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## QUALITY ASSESSMENT OF WATER QUALITY IN IRAQI CITIES

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**Key words:** *quality assessment, water quality, tigris, the euphrates, the Shatt al-Arab, statistical data*

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## QUALITY ASSESSMENT OF WATER QUALITY IN IRAQI CITIES

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*The quality of drinking water directly affects human health and life. This study is concerned with the assessment of the drinking water quality in the main cities of 14 Iraqi governorates for the years 2011 and 2017 based on the Iraqi Central Statistical Organization statistical data for nine parameters. The Canadian method was used to calculate the Water Quality Index. The results showed a slight difference with the preference for water quality for the year 2011. The water quality is ranked excellent depending on the minimum values of statistical data, good based on the average value of statistical data, and poor depending on the maximum values of statistical data. The most influential parameters for the deviation of the water quality index values are sulphate and turbidity, and the lowest are the pH and electrical conductivity. The study showed that the water quality index does not give a consistent trend of the water quality change during the years 2011 and 2017. Therefore, the study recommends the use of other advanced statistical methods for this purpose. The study showed that the statistical data give less accurate results than the results of the tests, but it gives a clear initial picture for the decision-makers when the study area is wide and the research team is not available and the time period is long.*

*Key words: quality assessment, water quality, tigris, the euphrates, the Shatt al-Arab, statistical data*

### INTRODUCTION

Water is substantial and one of the priceless natural resources for the existence and life development on the Earth [1]. Also water plays an important role in various other sectors such as agriculture, industry, animals, forests, fisheries, energy generation and economics [2]. Water covers 71% of the planet's surface, so it is vital for all types of life [3]. Safe drinking of good quality water is one of the most important human needs (Iran), and access to safe drinking water at reasonable prices is the first goal of sustainable development set by the United Nations General Assembly in 2015 [4]. The provision of drinking water, is important for the development of any country, but when its polluted it may become a source of undesirable substances and hazardous to human health. Although the governments of many developing countries consider providing safe drinking water as one of their main responsibilities, most people in the developing countries do not have an access to safe drinking water [5]. Drinking water supports public health and ensures economic growth, but at the same time, water pollution can cause social and economic damage through water-related diseases such as typhoid fever, dysentery, hepatitis, Cholera, E. coli and polio, in addition to increasing the cost of medical treatment. [6,7]. The physical, chemical and biological properties of water are a major factor in controlling health and disease status in living organisms [8]. The quality of drinking water should be assessed to maintain good health. The management of water has become mandatory all over the world due to the increasing need for fresh water as a result of the rapid growth of the world's population and the increase in industrial and agricultural use. The quality and availability of ground and surface water are constantly changing

as a result of urbanization and the increase of industries and the resulting pollution [9]. One of the main points in the sustainable management of water resources is the monitoring of water quality at frequent intervals [10 to 14]. Water quality can be assessed using biological, chemical and physical parameters, and there are limits to these parameters that when exceeded it will be considered harmful. These limits are established at the international and national levels (WHO, MECC, EPA) [9]. The Water Quality Index (WQI) is one of the most appropriate ways to express water quality, and it is an effective tool for communicating information to decision makers [9,15]. The WQI is a mathematical tool for converting a large number of water quality data into a single value representing the water quality level presented as reports for decision makers and stakeholders to find out the water quality and to determine the type of treatment required [1,3,16,17]. The WQI can be used as a tool to compare water quality from different sources and to give a general idea of the potential water problems in a specific area [9]. Several water quality indices have been created by some national and international organizations such as: Canadian Council of Ministers of the Environment WQI (CCME-WQI), Oregon Water Quality Index (OWQI), Aquatic Toxicity Index (ATI), Universal Water Quality Index (UWQI), Overall Index of Pollution (OIP) and Bascaron WQI (BWQI), National Sanitation Foundation (NSFWQI), Weighted Arithmetic Water Quality Index Method, and other types of water quality indices mentioned in reference [18 to 21]. In this research, the Canadian method was chosen because it gives reasonable results in addition to other features as in [21]. Surface water is one of the main resources in Iraq and consists of the Tigris and its tributaries, the Euphrates,

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the Shatt al-arab and the lakes. Its amount varies from year to year depending on the variation of the quantities of water coming from outside Iraq or the amounts of rain and snow falling [18,22,23]. This research includes, in the following sections, an assessment of the quality of drinking water for fourteen major cities in Iraq, based on statistical data provided by the Iraqi Central Bureau of Statistics. The originality of this research is not only to rely on statistical data to calculate the quality of the water quality index, but also by adapting the Canadian method that depends on field models in calculating the water quality index, adapting this method to calculate this indicator based on statistical data. In addition to the extent of the area The study case to include fourteen Iraqi cities, which is one of the most important reasons why the researcher relied on statistical data, because obtaining field data for this study case requires a research team, at least, a researcher for each region, in addition to that it costs a lot of time.

**TIME AND AREA STUDY**

Surface water is one of the main resources in Iraq and consists of the Tigris and its tributaries, the Euphrates, the Shatt al-Arab and the lakes. Its amount varies from year to year depending on the variation of the quantities of water coming from outside Iraq or the amounts of rain and snow falling [23]. Statistical data for drinking water were chosen for the cities of fourteen Iraqi governorates, for the years 2011 and 2017.

**MATERIALS AND METHODS**

The Canadian method was used to calculate the water quality index based on the data of the Iraqi Central Statistical Organization for the years 2011 and 2017 for eight parameters: Turbidity (Tur), pH, Chloride(Cl-1), Calcium(Ca+2), Magnesium(Mg+2), Electrical conductivity (EC), Sodium(Na+1) and Sulfate (SO4-2). According to the statistical data provided by the Iraqi Central Bureau of Statistics, there are three values for the parameters used to calculate the water quality index, and according to the results of the tests for the field models approved by them, there are maximum values, minimum values, and average values for the parameters. The lower values always lead to obtaining acceptable results for the water quality index, while the higher values lead to obtaining unacceptable results for the water quality index, and therefore relying on the average values of the data gives moderate results. Therefore, the researcher believes that relying on the average values results alone well not shows the water quality existing problems that can be shown in the event of reliance on the higher values, and it well cancels or covers the optimistic picture of water quality that can be shown in the event of reliance on the lower values, so the three values were relied on in finding the water quality index to give the full picture of Iraqi water. The WQI is calculated using Equations 1, 2, 3, 4 and 5 as follows [22]: The calculation of the WQI

using the Canadian method depends on three factors, as in Equation 1.

$$WQI = 100 - \left[ \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right] \tag{1}$$

$F_1$  : The first factor represents the range : is calculated using Equation 2 represents the percentage of the number of failed variables that exceed the allowable limit value relative to the total number of variables

$$F_1 = \left( \frac{\text{Number of failed variables}}{\text{Total number of variables}} \right) \times 100 \tag{2}$$

$F_2$ : The second factor represents the frequency: is calculated using Equation 3 represents the percentage of the number of failed tests that exceed the allowed limit in relation to the total number of tests)

$$F_2 = \left( \frac{\text{Number of failed tests}}{\text{Total number of variables}} \right) \times 100 \tag{3}$$

$F_3$ : The third factor represents capacity: is calculated using Equation 4

$$F_3 = \left( \frac{nse}{0.01nse + 0.01} \right) - 1 \tag{4}$$

nse: represents the accumulated sum of the tests that did not match the targets and is calculated using Equations 5 and 6.

$$\text{excursion}_i = \left( \frac{\text{Failed test value}_i}{\text{Objective}_i} \right) - 1 \tag{5}$$

excursion<sub>i</sub> : The deviation of the value of each test represents the objective, and is found for all variables.

$$nse = \left( \frac{\sum_{i=1}^n \text{excursion}_i}{\text{Total number of tests}} \right) \tag{6}$$

nse: It represents the sum of the deviations divided by the total number of tests.

The Canadian method has been modified to accommodate the available data, as follows:

- When calculating F2, the number of failed tests was considered equal to the number of variables and the total number of tests was considered equal to the number of total variables.
- When calculating excursion<sub>i</sub>, the value of the test deviation from the Objective was considered equal to the value of the variable deviation from the Objective value.
- When calculating nse, the total of tests were considered equal to the total of the variables.

- In three governorates (Baghdad, Al-Qadisiya, Maysan), the value of the sodium parameter is not available. Therefore, the total number of variables for these governorates has been calculated equal to 7, and in the other governorates the total number of variables has been calculated equal to eight as a result of the availability of data for all the parameters in them.

Consequently, the new in this study is the reliance on statistical data, not on tests, as well as modifying test values by making them equal to the values of the variables. Relying on the test values gives more accurate results, but covering the case study of many regions requires a long period of time and a research team not less than 14 researchers (a researcher for each study area). In addition, the tests are required to be in all study areas at the same time. Table 1 shows the code for each of the governorates of Iraq within the study case. The code was used instead of the name of the governorate to facilitate display of the information. Tables 2,3 and 4 shows the maximum, average and minimum values for the statistical data of chemical and physical tests of drinking water for governorates under study.

Table 1: The code for each of the governorates of Iraq within the study case.

G code	Governorates
1	Kirkuk
2	Diala
3	Al-Anbar
4	Baghdad
5	Babylon
6	Kerbela
7	Wasit
8	Salah AL-Deen
9	Al-Najaf
10	Al-Qadisiya
11	Al-Muthanna
12	Thi-Qar
13	Maysan
14	Al Basrah

Table 2: Maximum values for the statistical data of chemical and physical tests of drinking water [23,24]

Parameters	Turbidity		pH		Chloride		Calcium		Magnesium		Electrical conductivity (EC)		Sodium		Sulfate		
	Tur				Cl-		(Ca <sup>2+</sup> )		(Mg <sup>2+</sup> )			(Na <sup>+</sup> )		SO <sub>4</sub> <sup>2-</sup>			
Unit	NTU		....		mg/L		mg/L		mg/L		µS/cm-1		mg/L		mg/L		
OBJ.	5		8.5		200		150		100		2500		200		200		
G. code	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	
1	5	7	8.2	7.8	22	112	68.4	152	27.8	92	467	1355	14	165	59	515	
2	93	32	8.3	8.4	365	286	251	330	118	278	3107	2670	190	196	720	820	
3	83.3	19.9	8.5	8.7	237	125	168	110	72	63	1319	1246	152	86	509	310	
4	101	121	8.34	8.7	153.6	342	147	200	83	79	1656	2000	77	.....	429	616	
5	167	21	8.6	8.4	214	171	136	119	77	61	1906	1394	179	122	436	331	
6	27	6.6	8.43	8.4	185	154	144	117	67	47	1588	1458	130	126	398	370	
7	96	190	8.3	8.2	290.4	322	219	180	39.23	74	1784	2000	135	190	437	499	
8	89.2	4.95	8.5	8.9	46	40	108	81	48	31	949	597	73	23	337	114	
9	38	39	8.2	8.7	277	198	149	131	71.6	59	2143	1852	175	143	435	419	
10	32	40	8	8.6	170	266	139	168	8855	87	1600	2270	126	.....	360	530	
11	4.9	98	7.9	8.5	257	2366	159	851	63	427	1776	10378	190	1639	454	2684	
12	557	734	8.45	8.2	1458	774	570	262	362	183	6270	4510	342	382	1256	852	
13	30	83	8.7	8.3	643	760	200	143	108	117	3270	3670	197	.....	582	646	
14	13.1	26.7	8.3	8.05	3780	2900	395	531	247	330	13090	11995	2443	2020	1821	2533	

Table 3: The average values for the statistical data of chemical and physical tests of drinking water [23,24]

Parameters	Turbidity Tur		pH		Chloride Cl <sup>-</sup>		Calcium (Ca <sup>+2</sup> )		Magnesium (Mg <sup>+2</sup> )		Electrical conductivity (EC)		Sodium (Na <sup>+1</sup> )		Sulfate SO <sub>4</sub> <sup>-2</sup>	
	Unit	NTU	....		mg/L		mg/L		mg/L		µS/cm-1		mg/L		mg/L	
OBJ.	5		8.5		200		150		100		2500		200		200	
G. code	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017
1	3.99	1.13	7.79	7.4	16.5	25	42.91	53	17	30	367	603	14	25	32	98
2	6.154	4.06	7.1	7.3	40	50	64.31	78	27	26	885	726	23	37	146	190
3	3.27	3.19	7.83	7.9	127	97	74	79	37	31	925	1034	92.36	76	246.5	241
4	7.78	7.3	7.5	6.6	85	87	77.13	81	34	32	932	894	51.4		199	198
5	11.44	2.72	7.9	7.6	129	109	94.62	60	42	32	1189	1015	86	82	294	249
6	2.44	2.45	7.69	7.8	139	110	10.6	88	39	34	1295	1062	92	84	290	259
7	10.96	11.84	7.35	7.3	101	110	98	97	32	37	974	1137	70.26	94	269	269
8	4.11	3.86	7.72	7.7	22.23	24	58	59	16.19	17	976	461	11.42	16	68.98	72
9	4.62	5.07	7.69	7.6	174	124	106	97	47	36	1552	1206	120	89	313	287
10	2.22	3.75	7.6	7.6	142	131	101.82	88	47	40	1399.7	1114	84		310	267
11	2.83	9.63	7.62	7.9	175	358	122	141	42	69	1450	2061	108	241	367	513
12	24.2	37.49	7.71	7.7	123	124	113.6	88	38.5	51	1076	1187	79.5	89	257	280
13	4.17	16.8	7.59	7.4	236	386	113.87	100	63.45	65	1760	2958	132.22		347.74	386
14	4.14	4.83	7.61	7.4	441	829	123	162	86	95	2333	3825	272	548	423	629

Table 4: The minimum values for the statistical data of chemical and physical tests of drinking water [23,24]

Parameters	Turbidity Tur		pH		Chloride Cl <sup>-</sup>		Calcium (Ca <sup>+2</sup> )		Magnesium (Mg <sup>+2</sup> )		Electrical conductivity (EC)		Sodium (Na <sup>+1</sup> )		Sulfate SO <sub>4</sub> -2	
	Unit	NTU	....		mg/L		mg/L		mg/L		µS/cm-1		mg/L		mg/L	
OBJ.	5		8.5		200		150		100		2500		200		200	
G. code	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017	2011	2017
1	0.02	0.02	7.3	7	11.74	12	150	150	27.8	7	304	346	4.7	7	15	14
2	0.1	0.1	6.5	6	14.6	18	31	22	10.5	16	558	354	6	13	60	68
3	0.2	0.3	6.5	7.1	57	72	33	46	13	21	491	832	46	51	65	149
4	0.1	0.17	6.87	7.8	16.32	28	26	55	7.8	9	543	429	29		60	40
5	0.4	0.2	7.2	6.8	90	90	38	39	20	14	815	872	22	55	172	177
6	0.1	0.01	7	7.1	92	88	62	79	13	23	998	930	42	65	137	208
7	1	0.8	6.5	6.1	41.3	73	72	70	12.23	21	541	781	47.8	61	50	156
8	0.4	1.15	7	7	10	13	47	57	3.7	6	302	299	6	9	36	46
9	0.7	0.5	6.5	6.1	100	105	29.8	44	26.7	18	994	1003	85.5	70	212	207
10	0.5	0.01	7	6.1	121	70	74.5	78	28.67	12	1180	638	72		265	147
11	1.1	0.54	7.1	7.1	124	125	73	36	27	18	1083	1066	7.4	86	241	219
12	0.4	0.6	7.02	6.93	60	59	81	64	13.7	28	682	733	44	52	125	155
13	0.4	0.2	6.6	6.8	162	98	60	56	28	13	1030	870	90		200	128
14	0.9	0.6	6.86	6.84	93	124	68	63	33	35	868	909	40	58	125	146

Table 5: An example for calculating WQI (AL Basra, average values for the year 2017)

Variables	Avg.	U.L.	F1	F2	exc.1	exc.3	exc.4	exc.5	exc.6	exc.7	exc.8	exc.9	nse.	F3	WQI.
Turbidity	4.83	5			0										
pH	7.4	8.5				0									
Chlorides	829	200					3.145								
Calcium	162	150						0.08							
Magnesium	95	100							0						
Electrical conductivity	3825	2500								0.53					
Sodium	548	200									1.74				
Sulfates	629	200										2.145			
No.of failed	5														
Total NO.	8														
Results			62.5										0.955	48.849	41.692

### Calculating the Canadian water quality index in Iraqi cities and the results

Table 5 shows an example of calculating WQI using the excel sheet for AL-Basra Governorate, based on the average values for the statistical data for the year 2017. WQI values are ranged from 0 to 100. Index values have been classified into five levels [25] as in Table 6. Table 7 shows the results of the WQI using the maximum, minimum and average values for the statistical data of the physical and chemical tests for the year 2011. Table 8

Table 6: WQI levels

Range Value	0-44	45-59	60-79	80-94	95-100
Level	Poor	Marginal	Fair	Good	Excellent

shows the results of the WQI using maximum, minimum and average values for the statistical data of the physical and chemical tests for the year 2017.

Table 7: WQI for the year 2011

Governorates	Max.		Min.		Avg.	
	WQI	Level	WQI	Level	WQI	Level
Kirkuk	100.00	Excellent	100.00	Excellent	100.00	Excellent
Diala	25.51	Poor	100.00	Excellent	89.67	Good
Al-Anbar	43.10	Poor	100.00	Excellent	89.66	Good
Baghdad	53.80	Marginal	100.00	Excellent	89.13	Good
Babylon	38.01	Poor	100.00	Excellent	77.09	Fair
Kerbela	69.07	Fair	100.00	Excellent	89.34	Good
Wasit	41.85	Poor	100.00	Excellent	77.57	Fair
Salah AL-Deen	55.41	Marginal	100.00	Excellent	100.00	Excellent
Al-Najaf	57.72	Marginal	89.78	Good	89.11	Good
Al-Qadisiya	38.62	Poor	89.55	Good	89.14	Good
Al-Muthanna	67.88	Fair	89.69	Good	78.87	Fair
Thi-Qar	10.21	Poor	100.00	Excellent	71.67	Fair
Maysan	21.76	Poor	100.00	Excellent	88.69	Good
Al Basrah	13.25	Poor	100.00	Excellent	77.70	Fair

Table 8: WQI for the year 2017.

Governorates	Max.		Min.		Avg.	
	WQI	Level	WQI	Level	WQI	Level
Kirkuk	67.29	Fair	100.00	Excellent	100.00	Excellent
Diala	29.65	Poor	100.00	Excellent	100.00	Excellent
Al-Anbar	64.60	Fair	100.00	Excellent	89.69	Good
Baghdad	25.96	Poor	100.00	Excellent	87.80	Good
Babylon	72.27	Fair	100.00	Excellent	89.65	Good
Kerbela	78.30	Fair	89.79	Good	89.59	Good
Wasit	37.01	Poor	100.00	Excellent	77.19	Fair
Salah AL-Deen	89.79	Good	100.00	Excellent	100.00	Excellent
Al-Najaf	58.02	Marginal	89.79	Good	79.36	Fair
Al-Qadisiya	33.16	Poor	100.00	Excellent	88.04	Good
Al-Muthanna	12.24	Poor	89.77	Good	55.57	Marginal
Thi-Qar	9.89	Poor	100.00	Excellent	66.36	Fair
Maysan	27.28	Poor	100.00	Excellent	37.56	Poor
Al Basrah	13.15	Poor	100.00	Excellent	41.69	Poor

**DISCUSSION**

The WQI based on the minimum values of the statistical results ranges between 100 and 89, meaning that the water quality is excellent for all except for AL-Najaf, Al-Qadisiya and AL- Muthanna for the year 2011, and except for Karbala, AL-Najaf and AL-Muthanna for the year 2017 due to the high amount of sulfate in both years. The WQI based on the maximum values of the statistical results ranges between 100 and 10.21 for the year 2011. The WQI is excellent for Kirkuk, fair for Karbala (due to high turbidity and sulfate) and AL-Muthanna (due to high Cl<sup>-1</sup>, Ca<sup>+2</sup> and SO<sub>4</sub><sup>-2</sup>), Marginal for Salah al-Din (due to high turbidity and Sulfate) , AL-Najaf (due to high turbidity and Cl-1), Baghdad (due to high turbidity and sulfate) and Poor for the governorates of Qadisiya (due to high turbidity, Mg+2 and Sulfate), AL-Anbar and Wasit (due to high turbidity and Sulfate), Babylon (due to high turbidity, pH, Cl<sup>-1</sup>, Ca<sup>+2</sup> and Sulfate), Maysan (due to the high level of all variables except Na<sup>+1</sup>), Thi-Qar (due to the high level of all variables except pH) and Diala (due to high level of all variables except pH and Na<sup>+1</sup>). The WQI based on the maximum values of the statistical results ranges between 89.79 - 9.89 for the year 2017. There is no excellent water quality, the WQI for Salah al-Din is good (due to the high pH) and this differs from the year 2011. Fair water quality for Babylon, Kirkuk and Karbala (due to the high Sulfate), the water quality of these governorates differs from 2011. Marginal water quality for Al-Najaf (due to high turbidity, pH and Sulfate) , This value is close to the value of water quality in 2011. Poor water quality for Wasit (due to high turbidity, Cl<sup>-1</sup>, Ca<sup>+2</sup> and sulfate), Al-Qadisiya (due to high level of all values except Mg<sup>+2</sup>, EC) ,

Diala (due to the high level of all variables except pH and Na<sup>+1</sup>) , Maysan (due to the high level of all variables except pH and Ca<sup>+2</sup>), Baghdad (due to the high levels of all values except Mg<sup>+2</sup> and EC), AL-Basra, AL- Muthanna, and Thi Qar (due to the high level of all values except PH), the water quality of these governorates is similar to 2011 except Baghdad and AL-Muthanna. The WQI based on the average value of the statistical results for the year 2011 ranges between 100 to 71.67. The WQI is excellent for Kirkuk, and Salah AL-Deen. Water quality is good for Diyala ,Anbar, AL-Qadisiya, AL-Najaf (due to high sulfate), Karbala, Baghdad and Wasit (due to the high sulfate and turbidity) and Maysan (due to high sulfate). Fair water quality for AL-Muthanna (due to the high sulfate) , Babylon (due to high turbidity and sulfate), Thi-Qar (due to high turbidity and sulfate) and AL-Basra (due to high Na<sup>+1</sup> and sulfate). The WQI based on the average value of the statistical results for the year 2017 ranges between 100 to 37.56. Excellent water quality for Kirkuk, Diyala and Salah AL-Deen. Good water quality for AL-Anbar, Babylon and Karbala, Baghdad Al-Qadisiyah (due to high sulfate), the WQI of these governorates is similar to the year 2011 except for Babylon and AL-Najaf . Fair water quality for AL-Najaf (due to high sulfate and turbidity) Wasit and Thi- Qar (due to high turbidity and sulfate) , the water quality of these governorates differs from 2011 .Poor water quality for Maysan (due to high Turbidity, Cl<sup>-1</sup>, EC and sulfate) and AL-Basra (due to high Cl<sup>-1</sup>, EC, Na<sup>+1</sup> and sulfate) , the water quality of these governorates differs from 2011. To assess the trend of change in water quality using the values of the WQI for the years 2011 and 2017, Figures 1,2 and 3 show the

comparison of the calculated WQI values, based on the maximum, minimum and the average values, respectively. Figure 1 shows that the values of the WQI based on the maximum values in 2011, for Kirkuk, Baghdad, Thi-Qar and AL-Muthanna governorates are higher than the values of the WQI for the year 2017. As for the rest of the governorates, it is clear that the values of the water quality for the year 2017 are higher than for the year 2011 with the convergence of values in AL-Basra. Figure 2 shows, equal values of the WQI for Kirkuk, AL-Anbar, Baghdad, Karbala, Salah al-Din, al-Qadisiyah. The figure shows that the values of the WQI for the year 2011 are higher than its value in the year 2017 for the governorate of AL-Basra, Maysan, AL-Muthanna, Najaf, while the governorates of Thi Qar and Diala, the figure shows that the values of the WQI for the year 2011 are lower than for the year 2017. Figure 3 shows the equal values of the WQI for the year 2011 with its value for the year 2017 in most governorates except for Karbala where WQI value for 2011 is higher than its value for 2017. On the contrary, the WQI for AL-Qadisiyah for the year 2017 is higher than its value for the year 2011.

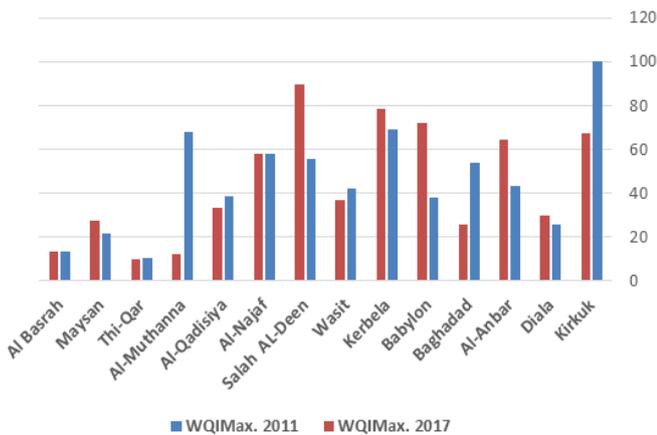


Figure 1: The comparison of WQI values based on the maximum values

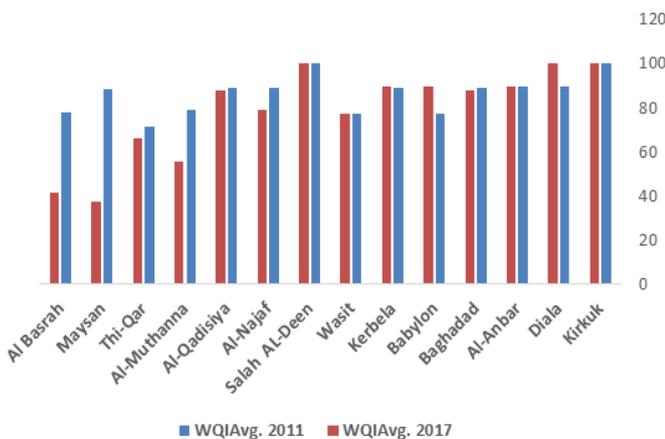


Figure 2: The comparison of WQI values based on the average values

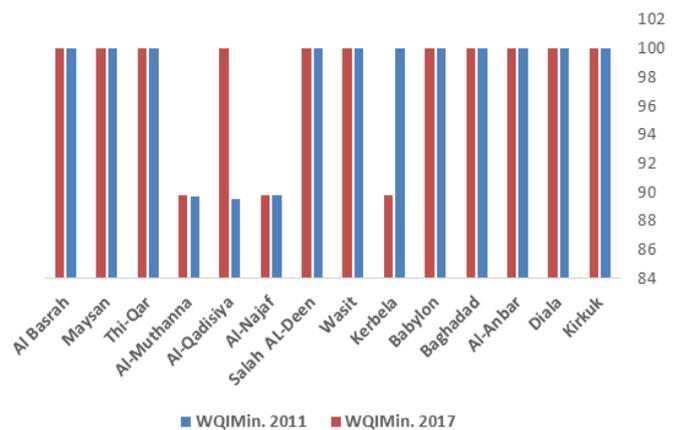


Figure 3: The comparison of WQI values based on the minimum values

### CONCLUSION

In this research, the value of WQI was calculated using the Canadian method for the main cities of 14 Iraqi Governorates, based on the statistical data for the years 2011 and 2017. The results calculated based on the minimum values of the statistical results for the years 2011 and 2017 showed WQI ranges between excellent and good. Water quality based on the maximum values of the statistical results for the year 2011, were excellent for one governorate, fair for two, marginal for three and poor for eight governorates, indicating that the predominant characteristic is poor. For the year 2017, the water quality was good for one governorate, fair for five governorates, and poor for eight, indicating that the predominant characteristic is poor. Water quality based on the average values of the statistical results for the year 2011, were excellent for two governorates, good for ten governorates, fair for two governorates, indicating that the dominant quality is good. For the year 2017, the water quality was excellent for two governorates, good for nine governorates, fair for two and poor for one governorate, indicating that the dominant quality is good. Usually, the waters of the northern governorates cities are of better quality than the cities of the southern governorates because they are closer to the headwaters of the river, whether it is the Tigris or the Euphrates. In general, the water quality for the two years (2011 and 2017) is almost the same with a slight preference for water quality for the year 2011. The most important reason for the deviation of the index values is the high values of SO<sub>4</sub> and turbidity. The most variable that does not deviate from its objective values was the pH and E.C. There is no consistent trend to change the quality of water depending on the values of the WQI, so the research recommends using other advanced statistical methods to assess the trend of changing the quality of water quality in Iraqi cities. It is clear from the lack of regularity in similarity and difference in the results, the reliance on statistical data gives results less accurate than the results that depend on field tests. However, the statistical results were relied

on instead of the results of tests for the expansion of the study area, which requires a research team in addition to a long period of time. This method was used to take advantage of many statistical results and summarize them with a single value representing these data and give a clear initial picture to decision makers on water quality in each governorate to conduct more detailed tests and take the necessary treatments.

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