Evaluation the water quality of the potable water network in Al-Shuala/ Baghdad City

Zainab Bahaa Mohammed, Tariq Abed Hussain, Ghaidaa Majeed Jaid, Ali Zamil

Building and Construction Engineering Department, University of Technology, Baghdad

E-mail: Zbn_asr@yahoo.com

Abstract

In this research, the water quality of the potable water network in Al-Shuala Baghdad city were evaluated and compare them with the Iraqi standards (IQS) for drinking water and World Health Organization standards (WHO), then water quality index (WQI) were calculator: pH, heavy metals (lead, cadmium and iron), chlorides, total hardness, turbidity, dissolved oxygen, total dissolved solid and electrical conductivity. Water samples are collected weekly during the period from February 2015 to April 2015 from ten sites. Results show that the chlorides, total dissolved solid and electrical conductivity less than acceptable limit of standards, but total hardness and heavy metals in some samples higher than acceptable limit of standards while the other parameter is good.WQI shows that results is excellent and good for drinking for all location and months except site (2) gave higher value (65.184) in March and site (9) gave high value (57.78, 57.23) at March and April indicate that sites is poor for drinking water.

Keywords

Iraqi standards, Water Quality Index, Drinking Water, Al-Shuala/ Baghdad city.

Article info.

Received: Sep. 2015
Accepted: Oct. 2015
Published: Dec. 2015

تقييم نوعية المياه في شبكة مياه الشرب في مدينة الشعلة/ مدينة بغداد

زينب بهاء محمد، طارق عبد حسين، غيداء مجيد جاعد، علي زامل

الجامعة التكنولوجية، قسم هندسة البناء والانشاءات، بغداد

الخلاصة

هذا البحث يتضمن تقييم نوعية مياه الشرب لشبكة التوزيع في منطقة الشعلة ومقارنة النتائج مع المواصفات العراقية ومنظمة الصحة العالمية ثم حساب مؤشر نوعية المياه من خلال قياس الدالة الحامضية والعناصر الثقيلة (الرصاص والحديد والكادميوم) الكلوريدات والعسرة والعكارة والاوكسجين المذاب والمواد الصلبة المذابة والموصلية الكهربائية. لقد جمعت العينات من عشرة مواقع اسبوعيا خلال الاشهر شباط واذار ونيسان. وقد بينت النتائج بان الكلوريدات والمواد الصلبة الذائبة والموصلية الكهربائية اقل من الحدود المسموح بها، وكان معدل العسرة وتركيز العناصر الثقيلة لبعض العينات اعلى من الحدود المسموح بها بينما لعينات اخرى كانت النتائج ضمن الحدود المسموح بها. نوعية مؤشر المياه يتراوح بين جيد الى ممتاز لجميع المواقع عدا موقع 2 كانت قيمته عالية (65.184) في شهر اذار وكذلك موقع 9 كانت قيمته عالية خلال شهري اذار ونيسان (57.8,57.23) وهذا مؤشر بان هذه المناطق ضعيفة في تجهيز مياه الشرب.

Introduction

Water is essential for the survival of any form of life. Water scarcity is increasing worldwide and pressure on the existing water recourses is increasing due to the growing demands in several sectors such as Drinking, Bathing, Showering, Agriculture, and Industrial activities, etc. [1, 2]. In general, the quality of water is equally important as the quantity. Therefore, water quality is considered as an important factor to judge environment changes which are strongly associated with social and economic

development[3]. Drinking water is considered as one important topic that has been received a great attention due to the high demand of human consumption used daily [4] and is defined as having acceptable quality in terms of physical, chemical, and biological parameters so that it can be safely used for drinking, cooking and other domestic applications[5]. Some of potable water have become contaminated and that is due to the growing of population, which increased the economic activities and industrialization, as a result of that, many researchers have studied to evaluate the performance of the water treatment plants and on how to improve the quality of drinking water[6]. One of the simplest methods to assess water quality conditions is by using Water quality index (WQI) is a numeric expression used to depict the overall water quality status in a single term which represents the water quality level,that is helpful for selecting appropriate treatment technique to meet the concerned issues [7,8].

The aim of this search is to evaluate the water quality of the potable water network in Al-Shuala Baghdad city and compare them with the Iraqi standards and World Health Organization standards (WHO) for drinking water then calculate Water quality index by measurement: pH, heavy metals (lead, cadmium and iron), chlorides, total hardness, turbidity, dissolved oxygen, total dissolved solid and electrical conductivity.

Materials and methods

1. Study area

The study area is located in Al-Shuala city in the North- West part of Baghdad Iraq,This city characterized by high population density Fig. 1.

2. Data collection and analysis

A total of about 130 water samples were collected in pre cleaned plastic bottles of 2 liters and were analyzed for water quality parameters .Water samples are collected weekly from ten sites in Al-Shuala Baghdad city as shown in Fig.1, during period extended from the February 2015 to April 2015. In this study, evaluate the water quality index of the potable water network were chosen ten parameters namely: pH, heavy metals (lead, cadmium and iron), chlorides, total hardness, turbidity, dissolved oxygen, total dissolved solid and electrical conductivity. pH , total dissolved solid and electrical conductivity were determined with portable Multi-meter ISOLAB, turbidity was measured by turbidity meter(Thermo Orion AQ4500), dissolved oxygen was measured by Lovibondmeter (senso direct oxi 200),chloride and total hardness were determined by titrimetric method [9] and heavy metals (lead, cadmium and iron) were analyzed by flameless atomic absorption spectrometry (Shimadzu AA-6300).

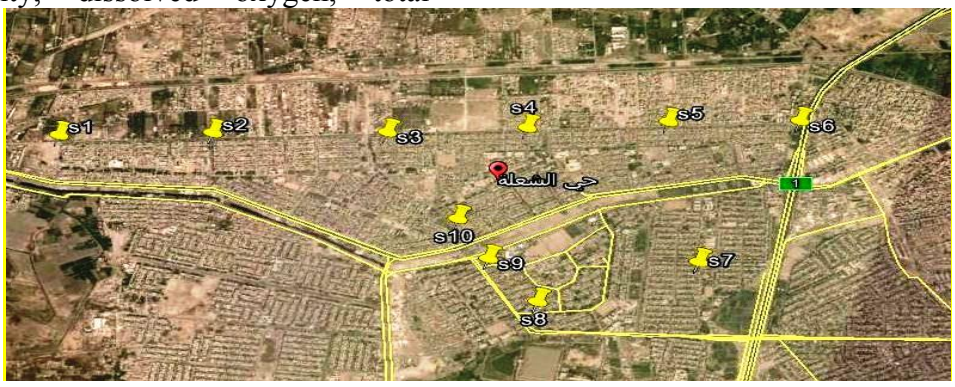

Fig. 1: Sampling sites in Al-Shuala Baghdad city.

3. Calculations of the WQI

WQI indicates the quality of water in terms of index number, which represents overall quality of water for any intended use. It is defined as a rating reflecting the composite influence of different water quality parameters [10, 11]. WQI of drinking water was calculated considering ten important physic-chemical parameters using WHO and the Iraqi standards (IQS) for drinking water. For calculating WQI, the following steps were used:

In the first step, unit weight (Wi) for various parameters is inversely proportional to the recommended standard (V_S) for the corresponding parameter. W_i values were calculated by using the following formula [12, 13]:

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

$$K = \frac{1}{\sum_{i=1}^{i=n} \frac{1}{V_S}} \quad (2)$$

where K = proportionality constant, V_S = world- widely accepted drinking water quality standard. The constant of proportionality K in the above equation can be determined from the following formula [7, 14]:

In the second step, Quality rating (Qi) is calculated as

$$Q_i = 100\left[\frac{V_a}{V_s}\right] \quad (3)$$

While, the quality rating for Ph and Dissolved oxygen ($Q_{pH,DO}$) was calculated on the basis of

$$Q_{Ph,Do} = 100\left[\frac{(V_a - V_i)}{(V_S - V_i)}\right] \quad (4)$$

where, V_a = value of the water quality parameter obtained from the laboratory analysis.

V_i = the ideal value of pH considered as equal to 7.00 and for DO considered as equal to 14.6 (mg/l) [15].

V_s = value of the water quality parameter obtained from recommended standard of corresponding parameter.

This equation ensures that Qi = 0 when a pollutant is totally absent in the water sample and Qi = 100 when the value of this parameter is just equal to its permissible value. Thus the higher the value of Qi is the more polluted in the water, Table 1 shows **the** water quality index scale. Then, the overall WQI was calculated on the basis of weighting and rating of the different physicochemical parameters, as follows [14, 16]:

$$WQI = \sum_{i=1}^{i=n} W_i Q_i \quad (5)$$

Table1: Water quality index scale.

WQI	0-25	26-50	75-51	76-100	>100
Water Quality	Excellent	Good	Poor	Very Poor	Unsuitable

Results and discussion

1- Results and discussion of physical-chemical parameters

The physical and chemical parameters of analyzed drinking water is summarized in Table 2-11 at ten sites in Al-Shuala Baghdad city and in Figs. 2-11 Compares between month we took average value of parameter in each month. pH: The results show that some values of pH are within the maximum permissible limit of WHO and IQS standards and slightly higher in other values than WHO and IQS standards, reaching the highest value 8.66 in site 10 and the lowest value 7.71 in site 8.Gradually pH decreasing from month February to April (2015) as it is shown in Fig. 2. Turbidity and Dissolved Oxygen: Table3 and 4 and Fig. 3 and 4 show that all the turbidity and dissolved oxygen values were

good and bellow the upper acceptable limit, reaching the highest value of turbidity 1.15(NTU) in site 7 and the lowest value 0.11(NTU) in site 6 and for dissolved oxygen the highest value 2.95 (ppm) in site 3 and the lowest value1.6 (ppm) in site 9. Chlorides:The result in Table 5 and Fig.5 shows low concentration of chloride element in some samples less than acceptable limit of WHO and IQS standards, reaching the highest value of chloride 320 (ppm) in site10 and the lowest value 80.25 (ppm) in 1. Total Hardness**:** The results in Table 6 and Fig.6 showed that the values ofTotal hardness in Februaryhigher in some values than WHO and IQS standardsand reach the acceptable limit in March and April (2015), the highest value of Total hardness 650 (ppm) in site 2 and the lowest value 150 (ppm) in site 8. Total dissolved solid and electrical conductivity: The result of these parameters in Table 7 and 8 and Fig. 7 and 8 shown relatively low for Total dissolved solid and electrical conductivity than acceptable limits values except two point for Total dissolved solid in site 1 and 2 in February they reached the acceptable limits. The highest value of Total dissolved solid 520 (ppm) in site 1 and the lowest value 344 (ppm) in site 4, and for electrical conductivity the highest value 773 (µS/cm) in site 1 and 2 and the lowest value 605 (µs/cm) in site 5. Heavy metals: Tables (9,10and11) and Figs. (9,10and11) show that the results of heavy metals, Cd and Pb in February Cd and Pb in February showing good result they didn't give any concentration in drinking water, in march and April the results showed that drinking water samples in site 2, 4 and 9 for Cd and site 1, 2, 4 and 9 for Pb have higher concentration than that recommended by WHO and IQS standards. The highest value of Cd is 0.00912 (ppm) in site 2 and for Pb is 0.0806(ppm) in site 1.The higher concentrations of Fe shown in most sample especially in site 9 And in February reaching the highest value 3.78 (ppm) in site 9.

Table 2: pH values.

Site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	05/4	12/4	19/4	26/4
1	8.35	8.2	8.24	8.13	8	8.07	8.2	8.22	8.16	8.3	8.29	8.15	8.11
2	8.33	8.21	8.16	8.08	8.03	8.05	8.11	8.14	8.12	8.09	8.03	8	7.82
3	8.51	8.42	8.22	8.05	8.02	8	7.9	8.12	8.2	8.06	8.09	8.1	7.89
4	8.43	8.33	8.25	8.01	8	8.03	8.04	7.9	8	8	7.93	7.88	7.84
5	8.56	8.38	8.2	8.12	8.02	8.02	8.03	8.05	8.2	8.03	7.9	7.87	7.84
6	8.5	8.42	8.33	8.31	8.35	8.3	8.23	8.21	8.17	8.1	7.91	7.9	7.8
7	8.45	8.35	8.33	8.38	8.37	8.28	8.24	8.23	8.2	8	7.88	7.86	7.91
8	8.38	8.4	8.32	8.36	8.42	8.43	8.4	8.37	8.18	7.97	7.89	7.8	7.71
9	8.44	8.41	8.38	8.38	8.36	8.31	8.27	8.25	8.04	7.88	7.81	7.76	7.68
10	8.39	8.4	8.43	8.5	8.66	8.56	8.45	8.4	8.1	7.9	7.86	7.83	7.8

Table 3: Turbidity values in Nephelometric Turbidity Unit (NTU).

Site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	05/4	12/4	19/4	26/4
1	0.22	0.2	0.23	0.25	0.33	0.24	0.22	0.21	0.2	0.23	0.21	0.2	0.21
2	0.19	0.2	0.17	0.26	0.41	0.34	0.29	0.24	0.2	0.19	0.23	0.21	0.18
3	0.36	0.33	0.35	0.33	0.351	0.29	0.32	0.34	0.31	0.32	0.32	0.33	0.36
4	0.22	0.18	0.28	0.32	0.37	0.29	0.23	0.19	0.25	0.22	0.16	0.16	0.18
5	0.29	0.28	0.25	0.27	0.25	0.25	0.27	0.29	0.27	0.28	0.29	0.28	0.27
6	0.12	0.11	0.14	0.14	0.15	0.13	0.15	0.14	0.12	0.12	0.11	0.15	0.2
7	0.38	0.4	0.42	0.44	0.45	0.45	0.43	0.44	0.41	0.45	0.41	0.86	1.15
8	0.24	0.28	0.33	0.35	0.38	0.4	0.38	0.36	0.37	0.4	0.42	0.39	0.36
9	0.23	0.25	0.3	0.32	0.35	0.33	0.28	0.3	0.27	0.28	0.27	0.57	1.12
10	0.21	0.22	0.2	0.21	0.2	0.22	0.23	0.21	0.23	0.24	0.24	0.22	0.23

Table 4: Dissolved oxygen values (ppm).

Site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	05/4	12/4	19/4	26/4
1	2.16	2.22	2.5	2.55	2.71	2.77	2.63	2.35	2.54	2.42	2.83	2.31	1.98
2	1.98	2	2.3	2.29	2.25	2.6	2.36	2.21	2.33	2.51	2.26	2.54	2.93
3	2.31	2.14	2.19	2.21	2.28	2.32	2.55	2.48	2.73	2.49	2.95	2.45	2.61
4	1.91	2.18	2.34	2.21	2.52	2.33	2.39	2.4	2.21	2.32	2.19	2.38	2.44
5	2.48	2.35	2.42	2.37	2.68	2.5	2.45	2.38	2.38	2.44	2.35	2.3	2.21
6	2.3	2.5	2.33	2.45	2.71	2.41	2.25	2.32	2.46	2.33	2.15	2.46	2.5
7	2.37	2.66	2.28	2.3	2.58	2.47	2.81	2.51	2.45	2.67	2.91	2.52	2.12
8	2.32	2.52	2.41	2.8	2.73	2.41	2.5	2.49	2.37	2.22	2.5	2.31	2.42
9	1.6	1.98	2.21	2.51	2.78	2.5	2.32	2.37	2.22	1.98	2.42	2.27	2.14
10	2.86	2.7	2.68	2.54	2.7	2.43	2.35	2.48	2.27	2.3	2.25	2.28	2.3

Table 5: Chlorides values (ppm).

Site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	5/4	12/4	19/4	26/4
1	165	145	130	112	80.25	88	96	112	120	118	111	133	164
2	125	136	140	112	80.5	125	138	143	145	138	151	177	273
3	275	250	217	142	135	156	178	241	255	271	297	230	223
4	100	110	115	100	100	120	119	122	138	165	198	187	164
5	170	156	141	120	115	127	121	136	150	143	149	165	189.5
6	275	230	250	248	280	267	190	164	142	130	112	178	263
7	175	180	210	254	275	260	233	220	246	254	268	241	200
8	225	218	220	251	273	255	247	216	210	169	198.5	151	149
9	200	210	230	225	250	235	228	231	229	218	223	211	198.5
10	320	284	278	255	245	267	285	281	279	284	273	278	288

Table 6: Total Hardness values (ppm).

Site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	05/4	12/4	19/4	26/4
1	330	400	375	390	410	378	350	365	315	320	312	325	300
2	650	520	555	530	550	480	445	365	300	275	255	210	200
3	550	530	575	550	600	555	400	310	288	265	255	275	250
4	400	555	500	520	565	520	475	430	465	410	350	310	275
5	340	350	380	365	400	380	335	365	310	312	320	255	215
6	550	600	565	580	600	576	522	435	375	200	216	230	255
7	350	370	330	350	400	365	315	382	357	400	370	220	175
8	450	480	475	455	487	458	400	410	370	325	275	210	150
9	400	550	520	500	550	466	420	380	315	275	230	250	200
10	640	580	600	625	580	555	500	450	375	210	185	200	175

Table 7: Total dissolved solid values (ppm).

Site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	5/4	12/4	19/4	26/4
1	472	471	490	482	502	497	475	460	463	448	436	447	457
2	510	508	501	490	499	481	489	466	460	461	429	448	465
3	400	405	404	415	413	410	432	439	447	440	444	451	466
4	474	434	432	376	344	386	406	432	436	437	435	445	472
5	450	444	424	406	398	408	423	427	430	451	442	452	466
6	434	436	446	456	461	450	455	448	452	451	444	459	469
7	436	435	415	423	400	423	432	435	444	447	448	447	448
8	440	438	444	425	410	437	434	446	443	445	442	448	463
9	440	438	452	453	470	454	448	451	443	438	436	460	465
10	448	447	455	460	458	454	452	455	454	452	449	454	462

Table 8: Electrical conductivity values (µs/cm).

Site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	5/4	12/4	19/4	26/4
1	716	725	765	743	773	766	732	708	713	690	662	689	693
2	773	771	761	745	758	730	743	708	699	700	651	680	705
3	606	615	613	630	627	622	655	666	678	666	675	684	706
4	721	661	665	558	524	587	618	657	663	665	661	676	717
5	682	676	645	618	605	621	643	650	653	687	671	687	709
6	660	664	678	694	702	685	692	681	688	687	672	698	712
7	662	661	632	643	607	644	657	662	676	680	679	680	681
8	667	676	680	646	624	665	661	678	674	677	670	681	703
9	666	687	700	689	714	690	682	686	674	666	662	700	707
10	680	692	688	700	697	691	687	692	690	688	681	690	700

Table 9: Cd values (ppm).

site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	5/4	12/4	19/4	26/4
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0.00912	0	0	0.0009	0	0.001128
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0.0038	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0.0077	0	0	0	0	0.0088
10	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10: Fe values (ppm).

site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	5/4	12/4	19/4	26/4
1	0	0	0	0	0	0	0	0.0538	0	0	0	0	0.0806
2	0	0	0	0	0	0	0	0.04	0	0	0.0134	0	0.0134
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0.0007	0	0	0	0	0.08
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0.0403	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11: Pb values (ppm).

site	1/2	8/2	15/2	22/2	1/3	8/3	15/3	22/3	29/3	5/4	12/4	19/4	26/4
1	0	0	0	0	0	0	0	0	0	0	0	0.0595	0
2	0.0905	0	0	0	0	0	0.0643	0.159	0	0	0	0.0255	0
3	0	0	0	1.0402	0	0	0	0.1035	0	0	0	0	0
4	0	0	0	0.0905	0	0	0	0.0007	0	0	0	0	0
5	0	0	0	0	0	0.0084	0.0876	0.0671	0	0	0	0.0312	0.0454
6	0	0	0	0.4774	0	0	0	0.0895	0	0	0	0	0
7	0	0	0	0	0	0	0	0.0531	0	0	0	0	0
8	0	0	0	0	0	0	0	0.1147	0	0	0	0	0
9	1.005	1.08	0.932	3.78	0.15	0.0895	0.9087	0.2629	0.095	0.9844	0.1844	0.5642	0.2241
10	0	0	0	0.0266	0	0	0	0.0895	0	0.0531	0.0057	0.0056	0.0255

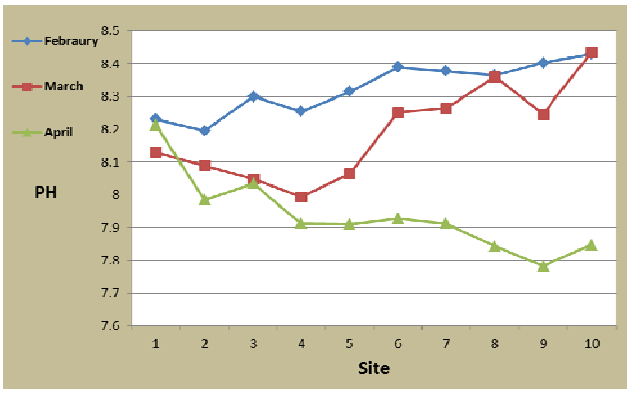

Fig. 2: pH values.

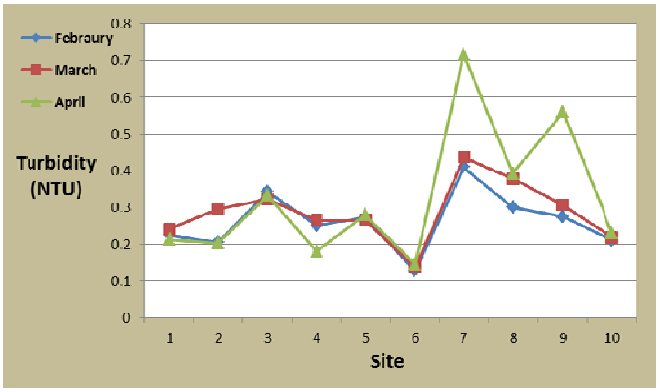

Fig. 3: Turbidity values.

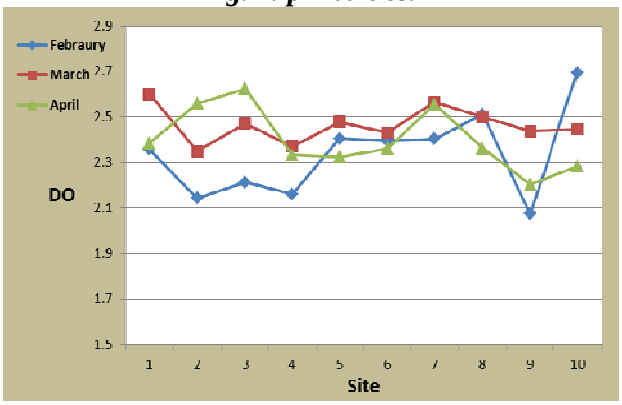

Fig. 4: DO values.

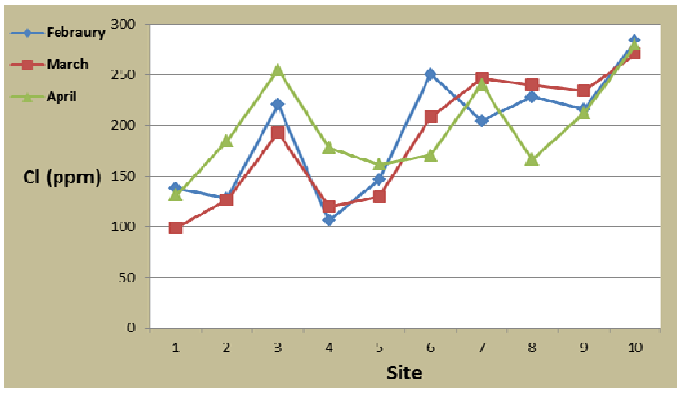

Fig. 5: Chlorides values.

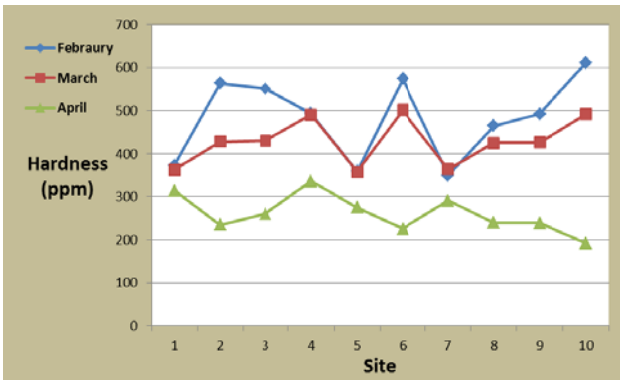

Fig. 6: Total Hardness values.

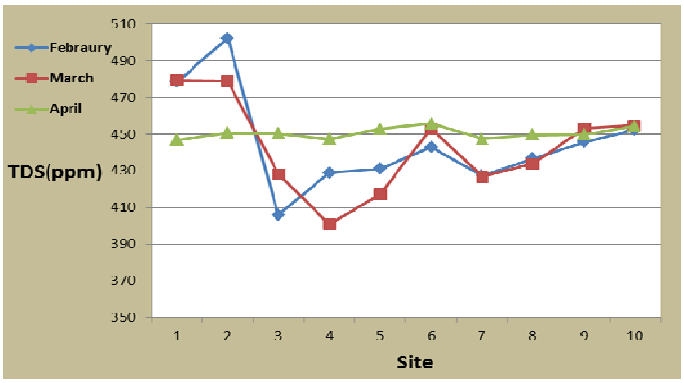

Fig. 7:Total dissolved solid values.

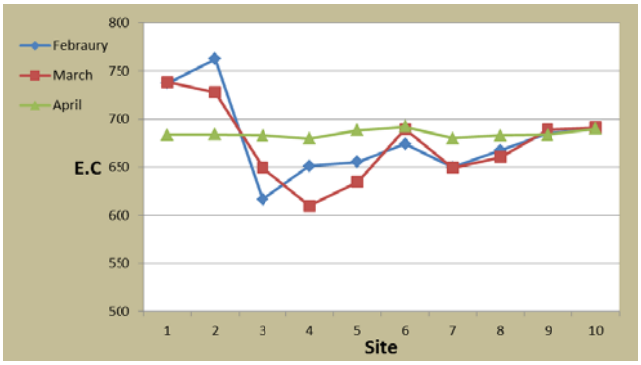

Fig. 8: Electrical Conductivity values.

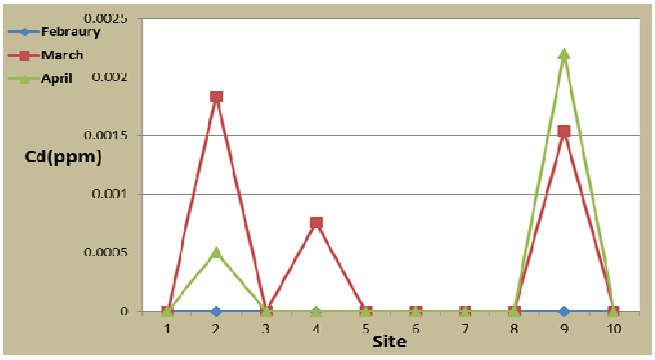

Fig. 9: Cd values.

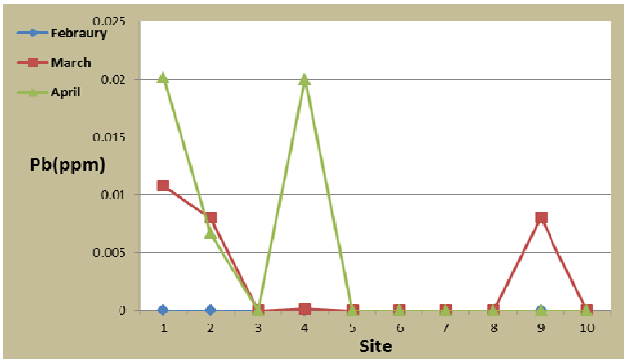

Fig. 10: Pb values.

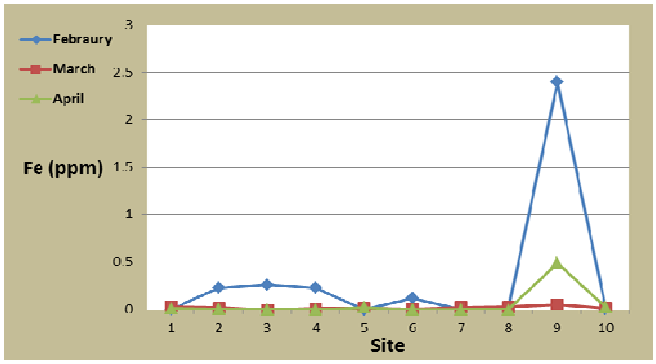

Fig. 11: Fe values.

2- Water quality index (WQI)

The physico-chemical parameters with their WHO and IQS standards, and weights are listed in Table 12. The water quality index that were found in three different months for ten sites have been represented in Table 13 and Fig. 12. From the comparative analysis of WQI values for all sampling location in both Months it was observed that The WQI in site (1, 3, 4, 5,6,7,8 and 10) various between Excellent and good for drinking water, for site 2 Showed the higher value (65.184) in March than other sites and months which imply that the water in this month is poor for drinking and for Site 9 Gave WQI variation ranged from lower value (3.1358) at February and higher values (57.78 and 57.23) at March and April and classify from excellent to poor water quality for drinking. The values of WQI indicate that site 2 and 9 should practice more efforts in controlling of treatment systems.

Table 12: The physico-chemical parameters with WHO and IQS standards.

Parameter	IQS,2001	WHO	Weight of the factor
PH	6.5-8.5	6.5-8.5	0.0002691
Dissolved Oxygen(DO) ppm	5	5	0.00046
Turbidity (NTU)	5	5	0.00046
Chloride (Cl) ppm	200-600	250	0.0000092
Total hardness as CaCO3 ppm	100-500	500	0.0000046
Electrical conductivity (EC) µS/cm	1000	1500	0.0000023
Total Dissolved Solid(TDS)ppm	500-1000	1000	0.000004574
Iron(Fe) ppm	0.3	0.3	0.007623333
Cadmium(Cd)ppm	0.003	0.003	0.762333333
Lead(pb)ppm	0.01	0.01	0.2287

Table 13: The water quality index.

Site	WQI, February	WQI 2,March	WQI 3,April
1	0.0839	24.77	46.2
2	0.66	65.184	28.301
3	0.748	0.0787	0.0804
4	0.66	19.42	45.82
5	0.0853	10.6	0.127
6	0.391	0.1076	0.0777
7	0.087	0.141	0.082
8	0.086	0.1513	0.0785
9	3.1358	57.78	57.23
10	0.103	0.13	0.135
Total	6.04	178.3626	178.1316

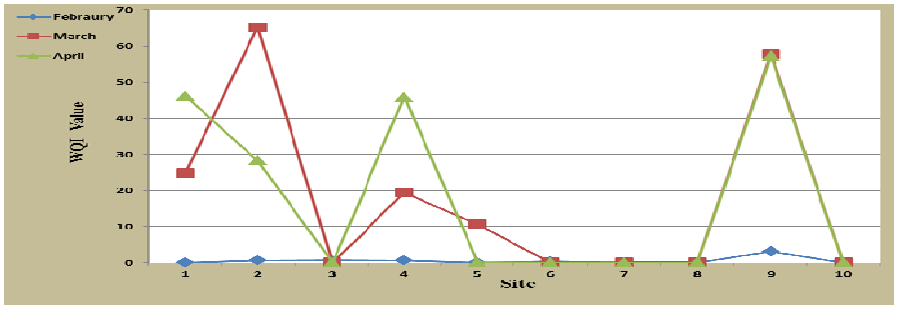

Fig. 12: The water quality index.

References

[1] K .A.H Al-Morshidy, M. J.Y Al-Amari,Advances in Natural and Applied Sciences Journal, Iraq, 9, 3 (2015) 80-84.

[2] M. M Nua'man, Tikrit Journal of Engineering Sciences, Iraq, 20, 3 (2013) 53-63.

[3] A. I. Khwakaram, S .N. Majid, N. Y. Hama, IJPAES, Iraq, 2, 4 (2012) 65-75.

[4] M. S. Moyel, A. H. Amteghy, T. K. Naseer, E. A. Mahdi, B. M. Younus, M. A. Albadran, Marsh Bulletin, Iraq, 8, 1 (2013) 65-75.

[5] W. B. Al-Tmemy, A. J. Al-Azzawi, Wasit Journal for Science and Medicine, Iraq, 7, 4 (2014) 277-288.

[6] H. Janna, A. A. Al-Samawi, International Journal of Advanced Research, Iraq, 2, 10 (2014) 823-829.

[7] A.B. Ahmad, IOSR Journal of Agriculture and Veterinary Science, Iraq, 7, 9 (2014) 34-41.

[8] A.H.M. Alobaidy, H.S. Abid, B.K. Maulood, Journal of Water Resource and Protection, Iraq, 2 (2010) 792-798.

[9] APHA, AWWA, WEF, Standard Methods for the Examination of Water and Wastewater. 20th Edn, APHA, Washington, DC. (1998).

[10] F.A.A. Al-Badran, Journal for Engineering Science, Iraq.2, (2013) 65-75.

[11] K.A. Abdulrazzaq, W.S. Kamil, Journal of Engineering, Iraq, 16, 4 (2010) 45-57.

[12] A.S. Alsaqqar, B.H. Khudair, A.A. Hasan,Journal of Engineering, Iraq, 19, 12 (2013) 1619-1633.

[13] A.H.M. Alobaidy, B.K. Maulood, A.J. Kadhem, J. Water Resource and Protection, Iraq, 2, (2010) 629-635.

[14] M.K. Akkaraboyina, B.S.N. Raju, Universal Journal of Environmental Research and Technology, India, 2, 3 (2012) 161-167.

[15] C.S. Rao, B.S. Rao, N.M. Bharathi; IJABPT, India, 1, 1 (2010) 79-86.

[16] A. Chauhan, S. Singh, J.N.G.O., India, 2, 9 (2010) 53-61.