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Water Quality Assessment of Al-Gharraf River, South of Iraq by the Canadian Water Quality Index (CCME WQI)

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Abstract

Water quality of Al-Gharraf River, which considered the main branch of Tigris River south of Iraq was examined using the Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI) for aquatic life protection and irrigation. Water samples were collected monthly from five sampling stations during 2013-2014 and 17 physicochemical parameters were analyzed: Temperature, hydrogen ion concentration (pH), electrical conductivity, dissolved oxygen, turbidity, alkalinity, chloride, calcium, magnesium, sulfate, phosphate, nitrate, sodium, lead, cadmium, nickel and zinc.

The model classified water of Al-Gharraf River as poor for aquatic life protection and fair for irrigation with seasonal overall WQI value of 30-39 and among stations was 38-39.

Keywords: water quality, Al-Gharraf River, CCME WQI.

تقييم نوعية مياه نهر الغراف، جنوب العراق بواسطة دليل نوعية المياه لمجلس وزراء البيئة الكندي (CCME–WQI)

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الخلاصة

تم تقييم نوعية مياه نهر الغراف، الذي يعد الفرع الرئيسي لنهر دجلة جنوب العراق من ناحية صلاحيتها للحياة المائية وللري باستخدام دليل نوعية المياه لمجلس وزراء البيئة الكندي CCME-WQI.

جمعت عينات المياه شهريا من خمس محطات على النهر لمدة عام خلال 2014–2015 وتم تحليل 17 من المعايير الفيزويكيميائية لجودة المياه وهي: درجة الحرارة ، تركيز أيون الهيدروجين (pH)، التوصيلية الكهربائية، الأوكسجين المذاب، العكارة، القلوية ، الكلوريد، الكالسيوم، المغنسيوم، الكبريتات، الفوسفات، النترات، الصوديوم، الرصاص، الكادميوم ، النيكل والزنك.
نتيجة التقييم كانت هي ان نوعية مياه نهر الغراف ضعيفة بالنسبة لحماية الحياة المائية ومعتدلة للري وكانت قيمة الدليل العامة الموسمية 30–39 و 38– 39 لمحطات الدراسة.

Introduction:

Water quality is the chemical, physical and biological features of water, it is an evaluation of water condition relative to the requirements of human need [1]. It is used by reference to a set of standards against which compliance can be assessed. The common standards used to assess water quality relate to the health of ecosystems and safety of human uses [2].

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Al-Gharraf River branches from Tigris near Al-Kut city and flows through Wasit and Dhi-Qar provinces south of Iraq. It is the main water source for agriculture and public water supply and has impacts on the socio-economic aspects of the area [3].

The river receives most of the wastewater from many activities like, agricultural, domestic and some industrial wastewater. Because of the development of the area and the reduction of water level in the river, the increase of pollutants has been a recent cause for alarm [4].

The CCME WQI was developed to use as a tool for simplifying and definition the water quality data. Three measures were selected to calculate the CWQI ($F1$= scope, F 2 = frequency and F 3= amplitude) as follow: [5].

$$\boldsymbol{F1} = \frac{\textbf{Number of failed variables}}{\textbf{Total number of variables}} \times \mathbf{100}$$

$$\boldsymbol{F2} = \frac{\textbf{Number of failed testes}}{\textbf{Total number of variables}} \times \mathbf{100}$$

$$\textbf{excursioni} \ = (\frac{\textbf{failed test value}}{\textbf{Objective}!} - \mathbf{1})$$

$$\textbf{excursioni} \ = (\frac{\textbf{Objective}!}{\textbf{failed test valuei}} - \mathbf{1})$$

$$\textbf{nse} = \frac{\sum_{i=1}^{n} \textbf{excursioni}}{\textbf{number of tests}}$$

$$\boldsymbol{F3} = (\frac{\textbf{nse}}{\mathbf{0.01nse} + \mathbf{0.01}})$$

$$\textbf{CWQI} = \mathbf{100} - (\frac{\sqrt{\boldsymbol{F1}^2 + \boldsymbol{F2}^2 + \boldsymbol{F3}^2}}{\mathbf{1.732}})$$

The CWQI ranks water quality in the following 5 categories:

Table 1- Shows the CWQI ranks water quality in5 categories

Rank	Poor	Marginal	Fair	Good	Excellent
CCME WQI values	0– 44	45–59	60–79	80–94	95–100

The CCME has prepared software in Visual Basic, which is implemented in Microsoft Excel for computing the CWQI, the CCME-WQI model has been used due to its simplicity and robust nature of reporting water quality issues [5, 6].

Materials and Methods

Description of the Study Area

Al-Gharraf River is the main branch of Tigris River south of Iraq, its water type and discharge in conjunction with the hydrological characterizations of Tigris River in Al-Kut barrage and its average annual discharge has large yearly fluctuation and suffers from natural and human problems such as pollution, accumulation of clay, growth of plants, water squandering and reduction of water levels [6,7].

In Wasit and Thi-Qar governorates it passes through several towns and many green heavy populated villages. In Dhi-Qar it has two branches before its end in marshes [8].

Length of the main river is about 230 km, 50- 80 m width and 3-7 m depth. Its basin populated by more than million people using about 432000 m^3/year of refined water and passing through an agricultural area of about 215019 h in the south west of Iraq within the sediment plain [9].

The geographical position lies between the north latitude (32 Â 27 º - 31 Â 2 º) and east longitude (45 Â 45 º - 46 Â 4 º). This position gives the area climate features like; the high rate of sun radiation, high temperature, few rain occasions, low moisture, and high rate of evaporation [3]. Figure-1 shows the map and the sampling stations of the study area.

General Description of the Sampling Stations

Five stations were chosen, the positions of stations were determined by the Global Positioning System (GPS) model Geko 201.

The first station: In the beginning of the River (in Al-Kut) near Al- Gharraf head regulator in (32 Â º 30 N, 45 Âº 45 E), the river here has the same features of Tigris River which characterizes with no cities or large pollution sources for a long distance after it leaved Baghdad.

The second station: It is about 5km south of Al-Hai city in (32 Â º 06 N, 46 Â º 01 E). This station characterizes by many agricultural fields and plants on its banks, it is affected by domestic wastewater and workshops from Al- Hai city which populated with about (75000) people [9].

The third station: It is about 5km south of Qala'at Sekar city in (31 Â º 29 N, 46 Â º 2 E). There are salt areas (Sabkha) on the left side and agricultural fields on the right .The urban waste water from Qalaat Sekar city which populated with about (55000) persons affected the River in this station [9].

The forth station: It lies near Al-Bada'a head regulator, about (165) km south of the first station, in (31 Â º 21 N, 46 Â º 14 E), there are four refinery stations on the right side, which provide drinking water to Dhi-Qar and Basrah governorates.

The fifth station: This station lies 3 km south of Al-Shatrah city in (31 Â º 19 N, 46 Âº 14 E), in a heavy populated area after the river has divided to its two main branches and characterizes with low water level, narrow width and accumulation of water plants. The river here affected with much sewage and solid wastes.

Field Sampling and Analytical Procedures

Water samples were collected monthly from December 2014 to November 2015, at each sampling station. Samples were preserved and analyzed according to American Public Health Association (APHA) [10]. Physical and chemical parameters including water temperature (T), dissolved oxygen (DO), electrical conductivity (EC), and pH, were measured *in situ* using a WTW multi-meter model Multi 340i. Turbidity (Tur) was determined *in situ* using WTW portable turbidity meter model TURB 355 IR/T. Alkalinity (Alk) as $CaCO_3$ measured by titration method, Ca^{+2} and Mg^{+2} were measured by EDTA complex metric titration. Na^+ concentration was measured by flame photometer model M410، UK and Cl^- concentration was measured by silver nitrate titration. Sulphate (SO_4^{-2}) concentration was determined specrophotometrically using the barium sulphate turbidity method. Nitrate (NO_3) and phosphate (PO_4) concentrations were measured by cadmium reduction and molybdate ascorbic acid methods, respectively. Pb, Cd, Ni and Zn were measured by Atomic Absorption Spectrophotometer model Phoenix – 986 AAS.

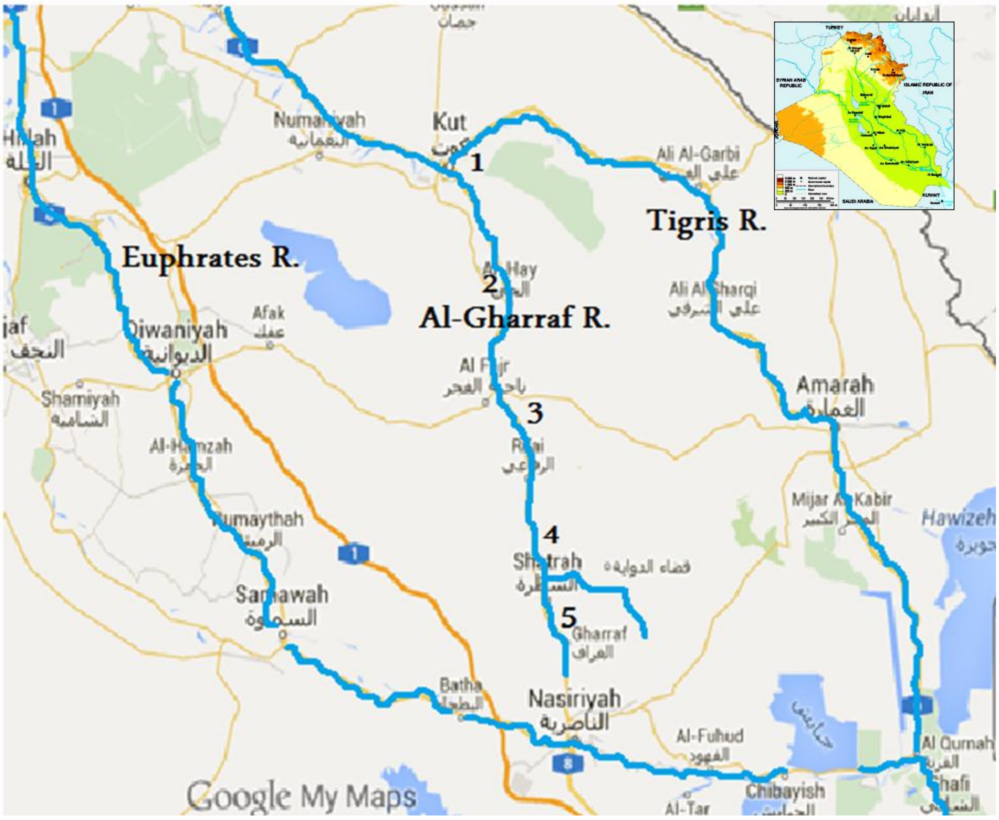

Figure 1-The map and the sampling stations of the study area.

Results and Discussion

Water Quality Index for the five stations along the river was determined monthly during a year using the physicochemical parameters listed in Table-2. The annual values of the various scopes (F1), frequencies (F2), and amplitudes (F3), with their respective water quality index in all the five river stations are presented in Table-3 and the seasonal variation of CWQI is presented in Table-4.

Table 2- Annual simple statistical analysis of water quality parameters at the study stations on Al-Gharraf River, turbidity in (NTU), electrical conductivity in (µS/cm) and the rest in mg/L.

Parameter	1st Station			2nd Station			3rd Station			4th Station			5th Station		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
T C°	17	32	24.5	18	32	24	18	33	24.25	18	33	23.75	19	34	25.25
pH	7.1	7.8	7.4	7.3	7.9	7.5	6.8	7.7	7.175	7.2	8.0	7.5	7.1	7.9	7.5
EC	928	1100	997	98	1200	1075	970	1210	1083	980	1292	1096	1020	1270	1095
DO	7	9.6	8.2	6.2	10	7.95	6.8	7.8	7.325	6.2	7.8	6.825	6	8.8	7.125
Tur	75	91	81	64	92	75.25	55	84	68	60	78	67	40	70	58.5
CO_3	145	175	165	143	240	189	150	240	200	155	268	207	160	225	181.3
Cl	123	225	167	160	240	196.3	165	265	216.3	165	230	185	170	220	196.3
Ca	64	95	79.25	72	103	84.5	70	98	84.75	75	90	83.75	80	97	89.3
Mg	22	31	25.5	23	34	27.5	23	34	28	24	28	26.25	25	27	26
SO_4	110	142	128.5	138	162	148	136	162	148.3	143	162	150.3	136	168	153
PO_4	.10	.21	.13	.11	.27	.195	.13	.65	.3	.46	.66	.59	.4	.7	.6
NO_3	2.9	5.6	4.1	2.6	7	4.55	3	7.5	4.7	3.4	6.3	4.775	3	6.5	4.68
Na	78	98	86.75	84	130	101	78	132	104.5	68	111	85.25	80	118	96.5
Pb	.0024	.02	.009	.0024	.025	.009	.0037	.021	.01	.009	.025	.0017	.003	.02	.0095
Cd	.00012	.000057	.000028	.00012	.0009	.0004	.00017	.0001	.0004	.0009	.0004	.00017	.0001	.0008	.0003
Ni	.0002	.0035	.0017	.00036	.004	.002	.00035	.004	.002	.004	.002	.00035	.00025	.0036	.0018
Zn	.012	.07	.029	.017	.062	.032	.014	.072	.033	.062	.032	.014	.016	.075	.035

There was no significant statistical difference at 5% level for the parameters measured in this study among stations because of the same climate conditions and source of water but there were statistical significant differences among seasons. The CWQI value was 30 to 39 and the worst value was 30 in spring. The overall seasonal index values of the river ranged from 30 to 39 which indicates that water quality is poor, for drinking purposes it was 40 to 44, it does not meet the criteria for use as a source of drinking water and not suitable for potable water supply without elaborate treatment, it was poor 34 to 37 for protection of aquatic life and fair for irrigation 70 to 73 Table-3.

Table 3- Annual Variation of Water Quality Index at each Station.

	Overall		Drinking	Aquatic	Irrigation
Station 1	CWQI	38	44	32	83
	F1	42	25	60	20
	F2	40	19	55	20
	F3	90	91	85	9
Station 2	CWQI	39	45	32	82
	F1	42	25	60	20
	F2	40	19	55	20
	F3	90	90	85	14
Station 3	CWQI	38	43	31	81
	F1	42	38	60	20
	F2	42	22	60	20
	F3	89	90	85	16
Station 4	CWQI	38	45	31	82
	F1	42	25	60	20
	F2	42	19	60	20
	F3	89	89	85	12
Station 5	CWQI	39	46	31	82
	F1	42	25	60	20
	F2	42	19	60	20
	F3	88	88	85	14

Table 4- Seasonal Variation of CWQI in Al-Gharraf River stations

		Overall	Drinking	Aquatic	Irrigation
Winter	CWQI	39	43	37	73
	Category	Poor	Poor	Poor	Fair
	F1	42	25	60	20
	F2	36	19	47	38
	F3	91	93	78	20
Spring	CWQI	30	40	34	73
	Category	Poor	Poor	Poor	Fair
	F1	56	33	60	20
	F2	58	29	56	38
	F3	92	94	78	19
Summer	CWQI	39	42	34	70
	Category	Poor	Poor	Poor	Fair
	F1	33	38	60	20
	F2	29	21	56	38
	F3	94	91	79	30
Autumn	CWQI	39	44	34	72
	Category	Poor	Poor	Poor	Fair
	F1	42	25	60	20
	F2	40	19	56	38
	F3	89	91	79	21

The decrease in CWQI value in the River stations is a reflection of different types of pollutants entering its bassin due to natural reasons and various anthropogenic activities such as discharge of untreated domestic sewage and runoff water from agricultural lands near the banks of the River [11]. Another reason is the decrease in raw water levels that promote water seepage from ground water into the river column [12].

The river can't achieve the self purification because of the low level of water and shortage caused by limited rains in the north, the many dams which had been built in Turkey, Syria and Iran besides the bad planning with the old methods used in irrigation [11, 13].

When the CWQI value of Al-Gharraf River compared with other Iraqi rivers Table-5 we find that most of Iraqi river have poor water quality especially Tigris River and its branches like Al-Gharraf .

Table 5-Comparison of the CWQI value among Iraqi rivers

River	CWQI Value	Reference
Tigris in Baghdad	Poor, 31-44 for aquatic life	[14]
Hammar marsh	Overall value, 13	[15]
Euphrates River	Marginal to poor, 45.17	[16]
Tigris, Baghdad	Overall value 20.3 - 60.5	[17]
Hilla River	Overall value, 60-65	[18]
Tigris in Amarah	52-87 for irrigation	[19]
Kuffa River	62.7- 90.9 for aquatic life	[20]
Shatt Al-Arab	Marginal for aquatic life. Poor for irrigation.	[21]
Mahrut River	poor for Irrigation	[22]
Al-Gharraf River	Poor, for drinking 40-44 and aquatic life 34-37. Fair for irrigation 70-73	This Study

The physicochemical parameters analytical results for WQI calculation Table-2 supported the low water quality rate observed.

The pH value at the river stations meets the index criteria and fell within 6.8-8; it has a slightly alkaline average value as in many previous studies about Iraqi rivers [18-20].

It was observed that the turbidity value 40 to 84 NTU were higher than the allowable level recommended by the WHO and CCME for drinking water and it decreases downstream the river in all seasons like the Tigris River and all its branches [3, 4].

Dissolved Oxygen is the most important parameter for assessing water quality, it affects aquatic life and organism's distribution [11], its range was 6.2 to 10 mg/L but its mean was lower than the CCME standard (9.5 mg/L) and decreases downstream the river.

There are large yearly fluctuation in water level, in summer and autumn (the dry seasons) water comes from the reservoirs full with organic materials, planktons, algae and plants with dark green color causing decrease in pH and dissolved oxygen, increase in turbidity, total dissolved solids and affecting the water quality[4,9].

Sulfate, bicarbonate, chloride, calcium, magnesium and sodium which is composed the total dissolved solids is a vital parameters which cause an unusual taste to water and affect its usage as potable water [1, 2].

The value of chloride 132 to 240 mg/L, was observed in the river and it is more than the CCME standard of (110 mg/L). All the observed values of sulfate, bicarbonate calcium, magnesium and sodium were within the permissible level recommended by WHO and CCME for drinking water and protection of aquatic life. The observed values for phosphate (0.1mg/L to 0.7 mg/L) exceeded the permissible level recommended by CCME for aquatic life and lead to algal blooms in the stations downstream the river [4].

Nitrate is an undesirable ion in water. The maximum and minimum average values (2.9 mg/L and 7.5 mg/L) were observed, its values fell within the threshold values. The concentration of the heavy metals lead and zinc exceeded the permissible levels of the WHO and CCME for drinking water at all the seasons and stations. The average concentration was (0.0024 mg/L to 0.025 mg/L for lead and 0.012 mg/L to 0.75 mg/L for zinc. The concentration of nickel and cadmium didn't exceed the permissible level for drinking water.

The high values of lead and zinc due to disposal of domestic waste and atmospheric deposition is supported by the findings of [3, 4].

The observed temperature values of the river were above the permissible level recommended by CCME for aquatic life. The maximum and minimum values (17 C° and 34 C°) were recorded; the fluctuation in the temperature of river depends on the season, station location, sampling time [2].The values obtained agree with the findings of other researchers [14-16].

Conclusion

The results of the study revealed that the river is not suitable for use as drinking water without elaborate treatment, poor for aquatic life protection and fair for irrigation. Among the 17 quality parameters studied, the temperature, turbidity, dissolved oxygen, chloride; lead and zinc were out of the standards recommended by the (CCME-WQI) for aquatic life protection. The shortage of water in the river and runoff of the domestic sewage impacted negatively on the quality of water. The study showed that application of CWQI is a useful tool in assessing the overall quality of river.

References

1. Diersing, N. **2009**. Water Quality: Frequently Asked Questions. Florida Brooks National Marine Sanctuary, Key West, FL.
2. United States Environmental Protection Agency (EPA). **2006**. Water Quality Standards Review and Revision. Washington, DC.
3. Al-Gizzy H. S. N. **2005.** Hydrology of Shatt Al-Gharraf and its investment. M.Sc Thesis, University of Basrah, Basrah, (in Arabic).
4. Ewaid S. H. **2011**. Investigation of Some Heavy Metals in Water, Sediment and Some Biota of Al-Gharraf River, South of Iraq. M.Sc. Thesis, University of Baghdad, Baghdad, Iraq.
5. Canadian Council of Ministries of the Environment (CCMC) .**2001**. Canadian Water Quality Index 1.0 Technical Report and User's Manual. Canadian Environmental Quality Guidelines, Tech. Subcommittee, Gatineau.
6. United Nations Environment Programme (UNEP) **.2007**. National Water. Global Environment Monitoring System/Water Programme, UNEP/GEMS. C/O.
7. Ministry of Agriculture and Irrigation Republic of Iraq (MOAI) **.1991**. East Gharraf Project AL-Hai South Zone, Sector (A) irrigation & drainage system of the main canal and drainage pumping station. State Commission for Irrigation and Reclamation Projects, Al-Furat Center for Studies and Designs of Irrigation Projects**.**
8. Ministry of Water Resources (MOWR) .**2005**. Iraq Reconstruction- Water Resources Sector. Speech by the Minister of Water Resources in USA.
9. Iraq Ministries of: Water Resources **.2006.** Municipalities and Public Works and Environment, New Eden Master Plan for Integrated Water Resources Management in the Marshland Area. Main Water Control Structures (Dams and Water Diversions) and Reservoirs. *Annex III*.
10. American Public Health Association (APHA) .**2012.** *Standard Methods for the Examination of Water and Wastewater*, Twentieth Seventh Edition. Washington, DC.
11. Al-Obaidy, A. M. J. and Al-Khateeb, N**. 2013.** The Challenges of Water Sustainability in Iraq. *Eng. & Tech. Journal*, 31(5), Part (A).
12. Jerry, W. and Webb P. E. **2004.** *Water issues in Iraq, challenges / status*. World Water and Environmental Resources Congress. Salt Lake City, Utah, USA.
13. Issa, I. E., Al-Ansari, N. A. Sherwany, G. and Knutsson S. **2013.** Trends and future challenges of water resources in the Tigris–Euphrates Rivers basin in Iraq. *Hydrol. Earth Syst. Sci. Discuss.*, 10, pp: 14617–14644.
14. Al-Obaidy, A. M., Al-Janabi, Z. Z. and Shakir, E. **2015**. Assessment of water quality of Tigris River within Baghdad City *Mesop. Environ. J.* 2015, 1(3), pp:90-98.
15. AL-Shammary, A. C., AL-Ali, M. F. and Yonuis, K. H. **2015.** Assessment of Al-Hammar marsh water by uses Canadian water quality index (WQI) Mesop. *Environ. J*. 2015, 1(2), pp:26-34.
16. Al- Heety, E. A., Turki, A. M and Al-Othman, E. M. **2011.** Assessment of the Water Quality Index of Euphrates River Between Heet and Ramadi Cities, Iraq. *Inter. J. of Basic & Applied Sciences*, 11(6).
17. Hassan, F. M., AL-Zubaidi, N. A. and Al- Dulaimi, W. A. **2013.** An ecological assessment for Tigris River within Baghdad, *Iraq J. of Babylon* Univ. Special Issue **-** Proceeding of 5th

International Conference of Env. Science Univ. of Babylon / Env. Research Center 3-5 December 2013.

18. Salman, J. M., Abd- Al-Hussein, N. A. and Al-Hashimi, O. **2015**. Assessment of Water Quality of Hilla River for Drinking Water Purpose by Canadian Index (CCME WQI). *International Journal of Recent Scientific Research,* 6(2), pp:2746-2749.

19. Hadi, N. S. **2012.** Comparison between the results of applications of the Canadian and Bhargava methods for irrigation water quality index at multi locations in Tigris River. *Journal of Kerbala University* , 10(4) Scientific.

20. Hassan, H. A., Rasheed, K. A. and Nashaat, M. R. **2014.**Assessing Water Quality Of Kuffa River For Aquatic Life By Using Canadian Water Quality Index (CCME WQI) *Euphrates J. for Agric*. Sciences, 1(6), pp:276-280.

21. Moyel, M. S. and Hussain, N. **2015.** Water quality assessment of the Shatt Al-Arab River, Southern Iraq. *J. of Coastal Life Medicine* 2015, 3(6), pp: 459-465.

22. Obaidy, A. M., Awad, E. S., Kadhem, A. J. and Al Mashhady, A. **2015.** Evaluating Water Quality of Mahrut River, Diyala, Iraq for Irrigation. *Eng. & Tech. Journal,* 33(4),Part (A), 2015.