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EVALUATION OF THE FILTRATION PROCESS AT EL- MANSHIA WATER PURIFICATION PLANT.

BY

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Key word: Filtration, coliform, standard plate count, total algae, turbidity.

ABSTRACT

Filtration is the most important process in the chain of any water purification plant, which aids in the removal of color, taste and odor causing substances. It is considered as a polishing process. El-Manshia Water Purification Plant is one of the eight drinking water purification plants in Alexandria. It was constructed in 1976 over an area of about 58700 m². El-Manshia Water Purification Plant takes its raw water directly from the special drinking water canal branched from the Mahmoudia canal. This study aims at evaluation of the efficiency of the different rapid sand filters located at El-Manshia water purification plant. Results indicate that Italba filter had the highest efficiency in removing turbidity (84%), coliform (91%), total viable bacteria (85.92%) and algae. Immediately before and after backwash, all physical and biological parameters recording high values.

INTRODUCTION

Drinking water should be clear and free from any pathogenic microorganism and chemical substances, which may be hazardous to Health (UNEP/WHO, 1997). The purification process of the surface water includes: chemical clarification by coagulation, followed by sedimentation, filtration and disinfection (Schofield *et. al*, 1991). Filtration is the most important process in the chain of any water purification plant (Gregory and Ronald1996).

There are two types of sand filters, slow and rapid sand filters. The decision to use rapid sand filter over slow sand filter much depends upon available land and the life expectancy of the treatment works (Collins,1990).

The most commonly filter materials used are the conventional sand and dual-media filters. Granular activated carbon replaced sand or anthracite in filter adsorbers, It can be used alone or in dual-or triple- media configurations (John, 1990).

Backwashing is a critically important step in the filtration process and inadequate backwashing causes most operating problems associated with filtration. For a filter to operate efficiently, it must be cleaned thoroughly before the next filter run begins (Stephen ***et. al***, 1979).

El-Manshia Water Purification Plant is one of the eight drinking water purification plants in Alexandra. It was constructed in 1976 over an area of about 58700m^2. It takes its raw water directly from the special drinking water canal branched from The Mahmoudia canal.

The processes of water purification are: prechlorination, coagulation, sedimentation، filtration and disinfection.There are three types of rapid sand filters houses at the plant (Italba, Czech and Degremont.) with characteristics shown in Table (1).

MATERIAL AND METHODS

The present work is concerning the drinking water quality at El-Manshia Water Purification Plant of Alexandria governorate. Weekly grab samples were taken from the water influent and effluent of each filter to evaluate the filtration process. Another grab samples were taken from the influent and the effluent of each filter to represent complete filter runs (24H.for both degremont and Czech, 48 H.for Italba). Collected water samples were analyzed for physical and biological parameters according to the standard procedures listed in the Standard Method for Examination of Water and Wastewater (1995).

The parasitological examination was performed according to Logsdon et.al (1981) and Melvin and Brooke (1989). Sieve analysis were done using the American Society for Testing and Materials (ASTM, 1985) Standard Test C136-84a, Sieve Analysis of Fine and Coarse Aggregates. It is the target of the present study, to evaluate the efficiency of the different rapid sand filters located at El-Manshia water purification plant.

RESULTS AND DISSCUSION

Physical characteristics of filters media: -

Experiments for the determination of effective size (E.S.) and uniformity coefficient (U.C.) were carried out for the sand media of each filter type (Italba, Czech and Degremont filters). The results of the sand sieve analysis and determination of E.S. and U.C. for the sand media of different filters are presented in Table (2).

It was noticed that U.C. for the three types of filters less than 1.65 and this agree with AWWA, while E.C. values higher than the recommended values by AWWA (1980).

Parasitological examination of the water samples: -

Parasites were not detected in all water samples collected from the influent and effluent of the three filter types.This may be due to efficient clarification which remove all the gardia and cryptosporidium before reaching the filters James (2000).

Another study by Mohamed *et. al* (1998) proved that the depth of sand is roportional to removing of Gardia.

Turbidity:

The turbidity results obtained are represented in Figure (1). Italba filter had the highest efficiency in removing turbidity (84%) followed by Degremont (72.18%). This is due to the higher depth of Italba sand media. This indicates that the turbidity removal efficiency is directly proportional with the depth of the sand media (John *et. al*, 1988).

Table (1): Summary for filter unit specifications.

Location & Installation date	No.	Dimensions per unit			Media			Filter type	Control valve type	Flow meter type	Filter run	Design rate $m^3/m^2/hr$	Backwash	
		Length (m)	Width (m)	Depth (m)	Type	Depth & E.S.							Type	Time of water
						Sand	Gravel							
Czech 1975	24	7.15	6	2.2	Mono	0.75m 1.04mm	0.20m	Constant rate	Pneumatic valve	None	24 hr	7.0	Wash water /Air scour	8 min.
Degremont 1981	12	9.10	6	2.0	Mono	0.50m 1.10mm	0.20m	Constant rate	Pneumatic valve	None	24 hr	8.5	Wash water /Air scour	8 min.
Italba 1990	7	17.25	6	3.1	Mono	1.50m 1.20 mm	0.40m	Constant rate	Pneumatic valve	None	48 hr	11.0	Wash water /Air scour	30 min.

Table (2): The grain size analysis of the sand used in:

1- Italba filter type

Sieve Serial number	Diameter of sieve mesh (mm)	Retained by weight (gm)	Total retained weight (gm)	%Retained by weight (gm)	%Passing by weight (gm)
8	2.36	0.1	0.1	0.10%	99.90%
12	1.7	12	12.1	12.10%	87.90%
16	1.18	78.5	90.6	90.60%	9.40%
18	1	7.11	97.71	97.71%	2.29%
20	0.85	0	97.71	97.71%	2.29%
30	0.6	2.21	99.92	99.92%	0.08%
40	0.425	0.08	100	100.00%	0.00%
Pan		0	100		

* ES =1.2 mm, * UC =1.13

2-Degremont filter type

Sieve Serial number	Diameter of sieve mesh (mm)	Retained by weight (gm)	Total retained weight (gm)	%Retained by weight (gm)	%Passing by weight (gm)
8	2.36	1.17	1.17	1.17%	98.83%
12	1.7	23.57	24.74	24.74%	75.26%
16	1.18	60.09	84.83	84.83%	15.17%
18	1	10.79	95.62	95.62%	4.38%
20	0.85	0	95.62	95.62%	4.38%
30	0.6	4.24	99.86	99.86%	0.14%
40	0.425	0.14	100	100.00%	0.00%
Pan		0	100		

* ES =1.1 mm, * UC =1.34

3- Czech filter type

8	2.36	0.07	0.07	0.07%	99.93%
12	1.7	4.28	4.35	4.35%	95.65%
16	1.18	69.05	73.4	73.40%	26.60%
18	1	18.76	92.16	92.16%	7.84%
20	0.85	0	92.16	92.16%	7.84%
30	0.6	7.59	99.75	99.75%	0.25%
40	0.425	0.25	100	100.00%	0.00%
Pan		0	100		

* ES=1.04 mm, * UC=1.24

At the beginning of Italba filter run (during the first two hours) the turbidity values of effluent water had the highest values during the period of filter run with removal efficiency 77.68%. But the period during two hours before the backwashing, the turbidity had the lowest value with turbidity removal efficiency of 93.60%. The Italba filter effluent turbidity was under 1.0 Nephelo Turbidity Unit(NTU), as representing in table3, and this was considered within the limits of the WHO guidelines (1996) values and the Egyptian Standards (1995) for drinking water quality. While in case of Degremont and Czech filters, effluent turbidity values were slightly higher than the WHO guideline values and the Egyptian Standard, part of the time during filter run. In the case of Degremont filters the higher values were detected after zero time from backwash immediately and before the next backwash. In the case of the Czech filter the higher values were detected before the next backwash only. Degremont (1991) have stated that the rate of filtration through a filter should always be uniform and never suddenly increased or decreased.

Biological characteristics

Coliforms:

It was found that the highest removal efficiency of coliform was (91%) by Italba filter. Figure (2) shows small values of total coliforms, this is due to the action of prechlorination (Hass and Marrison 1981,and Ahmed and Amirtharajah, 1998).

At the beginning of the Italba filter run, (during the first two hours) the filter have no effect in removing coliforms. While, after the beginning of filter run by two hours and before backwashing by two hours, the removal efficiency attained to the highest values during the period of filter run (89.33%).

For Both Czech and Degremont filters, the results indicate that the filters have no effect in removing coliforms during specific times of operation as presented in tables (4,5). The operating times were, the first one-hour after backwash and approximately eight hours before backwash. This point is agreeable with Bucklin et.al (1991), and Logsdon et.al (1985) who indicated that coliform bacteria were able to pass through the filter into filtered water immediately after the backwash.

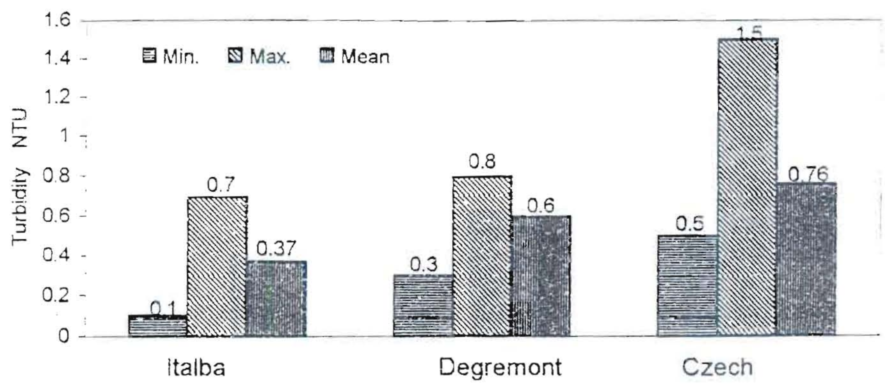

Fig. (1): The Turbidity values of effluent samples for different types of sand filters

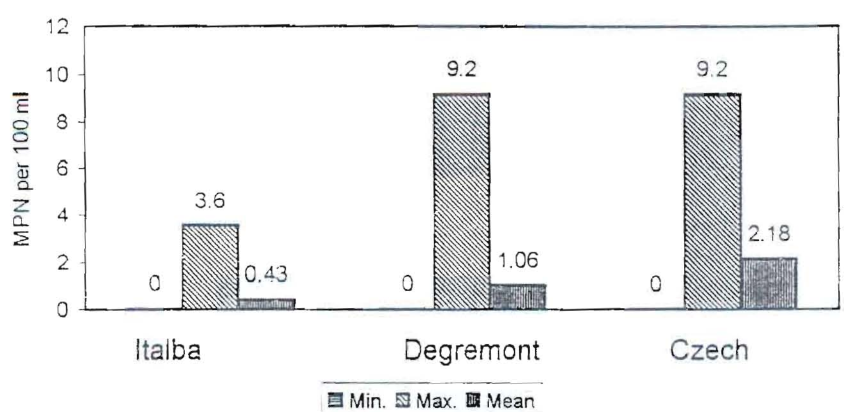

Fig. (2): The MPN of coliform values of effluent samples for different types of sand filters

Al-Ani *et. al* (1984) found that the turbidity removal over 70 % ,produces coliform removal over 90 %. On the other hand, in the present study it was found that the turbidity removal of all types of filter was over 70 %, while removal of coliform were 89.33%, 66.29% and 15.19% for Italba, Degremont and Czech, respectively. This may be due to the deficiency in backwashing processes.

Faecal coliforms: -

In case of Italba filter, after backwash immediately, the filtered water was free from faecal coliforms, and remains as it is during the all period of filter run.

Degremont and Czech filter has no effect in removing faecal coliforms and increases its MPN of the effluent water during specific times of operation. The operating times were the first one-hour after backwash for both and approximately eight hours and one hour before backwash, respectively.

This was due to two reasons. First, the effective size of sand media (1.1 mm) was higher than the design value (0.95 mm). Second, the backwash system was not working effectively (Abd El-Kerim,1988).

El-Sharkawi (1989) and Kamal (1992) revealed the problems of Degremont filter operation installed in Bab-Sharky to the backwash process and air blowers malfunction.

Standard plate count: -

Figure (3) shows the mean and range of standard plate count recorded by the three types of filters. Results indicated that Italba filter had the highest removal efficiency of total viable bacteria (85.92%) while Czech had the lowest one (27.08%)

The results proved that when the depth of filter media increases, the bacterial count of filtered water generally decreases, which is agreeable with the results of Vigneswaran (1986).

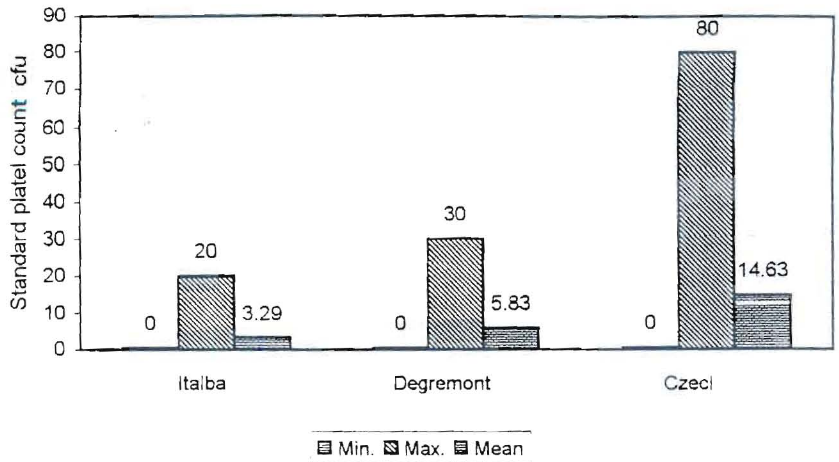

Fig. (3): The Standard plate count values of effluent samples for different types of sand filters

The removal efficiency of total viable bacteria by Italba filter was 82.48% and 11.68% during the first two hours from the beginning of filter run and the last two hours before backwash, respectively as shown in table (3). While Czech filter had the removal efficiency of 49.2% during the first two hours from the beginning of filter run. And there was an increase of the mean value during the last two hours before backwash.

In case of the Degremont filter, the removal efficiency was 56.16% and 76.78% during the first two hours from the beginning of filter run and the last two hours before backwash respectively.

In comparison of standard plate count results with coliform results, it was noticed that there was no constant correlation between the Standard plate count and coliforms. This is in agreement of Geldreich et.al (1972) who stated that," although no constant correlation appears between the Standard plate count and the number of coliforms that may be present; it was logical to assume that chance occurrences were proportionally greater as the general bacterial population increases."

The standard plate count is a valid indicator of bacteriological quality of drinking water and it is recommended that it should be used in appropriate cases in conjunction with coliform tests (EPA,1975).

Total algal count: -

Results of figure (4) show that all types of filters had high efficiency in removing algae that ranged between 97-98%. The algae removal efficiency by Italba filter is about 98.6% after backwash, and 98% before backwash. The removal efficiency by Czech filter was 94.66% after backwash and 96.37 % before backwash .While the removal efficiency by the Degremont filter was 98.35% after backwash and 96.6% before backwash.Two dominant groups were found:

1-Green Algae *(Coelastrum, pediastrum, Oedogonium, Scendesmus, Agmenellum, Ankistrodesmus, and Chlorella),* and this agreed with kamal(1992).

2- Diatoms (*Cyclotella, Melosira, Asterionella,* and *Synedra*)

Boston et.al (1974) reported that these diatom species cause filter clogging. David and Detlef (2002), stated that the ferric sulfate coagulation is the more effective process, which removes most of the algae in the water entering the filters. In our case of El-Manshia Water Purification Plant, alum coagulation is used. Accordingly,(as shown on figure 4) the algal count in the filter influent water exist in large numbers.

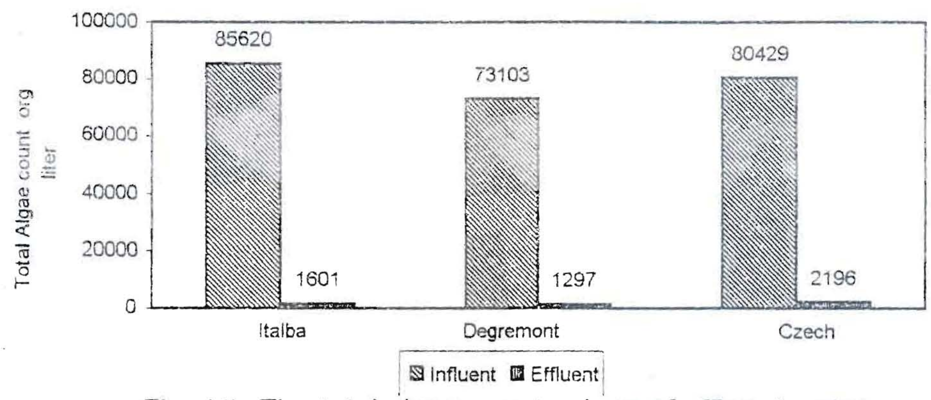

Fig. (4): The total algae count values of effluent water samples taken form different types of sand filters

Table (3): Physical and biological analysis of influent and effluent water samples taken from Italba filter during filter run.

Parameters	Period		Influent	Effluent	Filter removal efficiency
Turbidity (NTU)	(0.0-2) hr	Range Mean S.D.	1.8-2.6 2.33 0.20	0.4-1.00 0.52 0.16	77.68 %
	(3-45) hr	Range Mean S.D.	2.0-5.6 2.96 0.72	0.1-0.7 0.36 0.16	87.84 %
	(46-48) hr	Range Mean S.D.	2.9-3.8 3.28 0.31	0.20-0.30 0.21 0.03	93.60 %
Standard plate (CFU/ml)	(0.0-2) hr	Range Mean S.D.	0.0-22 5.25 6.19	0.0-5.0 0.92 1.44	82.48 %
	(3-45) hr	Range Mean S.D.	0.0-100 20.60 29.58	0.0-80 6.60 16.86	68.00 %
	(46-48) hr	Range Mean S.D.	0.0-56 8.56 17.28	0.0-25 7.56 12.56	11.68 %
Total coliforms (MPN/100ml)	(0.0-2) hr	Range Mean S.D.	0.0-5.20 0.61 1.51	0.0-5.1 0.79 1.53	-29.51 %(*)
	(3-45) hr	Range Mean S.D.	0.0-93 9.00 19.87	0.0-5.10 0.96 1.61	89.33 %
	(46-48) hr	Range Mean S.D.	0.0-2.2 2.51 4.87	0.0-2.2 1.79 1.54	28.69 %
Faecal coliforms (MPN/100ml)	(0.0-2) hr	Range Mean S.D.	0.0 0.0 0.0	0.0 0.0 0.0	
	(3-45) hr	Range Mean S.D.	0.0-23 1.73 5.37	0.0 0.0 0.34	100 %
	(46-48) hr	Range Mean S.D.	0.0-16 2.67 5.96	0.0 0.0 0.0	100 %
Total Algae count (org./liter)	hr 0.0 48 hr		31933 28517	450 563	98.59 % 98.03 %

(*) The effluent value is higher than the influent value.

Table (4): Physical and biological analysis of influent and effluent water samples taken from Degremont filter during filter run.

Parameters	Period		Influent	Effluent	Filter removal efficiency
Turbidity (NTU)	(0.0-2) hr	Range Mean S.D.	2.80-3.70 3.11 0.38	0.60-1.20 0.81 0.21	73.95 %
	(3-21) hr	Range Mean S.D.	1.90-4.20 3.28 0.75	0.48-0.98 0.77 0.14	76.52 %
	(22-24) hr	Range Mean S.D.	3.20-3.90 3.58 0.32	0.98-1.18 1.05 0.09	70.67 %
Standard plate (CFU/ml)	(0.0-2) hr	Range Mean S.D.	0.00-48.00 15.58 15.09	0.00-26.00 6.83 8.65	56.16 %
	(3-21) hr	Range Mean S.D.	0.0-300 16.40 47.86	0.00-38.00 3.90 7.89	76.22 %
	(22-24) hr	Range Mean S.D.	0.00-300 51.67 91.38	0.00-45.00 12 18.49	76.78 %
Total coliforms (MPN/100ml)	(0.0-2) hr	Range Mean S.D.	0.00-16.00 3.93 4.55	0.00-23.00 4.81 7.23	-22.39 %(*)
	(3-21) hr	Range Mean S.D.	0.00-240 12.31 37.20	0.00-23.00 4.15 7.20	66.29 %
	(22-24) hr	Range Mean S.D.	0.00-93.00 39.33 32.84	0.00-43.00 19.96 17.47	49.24 %
Faecal coliforms (MPN/100ml)	(0.0-2) hr	Range Mean S.D.	0.00-2.20 1.10 1.10	0.00-16.00 4.20 6.26	-310 %(*)
	(3-21) hr	Range Mean S.D.	0.00-9.10 0.99 2.51	0.00-5.10 0.35 1.11	64.65 %
	(22-24) hr	Range Mean S.D.	0.00-3.60 1.53 1.46	0.00-23.00 9.23 9.60	-503 %(*)
Total Algae count (org./liter)	hr 0.0 24 hr		46583 36200	767 1233	98.35 % 96.60 %

(*) The effluent value is higher than the influent value.

Table (5): Physical and biological analysis of influent and effluent water samples taken from Czech filter during filter run.

Parameters	Period		Influent	Effluent	Filter removal efficiency
Turbidity (NTU)	(0.0-2) hr	Range Mean S.D.	2.40-3.40 2.78 0.30	0.60-0.90 0.69 0.10	75.18 %
	(3-21) hr	Range Mean S.D.	1.70-7.70 3.06 0.94	0.20-0.90 0.51 0.25	83.33 %
	(22-24) hr	Range Mean S.D.	2.80-4.00 3.49 0.53	0.90-1.20 1.02 0.12	70.77 %
Standard plate (CFU/ml)	(0.0-2) hr	Range Mean S.D.	2.00-40.00 21.16 13.29	0.00-21.00 10.75 5.86	49.20 %
	(3-21) hr	Range Mean S.D.	0.00-100 11.36 20.98	0.00-44.00 5.81 10.10	48.86 %
	(22-24) hr	Range Mean S.D.	12.0-25.0 26.56 21.19	17.0-25.0 21.89 9.94	-17.58 %(*)
Total coliforms (MPN/100ml)	(0.0-2) hr	Range Mean S.D.	0.00-5.10 1.77 1.80	0.00-5.10 2.62 1.96	-48.02 %(*)
	(3-21) hr	Range Mean S.D.	0.00-9.20 0.79 1.92	0.00-5.10 0.67 1.81	15.19 %
	(22-24) hr	Range Mean S.D.	0.00-9.20 5.11 4.57	0.00-9.20 2.64 3.04	48.34 %
Faecal coliforms (MPN/100ml)	(0.0-2) hr	Range Mean S.D.	0.00-2.20 0.55 0.95	0.00-5.10 1.95 1.72	-254.55 %(*)
	(3-21) hr	Range Mean S.D.	0.00-2.00 0.05 0.33	0.00-9.20 0.34 1.59	-580 %
	(22-24) hr	Range Mean S.D.	0.00 0.00 0.00	0.00-2.20 0.98 1.09	-ve (*)
Total Algae count (org./liter)	0.0hr 24 hr		49667 54667	2117 1982	94.66 % 96.37 %

(*) The effluent value is higher than the influent value.

CONCLUSION

1- Italba filter had the highest removal efficiency of turbidity, total viable bacterial count and total coliform.

The high percentage removal of algae was found by both Italba and Degremont filters.

The turbidity of filtered water of Degremont and Czech filters is affected immediately after the back washing process. It is higher than the UNEP/ WHO guidelines.

2- All the filters have no effect in removing coliforms during the first one-hour after backwash and approximately eight hours before backwash.

3- Degremont filter has no effect in removing faecal coliforms and increase its MPN of the effluent water during the first one-hour after backwash and approximately eight hours before backwash. While Czech filters have no effect in removing faecal coliforms during the first one-hour after backwash and approximately one-hour before backwash.

Recommendation

1. The effective size of sand media (ES) for Degremont and Czech filters must be below 0.95 mm.
2. The backwash processes for the filter must be carried out every 40 hr of operation for Italba filter and 16 hr of operation for both Degremont and Czech filters.
3. The effluent water after the backwash processes of the filter must be drained to the sewerage system for at least 10 minutes after the backwash processes.
4. Replacement of Degremont and Czech by Italba filters are recommended in the future to increase plant production and improve water quality.

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