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REUSE OF SPENT FILTER BACKWASH WATER

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ABSTRACT

In this study several tests were conducted to investigate the possibility of re-use the filter backwash water (FBWW) by re-introducing it with raw water (RW) for treatment. FBWW in water purification plants is being thrown into sewage plants without any benefit. The amount of wash water generated estimated at a rate of (10-15%) of the amount of purified water in the plant. The treatment of Backwash water depends on the need for re-use, either for drinking or for irrigation purposes, depending on the compliance with the standards in the water quality specifications. The FBWW resulting from Giza water plant have been analyzed scientifically and mixed with RW at different ratios (from 10% to 50%). The results of experiments showed that the best mixing ratio was 40% FBWW to 60% RW, also the economic feasibility of water reuse have been discussed.

Key words: Backwash, Filtration, Reuse, Treatment, Water.

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1. INTRODUCTION

Actually, only 1% of the world's water is usable to us. About 97% is salty sea water, and 2% is frozen in glaciers and polar ice caps. Thus that 1% of the world's water supply is a precious commodity necessary for our survival. Dehydration will kill us faster than starvation **[1]**. Most drinking water systems use filters to collect, catches, or gather particles from an incoming flow. When the filter's pores become clogged, they need to be cleaned. One of the best ways to clean a drinking water system's filter is to backwash it, meaning reversing the flow and increasing the velocity at which water passes back through the filter. This, in effect, blasts the clogged particles off of the filter. Although every filter is unique, the principles of backwashing are similar for all of them. One key ingredient to a good filter backwash is using clean water, usually out of the clear well, first storage tank, or distribution system **[2]**. SFBW is discharged without treatment to a sanitary sewer system **[3]**. Historically, backwash water was discharged directly to surface water supplies. Used backwash water contains high concentrations of particulate material **[4]**. Backwash recycling capability is another great option that can come in handy in times of need **[2]**. There was a previous studies related to the treatment of SFBW like the city of Durham-nc, Boulder-co, Cleveland-oh and Phoenlx-az which used DAF for treating SFBW, also the city of Modesto-ca, Tempe-az and Walnut creek-ca used Actiflo for treating SFBW **[5],** immersed ultrafiltration membranes **[7]**, a study about the removal characteristics of dissolved organic matter of recycling filter backwash water **[8]**. This study was conducted through six runs each run performed on different doses of alum ranged between 15 to 40 mg/l. The main objective of this study is the determination of the best mixing ratio between the FBWW and the RW that will show the best characteristics and attributes that is valid for reuse in drinking water and to save as much water as possible.

2. MATERIALS AND METHODS

The main objective of this study was evaluating the feasibility of reuse FBWW. The FBWW used in these experiments was obtained from the effluent filter backwash pipe of El- Giza Water treatment Plant. The physical and chemical properties of filter back wash water, and the raw water presented in Table (1).

Table 1 The physical and chemical properties of the FBWW and the RW

Measuring parameters	RW	FBWW
Turbidity (NTU)	5.8	25
pH	8.15	7.25
TDS (mg/l)	343	351
Conductivity (µS/cm)	571	587
Cl_2	Nil	2.7
Al (mg/l)	0.04	0.4
So_4 (mg/l)	18.5	36
Fe (mg/l)	Nil	Nil
Mn (mg/l)	Nil	Nil
Alkalinity (mg/l as $CaCO_3$)	172	136
Temp (°C)	21.7	21.6
Consumed O_2	6.5	3.4

El Giza water treatment Plant is located at Murad Street, Giza. The capacity of the water treatment plant is 168000 m^3/day pumped through a shore intake. The filtration process of the water treatment plant consists of 48 rapid sand filters which needs backwashing water estimated about 10% to 15% of the total water pumped to the water treatment plant which ranged from 16800 m^3/day to 25200 m^3/day. To find the optimum recycling ratio of the FBWW. The FBWW mixed with the RW at different mixing ratios ranged between 10% to 50%. The filter backwash water and the raw water were mixed in a holding tank for each run. The experiments conducted through five runs. The mixing ratios for all runs are shown in Table (2).

Table 2 Tests and Mixing Ratios

Run	Mixing Ratio	Performed tests (For All Runs)
Run1	10% FBW to 90% SW	Turbidity – pH TDS – Conductivity Chlorine – Aluminum Sulphates – Iron Manganese – Alkalinity - Consumed Oxygen
Run2	20% FBW to 80% SW	
Run3	30% FBW to 70% SW	
Run4	40% FBW to 60% SW	
Run5	50% FBW to 50% SW	

The experiments were performed in a conventional jar-test apparatus, equipped with six beakers of 1 l volume at room temperature. The experimental process consisted of three subsequent stages: the initial rapid mixing stage took place for 1 min at 200 rpm, followed by a slow mixing stage for 20 min at 30 rpm. Stirring was then discontinued and the sludge was left to settle. After the settling period, the supernatant was withdrawn from a point located about 2 cm below the top of the liquid level of the beaker to determine the turbidity of the water using a turbidimeter Hach model 2100N. pH test to indicate the pH value for the water using pH/ISE meters, ORION model 710A with PerpHect Ag/AgCl low maintenance Gel triode pH electrode, model 9207 BN. Total dissolved solids (TDS) test, the TDS have been measured using the Conductivity Meter Instrument. Electrical conductivity (EC) test provides an indication of changes in water's composition and it was is measured using ATC bench electric conductivity meter. Chlorine test to indicate the presence of chlorine residual in water and it was measured using Stabilized neutral orthotolidine method using a spectrophotometer at a Wavelength of 625nm and Light-Pass of 10mm with Neutral orthotolidine reagent, Buffer – stabilizer reagent. Aluminum test to detect aluminum in water using a spectrophotometer at a Wavelength of 553nm and Light-Pass of 10mm with Eriochrome cyanine R stock solution, Working dye solution, Sulfuric acid 0.02 N, Ascorbic acid. Sulfate test to determine of the sulfate concentration by the means of a spectrophotometer at a Wavelength of 420nm and Light-Pass of 10mm with conditioning reagent, BaCl2 – crystals (20 – 30 mash). Iron test to measure the amount of Fe II, Fe III in water using a spectrophotometer at a Wavelength of 510nm and Light-Pass of 10mm with Hydrochloric acid concentration not containing more than 0.00005% of iron, Hydroxyl amine chloride solution, Ammonium acetate buffer solution, Sodium acetate buffer solution, Phenanthroline solution. Total alkalinity test to indicate the presence of carbonates, bicarbonates and hydroxides Total alkalinity was determined by electrometric titration of a sample aliquot with a standard solution of strong acid (0.02N H2SO4), the endpoint is determined with a pH-meter. Tri Halo Methane Test was performed only on the best Run which was 40% FBWW to 60% RW at the Central Labs of Ministry of Health.

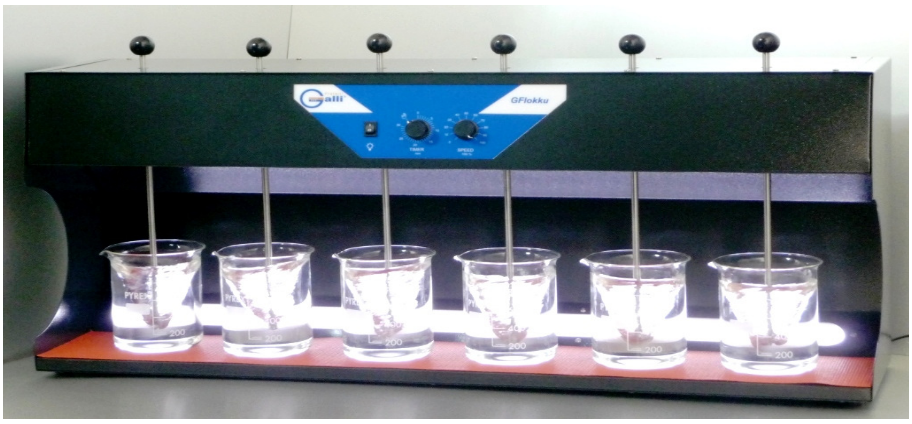

Figure 1 Jar test

3. RESULTS AND DISCUSSION

The evaluation has been done by using jar test; the physical, chemical characteristics of water before and after mixing with FBWW were studied in comparison with water treated by aluminum Sulphates through the six runs.

Table 3 shows the plant raw water results on the day of mixing 10% FBWW with 90% RW. Jar test was conducted for this mix with different alum doses ranged from 15 to 40 mg/l. It was concluded that the best alum dose ranged from 15 to 20 mg/l

Table 3 Run1 Results (Mix Of 10% FBWW+ 90% RW)

Test	Raw Water	Alum Dose					
		15	20	25	30	35	40
Turbidity (NTU)	1.2	1	0.85	0.7	0.7	0.6	0.4
pH	7.3	7.3	7.25	7.25	7.25	7.25	7.25
TDS (mg/l)	293	290	292	294	295	297	298
Conductivity (µS/cm)	489	486	487	490	493	493	498
Cl_2	1.4	1.5	1.5	1.5	1.5	1.5	1.5
Al (mg/l)	0.25	0.18	0.22	0.28	0.32	0.36	0.39
So_4 (mg/l)	38.7	38.1	40.8	41.7	42.6	44.1	46.3
Fe (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Mn (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Alkalinity (mg/l as $CaCO_3$)	134	134	132	132	130	130	128
Temp (°C)	22.6	22.6	22.6	22.7	22.7	22.7	22.7
Consumed O_2	4.5	4.1	4.5	4.5	4	4	4.2

Table 4 shows the plant raw water results on the day of mixing 20% FBWW with 80% RW. Jar test was conducted for this mix with different alum doses ranged from 15 to 40 mg/l. It was concluded that the best alum dose ranged from 15 to 20 mg/l

Table 4 Run2 Results (Mix Of 20% FBWW+ 80% RW)

Test	Raw Water	Alum Dose					
		15	20	25	30	35	40
Turbidity (NTU)	1.1	1.1	1	1	.8	0.8	0.6
pH	7.3	7.3	7.3	7.29	7.26	7.23	7.2
TDS (mg/l)	292	347	350	354	357	360	364
Conductivity (µS/cm)	490	574	583	590	600	605	610
Cl_2	1.5	2	2.2	2	2.2	2	2
Al (mg/l)	0.24	0.33	0.4	0.59	0.61	0.68	0.72
So_4 (mg/l)	39.4	55.1	61.5	68.1	74.3	78.4	82.3
Fe (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Mn (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Alkalinity (mg/l as $CaCO_3$)	134	154	150	150	148	148	146
Temp (°C)	22.6	22	22.1	22.1	22.2	22.2	22.3
Consumed O_2	4.5	4.1	4.6	4.1	4	4	4.1

Table 5 shows the plant raw water results on the day of mixing 30% FBWW with 70% RW. Jar test was conducted for this mix with different alum doses ranged from 15 to 40 mg/l. It was concluded that the best alum dose ranged from 15 to 20 mg/l

Table 5 Run3 Results (Mix Of 30% FBWW+ 70% RW)

Test	Raw Water	Alum Dose					
		15	20	25	30	35	40
Turbidity (NTU)	1.1	1	0.8	0.9	0.8	0.7	0.7
pH	7.2	7.3	7.3	7.3	7.2	7.15	7.12
TDS (mg/l)	294	353	355	355	357	360	361
Conductivity (µS/cm)	489	585	591	591	594	599	603
Cl_2	1.35	2.5	2.5	2.5	2.5	2.5	2.4
Al (mg/l)	0.26	0.56	0.59	0.6	0.6	0.64	0.69
So_4 (mg/l)	38.4	63.2	66.9	68.4	70.1	72.3	75
Fe (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Mn (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Alkalinity (mg/l as $CaCO_3$)	136	150	146	140	134	132	128
Temp (°C)	22.6	22	22.1	22.1	22.2	22.2	22.3
Consumed O_2	4.4	3.6	3.9	4	3.6	3.6	3.5

Table 6 shows the plant raw water results on the day of mixing 40% FBWW with 60% RW. Jar test was conducted for this mix with different alum doses ranged from 15 to 40 mg/l. It was concluded that the best alum dose ranged from 15 to 20 mg/l

Table 6 Run4 Results (Mix Of 40% FBWW+ 60% RW)

Test	Raw Water	Alum Dose					
		15	20	25	30	35	40
Turbidity (NTU)	1	0.9	0.7	1	0.8	0.7	0.6
pH	7.3	7.24	7.2	7.2	7.2	7.17	7.15
TDS (mg/l)	293	355	358	358	359	361	363
Conductivity (µS/cm)	491	590	597	596	602	604	606
Cl_2	1.4	2.8	3	2.7	3	3	3
Al (mg/l)	0.25	0.5	0.6	0.64	0.67	0.69	0.71
So_4 (mg/l)	39.4	71.2	72.3	70.2	7.2	73.2	74.4
Fe (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Mn (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Alkalinity (mg/l as $CaCO_3$)	135	142	140	138	136	136	134
Temp (°C)	22.7	22.1	22.2	22.3	22.3	22.4	22.4
Consumed O_2	4.5	3.9	3.9	4	3.9	4	3.8

Table 7 shows the plant raw water results on the day of mixing 50% FBWW with 50% RW. Jar test was conducted for this mix with different alum doses ranged from 15 to 40 mg/l. It was concluded that the best alum dose ranged from 15 to 20 mg/l

Table 7 Run5 Results (Mix Of 50% FBWW+ 50% RW)

Test	Raw Water	Alum Dose					
		15	20	25	30	35	40
Turbidity (NTU)	1	1.2	1. 2	1	1	0.9	0.9
pH	7.3	7.4	7.3	7.3	7.3	7.3	7.2
TDS (mg/l)	293	325	328	332	335	338	342
Conductivity (µS/cm)	489	540	546	554	561	568	574
Cl_2	1.5	1.5	1.5	1.5	1.5	1.5	1.4
Al (mg/l)	0.26	0.57	0.6	0.69	0.73	0.79	0.83
So_4 (mg/l)	38.2	60.3	63.2	66.6	68.1	70.1	74.8
Fe (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Mn (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Alkalinity (mg/l as $CaCO_3$)	134	142	140	138	138	136	123
Temp (°C)	22.6	22.3	22.4	22.4	22.5	22.4	22.6
Consumed O_2	4.5	5	5	4.5	4.5	4.5	4.5

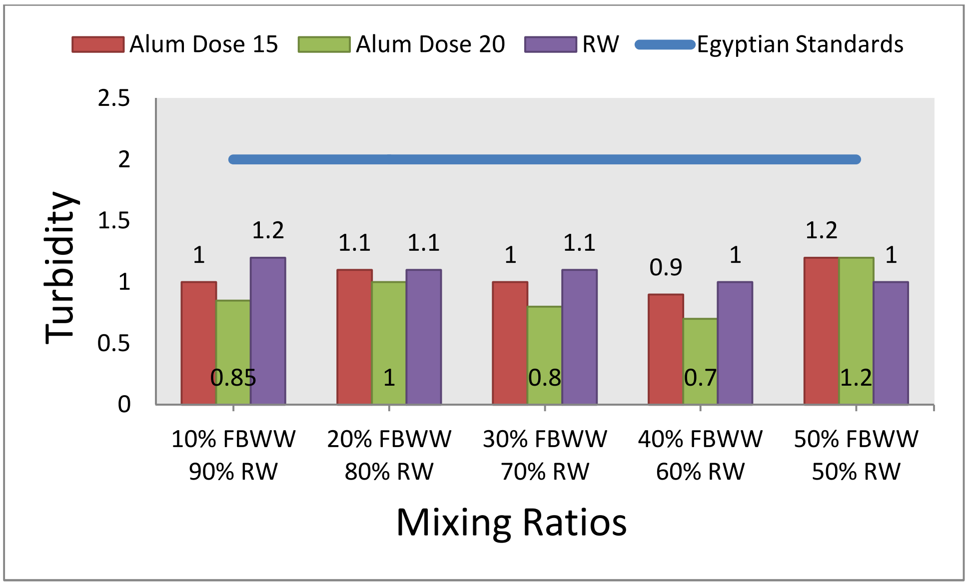

Figure 2 Relationship between turbidity and alum doses

Results shown on Fig2 indicated the effect of alum dose on the turbidity. During the jar test procedures, The FBWW was added to the two vessels that had different coagulant dosages ranged (15-20 mg/l). It was shown that the turbidity of samples before Jar was 7.72, 9.64, 11.56, 13.48, and 15.4 respectively, and after Jar as shown in the figure. It can be noticed that 40% to 60% mixing ratio was the best run as it lies between the design values of the plant (1-2 NTU) plus it saves more water.

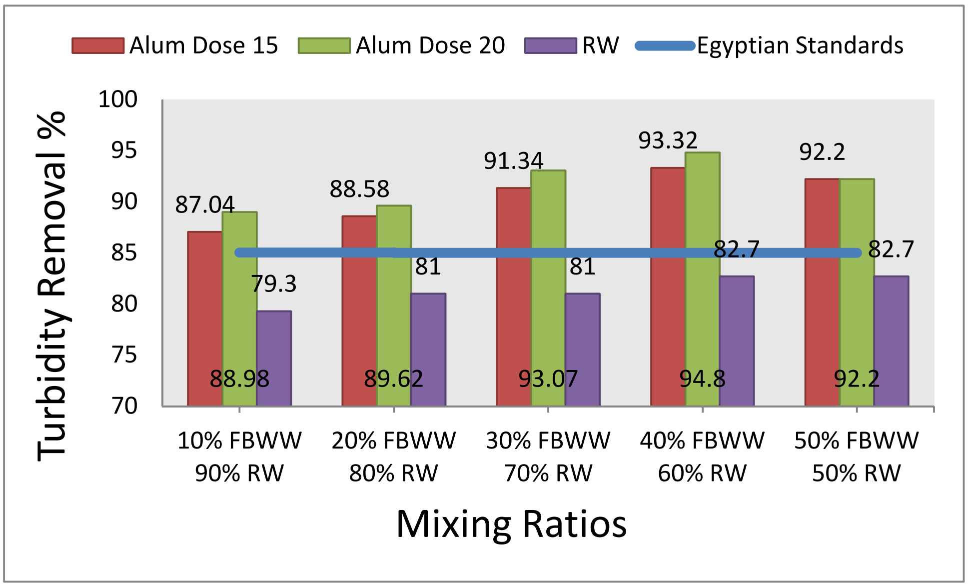

Figure 3 Relationship between turbidity removal and alum doses

Results shown on Fig3 indicated the effect of Alum dose on the turbidity. During the jar test procedures. It could be noticed that the Alum dose enhanced the turbidity removal. It is noticed that the best run was run4 as its removal efficiency ranged between 93.32% to 94.8% which lies between 85% to 95% which are the allowed Percentages plus it saves more water.

Fig4 shows the pH values for all Runs also with different doses of alum. As shown in figure, the values lies between 6.5 and 8.5 which are the allowed values referring to the Decree of the Minister of Health and Population No.458 for the year 2007[6],run4 considered the best run as it saves more water.

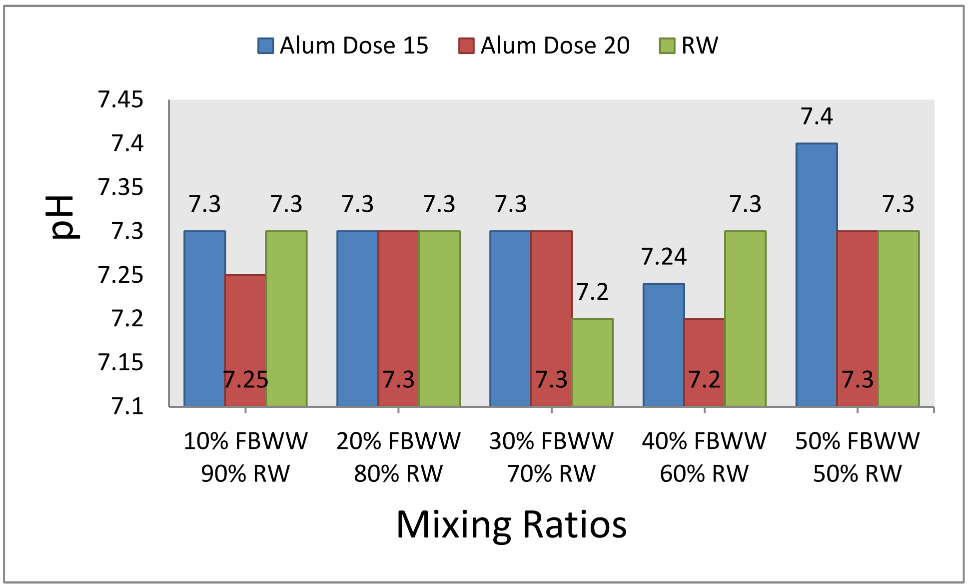

Figure 4 Relationship between pH and alum doses

Results shown on Fig5 indicated the effect of alum dose on the Chlorine. It was noticed that the effect of alum dose on chlorine is imperceptible, all runs didn't exceeded the max allowed value of Chlorine which is 5 mg/l referring to the Decree of the Minister of Health and Population No. 458 for the year 2007[6],run4 considered the best run as it saves more water.

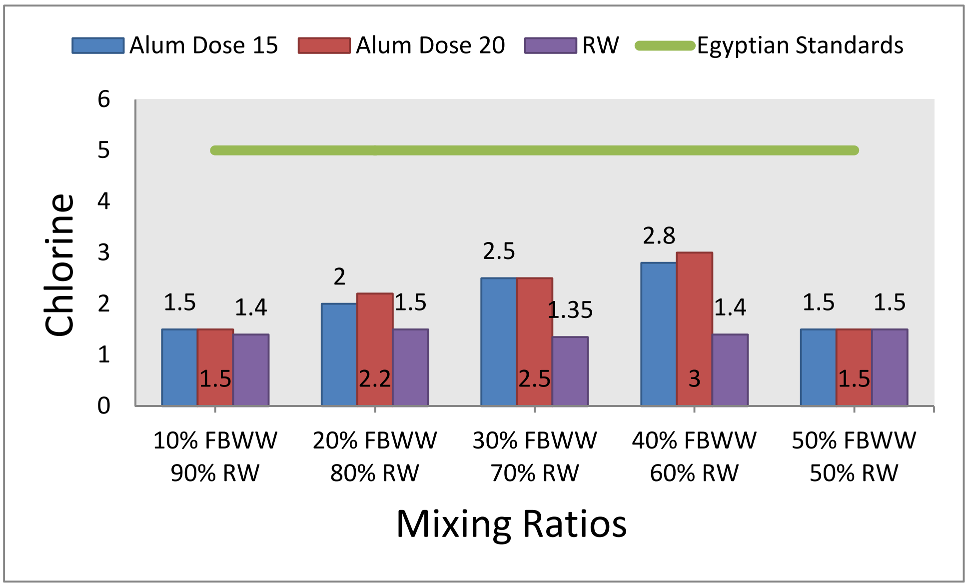

Figure 5 Relationship between chlorine and alum doses

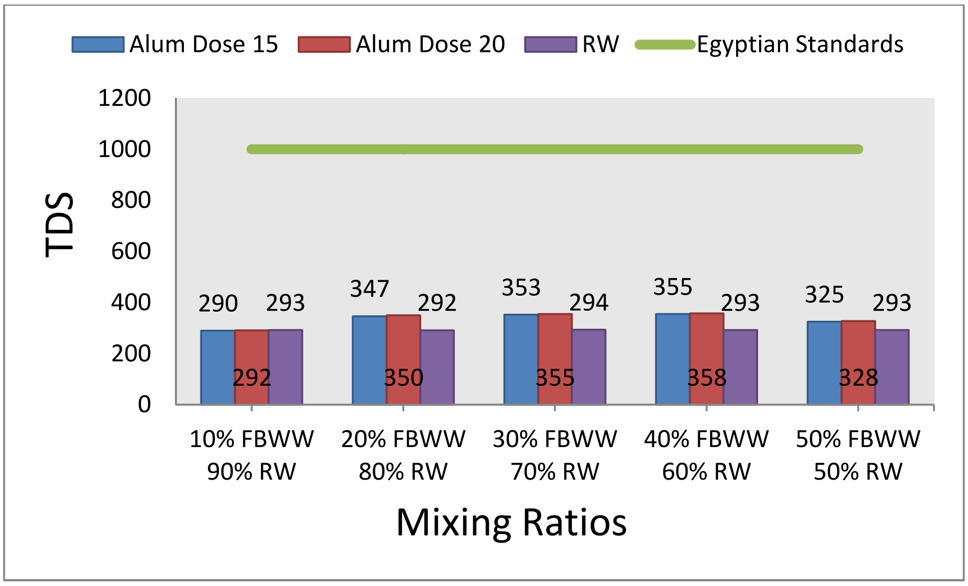

Figure 6 Relationship between TDS and alum doses

Results shown on Fig6 indicated the effect of alum dose on the TDS. It was noticed that the effect of alum dose on TDS is imperceptible, all runs didn't exceeded the max allowed value of TDS which is 1000 mg/l at 120°C referring to the Decree of the Minister of Health and Population No. 458 for the year 2007[6], while the average temperature of water was 22.4 also run4 considered the best run as it saves more water.

Results shown on Fig7 indicated the effect of alum dose on the Conductivity. It was noticed that the effect of alum dose on Conductivity is imperceptible; all runs didn't exceeded the max allowed value of Conductivity which is 1000µS/cm at 25°C.

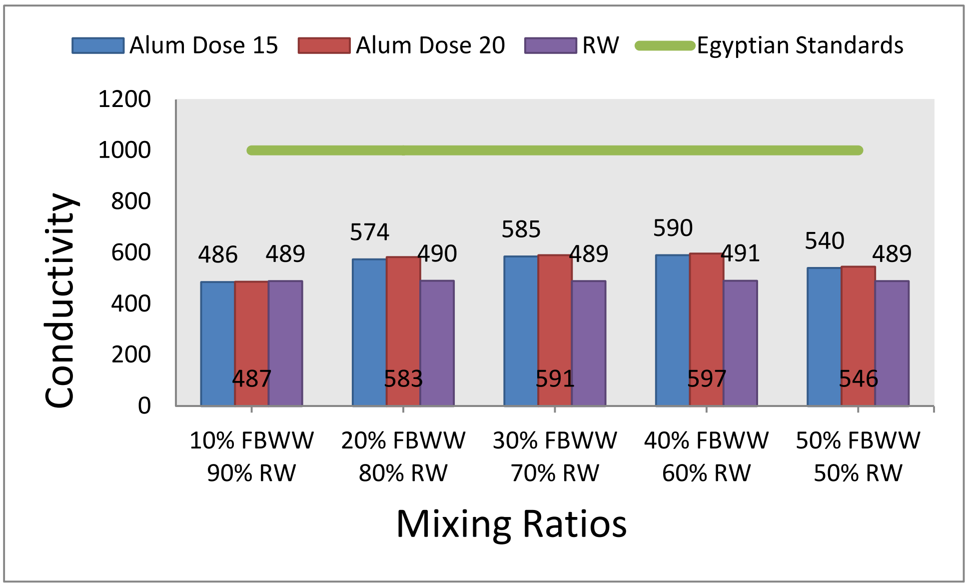

Figure 7 Relationship between conductivity and alum doses

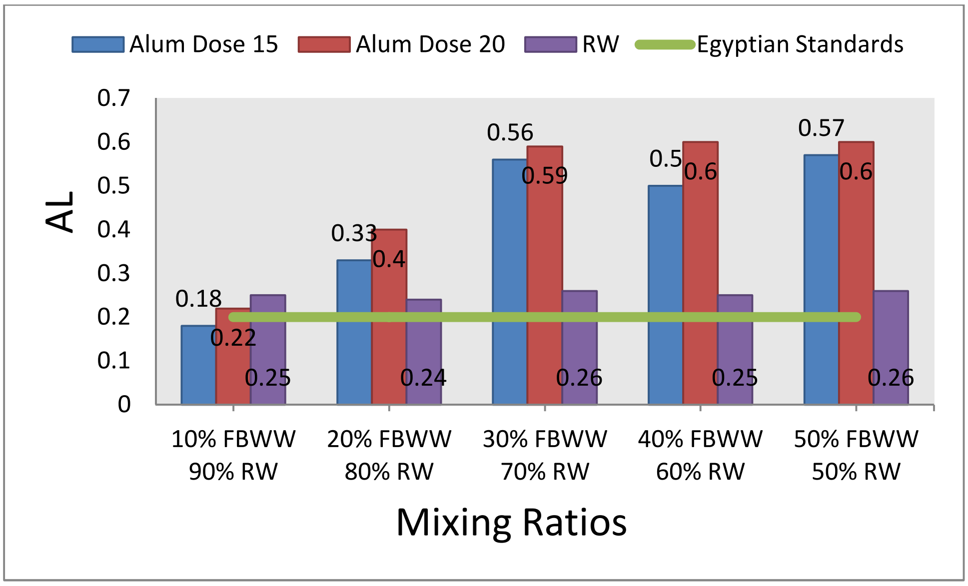

Figure 8 Relationship between aluminum and alum doses

Results shown on Fig8 indicated the effect of alum dose on the aluminum, referring to the Decree of the Minister of Health and Population No. 458 for the year 2007 which indicates that the allowed value for alum in water should not exceed 0.2 mg/l and as run4 considered the best run for saving more water it's average alum value at 15-20 mg/l of alum dose is 0.55 mg/l, in spite of this is exceeding the allowed value, it is acceptable as it will go through the filtration stage which will decrease the value to reach the allowed values.

Results shown on Fig9 indicated the effect of alum dose on the Sulphates, referring to the Decree of the Minister of Health and Population No. 458 for the year 2007[6] which indicates that the allowed value for Sulphates in water should not exceed 250 mg/l, all runs didn't exceeded the max allowed, so run 4 Considered the best run as it saves more water.

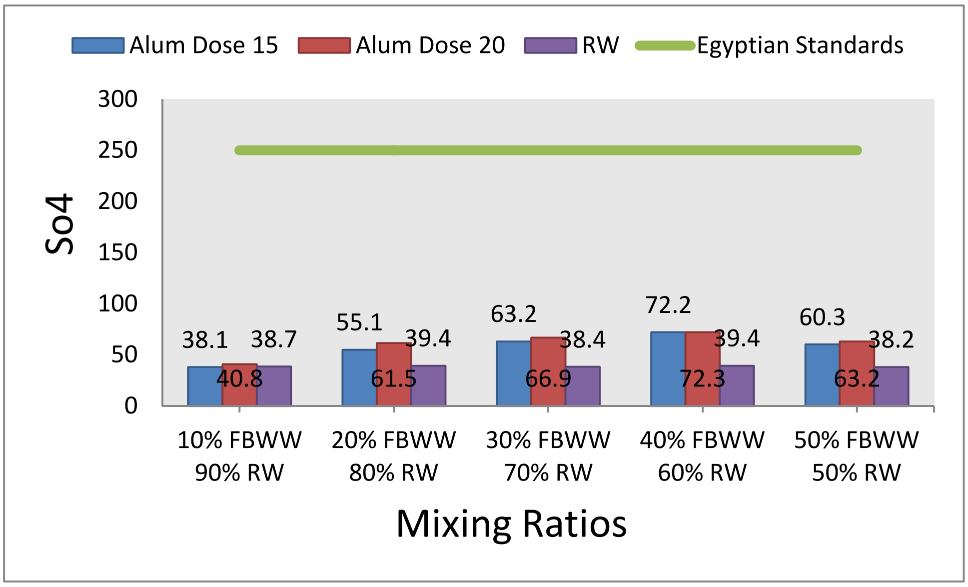

Figure 9 Relationship between sulfates and alum doses

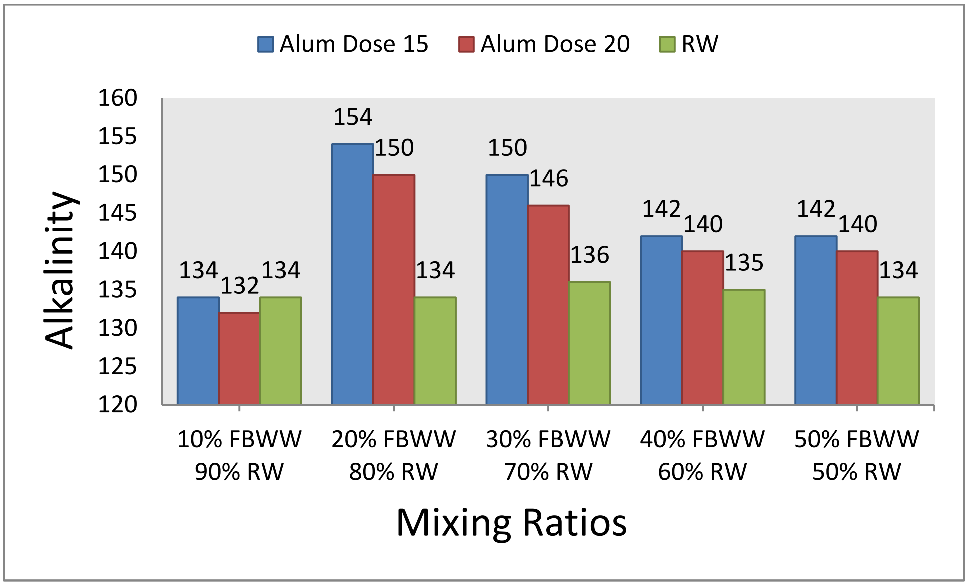

Figure 10 Relationship between alkalinity and alum doses

Results shown on Fig10 indicated the effect of alum dose on the Alkalinity, by increasing the alum dose, the Alkalinity decreases.

After Analyzing and discussing all runs, the results showed that run4 is going to be used and Tri Halo Methane was performed on this run and result of test are in Table 8

Table 8 Tri Halo Methane Test Result

Chemical Compound	Concentration	Allowed Dose (mg/l)
Chloroform	0.03 mg/l	0.3 mg/l
Bromodichloromethane	0.009 mg/l	0.06 mg/l
Dibromochloromethane	0.0018 mg/l	0.003 mg/l
Bromoform	0 mg/l	0.1 mg/l
Total	0.0408 mg/l	0.1 mg/l

3.1. Economic Feasibility

As the water pumped to the plant equals 168000 m3/day. And the alum dose used by the plant ranged between 22 mg/l to 26 mg/l, if the liquid alum price per ton is 680 EGP. Thus the alums cost 2740 EGP/day equals 82250 EGP/month equals 987033 EGP/year, after mixing the FBWW with the raw water, it was clear that the dose of alum ranged between 15 mg/l to 20 mg/l gives acceptable values which is less than the plant dose by 32%, that's mean the alum dose approximately reduced by 5 mg/l.

As 168000 m3 equals 168,000,000 l , if 5 mg/l reduced that's mean 840,000,000 mg was reduced, this equals 0.84 Ton a day, so we can save 571.2 EGP/day equals 17130 EGP/month equals 205560 EGP/year.

4. CONCLUSIONS AND RECOMMENDS

The study concluded that the FBWW can be reused in drinking after re-introducing it with RW for treatment.

- Mix Ratio of 40% FBWW to 60% RW gave acceptable values for all parameters beside it saved much water compared to other ratios.
- Turbidity removal efficiency ranged from 93.32 % to 94.8 %.
- Alum dose between 15mg/l to 20 mg/l gave acceptable values for all parameters according to the Egyptian standards.
- Decreased the alum dose by 32% compared to the dose used in Giza Water Plant.
- Reusing FBWW saved water for approximately 67200 to 100800 Capitals, as the Liquid alum price per ton equals 680 EGP, it saved 571.2 EGP/day equals 17130 EGP/month equals 205560 EGP/year.
- The study also recommends using the holding tank as a sedimentation tank; analyze the FBWW to study if it can be used in agriculture, use innovative application in treating FBWW like plate tube settler, Dissolved air flotation, High rate Dissolved air flotation, and Sand ballast.

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