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Innovative System for Recycling of Backwashing Water in Drinking Water Plant

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THE PRESENT study focuses on the efficiency of a suggested innovative system for the treatment of the sand filter backwashing water (SFBW) in the Drinking water treatment plant (DWTP). Usually, the DWTP is consumes between 15 to 20% of their clean treated drinking water to backwashing their sand filter. Such sand filter backwashing water (SFBW) is, usually, discharged as waste. Presently, the suggested innovative system as pilot plant (PP) was employed for the treatment of SFBW. Physical and chemical characteristics of the raw Canal fresh water and the treated drinking water were extensively determined via sampling program. Meanwhile, the inlet SFBW and the treated outlet of the suggested PP were also sampled and subjected to the physical and chemical analysis. The settled particles as sludge of the PP were sand filtered. The filtered water was also evaluated in terms of the physical and chemical characteristics.

The suggested PP was operated continuously where it proved efficient removal of TSS, turbidity, and aluminum at 74.1, 84.2 and 71.4%, respectively. Removal of total residue, and alkalinity reached 30.1 and 29.1%, successively. The residual Al^{3+} was 3.0 mg/l. Correlation between the physical and chemical characteristics of Canal water in one hand and the treated SFBW and the filtered water of the sludge on the other hand indicated that both later waters were at better quality than the former. Therefore, it was suggested to reuse this treated effluents as an additional fresh water resource to the DWTP. The advantages are: saving this wasted water, save the intial supply of water to the DWTP, and to decrease the amount of added alum to the water treatment system while protecting the Canal water from the dischrge of the SFBW that contained residual of Al^{3+}.

Keywords: Backwashing water, Chemical and physical treatment, Drinking water treatment plants, Drinking water treatment, Innovative water treatment system, Sand filter, Water reuse.

Introduction

Fresh water is a scarce resource in certain parts of the world and; thus; for some parts of population [1]. Generally, water consumption in developed countries is about 10 times more than those in developing countries as water daily use [2].

Worldwide, clean water is one of the top key challenges of the 21st century. Over consumption of water is a serious threat to the sustainable use of water resources and its ecosystems services. Uses of water include drinking, household, domestic, municipal, agricultural, industrial, recreational and other environmental activities [3].

Fresh water is a renewable resource, yet the world's supply per capita is steadily decreasing due to the continuous increase of world population, with most prominently in Middle East & North Africa (MENA), Asia, and South America [1]. Although it is still unclear how far the natural ecosystems are threatened [3]. In this respect, the framework for allocating water resources to water users (where such a framework exists) is known as national and international water rights [4].

In this respect, Nile River is the main source

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of water to Egypt and Sudan [5, 6]. Rainfall in Egypt is minimal at 18 mm per year as storm water; occurring mainly during autumn and winter time [5]. The Nile waters treaty in 1959 between Egypt and Sudan allocates 55.5 billion m^3 /yr of water to Egypt, and 18.5 billion m^3/yr to Sudan [6]. Additional water resource in Egypt is mostly fossil groundwater [3].

The main groundwater aquifers in Egypt are the Nubian Sandstone Aquifer, Nile Aquifer, Moghra Aquifer (between the West of the Nile Delta and the Qattara Depression), and coastal aquifers on the North-Western coast [3]. The Moghra Aquifer, the Nile Aquifer, and the Coastal Aquifer are renewable. The Nubian Sandstone Aquifer System contains 150,000 billion m^3 of freshwater. It is almost equivalent to 3,000 times the annual flow of the Nile. It is a non-renewable water resource shared with Sudan, Chad and Libya [3, 6]. Egypt's non-conventional water resources include treated agriculture drainage water, wastewater (municipal and industrial), salt water desalination, and brackish water desalination [3, 4, 6, 7].

In Egypt, fresh waters are treated via Drinking Water Treatment Plants (DWTP) to provide clean drinking waters almost all over the country via adequate conventional treatment of Nile water and its branches in most cases [8]. In these DWTP's the convention treatment system; generally; includes chemical coagulation using alum, followed by flocculation, sedimentation, disinfection, and finally filtration through sand filters [9]. The used alum in DWTP is high quality Egyptian made that gives great efficiency of treatment, practically suspended solids, turbidity, some dissolved solids as well as great amount of micro-algae. The sand filters are regularly backwashed with the final treated water several times per day [10]. The backwashing waters are generally discharged back to the river as wasted water or discharged as wastewater to the environment. As a result, the amounts of produced drinking waters are wasted and drained that estimated about 20% of the total produced clean waters [10]. Meanwhile, the treated drinking water should be coped with the international guidelines [11, 12].

Due to the limited water resources in many countries including Egypt [13, 14, 15], it is important to consider this huge amount of wasted water as a valuable source. If it is treated, it can be reused for other purposes such as irrigating lumber trees or gardening landscape around the DWTP. However, it is preferred to conceder such amount of water as additional source of water [14, 15].

The present case study deals with a selected drinking water treatment plant (DWTP) that supplies water to several areas around it including villages and small towns. The employed process for the treatment of fresh water in this DWTP is the common system used in local as well as the international DWTP. This DWTP receive raw fresh water from the Nile River. The quantity and quality of the treated drinking water is important to the consumers in terms of hygienic point of view and suitability for drinking that should cope with the Egyptian regulations (EEAA, 2000) [16, 17]. The present study is to introduce an innovative design of a pilot plant (P.P.) that is constructed for the purpose of treating sand filer backwashing water (SFBW). The purpose is to remove the suspended solids and the sludge from the backwashing water and to separate the sludge as dried materials and to obtain a final treated fresh water. Efficiency of the PP and the treated SFBW water were evaluated as an additional water resource along with the raw fresh water inlet to drinking water treatment plant. This study was implemented and carried out practically in one of the drinking water treatment plant in Egypt using real samples.

Material and Methods

Chemicals

In the DWTP chlorine gas is usually added as pre-treatment and also as post chlorination before distribution system. The added amount ranged between 3 to 5 mg/l.

Alum as aluminum sulfate $[Al_2(SO_4)_3.18 H_2O]$ as coagulant followed by flocculation in the DWTP. The used Alum is Egyptian made.

Drinking water treatment plant (DWTP)

The schematic diagram of the sequence treatment steps of this pilot plant is illustrated in Fig. 1.

The amount of the inlet fresh water to the plant is 73, 440 m^3/d. The inlet water is pumped to the plant and subjected to two settling tanks. The settled water is to be injected by both chlorine water as pre-chlorination and liquid alum at the dose of 6.8 g/m^3 of chlorine and 50 g/

m^3 of alum. The alum as coagulant is to be mixed and allowed to form flucculants. Water is allowed to be clarified in 6 clarifiers for 3 hr settling time. The settled water is then filtered using 14 sand filters. The flow rate of the sand filter is 220 l/sec. The final treated drinking water is further injected with chlorine at 2.0 to 2.5 mg Cl_2/l as post-chlorination.

The aluminum level in this final treated drinking water should not exceeding 0.2 mg/l according to the Egyptian regulations (EEAA, 2000) [16, 17]. This final post chlorinated water are to be stored in four storage tanks at the capacity of 5000 m^3 each. The amount of the final treated drinking water is enough to cover the consumers need of the areas arround the DWTP.

The water is further injected with chlorine in the way to the distribution system to insure the presence of 0.2 mg/l chlorine for the hygienist of this drinking water.

Chlorine is important as one of the most commonly used disinfectants for wastewater and water disinfection. It can be easily applied for deactivation of most microorganisms. And it is relatively more economical than any other disinfectant agents. Chlorine, as a strong oxidizing agent, kills microorganisms via oxidation of organic molecules [19]. Chlorine and hydrolysis product hypochlorous acid is neutrally charged and therefore easily penetrate the negatively charged surface of pathogens. It is able to disintegrate the lipids that compose the cell wall and react with intracellular enzymes and proteins, to convert them nonfunctional. As a result, microorganisms either die or are no longer able to multiply [19].

When chlorine, dissolved in water, it rabidly converts to an equilibrium mixture of chlorine, hypochlorous acid (HOCl), and hydrochloric acid (HCl):

$$Cl_2 + H_2O \rightleftharpoons HOCl + HCl$$

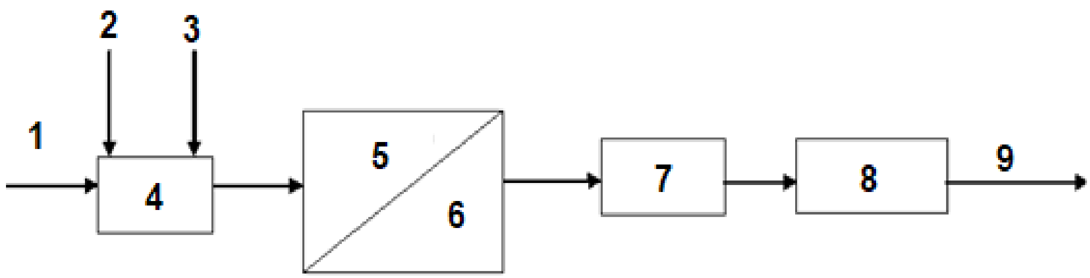
In acidic solution, the major species are Cl_2 and HOCl, whereas in alkaline solution, effectively only ClO^- (hypochlorite ion) is present. Very small concentrations of ClO_2^-, ClO_3^-, ClO_4^- are also found.

By adding Alum (Aluminum Sulfate $Al_2(SO_4)_3$) to raw water it reacts with the water alkalinities as bicarbonate to forms a gelatinous precipitate. This floc attracts other fine particles and suspended material in raw water, and settles down at the bottom of the container. Alum is usually the best choice as coagulant for drinking water treatment plant due to its effectiveness for clarification, high efficiency, and its utilization as a sludge dewatering agent [20].

The 14 sand filters of this plant are to be backwashed with the treated drinking water at the rate ranging between 11,016 to 14,688 m^3/day (i.e. 15 to 20% of the treated produced drinking water). The process of "water treatment and distribution" is as follows: canal water, chlorine, alum, mixing, flocculation, sedimentation, sand filter, storage tank, and distribution system (Fig. 1).

Construction of the pilot plant for treatment of backwashing water

A schematic diagram of the pilot plant is given in Fig. 2. SFBW was pumped continuously to the pilot plant, where the intake was from the storing tanks of the backwashing water. This PP was designed in an order that the inlet will be allowed to settle down all the particles and suspended solids through 3 successive settling tanks by gravity. The settled particles and suspended solids are collected from the bottom and directed to a sand filter as shown in Fig. 2.



(1) Canal water, (2) Chlorine, (3) Alum, (4) Mixing, (5) Flocculation, (6) Sedimentation, (7) Sand filter, (8) Storage tank, (9) Distribution system.

Fig. 1. Illustration of the treatment steps of the studied Drinking Water Treatment Plant.

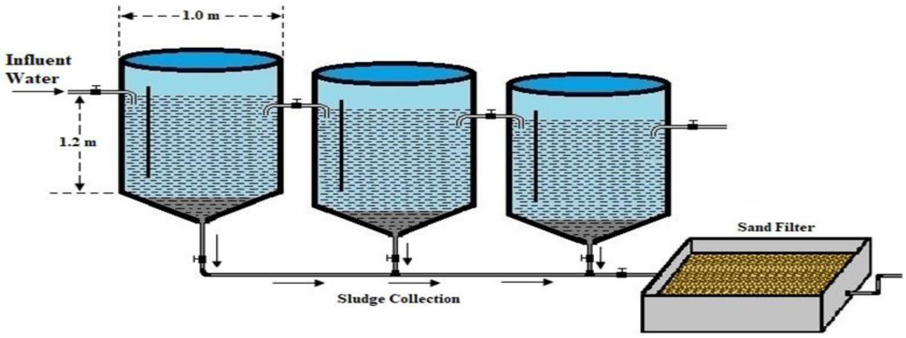


Fig. 2. Schematic diagram of the pilot plant for the removal of the suspended solids from the sand filter backwashing water.

Sampling program was implemented to collect the following water samples: raw Canal fresh water, raw SFBW, treated water from each of the 3 settling PP system, the formed sludge, and the final sludge filtrate. Outdoors, temperature is subjected to the seasonal variation between summer, autumn, winter and spring, namely between 8 and 40 °C from winter to summer during the day time.

The precipitated sludge of the constructed pilot plant was filtered through a constructed sand filter (Fig. 2).

Connecting the pilot plant with the DWTP

The PP final treated water was stored and thus pumped back to DWTP as an additional clean water to the plant. Samples of the this treatment system were taken to follow-up the operation of this system. The constructed PP is shown in Fig. 3.

Fig. 3. The constructed pilot plant for the recycling of the sand filter "backwashing" water.

Physical and chemical charactristics of water

Samples of the raw Canal water, final treated drinking waters as well as the backwashing water were colleced on weekly basis for the determination of the physical and chemcial characteristics. In addition, water samples from the PP innovative treatment system,namely: the inlet, outlet of each step and the final treated water were also collected on weekly basis. The physical, chemical, characteristics and biological contamination (including Nimatoda and E.Coli) of each sample were determined according to the procedures described by APHA (2012) [18]. Level of aluminum residues were also determined in the same samples using Atomic Absorption Sepectroscopy (Agilent 240 Fast Sequential Atomic Absorption). pH was measured using bench top pH meter (Jenway 3510). Conductivity and TDS were measured using bench top conductivity meter (Jenway 4510). Turbidity meter (Hach 2100Q Portable) was used to measure turbidity.

Results

Physical and chemical properties of raw and treated canal water

Physical, chemical and biological characteristics of the raw canal water as inlet and the treated drinking water as outlet water of the studied DWTP were studied extensively for a period of 6 months. Results are given in Table 1. This table showed that the level of turbidity and TDS decreased from 30 to 0.5 (NTU), and from 388 to 298 mg/l respectively. Other parameters namely alkalinity, chloride, sodium, potassium, and calcium decreased also from 141, 39, 29, 6.75, 32 mg/l to 128, 28, 22, 5.05, and 29 mg/l respectively. On the contrary, the aluminum in the canal water was 0.03 mg/l, it icreased to 0.31 mg/l as a result of using alum in the treatment process.

The overall results (Table 1) indicate that the DWTP is effecient for the treatment of the raw fresh water and the treated drinking water could successfully cope with the WHO, USEPA, and Egyptian Regulatian EEAA (2000) [16,17] (Table

2). Thus, it can be concluded that this DWTP is effecient for producing drinking water with highly acceptable quality.

Physical and chemical properties of raw backwashing water and sedimentation

Table 3 presents physical and chemical characteristics of backwashing water. It is turbid at 107 NTU. It also contains considerable levels of TSS, total solid residues, and alkalinity, namely 204, 345, and 127 mg/l respectively. By comparing these characteristics with the raw canal water (Table 1) it can be noticed that the level of E.C., TDS, turbidity, and alkalinity of the backwashing water is lower than the corresponding parameters of the raw canal water (Table 3). Only two parameters in the backwashing water namely aluminum and TSS; are noticeable higher than their corresponding parameters in the raw canal water (Fig. 3 and 4). The other parameters in both types of water are almost within the same levels (Tables 1 and 3).

Physical and chemical properties of treated backwashing water

Sampling program was designed to collect the backwashing water befor and after treatment through the continuous operation of the implemented PP on a daily basis. Results are given in Table 3. The obtained results indicate that the PP system could efficiently reduce the TSS, turbidity, and aluminum by 74.1, 84.2, and 71.4%, respectively. Removal of total residue and alkalinity reched 30.1 and 29.1%, respectively (Table 3). The treated water can, then, be used as an additional source of raw fresh water and/or for irrigation.

TABLE 1. Physical, chemical and bacteriological characteristics of raw fresh Canal water and the treated drinking water of Drinking Water Treatment Plant.

Parameter	Raw Fresh Ismaila Canal Water			Treated Drinking Water		
	Max.	Min.	Avg.	Max.	Min.	Avg.
pH	8.5	7.6	8.05	7.6	7.5	7.55
Color (TCU)	9	5	7	----	-----	------
Taste and Odor	---	----	-----	Acceptable	Acceptable	Acceptable
EC (µS)	622	512	567	542	498	520
TDS (mg/l)	410	365	388	310	285	298
Turbidity (NTU)	35	25	30	0.9	0.3	0.5
TSS (mg/l)	186	132	165	Nil	Nil	Nil
Total solids residue (mg/l)	621	439	573	Nil	Nil	Nil
Alkalinity (mg/l) as $CaCO_3$	156	125	141	130	125	128
Chloride (mg/l)	42	36	39	30	25	28
Sodium (mg/l)	36	22	29	27	16	22
Potassium (mg/l)	7.5	6	6.75	5.6	4.5	5.05
Calcium (mg/l)	35	29	32	31	27	29
Aluminum (mg/l)	0.05	0.01	0.03	0.35	0.24	0.31
Magnesium (mg/l)	25	21	23	21	19	20
Iron (mg/l)	1.5	0.15	0.09	0.9	0.05	0.07
Nitrate (mg/l)	24	14	16	20	12	14
Nitrite (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil
Sulfate (mg/l) as SO_4	32	26	27	25	20	21
Total Hardness (mg/l) as $CaCO_3$	263	233	243	250	223	230
Number of cells or eggs of Nimatoda (Count/l)	ND	ND	ND	ND	ND	ND
E. coli count (100/m1)	ND	ND	ND	ND	ND	ND

EC = Electrical Conductivity, TDS = Total Dissolved Solids
TSS = Total Suspended Solids, ND= Not detected
NTU= National turbidity unit TCU= true color unit

TABLE 2. Drinking water guidelines according to the Egyptian regulation* as well as the World Health Organization (WHO) and the US-Environmental Protection Agency (USEPA).

	Parameter		Unit	Guidelines		
				Egypt	WHO	USEPA
	Physical examination					
1	Turbidity		NTU	1	1	-------
2	Electrical Conductivity		µS	2000	1700	800
3	pH		------	6.5 - 9.2	---	6.5 - 8.5
4	Color		TCU	20-30	15	15
5	Taste and Odor		-----	Acceptable	Acceptable	3 TON
	Chemical examination					
6	Aluminum	as Al^{3+}	mg/l	0.2	0.2	0.05 - 0.2
7	Iron	as Fe (total)	mg/l	0.3	0.3	0.3
8	Nitrate	as NO_3^-	mg/l	44	50	45
9	Nitrite	as NO_2^-	mg/l	0.016	3	3.3
10	Phosphate	as PO_4^{3-}	mg/l	--------	--------	-------
11	Potassium	as K^+	mg/l	--------	--------	--------
12	Magnesium	as Mg^{2+}	mg/l	150	--------	--------
13	Manganese	as Mn^{2+}	mg/l	0.1	0.5	0.05
14	Sodium	as Na^+	mg/l	200	200	
15	Sulfate	as SO_4^-	mg/l	400	250	250
16	Total Alkalinity	as $CaCO_3$	mg/l	-------	--------	-------
17	Total Dissolved Solids	at 105°C	mg/l	1200	1000	500
18	Total Hardness	as $CaCO_3$	mg/l	500	--- ---	-------
19	Chloride	as Cl^-	mg/l	250	------	-------

* EEAA - Egyptian Environmental Association Affair, Law 4, Law of the Environmental Protection (1994)-updating No.(44), (2000); and EEAA - Egyptian Environmental Association Affair, Law 48, No. 61-63, Permissible values for wastes in River Nile (1982) and Law 4, Law of the Environmental Protection (1994)-updating No.(44), (2000) (Government of Egypt, Cabinet of Minister's (1997) Egypt and 21st Century. AUC Library, Cairo).

It is worth to mention that this backwashing waters are; daily; disposed to the closest desert as a routine practice. Thus, the disposed water forms huge shalow swamp with mosquitos and flies. The leackage of such water penetrates beneath the DWTP buildings. This certainly is certainly threatening these buildings.

This disposed water is, thus, a waste of good quality of drinking water, forms unhealthy swamps, and threatens the plant buildings. Therefore, it was important to treat such disposed water for the purpose of reuse in irrigating the surounding landscape, planting woody trees or to be returned back along with the raw fresh water. The later has an important benificial objective, that is, an addition water resources. Besides, it contains reasonable amount of alum that could save the consumption of this coagulant during the treatment of raw fresh water.

Discussion

The sand filter backwashing water (SFBW) of the DWTP consumes about 20% of the produced drinking water, where it is discharged to the environment as a waste. The present study was conducted to investigate the effeciency of the suggested pilot plant (Fig. 3) as new design for the treatment of the SFBW for the purpose of recycling. The physical and chemical characteristics of SFBW before and after treatment were evaluated (Table 3). The results proved that the suggested pilot plant was effecient in the treatment of SFBW with an effecient removal of 79, 87, 30.1, 29.1, and 71.4% for TSS, turbidity, total solids residues, alkalinity, and Aluminum, respectively.

TABLE 3. The physical and chemical characteristics of the "raw backwashing water" and the three successive sedimentation tanks.

Parameter	Raw (Backwashing)			Stage (1) Sedimentation			Stage (2) Sedimentation			Stage (3) Sedimentation			Overall % removal
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	
pH	8.0	7.48	7.74	8.0	7.32	7.66	8.2	7.27	7.7	8.2	7.48	7.84	-----
EC (µS)	398	355	376.5	394	350	372	390	348.0	369	388	343	365.5	3
TDS (mg/l)	249	223	236	247	212	229.5	242	210	226	242	202	222	6
TSS (mg/l)	249	160	204.5	157.5	110	127	110	85	87.5	60.5	45.6	43.05	79.0
Turbidity (NTU)	125	90	107.5	85	45	65	52	12	32	30	4	14	87.0
Total solids residue (mg/l)	360	330	345	324	294	309	296	266	281	256	226	241	30.1
Alkalinity (mg $CaCO_3$/l)	114	140	127	124	59	91.5	130	51	90.5	130	50	90	29.1
Chlorides (mg/l)	42.7	45	43.8	48	41.8	44.9	50	41.7	45.8	40.7	49	44.8	-----
Sodium (mg/l)	63.8	5.9	34..8	63.5	5.8	34.6	63.3	6.2	34.7	63	6.1	34.5	-----
Potassium (mg/l)	6.0	5	5.5	5.8	4.7	5.25	6.1	4.5	5.3	6.3	4.3	5.3	------
Calcium (mg/l)	59.6	29	44.3	52.7	33.2	43	52.3	33.1	42.7	51.5	32	41.7	------
Aluminum (mg/l)	15	6	10.5	13	4	8.5	8	3	5.5	5	1	3.0	71.4

Max. = maximum, Min. = minimum, Avg. = average value EC= Electrical Conductivity, TDS = Total Dissolved Solids, TSS = Total Suspended Solids

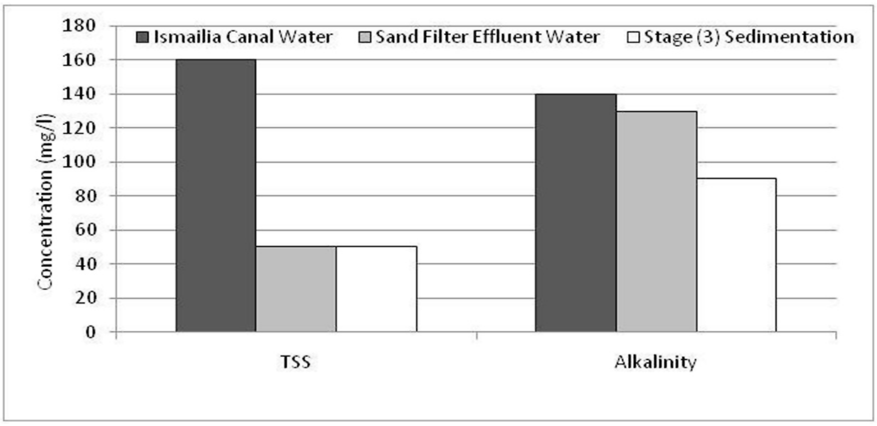


Fig. 4. Correlation between the level of TSS, and alkalinity in raw Canal fresh water, the treated Sand filtered water, and treated backwashing water (as mg/l).

It is worth mentioning that our plan was reuse this treated water for irrigating non-edible plants or lumber trees. But, the monitoring results showed that level aluminium in the treated effluent is between 1.0 to 5.0 Aluminum with an average of 3.0 mg/l Aluminum (Table 3). Such water may harm the plant if this water going to be used for irrigation. Thus, it is not recommended to be used for irrigation. Rather, it is prefered to be recycled again as an additional source along with raw fresh water to the DWTP. The advantages are: saving this wasted water, decrease the intial supply of water to the DWTP, and to decrease the amount of added alum to the water treatment system.

İn the designed pilot plant, the precipitated suspended solids was drained to sand filter system to separate the sludge from water (Fig. 3). Meanwhile, the sludge was collected and oven dried. Further study will be carried out on the reuse of this sludge. On the other hand, the filtered water was characterized by slightly high level of turbidity, TSS, total solid residue, and Aluminum, namely 10.6 NTU, 53.5 mg/l, 225 mg/l, and 0.6 mg/l respectively (Table 4). This water was discharged back again to the collection tanks of the backwashing water.

TABLE 4. The physical and chemical characteristics of the settled particles in the treatment system before and after sand filtration (in El-Tawteen drinking water treatment plant, Sinai).

Parameter	Sludge Inlet to sand filter			Water filtered from the sludge (Outlet water from the sand filter)		
	Max	Min.	Avg.	Max.	Min.	Avg.
pH	8.4	7.7	8.05	7.9	7.66	7.8
EC (μS)	450	356	403	413	366	389.5
TDS (mg/l)	294	254	274	248	220	234
TSS (mg/l)	400	350	375	57	50	**53.5**
Turbidity (NTU)	200	160	180	13.1	8	**10.6**
Total solids residue (mg/l)	250	200	255	235	215	225
Alkalinity (mg $CaCO_3$/l)	144	135	139.5	136	122	129
Chlorides (mg/l)	46.7	30	38.4	40.5	32.4	36.5
Sodium (mg/l)	65.7	7.9	36.8	63	6.9	35
Potassium (mg/l)	6.7	4.4	5.6	6.3	3.8	5.05
Calcium (mg/l)	38.4	30.8	34.6	35.4	27.5	31.5
Aluminum (mg/l)	3	2.1	2.55	0.8	0.4	0.6

EC = Electrical Conductivity, TDS = Total Dissolved Solids,
TSS = Total Suspended Solids

The results sludge filtration effeluent are given in Table 4. İt can be noticed that this filtered water is characterized by lower levels than the raw canal water with respect to turbidity (10.6 NTU), E.C. (389.5 µS), TSS (35.5 mg/l), and TDS (234 mg/l) against 30 NTU for turbidity, 567 µS for E.C., 165 for TSS, and 388 mg/l for TDS, respectively for Canal water (Tables 1 and 4). The rest of the parameters are within almost the same range of the raw Canal water with the exception of relatively higher contents of aluminum (0.6 mg/l) against 0.03 mg/l for the Canal raw water.

The comparison between raw canal water, treated backwashing water, and water filtered from the sludge (Outlet water from the sand filter) in terms of chemical and physical properties are given in Table 5. By correlationg this treated SFBW and water filtered from the sludge (Outlet water from the sand filter) on one hand with raw canal water on the other hand, (Table 5), it can be seen that the former treated water are in better quality than the raw Canal water in terms of physical and chemical characteristics (Fig. 4 and 5).

TABLE 5. Comparison between the physical and chemical characteristics of raw canal water, treated backwashing water, and water filtered from the sludge as average values

Parameter	Raw canal water	Treated SFBW	Water filtered from the sludge (Outlet water from the sand filter)
pH	8.05	7.84	7.8
EC (µS)	567	365.5	389.5
TDS (mg/l)	388	222	234
TSS (mg/l)	165	43.05	53.5
Turbidity (NTU)	30	14	10.6
Total solids residue (mg/l)	573	211	225
Alkalinity (mg $CaCO_3$/l)	141	90	129
Chlorides (mg/l)	39	34.8	36.5
Sodium (mg/l)	29	34.5	35
Potassium (mg/l)	6.75	5.3	5.05
Calcium (mg/l)	32	31.7	31.5
Aluminum (mg/l)	0.31	3.0	0.6

EC = Electrical Conductivity, TDS = Total Dissolved Solids,
TSS = Total Suspended Solids

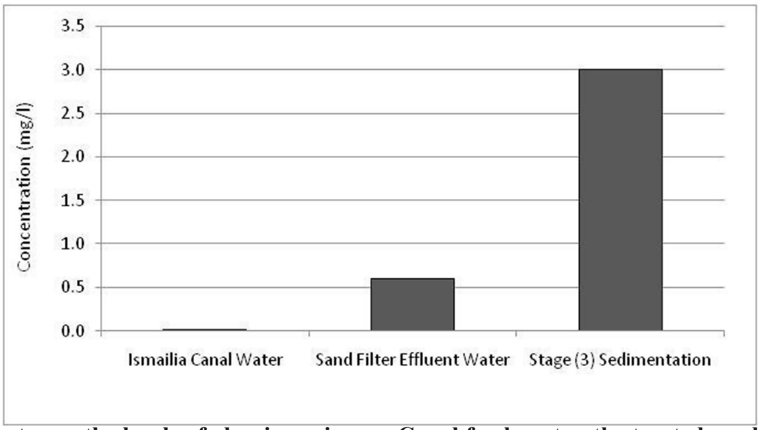


Fig. 5. Correlation between the levels of aluminum in raw Canal fresh water, the treated sand filtered water, and treated backwashing water (as mg/l).

Conclusions

Generally, drinking water treatment plants consume between 15 to 20 % of their produced clean water for backwashing their sand filters. The disposal of such sand filter backwashing water (SFBW) is a troublesome.

The suggested pilot plant (PP) could efficiently treat this SFBW, where the treated water was at higher quality than the raw Canal water in terms of physical and chemical characteristics.

It was then concluded that the SFBW should not be wasted; it should be saved in this vital area that is striving for water resources. Therefore, it is strongly recommended that the treated effluent should be added to the raw fresh water as an additional quantity to the inlet of the DWTP. The advantages are saving this wasted water, protect the environment, saving part of the intial inlet of water supply of water to the DWTP, and to decrease the amount of added alum as coagulant to the water treatment system in the DWTP .

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معالجة كيميائيه فيزيائيه مبتكره لمياه غسيل المرشحات الرملية لاعادة استخدامها فى محطات مياه الشرب

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تركز هذه الدراسة على تعيين كفاءة النظام المبتكر الكيميائي لمعالجة مياه الغسيل العكسي لمرشح الرمال (SFBW) في محطة معالجة مياه الشرب (DWTP). عادةً، يستخدم فى DWTP ما بين 15 إلى 20٪ من مياه الشرب النظيفة لغسل مرشح الرمل. عادة ما يتم تصريف النفايات السائلة الناتجة عن SFBW كنفايات. في الوقت الحاضر، تم استخدام محطة تجريبية مقترحة (PP) لعلاج SFBW. تم تحديد الخصائص الفيزيائية والكيميائية للمياه العذبة في القناة الخام ومياه الشرب المعالجة من خلال برنامج واسع النطاق لأخذ العينات. وفي الوقت نفسه، تم أخذ عينات من مدخل SFBW والمخرج المعالج للـ PP المقترح، وتم إخضاعهما للتحليل الفيزيائي والكيميائي. تم ترشيح الجسيمات المترسبه مثل حمأة PP. تم تحديد أيضًا الخصائص الفيزيائية والكيميائية للماء المرشح من تلك الحماه.

تم تشغيل PP المقترح بشكل مستمر حيث أثبتت كفاءة إزالة TSS، التعكر، والألمنيوم عند 74.1، 84.2 و71.4 ٪ على التوالي. بلغت إزالة البقايا الكلية والقلوية 30.1 و29.1٪ على التوالي. كان Al^{3+} 3.0 ملغ / لتر. وفي الوقت نفسه، تم الحصول على ترشيح للحمأة، الجسيمات المترسبه من PP، واثبتت نتائج التحليل لتلك المياه المرشحه أن خصائصها الفيزيائية والكيميائية ملائمه. أوضحت العلاقة بين الخصائص الفيزيائية والكيميائية لمياه القناة في جهة و SFBW المعالجة من ناحية أخرى أن الأخير كان في نوعية أفضل من السابق.

لذلك، اقترح إعادة استخدام هذه النفايات السائلة المعالجة كمورد إضافي للمياه العذبة، حيث يتم اضافتها إلى DWTP. ثم تم استنتاج أنه لا ينبغي إهدار SFBW، بل يجب معالجتها وإعادة استخدامها في هذا المجال الحيوي الذي يسعى للحصول على موارد المياه. المزايا هي: توفير هذه المياه المهدورة، وحمايه البيئه، وتوفير الإمداد الأولى بالمياه إلى DWTP، وتقليل كمية الشبه المضافة إلى نظام معالجة المياه.