1, A2, A3, A4, and A6 stations and marginal at station A5 with values between 77.63 at station A1 and 58.23 at station A5 as shown in table 9. The vary of CWQI for study period between two-year 2019 year and 2020 year are shown in figure 8. The monthly CWQI during 2019-2020 for 10 months are shown in table 10 and figure 9.

Table 7: annual average Canadian WQI calculation for each station two years 2019-2020 for drinking water along AL-Abbasia River.

Station	F1	F2	F3	CWQI Value	Rating
A1	35.7	16.78	19.59	74.57	Fair
A2	42.85	35	38.41	61.112	Fair
A3	42.85	20.71	25.93	68.7	Fair
A4	42.85	23.21	28.1	67.52	Fair
A5	50	25	28.17	63.85	Fair
A6	42.85	34.3	37.56	61.6	Fair
average				66.23	Fair

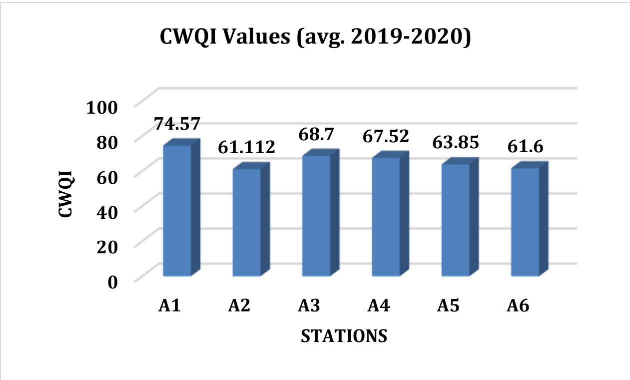

Fig. 7: Variation of annual average Canadian WQI for each station 2019-2020 for drinking water along AL-Abbasia River.

Table 8: Canadian WQI calculation for drinking water for each station during 2019 year along AL-Abbasia River.

Station	F1	F2	F3	CWQI Value	Rating
A1	28.57	15.7	18.63	78.32	Fair
A2	42.85	35.7	37.99	61.04	Fair
A3	21.43	12.85	16.1	82.83	Good
A4	21.43	12.85	16.3	82.77	Good
A5	21.43	12.85	16.28	82.78	Good
A6	42.85	33.57	36.42	62.2	Fair
average				74.99	Fair

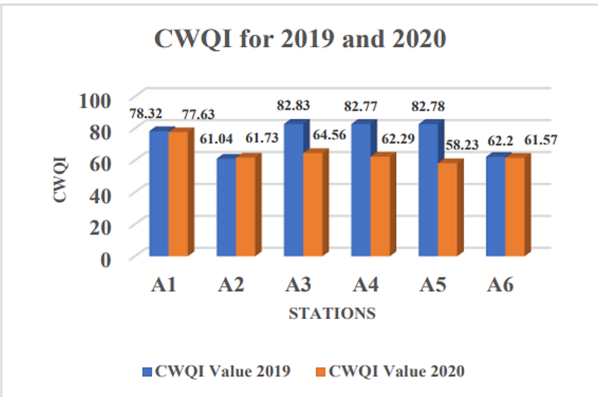

Fig. 8: variation of CWQI values for each station during study period (2019- 2020) along AL-Abbasia river.

Table 9: Canadian WQI calculation for drinking water for each station during 2020 year along AL-Abbasia River.

Station	F1	F2	F3	CWQI Value	Rating
A1	28.57	17.85	19.15	77.63	Fair
A2	42.85	34.28	37.17	61.73	Fair
A3	42.85	29.28	32.77	64.56	Fair
A4	42.85	33.57	36.1	62.29	Fair
A5	50	37.14	36.8	58.23	Marginal
A6	42.85	35	37	61.57	Fair
average				64.335	Fair

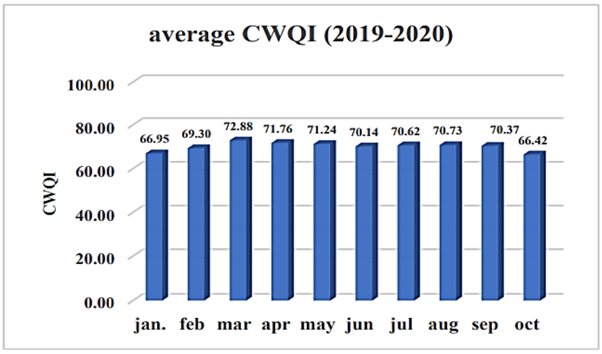

Fig 9: monthly CWQI variation during 2019-2020 along AL-Abbasia river.

Table 10: monthly CWQI during 2019-2020 along AL-Abbasia river.

Month	avg. CWQI (2019-2020)
Jan.	66.945
Feb.	69.3
Mar.	72.88
Apr.	71.7615
May.	71.235
Jun.	70.14
Jul.	70.62
Aug.	70.725
Sep.	70.365
Oct.	66.42
average	70.03915

According to Nemerow's Pollution Index method, the value of NPI is adopted for each parameter and for each measuring station. When the value of NPI is greater than 1. This means that there is a high concentration of this parameter, thus the water pollution is increased. The results obtained out of this method indicate that the occurrence of high concentrations of sulfate, T.H, and turbidity which had a significant impact on water quality during the study period. During 2019, The high

NPI was recorded at So4 and T.H was recorded at all stations. The NPI of So4 varies from 1.26 at station A1 to 1.17 at station A6 while the higher NPI of T.H was 2.13 at station A1 and lower NPI was 1.97 at station A2. during 2020, the highest NPI was recorded for T.S.S, So4, T.H, T.D.S, Mg, and turbidity. The highest NPI of T.S.S was 1.538 at station A3 while the lowest NPI was 1.16 at station A1. The highest NPI of So4 was 1.78 at station A6 while the lowest NPI was 1.16 at station A1. For T.H the highest NPI was 2.73 at station A6 while 1.97 at station A1 was the lowest value.

The NPI for Mg vary from 0.72 at station A1 to 1.34 at station A6. Table 11 and figure 11 shows the NPI values for year 2019 and table 12 and figure 12 shows the NPI values for year 2020. By conducting a statistical analysis of the available data, the NPI values for each parameter and all stations during the study period are shown in figure 13. This statistical analysis is very important in determining pollution areas for each parameter, as it gives an accurate description of the river's condition at each station.

Table 11: NPI values in 2019 of AL-Abbasia River.

Month/Parameter	Al	K	Na	T.S.S	T.D.S	SO4	Cl	Mg	Ca	T.H	Alk	E.C	PH	Turb
A1	0.3	0.48	0.43	0.25	0.805	1.26	0.67	0.79	0.71	2.13	0.62	0.63	0.91	0.6
A2	0.3	0.45	0.41	0.26	0.736	1.17	0.62	0.72	0.66	1.98	0.6	0.58	0.91	0.6
A3	0.3	0.47	0.41	0.24	0.743	1.17	0.62	0.75	0.64	1.98	0.61	0.58	0.92	0.7
A4	0.3	0.47	0.41	0.27	0.744	1.17	0.63	0.83	0.66	1.98	0.61	0.59	0.92	0.7
A5	0.3	0.47	0.4	0.25	0.749	1.18	0.63	0.77	0.66	2	0.6	0.59	0.9	0.6
A6	0.3	0.47	0.41	0.27	0.744	1.17	0.62	0.77	0.66	1.99	0.6	0.59	0.91	0.6
average	**0.3**	**0.47**	**0.41**	**0.25**	**0.754**	**1.19**	**0.63**	**0.772**	**0.67**	**2.01**	**0.6**	**0.59**	**0.91**	**0.6**

Table 12: NPI values in 2020 of AL-Abbasia River.

Month/Parameter	Al	K	Na	T.S.S	T.D.S	SO4	Cl	Mg	Ca	T.H	Alk	E.C	PH	Turb
A1	0.2	0.45	0.38	1.16	0.835	1.16	0.61	0.723	0.66	1.97	0.48	0.57	0.93	0.5
A2	0.3	0.52	0.57	1.46	0.96	1.64	0.78	1.054	0.78	2.55	0.61	0.76	0.92	2.3
A3	0.2	0.49	0.55	1.54	1.019	1.65	0.76	1.117	0.77	2.59	0.59	0.78	0.91	1.2
A4	0.3	0.5	0.56	1.37	1.027	1.69	0.77	1.178	0.76	2.64	0.58	0.78	0.94	2
A5	0.3	0.5	0.58	1.32	1.068	1.64	0.77	1.21	0.78	2.58	0.6	0.79	0.97	1.6
A6	0.3	0.49	0.6	1.41	1.064	1.78	0.79	1.346	0.78	2.73	0.61	0.8	0.94	2.1
average	**0.3**	**0.49**	**0.54**	**1.38**	**0.995**	**1.59**	**0.75**	**1.105**	**0.76**	**2.51**	**0.58**	**0.75**	**0.93**	**1.6**

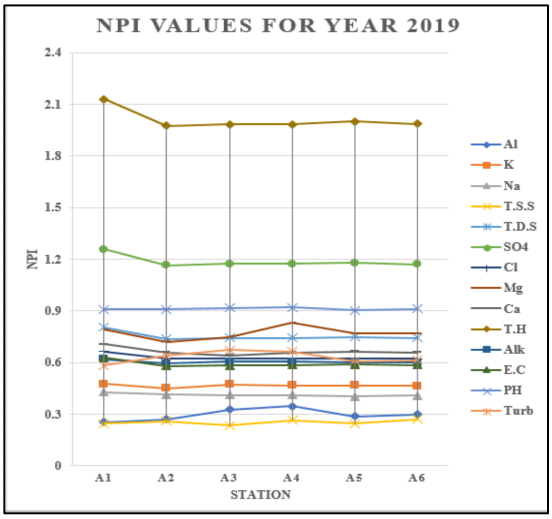

Figure 11: the NPI values of each parameter and each station of year 2019 of AL-Abbasia River.

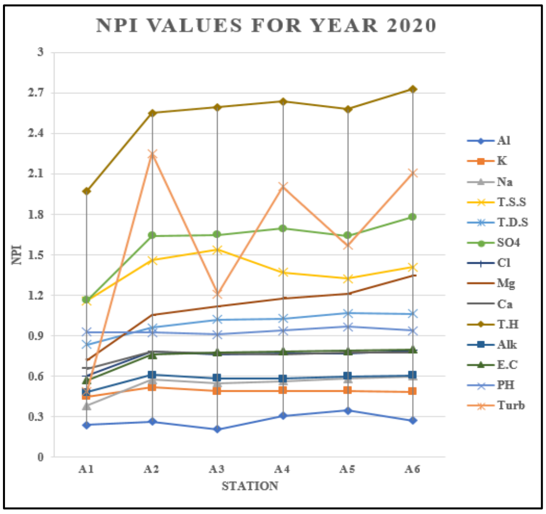

Figure 12: the NPI values of each parameter and each station of year 2020 of AL-Abbasia River.

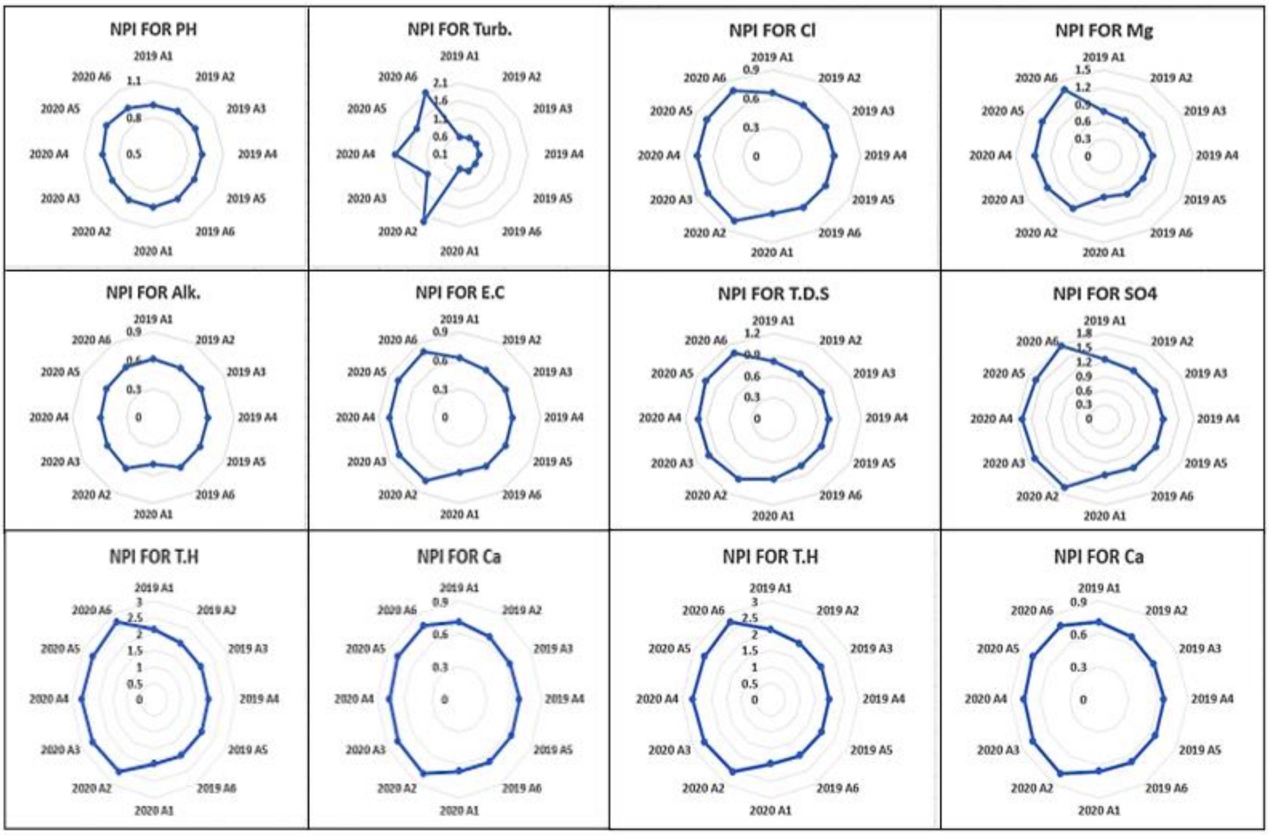

Figure 13: the NPI values of each parameter and all stations during the study period of AL-Abbasia River.

The rainfall intensity in AL-Najaf city varies among the year seasons. The high intensity ranged between January and April in the winter season with value between 30mm to 13mm, while its zero in the summer season with a high temperature. In general, it is known that there is a close inverse relationship between rainfall and WQI. When rainfall increase the WQI will decrease and vice versa. The reason is that when it rains, it carries dust particles and pollutants in the air and transfers them to the water body, thus increasing pollution. The relation between rainfall and WQI are shown in figure 14. Sometimes the effect of rain is unclear on the quality of the water when other pollutants are significantly present. Rain has little effect on the WQI value when the number of pollutants is high. In this thesis two method were used to calculate WQI and to show the relation between rainfall and WQI data for each method the linear chart used.

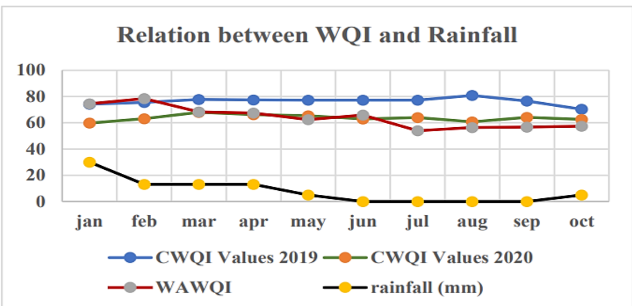

Fig. 14: relation between rainfall and WQI.

Conclusions

The Water Quality Index is one of the methods that is really powerful in being able to communicate water quality knowledge to residents and policy makers. It is an important figure for assessing and checking surface water quality. The maximum concentration of most of parameters for surface water were during spring season especially in April 2019. The minimum concentration of most of parameters for surface water were during summer season especially in July 2019. The degradation of the water quality of the AL-Abbasia River increased during 2019 due to the large number of agricultural drainages surrounding the river. The results showed that the maximum concentrations of (T.H., T.D.S., Mg+2, and SO4-2) were exceeded the World Health Organization standard for drinking water, for year 2019. This suggests that the water is unsuitable for drinking consumption (without treatment). The WAWQI results showed that the water quality of the AL-Abbasia River is generally "poor" in the upstream (A1) and downstream (A6) of the river for drinking water, indicating the effect of domestic and agricultural waste contamination. The results showed that, under the WQI classification, the lowest drinking water quality was in February 2019. The high concentrations of (T.H, sulfate and T.D.S) affected the water quality significantly more than other parameters, which made the water quality "poor". The CWQI results showed that the annual average water quality index of two years was fair in the upstream at station A1 with value of 74.57 and downstream at station A6 with value of 61.6. The water quality index during 2019 year was ranged between fair at A1, A2, and A6 stations and good at A3, A4, and A5 stations with a value ranged between 61.04 at A2 and 82.83 at A3, while the water quality index during 2020 year was ranged between fair at A1, A2, A3, A4, and A6 stations and marginal at station A5 with values between 77.63 at station A1 and 58.23 at station A5. Population activities and the wastes they cause have a major impact on water quality. The insufficiency of sanitation services and disposal of wastes over time greatly affect the quality of water. Use of fertilizers and pesticides in the soil, such as phosphates and nitrates. There are many farms near the river stream along AL-Abbasia city. In Nemerow's Pollution Index method the NPI indicator is adopted to evaluate water. One of the advantages of this method is that it gives an accurate description of the condition of each parameter separately. Whereas, the NPI represents the parameter status of whether or not it exceeded the limits. This method gives an accurate description of the water condition for each test site and for all times. It is important to be used by decision-makers and those who are in charge of improving water quality to identify pollution areas and direct causes of pollution. Yet, this method does not give an accurate number indicating the state of water at each measuring station.

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