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Evaluation and comparison of water treatment plants efficiency and clarifiers performance in removing pollutants in water treatment plants of Tehran, Iran

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ABSTRACT

Water treatment is performed using some conventional processes including coagulation, flocculation, sedimentation (clarification), and filtration. Due to the importance of clarification unit in potable water treatment, extensive studies on its advantages and disadvantages elucidate new horizons for evaluation of Accelerator and Pulsator. In this study, four water treatment plants in Tehran were compared with each other in terms of physical and chemical analysis, effluent water from clarifier unit, and effluent of treated water during 6 months from June to October 2012. Results showed the average turbidity in all plants is below standard except the plant No. 5. The total organic carbon (TOC) removal efficiency was undesirable in the both clarification systems (Accelator and Pulsator). On the other hand, TOC removal in Pulsator unit was monitored 40% more than that in Accelator unit. The TDS level was increased during the time period; however, the level lied down standard level. Pulsator is more efficient than Accelator in iron removal. The level of effluent iron in Accelator is more than that in Pulsator referring to iron escape from Accelator. Effluent iron in both systems is lower than the standard values. According to the consumption of chemical coagulants and coagulant aids, Accelator system consumes more than that of Pulsator system thus adding to the overall associated costs of the system. Effluent water in pulsator systems offer better quality than Accelator systems. Moreover, Pulsator system showed better resistance against qualitative and quantitative shocks on raw water.

Keywords: Water treatment; Clarification; Accelator; Pulsator; Turbidity; TDS; TOC; Iron; SI

1. Introduction

Water treatment is performed in water treatment plants (WTPs) using some conventional procedures including screening, controlling iron, manganese, taste and color, clarifying, filtration, disinfection, chemical quality modification such as hardness removal, desalination, fluoride injection, and stabilization [1]. Clarification unit is the most important stage in which colloidal particles are removed from water. This unit includes coagulation, flocculation, and sedimentation processes. Suspended solids can be removed in settling ponds with appropriate retention time; however,

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the colloids with diameters in the range of nanometer cannot be settled and therefore be removed from water. Coagulation process can be performed in less than a second in case of producing suitable conditions for important factors. The main determinants affecting this process are pH, alkalinity, temperature, the type and amount of coagulant and coagulant aid, and mixing energy [2]. Determining the optimum coagulant dose necessitates the performance of jar tests. Materials and equipment's application in clarification is inevitable to achieve acceptable efficiency. These affective factors include correct added chemical dose (coagulant, coagulant aid, and pH adjustment), appropriate point of injection in system, and speed of water mixing [3].

Among different types of clarifiers, Accelator and Pulsators have more applications than others in Iran. In these clarifiers, three processes coagulation, flocculation, and sedimentation are performed in one space. Accelator clarifier is one of the first successful clarifiers designed about half a century ago and was the most advanced clarifier of its time [4]. On account of some advantages resulting in relatively acceptable efficiency, this system is still adopted today. In this system, there is no need to have sludge remover, electro pump returning sludge from settling area to initial flocculation, and also flash mixing step [5]. Despite the difficult operation, maintenance, and frequent adjustment requirement, this clarifier can be operated effectively and produce water with desirable quality [6].

Pulsator is an up-flow-type clarifier having more application relative to Accelator in Iran. In this clarifier, the chemicals consumption and the required time to generate larger flocks will decline. Due to the sludge blanket existence, effluent water has better quality while showing good resistance against qualitative and quantitative shocks as well as short-term power outage. Consequently, it would be possible to have simple and reliable operation [7]. Most of the researches have been carried out by Degremont Company of France for the purpose of improving their performance. In this context, new systems of these clarifiers such as Super Pulsators, Pulsatubes, and Ultrapulsators with much higher surface load have been presented.

Kan and Huang in 1998 studied the possibility of optical monitoring methods for determining the coagulant dose and coagulation performance in treatment plants. The coagulant dose is determined according to jar test results or operator experience which in most cases leads to excessive coagulant injection. Optical monitoring showed that flocks size and their settling velocity are effective determinants. As a consequence, optical indicator is a useful tool in coagulation monitoring in WTPs [8]. Because of treatment difficulty in raining situations, Hurst et al. in 2004 investigated turbidity removal in water treatment process in England. Samples from raw water showed natural organic materials (NOM) augmentation after heavy raining. Based on the reported results, NOM increase disturbs coagulation leading to turbidity augmentation [9]. Leiknes et al. in 2004 studied the possibility of using inorganic micro metal filtration membranes with submerged membrane structure and pre-coagulation for producing potable water. The results indicated that the treatment using this method has more efficiency by offering 95% color removal, 65–75% total organic carbon (TOC) removal, turbidity less than 0.2 NTU, and total removal of suspended solids [10]. In 2009, Abbasi studied the treatment plants conditions in terms of consumed water quality. The results indicated using Accelator and Pulsator systems are more logical in high flows, while for low and average flows all of the systems can be applied [11]. Makungo et al. in 2011 evaluated the performance of small WTPs. The case study was Mutshedzi treatment plant. They showed that water with good quality is not produced from this treatment plant despite the efforts to comply with standard levels. Results showed that this WTP requires minor modification to increase the confidence toward achieving the efficiency of 100% in future [12]. In 2012, Zhang et al. presented an innovation framework to evaluate old and traditional WTPs performance by integration of reliable concepts for quantitative microbial risks assessment. WTP performance evaluation included three units; unit 1: Coagulation/flocculation and settling, unit 2: Filtration, and unit 3: Disinfection. The results from this study can assure the operators that multiple impediments in different conditions can be eliminated successfully [13].

This study focuses on comparing the efficiency of clarification unit in treatment plants No. 1 (Jalalieh), 3 and 4 (Tehranpars), and 5 (Sohanak) together from June to November 2012. As a matter of course, a comprehensive assessment of current condition in the WTPs is achieved leading to improved removal procedure of some factors such as turbidity, TDS, TOC, and iron. Efficiency, advantages, disadvantages, and optimal conditions of using clarifiers can be attained thus, contributing to scientific management of WTPs.This study also aims to:

(1) determine conventional processes in order to remove some pollutants,

(2) compare efficiency of Accelator and Pulsator together in turbidity removal,
(3) Identify advantages/disadvantages of using Pulsator and Accelator clarifiers,
(4) determine the relation between chemical consumption and raw water turbidity,
(5) study the seasonal impacts on turbidity removal efficiency.

2. Case study

Jalalieh treatment plant is one of the oldest WTPs in Tehran and has the capacity of 7.2 cubic meters per second in which Accelator clarifier has been applied. Tehranpars treatment plant No. 1 has been operated since 46 years ago, while the plant No. 2 has been operated since 29 years ago. Their capacities are 4 cubic meters per second. The other WTP is Sohanak being operated about 10 years and has the capacity of 5.7 m^3/s. More details about WTPs are indicated in Table 1.

According to the existing data during sampling, the water treatment plants Nos. 1, 4, and 5 are operated with nominal capacity, while the treatment plant No. 3 is operated more than the nominal capacity during our study period.

3. Methodology

In order to investigate the water treatment system and having a comparison in terms of clarification unit in Tehran WTPs, first the coagulant dose was examined vs. the influent turbidity value. Moreover, sampling of turbidity, TOC, Iron, and pH was done from both influent raw water and the treated water using the international standard methods, afterward by performing calculations, the levels of TDS and SI was obtained; thereafter, the quality parameters were analyzed in EXCEL. The data collection process was done from June to November done monthly.

4. Results and discussion

4.1. Coagulation process

4.1.1. Chloride ferric consumption (CFC)

According to the chloride ferric injection data, its consumption is not corresponding with influent raw water turbidity change which is resulting from lack of attention to jar tests. Jar tests are not implemented regularly and continually since, the operators adjust the chloride ferric amount empirically from observing the generated flocks size.

Maximum CFC in Jalalieh was experienced 12 mg/L for the turbidity of 19 NTU in November and minimum CFC is averagely 8 mg/L for the turbidity of 3.5 NTU in October. Despite of 70% decrease in influent turbidity from August to September, CFC has not been changed. Furthermore, the average CFC has been increased up to 50% from October to November, while the influent turbidity has increased by 44% (Fig. 1). Tehranpars treatment plant uses less chloride ferric relative to influent turbidity compared to other treatment plants. Maximum CFC in the Tehranpars treatment plant was experienced in September. The average CFC is 4 mg/L for the turbidity of 7.59 NTU. Moreover, minimum CFC with an average of 2.5 mg/L for the turbidity of 7.02 NTU was observed in October. Although the influent turbidity of 4.02 NTU in July has augmented such up to 24.6 NTU in August (increasing 511%), CFC has been increased only 3.4% (Fig. 2). Maximum CFC in Sohanak treatment plant is in July, averagely 5.7 mg/L for the turbidity of 2.57 NTU, and its minimum consumption is in October, averagely 5.1 mg/L for the turbidity of 3.36 NTU. Although influent turbidity has increased 59%

Table 1
Characteristics of Tehran treatment plants

Treatment plant characteristic	Nominal capacity (m^3/s)	Maximum operating capacity (m^3/s)	Preliminary sedimentation pond	Clarifier pond	Coagulant	pH adjusting material	Filter
No. 1	2.7	3	No	Accelator	Chloride ferric	Lime milk	Rapid gravity sand
No. 3	4	4.5	No	Pulsator	Chloride ferric	Lime milk	Rapid gravity sand
No. 4	4	4.5	Yes	Pulsator	Chloride ferric	Lime milk	Rapid gravity sand
No. 5	7.5	9	No	Pulsator	Chloride ferric	Lime milk	Rapid gravity sand

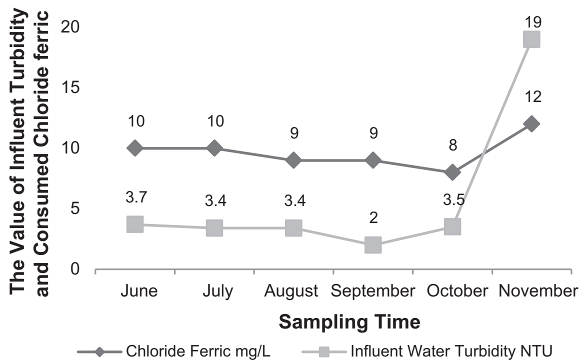

Fig. 1. The Comparison between Influent turbidity and Consumed Chloride ferric in Jalalieh treatment plant.

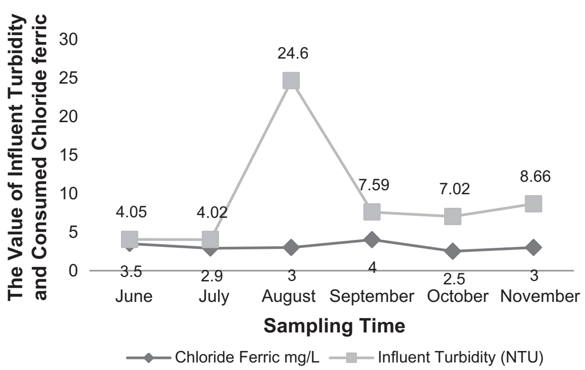

Fig. 2. The Comparison between influent turbidity and consumed chloride ferric in Tehranpars treatment plant Nos. 3 and 4.

from August to July, there is no change in chloride ferric consumption in July and August (Fig. 3).

In Accelator system with the average influent turbidity of 5.83 NTU, the average CFC is approximately 1.5 times more than that in the Pulsator system with the average turbidity of 7.37 NTU (i.e. average CFC in Pulsator is 40% of CFC in Accelator). Extensive range of CFC results in increasing iron values in Accelator effluent, thus, adding to overall associated costs of the system. In this manner, it is not recommended for Water and Wastewater Company of Tehran.

4.1.2. Lime consumption

Lime in WTPs is injected as milk of lime in order to adjust the alkalinity and achieve suitable pH in raw water coagulation process. Milk of lime injection in Accelator clarifiers is impossible in high turbidity conditions due to the fact that it may lead to lime deposition in injection pipes, mixers corrosion, and electro

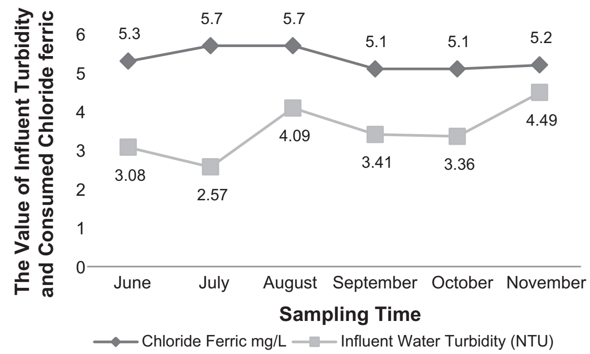

Fig. 3. The comparison between influent turbidity and consumed chloride ferric in Sohanak treatment plant.

pumps exhaustion. In normal conditions, low efficiency is observed by injecting milk of lime. Injection is performed without jar test manually and experimentally. Lime consumption in Accelator system is approximately 1.5 times as much as that in the Pulsator, and would not meet the suitable SI.[1] Besides magnafloc is used in Jalalieh treatment plant as an aid coagulant as well as lime, while it is not required in Pulsators. However, it is expensive and has probable dangers for consumer's health in non-normative application.

4.2. Turbidity removal

One of the process control indicators is effluent turbidity from different treatment stages. Average turbidity of influent water in WTPs Nos. 1, 3, 4, and 5 are 5.83, 9.32, 9.32, and 3.50 NTU, respectively. There were no serious climate changes, heavy rainfalls resulting in suspended solids and turbidity increment affecting surface water resources quality seriously. Owing to penstock conditions and suspended solids settling, low turbidity would reach to WTP. However, in three cases of heavy rainfall in Tehran, turbidity was increased after which the water was prevented from entering the WTP, and thus was overflowed. This stems from low efficiency of Accelator in accepting high turbidities indicate low resistance of this clarifier against quantitative and qualitative shocks. Although low turbidity is considered as a privilege, it would cause some difficulties during treatment process. Lack of particles in water treatment process effects on coagulation and flocculation operation by decreasing the collision and impact of the particles on each other leading to consuming more coagulant and coagulant aid. The average amount of effluent turbid-

[1]Saturation Index.

ity from the clarifiers in mentioned treatment plants are respectively 2.3, 2.44, 2.66, and 0.85 NTU. United States Environmental Protection Agency (EPA) announces that effluent turbidity from clarifiers should be less than 1 NTU, when average annual raw water turbidity is more than 10 NTU. In none of the Accelator and Pulsator units in the WTPs, except treatment plant No. 5, desirable results are achieved. The turbidity removal efficiency can be obtained from the following equation:

$$R_t = \frac{T_i - T_e}{T_i} \times 100 \quad (1)$$

where T_i is the influent water turbidity amount in the clarifier, T_e is the effluent water turbidity clarifier, and R_t is the turbidity removal efficiency in the clarifier (in percent).

The average turbidity removal efficiency in clarifiers of WTPs Nos. 1, 3, 4, and 5 are, respectively, 53.9, 66.8, 69.9, and 76.2%. More detailed data about the clarifiers' performance are shown in Tables 3, 5, 7, 9. From the obtained results it can be observed that Pulsator system is more efficient than Accelator in turbidity removal. The treatment plant No. 5 is more efficient than the other WTPs in turbidity removal in clarifier units.

Turbidity removal efficiency in effluent treated water of the WTPs are, respectively, 95.12, 96.86, 96.56, and 96.86%. In all of the cases, effluent water turbidities from WTPs are less than 1 NTU, and therefore less than the standard. The results can be seen in Tables 2, 4, 6, 8.

4.3. TOC

TOC is a key indicator of the propensity of trihalomethanes (THMs). The removal of excess organic carbon prior to chlorination will reduce the production of THMs and other substances. EPA has specified the limited amount of 2 mg/L TOC in effluent treated water. Due to the fact that the average TOC concentration in discharged effluent from the WTPs Nos. 1, 3, 4, and 5 are respectively 0.87, 1.02, 0.99, and 0.59 mg/L, satisfactory results have been gained from these WTPs. TOC removal efficiency is obtained from the equation below:

$$R_{TOC} = \frac{TOC_O - TOC_e}{TOC_O} \times 100 \quad (2)$$

In which TOC_o is input water TOC amount, TOC_e is output water TOC amount, and R_{TOC} is the TOC removal efficiency. Average TOC removal efficiency in these WTPs are, respectively, 22.26, 31.44, 32.87, and

Table 2
Turbidity measuring results from input raw water and output treated water of Jalalieh treatment plant

Month	Influent water turbidity (NTU)	Effluent turbidity (NTU)	Removal efficiency (%)	Output iron (mg/L)
June	3.7	0.12	96.79	0.05
July	3.4	0.16	95.29	0.05
August	3.4	0.22	93.53	0.13
September	2	0.23	88.50	0.24
October	3.5	0.1	97.14	0.03
November	19	0.1	99.47	0.03

Table 3
Accelator clarifier Performance in Jalalieh treatment plant

Month	Influent turbidity to clarifier (NTU)	Effluent turbidity from clarifier (NTU)	Removal efficiency (%)	Output iron (mg/L)
June	5.3	2	62.3	1.00
July	4.8	2	58.3	1.01
August	3.1	2.1	32.3	1.80
September	3.9	2.4	38.5	2.37
October	4.8	2.6	45.8	–
November	20	2.7	86.5	–

30.27%, which is undesirable in both the clarifications. It can be seen that average TOC removal efficiency in Pulsators of the three WTPs is 31.53% and in Accelator is 22.26%; consequently, TOC removal efficiency in Pulsator is 40% more than that in Accelator. As it is shown in Figs. 4–7 TOC in Jalalieh influent is less than the other treatment plants. Its low TOC removal efficiency can be a warning for future in the case influent TOC to the Jalalieh treatment plant increases. In view of the fact that these materials are as precursors of hazardous organic compounds such as THMs and more over their carcinogenic effect has been proved, specific considerations are required with the purpose of the efficiency increment of treatment plant units in TOC removal. The treatment plant No. 4 is more effective in TOC removal among the other ones.

4.4. TDS

The average influent TDS in these treatment plants are 246, 166, 166, and 176 mg/L, while its average effluent are 246, 170, 169, and 181 mg/L. As shown in Figs. 8–11, TDS in effluent water has increased. TDS levels are between 100 and 500 mg/L which is desirable for drinking water.

4.5. Iron

Iron concentration in drinking water is normally less than 0.3 mg/L, however it might be higher in countries using various iron salts as coagulating agents in WTPs. The results of iron concentration in both influent and effluent water from clarifiers and treated water indicate influent iron concentration in

Table 4
Turbidity measuring results from input raw water and output treated water of Tehranpars treatment plant No. 3

Month	Influent water turbidity (NTU)	Effluent turbidity (NTU)	Removal efficiency (%)	Output iron (mg/L)
June	4.05	0.32	92.10	0.018
July	4.02	0.17	95.77	0.024
August	24.6	0.26	98.94	0.021
September	7.59	0.18	97.63	0.026
October	7.02	0.1	98.58	0.032
November	8.66	0.16	98.15	0.029

Table 5
Pulsator clarifier performance in Tehranpars treatment plant No. 3

Month	Influent turbidity to clarifier (NTU)	Effluent turbidity from clarifier (NTU)	Removal efficiency (%)	Output iron (mg/L)
June	5.4	1.4	74.1	0.338
July	5.63	2.11	62.5	0.276
August	9.93	3.35	66.3	0.202
September	7.98	2.48	64.4	0.364
October	7.47	2.84	61.98	–
November	8.94	2.42	72.93	–

Table 6
Turbidity measuring results from input raw water and output treated water of Tehranpars treatment plant No. 4

Month	Influent water turbidity (NTU)	Effluent turbidity (NTU)	Removal efficiency (%)	Output iron (mg/L)
June	4.05	0.29	92.84	0.021
July	4.02	0.25	93.78	0.04
August	24.6	0.41	98.33	0.019
September	7.59	0.19	97.50	0.024
October	7.02	0.12	98.29	0.034
November	8.66	0.12	98.61	0.027

Table 7
Pulsator clarifier performance in Tehranpars treatment plant No. 4

Month	Influent turbidity to clarifier (NTU)	Effluent turbidity from clarifier (NTU)	Removal efficiency (%)	Output iron (mg/L)
June	5.8	1.9	68.1	0.34
July	9.27	2.2	76.7	1.81
August	13.9	4.53	67.4	0.287
September	8.26	2.16	73.85	0.315
October	6.72	2.79	58.48	–
November	9.37	2.38	74.6	–

Table 8
Turbidity measuring results from input raw water and output treated water of Sohanak treatment plant

Month	Influent water turbidity (NTU)	Effluent turbidity (NTU)	Removal efficiency (%)	Output Iron (mg/L)
June	3.08	0.08	97.4	0.036
July	2.57	0.12	95.33	0.049
August	4.09	0.12	97.07	0.03
September	3.41	0.12	96.48	0.034
October	3.36	0.09	97.32	0.021
November	4.49	0.11	97.55	0.028

Table 9
Pulsator clarifier performance in the Tehranpars treatment plant No. 5 (Sohanak)

Month	Influent turbidity to clarifier (NTU)	Effluent turbidity from clarifier (NTU)	Removal efficiency (%)	Output iron (mg/L)
June	3.63	0.9	76.3	0.38
July	3.34	1.2	63.5	0.35
August	3.86	0.67	82.6	0.275
September	3.36	0.75	77.7	0.385
October	3.35	0.9	73.1	–
November	4.54	0.72	84.1	–

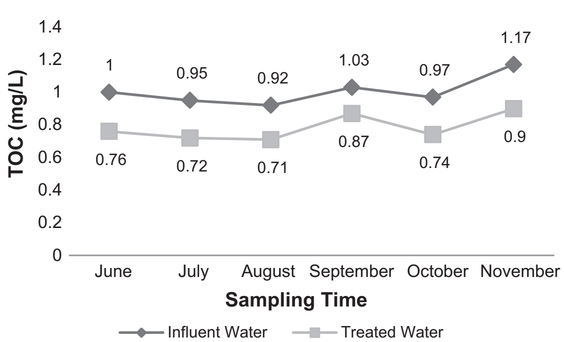

Fig. 4. TOC amount in Jalalieh treatment plant.

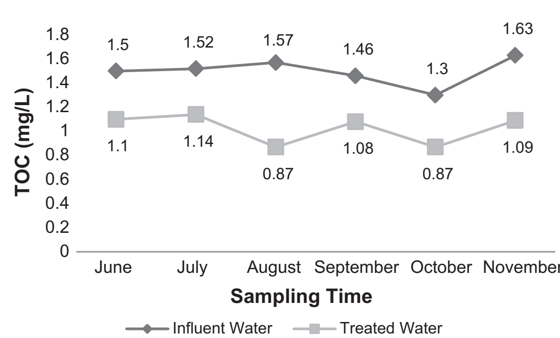

Fig. 5. TOC amount in Tehranpars treatment plant No. 3.

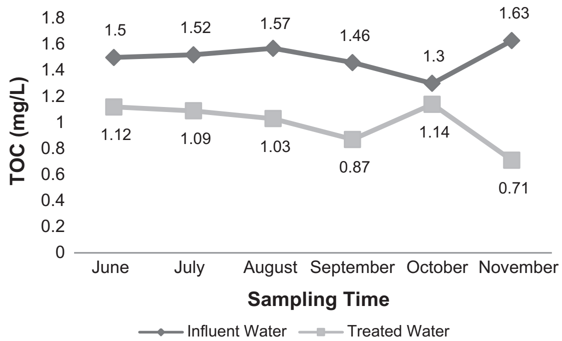

Fig. 6. TOC amount in Tehranpars treatment plant No. 4.

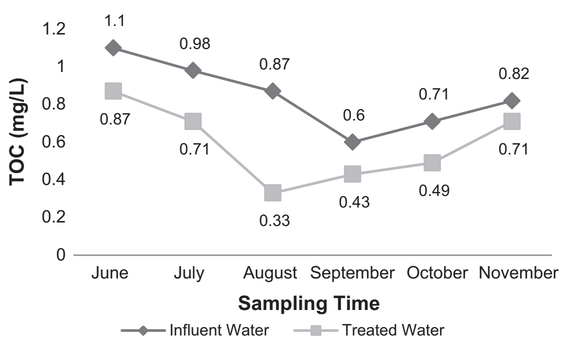

Fig. 7. TOC amount in Sohanak treatment plant.

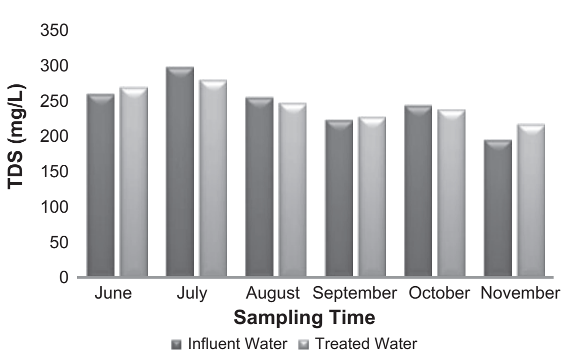

Fig. 8. TDS level in Jalalieh treatment plant.

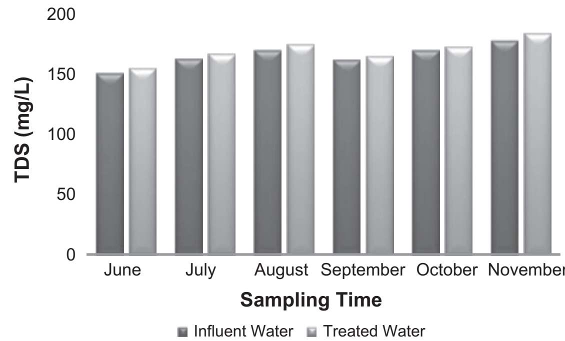

Fig. 9. TDS level in Tehranpars treatment plant No. 3.

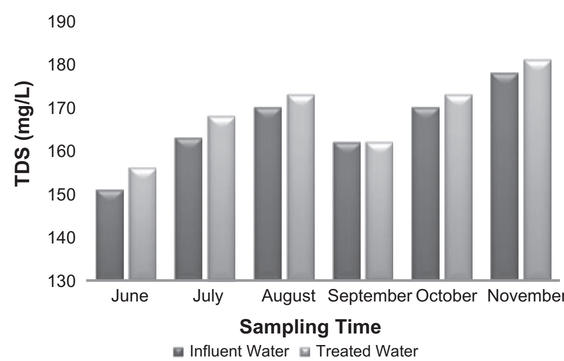

Fig. 10. TDS level in Tehranpars treatment plant No. 4.

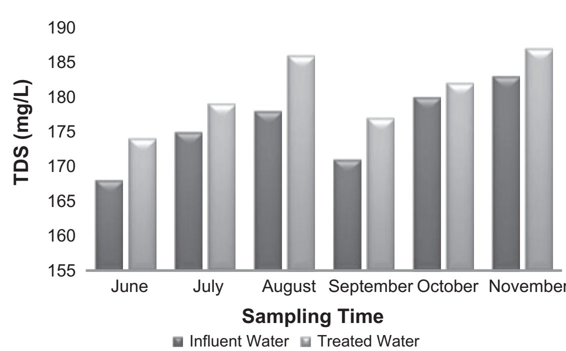

Fig. 11. TDS Level in Sohanak Treatment Plant.

plants No. 1 and 5 is less than the amount in plants Nos. 3 and 4. According to Figs. 12–15, the average influent iron concentration in WTPs are, respectively, 0.02, 0.089, 0.089, and 0.028 mg/L and its average effluent from them are, respectively, 0.09, 0,025, 0.028, and 0.033 mg/L. Referring to Tables 2–9, iron concentration in discharged effluent from Accelator is more than 1 mg/L and from Pulsator is averagely less than 0.45 mg/L. On the ground that iron in Pulsator influent is virtually 3.5 times as much as that in Accelator influent, this indicates Pulsator is more efficient in iron removal. According to the drinking water quality standard (EPA secondary standard of 0.3 mg/L), the total iron concentration in effluent water of both systems corresponds with the standard. Due to the high iron concentration in Accelator effluent water, the role of filter units in iron removal is obvious. It is worth noting that the amount of iron in effluent water from Accelator is more than that in the input water from Pulsator indicating iron escape from the system. The

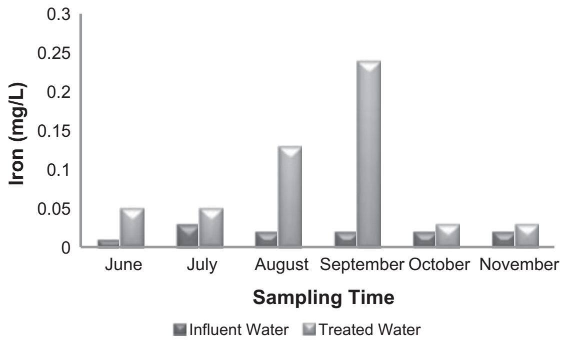

Fig. 12. Iron level in Jalalieh treatment plant.

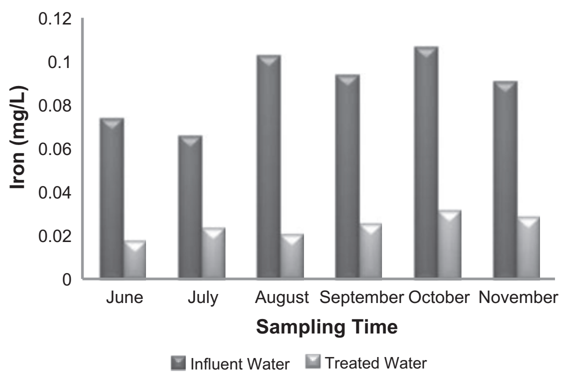

Fig. 13. Iron Level in Tehranpars Treatment Plant No. 3.

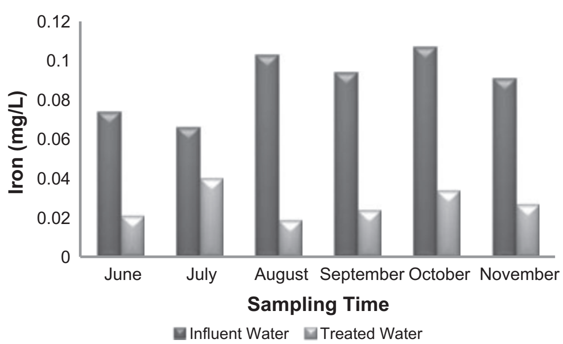

Fig. 14. Iron level in Tehranpars treatment plant No. 4.

high iron concentration in effluent of Accelator can arise from excessive chloride ferric consumption as coagulant and low efficiency of Accelator.

4.6. *SI*

Saturation Index (SI) is a means of evaluating water quality to determine whether the water has a tendency to form a chemical scale and can be obtained as below:

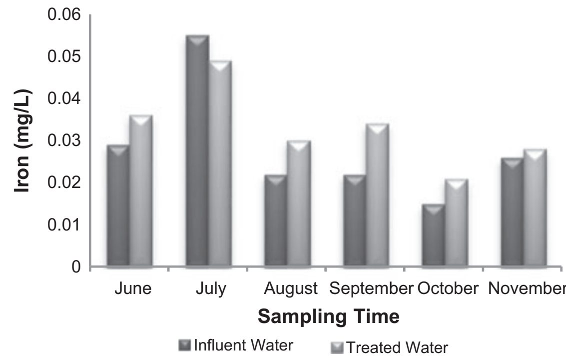

Fig. 15. Iron Level in Sohanak Treatment Plant.

$$SI = pH - pH_5$$

where pH is the actual pH of the water, and pH_s is the pH of saturation for calcium carbonate. SI calculation of effluent in plant No. 1, especially the values from June to September, indicates that in the produced water in Accelator, dissolution occurs so, the water is corrosive (Fig. 16). In plants Nos. 3 and 4, we encounter with slight scale formation and corrosion event in the effluent (Figs. 17 and 18). The produced water in plant No. 5 is almost balanced (Fig. 19). The protective scale formation is dependent on pH, bicarbonate ion, calcium carbonate, dissolved solids, and temperature; each may affect the water's corrosive tendencies independently. The factor most obviously low is pH. Some chemicals should be added in order to raise the alkalinity and therefore the pH. Here, more amount of lime (coagulant aid) should be used in Accelator system to increase SI so that the corrosion of water supply pipes can be reduced or eliminated. In the other treatment plants' SI corresponds with the

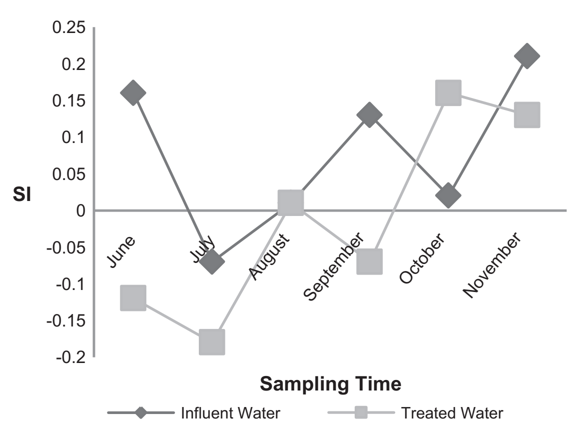

Fig. 16. SI value in Jalalieh treatment plant.

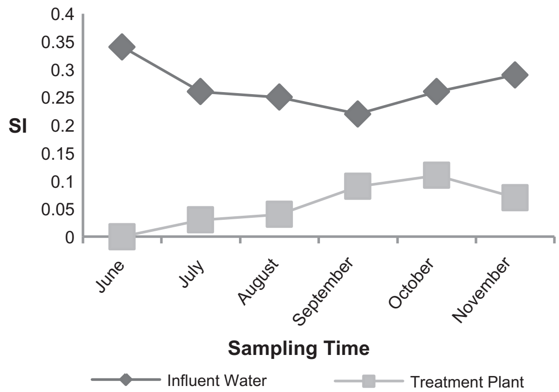

Fig. 17. SI Value in Tehranpars Treatment Plant No. 3.

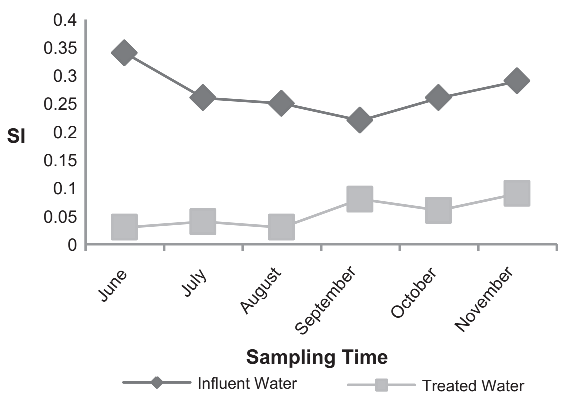

Fig. 18. SI value in Tehranpars treatment plant No. 4.

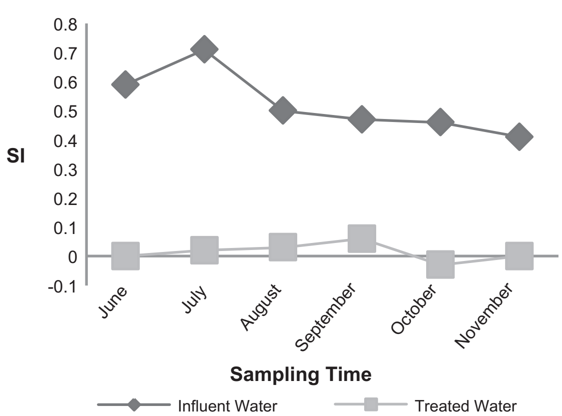

Fig. 19. SI value in Sohanak treatment plant.

standard. The indications for the LSI (Langelier Saturation Index) and the improved LSI by Carrier are based on Tables 10 and 11.

According to Tables 10 and 11 in WTPs using Pulsator, scale forming may occur considering this issue

Table 10
Interpretation of the Langelier Saturation Index [14]

LSI	Indication
SI < 0	Water is undersaturated with respect to calcium carbonate. Undersaturated water has a tendency to remove existing calcium carbonate protective remove existing calcium carbonate protective coatings in pipelines and equipment
SI = 0	Water is considered to be neutral. Neither scale forming nor scale removing
SI > 0	Water is supersaturated with respect to calcium carbonate ($CaCO_3$) and scale forming may occur

Table 11
Interpretation of the improved Langelier Saturation Index (carrier) [15]

LSI (Carrier)	Indication
−2 to −0.5	Serious corrosion
−0.5–0	Slightly corrosion but non-scale forming
SI = 0	Balanced but pitting corrosion possible
0–0.5	Slightly scale forming and corrosive
0.5–2	Scale forming but non corrosive

that we may encounter with corrosion as well as scale forming in Tehranpars treatment plants.

5. Conclusion

In this paper, the performance of four WTPs in Tehran was evaluated. Chloride ferric consumption, turbidity, TDS, TOC, Iron, and SI were the factors by which these plants were compared together. Required coagulant and coagulant aids in Pulsator is less than Accelator, and therefore leads to reducing associated costs. When compared to Accelator, Pulsator is more efficient in terms of turbidity removal. When raw water is virtually clean, while it has unfavorable microorganisms, Pulsator has better performance and can offer better effluent quality. The level of effluent turbidity in both systems is less than the standard. The less influent turbidity is entered to the Accelator, the less efficiency it has in turbidity removal. As the results indicate, good resistance of Pulsator against qualitative and quantitative shocks is another benefit of this system can be mentioned.

TOC removal efficiency in both systems is not in favorite limit, but TOC removal percent in Pulsator is 40% more than that in Accelator. Total organic carbon in effluent of these systems is less than the standard. Pulsator system offers another advantage over Accelator which is its efficiency in iron removal and moreover, the iron amount in effluent of Accelator system is more than that in Pulsator indicating iron escaping. However, the iron in effluent water is less than the standard in both systems. According to the SI value, the produced water in Accelator is corrosive, while scale forming would happen in Pulsator systems.

This study demonstrated that Pulsator system has high privileges due to the relatively easy operation, showing more promising results in producing better effluent quality and requiring less retention time.

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