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ASSESSMENT OF DIFFERENT TREATMENT METHODS OF SAND FILTERS BACKWASH WATER

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ABSTRACT: The sand filtration process is used in drinking water treatment to remove contaminants before disinfection. Continuous filtration can lead to clogging of sand pores, reducing filter efficiency. The backwashing process is performed to cleanse filters and eliminate the accumulated contaminants. Filter backwash water (FBWW) represents 5-8% of the total plant production and is discharged as waste. The reuse of FBWW has attracted significant attention, particularly for applications such as irrigation, after treatment. This study aimed to investigate possible treatment options on FBWW. Four processes were tested and evaluated: blending FBWW with raw water, coagulation-flocculation process, settling process and sand filter treatment. Results indicated that aluminum concentration increased by coagulation-flocculation treatment process. Blending FBWW with raw water was the most efficient treatment method for heavy metals reduction. The coagulation-flocculation process was an efficient treatment method for total plate count reduction. The settling process affected the turbidity reduction as it decreased from 102 to 11 (NTU). The highest removal of turbidity was achieved by treating FBBW using the settling process coupled with sand filter treatment. Along the FBWW treatment processes, total plate count was reduced and could be eliminated by final disinfection.

Key words: Backwash water treatment, filter backwash water, coagulation, flocculation, settling.

INTRODUCTION

The conventional drinking water treatment process of coagulation, sedimentation, filtration, and disinfection has been widely used in surface water treatment around the world **(Stackelberg *et al*., 2004; Jiang and Adams, 2006; Li *et al*., 2018)**. Filtration is one of the most important and essential processes of water treatment. This process helps to remove impurities present in the water like suspended colloidal particles that aren't trapped in the sedimentation process. At certain time intervals, sand pores may get clogged due to fine colloidal particles, reducing the efficiency of the filter bed **(Patil *et al*., 2020)**.

Filter backwashing is an integral part of treatment plant operation to clean periodically the filter media **(Li *et al*., 2018).** It is initiated when the pressure loss through the filter exceeds the design value. It can also be initiated when the turbidity value of the effluent water increases. The predetermined time for a filter run being an effective way to manage filters and reduce the impact on downstream processes **(Eidhin *et al*., 2020)**.

The backwashing procedure starts with the application of compressed air, followed by reverse water flow through nozzles from the bottom of the filter **(Arendze *et al*., 2014)**. The filter media is expanded, and the particles become separated. The smaller floc particles are removed and washed out of the bed. The backwash cycle should extend long enough to clean the media bed. The principles of backwashing are similar for all of the filters. The resulting water is termed waste or filter backwash water **(Arendze *et al*., 2014)**.

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The Filter backwash water (FBWW) has high concentrations of total suspended solids (TSS), total organic carbon (TOC), inorganic precipitates (e.g. aluminum, manganese and iron salts), as well as pathogenic micro-organisms such as Cryptosporidium and Giardia **(Cornwell *et al.*, 2001; Bourgeois *et al*., 2004; Gottfried *et al*., 2008; Li *et al*., 2018)**.

The volume and composition of the backwash water may differ depending on backwashing (duration/rate), the amount of the treated water, the degree of its contamination, raw water quality and the degree of contaminant removal **(McTigue *et al*., 2009; McCormick *et al*., 2010; Wiercik *et al*., 2016)**.

Due to worldwide challenges, there has been a need to improve the efficiency of water consumption and to supplement existing sources of water more sustainably. Water reuse serves to protect freshwater resources **(Arendze *et al*., 2014).** Filter backwash water (FBWW) and clarifier solids are the two most waste residual streams generated. **(Walsh *et al*., 2008; McTigue *et al*., 2009).** Historically, backwash water was discharged directly to surface water supplies by most of the water treatment plants (WTPs) (**Fouad *et al*., 2016),** discharged to the sewage system or recycled within the treatment plant **(Adin *et al*., 2002).** The treatment of filter backwash water would reduce the potential risk of contaminants and save the volume of filter backwash water **(Arendze *et al*., 2014).**

In selecting a specific technology for treating residual waste, it is important to note that the operational effectiveness and economic efficiency will vary according to the process design and waste residual characteristics **(Arendze *et al*., 2014)**.

There were previous studies related to the treatment of FBWW like settling process, sedimentation with flocculation process **(Arendze *et al*., 2014)**, settling coupled with filtration **(Abdel-shafy *et al*., 2020),** dissolved air flotation, **(Arendze *et al*., 2014)**, ultrafiltration membranes, **(Ćurko *et a*l., 2013; Mahdavi *et al*., 2017)** blending backwash water with raw water (**Suman *et al* ., 2012; Fouad *et al*.**, **2016)**, sedimentation with flocculation process coupled with filtration **(Diwakar *et al*., 2020)**.

This study aimed to investigate and evaluate potential treatments on the filter backwash water taking into consideration a case study in the Alexandria water plant (Manshia 2 WTP). Four processes were selected for testing: blending backwash water with raw water, coagulation-flocculation process, settling process and sand filter treatment.

MATERIAL AND METHODS

Description of the Studied Drinking Water Treatment Plant' s process

The treatment was performed in Manshia (2) drinking water treatment plant (DWTP), Alexandria, Egypt. It supplies drinking water to the east and middle areas of Alexandria. It is constructed directly on a small freshwater canal branched from El Mahmoudia Canal.

The amount of the inlet fresh water to the plant is 240,000 m^3/day. The inlet water is pumped to the plant and subjected to four clarifier tanks to be injected with both chlorine as pre-chlorination and liquid alum coagulant which is mixed and allowed to form flocculants. Water is allowed to be settled. The settled water is then filtered using 12 sand filters. The final treated drinking water is further injected with chlorine as post-chlorination and directed to 3 large storage tanks to be distributed to supply the surrounding areas with treated drinking water. This DWTP is operated 24 hours /day and produces about 2,500 liter/sec. The total daily produced water is around 220,000 m^3/day treated drinking water.

In the present WTP, the sand filters are backwashed every 24 hours periodically. Fig. 1 shows the backwashing process from the beginning to the end. The backwash process was done as follows: 1 minute air then 10 minutes air coupled with water and finally 10 minutes water only. It consumes a large quantity of water. The estimated amount of the backwashing water is about 11,000 - 18,000 m^3/day (*i.e*. 5 - to 9% of the produced drinking water). Fig. 2 illustrates the average amount of different types of water in the plant. This amount of backwashing water is drained into sewage. During the backwashing process, turbidity was observed to be very high in the first minute and decreased gradually until the end of the backwash. In different plants in Alexandria, there are operational differences between the plants including coagulant (alum) dose, doses and addition points for disinfectant, filter loading rate, and backwash length and flow but the steps of operation are the same.

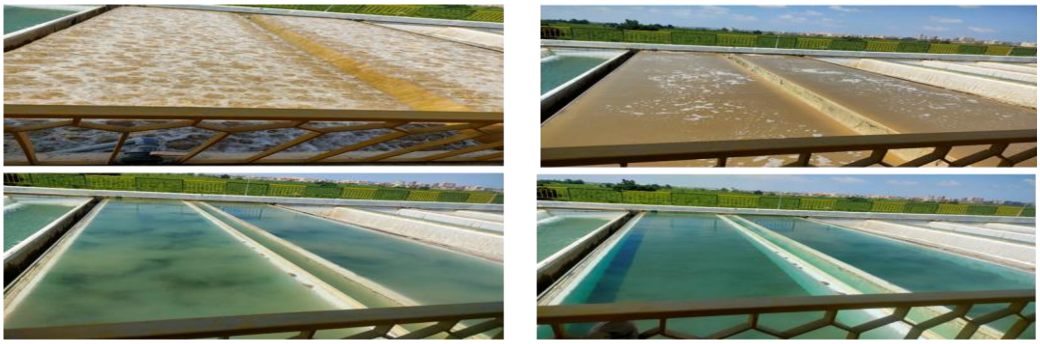

Fig. 1. Sand filter backwashing process

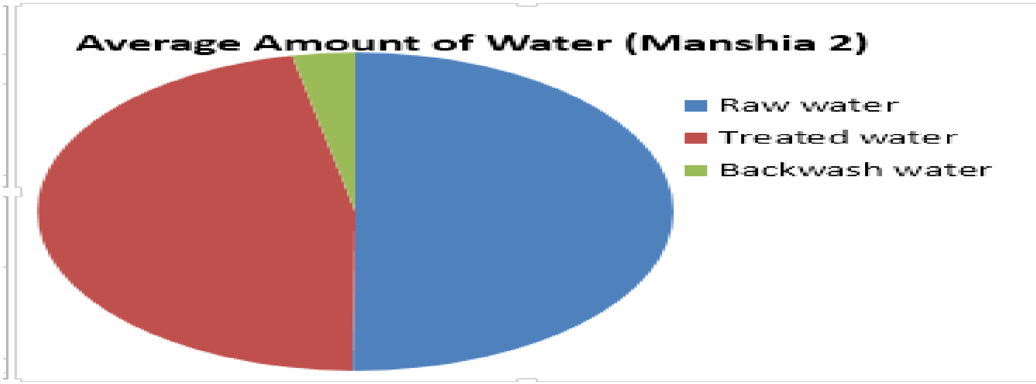

Fig. 2. The average amount of different types of water in the plant

Chemicals and media

All chemicals, reagents and reference materials of inorganic chemicals used were of high purity grade. Coagulant aluminum sulphate (alum) ($Al_2(SO_4)_3.18H_2O$) was purchased from Misr Chemical Company, Egypt. Conductivity and turbidity check standards were purchased from HACH company, Germany. pH buffer solutions, nitric acid (HNO_3), calcium carbonate ($CaCO_3$), ethylenediaminetetraacetic acid ($C_{10}H_{14}N_2Na_2O_8.2H_2O$), ammonium solution ($NH_4$) and sodium hydroxide (NaOH) were purchased from Fisher company, United Kingdom. Also, murexide ($C_8H_8N_6O_6$) and erichrome black T ($C_{20}H_{12}N_3NaO_7S$) were purchased from Panreac company, Spain. Multielement heavy metals standard solution was purchased from Merck company, Germany. Media utilized for microbiological tests was prepared from tryptic glucose yeast agar which was purchased from Biolife company, Italy.

Water Quality Measurements

Physical, chemical, and microbiological characteristics as well as the microscopic examination were carried out according to procedures described in the Standard Methods for the Examination of Water and Wastewater **(Lipps *et al*., 2020).**

Physical parameters

Turbidity, electrical conductivity, pH and total dissolved solids

Turbidity was measured by a nephelometric method (NTU) using a turbidimeter (HACH model 2100 N), HACH Co., USA. Electrical conductivity and Total Dissolved Solids were measured using an analytical electrical conductivity meter (HACH 14d), HACH company, USA. pH was measured using an analytical pH meter (HACH 11d), HACH company, USA. The instruments were calibrated daily using certified standards **(Lipps *et al*., 2020)**.

Chemical parameters

Total hardness and calcium

Total Hardness and Calcium were measured by a titration method using a digital burette (Digital Burette, 50 ml, Digitrate – Jencons). 50 ml samples were prepared by adding buffer solution and indicator powder. Titrate against 0.01 M EDTA until the endpoint. The calcium carbonate standard was prepared and used as a reference according to standard methods for water and wastewater treatment **(Lipps *et al*., 2020).**

Residual aluminum and residual iron

Aluminum and Iron Residuals were measured using ICP -OES 5300-DV, Perkin Elmer, Dual view System, Samples were filtered and acidified with (1+1) HNO_3 to pH <2. Daily calibration of the instrument is according to the instrument's manual calibration instructions.

Determination of bacterial count

The enumeration of total bacterial count in the water sample was done using the pour plate technique over difco plate count agar medium. 1 ml of undiluted sample or a suitable dilution was placed on a medium plate and incubated (Shel lab–1545, Germany) at 35 0C for 48 hours. The resulting colonies were counted using colony counter (560 Suntx-USA) **(Lipps *et al*., 2020).**

Determination of algal count

The samples were centrifuged and 1 ml of the sample was transferred to the Sedgwick-rafter counting chamber. An average count of 40 fields was done for algal count using a Carl Zeiss Axiolab Optical Microscope, Germany which fitted with a 3CCD color video camera attached to a TV monitor **(Lipps *et al*., 2020).**

Sampling

The sampling program was designed to collect different water samples. The samples were: raw canal water, treated drinking water and the "backwashing" water. All samples were manually collected in two-liter polyethylene bottles for physical and chemical characteristics. For the microbiological analysis, sterile glass bottles were used. Microscopic examination for microorganisms was also examined. The collected samples were freshly transported to the laboratory in an ice box at a temperature of $4^{o}C$. Fresh samples were immediately analyzed and used for experiments without any pre-treatment.

A sampling program was implemented to collect the following from El-Manshia (2) water treatment plant, Alexandria Water Company:

Raw water

Samples were collected under the water surface where care was taken not to disturb the bottom of the water stream and away from the canal sides. The samples were collected in a jar and mixed well.

Treated water

Samples were collected from the tap water of the plant's laboratory. The samples were collected in a jar and mixed well.

Backwash water

Backwash water samples were collected while filters were being washed. A representative sample was taken every minute during the backwashing process. The samples were collected in a jar and mixed well.

Treatment Methodology

Blending backwash water with raw water

The filter backwash water (FBWW) was blended with the raw water (RW) at different mixing ratios of 10%, 20%, 30%, 50%, 70% and 90% in a holding tank for each run. Add 900 ml FBWW to 100 ml RW to prepare 1000 ml sample blended at a ratio of 90% run… etc. Each run was analyzed to find the optimum ratio of blending.

Coagulation and flocculation method

The experiments of coagulation and flocculation were conducted using a Bench-scale jar test unit (Phippsbird-900, Phipps and Birds company, United States). Coagulant aluminum sulphate {(alum) $Al_2(So_4)_3.18H_2O$} solution was prepared. 2 L of the backwash water sample was taken in each jar. Pre-determined dosage of coagulant alum was added in each jar as 10, 20, 30, 40, 50 and 60 mg/l. The supernatant from each jar was collected for analysis without disturbing settled solids to determine the optimum dose.

Settling process coupled with sand filter treatment

A pilot plant was designed to perform the experiment. The system consisted of a settling tank, feeding pump and filtration column.

Settling method

The settling tank was designed such that, the backwash water is allowed to settle down all the particles and suspended solids by gravity through six interval times, (10, 20, 30, 60, 90 and 120 min). The outlet-treated backwash water for each time interval was analyzed.

Sand filter method

After settling FBWW for 120 min, the outlet-treated backwash water was pumped to the sand filter. Filter as cylinder consists of a sand layer. The effective size of the sand varies from 1.2 - 1.8 mm, having a uniformity coefficient D_{60}/D_{10} ranging from 1.35-1.5. The outlet-treated backwash water after the sand filter was analyzed.

RESULTS AND DISCUSSION

Water Quality Measurements of Raw Water, Treated Water and FBBW

Physical, chemical, biological, and bacteriological characteristics of the raw canal water as inlet and the treated drinking water as outlet water of the studied WTP were measured. Results are given in Table 1, as shown the turbidity of raw water decreased from 29 to 0.8 (NTU). Also, total hardness and calcium decreased from 200 and 42.4 mg/l to 198 and 41.1 mg/l respectively. The heavy metal iron decreased from 0.28 mg/l to 0.11 mg/l. parameters were decreased indicating the effectiveness of the treatment process.

On the contrary, the aluminum was increased from 0.08 mg/l to 0.18 mg/l as a result of using aluminum sulphate coagulant (alum) in the treatment process. On the other hand, conductivity, TDS and pH were affected imperceptible by conventional treatment process. The microscopic examination for living microorganisms indicated that blue-green algae decreased from 167 to 90 U/ml. The total plate count was decreased from 810 to 18 (CFU/ml) which indicates that the added chlorine was sufficient to get rid of most bacterial contamination. The overall results indicated good quality of raw water and the WTP was efficient for treating the raw water and the treated drinking water could successfully cope with the Egyptian guideline standards (EGL). Comparing the results of FBBW with the treated water in Table 1 indicated very high turbidity in the case of FBBW (102 NTU) compared to treated water (0.8 NTU). The alum solution was added to the RW to remove the turbidity thus aluminum hydroxide ($Al(OH)_3$) was produced. High turbidity of FBWW due to aluminum hydroxide ($Al(OH)_3$) which trapped in sand filter.

FBBW contains high concentrations of both aluminum and iron (1.2 and 0.53 mg/l respectively). Also, E.C., TDS, and pH were affected imperceptibly by the backwashing process. The total plate count is higher in FBWW than the corresponding of the treated water. The backwashing water also contains a higher amount of blue-green algae 2050 U/ml in correlation to the treated water 90 U/ml. These contaminants which were staked in the sand layer were released during the backwashing process. The quality of the filter backwash water changes during the backwash process from the beginning to the end. Therefore, a representative sample was collected that included the entire time of the washing process, as reported by **Wiercik *et al*. (2016)**. The quality of FBWW samples varied according to RW quality. Instead of wasting the backwashing water, it could be treated **(Abdel-shafy *et al*., 2018).** Based on the results, FBWW could be treated by the following four treatment methods: blending backwash water with raw water, coagulation-flocculation process, settling process and sand filter treatment.

Methods of Treating FBWW

Blending backwash water with raw water

The effect of blending FBWW with RW on different parameters at different ratios is presented in Fig. 3 where the percent of reduction was calculated according to the following equation **(Sperling *et al*., 2020):**

$$E(\%) = [(C_{in} – C_{out}) / C_{in}] \times 100$$

Where

E(%)= Removal efficiency

C_{in} = Parameter measurement of inlet water

C_{out} = Parameter measurement of outlet water

Table 1. Physical, chemical, bacteriological, and biological characteristics of the raw water (RW), treated water (TW) and filter back wash water (FBWW)

Parameters	Egyptian guidelines (EGLs)		Results		
	RW (EGLs, 2013)	TW (EGLs, 2007)	Raw water (RW)	Treated water (TW)	Filter back wash water (FBWW)
Turbidity (NTU)	NR	≤1	29	0.8	102
pH	6.5-8.5	6.5-8.5	7.73	7.2	7.5
Conductivity (µs/cm)	NR	NR	775	785	790
TDS (mg/l)	≤500	≤1000	449.5	455.3	458.2
Total hardness (mg/l)	NR	≤500	200	198	204
Calcium (mg/l)	NR	NR	42.4	41.1	46
Al (mg/l)	NR	≤0.2	0.08	0.18	1.2
Fe (mg/l)	≤0.5	≤0.3	0.28	0.11	0.53
Total plate count (CFU/ml)	NR	≤50	810	18	1100
Blue green algae (U/ml)	NR	NR	167	90	2050

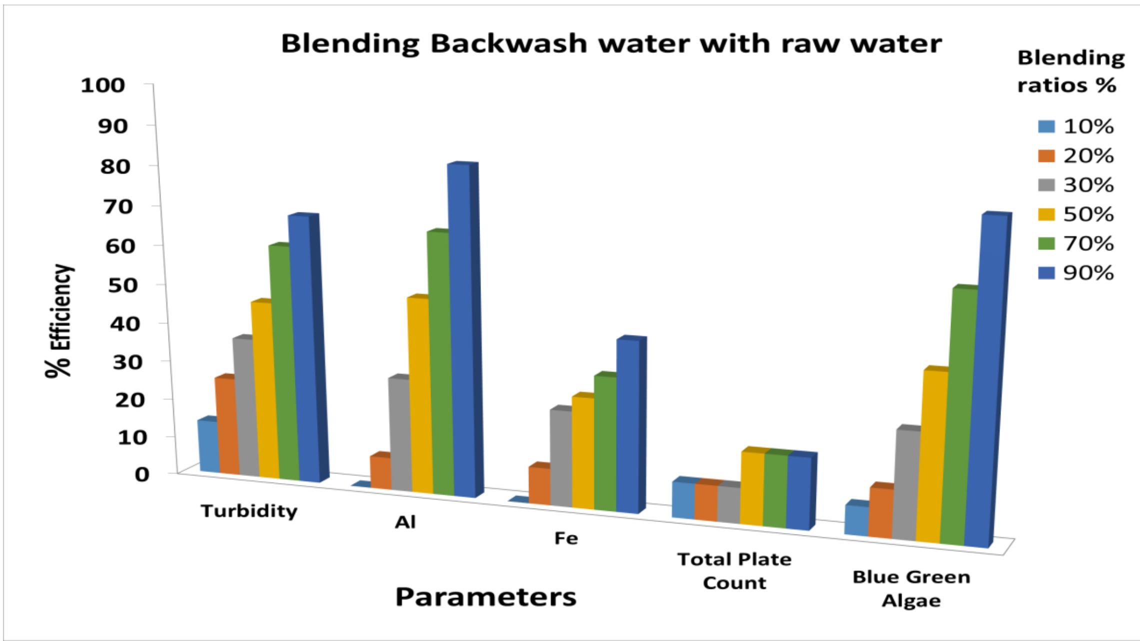

Fig. 3. Effect of blending of FBWW with RW method on different parameters at different blending ratios

As seen, increasing the blending ratio from 10% to 90% affected the quality of treated FBWW. The reduction of turbidity was increased gradually from 14% to 69% and the total plate count reduction was increased slightly from 9% to 18%. Aluminum and iron were not affected by law ratios of blending (10%, 20% and 30%). Aluminum was reduced by 50% at (50% blending ratio) and the reduction increased to reach 83 % at higher ratio (90%). Also, iron was reduced by 28% at (50%) and the reduction increased to reach 43% at (90%). The microscopic examination for living microorganisms indicated that blue-green algae reduction was increased strongly from 7% to 78% at (10% and 90% blending ratios), respectively. It was concluded that the blending ratio of 90% was the best ratio due to adding a high ratio of raw water. At 90 % blending the raw water was 90% of the total volume and FBWW was 10%. Also, **(Fouad *et al*., 2016)** reported that the best blending ratio was 60% raw water to 40% FBWW and **(Janiaczyk and Bylka, 2019)** stated that blending of different sources of water affected the quality of water.

Coagulation-flocculation process

One of the most important goals of filter backwash water treatment is the removal of solids, therefore coagulation-flocculation is one of the options for treatment. The presence of aluminum in FBWW contributed to the use of aluminum sulfate (alum) as a coagulant which is the most widely used coagulant **(Farhaoui and Derraz, 2016)**. Different doses of alum coagulants were added to FBWW using jar test and the turbidity was measured to determine the optimum dose. The presence of aluminum hydroxide in FBWW increases the efficiency of the coagulation process, **(Suman *et al*., 2012).** Fig. 4 shows the effect of the coagulation-flocculation process of FBWW treatment on different parameters in the presence of different doses of coagulant. As illustrated, the percentage of reduction of turbidity increased from 22% to 90% at (10 and 60 mg/l) alum dose, respectively. The optimum dose was determined to be 50 mg/l where turbidity reduction was 85%. Along with the doses of alum from 10 mg/l to the optimum dose of 50 mg/l, the microscopic examination for living microorganisms indicated that the reduction of blue-green algae was increased from 27% to 78% and the total plate count reduction was increased from 23% to 51%. Because of the electrostatic repulsive forces, negatively charged particles of contaminants were prevented from forming larger flocs **(El-Taweel *et al*., 2023).** Coagulation could combine small particles into larger aggregates and adsorb dissolved organic matter **(Jiang, 2015).** It can be noticed that increasing the coagulant dose destabilized the negatively charged particles and facilitated the sedimentation process, and thus decreased FBWW turbidity **(El-Taweel *et al*., 2023).** Otherwise, the heavy metal concentrations at different alum doses were increased as aluminum increased by 42%. Aluminum concentration in the treated FBWW was increased as a result of using alum coagulant. Also, iron concentrations were slightly increased from 2% to 4%. It could be concluded that coagulation enhanced the quality of FBWW following **(Diwakar *et al*., 2020).** It is an effective process but it is not recommended due to using high doses of coagulant.

Settling process

Settling could be effective in the removal of solids, during sufficient settling time. Gravitational force enables particles or droplets to settle or fall in suspension fluid **(Zaidi,2021)**. Fig. 5 presents the efficiency of the settling process of FBWW treatment to enhance water quality at different retention times. As seen, by increasing the retention times of the settling process from 10 min to 120 min, the reduction of turbidity greatly increased from 2% to 89% while the total plate count reduction slightly increased from 4% to 18%. Also, the reduction of the blue-green algae increased from 2% to 27%. After settling, the precipitated suspended solids (sludge) could be separated from water to be reused. The filter backwash water consists of a high concentration of suspended solids of coagulants which have been destabilized and settled very readily **(Abdel-Shafy *et al*., 2020)**. Aluminum was not affected by settling at different retention times and iron was affected by 2% and 6% reduction only at 90 min and 120 min settling time. It was concluded that 120 min was the most efficient retention time for the settling process. By increasing retention times, the quality of settled FBWW was improved. Gravity affected the movement of colloids and by increasing their size it will be more effective. Over time, individual particles collide with existing aggregates and particle-aggregate bonds were developed **(Guhra *et al*., 2021).**

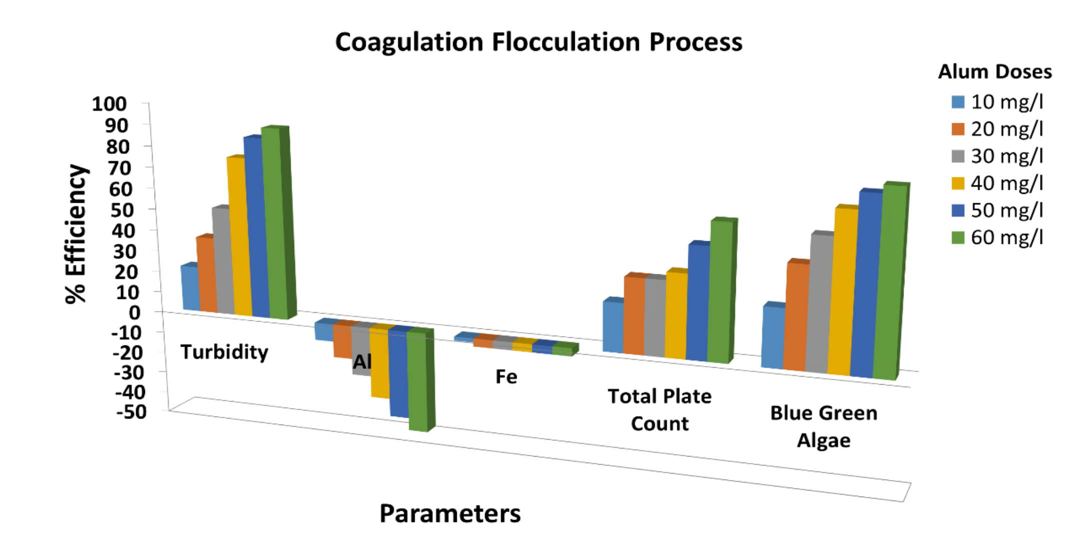

Fig. 4. The effect of the coagulation-flocculation process of FBWW treatment on different parameters in the presence of different doses of coagulant

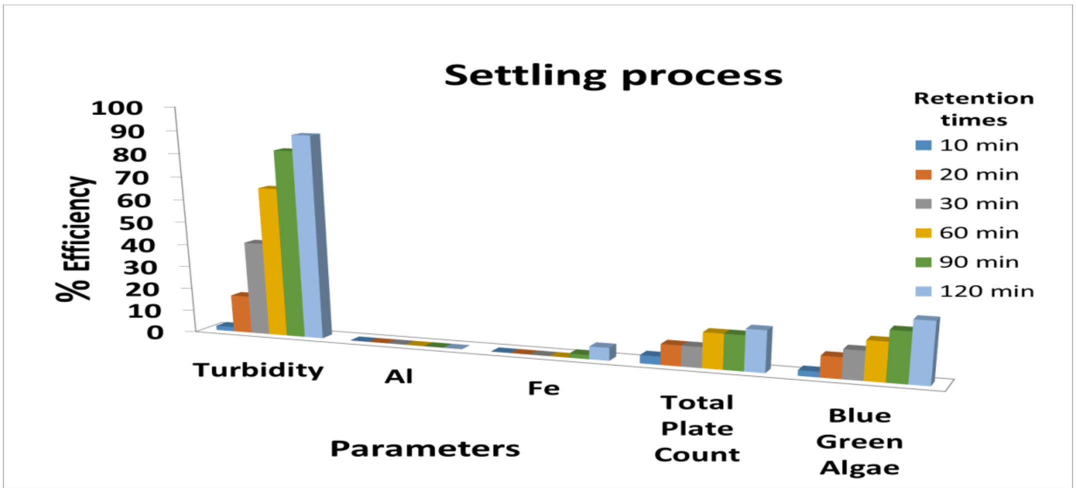

Fig. 5. Effect of settling process of FBWW treatment on different parameters at different retention times

Sand filter treatment

The produced settled FBWW at 120 min was used in sand filter treatment as it was the optimum retention time of the settling process where the highest turbidity reduction was 89%. By bypassing the settled FBWW through a sand filter, the quality of treated FBWW was enhanced as shown in Fig. 6 where the reduction of turbidity was increased to 95% and the total plate count reduction was increased to 36%. Also, the blue-green algae reduction was increased strongly to 80%. As seen, sand filtration was effective due to the sand layer which removed the impurities including suspended particles, biological matter and flocks **(Diwakar *et al.*, 2020)**. Aluminum and iron reductions were 4% and 9%, respectively which were affected imperceptible by the sand filter treatment process. Based on the results, the FBWW required the settling treatment processes as pre-treatment before sand filtration to obtain effective results and for maintenance where pretreatment delayed the clogging of filter pores **(Arendze *et al.*, 2014)**.

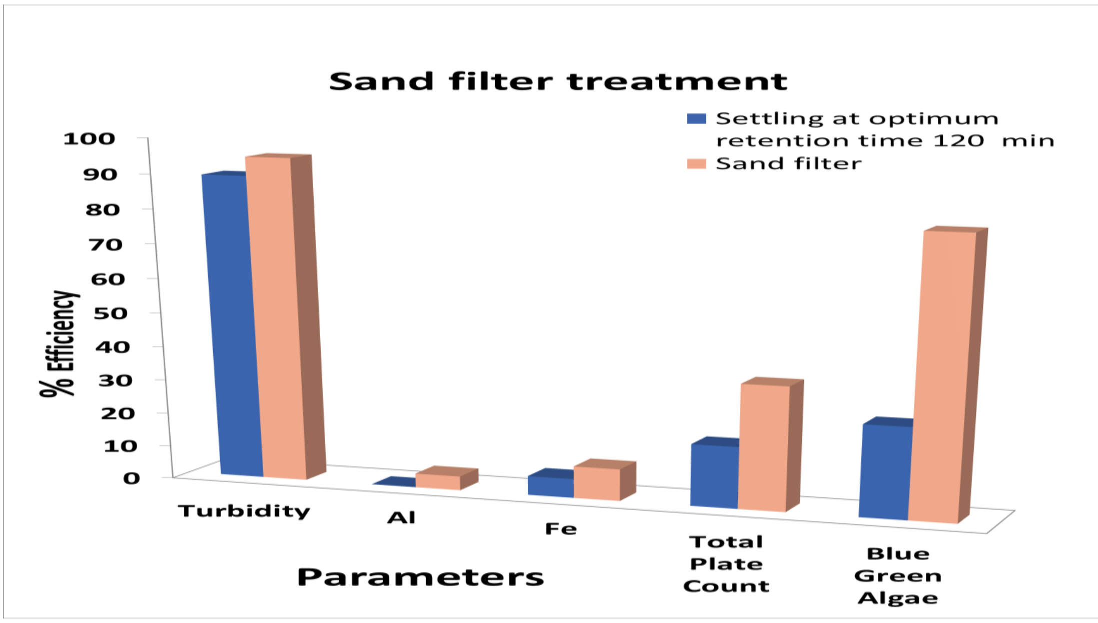

Fig. 6. Effect of sand filter method of FBWW treatment on different parameters at 120 min settling time

Comparison Between Different FBWW Treatment Methods

Table 2 and Fig. 7 represent the results of the coagulation-flocculation process at an optimum alum dose of 50 mg/l, blending FBWW with raw water process at an optimum blending ratio of 90%, settling process at optimum retention time of 120 min and the sand filtration treatment after settling process at optimum retention time. Table 2 indicates that no noticeable changes were observed in the values of EC, TDS, pH, total hardness and calcium. As seen in Fig. 7, the coagulation-flocculation process was an efficient treatment method for total plate count reduction by 55% where it decreased from 1100 to 500 CFU/ml. Otherwise, the blending method and settling method were less efficient on total plate count reduction where the reduction was 18% as it decreased from 1100 to 900 CFU/ml. Blending FBWW with raw water was the most efficient treatment method for heavy metals reduction. Aluminum concentrations decreased from 1.2 to 0.2 mg/l (95% reduction) and iron decreased from 0.53 to 0.3 mg/l (95% reduction). While the sand filtration affects the heavy metals removal imperceptible. Aluminum decreased from 1.2 to 1.15 mg/l (4% reduction) and iron decreased from 0.53 to 0.48 mg/l (9% reduction). Otherwise, the heavy metal aluminum and iron concentrations at the coagulation-flocculation process were increased to reach 1.7 mg/l and 0.55 mg/l at the optimum dose. The settling process affected the turbidity reduction to 89% as it decreased from 102 to 11 (NTU). Settling improved the sand filtration treatment efficiency of turbidity removal where the highest reduction of turbidity was 95% as it decreased from 11 to 5.5 (NTU). Almost all the FBWW treatment methods had the same efficiency of blue-green algae reduction which was about 80% except the settling method was 27% as blue-green algae decreased from 2050 to 450 U/ml.

Conclusions

Recycling filter backwash water is considered a big challenge. Treatment of FBWW saves capital money for water treatment plants as treated drinking water is wasted as a result of the backwashing process. The contaminants in the filter backwash water could affect the environment so treatment of FBWW is a benefit to the health. The coagulation-flocculation process enhances FBWW quality. But, this process is expensive because of using coagulants and represents a risk to the environment due to the high concentration of aluminum.

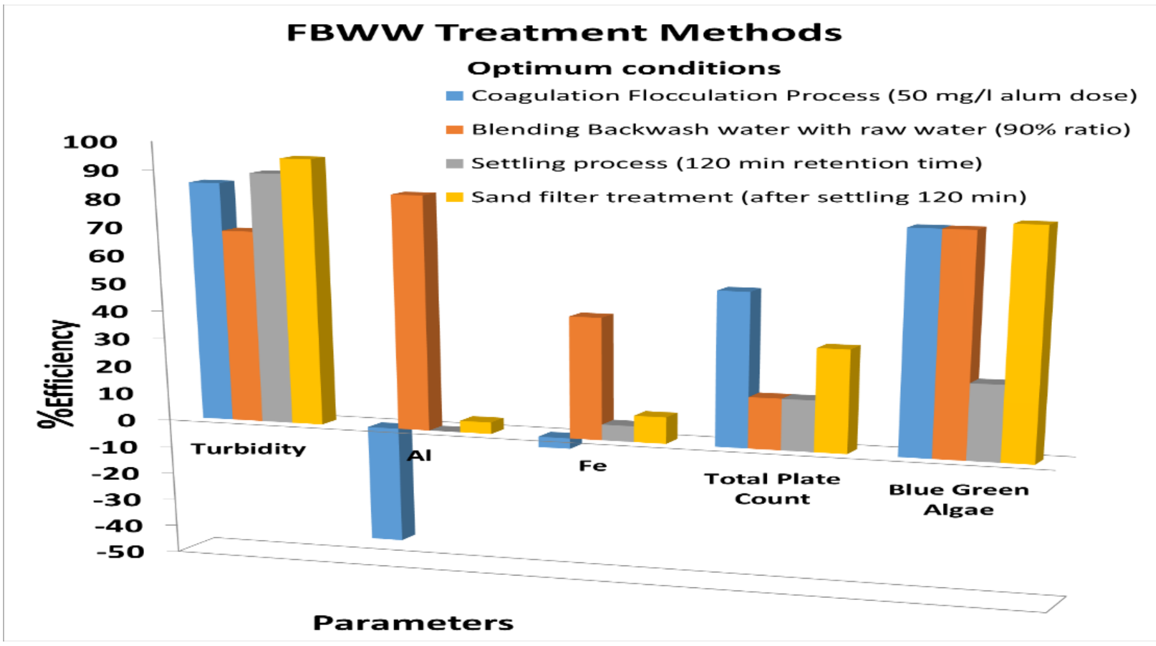

Fig. 7. Effect of tested FBWW treating methods on water quality parameters at their optimum conditions

Table 2. Physical, chemical, bacteriological and biological characteristics of the RW, FBWW and treated FBBW after different treatment methods

Parameters	Results					
	Raw Water	Filter back wash water	Coagulation flocculation process	Blending (90% ratio)	Settling process (120 min retention time)	Sand Filter (120 min retention time)
Turbidity (NTU)	29	102	15	32	11	5.5
pH	7.73	7.5	7.43	7.7	7.4	7.4
Conductivity (µs/cm)	775	790	820	780	785	785
TDS (mg/l)	449.5	458.2	492	468	471	471
Total Hardness (mg/l)	200	204	203.6	200	203	203
Calcium (mg/l)	42.4	46	45.8	45.6	46	46
Al (mg/l)	0.08	1.2	1.7	0.2	1.2	1.15
Fe (mg/l)	0.28	0.53	0.55	0.3	0.5	0.48
Total plate count (CFU/ml)	810	1100	500	900	900	700
Blue green algae (U/ml)	167	2050	450	450	1500	400

Treating FBWW by blending with RW at 90% produces water quality close to raw water characteristics in terms of turbidity and total plate count. The FBWW could be added to the raw fresh water as an additional quantity to the inlet of the water treatment plant (WTP) taking into consideration the risk of aluminum in the treated FBWW. Advanced technology for water treatment like membrane filtration has attracted attention globally but FBWW is not suitable to pass through membrane filtration because of the high level of turbidity, blue-green algae and bacteria which cause fouling of membrane, so it is recommended to use traditional methods for FBWW pre-treatment.

From this study, it is recommended to use a settling process coupled with sand filtration before membrane filtration technology for FBWW treatment to meet the water standard according to Egyptian guidelines. The produced water could be fed back into the mainstream without any contaminant risk.

REFERENCES

Abdel-Shafy, H.I., M.A. Salem, M.A. El-Khateeb, M.S. Mansour and N. Abdel Shafy (2020). Innovative System for Recycling of Backwashing Water in Drinking Water Plant. Egypt. J. Chem., 63 (3): 885-895.

Abdel-Shafy, H.I., M.A. Salem, M.S.M. Mansour, M.A. El-Khateeb and S.H. Abdel-Shafy (2018). Physico-chemical evaluation of drinking water treatment plant and sand filter backwashing water for possible recycling: A case study. Egypt. J. Chem., 61 (6):1039– 1047.

Adin, A., L. Dean, F. Bonner, A. Nasser and Z. Huberman (2002). Characterization and destabilization of spent filter backwash water particles. Water Supply, 2 (2): 115–122.

Arendze, S. and M. Sibiya (2014). Filter backwash water treatment options. J. Water Reuse and Desalination, 4 (2): 85–91.

Bourgeois, J.C., M. Walsh and G. Gagnon (2004). Treatment of drinking water residuals: comparing sedimentation and dissolved air flotation performance with optimal cation ratios. Water Res., 38(5): 1173–1182.

Cornwell, D and M.J. MacPhee (2001). Effects of spent filter backwash recycle on Cryptosporidium removal. Water Works Assoc., 93 (52): 153–162.

Curko, J., I. Mijatović, D. Rumora and V. Crnek (2013). Treatment of spent filter backwash water from drinking water treatment with immersed ultrafiltration membranes. Desalination and Water Treat., 51 (25-27): 4901-4906.

Diwakar, A., A. Rituja, G. Shubhangi, A. Suvarna and Y.Ansari (2020). Treatment of Sand Filter Backwash Water from Water Treatment Plant. Int. J. Advanced Sci. and Technol., 29 (7): 12130 – 12137.

EGLs (2007). Egyptian guidelines for drinking water. Ministry of health and population (MHP), Decree 458.

EGLs (2013). Egyptian guidelines for raw water. Ministry of water resources and irrigation (MWRI), Decree 49 law 48.

Eidhin, C.N., D. Page and M. Minihan (2020). Water Treatment Manual: Filtration, Environ. Prot. Agency (EPA), United States.

El-Taweel, R.M., N. Mohamed, K. Alrefaey, S. Husien, A. Abdel-Aziz, A. Salim, N. Mostafa, L. Said, I. Fahim and A. Radwan (2023). A review of coagulation explaining its definition, mechanism, coagulant types, and optimization models; RSM, and ANN. Current Res. in Green and Sustainable Chem., 6 (3): 1-23.

Farhaoui, M. and M. Derraz (2016). Review on optimization of drinking water treatment process. J. Water Res. and Prot., 8 (8): 777-786.

Fouad, H.A., R.M. Elhefny and M.A. Mohamed (2016). Reuse of spent filter backwash water. Int. J. Civil Eng. and Technol. (IJCIET), 7 (4): 176–187.

Gottfried, A., A. Shepard, K. Hardiman and M. Walsh (2008). Impact of recycling filter backwash water on organic removal in coagulation–sedimentation processes. Water Res., 42 (18): 4683–4691.

Guhra, T., T. Ritschel and K. Totsche (2021). The mechanisms of gravity-constrained aggregation in natural colloidal suspensions. J. Colloid and Interface Sci., 597 (23): 126-136.

Janiaczyk, A.S. and J. Bylka (2019). The effect of the mixing of water from different sources in the water supply system on tap water quality-a full-scale technical investigation case study. Water Supply, 19 (1): 303–312.

Jiang, H. and C. Adams (2006). Treatability of chloro-s-triazines by conventional drinking water treatment technologies. Water Res., 40 (8): 1657–1667.

Jiang, J.Q. (2015). The role of coagulation in water treatment. Current Opinion in Chem. Eng., 8: 36-44.

Li, W., X. Liang, J. Duan, S. Beechamb and D. Mulcahyb (2018). Influence of spent filter backwash water recycling on pesticide removal in a conventional drinking water treatment process. Environ. Sci. Water Res. and Technol., 4 (7): 1057–1067.

Lipps, W.C., E.B. Howland and T.E. Boxler. (2020). Standard methods for the examination of water and waste water. 24th Ed. Ame. Public Health Assoc., Washington, DC.

Mahdavi, M., A. Ebrahimi., H. Azarpira, H. Tashauoei and A. Mahvi (2017). Dataset on the spent filter backwash water treatment by sedimentation, coagulation and ultra-filtration. Data in Brief., 15: 916–921.

McCormick, N.J., M. Porter and M.E. Walsh (2010). Disinfection by-products in filter backwash water: Implications to water quality in recycle designs. Water Res., 44 (15): 4581 - 4589.

McTigue, N.E. and D.A. Cornwell (2009). Water treatment residual management for small systems. Environ. Prot. Agency (EPA), United States.

Patil, R and M. Chougale (2020). Perfection in backwashing of rapid sand filter to augment the performance of sand filter system. Int. J. Scient. and Technol. Res., 9 (3): 6765-6781.

Sperling, M.V., M.E. Verbyla and S.M. Oliveir (2020). Removal efficiencies, Assessment of Treatment Plant Performance and Water Quality Data: A Guide for Students, Res. and Practitioners, London, IWA : 181-206.

Stackelberg, P.E., E.T. Furlong, M. Meyer, S. Zaugg, A. Henderson and D. Reissman (2004). Persistence of pharmaceutical compounds and other organic wastewater contaminants in a conventional drinking-water-treatment plant. Sci. Total Environ., 329 (3): 99–113.

Suman, S., N.P. Singh, and C. Sulekh (2012). Effect of Filter Backwash Water when blends with Raw Water on Total Organic Carbon and Dissolve Organic Carbon Removal. Res. J. Cchem. Sci., 2 (10): 38-42.

Tobiason, J.E., J.K. Edzwald, V. Gilani, G. Kaminski, H. Dunn and P.B. Galant (2017). Effects of waste filter backwash recycle operation on clarification and filtration. J. Water Supply: Res. and Technol., 52 (4): 259 - 275.

Walsh, M.E, C.B. Lake and G.A. Gagnon (2008). Strategic pathways for the sustainable management of water treatment plant residuals. J. Environ. Eng. and Sci., 7 (1): 45-52.

Wiercik, P., K. Matras, E. Burszta-Adamiak, M. Kusnierz (2016). Analysis of the properties and particle size distribution of spent filter backwash water from groundwater treatment at various stages of filters washing. Eng. and Prot. Environ., 19 (1): 149 - 161.

Zaidi, A.A. (2021). Characteristics of settling of dilute suspension of particles with different density at high Reynolds numbers. Particuol., 56: 62-74.

تقييـــم طـــــرق المعــالجـــة المختلفـــة لميـــاه الغســـيل العكســـى للمـرشـــحات الرملية

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تم دراسة امكانية استخدام طرق معالجة مختلفة فى تنقية مياة الغسيل العكسى للمرشح. تم اختيار أربع عمليات للاختبار والتقييم: مزج مياه الغسيل العكسي مع المياه الخام، عملية الترويب، عملية الترسيب واخيرًا اختبار الترشيح الرملى بعد عملية الترسيب. اظهرت النتائج كفاءة عملية الترويب عند استخدام جرعة الشبة المثلى 50 ملجم/لتر، وكفاءة عملية مزج مياة الغسيل العكسى مع الماء الخام بنسبة مزج مثالية 90%، وعملية الترسيب عند الوقت الأمثل 120 دقيقة، وكفاءة معالجة الترشيح الرملي بعد 120 دقيقة الوقت الامثل لعملية الترسيب.اظهرت النتائج ان عملية الترويب باستخدام جرعة شبة 50 ملجم/ لتر طريقة معالجة فعالة في خفض العدد الكلي للبكتريا بنسبة 55% على العكس كانت عملية المزج وطريقة الترسيب أقل كفاءة في تقليل العدد الإجمالي للبكتريا حيث كان التخفيض 18% فقط.كان مزج مياة الغسيل العكسى مع الماء الخام هو الطريقة الأكثر فعالية لمعالجة المعادن الثقيلة حيث انخفض تركيز الألومنيوم بنسبة 95 % وانخفض تركيز الحديد بنسبة 95%. بينما الترشيح الرملي يؤثر على إزالة المعادن الثقيلة بشكل غير محسوس حيث انخفض تركيز الألومنيوم بنسبة 4% وانخفض تركيز الحديد بنسبة 9%. وبخلاف ذلك تم زيادة تركيز الألمنيوم والحديد في عملية الترويب بنسبة 42% و4% على التوالى عند الجرعة المثلى لعملية الترويب . أثرت عملية الترسيب على تقليل العكارة بنسبة 89% وأدت إلى تحسين كفاءة معالجة الترشيح الرملي فى إزالة العكارة حيث كانت أعلى نسبة خفض للعكارة 95%. كانت طرق معالجة مياة الغسيل العكسى بنفس الكفاءة فى خفض الطحالب والتي بلغت حوالي 80% فيما عدا عملية الترسيب كانت 27%.كما اوضحت الدراسة امكانية إضافة مياة الغسيل العكسى إلى المياه العذبة الخام ككمية إضافية إلى مدخل محطة معالجة المياه .كذلك يمكن استخدام تكنولوجيا الترشيح الغشائي لمعالجة مياة الغسيل العكسى وذلك بعد معالجتها مبدأيا باستخدام عملية الترسيب المقترنة بالترشيح الرملي ويمكن إعادة مياة الغسيل العكسى بعد معالجتها إلى المجرى الرئيسي دون أي خطر للتلوث أو استخدامها في عملية الغسيل العكسي بدلاً من مياه الشرب.

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