THE EFFECT OF WATER TREATMENT STAGES IN AL-WATHBA WATER TREATMENT PLANT ON THE BACTERIAL GROWTH (APPLIED STUDY)

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Abstract:

The aim of this research is to study the biological pollution in Al-Wathba water treatment plant stages (new extension) by taking water samples from the river, sedimentation tank, sand filter, pressure filter, and from three residential areas (Al-Atebaa neighborhood, Al-Amen neighborhood, Al-Shorja), with examining the bacterial growth, temperature, pH and turbidity in each stage. Weekly samples have been taken for the period from January 2011 to May 2011 by studying the bacterial existence using total plate count (TPC), also test for total and fecal coliform using presumptive and confirmed test because it's the evidence for the bacterial pollution. There was high percent of pollution in the sedimentation tank and in less amount in sand filter due to lack of the periodic cleaning. Fecal coliform reduced after the pressure filtration, small amounts of chlorine were added to the filter to reduce the bacterial growth in filter media. After chlorination removal efficiency was 99.99%. It was noticed that chlorine dose added for disinfection was so high reached to 3.5mg/l, which is dangerous especially for people near the water treatment plant.

Keywords: Total plate count, fecal coliform, chlorination, bacterial growth

Introduction

Water has long served as a mode of transmission of diseases. The most important of the waterborne diseases are those of the intestinal tract, including typhoid fever, paratyphoids, dysentery, infectious hepatitis, cholera, and some parasitic worm diseases.

Drinking water also should have a reasonable temperature.(Wisner and Adams,2002)

It is not practicable to test the water for all organisms that it might possibly contain. Instead, the water is examined for a specific type of bacteria which originates in large number from human and animal excreta and whose presence in the water is indicative of fecal contamination. (Colin, 1998)

The most basic test for bacterial contamination of a water supply is the test for total coliform bacteria. Total coliform counts give a general indication of the sanitary condition of a water supply. (New York state department of health,2011)

Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste. (New York state department of health,2011)

Fecal coliforms are the group of the total coliforms that are considered to be present specifically in the gut and feces of warm-blooded animals. Because the origins of fecal coliforms are more specific than the origins of more general total coliform group of bacteria, fecal coliform are considered a more accurate indication of animal or human waste than the total coliforms. (New York state department of health,2011)

Escherichia coli (E. coli) is the major species in the fecal coliform group, so it's considered to be the best indicator of fecal pollution and the possible presence of pathogens. (New York state department of health,2011)

Bacteriological Health Effect

The pathogenic agents involved protozoa which may cause disease that vary in severity from mild gastroenteritis to severe and sometimes fatal diarrhea, dysentery hepatitis, typhoid fever, cholera and other illness. Most of them are widely distributed throughout the world. (WHO, 2000)

It is not only by causing infection that microorganisms in drinking water can affect human health. In some circumstances cyanobacteria can produce toxins that may remain in the water even when the cyanobacteria themselves have been removed. (WHO, 2000)

Total coliform bacteria ferment lactose at 35 or 37^{o} C with the production of acid, gas and aldehyde within 24-48 hours. Fecal coliforms (thermotelerant coliform) are subgroup of total coliforms, having the same properties except that they tolerant and grow at higher temperature of 44-45 ^{o} C. (Ralph, 1992)

Finally, there are some organisms whose presence in water in a nuisance but which are of no significance for public health. (payment et al,1991)

The effect of Water Parameters on the Bacterial Growth

Bacteria can enter water supply through infiltration by flood waters or by surface runoff. Flood waters commonly contain high levels of bacteria. Small depression filled with flood water provides an excellent breeding ground for bacteria. (Extension Educator, 2004)

Treatment effectiveness is a function of disinfectant dose, contact time, temperature and sometimes pH. Chemical disinfection to inactivate pathogens is an important treatment barrier. (Stanfield et.al., 1998)

The activity of a disinfectant may be greatly affected by factors such as dilution, temperature, pH, or the presence of organic matter, a disinfectant needs appropriate conditions, at a suitable concentration, for an adequate period of time. (white, 1997)

An increased risk of bladder cancer appeared to be associated with consumption of chlorinated tap water. (Cantor et. al., 1996)

Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection, for effective disinfection with chlorine pH should preferably be less than 8. (WHO,2003)

The pH of water markedly influenced the survival of bacteria. The addition of lime to the raw water was an effective method of pH bacteria control. The results of a study done by Martin et. al. , 1982 illustrate the delicate balance that can exist between bacterial growth, pH, and chlorine residual.

Increasing the pH level over 7.2 affect negatively on chlorine action, it decreases its action on killing bacteria. (WHO, 1996)

Water temperature directly or indirectly affects all of the factors that govern microbial growth. Temperature influences treatment plant efficiency, microbial growth rate, disinfection efficiency, decay of disinfectant residuals, corrosion rates and distribution system. (Singleton, 1997)

At temperature above 15^{o}C the growth of nuisance organisms in distribution system becomes a problem and could lead to the development of unpleasant taste and odors. (Silvey et. al., 2009)

The ideal temperature of water for drinking purpose is (5-12)^{o}C, above 25^{o}C water is not recommended for drinking. (Raju , 1995)

To define the interrelationship between elevated turbidities and the efficiency of chlorination in drinking water experiments were performed to measure bacterial survival, chlorine demand, and interference with microbiological determinations. Results indicated that disinfection efficiency was negatively correlated to turbidity and was influenced by season, chlorine demand of samples and the initial coliform level. (Le Chevallier, 2011)

Turbidity is of great importance, first because of aesthetic consideration and second because pathogenic organisms can hid on(or in) tiny colloidal particles. (Pierce et. al., 1988)

Turbidity in rivers can change from 10 to over 4000 NTU (MWH, 2005)

Twort et. al., 1994 wrote that turbidity level for treated water should not be exceed 5 NTU, and should be under 1 NTU for efficient disinfection with chlorine.

Previous Studies

Studies have been down to study water quality in water treatment plants all these studies indicated that water quality for Tigris River in Baghdad, affected by discharging the untreated sewage and wastes from industries and hospitals to the river.

Al-Malikey (1993), studied the effect of the pollution of the Tigris River, he indicated that Al-Wathba water treatment plant which is located in the middle of Baghdad was not suitable for its use as a source of drinking water, this is due to exceeding number of total coliform bacteria.

Alwan (2001), stated that bad quality of drinking water can attributed to two sources first, the embargo which was supposed on our country lowered the efficiency of water treatment plants and second source of the problem deals with treated water pipe networks as most of these are very old and need replacement.

This study indicated that al-Wathba water treatment plant shows an improvement in its water quality.

Field work and Sampling

This research has been done to evaluate water quality for Al-Wathba water treatment plant, and study the microbiological effect. Samples of water were taken two times monthly from the following points :-

1- River water.
2- Sedimentation tank.
3- Sand filter.
4- Pressure filter.
5- Al-Ateba neighborhood.
6- Al-Ameen neighborhood.
7- Al-Shorja.

Samples were collected in a soft glass sterilized bottles with screw-top closures for the period from January to June 2011. All chlorinated samples dechlorinated by adding a measured amount of the prepared sodium thiosulfate solution to empty sample bottle before sterilization to neutralize. Any residual chlorine and prevents the continuation of the disinfection action during the time the sample is in transit to the laboratory. (Hammer, 1986).

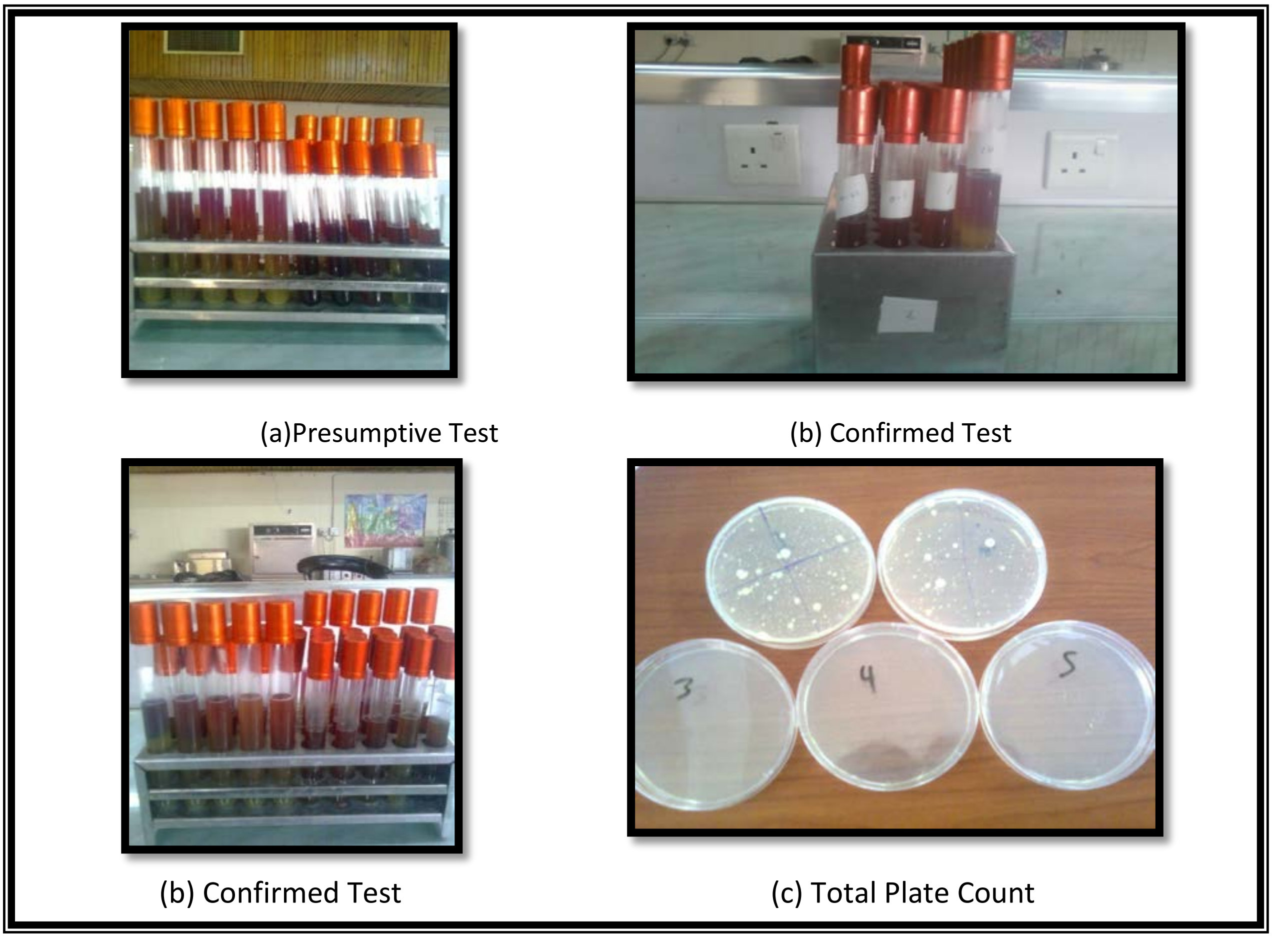
Bacteriological examination was done at Al-Mustansirya university, engineering college (Environment laboratory). The examination included the presumptive test then the confirmed test (to find out total and fecal coliform) and total plate count, Temperature , pH and turbidity was also tested on sight.

All apparatus has been sterilized prior to use . Always use a fresh sterile pipette for each sample and for each dilution.

Lauryl Tryptose Broth (Lauryl sulfate Broth) used at the presumptive test and after incubation the samples for 48 hours at 37^{o}C growth in production of gas, identified by the presence of bubbles in the inverted vial , is a positive test indicating coliform bacteria may be present. A negative reaction, either no growth or growth without gas, excludes the coliform group.

The confirmed test is used to substantiate, or deny, the presence of coliform in a positive presumptive test (polluted samples) by using (Brilliant Green Broth) to find out (total coliform) and incubation for 48 hr at 37 ^{o}C . EC Broth is used to find out (fecal coliform) by using water bath at 45 ^{o}C for 48 hr. If growth with gas occurs the presence of coliforms is confirmed.

Total plate count was made to discover the bacterial colonies per 1 ml of sample, by using (Nutrient Agar). Figure (1) illustrate stages of Bacteriological examination.



(a)Presumptive Test (b) Confirmed Test

(b) Confirmed Test (c) Total Plate Count

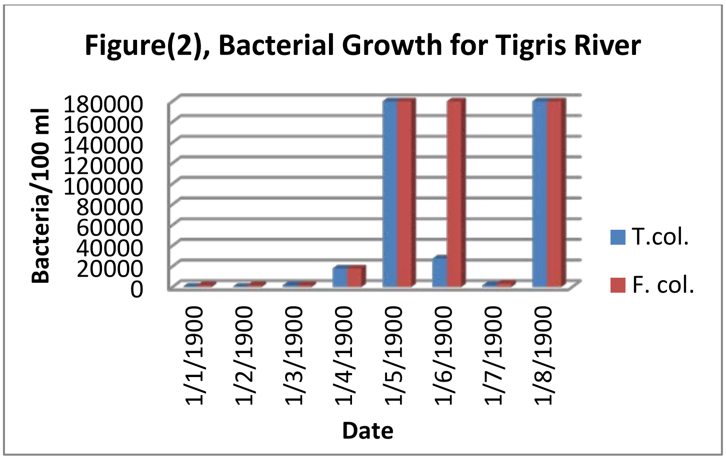
Figure (1), Stages of Bacteriological Examination

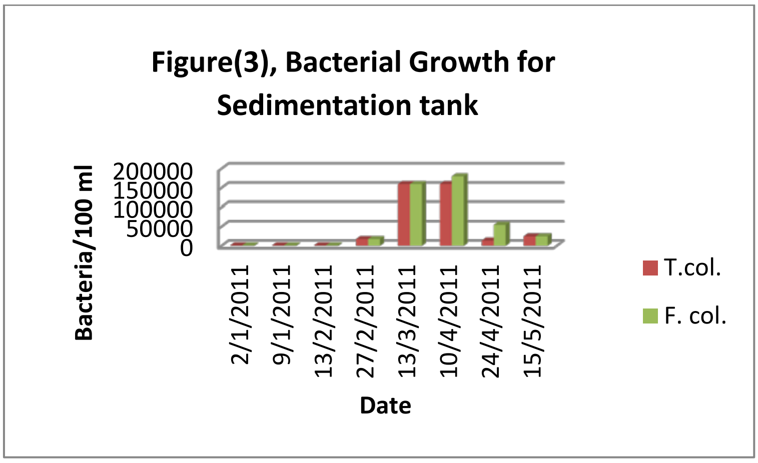
Results and Discussion:

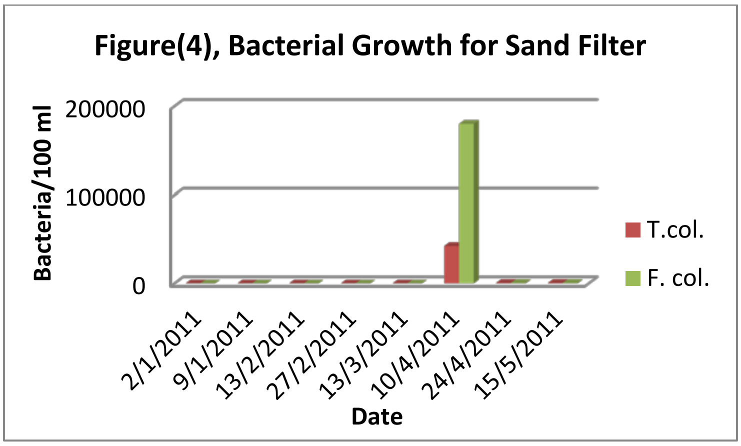
Total coliform consists of many types of bacteria including fecal coliform, so comparison between (total and fecal) coliform was made to all sampling points, figure (2 to 8).

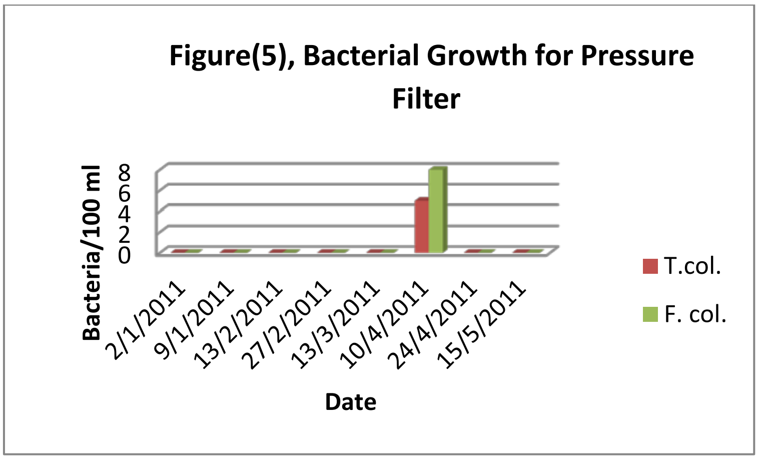
For all samples there was an increasing in fecal coliform concentration in April this was because of raising in water temperature to about 22^{o}C which helps bacteria to live especially river water and sand filter media. Concentrations of fecal coliform reached to 180000 /100 ml of sample.

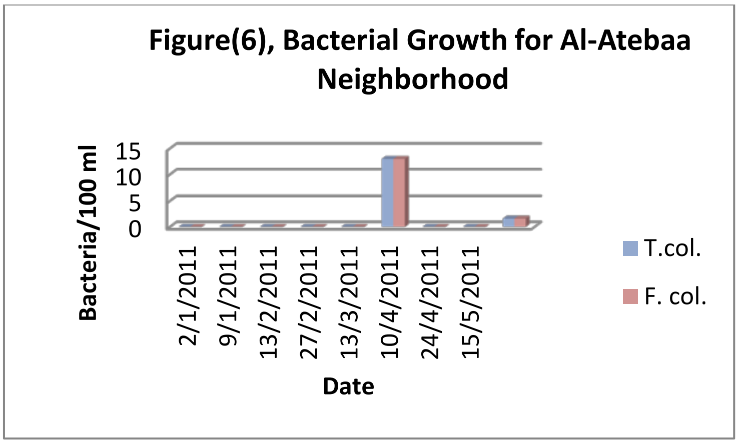
Generally, sedimentation tank and sand filters need to be cleaned continuously from sediments, algae, and bacterial growth.

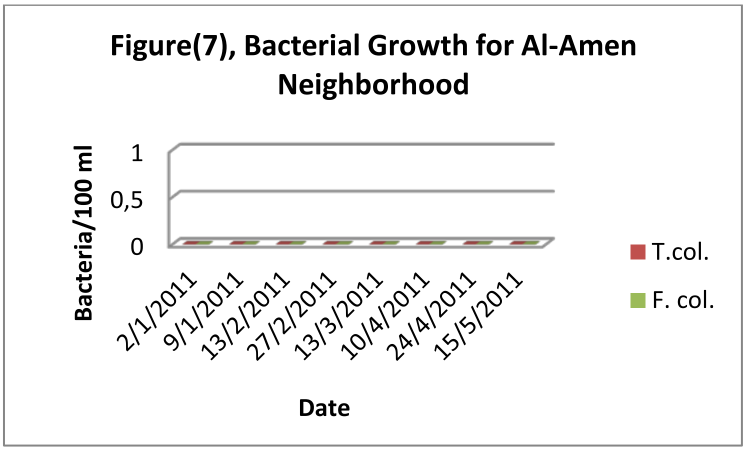

Figure(2), Bacterial Growth for Tigris River
Bacteria/100 ml
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1/1/1900
1/2/1900
1/3/1900
1/4/1900
1/5/1900
1/6/1900
1/7/1900
1/8/1900
Date
T.col.
F. col.

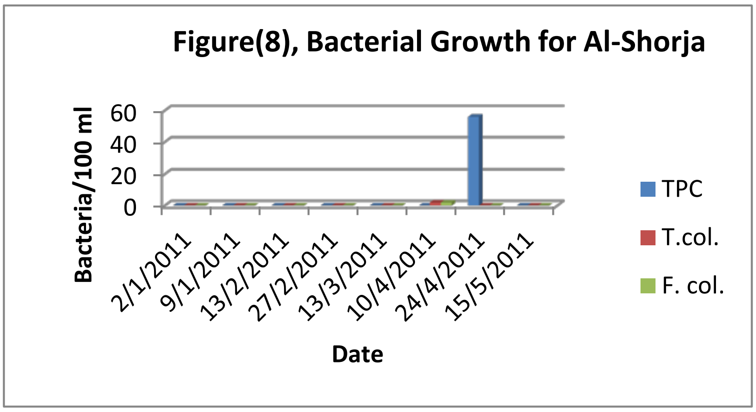

Figure(3), Bacterial Growth for Sedimentation tank
Bacteria/100 ml
200000
150000
100000
50000
0
2/1/2011
9/1/2011
13/2/2011
27/2/2011
13/3/2011
10/4/2011
24/4/2011
15/5/2011
Date
T.col.
F. col.


Figure(4), Bacterial Growth for Sand Filter
Bacteria/100 ml
200000
100000
0
2/1/2011
9/1/2011
13/2/2011
27/2/2011
13/3/2011
10/4/2011
24/4/2011
15/5/2011
Date
T.col.
F. col.

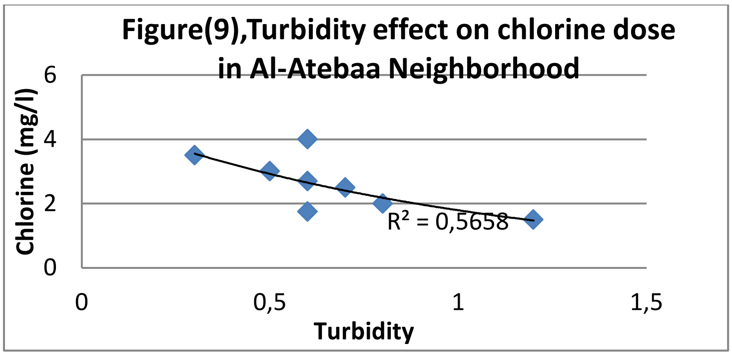

Figure(5), Bacterial Growth for Pressure Filter
Bacteria/100 ml
8
6
4
2
0
2/1/2011
9/1/2011
13/2/2011
27/2/2011
13/3/2011
10/4/2011
24/4/2011
15/5/2011
Date
T.col.
F. col.

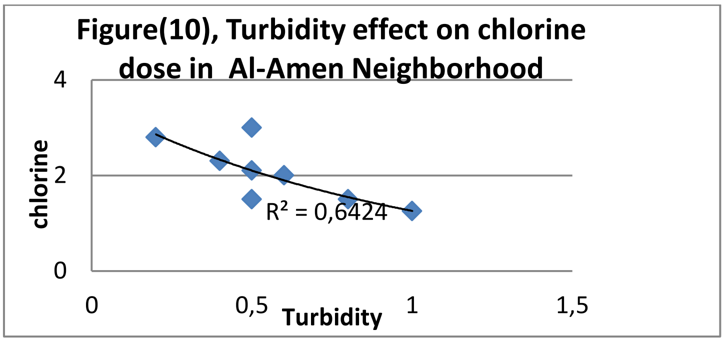


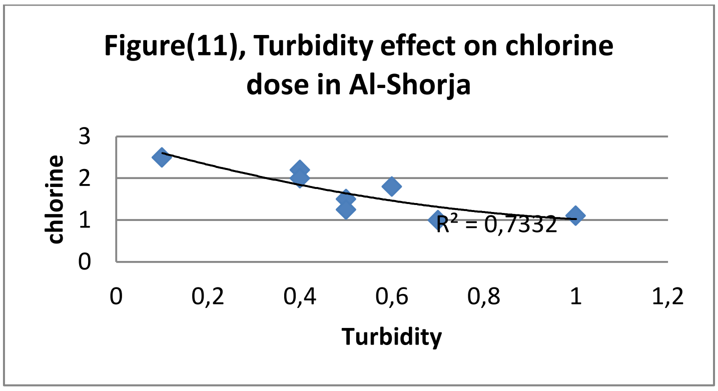




The turbidity increasing causes decrease in the effect of the chlorine dose, there are many reasons influence this negative relation like the season, chlorine demand, and initial coliform and total organic carbon as stated by Le Chevallier, 2011. Organic carbon could absorb chlorine on its particles creating chlorine demand. Figures (9 to 11) illustrate the negative interrelationship.

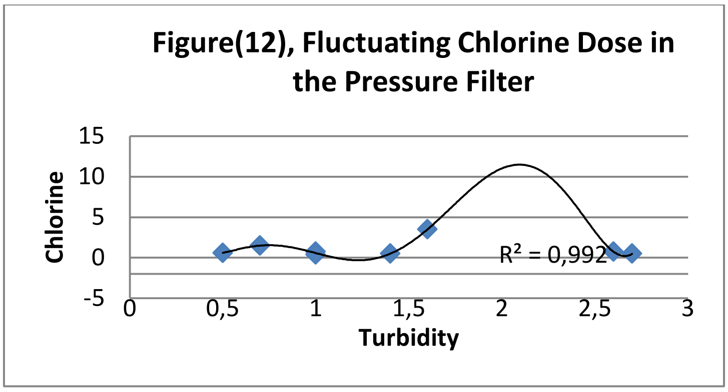






Maximum concentration of chlorine dose appears in Al-Ateba neighborhood (a few meters from the water treatment plant), which reached to (3.5 mg/l) with turbidity of (0.2 NTU), and this is a high dose which could be harmful for the people living near water treatment plant especially this dose was in January, chlorine dose reduced to (1.5 mg/l) with turbidity (1.2 NTU) in February.

Pressure filter shows a fluctuating chlorine dose, because of the difficulty to control the chlorine dose required for the pressure filter, hence it does not depend on the water turbidity entering the filter only, but also filter may have an accumulative concentration of suspended solids on filter media, bacteria, and organic matter. (figure 12)

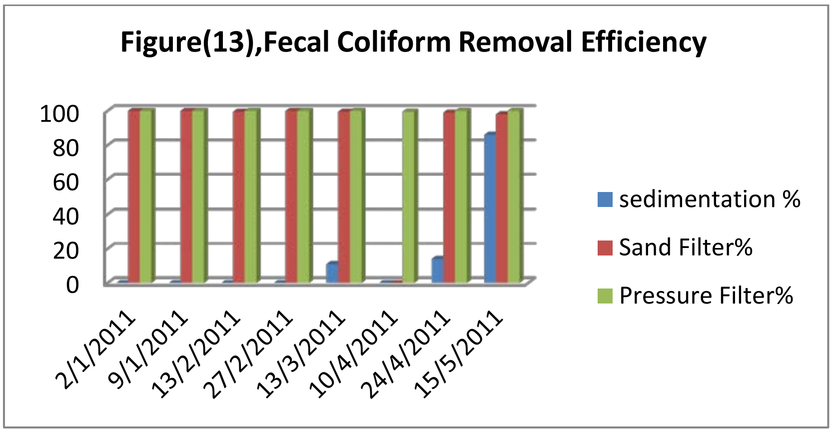


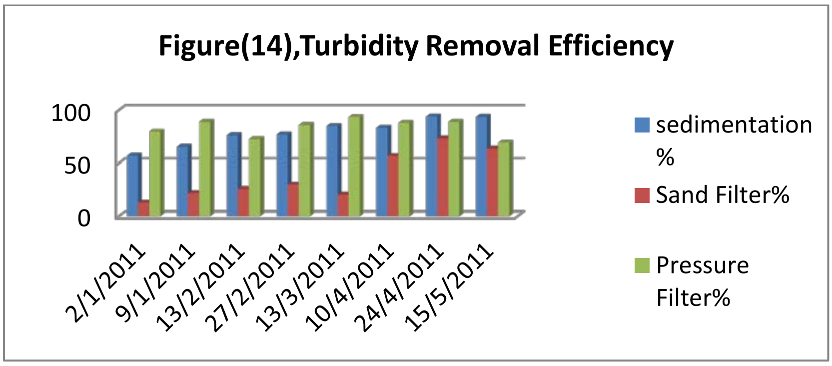
Figures (13, 14) represent fecal coliform and turbidity removal efficiency respectively. Turbidity removal efficiency for sedimentation tank was better than its removal for fecal coliform, it reached to 94% in April while fecal coliform removal efficiency was nearly 0%.

Sand and pressure filter removal efficiency for fecal coliform ranged from (98-100) %. In April, sand filter removal efficiency dropped to 0%.

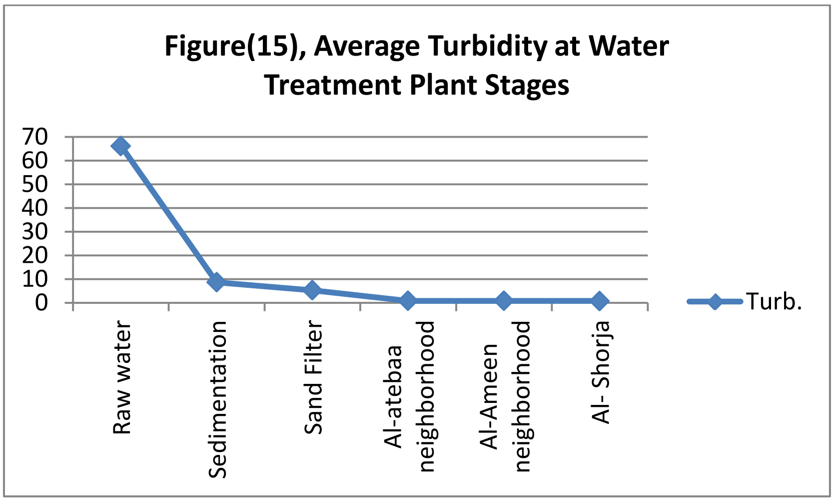
Turbidity removal efficiency ranged from 13% in January to 73.3% in April for sand filter and from 69.3% in May to 93.5% in March in the pressure filter.

Turbidity of the water applied to the filters should not exceed 10 units and preferably 5 units. (Steel, 1986)

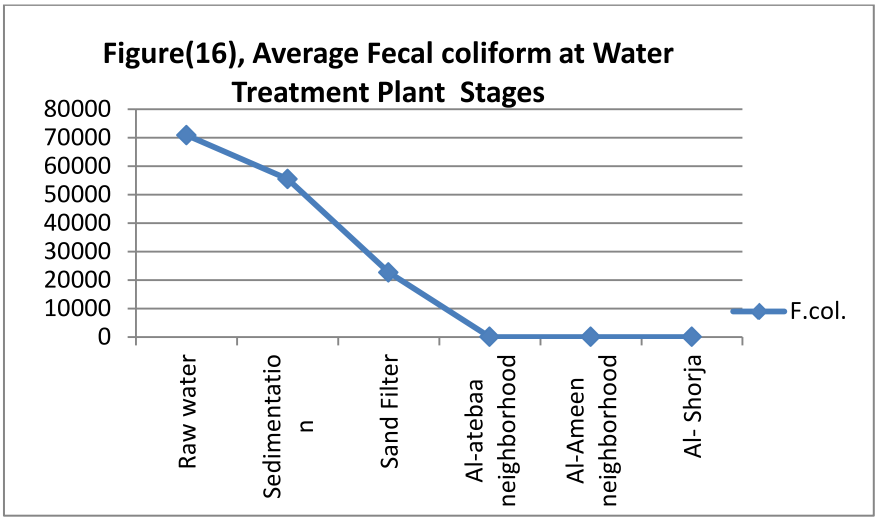




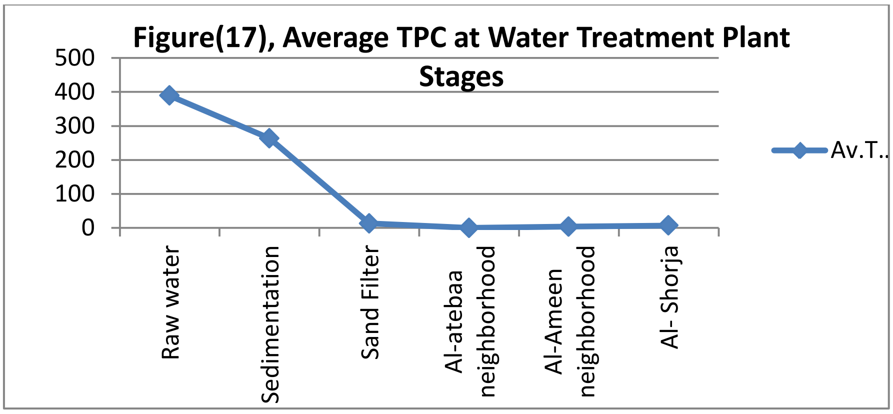
Turbidity reduced frequently, Maximum turbidity level reached to (150 NTU) in April and the average raw water turbidity was (66.125 NTU), average turbidity for water treatment plant stages shown in (figure 15).



Fecal coliform found in water was reduced frequently at the stages of treatment till it drops to 0% after chlorination. (Figure 16)



Bacterial colonies appear obviously after testing in petri dishes for 1 ml of sample of raw water and sedimentation tank water, the average total plate count reached to 400 colonies for raw water sample and 250 colonies for a sedimentation tank sample, colony counts reduced after treatment (Figure 17) . EU standards indicate that colony count for drinking water must not be more than 100/ml at 22^{o}C and 20/ml at 37^{o}C.



Generally, average disinfection efficiency at Al-Wathba water treatment plant for total and fecal coliform was 99.99%, percents of fecal to total colifrom are shown in table (1).

From table it appears that the percent of fecal coilform is high in raw water the percent was 6% that means the percent of fecal coliform bacteria was 6% from the total coliform found in water, the 94% was another type of bacteria. This percent reduced after chlorination in Al-Atebaa and Al-Shorja neighborhood it was 100%, which means that most of coliform bacteria were from the fecal type this indicates that there are may be some leakages from sewage pipes in the surrounding area; the percent of fecal to total coliform was 0% in Al-Amen neighborhood.

Concerning sand and pressure filters the percents were very high due to increasing the percent of fecal coliform in filters which hide on (or in)the filter media, filters need continuous cleaning to eliminate bacterial growth.

Table(1), Percents of Fecal to Total Coliform in Al-Wathba Water Treatment Plant Stages

Fecal Coliform(Fc)	Total Coliform(Tc)	Fc/Tc %
1579.375	28918.75	6 %
1425	47800	3 %
22627.125	5439.625	416 %
1	0.625	160 %
1.625	1.625	100 %
0	0	0 %
0.25	0.25	100 %

Table (2) represents international standards for drinking water some readings were higher than the standards especially in April but the average results of the samples collected were identical to those in the table.

Table (2), National requirements for Drinking Water Parameters
(Drinking Water Inspectorate, Ergon House, Horseferry Rd, London,2010)

Parameters	*Concentration or Value maximum)*	*Units of Measurement*
Enterococci	0	number/100ml
Escherichia coli (E. coli)	0	number/100ml
Coliform bacteria	0	number/100ml
*Colony count 22^{o}C	100/ml	Colony count 22oC
*Colony count 37^{o}C	20/ml	Colony count 37oC
*Hydrogen ion concentration [H+]	6.5-9.5	
Aluminium	200	μgAl/l
Colour	20	mg/l Pt/Co
Iron	200	μgFe/l
Manganese	50	μgMn/l
Odour	<1 at 25°C	Dilution number
Sodium	200	mgNa/l
Taste	<1 at 25°C	Dilution number
Tetrachloromethane	3	μg/l
Turbidity	4	NTU

*EU's drinking water standards Copyright © 1998-2011

Conclusions:

1- Fecal coliform bacteria were reduced gradually during treatment and increased in April in Al-Atebaa neighborhood although the high dose of chlorine added sometimes this may be because of leakages from waste-water pipes.
2- Fecal coliform percent increased sometimes due to sediments in sedimentation tank and filters.
3- Chlorine dose affected negatively by the increasing of turbidity, causing lack of chlorine residual.
4- Removal efficiency for total and fecal coliform was 99.99%.
5- There was no clear relation appeared with pH value.
6- To control water quality , treatment plant needs a periodic maintenance and inspection for all treatment stages (especially sedimentation tank and filters) with the annual evaluation of treatment efficiency.

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