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Research Article

EVALUATION OF TOTAL ORGANIC CARBON REMOVAL EFFICIENCY IN SANLIURFA DRINKING WATER TREATMENT PLANT

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Abstract: *5.8 billion cubic meters of water is drawn from the water resources in Turkey for drinking and potable water network, according to the Turkey Statistical Institute's 2016 Municipal Water Statistics results. 92.9% of this water is treated by conventional treatment methods, 6.1% by advanced treatment techniques and 1% by physical treatment methods. Conventional drinking water treatment plants generally include oxidation, pretreatment, chemical treatment (coagulation-flocculation-sludge), filtration and disinfection units. Similar treatment units are used in Sanliurfa drinking water treatment plant which is the subject of the present study. Total Organic Carbon (TOC) is one of the water quality determination methods such as BOD and COD. It refers to organic substances dissolved or suspended in water. With this study; the treatment efficiency of Sanliurfa drinking water treatment plant was evaluated according to the TOC parameter. The TOC removal efficiency performance evaluation of treatment plant was made by comparing experimental data for January-May period. According to this; average efficiency was determined as 28.51%. As a result, this performance value is concluded to be an average treatment efficiency for such conventional drinking water treatment plants.*

Keywords*: Total organic carbon (TOC), treatment system, drinking water treatment plant, Sanliurfa.*

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1. Introduction

Water is vital for human life. Most of the human body consists of water and it is impossible for human life to continue without reaching the water. Although water is at the forefront of almost all needs in human life, 1.1 billion people do not have access to healthy drinking water resources. Therefore, in order to increase the potable water resources, it is necessary to purify and improve the water from all pollutants [1]. Water resources in nature are generally not suitable for direct use as drinking water. It should, therefore, be ensured that the water is subjected to a purification process.

Surface water is the main source of drinking water in many regions of the world. High concentrations of organic carbon are a cause of concern all over the world. Because dissolved and particulate organic carbon pollutants in water are transportable and can adversely affect drinking water treatment processes [2].

A typical drinking water treatment plant generally includes oxidation, pretreatment, coagulation, flocculation, precipitation, filtration and disinfection units. Chlorine agents are used in raw water to significantly reduce the charge of pollutants in the pre-chlorination (oxidation) process [3, 4]. However, the reaction of chlorine with NOM or micro-contaminants during this process leads to the formation of carcinogenic trihalomethanes (THMs) and haloacetic acids (HAAs) [5-8]. In the coagulation, flocculation and precipitation units, the turbidity of the water is removed and then the final residues are removed by filtration. Finally, the pH of the effluent is neutralized, and a disinfection process is applied to stabilize the drinking water quality [9, 10].

In this study water samples were taken from Sanliurfa Drinking Water Treatment Plant. The total treatment capacity of the plant is 540 000 m^3/day and the hydraulic capacity is 600 000 m^3/day. As in Sanliurfa drinking water treatment plant, a conventional drinking water treatment plant generally has oxidation, coagulation, flocculation, filtration, and disinfection units.

TOC is a collective parameter used to determine the amount of organic matter in the water. It measures the concentration of organic matter in the water. Drinking water may contain organic substances below certain limits. The limit for the TOC parameter is 4 mg/L. In order to minimize disinfection by-product formation in the world, the maximum TOC concentration that should be observed at the exit of the drinking water treatment plant is limited to 4 mg per liter. According to the results of monitoring performed within the context of each of the at least one drinking water treatment plant in Turkey it has been reported to provide this value [2].

In a study carried out in terms of quality control parameters of the drinking water system of the central province of Sanliurfa, serious problems were found in the source, storage and network system [11]. In the study conducted by Kırıkçı (2006), it was aimed to observe the formation of trihalomethanes, which are known to occur after pre- chlorination and which have serious limitations in the world as a carcinogenic substance, in the water supplied from Sanliurfa Drinking Water Treatment Plant and are far below the predicted [12].

The measurement of organic carbon in natural water resources is a quick and simple method for monitoring pollution. In addition, TOC measurements of drinking water treatment plants allow the observation of the relationship between THM and organic matter in the effluent. The removal of pollutants varies according to the coagulants used in conventional drinking water treatment plants. Polialuminum Chloride Hydroxide Sulphate (PACS) is used as coagulant and polyelectrolytes are used as an auxiliary coagulant in the treatment plant.

In this study, the efficiency of the treatment plant will be determined by the analyzes to be performed at the entrance and exit of these coagulants used in the treatment plant. In addition, the

deterioration of water quality in drinking water, the formation of carcinogenic disinfection by-products by the final chlorination at the output of the treatment, and thus the removal of TOC, which causes some operational problems in the treatment system is targeted.

2. Materials and Methods

TOC parameter was measured in Sanliurfa drinking water treatment plant.

2.1. Sampling and analysis

Samples were taken from 3 different points of the plant for analysis. These points were; the inlet unit of the treatment plant (raw water), the filtrate, and the effluent of the plant (clean water). A total of 8 samples were collected at different times in January-May. The pH analyzes were carried out in situ in the plant influent and effluent of water. In this way, the changes between the parameter of TOC and raw water, filtrate, and effluent were observed, and the efficiency was calculated. The samples were analyzed with TOC device and glass sample vessels which were calibrated without any chemical treatment. The sample vessels were named Raw Water (H), Filtrate (F), and Treatment Plant Waste (Clean Water) (T). Samples were taken to the laboratory and measurements were made.

2.2. TOC analysis

TOC analysis was made as to the TOC parameter value by making necessary adjustments on the device. In the TOC method, organic substances in water are catalytically burned at high temperature (680 °C) to form carbon dioxide (CO_2). The amount of TOC in the sample was determined by measuring the CO_2. The TOC analysis was carried out within the scope of TS 8195 EN 1484 Effective Water Quality TOC Determination Method with TOC analyzer in the treatment plant laboratory. Fig. 1 shows the TOC analyzer used in the study.

Figure 1. TOC analyzer used in the study.

As a result of these analyses, the treatment efficiency and removal percentage of the TOC parameter was calculated with the formula Eq. (1) in accordance with the regulation of Quality and Treatment of Drinking Water Supply Water as follows.

$$Treatment\ Efficiency(\%) = \frac{(Influent\ concentration - Effluent\ Concentration)}{Influent\ concentration}\ x\ 100 \quad (1)$$

The limit value determined for the effluent of the TOC drinking water treatment plant is 4 mg/L and the regulation is obliged to provide this value.

3. Result and Discussion

In recent years, one of the most important problems in drinking water treatment plants is the disinfection by-products indicated by many studies such as halo acetic acid (HAA) and THM, which are formed by chlorination process by organic substances in the water and the TOC parameter. Elimination or reduction of pollution and damages is a major problem. The removal of organic matter by coagulation depends on the amount, nature and structure of the organic matter in the water environment, the coagulant to be used, the dose of the coagulant and the pH of the water [8, 14]. In many scientific studies, it was determined that TOC removal decreased with increasing alkalinity and pH value, and removal efficiency increased with increasing TOC content and amount [15].

When the results of the analyses were examined; the highest TOC value in the raw water was 4.63 mg/L in January and 3.73 mg/L on April 19. The TOC value obtained in the filtrate was 3.41 mg/L in January and 2.73 mg/L in March. The arithmetic mean of all analyses for the filtrate was found to be 3.09 mg/L. The highest value of TOC in the effluent was 3.36 mg/L in January and the lowest value was 2.37 mg/L on February 7. The average TOC value of raw water was measured as 4.11 mg/L. The average of TOC in the effluent was 2.94 mg/L.

When the raw water in the treatment plant inlet unit and the pH values at the effluent of the plant were examined, it was observed that there was no significant decrease and increase. It was evaluated that there was a decrease in four of the measurements taken and an increase in four of them, and the mean values of raw and treated water values of this parameter were 7.47 and 7.55. The pH of the raw water was measured as 7.11 in May and 7.83 in January. It is seen in Tab.1 that the maximum pH of the treated effluent is measured in 8.16 in February and 7.15 in late January.

Table 1. Treatment Plant pH and TOC analyses results.

Measurement Number	Date	pH raw water	pH effluent	TOC raw water (mg/L)	TOC filtered (mg/L)	TOC effluent (mg/L)
1	19.01.2018	7,83	8,1	4,63	3,41	3,36
2	31.01.2018	7,56	7,15	4,18	2,85	2,91
3	07.02.2018	7,67	8,16	4,02	2,75	2,37
4	28.02.2018	7,39	7,27	4,12	3,15	2,85
5	15.03.2018	7,32	7,26	3,81	2,73	2,65
6	03.04.2018	7,46	7,33	4,23	3,25	3,18
7	19.04.2018	7,44	7,61	3,73	2,86	2,9
8	08.05.2018	7,11	7,52	4,12	3,71	3,26
Average Values		7,47	7,55	4,11	3,09	2,94

The change of TOC values in raw water, filtrate and effluent are given in Fig. 2. It is seen that the value of raw water and treated water (at the filtrate and effluent) changes according to the direction of treatment flow decreasing. In addition, the filtrate and final effluent concentration values of TOC were found to be parallel and close to each other.

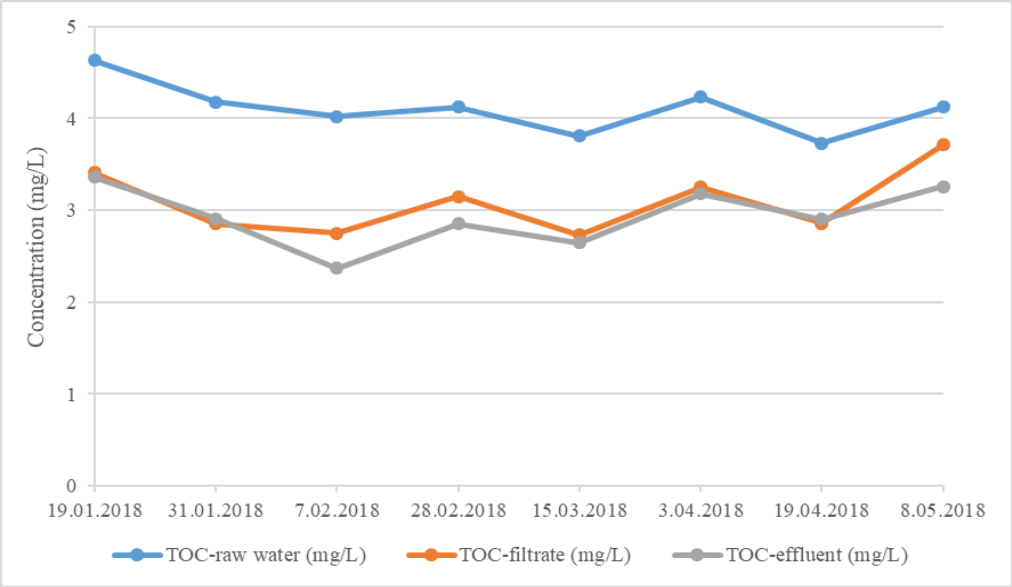

Figure 2. Variation of TOC analyses results with sampling times.

3.1. Calculation of Treatment Efficiency

The treatment efficiency of the Sanliurfa treatment plant, the results of TOC analysis the influent, the filtrate, and the effluent are given in Tab. 2 below.

Table 2. TOC analyses results and treatment efficiencies in filtrate and effluent.

Measurement Number	Date	TOC raw water (mg/L)	TOC filtered (mg/L)	TOC effluent (mg/L)	Efficiency filtered (%)	Efficiency effluent (%)
1	19.01.2018	4,63	3,41	3,36	26,35	27,43
2	31.01.2018	4,18	2,85	2,91	31,82	30,38
3	7.02.2018	4,02	2,75	2,37	31,59	41,04
4	28.02.2018	4,12	3,15	2,85	23,54	30,83
5	15.03.2018	3,81	2,73	2,65	28,35	30,45
6	3.04.2018	4,23	3,25	3,18	23,17	24,82
7	19.04.2018	3,73	2,86	2,9	23,32	22,25
8	8.05.2018	4,12	3,71	3,26	9,95	20,87
Average Values		4,11	3,09	2,94	24,76	28,51

When the treatment efficiency between raw water and filtrate and effluent summarized in Tab.2 was examined, the lowest amount of TOC was measured in May (9.95%) and the highest in January (31.82%). It can be seen that TOC treatment efficiency at the effluent is measured as 20.87% in May and highest in February (41.04%). The lowest treatment efficiency in May was 9.95%.

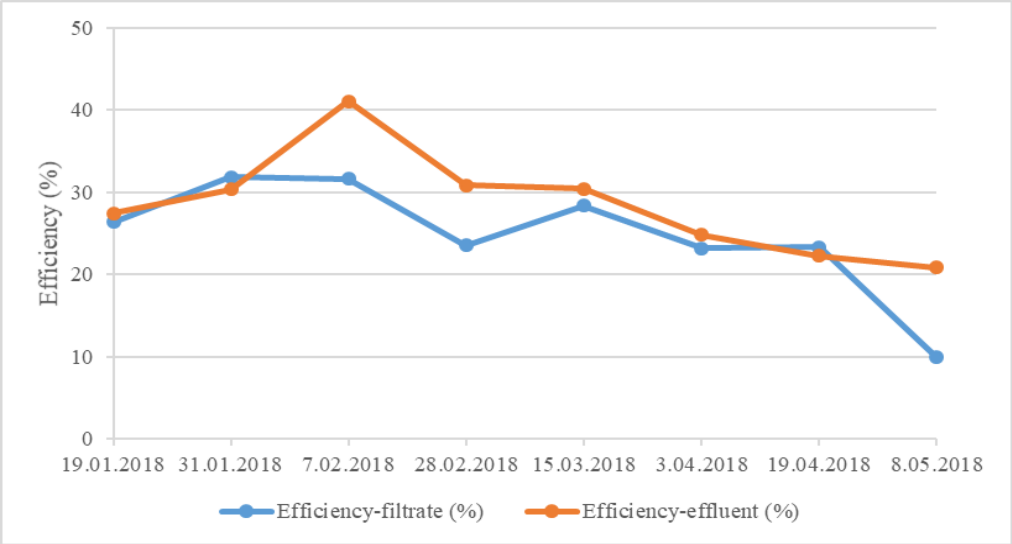

Figure 3. Variation of TOC efficiency percentage of treatment over time.

It is seen in Fig. 3 that the percentage of efficiency of the treatment in terms of TOC decreases over time, especially towards February-May. It has been evaluated that the reduction of treatment efficiency can be explained by the increase in water temperature.

4. Conclusion

Treatment efficiency of drinking water treatment plant in terms of TOC showed that; the average of all measurements at the filtrate was 24.76% and the TOC treatment efficiency of the effluent was 28.51%. The mean value of the TOC parameter was 2.94 mg/L at the effluent and it was found to provide the standard of 4 mg/L. However, it has been determined that TOC measurements and attempting to be below the standard value should be done in order to stay on the safe side for the control of disinfection by-products. It has been evaluated that this situation can be achieved by using coagulants in optimum treatment according to TOC value in raw water considering the TOC efficiency of treatment.

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