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Rodhan Abdullah Salih

Idan I. Ghdban

AbdulRazaq Khader Abdul
Wahid *
 Technical Institute Hawijah
 Northern Technical University
 Kirkuk, Hawijah
 Iraq
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Evaluation of a Number of Water Treatment Plants in Kirkuk Governorate using the Water Quality Index

ABSTRACT

A study was conducted on sixteen water purification plants in Kirkuk governorate to evaluate the treatment of water in them, where physical and chemical tests were conducted for raw water and treated water for a period of (6) months from December until May. Temperature, turbidity, pH, Total Dissolved Solid (TDS), Electric Conductivity (EC), alkali, Total Hardness (TH) and calcium (Ca^{+2}) were measured. Water quality index Canadian method (CCME) was used to classify raw water quality and treated water. The results showed that the raw water for all stations was classified as category (4) (bad) during the study period. The treated water was different for the treatment plants. Two of the treatment plants recorded good efficiency in water treatment (AL-Shallalah plant and Sin AL-Thiban) the treated water remained in category (2) (good). While the water quality of AL-Mosanaa plant indicated that there was a problem in the treatment of water in this plant, the treated water remained in category (4) bad during the study period. Water quality index fluctuated for other plants during the study period. The study also showed that alkali values of all stations were higher than the allowable limit for raw water and treated water.

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تقييم عدد من محطات تصفية المياه الخام في محافظة كركوك باستخدام مؤشر نوعية الماء

الخلاصة

تم إجراء دراسة على ستة عشر محطة لتصفية الماء في محافظة كركوك لتقييم معالجة الماء فيها، حيث أجريت بعض الفحوصات الفيزيائية والكيميائية للماء الخام والماء المعالج ولمدة (6) أشهر ابتداءً من شهر كانون الأول حتى شهر ايار. تم قياس درجة الحرارة Temperature والعكارة turbidity والذائبة TDS والصلابة water quality index الكهربية EC والقاعدية Alkali والعسرة الكلية Total Hardness والكالسيوم Ca^{+2} . استخدمت تقنية مؤشر نوعية الماء CCME لتصنيف نوعية الماء الخام والمعالج. بينت النتائج ان الماء الخام لجميع المحطات صنف ضمن الفئة الرابعة (سيئة) خلال فترة الدراسة اما الماء المعالج فقد تبين نتاج للمحطات، فقد سجلت اثنين من المحطات كفاءة جيدة في معالجة الماء هي محطة الشلالة ومحطة سن الذبان حيث صنف المياه المعالجة فيها ضمن الفئة الثانية (جيدة) بينما اشار مؤشر نوعية الماء لمحطة المصنعة ان هناك خلل في معالجة الماء في هذه المحطة اذ بقيت المياه المعالجة ضمن الفئة الرابعة (سيئة) خلال فترة الدراسة. تنبذ مؤشر نوعية الماء لبقيّة المحطات خلال فترة الدراسة. بينت الدراسة ايضاً ان قيم القاعدية لجميع المحطات كانت اعلى من الحد المسموح به للماء الخام والمعالج.

1. INTRODUCTION

It is known that the goal of any water treatment plant is to produce safe water for drinking and tasteful and suitable for domestic use [1]. The water treatment is carried out in the form of sedimentation and filtration units to

remove the impurities. Water is a quick way to spread many diseases and parasites. The water medium is an important part of the life cycle of some pathogens. The WHO reports that 80% Human rights in developing countries are related to water pollution [2]. The water quality depends on its physical, chemical and biological properties. The water contains impurities in addition to

* Corresponding author: E-mail : abd.kder@yahoo.com

dissolved materials. These impurities are often removed or reduced to certain limits to make the water potable [3]. Several studies have been conducted to evaluate the efficiency of water treatment plants in different regions in order to determine the suitability and need of these plants for the maintenance and control of water production. Several methods were used to evaluate the efficiency of the filtration plants. The water quality index is one of the methods used to evaluate the quality of water in the water treatment plant and other water sources, where scientists and water quality experts have developed the water quality index (WQI). This indicator is considered the preferred scientific method because it uses many qualitative variables. Water and its formulation in numerical expression includes the integrated effect of these variables on the quality of water and has an effective role in the process of control of water quality and strategic management so that the classification of water qualitatively for various activities within a specific category in a simple scientific and useful [4]. The water quality index was first used in 1965 by Horton and was developed by several researchers later. Abdul-Rahman and Ahmed [5] used the Canadian method of calculating the water quality index (CCME 2001) using this method to study a number of water treatment plants in Baghdad [6]. WQI (Waleed et al.) was used to study a number of water treatment plants in Tikrit. Zainab used the same method to evaluate the efficiency of a number of water treatment plants in Baghdad. Al-Hadithi [4] used the water quality index to assess water quality for wells in Al-Qaim city, Anbar province. Al-Alwani and Yassin [7] studied the validity of surface and groundwater for consumption in the city of Zintan Libya and using the method of water quality index [8]. Muthanna used the Canadian method to calculate the water quality index for a number of water treatment plants in Salah al-Din Governorate. AL-Bassam et al. [9] studied groundwater quality in Jingju province, China using water quality index [10]. Al-Badran calculated the water quality of some of water treatment plants in the province of Basra [11].

The current study aims to evaluate a number of water treatment plants in the western Kirkuk area by using the water quality index based on the measurement of a number of physical and chemical properties of the raw water and the treatment of these plants based on the Iraqi standards for drinking water and comparing the results with the Canadian classification of water quality according to Table 1.

Table 1

Canadian classification for water quality index (CCME)[6].

Water quality class	Category	WQI
Excellent	1	95-100
Good	2	80-94
Moderate	3	65-79
Bad	4	45-64
Very bad	5	0-44

2. PRACTICAL PART

Sixteen water treatment plants were selected in different areas west of Kirkuk Governorate. As shown in Table 2, samples were taken for raw water from the plants

intakes. The treated water samples were taken from the distributed network. Plastic bottles were used to store the samples. Examine each month for a period of (6) months starting from December until May according to standard methods [12]. Temperature, turbidity, pH, Total Dissolved Solid, Electrical conductivity, Alkali and Total Hardness were examined) and calcium, and used Iraqi standard specifications for drinking water to compare the results [1,13].

2.1. Water Quality Index Calculation

The Canadian method was used to calculate the WQI water quality index [4,6]. The method computes three parameters: scope F1, frequency F2, and amplitude F3.

The first factor F1 is calculated from the equation:

$$F1 = \frac{\text{No. of failed parameters}}{\text{total parameters}} \times 100 \quad (1)$$

The second factor F2 is then calculated from the equation:

$$F2 = \frac{\text{No. of failed tests}}{\text{total tests}} \times 100 \quad (2)$$

Table 2

Water treatment plants names and site.

No.	Plant Name	GPS
1	Al-Faris	E=43°40'36", N=35°21'02"
2	Al-Gasia	E=43°45'40", N=35°23'15"
3	Al- Kadhimiya	E=43°46'20", N=35°22'55"
4	Arisha	E=43°48'30", N=35°27'54"
5	Al-Musanaa	E=43°46'32", N=35°22'28"
6	Tel Hussein	E=43°43'50", N=35°20'14"
7	Hoth 6	E=43°38'24", N=35°18'00"
8	AL Basal	E=43°39'07", N=35°17'53"
9	Tal Ali	E=43°38'35", N=35°22'02"
10	Al-Shalalah	E=43°43'16", N=35°23'07"
11	Sin Althiban	E=43°51'25", N=35°30'21"
12	Al Shajarah	E=43°24'49", N=35°12'17"
13	Gharib	E=43°29'06", N=35°14'30"
14	Al Tarqia	E=43°34'01", N=35°15'02"
15	Abbasid	E=43°35'47", N=35°16'32"
16	Abu al-Jess	E=43°50'50", N=35°17'46"

The third factor F3 is calculated in three stages:

-Calculate the deviation of each failed test from the equation:

$$\text{Excursion } i = \frac{\text{failed test value}}{\text{objective}} - 1 \quad (3)$$

- Calculate the normalized state of exclusions from the equation:

$$nse = \frac{\sum \text{excursios}}{\text{No. of tests}} \quad (4)$$

- The third factor F3 is calculated from the equation:

$$F3 = \frac{nse}{(0.01 \times nse + 0.01)} \quad (5)$$

The results of the tests were presented in [Tables 3-18](#)

After finding the three factors, the water quality index is calculated from the equation:

$$WQI = 100 - \frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732} \quad (6)$$

The water quality index for each station was calculated based on the laboratory results using the equations above and then comparing the results obtained for each station with the [Table 1](#) for the category representing the quality of the sample examined according to the table and the diagram of the change in the water quality throughout the study period using the excel program Variance during this period for raw and treated water.

3. RESULTS AND DISCUSSION

[Fig. 1](#) represents the water quality index (WQI) of Al-Faris water treatment plant. The results showed that the raw water was in category 4 (bad) according to the classification (CCME 2001) shown in [Table 1](#) The second category (good) for the first three months of the study, but in the next three months was the classification of water treated in the third category (moderate) and [Table 3](#), which shows the results of tests for this plant shows that the electric conductivity (EC) in the last three months was higher than the specifications, The decline in the quality of treated water from the second category to the third category in addition to that alkali was higher than the standard for all months of the study.

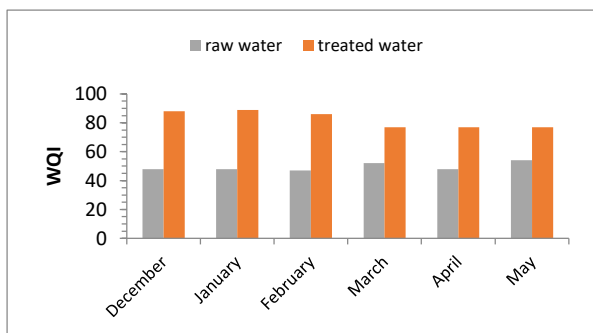


Fig. 1. WQI for Al-Faris water treatment plant.

[Fig. 2](#) shows the water quality of Al-Gasia water treatment plant. In this [Figure](#), raw water was found to be in Category 4 (bad) because the turbidity exceeded the limits allowed in the specification as shown in [Table \(4\)](#) The quality of the water was in the second category (good) during the month of December and May, but in the other four months, the water treated in this plant within the third category (moderate).

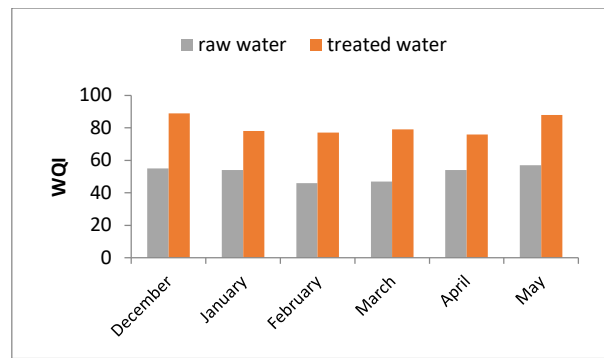


Fig. 2. Water quality index of Al-Gasia water treatment plant.

The water quality index (WQI) of Al- Kadhimiya water treatment plant shown in [Fig. 3](#) for raw water was classified as Category 5 (very bad) for December and Jan., as turbidity, EC and alkali exceeded the allowable limits in [Table 5](#) and became in the fourth category (bad) for the next four months. After treatment, the water was classified into the third category (moderate) during the study period.

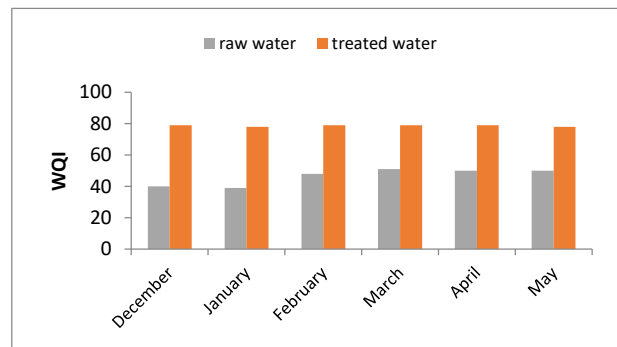


Fig. 3. Water quality index of Kadhimiya water treatment plant.

(Arisha) water treatment plant experienced fluctuation in the water quality index during the study period as shown in [Fig. 4](#). The raw water was classified in the fourth category (bad) for the first and second months of the study and was classified in the third category (moderate) Subsequent, either treated water has fluctuated between good and moderate and bad as shown in [Table 6](#).

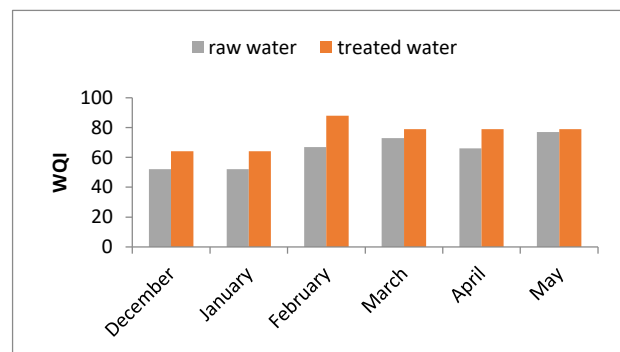


Fig. 4. Water quality index of Arisha water treatment plant.

Al-Musanaa water treatment plant results showed a defect in water treatment as shown in [Fig. 5](#). Raw water in category (4) was classified as bad during the study period, while the classification of treated water was not changed after treatment as in [Table 7](#).

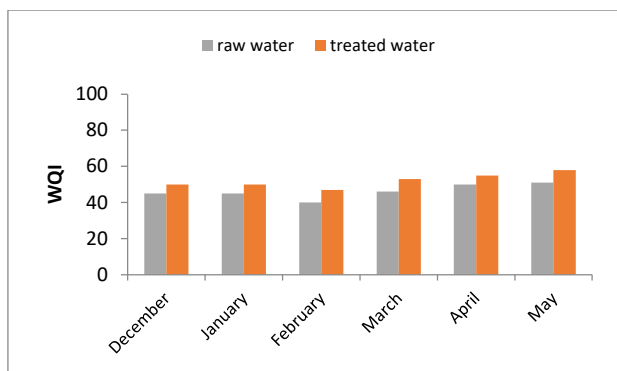


Fig. 5. Water quality index of Al-Musanaa water treatment plant.

Fig. 6 shows the water quality of (Tel Hussein) water treatment plant showing the results of its tests in Table 8, where the raw water was classified as category 4 (bad) except for December was in the second category (good), the treated water was classified in category III (moderate) for all months of the study.

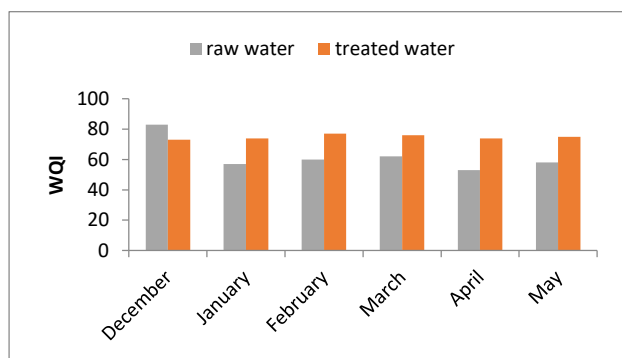


Fig. 6. Water quality index of Tel Hussein water treatment plant.

The results shown in Fig. 7 showed that there was a defect in the treatment of water for the month of December and Jan. in (Hoth 6) water treatment plant where the raw and treated water in the fourth category (bad) That the turbidity values remained above the allowable limit after treatment, indicating a defect in the sedimentation and filtration units.

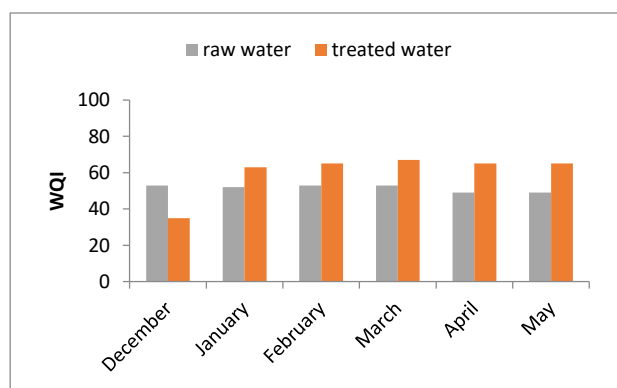


Fig. 7. Water quality index of Hoth 6 water treatment plant.

A raw water for AL Basal water treatment plant shown in Fig. 8 was between the third category (moderate) in December and April and the fourth category for the rest

of the study months. The treated water was in the third category (moderate) except in May. (Good) as is evident from Table 10.

Fig. 9 represents the water quality index (WQI) of Tal Ali water treatment plant. The results showed that the raw water was in the fourth category (bad). The treated water showed the results because the water quality did not improve in the first two months, while the indicator improved for the next four months to the third category (moderate) as is evident in the Table 11.

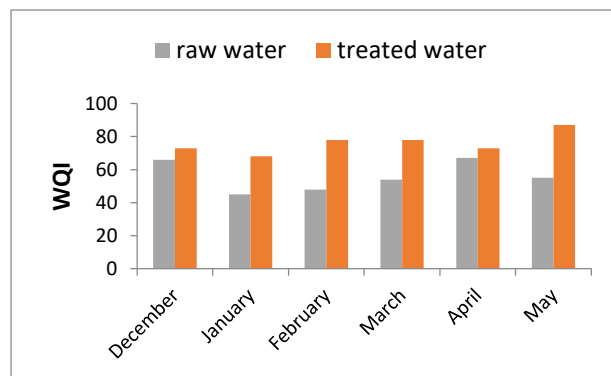


Fig. 8. Water quality index AL Basal water treatment plant.

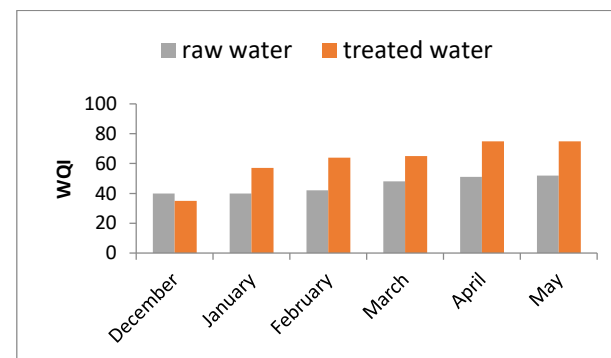


Fig. 9. Water quality index Tal Ali water treatment plant.

in Al-Shalalah and Sin Althiban water treatment plants The results of the water quality index showed good water treatment efficiency as shown in Figs 10 and 11 respectively, as the raw water quality index of the two plants in category 4 (bad) improved after treatment to the second category for both plants and for all study months as shown in Tables 12 and 13.

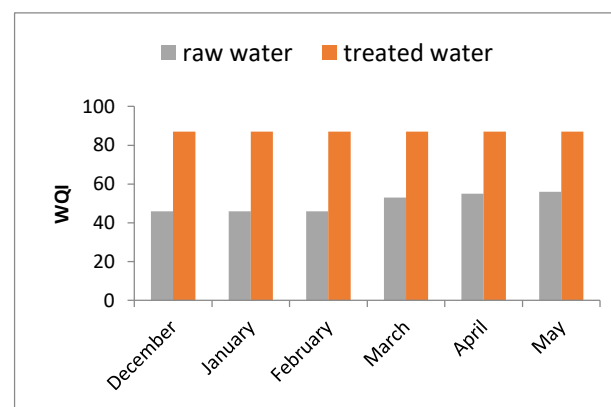


Fig. 10. Water quality index Al-Shalalah water treatment plant.

Table 3

Chemical and physical tests for Al-Faris water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
88	48	0.75	0.7	40	98	389	579	460	438	334	315	7.5	8.3	2.9	181	10	Dec.
89	48	0.9	0.6	41	98	280	580	461	438	330	314	8.52	8.4	2.9	181	9.4	Jan.
86	47	0.9	0.5	40	49	514	801	470	442	344	314	7.9	8.3	3	191	9.0	Feb.
77	52	1.1	1.5	31	60	510	709	510	500	383	390	8.2	8.5	2	117	20	March
77	48	1.9	2.1	19	81	560	614	503	501	399	393	7.9	7.9	1.8	100	20	April
77	54	0.9	2	20	80	550	615	507	500	390	385	8.1	8	1.1	96	20	May
		200-125 mg/l		500mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 4

Chemical and physical tests for Al-Gasia water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
89	55	0.99	0.8	59	80	650	825	470	450	330	310	8	7.8	5	80	10	Dec.
78	54	0.99	0.7	62	83	640	830	470	443	335	320	8.2	7.6	5.3	80.2	9.4	Jan.
77	46	0.53	1.2	31	91	679	710	525	502	366	342	8.1	7.8	4.1	124	9.0	Feb.
79	47	1.3	1.9	33	70	519	790	539	503	362	315	7.5	7.3	3.9	99	20	March
76	54	1.8	2	21	50	760	781	580	479	334	312	8	7.8	3	88	20	April
88	57	1.6	1	22	49	760	780	493	480	333	312	8	7.6	2.5	70	20	May
		200-125 mg/l		500mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 5

Chemical and physical tests for Al- Kadhimiya water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	treated water	raw water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
79	40	0.99	0.9	25	38	551	860	551	530	400	379	7.2	7.7	0.5	250	10	Dec.
78	39	0.94	0.85	25	38	550	870	558	530	403	379	7.2	7.7	0.5	302	9.4	Jan.
79	48	1.1	1	56	69	623	760	581	504	410	390	7.3	7.9	0.9	400	9.0	Feb.
79	51	1.3	1.5	17	53	401	509	586	515	455	399	8	7.8	1	103	20	March
79	50	1.9	2.5	23	90	510	470	589	573	410	385	7.9	7.5	0.8	77	20	April
78	50	1.4	1.5	22	93	552	860	540	533	420	385	7.9	7.6	0.9	70	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 6

Chemical and physical tests for Arisha water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
64	52	0.97	0.7	63	95	179	365	455	425	319	306	7.9	8.5	62	115	10	Dec.
64	52	0.97	0.7	62	95	180	370	455	430	319	306	7.9	8.6	62	116	9.4	Jan.
88	67	0.5	0.9	62	95	182	300	401	399	352	346	8.5	8.5	8.5	35	9.0	Feb.
79	73	0.9	1.1	21	93	193	400	400	415	489	400	8.1	8.2	8.8	16	20	March
79	66	1.9	2.5	31	85	200	335	422	409	405	386	8	8	8	14	20	April
79	77	2.1	2.8	22	80	160	330	430	410	399	380	7.9	7.9	7	10	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 7

Chemical and physical tests for Al-Musanaa water treatment plant.

WQI		Ca ⁺²		TH		Alkali		ec		TDS		Ph		turbidity		Temp.	months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
50	45	1.05	0.94	96	115	508	735	487	458	349	329	7.36	7.47	140	285	10	Dec.
50	45	1.01	0.90	98	118	510	750	496	460	354	331	7.38	7.46	144	280	9.4	Jan.
47	40	1.33	1.70	49.3	59.2	793	910	752	690	570	553	7.2	7.9	101	268	9.0	Feb.
53	46	1	0.91	21	64	600	803	640	550	494	492	8	7.8	55	113	20	March
55	50	1.20	0.74	17	58	536	750	520	490	743	886	7.5	7.8	49	130	20	April
58	51	1.25	0.77	15	57	547	785	520	488	742	880	7.5	7.8	35	125	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 8

Chemical and physical tests for Tel Hussein water treatment plant.

WQI		Ca ⁺²		TH		Alkali		Ec		TDS		Ph		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
73	83	1.1	0.88	95	144	400	650	459	478	393	400	7.43	8.44	16	5	10	Dec.
74	57	0.52	0.90	23	27	401	622	492	486	396	421	8.2	8.1	14	62	9.4	Jan.
77	60	1.1	1.9	19	29	391	597	352	390	460	513	8	7.9	9	51	9.0	Feb.
76	62	1	0.9	18	29	410	570	335	350	450	500	7.8	7.9	8.8	45	20	March
74	53	1	1.9	96	640	400	645	422	430	386	393	7.7	7.8	15	52	20	April
75	58	0.51	0.93	20	25	403	600	450	473	395	400	8	8	12	60	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 9

Chemical and physical tests for Hoth 6 water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
35	53	0.8	0.60	37	58	540	675	780	449	344	320	8.09	8.10	12	1001	10	Dec.
63	52	0.8	0.65	37	56	540	680	771	449	343	318	8.07	8.09	14	1010	9.4	Jan.
65	53	1	1.2	18	19.28	495	610	691	429	334	302	9.0	9.1	10.1	981	9.0	Feb.
67	53	1.1	1.7	17	61	403	615	609	500	329	300	8	8.1	8	104	20	March
65	49	1.1	7.9	14	50	620	583	702	600	295	286	7.9	7.8	9	89	20	April
65	49	1	7.8	12	47	622	580	700	605	299	290	7.9	7.6	8.5	85	20	May
		200-125 mg/l		500mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 10

Chemical and physical tests for AL Basal water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
73	66	33	50	80	87	320	630	323	445	227	331	7.5	7.1	19.4	29.7	15.1	Dec.
68	45	45	86	98	193	311	591	610	620	295	322	7.2	7.3	8	135	9.1	Jan.
78	48	45	84	93	120	400	501	498	587	366	495	8.1	8.2	5	98	20	Feb.
78	54	90	95	61	111	436	509	433	450	450	466	7.5	7.4	5	90	20	March
73	67	33	51	78	80	318	622	320	440	223	334	8.2	8.2	18.7	27.3	20	April
87	55	75	75	51	110	430	500	430	444	430	450	7.3	7.5	4.8	87	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 11

Chemical and physical tests for Tal Ali water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
35	40	1.2	1.7	48	94	660	890	776	733	530	510	7	7.8	32	290	10	Dec.
57	40	1.46	1.62	53	99	680	900	780	741	543	524	7.28	7.39	34.4	298	9.4	Jan.
64	42	0.5	1.1	97.2	157	660	848	705	663	502	494	7.4	7.5	10.5	205	9.0	Feb.
65	48	0.9	1.5	51	130	593	760	699	610	516	483	8	7.8	8	89	20	March
75	51	1.2	1.9	31	89	601	773	693	640	500	490	8.1	8	5	62	20	April
75	52	0.9	1.4	29	81	600	763	650	530	505	495	7.2	7.9	5	59	20	May
		200-125 mg/l		500 mg/l		200 mg/l		-500 1Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 12

Chemical and physical tests for Al-Shalalah water treatment plant

WQI		Ca ⁺²		TH		Alkali		Ec		TDS		Ph		turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
87	46	0.95	1.18	37	50	420	587	437	486	280	344	8.15	8.3	1.09	223	10	Dec.
87	46	0.94	1.19	43	56	420	590	388	485	280	350	8.18	8.6	1.00	225	9.4	Jan.
87	46	1.1	1.9	68.2	87	430	570	471	382	401	291	8.1	8.6	1.2	239	9.0	Feb.
87	53	1	1.8	22	73	435	501	402	391	410	400	8.1	8.1	0.9	101	20	March
87	55	0.9	1.2	31	91	430	501	459	465	402	329	8.1	8	1	83	20	April
87	56	0.8	1.1	28	87	434	502	463	467	405	327	8.9	8.1	0.9	80	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 13

Chemical and physical tests for Sin Althiban water treatment plant.

WQI		Ca ⁺²		TH		Alkali		Ec		TDS		ph		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
87	48	0.70	0.99	42.3	50.6	440	500	468	490	335	349	8.30	7.85	3.50	180	10	Dec.
86	47	0.7	0.9	39.7	42.3	499	532	460	493	382	400	7.95	8.31	4.1	205	9.4	Jan.
86	47	1.3	1.9	23	49.1	499	583	500	520	402	415	8.1	8.1	4	116	9.0	Feb.
78	44	1	0.84	38	50	440	507	505	430	400	420	7.8	8	4.8	160	20	March
87	48	0.83	0.86	43	51	438	498	462	485	328	337	7.89	7.80	3.48	174	20	April
86	47	1	1	39	42	490	528	455	488	379	398	8	8.22	4.3	197	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 14

Chemical and physical tests for Al Shajarah water treatment plant.

WQI		Ca ⁺²		TH		Alkali		Ec		TDS		ph		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
35	53	9	58	35	55	530	770	563	576	393	414	7.7	7.6	24	54.5	14	Dec.
70	56	10	55	68	78	650	683	420	499	387	400	7.5	7.5	17	70	9	Jan.
74	54	14	80	41	68	593	621	415	508	390	419	7.9	7.9	9	53	20	Feb.
76	55	49	60	27	58	583	519	433	502	363	420	7.3	7.2	6	48	22	March
60	52	6	60	30	45	630	750	550	577	380	414	7.2	7.6	23	58	12	April
76	62	40	85	25	56	581	510	444	500	370	430	7.5	7.3	6.4	45	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 15

Chemical and physical tests for Gharib water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		Ph		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
35	53	1.17	0.81	88	160	410	770	649	576	463	414	7.9	7.6	13	54.5	10	Dec.
66	50	0.82	1.5	14	18	403	702	644	564	450	453	7.93	8.0	12	72	9.4	Jan.
68	62	1.6	2	17	20	415	639	513	500	425	419	8.1	7.8	7	41	9.0	Feb.
74	54	0.82	1.8	15	18	420	600	500	520	418	420	8	7.6	14	52	20	March
66	53	1	0.80	86	158	418	768	647	570	460	410	7.7	7.8	11	54	20	April
66	51	1	1.3	12	16	400	698	600	562	445	448	8	8	13.5	70	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 16

Chemical and physical tests for Al Tarqia water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		Ph		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
39	53	50	36	54	72	780	880	548	645	390	465	8.08	8.05	2	47	14	Dec.
77	53	39	43	52	86	456	676	593	627	389	472	8.1	8.3	2.5	50	9	Jan.
85	54	50	90	48	77	530	600	469	564	401	420	8	7.4	1.8	49	20	Feb.
77	56	95	105	29	65	501	597	589	573	393	400	8	8.1	1.2	43	21	March
74	54	50	35	53	72	750	870	550	640	370	450	7.08	8.04	1.8	42	13	April
77	55	100	155	28	55	500	580	570	570	380	390	8.4	7.1	1.2	44	11	May
		200-125 mg/l		500mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 17

Chemical and physical tests for Abbasid water treatment plant.

WQI		Ca ⁺²		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
86	61	0.85	1.16	32	79	509	670	499	295	440	250	7.3	8.9	0.8	46	10	Dec.
72	53	0.9	1.19	52	83	520	680	508	306	508	207	87.4	8.14	15.4	52.1	9.4	Jan.
86	57	0.85	1.25	76.1	91.6	498	633	333	291	390	325	7.9	8.3	1.9	66	9.0	Feb.
87	61	1.15	1.39	43	95	442	562	301	250	490	402	7.9	7.8	1.2	50	20	March
85	61	1	1.16	37	81	530	620	326	305	433	333	7.8	7.8	0.9	48	20	April
86	60	0.99	1.13	29	72	520	610	329	310	432	330	7.4	8.1	1.4	51	20	May
		200-125 mg/l		500mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25	I.S.S

Table 18

Chemical and physical tests for Abu al-Jess water treatment plant.

WQI		Ca+2		TH		Alkali		EC		TDS		PH		Turbidity		Temp.	Months
treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water	treated water	raw water		
79	70	0.23	0.29	20	23	230	640	300	310	222	240	7.7	8.8	5.6	18	10	Dec.
79	67	0.36	0.27	22	25	270	670	325	329	221	234	8.8	8.7	6.30	20	9.4	Jan.
76	53	0.18	0.36	11.28	12.6	405	701	317	338	535	555	8.7	8.7	9	100	9.0	Feb.
78	55	0.14	0.30	12	39	410	635	299	320	400	450	8	8	6	82	20	March
76	59	0.9	1.9	20	31	550	630	289	315	387	443	8	8.1	5.5	58	20	April
85	61	0.4	1.4	26	29	530	615	287	311	381	439	7.1	7.9	5	45	20	May
		200-125 mg/l		500 mg/l		200 mg/l		500 Mmohs/cm		1000mg/l		8.5-6.5		5 NTU		25 I.S.S	

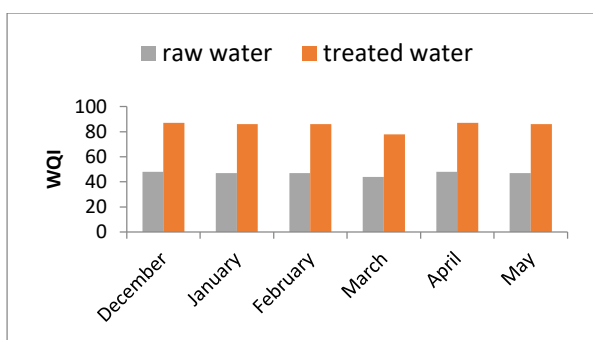
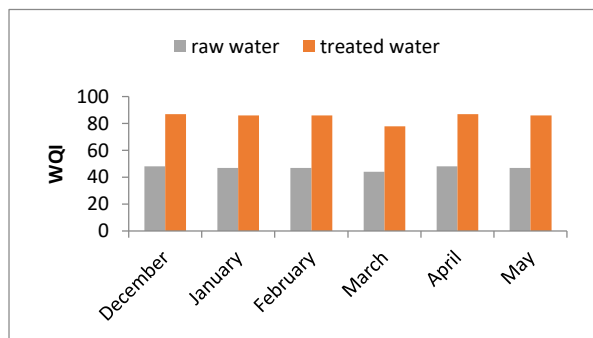
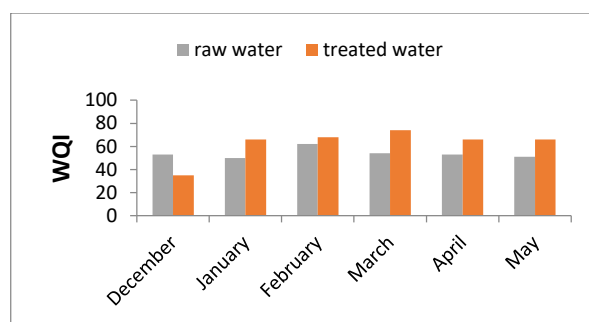
**Fig. 11.** Water quality index Sin Althiban water treatment plant.

Fig. 12 shows the water quality of Al Shajarah water treatment plant, which shows that the raw water was in the category of the fourth (bad), but after treatment became water in the third category (moderate) except for the month of December has remained water quality in the fourth category as is clear in the Table 14.

**Fig. 12.** Water quality index Al Shajarah water treatment plant.

The quality of raw water in (Gharib) water treatment plant was classified as four category (bad) during the study period (Fig. 13). After treatment, the water quality index improved to the third category (moderate) except for December. In the fifth category (very bad), which indicates a defect in this period in the plant as shown in Table 15.

Fig. 14 shows the results of water quality index for (Al Tarqia) water treatment plant and shows that there was a defect during the month of December where the quality of water treated in category V (very bad) The rest of the months of the study was in the

**Fig. 13.** Water quality index Gharib water treatment plant.

second category (good) for the month of Jan, February, March and in the third category (moderate) for April and May as shown in Table 16.

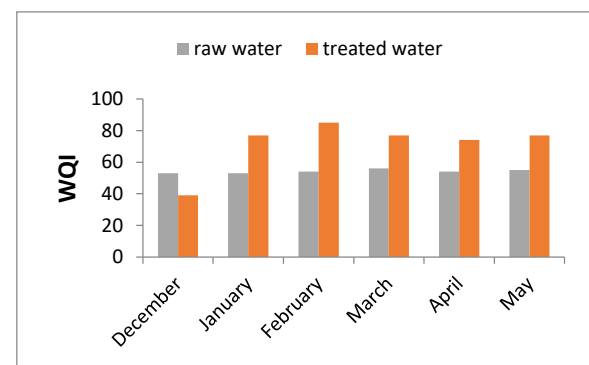
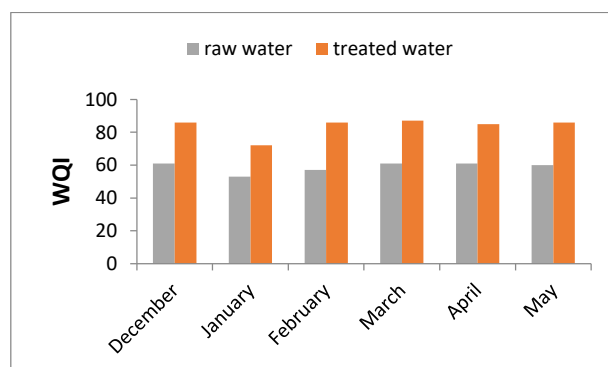
**Fig. 14.** Water quality index Al Tarqia water treatment plant.**Fig. 15.** Water quality index Abbasid water treatment plant.

Fig. 15 represented Water quality index for (Abbasid) water treatment plant. The results indicated that the raw water was classified as category 4 (bad), the treated water was classified in the second category (good) except for Jan. was the quality of water in the third category (moderate) Table 17.

Fig. 16, which represents the water quality index at (Abu al-Jess) water treatment plant indicated that the raw water was in the category of the fourth (bad) to be after treatment in the third category (moderate) except May was in the second category (good) Table 18.

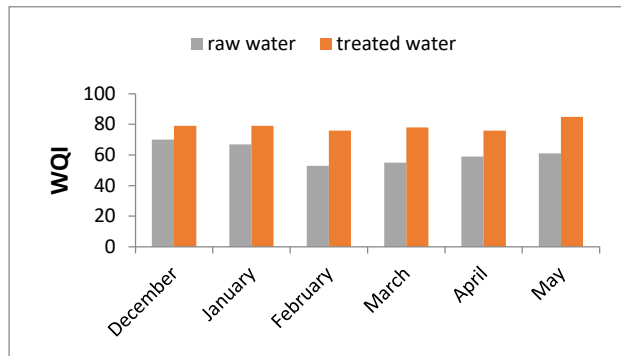


Fig. 16. Water quality index Abu al-Jess water treatment plant.

4. CONCLUSIONS

1. The water quality index of raw water was less than (65) for most plants and most of the months of the study, which is classified in the fourth category (bad).
2. The quality of treated water in Al-Musanaa water treatment plant did not change after the treatment and remained in the fourth category, indicating that there is a defect in the treatment of water in this plant.
3. The values of the water quality index for Al-Shalala and Al-Zaban plants ranged from (80-87), which is classified as category II (good), indicating that these plants work well.
4. The water quality index for the rest of the plants was fluctuated between the fourth and third and the second as shown in the tables and shapes.

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