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Comparison of Water Quality Index at Intakes of Water Treatment Plants in Baghdad City

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Abstract

The studying of water quality (WQ) is to determine the competence of water source for different uses. Water Quality Index (WQI) is a mathematical device used to translate huge data for water testes to simple number, This number gives comprehensive idea to the water source quality level. In this study, many samples from selected points of Tigris river stage within the intakes of eight Water Treatment Plants (WTPs) of Baghdad city were collected and tested during (2009-2010) , These (WTPs) arranged according to its position from the north of Baghdad city to it's south respectively as follows (Karkh ,Tigris-East ,Wathba, ,Karama ,Qadisiya ,Dora ,Wahda and Rashid in the south).Twenty parameters were tested for an average one sample of each parameter in each month within the year(2009-2010).Canadian Council of Ministry of the Environment (CCME,2001) procedure was used to determine (WQI) of the raw water in the intake of these (WTPs). Results showed that the best (WQI) was in the intake of Al-Karkh and the worst was in Al-Rashid (WTP). Another comparison for the suitability of the raw water in irrigation purpose was tested by comparing the average of each (T.D.S and EC.) for a one year with the criteria of each of American Salinity Library (ASL) and with Russian classification(R.C), and the results showed high concentrations of salinity , so the irrigated soil with this raw water needs good drainage system.

Key words : Water quality index , Water Treatment Plants in Baghdad city.

مقارنة مؤشر نوعية المياه عند مآخذ محطات تصفية مياه مدينة بغداد

الخلاصة

إن دراسة نوعية المياه هو تحديد صلاحية المصدر المائي للاستخدامات المختلفة ويعتبر مؤشر نوعية المياه هو أداة رياضية تستخدم لتحويل البيانات الضخمة لنوعية المياه إلى رقم منفرد وهو بدوره يعطي فكرة شاملة عن مستوى نوعية المصدر. في هذه الدراسة أخذت بيانات للمياه السطحية لنهر دجلة لسنة (2009–2010) في بداية كل مأخذ من مشاريع تصفية مدينة بغداد الثمانية وهي حسب تسلسلها من شمال بغداد إلى جنوبه وكما يلي: (الكرخ ، شرق دجلة، الوثبة، الكرامة، القادسية، الدورة، الوحدة وآخرها مشروع الرشيد)، ولمدة سنة كاملة وبمعدل نموذج لكل معلمة شهريا، وتم استعمال الطريقة الكندية الحديثة CCME لاحتساب مؤشر نوعية المياه وصلاحيته لمياه الشرب وتبين من المؤشر أن أفضلها يقع عند مشروع الكرخ وأردأها عند مأخذ مشروع الرشيد وكذلك تم اختبار صلاحية المياه للري والسقي إذ أخذت معدل تركيز المواد الصلبة الذائبة و التوصيلية الكهربائية ومقارنة نتائجها بمواصفات كل من المختبر الأمريكي للملوحة والتصنيف الروسي وتبين أن الماء عالي الملوحة وتحتاج الترب الزراعية المروية به إلى نظام بزل جيد.

الكلمات الدالة : مؤشر نوعية المياه ، محطات تصفية الماء لمدينة بغداد .

the suspended and dissolved material in Tigris river at Baghdad. The results of his study indicated that the water at Baghdad city was hard to very hard, fresh and suitable for drinking. Al-Ani (1988) [12] has many studies in classifying (WQ) for Tigris river by using (WQI). Al-Ani (1991)[13] studied the effect of flow on Tigris (WQ). Shihab and Al-Rawi, (1994)[14] studied (WQI) for Tigris river in Mosul city within twenty kilometers distance , and they selected (9) sections for their samples. They depends on geometric mean in their calculating (WQI). Their results showed that (WQI) classification lies within first degree for irrigation, and second for other deferent uses. Noaman (2008)[15] used (WQI) to classify Tigris river between Al-Shargat city and Al-Boagjeel village. He used (7) sections in taking his samples for a period started from the begging of October 2007 until June 2006. His results indicated that all sections falls within the range (58.34 - 80.8) by using weighted geometric mean in his calculation, which he described this range as (marginal to very good) for different uses. Lilian (1999)[16] concluded that Al-Karkh station ranked first among all seven station of (WTPs) within Baghdad city and she used statistical ways to analysis (WQ) for different uses.

The objectives of this study aimed to :

1-Determine WQI of tigers river at eight (WTPs), by using (CCME,2001) procedure.
2-Classify the raw water of Tigris river in the intakes of eight WTPs according to the results of (CCME WQI,2001) .
3-Determine the main parameters that is consider the main contaminant to the river.
4-Determine the suitability of using the raw water in the landscape application.
5-Determine the suitability of using this water for swimming purpose depending on the Fecal Coli form number.
6-Point if there is need to add an additional treatment for the raw water in the existing (WTPs) works of Baghdad city .

Methodology

The following six stages indicates the way to calculate the (CCME WQI). These stages includes the calculation each of F1,

Introduction

There are (20) parameters (DO, pH, BOD_5, Temp., PO_4, Tur., TDS, NO_3, Fe, F, AL, ALK., Ca, Hardness, CL, Mg, Color, SO_4, Fecal coliform bacteria, Ec.) has been tested and studied by using standard method for examination[1] during the year (2009-2010) to calculate (WQI) at Baghdad city. The samples has been taken from the intakes of eight (WTPs) at Baghdad city .All these plants lies on Tigris River as shown in figure (1). Canadian Council of ministry of the Environment Water Quality Index (CCMEWQI , 2001) [2] procedure was used to classify Tigris river depending on the objectives of Iraqi-Rivers Maintenance Number(25) for 1976 [3,4] and the objectives of World Health Organization (WHO,2003)[5]**.** There are many kinds of (WQIs) which often depends on the activities such as drinking water , aquatic life , irrigating water and recreation (WQIs). Most research used often a mathematical and statistical ways to calculate (WQI) and they almost used relative weight for the main parameters (often six) which there are somewhat difference from one to another in their estimation of these relative weights of the main parameters, while (CCMEWQI,2001) procedure has the ability to hold all the available parameters (but not less than four). A second important point, the procedure which takes the relative weight to determine (WQI) doesn't include the toxic parameters such as herbicides in their calculations because it may reduce (WQI) to the zero level , but (CCME WQI) has the ability to include those toxicant parameters.

The suitability of raw water of Tigris river for landscape purpose such as (house garden irrigation and washing the roads) was studied by comparing the results of (TDS and EC) parameters with the objectives of American salinity laborers (ASL)[6,7] and Russian classification (RC)[8]. Finally the suitability of the swimming purpose in Tigris river has been compared with the number of Fecal coliform Bacteria according to National technical advisory Committee (NTAC)[9]. Ali (1978)[10] concluded that Tigris River is highly polluted comparing with Euphrates. Al-Khafaj (1985)[11] studied

Dora and Al-Rashid (WTPs) were (marginal class) . Their (WQIs) were (67 , 63.6 , 56.89) respectively. The raw water in the intakes of the last three (WTPs) has low index, So it needs an additional treatment to raise their level of (WQ). 2) Figs (2) shows that the main contaminant was the fecal coliform bacteria in the most of raw water (except in the intake of Al-Karkh and Tigris-east) . The reason to appear these contaminant in all tests because of the discharge of domestic water to the river directly especially in the zones which are not connected in main sewage pipes of the city. The maximum value of these contaminant was in the intake of Al-Rashid which it reaches (90000) MPN / 100ml while it must not exceed than 2000 MPN/ 100 ml for Global limitation . 3) Figure (3) shows an increasing of BOD_5 values more than the objectives (5)mg/l , started from the begging of seventh month and go on to the intake of al-Karkh (WTP) due to the low discharge of Tigris river in the hot season. The same Figure shows that the BOD_5 concentration increases as far as we go down ward with a wide range to include all the year especially in the intakes of the last (WTPs) due to the discharge of organic contaminants which is the most of it is a domestic wastewater. 4)Figure (4) shows high concentrations of (Fe) ions more than (0.3)mg/l in the intakes of all (WTPs) and theses values increases in the intakes of (WTPs) that lies in the south of Baghdad city, because the discharge of industrial wastewater to the river without treatment.

5) Figure (5) indicates an auscultative in the concentration of SO_4 ions of the raw water in the intakes of Al-Wahda , Al-Dora, and Al-Rashid (WTPs) for the last four months of the year, these height concentrations may be comes from the existence of thermal and gases electrical power stations . 6) Figure (6) shows the Turbidity values in the water river exceeds the Global limitations (25)NTU . The high concentrations of turbidity in the raw water in the intakes of most (WTPs) belongs to the high rainfall in Spring and Winter flood seasons.

7) From table (7) and Figure (7), EC values exceeding the limitations of raw water along this year .

F2, Excursion, normalized state of excursion (nse), F3, then WQI

1) F1 =[Number of failed parameters / Total number of parameters]*100

2) F2=[Number of failed tests / Total number of tests] * 100

3) Excursion : There are two cases to calculate this step.

a) When test value must not exceed objective (limitation), then: Excursion = [failed test value / Objective] - 1

b)When objective exceed test value, then : Excursion = [Objective / failed test value] - 1

4) normalized state of excursions (nse) = sum (excursion) / total of tests

5) F3=[nse / 0.01*nse+0.01]

6) $WQI=100-[(F_1^2+F_2^2+F_3^2)^{1/2}/1.732]$

Samples of Calculation

The calculation Of (WQI) by (CCME) procedure of AL-Karkh as an example was determined in the table (8) and explained as follows :

Number of failed parameters = 4, They are (BOD, Temp., Tur., Fe)

Total number of parameters =19,Then:

F_1= (4/19)*100 =21.0

Number of failed tests =25

Total number of tests =288,Then:

F_2= (25/288)*100 =8.68

Excursion of BOD = 0.74, Exc. of Temp.=1.16, Exc. of Tur..=36.72 , and Exc. of Fe.=1.16.

Sum of Excursion = 48.76

nse = 48.76 / 288 = 0.1693

F_3=0.1693 /(0.01*0.1693+0.01) =14.27

CCMEWQI=100-

$[\{(21)^2+(8.68)^2+(14.478)^2\}^{1/2} /1.732] = 84.4$

Results and Discussions

1) Results of (WQI) are detailed in table (5) while table (2) showed that the best (WQ) was in the intakes of Al-Karkh and Tigris-east (WTPs) which classified as (good class) , The degree of their (WQI) was (84.4,81.4) respectively .

Al-Karama , Al-Qadisiya and Al-Wathba (WTPs) classified (fair class) and the degree of the (WQI) (77.77, 73.89,71.56) respectively .

The (WQI) in the intakes of Al-Wahda, Al-

mix unit for all (WTPs) especially that lies in south of Baghdad. and hazardous signs must be instilled to forbidden of swimming directly in the river, especially in last three (WTPs) .
3-)The second effective parameter was the presence of high concentrations of iron Ions which exceed the objectives along the river stream ,so there is need to add an iron removal unit within these (WTPs), or by adding an aeration units in the present (WTPs) especially in AL-Wahda and AL-Rashid (WTP_S).
4-) Because of the presence of high values of (EC) and high concentrations of (TDS) in the intakes of the most (WTPS), which it refers to high concentrations of salt, so it must be done a good drainage to the irrigated soils which supplied with the raw water, especially in the intakes of the last three (WTPs).

References

1. APHA, AWWA, WPCF, (1989), "Standard Methods for Examination of Water and Wastewater ", 20th edition. Washington, D. C. , USA .
2. Canadian environmental Quality Guidelines (Canadian Council of Ministers of the Environment,(2001) (CCME).
3. الجهاز المركزي للتقييس والسيطرة النوعية "المواصفة العراقية القياسية لمياه الشرب رقم 14/ 2270 لسنة 1967 بغداد".
4. دائرة حماية وتحسين البيئة (وزارة الصحة "التشريعات البيئية لعام 1988 بغداد .
5. WHO (2003), "Guidelines for Drinking Water Quality", 2nd edition. Vol . 2, Geneva .
6. ليث خليل اسماعيل، "الري والبزل" جامعة الموصل (1988).
7. بدر جاسم علاوي و بدر خالد حمادي، "استصلاح الاراضي"، جامعة الموصل (1988)
8. Abbas, W. A.,1968 ,"Evaluation of Tigris Raw Water Quality for Different Uses", M.Sc. Thesis, College of Eng., University of Baghdad
9. Nemerow, N. L., 1974, "Scientific Stream Pollution Analysis" Mc-Graw Hill book company.

8) Figure (8) appears there are an oscillate in the hardness concentration ,especially in the raw water of the intakes of each of Al-Qadisiy, Al-Wahda, Al-Dora and Al-Rashid (WTPs).
9) Figure (9) shows the temperature degree was high along the stream river from the fifth month to the end of the tenth month of the year because the surface of raw water influence by the hot season of the weather , but there are an observation of unusual increase of temperature degree of the raw water in the intakes of Al-Rashid (WTP) because there was high discharge of the industrial wastewater comes from the electrical thermal Baghdad plant which is near to this (WTP).
10)Tables (3 and 4) show that this raw water was unsuitable for irrigation purpose which it classified (high- salt) by American Salinity Laboratory (ASL) while the Russian classification (RC) considered it causing damages to the plants and needs good drainages to the irrigated soil.
11) Figures (10-19) show that all the remaining parameters are not exceeds their global limitations in the all (WTPs)
12) Table (5) and Figure (16) show that the (TDS) values can be acceptable along the year because it was not exceed the global limitations for drinking water.
13) For the swimming purpose in this river, the results from the Figure (2) showed that raw water is not suitable because there were high numbers of fecal coliform bacteria which exceeds the limitations (400) MPN/100 ml , especially in the raw water along the river which flows behind Tigris-East (WTP) and downward to the other (WTPs) which lies in the south of the city .

Conclusions and Recommendations

1-) (WQI) classified (Good) in the upstream in the intakes of the first two (WTP_S), and the Index decrease slowly to (Fair) in the middle three (WTP_S) , while it decreases sharply in the downstream for the last three (WTPs) which classified (Marginal).
2-) The effective parameter which decrease the index was the presence of huge number of Fecal Coliform bacteria, So there is need to added a pre-chlorination to the rapid

14. Shihab, A. S. and Al-Rawi, S. M. , 1994, "Application of Water Quality Index to Tigris River within Mosul city", Journal of Al-Rafidain Eng. Vol. 4, No.3, pp.80-92
15. Noaman , M., Muthanna, (2008), "Development of Water Quality Index for Tigris River Between Al-Sharqat and Al-Booajeel", M.Sc. thesis, Collage of Engineering, Tikrit university.
16. Lilian, Y., M., (1999), "Evaluation of the Location of Baghdad Water Supply and Wastewater Treatment Plants",, M. Sc . Thesis, University of Technology.
10. Ali, A. I., 1978, "Study the Bacterial Quality of Water in Iraq ", M.Sc, Thesis, Agricultural College, University of Baghdad.
11. Al-Khafaj, L. A. ,(1985), "Study of Dissolved Load in Tigris River within Baghdad" , M. Sc. Thesis, University of Baghdad.
12. Al-Ani, M ,(1988), "Water Quality Index for Tigris River Classification", Journal of Biological Science and Research. Vol.14(3).
13. Al-Ani, M , (1991) "Effect of Flow on Tigris Water Quality", water R.C. Baghdad, Iraq.

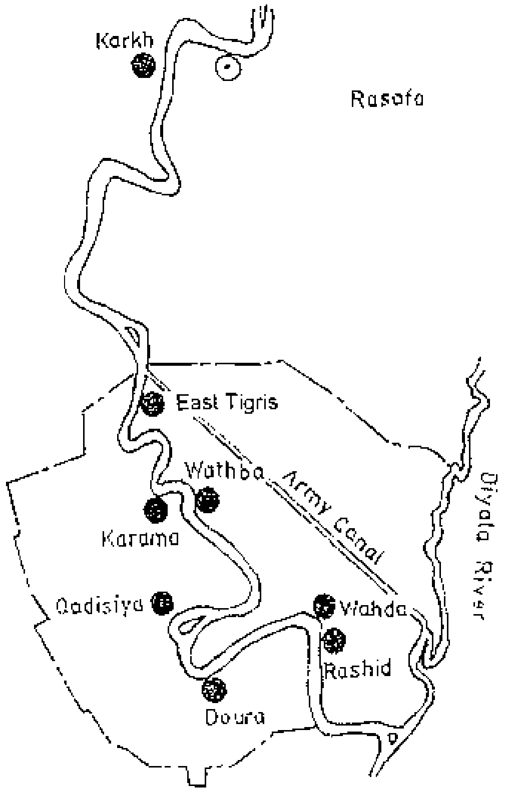

Fig . (1) Existing (W.T.Ps) Works at Baghdad City (2009 – 2010)

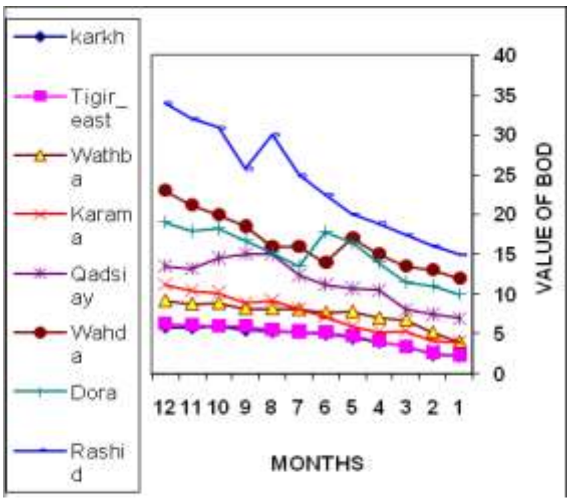

Fig.(3) values of (BOD_5) which obj.< 5mg/l

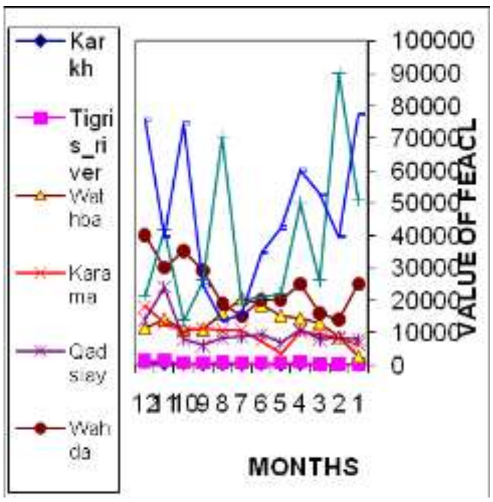

Fig.(2) values of (Fecal coilform) which Obj.< 2000MPN/100ml

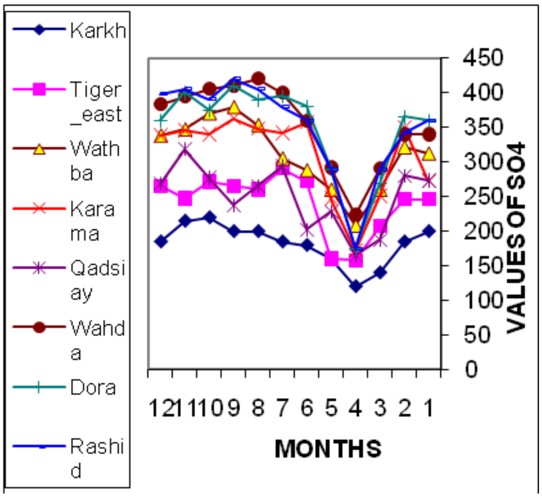

Fig.(5) values of (SO_4)which obj.< 400mg/l

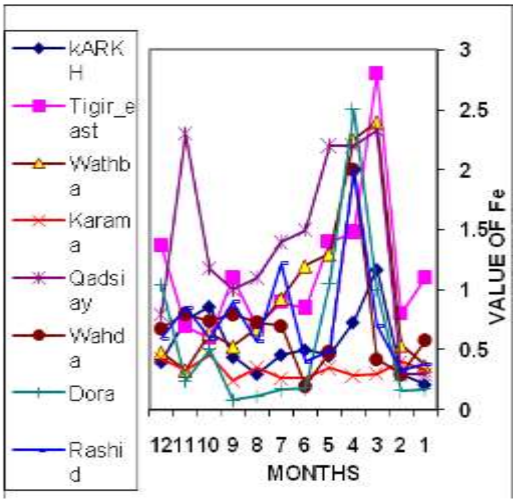

Fig.(4) values of (Fe) ions which obj.< 0.3 mg/l

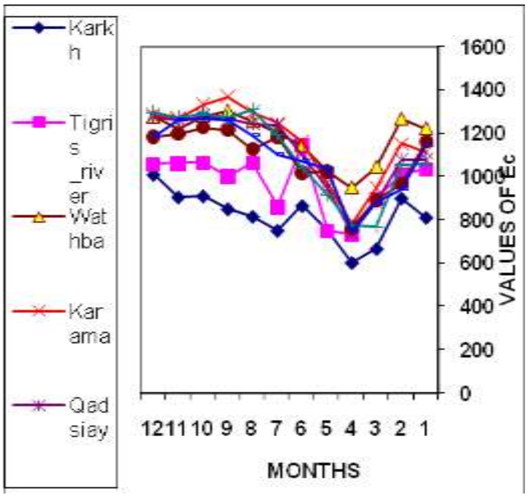

Fig (7) values of (EC) which obj.< 750 µ Mos/cm

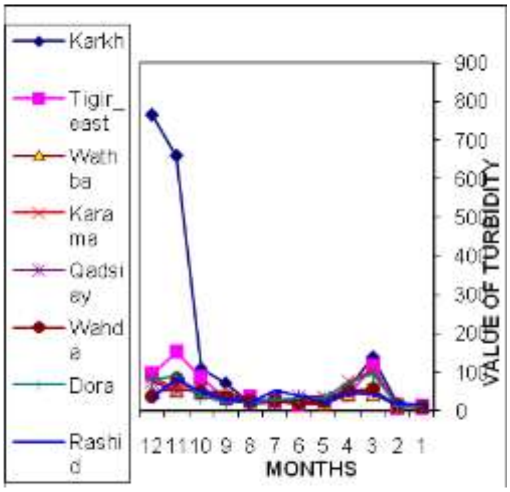

Fig.(6) values of (Turbidity) which obj. < 25NTU

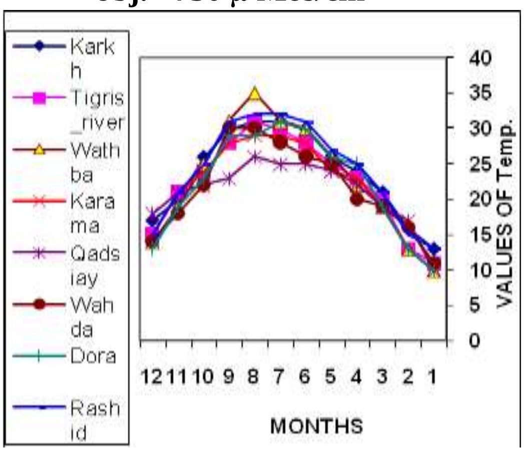

Fig.(9) values of (Temperature) which obj.< 25 ^oC

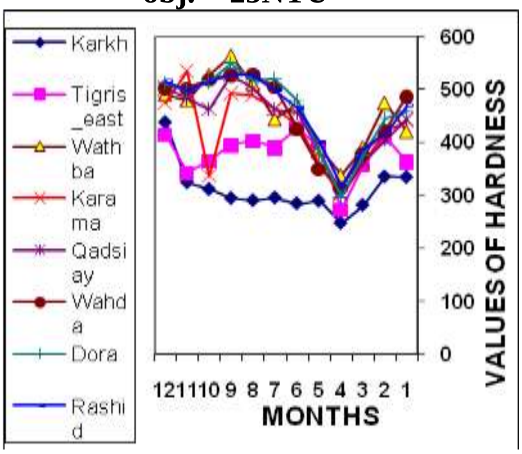

Fig.(8) values of (Hardness) which obj.< 500 mg/l as $CaCO_3$

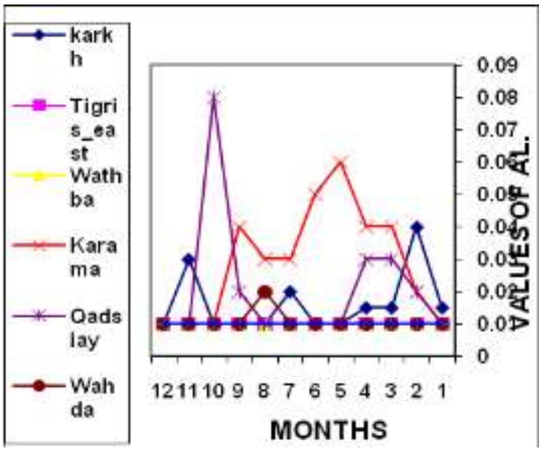

Fig.(11) values of (AL) ions which obj.< 0.1mg/l

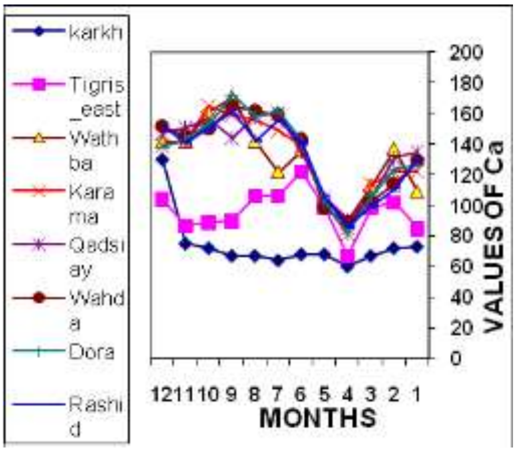

Fig.(10) values of (Ca) ions which Obj. < 200 mg/l

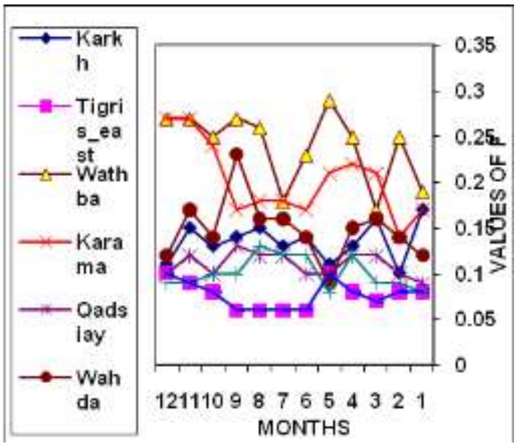

Fig.(13) values of (Florid) which obj.< 0.1 mg/l

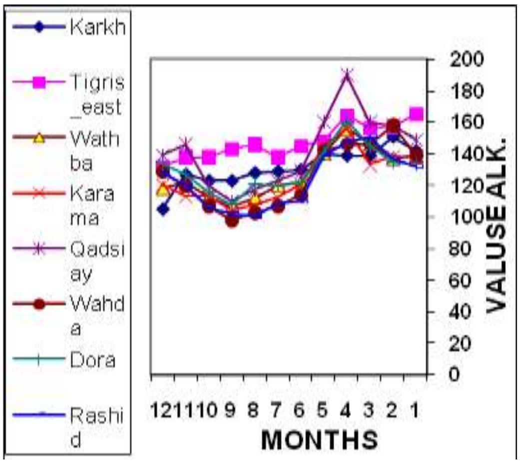

Fig.(12) values of (ALK.) which obj.< 200 mg/l as $CaCO_3$

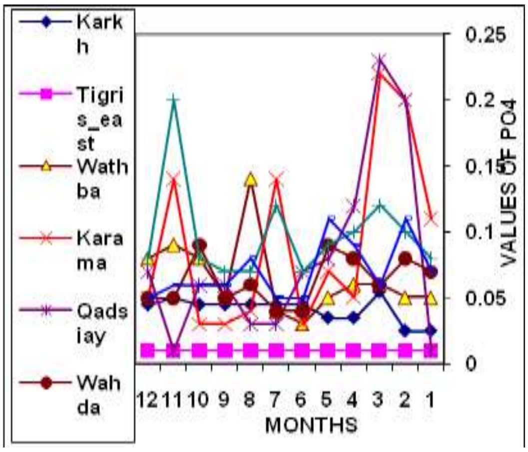

Fig.(15) values of (PO_4)which obj. < 0.4 mg/l

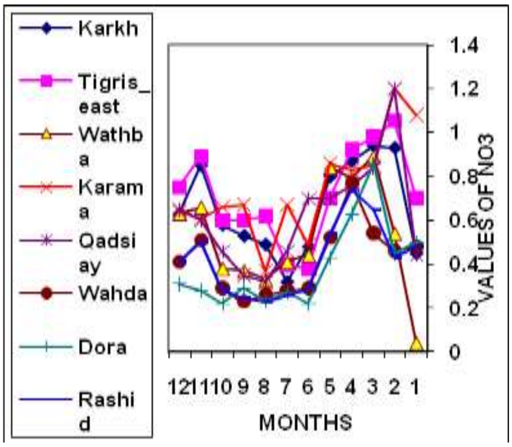

Fig.(14) values of (NO_3) which obj.< 20mg/l

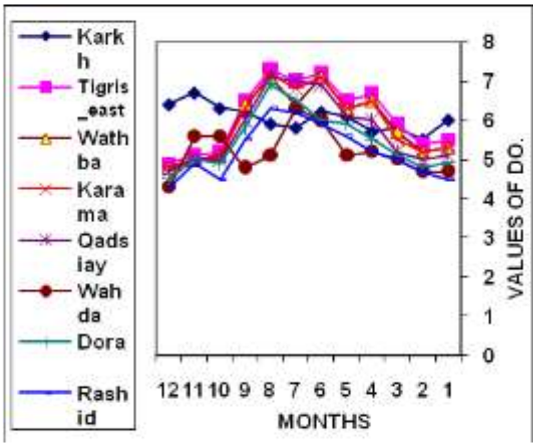

Fig.(17) values of (DO) which obj. >5 mg/l

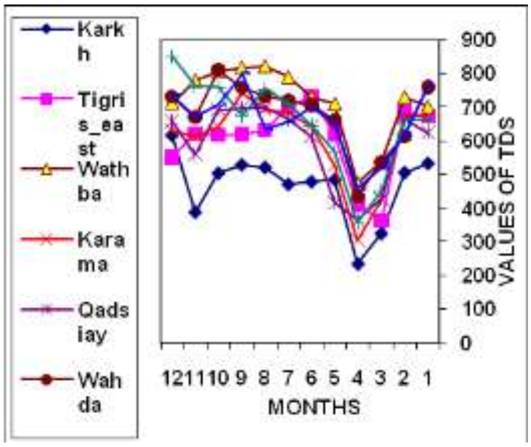

Fig.(16) values of (TDS) which obj.< 1500 mg/l

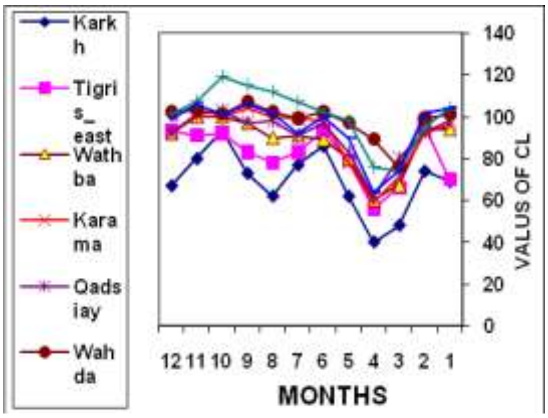

Fig.(19) values of (CLORIDE) ions which obj. < 250 mg/l

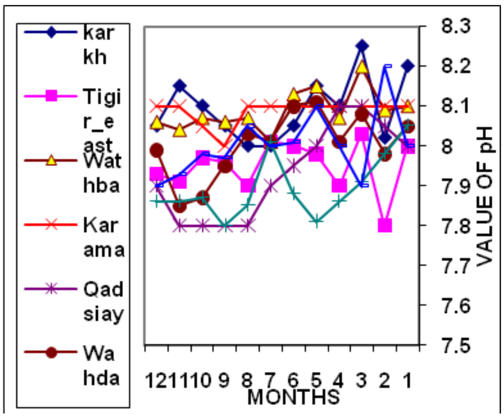

Fig.(18) values of (pH) which obj. (6.5-8.5) mg/l

Table (1): Maximum limitations raw water (WHO)

NO.	Parameters	Limit (objective)	Units
1	DO	> 5	mg/l
2	EC	< 750	µ Mos/cm
3	pH	6.5 -8.5	-----
4	BOD_5	< 5	mg/l
5	Temp.	< 25	C
6	PO_4	< o.4	mg/l
7	Turbidity	< 25	NTU
8	TDS	< 1500	mg/l
9	NO_3	< 15	mg/l
10	Fe	< 0.3	mg/l
11	F	< 1.0	mg/l
12	Al	< 0.1	mg/l
13	Total ALK. as $CaCO_3$	< 200	mg/l
14	Ca	< 200	mg/l
15	Total Hardness as $CaCO_3$	< 500	mg/l
16	Cl	50 -250	mg/l
17	Mg	< 150	mg/l
18	color	< 15	Platien-cobalt
19	SO_4	< 400	mg/l
20	Fecal coliform bacteria	< 2000	MPN/100ml

Table (2): Canadian classification for water quality index (CCME,2001)

Water Quality Class	WQI
Excellent	95-100
Good	80-94
Fair	65-79
Marginal	45-64
Poor	0-44

Table (3) :Classification of American salinity Lab.(ASL) of raw water for irrigation purpose

Class	Quality	(µ Mos /cm) Ec.	(mg/l) TDS
A	little Salt	250-0	Less than 160
B	Medium salt	750-250	480-160
C	high salt	2250-750	1440-480
D	Very high salt	5000-2250	3200-1440

Table (4): Russian Classification(RC) of raw water for irrigation purpose

Class	TDS (mg/l)
Excellent water	500-200
Salty water causes damages to the plants	2000-1000
irrigated soil for this water needs good drainage system	7000-3000

Table (5) :Classifications of (WQI) of the raw water in the intakes of eight (WTPs) according to (CCME, 2001) procedure

NO.	WTPs	WQI	CLASS
1	AL-KARKH	84.4	Good
2	TIGRIS- EAST	81.4	Good
3	AL-WATHBA	71.56	Fair
4	AL-KARAMA	77.77	Fair
5	AL-QADISIYA	73.89	Fair
6	AL-DORA	63.6	Marginal
7	AL-WAHDA	67.0	Marginal
8	AL-RASHID	56.89	Marginal

Table (6) :Values of (TDS) in (mg/l) of the raw water in the intakes of eight (WTPs) during the year (2009-2010)

Months	Al-Karkh	Tigris-east	Wathba	Karama	Qadsiya	Wahda	Dora	Rashid
1	523	674	702	674	626	760	658	761
2	505	685	730	673	667	615	663	620
3	325	365	538	427	428	538	450	520
4	235	410	474	305	363	436	355	459
5	484	620	710	530	416	661	568	655
6	478	730	730	644	613	707	646	699
7	470	702	790	686	665	720	710	659
8	520	633	822	694	701	734	753	634
9	528	620	817	743	698	759	676	800
10	503	617	808	643	695	811	759	709
11	388	622	779	614	560	671	762	673
12	615	552	713	631	658	732	850	736

Table (7) :Values of EC in (µ Mos/cm) of the raw water in the intakes of eight WTPs during the year (2009-2010)

Months	Al-Karkh	Tigris-east	Wathba	Karama	Qadsiya	Wahda	Dora	Rashid
1	810	1035	1221	1113	1077	1162	1055	1146
2	900	1009	1265	1152	1078	967	1054	940
3	665	898	1044	946	882	891	766	883
4	600	733	948	779	740	762	771	748
5	750	750	1023	967	948	1023	912	1037
6	865	1145	1142	1163	1103	1018	1039	1072
7	750	860	1203	1247	1236	1185	1191	1102
8	815	1064	1256	1300	1244	1128	1308	1188
9	850	1000	1301	1369	1265	1215	1270	1264
10	910	1062	1280	1335	1279	1227	1289	1267
11	905	1060	1220	1270	1262	1200	1272	1262
12	1010	1959	1275	1284	1273	1183	1294	1183

Table No.(8) Sample of calculations of Al-KARKH (W TP) by(CCME WQI)

Month	SO_4	Color	Mg	Cl	Hard	Ca	ALK	Al	F	Fe	NO_3	TDS	Tur.	PO_4	T	BOD	pH	DO	Fecal
1	200	<5	36	69	335	73	142	0.015	0.17	0.21	0.45	532	10	0.025	13	2.2	8.2	6	170
2	185	=	35	74	336	72	151	0.04	=	0.3	0.93	505	15	=	16	2.4	8.02	5.5	70
3	140	=	27	48	282	67	139	0.015	0.16	1.17	0.94	325	140	0.055	21	3.5	8.25	5.8	150
4	120	=	24	40	248	60	139	=	0.13	0.73	0.87	235	60	0.035	24	4	8.1	5.7	290
5	160	=	28	62	290	68	140	=	0.11	0.45	=	484	25	=	26	4.5	8.15	6.1	143
6	180	=	30	86	285	68	130	0.01	0.14	0.5	0.48	478	23	0.045	30	5	8.05	6.2	250
7	185	=	22	77	296	64	129	0.02	0.13	0.46	0.32	470	23	=	31	5.2	=	5.8	193
8	200	=	29	62	291	67	128	0.01	0.15	0.3	0.49	520	23	=	31	5.3	8	5.9	294
9	200	=	33	73	295	67	123	=	0.14	0.44	0.53	528	20	=	30	5.5	8.05	6.2	260
10	220	=	33	93	312	72	123	=	0.13	0.86	0.58	503	73	=	25	6	8.1	6.3	438
11	215	=	31	80	325	75	127	0.03	0.15	0.74	0.85	388	110	0.05	20	5.8	8.15	6.7	385
12	185	=	30	67	439	130	105	0.01	0.11	0.4	0.63	615	660	0.045	17	5.9	8.05	6.4	784
OBJ.	**<400**	**<15**	**<150**	**50-250**	**<500**	**<200**	**<200**	**<0.1**	**<1.0**	**<0.3**	**<20**	**<1500**	**<25**	**<0.4**	**<25**	**<5**	**6.5-8.5**	**>5**	**<2000**
EXC.										**10.14**			**36.72**		**1.16**	**0.74**			

NO. of parameters =19 , No. of tests = 288 , No. of failed tests =25

F_1 = 21 , F_2 = 8.68 , F_3=14.468 , CCME WQI = 84