

Effects of pre-ozonation and chemical coagulation on the removal of turbidity, color, TOC, and chlorophyll a from drinking water

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Abstract

Background: Ozone can be used as a single technology or in combination with other processes to improve the coagulation-flocculation or biodegradability in order to remove pollutants in natural water treatment.

Methods: In this study, the effects of pre-ozonation with coagulant substances on the quality parameters of drinking water were investigated using humic acid, kaolin, clay, and green algae in a pilot scale. This study was conducted under laboratory conditions (at both acidic and alkaline pH in different dosages of ozone and coagulant at ozone contact time with simulated water sample (5-20 minutes) in different scenarios).

Results: The highest removal efficiency of parameters in the state of pre-ozonation alone and pre-ozonation with a coagulant was observed at contact time of 20 minutes, ozone dosage of 5 g/h, coagulant dosage of 25 mg/L, at alkaline pH along with a decrease in temperature. So that, the average removal rate of turbidity, total organic carbon (TOC), color, and chlorophyll a in contact time of 20 minutes was 76.9%, 52.8%, 66.6%, and 85%, respectively. However, compared to ozonation under similar conditions, the reduction in turbidity, TOC, color, and chlorophyll a was 36.13%, 24.4%, 32.13%, and 79.6%, respectively. Also, it was revealed that pre-ozonation with coagulant could effectively improve the removal of parameters.

Conclusion: However, since pre-ozonation can be effectively used to improve the coagulation efficacy in the drinking water treatment, the pre-ozonation combined with coagulation is proposed as an alternative to conventional coagulation to improve the process of drinking water treatment plant.

Keywords: Pilot projects, Drinking water, Water quality, Ozone, Flocculation, Kaolin, Clay, Green algae

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Introduction

To purify potable water, a combination of chemical and physical processes is used (1). The most commonly used processes in the water treatment plant include filtration, flocculation, sedimentation, and disinfection for surface water (2). The physical characteristics (turbidity, color, temperature, and electrical conductivity), chemical characteristics (total dissolved oxygen, pH, and alkalinity), and biological characteristics of water are important factors that determine the quality of drinking water (3-6). High turbidity of the water is due to the presence of colloidal materials, which provide adsorption sites for chemicals that may be harmful or cause undesirable taste and odors (7). Generally, dissolved organic matters such as tannic,

humic, and fulvic acids make natural color in the water (8,9). Van Staden showed that natural color of water can be removed by direct filtration, conventional treatment or activated carbon, and ozone as an efficient oxidant is often used for removal of oxidative color (10). pH is an important chemical indicator of water. Temperature is also an important parameter because of its impact on the water chemistry (11). Turbidity and color are indirectly related to temperature and temperature affects coagulation. The performance of coagulation is temperature-dependent, and the optimum pH for coagulation depends on the temperature changes (12). Coagulation and flocculation are considered as the basic processes in the most water treatment plants (13). Flocculation by the addition of



synthetic or natural polymers, after the complete mixing step, permits transformation of micro-flocs into larger flocks that can be removed by the conventional water treatment processes (14). The amount of coagulant that was added to the water sample is an important factor in destabilizing colloidal particles in a given water sample (15). For every coagulant, there exists an "optimal dosage" for specific water chemistry and composition at which the coagulation of particles is optimized (15,16). The amount of chemical disinfectants is important since they can react with organic and inorganic precursors and produce disinfection byproduct (DBP) in the case of consuming more than the required dosage (17). Ozone is a powerful oxidizing agent and is an effective disinfectant in water without creating DBPs, which are formed in water with chlorine (18). Also, ozone is used for the removal of organic materials creating color in drinking water, and oxidation iron and manganese salts (19). Alum is used as a coagulant in water treatment processes, pre-ozonation increases the removal of total organic carbon (TOC), turbidity, and dissolved organic carbon (DOC) (0.5 to 0.8 mg/L ozone) under the conditions tested (20). Studies have shown that ozonation transforms natural organic matter from humic material to non-humic fractions (21,22). Ozone can be used as a single technology or in combination with other processes to improve the coagulation-flotation or biodegradability in order to remove pollutants in natural water treatment (23). Torabian et al evaluated the effect of pre-ozonation on the TOC removal in surface water treatment. The results showed that pre-ozonation not only supplied the required material to remove TOC, but also improved TOC removal (24). Generally, with increasing ozone dosage at different coagulant dosages slightly, TOC removal increased but at average coagulant dosages, it was decreased (25). Masoomi et al evaluated the performance of pre-ozonation in removing turbidity and TOC. He found that the average efficiency of the ozonation in the TOC removal with an average ozone concentration of 3 kg/h and a contact time of 18 minutes was 20.52%, and the average turbidity removal efficiency was 61% (26). Considering all the above-mentioned studies, the present study aimed to assess the effects of pre-ozonation alone and pre-ozonation with a coagulant on the removal of quality parameters (turbidity, color, chlorophyll a, and TOC) of drinking water, which was conducted in a pilot scale on the water entering the Koohsabz drinking water treatment plant, Fars.

Materials and Methods

Water samples and materials

In order to simulate turbidity and TOC of samples, clay, humic acid (95%) in powder form, and kaolinite were added to the raw water. To simulate chlorophyll a and watercolor during pre-ozonation alone and pre-ozonation with Coagulant, green algae (*Chlorella vulgaris*) were used. These algae were prepared from Ponds to drain

downstream of the Doroodzan dam. In order to supply nitrate required for algae, sodium nitrate (NaNO₃) was added. Aluminum sulfate (Kimia Materials Company) was used as a coagulant. The required ozone was supplied by an ozone generator (OPW27 model) with a nominal capacity of 5 g/h, equipped with an air pump.

Method of analysis

The study was conducted in a pilot and laboratory scale on a water sample entering the Koohsabz drinking water treatment plant in July 2017. This plant is located in Fars province, the South of Iran, at a distance of 12 Km from Marvdasht city, and near Koohsabz village with a longitude of 52°41'29.16" E and 29°55'16.79" N.

First, the raw water with turbidity of 9.8 FTU was simulated using clay and kaolin, clay was passed through a standard sieve (No 200), that the turbidity reached 21.8 FTU. Then, desired TOC concentration (9.5 mg/L) was simulated by adding humic acid in powder form. Desired chlorophyll a concentration and watercolor (1.6 mg/L and 19.6 TCU) were simulated by adding green algae (*Chlorella vulgaris*) in algae solution form. In order to supply nitrate required for algae to the algae solution of NaNO₃ was added. Aluminum sulfate used in the Koohsabz drinking water treatment plant was used as a coagulant in this study. Standard jar test procedures were used to evaluate aluminum sulfate requirements and the primary water quality parameters. The aluminum sulfate dosage selected for the removal of parameters (TOC, turbidity, color, and chlorophyll a) ranged from 5 to 25 mg/L. To study the effects of ozonation, the ozone dosage of 1 to 5 g/h and ozone contact time of 5 to 20 minutes were selected. Figure 1 illustrates a schematic plan of the reactor used in this study. Water temperature and pH influence the decomposition rate of ozone, and decrease of temperature increased dissolved ozone concentrations. The performance of coagulation is temperature-dependent and the optimum pH for coagulation depends on the temperature changes. Therefore, the effects of water temperature and pH changes in the removal of parameters in the process of ozonation alone and with coagulant material were also assessed in this study. The pH of water was adjusted to 4-8.6 by hydrochloric acid and sodium hydroxide. Finally, about 20 L of the sample solution was prepared based on the characteristics

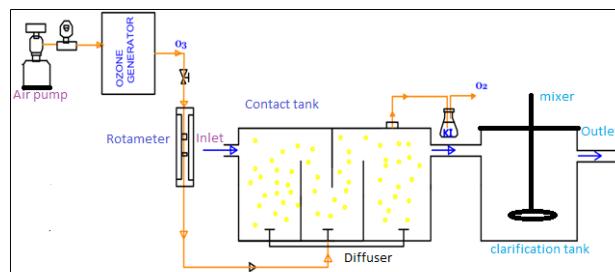


Figure 1. A schematic plan of experimental pre-ozonation.

Table 1. Characteristics of simulated water samples to study the effect of ozonation along with coagulant in removing water quality parameters

Parameter	pH	Temperature	Chlorophyll A (mg/m ³)	Turbidity (FTU)	Color (TCU)	TOC (mg/L)
Amount	7.6	21.9	1.6	21.8	19.6	9.5

indicated in Table 1. In the next step, the effects of the pre-ozonation process alone and with coagulant on the parameters of turbidity, color, chlorophyll a, and TOC were investigated. Also, to determine the effects of alum on parameters, different doses of alum from 5 to 25 mg/L were added to the water sample taken at pH 7 and after the coagulation and flocculation process, the rate of change of parameters was evaluated at different doses. The required ozone was supplied by an ozone generator (OPW 27) with a nominal capacity of 5 g/h using an air pump. In this study, a 20-L glass container (40 × 25 × 20 cm) was used to conduct the ozonation process. The entire ozone reactor was divided into four cells with three baffles of 20 × 20 cm. The first baffle was selected with a cell wall of about 13 cm, and other three cells were selected with a distance of 9 cm. The generated ozone in the reactor was injected from the floor into the reactor by four diffusers in the form of ultra-fine bubbles (Figure 1). The ozonation process of simulated water samples was conducted on simulated water samples in different scenarios at different contact times (5, 10, 15, and 20 minutes) and different doses of ozone (1 to 5 g/h). Then, pH of the samples was calibrated daily using Metrohm device (Switzerland, Model 830) and standard buffer solutions. TOC was measured by a spectrophotometer (DR 4000) using method 10129, and the turbidity and chlorophyll a were monitored using Algaturch device. Finally, the color was measured according to the standard method 2120 C using an spectrophotometer (HACH DR-5000 model), having 10-mm absorption cells, a narrow (10-nm or less) spectral band, and an effective operating range from 400 to 700 nm (27).

Results

In order to examine the effects of pre-ozonation alone and with coagulant (aluminum sulfate) on water quality parameters, the turbidity, color, and TOC were simulated using clay, kaolin, and humic acid in several stages. Table 1 indicates the average of simulated water quality parameters in four scenarios.

In order to evaluate the pre-ozonation effects on water quality parameters alone and with coagulant (aluminum sulfate), the turbidity, color, and TOC were simulated using clay, kaolin, and humic acid in several steps. The transferred ozone dosage, contact time, the amount of coagulant changes in each scenario, and the rate of change were accordingly evaluated. The results obtained from the review of the variation of the parameters are illustrated in Figure 2. As shown in this figure, the trend of change of water quality parameter changed in the ozonated water

with coagulant substances (chlorophyll a, color, turbidity, and TOC) at different doses of ozone with different doses of coagulant (5 to 25 mg/L) at different contact time. As shown in this figure, by increasing the time of ozone contact with water and increasing the injectable ozone dose and coagulant material to the experimental pre-ozonation pilot, the trend of change of parameters was also increased. In this case, the trend of changes of pH increased but the trend of changes of temperature decreased.

Evaluation of the removal efficiency of parameters in the second state (pre-ozonation + coagulant)

Figure 3A shows the removal efficiency of the parameters in the simulated sample studied in 5 minutes at different doses of ozone (1 to 5 g/h) with various doses of coagulant (5 to 25 mg/L) at different pHs and temperatures. The average removal rate in turbidity, TOC, color, and chlorophyll a was 26.79%, 5.7%, 11.3%, and 14.5%, respectively. In this case, compared with ozonation alone, the rate of reduction of the parameters was 15.04%, 0.84%, 5.4%, and 40.4%, respectively. Further, by increasing the contact time of ozone with water along

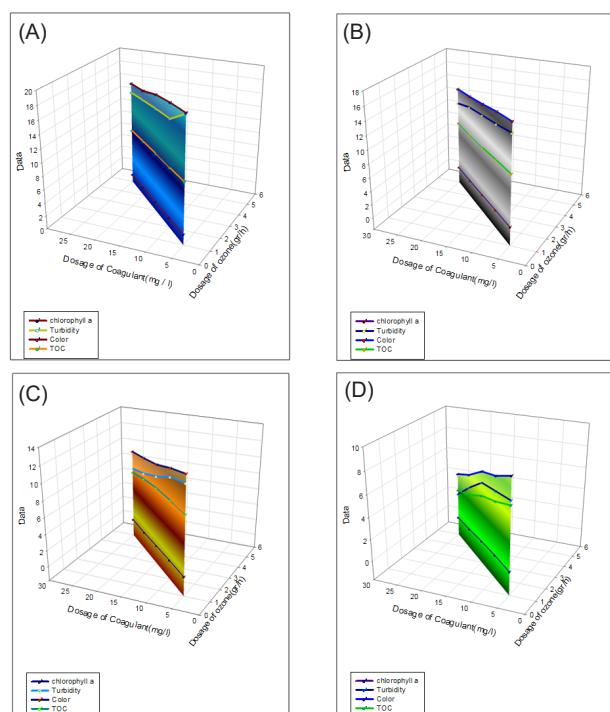


Figure 2. The trend of changes of quality parameters (chlorophyll a, color, turbidity, and TOC) in the ozonated water with coagulant materials at different doses of ozone with different doses of coagulant (5 to 25 mg/L) at different contact time (A: 5 min, B: 10 min, C: 15 min, and D: 20 min).

with the injection of aluminum as coagulant at different doses, the removal efficiency of turbidity, TOC, and color parameters increased compared to the ozonation alone while the removal efficiency of chlorophyll a decreased. Furthermore, it was revealed that an increase in ozone dose (5 g/h), along with an increase in the coagulant dose (25 mg/L), contact time (20 minutes), and pH (alkaline pH) has the best efficiency in removing the parameters. Figure 3B shows the removal efficiency of the parameters in the simulated water sample studied in 10 minutes at different doses of ozone (1 to 5 g/h) with various doses of coagulant (5 to 25 mg/L) at different pHs and temperatures. The average removal rate of turbidity, TOC, color, and chlorophyll a was 41.7%, 13.5%, 26.3%, and 46.9%, respectively. In this case, compared with the ozonation alone, the rate of reduction of the parameters was 22.28%, 4%, 12.24%, and 57.8%, respectively. Figure 3C shows removal efficiency of the parameters in the simulated water sample studied in 15 min at different doses of ozone (1 to 5 g/h) with various doses of coagulant (5 to 25 mg/L) at different pHs and temperatures. The average removal rate of turbidity, TOC, color, and chlorophyll a was 57.3, 20.4, 44.8, and 68.8%, respectively. In this case, compared with ozonation alone, the rate of reduction of the parameters was 29.62%, 10.52, 20.44%, and 66.56%, respectively.

Figure 3D shows removal efficiency of the parameters in the average removal rate of some parameters such as turbidity, TOC, color, and chlorophyll a during a 20-minute contact with an ozone dose of 5 g/h and coagulant dose of 25 mg/L at different pHs and temperatures, was 76.9%, 52.8%, 66.6%, and 85%, respectively. However, compared to the ozonation with similar conditions, the reduction in turbidity, TOC, color, and chlorophyll a was 36.13%, 24.4%, 32.13%, and 79.6%, respectively. While the effect of alum in the removal of turbidity, color, TOC, and chlorophyll a in the same state at pH 7 and doses of 5 to 25 mg/L, was 20%, 18.4%, 7.4%, and 25.5%, respectively. Furthermore, the effect of temperature and pH on the parameters removal was investigated in the present study. The results indicated that the removal efficiency of parameters increased by decreasing the temperature. The pH changed from acidic state (pH = 4) in the first scenario to an alkaline state (pH = 8.6) in the fourth scenario. Thus, the removal efficiency of the parameters in the fourth scenario was higher than that in the other scenarios. The removal efficiency of chlorophyll A, color, turbidity, and TOC of the simulated water relative to the dosage of injectable ozone, the coagulant dosage, pH, and temperature changes at contact time of 5 to 20 minutes is shown in Figure 3A-D. As shown in this figure, by increasing the time of ozone contact with water

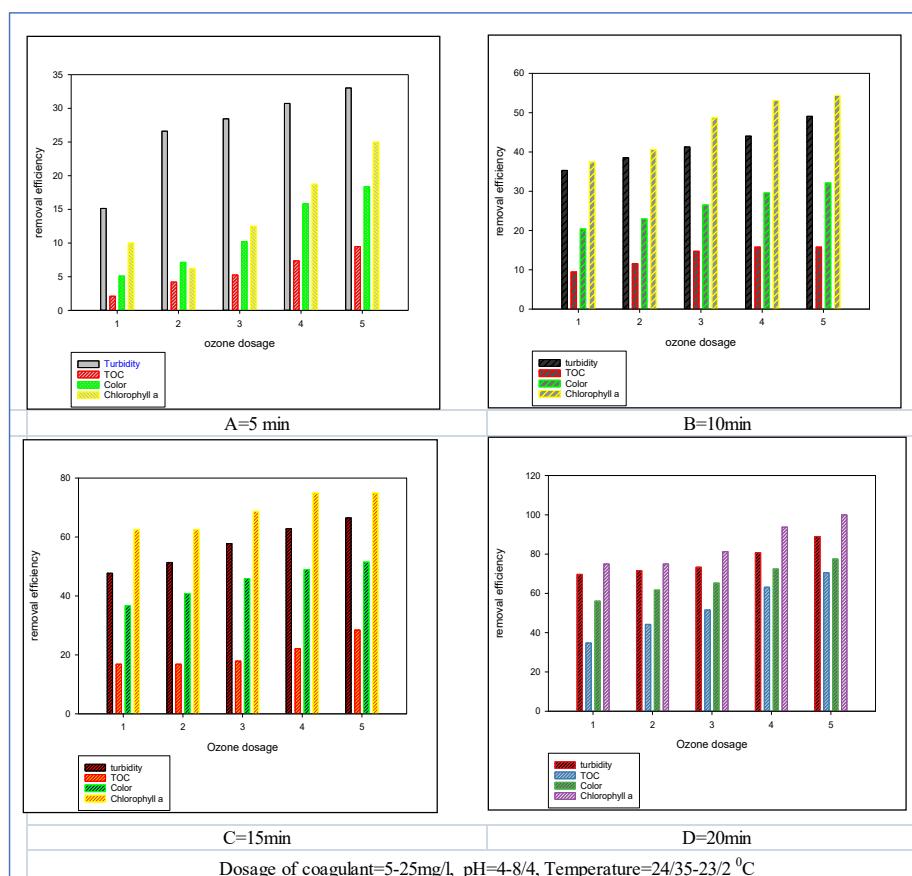


Figure 3. The trend of changes of the removal efficiency of turbidity, TOC, color, and chlorophyll a relative to the dose of ozone injected and contact time.

and increasing the injectable ozone dose and coagulant material to the experimental pre-ozonation pilot, the removal efficiency of parameters increased. In this case, the trend of changes of pH increased but it was decreased for temperature. Therefore, it can be said that temperature, pH, dose of oxidant and coagulant, and contact time, were important operational factors for the quality of the treated water, and pre-ozonation with coagulant could effectively improve the removal of parameters.

Statistical analysis of results

Statistical analysis was performed to determine the changes in parameters at different times of ozone (1 to 5 g/h) contact with coagulant (5 to 25 mg/L) by SigmaPlot 12.5 software. The linear regression of laboratory data indicated that all results were significant at confidence level of 95%. Figure 4 and Table 2 indicate the results

of the statistical analysis for the changes in parameters with injected ozone (1 g/h) and coagulant (5 mg/L) at different contact times (5 to 20 minutes). In addition, Table 3 demonstrates the results of the statistical analysis for changes in parameters with injected ozone (5 g/h) and coagulant (25 mg/L) at different contact times (5 to 20 minutes). Based on the results, the R-squared value and P-value of the parameters ranged from <0.05 to 1 (200 repetitions), which indicates the significance of the parameters. Furthermore, in order to validate the obtained data, 95% confidence level was used from the statistical analysis. As shown in Figure 5, all of the data are within the 95% confidence level.

Discussion

In this study, to evaluate the effects of pre-ozonation alone and pre-ozonation with coagulant, the water samples were

Table 2. Statistical analysis of the changes in parameters by the injection of ozone (1 g/h) + coagulant (5 mg/L) at different contact times

Parameters	R	R ²	P value	Iterations	Number of iterations performed
TOC (mg/L)	0.9746	0.9533	0.0236	200	22
Turbidity (FTU)	0.9979	0.9959	0.0021	200	37
Color (TCU)	0.9985	0.9971	0.0015	200	24
Chlorophyll A (mg/m ³)	0.9759	0.9524	0.0241	200	1

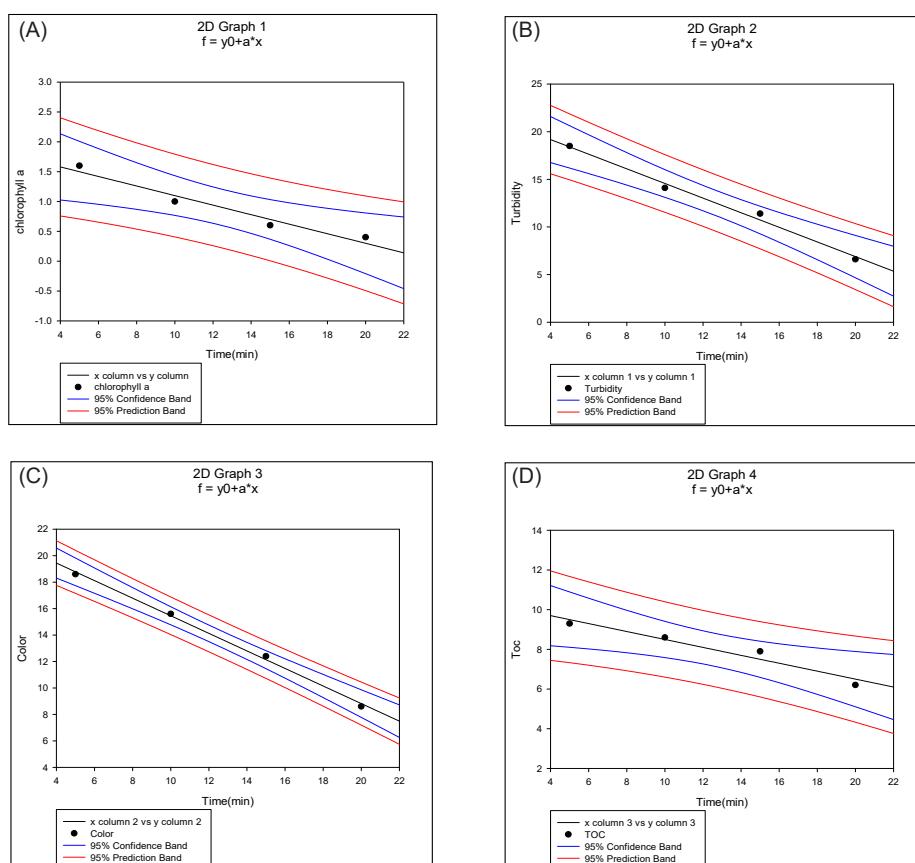
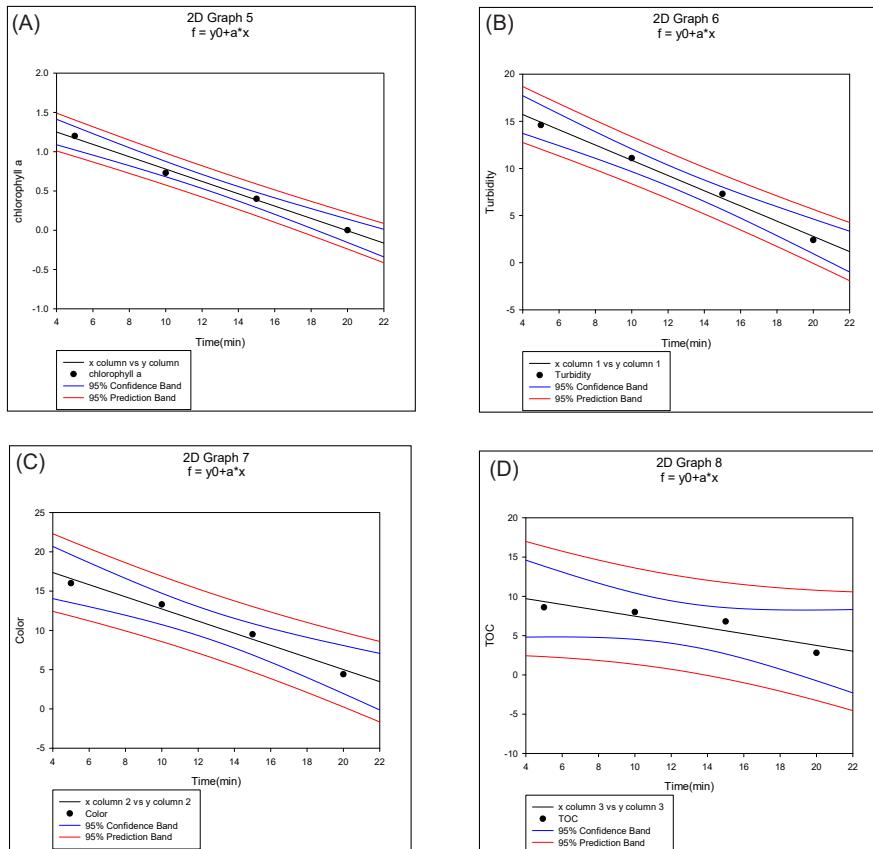


Figure 4. Statistical analysis of the changes in turbidity, TOC, and color in terms of contact time by the injection of ozone (1 g/h) with coagulant (5 mg/L) (A: chlorophyll a, B: Turbidity, C: Color, D: TOC).

Table 3. Statistical analysis of the changes in parameters by the injection of ozone (5 g/h) + coagulant (25 mg/L) at different contact times

Parameters	R	R ²	P value	Iterations	Number of iterations performed
TOC (mg/L)	0.9831	0.9665	0.0169	200	39
Turbidity (FTU)	0.9972	0.9944	0.0028	200	77
Color (TCU)	0.9910	0.9821	0.0090	200	47
Chlorophyll A (mg/m ³)	0.9978	0.9956	0.0022	200	10

**Figure 5.** Statistical analysis of variation of turbidity, TOC, color, and chlorophyll in terms of contact time by the injection of ozone (5 g/h) + coagulant (25 mg/L) (A: chlorophyll a, B: Turbidity, C: Color, D: TOC).

evaluated under various conditions. Various factors such as ozone dose, ozone contact time with water, coagulant dose, temperature, and pH are considered as some of the factors influencing the pre-ozonation process. Water temperature and pH influence the decomposition rate of ozone and lower temperature permits higher dissolved ozone concentrations. In this study, the temperature decreased in the pre-ozonation alone and with coagulant. Considering higher reduction of the parameters in the fourth scenario compared to the former ones, it can be said that the ozone contact time with water and temperature change affect the ozonation process significantly. The pH value influences the mechanism of the reaction and the type of created products. The results showed that different doses of ozone are needed at different pHs. The highest removal efficiency of water quality parameters occurred due to OH[·] (pH=8.6), as the main initiator

of ozone decomposition. Therefore, an increase in pH increases the ozone decomposition rate and affects the reaction of ozone oxidation with other elements. More radicals would be produced consequently if the amount of ozone decomposition increases under alkaline conditions (28). In addition, the results demonstrated that the high removal efficiency of water quality parameters occurred in the presence of hydroxyl radicals (alkaline pH), which is consistent with the results of the previous studies (28,29). A study by Sumegová et al showed that after 10 minutes of ozonation at pH = 11, the concentration of methylene blue was significantly decreased. The results indicated that the highest performance was observed at alkaline pH (29). Contact time is one of the basic parameters in designing an ozonation unit contactor. Increasing contact time will have a positive effect on the ozonation function, which was observed well in the experimental pre-ozonation pilot. The

results showed that by increasing ozone doses and contact time, the level of residual ozone in the system decreased and the removal efficiency of the parameters increased. Application of ozone before enhanced coagulation, can sufficiently change to remove low molecular weight and non-humic fractions. Also, the results showed that the addition of ozone before alum coagulation increased TOC removal. The removal efficiency of TOC in the pre-ozonation at contact time of 5 to 20 minutes, was 0.84%, 4%, 10.52%, and 24.4% respectively, and in the pre-ozonation with coagulant at contact time of 5 to 20 minutes, was 5.7%, 13.5%, 57.3%, and 76.9%, respectively. While the effects of alum in the removal of TOC in the same state with pH 7 at ozone doses of 5 to 25 mg/L, was 7.4%. Thus, the results indicated that the removal efficiency of TOC was more than that of ozonation alone in the case of using ozone with the coagulant. Therefore, pre-ozonation is used to enhance coagulation and clotting in water treatment. The results of the present study confirm the results of the previous studies. A study by Mamba et al showed the TOC reduction from 14.53 to 10.40 mg/L in the source water after ozonation (30). Pryor et al found that ozone in the water treatment plant has little or no effect on the TOC removal (19). Yan et al reported that the pre-ozonation has an effect on coagulation and depends on the dosage of ozone, coagulant type, and water contamination (31). If an alum as a coagulant is used, as in the conditions tested, pre-ozonation prevents the removal of turbidity and DOC. The results showed that pre-ozonation leads to better coagulation with reduced surface charge of particulates (20). The removal efficiency of turbidity in the pre-ozonation alone at contact time of 5 to 20 minutes, were 15.04%, 22.28%, 29.62%, and 36.13%, respectively, and in the pre-ozonation with coagulant at contact time of 5 to 20 minutes, were 26.8%, 41.7%, 57.3%, and 76.9%, respectively. While the effects of alum in the removal of turbidity in the same state with pH 7 at doses of 5 to 25 mg/L, was 20%. Amirsardari et al, reported that pre-ozonation by alum in acidic conditions reduces turbidity to 30% (32). Ozonation decreases the color in water by breaking the polymers and organic materials in the water. By increasing ozone doses, the color removal in water is approximately 80% (33). The removal efficiency of color in the pre-ozonation alone at contact time of 5 to 20 minutes, were 5.4%, 12.24%, 2.44%, and 32.13%, respectively, and in the pre-ozonation with coagulant at contact time of 5 to 20 minutes, was 11.3%, 26.3%, 44.8%, and 66.6%, respectively. While the effects of alum in the removal of color in the same state with pH 7 at doses of 5 to 25 mg/L, was 18.4%. Basak et al found that at ozone contact time of 10 min, color and DOC are removed by 80 and 65%, respectively (34). The removal efficiency of chlorophyll a in the pre-ozonation alone at contact time of 5 to 20 minutes, was 40.4%, 57.8%, 66.56%, and 79.6%, respectively, and in the pre-ozonation with coagulant at contact time of 5 to 20 minutes, was 14.5%, 46.9%,

68.8%, and 85%, respectively. While the effects of alum in the removal of chlorophyll a in the same state with pH 7 at doses of 5 to 25 mg/L, was 25.5%. Thus, the results of the present study confirm the results of the previous studies. Morrison et al reported that pre-ozonation and medial ozonation do not have sufficient effects on pH, EC, DOC, and TOC. Furthermore, chlorophyll a, total chlorophyll, and the spectral absorption coefficient at 254 nm (SAC254) do not change significantly under the influence of pre-ozonation, but it is strongly influenced by the medial ozonation (19). The results of a study by Geldenhuys et al showed that ozonation by sedimentation and filtration improved the physical removal of algae by 17.7 and 17.0%, respectively, but ozonation alone could not decrease the total chlorophyll values much (35).

Conclusion

The results indicated that contact time, temperature, pH, ozone dosage, and water quality are among the factors affecting the pre-ozonation process alone and with coagulation process of water. Temperature plays a major role in the ozonation process. The results indicated that the removal efficiency of water quality parameters was increased by decreasing the temperature because ozone solubility increases by decreasing the temperature in water. The removal efficiency of the parameters in scenario 4 was higher than that in the other scenarios. It can be said that alkaline pH had significant effect on the process of ozonation because an increase in the pH, leads to an increase in the ozone decomposition rate due to the production of highly-reactive free radicals such as radical hydroxyl (OH). The results related to the removal efficiency of water quality parameters in the pre-ozonation alone and with coagulant, showed that the highest removal efficiency of parameters was observed at contact time of 20 min, ozone dosage of 5 g/h, coagulant dosage of 25 mg/L, at alkaline pH along with a decrease in temperature. In this case, in the pre-ozonation process alone, the percentages of turbidity, TOC, color, and chlorophyll were 36.13%, 24.4%, 32.13%, and 79.8%, respectively. The results showed that the lowest removal efficiency belonged to TOCs (24.4%) and the highest one belonged to chlorophyll a (79.8%). According to the analyses, it was revealed that alum (7.4%) and pre-ozonation alone has the least effect on the TOC removal (24.4%). Generally, it can be concluded that pre-ozonation alone cannot be so effective in removing TOC. The removal efficiency of turbidity parameters, TOC, color, and chlorophyll a in the state of the pre-ozonation with coagulant in the optimal conditions, was 76.9%, 52.8%, 66.6%, and 85%, respectively. The results show that the lowest removal efficiency belonged to TOC (52.8%) and the highest one belonged to chlorophyll (85%). While the effects of alum in the removal of turbidity, color, TOC, and chlorophyll a in the same state with pH 7 at doses of 5 to 25 mg/L, was 20%, 18.4%, 7.4%, and 25.5%,

respectively. Therefore, it can be said that in the second case (pre-ozonation with coagulant), the average removal efficiency of parameters was 70%, but in the first case (pre-ozonation alone), the average removal efficiency of parameters was 43%. Thus, high performance of pre-ozonation with coagulant in the removal of water quality parameters in comparison to ozonation alone has a double effect on the removal of the parameters. The coagulation process makes the colloidal particles unstable by adding coagulants. Ozone be injected into the process prior to the coagulation and flocculation process, which results in increasing the ability to become flocculate. However, since pre-ozonation can be effectively used for the improvement of coagulation efficacy in the drinking water treatment, the pre-ozonation combined with coagulation is proposed as an alternative to conventional coagulation to improve the process of drinking water treatment plant.

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Ethical issues

The authors certify that all data collected during the study are as stated in the manuscript, and no data from the study has been or will be published separately elsewhere.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

All authors participated in the data collection, analysis, and interpretation. All authors critically reviewed, refined, and approved the manuscript.

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