Evaluation of raw water quality in Wassit governorate by Canadian water quality index

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Abstract. In this work an attempt has been done to evaluate the raw water quality in Wassit Governorate by using Canadian Council of Ministers of Environment Water Quality Index (CCME WQI). Six stations along Tigris River were located and the field work was conducted during one year from October 2015 to September 2016 in collecting data. Twelve water parameters were used to evaluate the water quality index (pH, turbidity, total dissolved solid, total alkalinity, total hardness, nitrate, calcium, sodium, potassium, magnesium, chloride, and sulfate). The raw water quality in Wassite Governorate has been ranged between (65-79) based on CCME WQI results, which means that the river has not been in its good condition, and need to be manage to control the sources of pollutants by monitoring to keep them in their natural condition.

1 Introduction

One of the essential part of any environmental monitoring program is the reporting of results to both general public and the managers. This task is so complex in water quality monitoring because of the large number of measured variables required analyzing. One of the suggested solution of this problem is employing an (water quality index), that will arithmetically combine all water variable parameters measures and provide a general understood description of water. This index is a good tool for ranking the suitability of water use by humans, wild life, aquatic life, etc. [1]. Water quality index was creating by the Canadian Council of Ministries of Environment (CCME) in 1997. The index value can range between 0 and 100. Increasing values are indicative of increasing water quality in which CCME WQI value between 95-100 means that the water quality is excellent while CCME WQI values between 0-44 means that the water quality is poor. In Iraq, many attempts has been done to evaluate the water quality index for both Tigris and Euphrates rivers in different locations. Shaymma and Ayad, 2012 studied the water quality index for Euphrates river from Al-Qaim to Al-Qurna for both drinking and irrigations water. The results shows that the water quality for overall drinking and irrigation uses in the period between April 1998 to April 2001 is mostly rated between good to very poor [2]. Alhassan, 2013 make an attempt to calculate the overall water quality index for

Tigris river as a case study using six water parameters in Baghdad city. The results indicated that the Tigris water quality are ranged between poor and slightly polluted [3]. Layla, 2015 used CCME QWI to evaluate the water quality index of three adjacent water treatment stations in Shat Al-Hila River. The results showed that all evaluated parameters of treated water were within Iraqi standard except turbidity and the water quality is good [4]. Salam, 2016 studied the water quality of Al-Gharraf river in south of Iraq using CCME WQI. The result shows that the water of Al-Gharraf classified to poor for aquatic life and fair for irrigation with seasonal overall WQI values of 30-39 and among stations was 38-29.

The objective of the present research is to evaluate the raw water quality of Tigris river in Wassit Governorate using CCME WQI.

2 Data and samples collection

To assess water quality conditions relative to water quality objectives, twelve water parameters were **tested** during one year from October 2015 to September 2016. Six locations were used for tacking samples over 160 km long on Tigris River within Wassite governorate. The sampling locations distributed between Al-Swiara and Al-Kut City. Water samples were tested twice in month and the average values for each parameters were recorded for WQI evaluation.

Figure 1 shows the aerial photo for sampling location within Wassite governorate, while table 2.1

shows the UTM coordinate for sampling locations.

Fig. 1. Aerial photo for sampling locations within Wassite governorate.

Table 1. The UTM coordinates for sampling locations

Sample no.	N	E
1	3642820	481467
2	3602139	539368
3	3597279	575568
4	3594828	579097
5	3595648	575885
6	3595150	576391

2.1 Water quality index measurement

The selection of appropriate water quality variables is necessary to yield meaningful water quality index results. This related to a professional judgment of the observer. After collecting the data for the twelve parameters for raw water in Wassite governorate during one years, the water quality index were calculated using CCEM WQI. The values of water quality index factors (F1, F2, and F3) are calculated as flow, F1, and F2 are calculated directly, while F3 are need some additional steps.

$$F1 = \frac{\text{Number of variables that failed}}{\text{Total number of variables}} * 100 \quad (1)$$

Where F1, is the percentage of variables that not meet the objectives at least one during the period of observation failed variables).

$$F2 = \frac{\text{Number of failed test}}{\text{Total number of tests}} * 100 \quad (2)$$

Where F2, is the percentage of tests that not meet the objectives (failed test). For calculation the factor F3, which represented by the equation

$$F3 = \frac{nse}{0.01 nse + 0.01} \quad (3)$$

In which, F3 represent the amount by which failed tests values don't meet their objectives, and nse is the normalized sum of excursion, which are calculated by

$$nse = \frac{\sum_{i=1}^n \text{excursion}}{\# \text{ of tests}} \quad (4)$$

equation are calculated by dividing the sum of excursion that represented the amount by which each failed test are out of complains with relative of all tests(sum of tests meet and not meet objectives).

The excursion are calculated either by

$$\text{Excursion} = \left(\frac{\text{test values failed}}{\text{objectives}} \right) - 1 \quad (5)$$

This equation is used when the test values must not exceed the objectives.

$$\text{Excursion} = \left(\frac{\text{objectives}}{\text{test values failed}} \right) - 1 \quad (6)$$

This equation is used when the test values is fall below the objectives.

After calculating the three factors (F1,F2, and F3) the

$$\text{CCME Water Quality Index} = \frac{\sqrt{F1^2+F2^2+F3^2}}{1.732} \quad (7)$$

The CCME.WQI results ranged between 0 and 100 as shown in table 2.

Table 2. Shows the ranking of water categories due to CCME results

Degree	Water categories
95 -100	Excellent (natural water, no threat detected)
80 - 94	Good (rarely depart from natural condition)
65 - 79	Fair (sometimes depart from natural levels)
45 - 64	Marginal (often depart from natural and desirable level)
0 - 44	Poor (usually depart from natural or desirable level)

3 Results and discussion

The average of some of the physical and chemical properties (turbidity, alkalinity, and calcium) in all six sample locations during study period are greater than the permissible level recommended by the Iraqi standard for drinking water, respectively greater than 5 NTU, 125 mg/L , and 100 mg/L. Figure 2 shows the variation in turbidity values during study period in two locations samples in Kut

city, while the sulfate values recorded are greater than recommended levels (250mg/L) in all locations during some specific months. Figure 3 shows the variation of sulfate also in these two locations in kut city. The results obtained by this investigation showed that the values of other parameters are within Iraqi standard. See tables in appendix A, while the permissible levels for all water parameters in the study are tabulated in table 3 for Iraqi, WHO, and CCME.

Fig.2. Variation of turbidity values in two locations samples in Kut City.

Fig.3. Shows the values of sulfate recorded during one year in two locations in Kut city

Table 3. Shows the limits of some raw water parameters for Iraq, WHO, and CCME

parameter	pH	TDS mg/l	Turbidity (NTU)	Alkalinity mg/l	Nitrate mg/l	T.H as CaCO_3	Ca^{+2} mg/l	Mg mg/l	K mg/l	Na mg/l	Cl mg/L	SO_4 mg/L
Iraqi standard	6.5-8.5	1000	5	125	50	500	50	50	10	200	250	250
WHO	6.5-9.5	500	5	100	50	250	100	50	12	200	250	250
CCME	6.5-9.0	500	5	-	48.2	250	-	50	12	100	110	125

The estimated values of water quality index by CCME method for all locations are tabulated in table 4, the values are ranged between 70.4 and 72.0 .

The water quality of Tigris river and its branches(Al- Djila and Ghraff)in Wassite governorate are ranged in

fair class (65-79), that means the river required to be managed, and take care to be under consideration to control the source of pollutant that thrown to the river to keep them in its natural conditions.

Table 4. Shows the values of CCME WQI for raw water in Wassite governorate.

location	F1	F2	F3	CCMEWQI
Al-Swaira	33.3	25.7	23.3	72.0
Al- Noamania	33.3	25.7	27.5	70.8
Before Kut Barrage	33.3	25.7	27.0	71.1
After Kut Barrage	33.3	27.0	27.0	70.4
Al-Djiala river	33.3	25.7	28.0	70.8
Al-Gharaff river	33.3	25.7	27.0	70.5

4 Conclusions

Water quality index is a useful tools for the assessment of raw water states and can be used in formulating the pollution control strategies in terms of required treatment.

The calculated water quality index results showed that the Tigris raw water quality in Wassit governorate in all six sampling location were in fair condition with accordance to CCME WQI categories.

The raw water of Tigris river in Wassite governorate required to be observed and managed well by the local authorities to keep it in its natural condition and prevent degradation of its properties.

References

- 1- CCME, Canadian Council of Ministers of the Environment (2001). *Water Quality Index 1.0*

- Technical Report". In Canadian Environmental Quality Guidelines.
- 2- S. Alhashimi, A. Mustafa. *International Journal of Environment and Water* (2012)
- 3- H. Ismail. J. Al-Taqani, vol.26, no. 2. (2013)
- 4- L. Abdulkareem. J. Appl. Science, Engineering and Technology10(11)- 1343-1346 (2015)
- 5- S. Ewaid. J. of Science, Vol. 57, No. 24, pp: 878-885(2016)
- 6- K. Husain, J. *Environmental Monitoring and Assessment*, 88: 221–242 (2003).
- 7- UNEP/GEMS,. <http://www.gemswater.org/>.
- 8- L. Boemo, A.Musso. j. Water SA., 33(4): 479-485 (2007)
- 9- S. Gholamreza , A. Masoud, j. *Environmental Science*, 6, (4):19-28(2009).
- 10- A. Al-Obaidy. J. Water Resource and Protection, 2: 629-635(2010)
- 11- Z. Al-janabi, j. Al-Nahrain Univ., 15(1) 119-126(2012)
- 12- Word Health Organization (WHO)," *Guidelines for Drinking Water Quality* " 4th Edition Word Health Organization (WHO), Geneva(2011)

APPENDIX A

Table A1. Chemical test results for raw water at Swiara city station.

parameter	pH	TDS mg/l	Turbidity (NTU)	Alkalinity mg/l	Nitrate mg/l	T.H as caco ₃	Ca ⁺² mg/l	Mg mg/l	K mg/ l	Na mg/l	Cl mg/ L	SO ₄ mg/L
Oct.2015	7.31	684	16	152	4.1	286	74	25	4.21	86.8	107.8	129
Nov.2015	7.26	824	29.2	160	5.4	324	88	25	5.2	105	137.2	240
Dec.2015	7.06	786	18.1	150	4.6	316	80.6	26	3.8	105.5	132.3	216
Jan.2016	7.21	864	14.9	180	4.6	356	88.2	34	4.2	120.5	135.2	336
Feb.2016	7.76	636	9.44	150	5.4	290	72	24.2	4.3	98.5	117.6	162
Mar.2016	7.15	602	14.4	146	4.2	308	70.4	28.8	3.2	92.5	109.7	173
Apr.2016	7.62	696	19.7	156	3.2	286	67.4	30.2	3.2	90	123.5	208
May.2016	7.6	522	23.6	140	3.6	286	72	24	3.4	86.4	107.8	176
Jun.2016	7.36	630	17.7	150	4.2	286	80.4	21.2	3.1	86.5	111.7	200
Jul.2016	7.6	590	31.5	152	4.4	280	73.2	25	3.4	95	113.7	132
Aug.2016	7.73	596	32.4	156	3.4	274	75	20.8	4.2	80.5	107.8	162
Sep.2016	7.2	658	10.2	166	3.4	310	82	26.6	2.8	95.5	129.3	200
objective	6.5- 8.5	1000	5	125	50	500	50	50	10	200	250	250

F1 = 33.3 , F2 = 25.7, F3= 23.3, **WQI = 72**

Table A2. Chemical test results for raw water at Noamania city station.

parameter	pH	TDS mg/l	Turbidity (NTU)	Alkalinity mg/l	Nitrate mg/l	T.H as caco ₃	Ca ⁺² mg/l	Mg mg/l	K mg/l	Na mg/l	Cl mg/ L	SO ₄ mg/L
Oct.2015	7.29	710	27.8	160	2.84	300	78	23.5	5.16	92	113	140
Nov.2015	7.22	820	23.6	166	5.8	320	86	28	5.6	115	139	248
Dec.2015	7.08	792	16.8	165	4.2	328	83.4	27.8	3.4	110	135	224
Jan.2016	7.32	860	20.6	170	5.2	340	86.2	36	4.8	115	137	314
Feb.2016	7.81	654	40.2	156	5.8	298	74.2	26.3	4.8	105	124	148
Mar.2016	7.32	674	13.5	160	4.4	316	72	28.2	3.8	98	115	162
Apr.2016	7.7	796	23.8	160	4.8	300	71	28.6	3.4	96	127	227
May.2016	7.4	564	21.8	156	3.4	300	80	23.4	4.1	91.5	115	166
Jun.2016	7.57	710	20.3	170	4.6	300	80	23.5	3.4	95	121	183
Jul.2016	7.4	610	36.8	150	4.8	294	78.6	23.6	3.6	98.5	119	128
Aug.2016	7.81	630	26.7	160	3.6	286	78	22.5	3.4	85.2	117	172
Sep.2016	7.6	666	32.6	172	3.2	320	86	25	3.2	90.5	132	186
objective	6.5- 8.5	1000	5	125	50	500	50	50	50	200	250	250

F1 = 33.3, F2 = 25.69 F3 = 27.53, **WQI = 70.97**

Table A3. Chemical test results for raw water at Kut city station. Before Kut Barrage section 1.

parameter	pH	TDS mg/l	Turbidity (NTU)	Alkalinity mg/l	Nitrite mg/l	T.H as caco ₃	Ca ⁺² mg/l	Mg mg/l	K mg/l	Na mg/l	Cl mg/ L	SO ₄ mg/L
Oct.2015	7.3	692	31.8	146	2.84	294	80	21.4	3.82	90.5	107.8	132
Nov.2015	7.2	826	24.8	178	5.2	336	91	30	4.8	98.8	133.3	236
Dec.2015	7.04	826	24.5	160	4.8	310	84	22.6	4.2	100.8	139	236
Jan.2016	7.64	986	19	200	6.8	380	98	38.4	5.6	138.6	152	320
Feb.2016	7.58	720	17.8	148	4.6	300	75.6	30	3.6	96.4	113.7	168
Mar.2016	7.23	620	20.3	155	5.2	294	68.7	30	4.6	105	120.5	152
Apr.2016	7.62	824	14.2	150	3.6	290	68.6	30	4.4	100.5	122.5	238
May.2016	7.8	618	18.9	144	2.8	282	77.4	26.4	3.2	85.5	109.8	196
Jun.2016	7.42	626	25.2	160	3.8	284	76	22.4	2.8	100	115.6	220
Jul.2016	7.5	616	28.6	166	3.8	266	70.6	21.8	4.2	105	127.4	138
Aug 2016	7.9	664	25.2	156	4.2	264	74.2	21.2	3.6	90.5	125.4	180
Sep.2016	7.4	654	19.4	160	4.4	300	80.2	27.5	2.8	100	127.4	198
objective	6.5- 8.5	1000	5	125	50	500	50	50	50	200	250	250

F1= 33.33, F2 = 25.7, F3 = 26.84, **WQI = 71.19**

Table A4. Chemical test results for raw water at Kut City station. Section 2. After Kut Barrage

parameter	pH	TDS mg/l	Turbidity (NTU)	Alkalinity mg/l	Nitrate mg/l NO ₃	T.H as caco ₃	Ca ⁺² mg/l	Mg ⁺² mg/l	K ⁺¹ mg/ l	Na ⁺¹ mg/l	Cl ⁻¹ mg/ L	SO ₄ ⁻² mg/L
Oct.2015	7.28	718	49.6	166	3.66	310	84	22	4.81	98.8	122	146
Nov.2015	7.19	832	28.6	184	6.6	342	90	32	6.4	126	147	252
Dec.2015	7.11	818	18.7	156	5.6	330	90	28	4.8	120	143	246
Jan.2016	7.52	876	25.2	176	4.8	336	96	36	5.2	125	139	288
Feb.2016	7.78	766	42.6	166	5.8	312	80	28	4.8	115	131	178
Mar.2016	7.08	604	13.8	166	4.8	310	71.5	29	3.8	100	117	148
Apr.2016	7.84	838	8.91	166	5.2	310	72	31	4.2	110	135	263
May.2016	7.5	632	28.6	160	4.6	318	82	24.6	4.6	105	121	184
Jun.2016	7.64	642	36.8	170	4.2	296	81	21.6	3.2	105	125	216
Jul.2016	7.7	622	30.4	170	4.2	290	75	25	4.8	110	125	142
Aug 2016	7.93	668	32.4	166	3.8	276	71.5	23	3.2	95	129	187
Sep.2016	7.7	686	38.8	180	3.8	328	82	28.8	4.2	105	137	210
objective	6.5- 8.5	1000	5	125	50	500	50	50	50	200	250	250

F1 = 33.33, F2 = 27, F3 = 27, **WQI = 70.42**

Table A5. Chemical test results for raw water at Kut City station. Al- Dijialy section

parameter	pH	TDS mg/l	Turbidity (NTU)	Alkalinity mg/l	Nitrate mg/l NO ₃	T.H as caco ₃	Ca ⁺² mg/l	Mg ⁺² mg/l	K ⁺¹ mg/l	Na ⁺¹ mg/l	Cl ⁻¹ mg/ L	SO ₄ ⁻² mg/L
Oct.2015	7.25	734	30.4	180	2.85	330	82	30	3.6	100	128	156
Nov.2015	7.17	816	34.4	156	5.2	310	82	24	5.8	105	137	246
Dec.2015	7.14	828	21.4	160	5.3	328	88	25	3.6	115	140	228
Jan.2016	7.26	870	8.47	180	4.2	350	87	35	4.3	132	127	276
Feb.2016	7.43	732	8.4	160	4.2	308	75	28	3	109	123	172
Mar.2016	7.17	616	5.71	140	4.6	286	69	26	4.4	116	127	137
Apr.2016	7.72	882	6.51	150	4.2	326	80	32	3.2	92	124	221
May.2016	7.4	642	34.5	156	3.8	305	80	25	4.2	100	137	168
Jun.2016	7.64	746	15.4	176	5.1	310	82	26	4.1	116	129	250
Jul.2016	7.8	630	39.6	176	4.6	272	72	22	3.7	100	124	152
Aug 2016	7.84	660	16.3	150	3.2	292	80	22	3.4	87	131	176
Sep.2016	7.8	668	52.4	170	4.8	308	82	28	3.4	95	132	188
objective	6.5- 8.5	1000	5	125	50	500	50	50	50	200	250	250

F1 = 33.3, F2 = 25.7, F3 = 28, **WQI= 70.82**

Table A6. Chemical test results for raw water at Kut City station. Al- ghraf section

parameter	pH	TDS mg/l	Turbidity (NTU)	Alkalinity mg/l	Nitrate mg/l NO ₃	T.H as caco ₃	Ca ⁺² mg/l	Mg ⁺² mg/l	K ⁺¹ mg/ l	Na ⁺¹ mg/l	Cl ⁻¹ mg/ L	SO ₄ ⁻² mg/L
Oct.2015	7.21	726	60	176	2.46	324	80	31.5	3.44	105	122.5	156
Nov.2015	7.16	808	32.6	148	5.4	300	84	21.4	5.4	100	135	240
Dec.2015	7.08	842	26.2	170	5.8	340	92	26.5	4.4	110	137	248
Jan.2016	7.66	852	30.9	166	6.4	330	84	30.8	4.2	105	140	310
Feb.2016	7.52	728	19.6	155	4.8	296	70.6	30	3.8	110	127	184
Mar.2016	7.21	586	6.25	146	4.8	300	65	28.2	4.2	96.5	111	128
Apr.2016	7.82	834	21.8	146	3.6	296	70	31.5	3.5	95	119	250
May.2016	7.7	626	22.6	140	4.1	300	79	27.2	3.8	96	118	179
Jun.2016	7.72	660	43.6	180	5.4	268	80.5	26	4.2	110	132	210
Jul.2016	7.3	624	29.6	160	3.8	264	70.8	23.2	3.8	116	132	148
Aug 2016	7.82	666	28.7	152	4.2	320	72.8	22.4	3.2	88.5	122	178
Sep.2016	7.3	672	22.6	166	3.6	325	88	25.6	3.2	105	129	192
objective	6.5- 8.5	1000	5	125	50	500	50	50	50	200	250	250

F1 = 33.3, F2 = 25.7, F3 = 27, **WQI= 70.5**

Fig. A1 Shows the variation of TDS in four location during study period.