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Alternative Chemical Treatments of Raw Water for Production the Drinking Water in Baghdad City

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Abstract: We found that the specification of raw water for Tigris river in Baghdad city (approximately from the midpoint of water stream in the city) was a good and need no effective treatments because the main pollutants are the turbidity and Total Suspended Solids (TSS) which represent the major pollutants only. These could be treated efficiently through the use of the new chemical treatment other than the alum and producing a large quantity of drinking water with high quality. The work included the collection and analysis of raw water samples from Tigris river during the first six months of 2011 at Alwahda project laboratories and our laboratories in university of technology . analysis results for raw water during this period showed that a number of determinants were within the acceptable range of the Iraqi drinking water specification (especially the Total Hardness TH , 260 – 500 mg / l ; Alkalinity , 150 – 170 mg / l as CaCO3 and Total Dissolved Solids TDS , less than 800 mg / l) . The Turbidity and Total Suspended Solids (TSS) were not within acceptable values of Iraqi specification for drinking water and ranged between 14 -180 NTU and 27 – 362 mg / l respectively . We have used in our study a group of coagulant agents and flocculents like ferric chloride , wood ash and also the new manufactured organic compounds named (XX-1 and poly XX-1) which have a good affinity to the heavy metals . The results showed that treatment the alum with ferric chloride at concentrations of 8 mg / l and 4 mg / l respectively and treatment with ferric chloride in concentration 8 mg /l were the best in decreasing the turbidity and TSS .The treatment with ferric chloride and the mixture of XX-1 and Ash gave negative results .The results showed the ability of synthetic organic XX-1 to remove the heavy metals from raw water , but have less ability to reduce the turbidity and TSS . It also observed the effect of ash in decreasing the turbidity and suspended solids when used with a alum .The clearness time was reduced to less than one hour after treatment with ferric chloride compared with alum (that use in Alwahda project) . The results showed high efficiency for ferric chloride in reducing microbial contaminants especially the Total Viable Count (TVC) and coliform viable count . The effect of ferric chloride was started from 10 mg / l compared with the alum treatment . Microbial contamination decreased about 4 log by using 20 mg / l of ferric chloride to become 102 cell / 100 ml compared with the alum treatment (106 cell / 100 ml)

Key words : Raw water , Drinking water ,Primary treatment ,Chemical treatments , Contamination.

المعالجات الكيميائية البديلة للمياه الخام لانتاج مياه الشرب في مدينة بغداد

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الخلاصة: وجدنا أن مواصفات المياه الخام لنهر دجلة في مدينة بغداد (تقريبا من منتصف مجرى المياه في المدينة) كانت جيدة ولا تحتاج إلى معالجة فعالة لأن الملوثات الرئيسية هي الكدرة Turbidity والمواد الصلبة العالقة الكلية Total Suspended Solids (TSS) يمكن التعامل معها بكفاءة من خلال استخدام معالجة كيميائية جديدة غير الشب وانتاج كمية كبيرة من المياه الصالحة للشرب ذات الجودة عالية.لقد تضمن العمل جمع وتحليل عينات من المياه الخام من نهر دجلة خلال الأشهر الستة الأولى من عام 2011 في مختبرات مشروع الوحدة و في مختبرات الجامعة التكنولوجيا . وأظهرت نتائج تحليل المياه الخام خلال هذه الفترة إلى أن عددا من المحددات كانت ضمن الحدود المقبولة في مواصفة مياه الشرب العراقية (وخاصة العسر الكلية TH ، 260-500 ملغم / لتر، القاعدية ، 150- 170 ملغم / لتر محسوبة ككربونات الكالسيوم $CaCO_3$، والاملاح االذائبة الكلية TDS، أقل من 800 ملغم / لتر) . تراكيزالكدرة والمواد الصلبة العالقة الكلية كانت خارج القيم المقبولة للمواصفات العراقية لمياه الشرب وتراوحت بين 14 – 180 NTU و 27 – 362 ملغم / لتر على التوالي . استخدمنا في دراستنا مجموعة من مواد التخثير والملبدات مثل كلوريد الحديديك، ورماد الخشب، وكذلك مركبات عضوية جديدة مصنعة سميت (XX-1 وبولي XX-1)ولهاميل جيدة للمعادن الثقيلة . أظهرت نتائج المعالجات الى ان معاملة الشب مع كلوريد الحديديك بتراكيز 8 ملغم / لتر و 4 ملغم / لتر على التوالي والمعاملة مع كلوريد الحديديك لوحده بتركيز 8 ملغ / لتر هي الافضل لتقليل الكدرة والمواد العالقة الكلية . أعطت المعالجة بكلوريد الحديديك وخليط من XX-1 مع الرماد نتائج سلبية. أظهرت النتائج إلى قدرة المركب العضوي الصناعي XX-1 في إزالة المعادن الثقيلة في المياه الخام، وقدرة اقل للحد من العكارة المواد العالقة الكلية . ولوحظ أيضا دور الرماد في خفض الكدرة والمواد الصلبة العالقة عند استخدامها مع الشب . تم تخفيض وقت وضوحية المياه إلى أقل من ساعة واحدة بعد المعالجة بكلوريد الحديديك مقارنة مع الشب (المستخدم في مشروع الوحده) . أظهرت النتائج كفاءة كلوريد الحديديك العالية في الحد من الملوثات الميكروبية وخصوصا العدد الحي الكلي (TVC)، وعدد بكتريا القولون الحية . ابتدأ التركيز الفعال من كلوريد الحديديك ا من 10 ملغم / لتر مقارنة مع معاملة الشب . انخفض التلوث الميكروبي حوالي 4 اسس باستخدام 20 ملغ / لتر من كلوريد الحديديك، وأصبح 10^2 خلية / 100 مل بالمقارنة مع المعالجة بالشب (10^6 خلية / 100 مل).

Introduction

The raw water prosperities of Tigris River as mentioned in many references are rich in fine suspended materials according to the British company that analyzed the samples waters of the Tigris [1] . It also contains TSS ranged between 25 - 40000 mg / l . Two investigators showed 70 years ago that on 1 hr capacity uncoagulated pre-settlement tanks in Baghdad and elsewhere confirm that effluents with considerably less than 1000 mg /l of suspended solids can safely be expected from such tanks ,even though the incoming raw water might have TSS of 10000 mg /l or more [2] . These results revealed the instability of the natural pollutants concentration in Tigris River before this long period where there were no active industries and water supplied in excess from resources .

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Turbidity is caused by suspended matter or impurities that interfere with the clarity of the water. Simply stated , turbidity is the measure of relative clarity of a liquid. Clarity is important when producing drinking water for human consumption and in many manufacturing uses. Once considered as a mostly aesthetic characteristic of drinking water, significant evidence exists that controlling turbidity is a competent safeguard against pathogens in drinking water [3] .

Coagulants are used to complete the coagulation of the suspended and dissolved contaminants materials according to the type and chemical nature of coagulant . The most solid matters settled by gravity and the remaining are settling by using the coagulants through the formation large and highly density flocs . The salts of iron , alum and Calcium Oxide are used as coagulants in removing the small particles size of suspended solids. They accumulate by adsorption property . [4] .

The flocculation process is including the slow mixing after adding the flocculent . The terms coagulation and flocculation were often used interchangeably . In more accurately , the coagulation process is defined as the reducing of the electric infraction forces on the surface of the particles, while the flocculation is accumulation of unstable electrically particles through chemical links to. The mixing time not exceed 15 second to several minutes in coagulation tanks then go to the flocculation or settling tanks [5] . Sedimentation by using coagulant reduces the time required to settle out suspended solids and is very effective in removing fine particles. Some bacteria and viruses can also attach themselves to suspended particles. Therefore, reducing turbidity level through coagulation may also improve some microbiological quality (bacteria, viruses, protozoa and helminthes) of water [6] . It was found that the pH affected the efficiency of coagulation and the coagulant is very important

e.g., the addition of metal cationic compounds of iron ions (in this case Fe^{+3}) , lead to a reduction in the pH of the water and then decrease in the formation the clot to the types of few alkalinity water . The process of coagulation completed in the pH range of 7- 9 [7].

No health-based guideline values have been set for aluminum and iron, because neither is considered to be of significance to health when used under normal circumstances in water treatment. However, both substances can give rise to problems of discoloration and deposition of sediment in distribution if present in excessive amounts. The concentrations in drinking-water above which problems are likely to occur are 0.3 mg/l for iron and 0.2 mg/l for aluminum [8] .

For conventional treatment processes, chemical coagulation is critical for effective removal of microbial pathogens. Together, coagulation, flocculation and sedimentation can result in 1–2 log removals of bacteria, viruses and protozoa. For waters with high levels of algae, care must be taken to remove these organisms without disrupting the cells, which may release liver or nerve toxins. High-rate clarification using solids contact clarification, ballasted-floc, or contact clarification systems can be as, or more, effective than conventional basins for removal of microbes . Lime softening can provide good microbial treatment through a combination of inactivation by high pH and removal by sedimentation. Under optimal conditions, the combination of coagulation, flocculation, sedimentation and granular media filtration can result in 4-log or better removal of protozoan pathogens [9] **.**

In Fact , the shortage availability of drinking water (D.W.) in Iraq is due to many reasons starting from the low quantity entrances to rivers , low rate rain and the unfair distribution between the growth of population and the classical water treatments methods . The aim of this study was to improving the treatment and water quality without changing the basic designs of the stations by using substituted materials in pretreatment stage .

Materials and Methods

A- Collection and analysis raw water samples during the first six months of 2011.Part of determinants (components) analyzed in project laboratory (Silica , Aluminum , Fluoride , Temperature and pH) and the others tests in Technology University laboratory using the programming instruments (Photolab-Spectral S12 with standard kits supplied from WTW company) .

B- The data of analysis regulated in suitable manners and simple statics analysis was achieved to determine the mean and standard deviation .

C- Primary Substituted treatments

In primary treatments of inlet raw water , the concentrations of coagulants and flocculents agents were determined in

concerned with the actually treatment with alum that followed in Alwahada project .The other agents were determined according to the information mentioned in the many references mentioned above .

The treatments in the present study achieved in the Jar – Test instrument supplied by Lovibond company . It was started with high speed mixing (300 rpm /min) of standard one litter of raw water for one minute after adding the coagulant followed with slow speed for 10 minutes after the flocculent added . The mixing was stopped and lift for one hour then examined . During this period the initial clotting time was recorded . The treatments included :

1- a- Alum (8mg/l) : Mixing vigorously (1 min) . Then add ,

b- Ash (2mg/l) : Mixing vigorously (1 min) .The source of the ash was the burning the trees wood completely , then grinding and washing with distil water many times and drying . This agent was added as flocculent .

c- Slow mixing for (10 min) .

d- Left , monitoring , record the time of the first cloud formation . The sample has been taken after (1 hr .) and many examination were achieved .

2- a- Ferric Chloride ($FeCl_3$) , 8 mg /l : Mixing vigorously (1 min) .

b- XX-1 (2 mg /l : This compound has a good ability to separate the heavy metals .

c - The remaining steps as mentioned in treatment No . 1 .

3- a- Alum + FeCl3 (8 mg/l : 4 mg/l) : Mixing vigorously (1 min) .

b- XX -1 (2 mg/l) .

c- The remaining steps as mentioned in treatment No . 1 .

4- a- Alum (8mg/l) : Mixing vigorously (1 min) .

b- Ferric Chloride ($FeCl_3$) , 4 mg /l : Mixing vigorously (1 min)

c- The remaining steps as mentioned in treatment No . 1 .

5- a- Ferric Chloride ($FeCl_3$) , 4 mg /l : Mixing vigorously (1 min).

b- Alum (8mg/l) : Mixing vigorously (1 min).

c- Ash (2mg/l) : Mixing vigorously (1 min) .

d- The remaining steps as mentioned in treatment No . 1 .

6 – a- XX-1 : (2 mg /l) : Mixing vigorously (1 min) .

b- The remaining steps as mentioned in treatment No . 1 .

7 – a- Ferric Chloride ($FeCl_3$) , 8 mg /l : Mixing vigorously (1 min).

b- Alum (4mg/l) : Mixing vigorously (1 min) .

c - The remaining steps as mentioned in treatment No . 1 .

8- a- Ferric Chloride ($FeCl_3$) , 8 mg /l , then adding the ash (2 mg/l) directly and Mixing vigorously (1 min) .

b- The remaining steps as mentioned in treatment No . 1 .

9 - a- Ferric Chloride ($FeCl_3$) , 8 mg /l , then adding the ash (2 mg/l) directly : Mixing vigorously (1 min) .

b- Alum (8mg/l) : Mixing vigorously (1 min) .

c- Ash (2mg/l) + XX -1 (2 mg/l) : Mixing vigorously (1 min) .

d- The remaining steps as mentioned in treatment No . 1 .

10 -a- Alum (8mg/l) : Mixing vigorously (1 min) .

b- Ferric Chloride ($FeCl_3$) , 8 mg /l , then adding the ash (2 mg/l) directly : Mixing vigorously (1 min) .

c- The remaining steps as mentioned in treatment No . 1 .

11 – a- Ferric Chlorid (8 mg/l) : Mixing vigorously (1 min) .

b-The remaining steps as mentioned in treatment No . 1 .

12 – Poly XX -1 .: Mixing vigorously (1 min) .

13 – XX-1 (2 mg/l) + FeCl3 (4 mg/l) . Mixing vigorously (1 min) .

In the treatments (12 ,13 and 14) , the remaining steps are as mentioned in treatment No . 1.

D- Microbial examination of raw water

In order to comparison between the Alum as classical coagulant used in Alwahda project and ferric chloride as substituted coagulant in their effect on microbial contamination of raw water at primary treatment , the raw water sample were taken under aseptic condition and cooling and immediately transfer to the our laboratory .We determined Total viable count and Total coliform using membrane filtration technique . The Millipore filters were transferred to prepared Nutrient agar and McConky agar plates and incubate at 37 $^{\circ}$C for 24- 48 hr. The count was calculated as cells / 100 ml of sample .

All examinations were performed after treated of raw water samples with alum (40 mg / l) , as recommended by project , and ferric chlorides of serial concentrations (5 -20 mg /l) .

Results and Discussion

Periodical examination of Raw Water

Table 1 shows of the results of raw water tests of the Tigris river during the first six months of the year 2011. The results indicated that the waters of the Tigris river taken from Alwahda project, which is located in the middle of Baghdad city and during this period winter, spring and summer, was a good as their correlation with pollution levels. We have included the Turbidity and Total Suspended Solids TSS as a primary pollutants in raw water because

of their high concentrations. The remaining components of Alkalinity , Total Soluble Solids and Total Hardness were within the acceptable levels of Iraqi standard 2010.

The other components even lower than the drinking water specifications in the same Iraqi standard .

Table (1) illustrates that in January , in general , was recognized in normal concentrations of primary pollutants. In the February, we found that the concentrations of primary pollutants were natural except the turbidity (129 NTU) and TSS (153 mg / l).

But in March, the alkalinity and silica were the highest . In April, the turbidity was the highest . May was distinguished month for the highest in the turbidity and TSS concentrations during the six months (180 NTU, 362 mg / L, respectively) and that may be due to the reason of melting the snow and drift clay with water that caused for high concentrations of these pollutants in the raw water.

The best months was June and may be due to the pumping of water from natural reservoirs (such as the Tharthar Lake and dams water) which have good characteristics and the water that normally run at normal stream , so no cliffs the clays in .

Table 2 and Figure 1 illustrate the results for the raw water components that were elected from Table 1 . These components were the TSS , turbidity , Alkalinity , TH and TDS as well as statistical analysis which was represented by the standard deviation from the values of the means . It seems that the standard deviation for turbidity and TSS were the large values . The alkalinity was not affected during the first six months and stayed within the acceptable limits the drinking water specification .

Primary Substituted treatments

The Alum treatment that used routinely in the Alwahda project was set as a control treatment for the purpose of comparison with our new treatments . We named these treatments as primary treatments for the purpose of standing on the effect of coagulant and flocculent agents that selected or prepared by us on removing raw water contaminants and settling time.

Table - 1 : Summary examinations of Tigris river raw water in first six months of 2011.

Collection Date / **Parameters**	**Units**	**Jan.**	**Feb.**	**March**	**April**	**May**	**Jun**	**Mean**
Temperature	°c	17.9	14	16	22	23	24	
Turbidity	**NTU**	**14.8**	**129**	**52**	**158**	**180**	**87**	**103**
Alkalinity as CaCO3	**mg/L**	**160**	**160**	**175**	**168**	**154**	**156**	**162**
T.Hardness as CaCO3	**mg/L**	**503**	**391**	**340**	**261**	**270**	**255**	**353**
Calcium as Ca	mg/L	126	96	86	72	68	66	
Chloride as Cl	mg/L	107	83	67	73	69	61	
Magnesium as Mg	mg/L	37	36	31		22	23	
PH	units	8.0	7.9	8.02	8.01		7.97	
Color	units							
Conductivity	µs/cm	1243	980	850	779	740	640	
Free Chlorine	mg/L							
Sulfate as SO4	mg/L	300	272	139			115	
Total dissolved solids	mg/L	800	667	568	468	508	430	
Suspended solids	**mg/L**	**27**	**153**	**110**	**89**	**362**	**163**	**150**
Iron as Fe	mg/L	0.45	0.857	1.5	1.4	1.45	1.6	
Fluoride as F	mg/L	0.17	0.19	0.18	0.17	0.17		
Aluminium as AL	mg/L	0.03	0.02		0.02	0.02	0.02	
Nitrite as NO2	mg/L	0.014	00.025	0.015	0.018		0.011	
Nitrate as NO3	mg/L	0.58	1.67	1.6	1.15			
Ammonia as NH3	mg/L	0.32	0.43	0.25	0.31			
Silica as SiO2	**mg/L**	**1.12**	**2.2**	**3.18**	**3.15**		**2.6**	**2.6**
Orthophosphate as PO4	mg/L		0.07	0.06	0.07			

The common coagulants and flocculents agents like alum and ferric chloride were selected and added to the raw water according to the pollutants concentrations concerned with the turbidity , TSS and alkalinity **.** The concentrations of these agents were selected according to the international

researches and recommendations of related companies .

Table -2 : Results and statics analysis of important parameters of Tigris raw water during the first six months in 2011 .

Parameter	***Jan***	***Feb***	***March***	***April***	***May***	***Jun***	***Mean***	***SD***
Turbidity(NTU)	**14.8**	129	52	158	180	87	**103**	**66.56**
Alkalinity (Mg/l)	160	160	175	168	**154**	160	**162**	**7.8**
T H (Mg/l)	503	391	340	**261**	270	255	**353**	**97.8**
TSS (Mg/l)	**27**	153	110	89	362	163	**150**	**114**
Silica (Mg/l)	2.6	**2.2**	3.2	3.18	3	2.6	**2.6**	**0.78**

The process of addition these separately or combined agents were done in jar test instrument at maximum speed (300 rpm) for one minute and 10 minutes at minimum low speed (20 rpm) then left for standing for 1 hour .

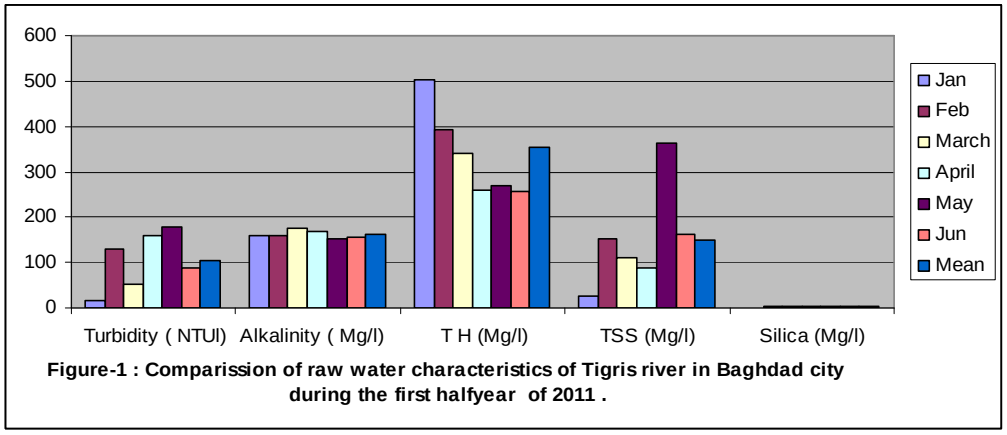


Figure-1 : Comparission of raw water characteristics of Tigris river in Baghdad city during the first halfyear of 2011 .

We also examined a synthetic organic compound called (XX-1 and poly XX-1) and weed ash which prepared by washing with distilled water , drying and grinding . These material were used at low concentrations as coagulant aids ,so they added alone or in combination with above classical materials .

Table 3 , summarized the results of substituted primary treatments of Tigris river raw water collected from Alwahda project . The results of treatments showed that the treatment of alum and ferric chloride at consecutive concentrations of 8 mg /l and 4 mg/l (Treatment No. 4 in the same table)and the treatment Number (11) with ferric chloride at concentration 8 mg /l were the best treatments to decrease the turbidity and TSS to the very low concentrations and in addition to the emergence of cloud at a time less than 5 minutes and high leaching in more than 75% of the height of the water column in the beaker of 1 litter after hours of settling .

The use of materials varied in their effect in removing or reducing pollutants concentrations in the raw water. It was founded the ability of the synthetic organic flocculents to remove the heavy metals present in water (treatment No. 6) but have less ability to remove the turbidity and TSS . It also observed the role of ash in reducing the turbidity and reducing the suspended solids when used with a classical treatment agents.

(Treatments No. 5 , 8) especially when it used with ferric chloride or combination with alum and ferric chloride .

Use of XX-1 with ferric chloride gave encourage results (treatment No . 2) .

We can conclude the efficiency of ferric chloride as coagulation agent replacement for alum (at concentration of 8 mg / L) or with other factors like the alum and ash or with the XX-1 agent . Each of these agents has a specific prosperities for removal of certain pollutants from the water . The presence of these factor combined together with ferric chloride gave negative results, as evident in treatment No. 10 .

Table – 3 : Primary substituted treatments of raw water from Tigris river

a Parameter / Treatment	pH	Turbidity (NTU)	TSS mg/l	Cloud Time (min)	Alkality mg/l	b Clearnes	TH mg/l	TDS mg/l	Fe mg/l	Pb mg/l	OD (450 nm)	Al mg/l	SiO_2 mg/l
1- (Alu +Ash) 8mg/l +2mg/l	7.5	3.6	2.6	6	165	Turbid	150	490	0.13	0.02	0.040	BDL[d]	
2- ($FeCl_3$ +XX-1) 8+2 mg/l	7.4	3.4	1.0	7	160	Clear	149	440	0.10	0.015	0.020	BDL	2.3
3- (Alu+ $FeCl_3$ +XX-1) 8mg/l+ 4 mg/l + 2 mg/l	7.3	1.8	0.6	7	160	Clear +	148	410	0.12	0.02	0.020	BDL	2.5
4- (Alu+ $FeCl_3$) 8mg/l +4mg/l	6.9	0.9	0.3	< 5	158	Cear ++	156	400	0.15	0.02	0.012	BDL	2.7
5- ($Fe Cl_3$ + Alu+Ash) 4+8+2mg/l	7.4	1.0	0.4	"	158	Clear +	148	320	0.15	0.03	0.015	BDL	2.4
6- (XX-1) 2 mg/l	7. 4	30	20	Turb. natural	160	Turbid	155	370	0.08	0.010	0.050	BDL	2.0
7- ($Fe Cl_3$ +Alum) 8+4 mg/l	7.4	4.4	1.2	<10	162	Clear	155	378	0.14	0.03	0.02	BDL	2.4
8- ($Fe Cl_3$ + Ash) 8 +2 mg/l	7.4	2.0	1.7	<5	156	Clear+	160	390	0.15	0.02	0.015	BDL	2.8
9- ($Fe Cl_3$ + Alu+Ash +XX-1) 8+8+2+2 mg/l	7.3	3.8	2.4	<10	164	Turbid	157	370	0.14	0.02	0.015	BDL	2.4
10- (Alu + $Fe Cl_3$ +Ash +XX-1) 8+8+2+2 MG/L	7.2	4.9	2.6	<10	161	Turbid	154	360	0.15	0.02	0.017	BDL	2.4
11- ($Fe Cl_3$) 8 mg/l	7.6	0.6	0.3	< 5	160	Clear ++	156	300	0.15	0.02	0.013	BDL	2.7
12- PlolyXX-1	7.4	30	23	20	161	Turbid	160	300	0.05	0.02	0.052	BDL	2.4
13- (XX-1 + $Fe Cl_3$) 2 +4 mg/l	7.4	3.5	3	6	160	Clear	160	400	0.10	0.02			2.6
Control(Raw water)	7.5	34	30	Turbid (Natural)	170	Turbid	160	520	0.13	0.02	0.065	BDL	3.2
After Alum stage [c]	7.6	7.7	5.4	10	166	Turbid	158	500	0.14	0.04	0.025	BDL	2.8

a : Mean of two repeating . b : After one hour . c : Treatment of Alwahda project .d : The number represents the concentration in mg/l and sequences of treatment . e : BDL: Below Detection Limit .

So the alum is still the only the choice in pretreatment of raw water of Tigris and Nephrites rivers because of all drinking water production stations were designed to deal with it.

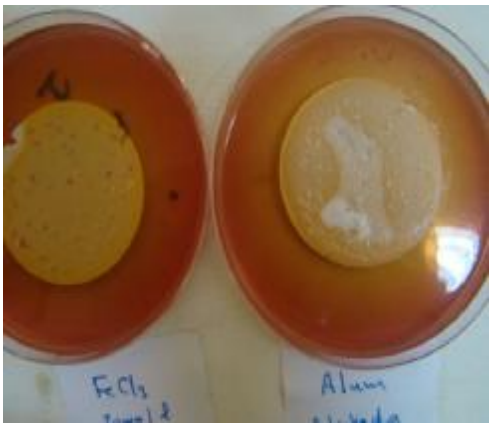
Table 4 and Figures 1 and 2 showe the results of treatment the raw water supplied from Alwahda project for drinking water production by using the alum according to the calculate dose (40 mg /l) recommended by the project based on the concentration of turbidity . As for the other treatments appears the effect of the use of ferric chloride in concentrations gradient (5-20 mg /l) on the total viable count and coliform count .

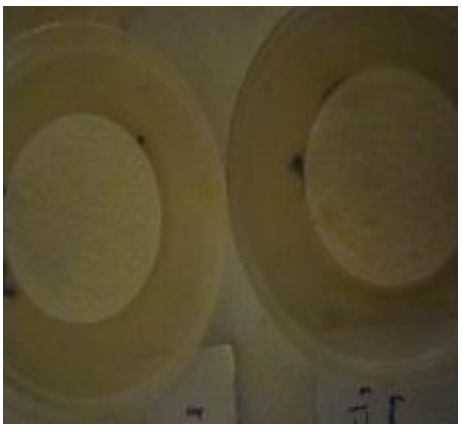
The choice of a higher concentration of ferric chloride (20 mg / l) was appropriate, depending on the concentration of total suspended and that fall within the limits (20 - 40 mg / l) . The results showed high efficiency of ferric chloride in reducing microbial contamination represented by the total viable count (TVC) and total viable cell count of Coliform bacteria starting from the concentration 10 mg / l up compared with the alum treatment . Microbial contamination has decreased to its lowest level at a concentration of 20 mg / l of ferric chloride and to less than about 4 log (10^2 cell / 100 ml) compared to alum treatment 10^6 cell/100ml . The treatment with ferric chloride of great significance after the results we have obtained and we recommend using this substance in treatment rather than the fact that alum with significant side effects especially when used in the primary treatment of drinking water production .

Table -4 : Effect of ferric chloride on microbial contamination of Tigris raw water after treatment with coagulants.

No .	Treatment	Medium	Total Viable count Cell (Cell / 100ml)
1	Alum (40 mg / l) *	Nutrient agar	1X 10^6
2	Ferric Chloride (20 mg /l)	Nutrient agar	2X 10^2
3	Alum (40 mg / l)	MA**	1X 10^5
4	Ferric Chloride (5 mg /l)	MA	1X 10^5
5	Ferric Chloride (10 mg /l)	MA	1X 10^4
6	Ferric Chloride (15 mg /l)	MA	1X 10^3
7	Ferric Chloride (20 mg /l)	MA	1X 10^2

* As recommended in Alwahda station . ** MA : MacConky Agar , the count of total coliform .





A - Total Coliform (Lift : $FeCl_3$, 20 mg/ l ; ; Right : Alum 40 mg /l) .

B – Total Viable count (Lift : $FeCl_3$, 20 mg/ l Right :Alum 40 mg /l)

Figure - 1 : Comparision between the effect of alum and ferric chloride on total viable count and coliform count in primary treatments of Tigris raw water .

5 mg / l

15mg / l

10 mg / l

20 mg / l

Figure -2 : The effect of different concentrations of ferric chloride on coliform count in primary treatment of tigris raw water .

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