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TREATABILITY STUDY OF SOAP AND DETERGENT INDUSTRY WASTEWATER BY OZONATION PROCESS

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ABSTRACT

The present study deals with analysis and investigation of the treatment of soap & detergent industry wastewater by ozonation process. The results obtained concerning the optimum conditions of ozone treatment dose and contact time have been used for the removal of parameters such as colour, COD, BOD, TDS and other parameters. The ozonation process for the treatment of soap and detergent wastewater is effective. A dose of 19 mg/L, 21.58 mg/L and 30.70 mg/L ozone gives overall percentage of COD and colour reduction of 50.8%, 53.4%, 60.8% and 52.6%, 57.4%, 61.8% respectively at ozone reaction time. The total COD and color reduction depends on ozone concentration and functional groups present in wastewater. In addition, optimal parameters of ozonation process were determined to be 19 mg/L, 21.58 mg/L and 30.70 mg/L ozone doses. At all three ozone doses the turbidity, COD, BOD, alkalinity, colour and suspended solid removal reached 58.6%, 55%, 55.4%, 32%, 57.2% and 60% under selected conditions, respectively. But in this study, the total solids, total dissolved solids and dissolved oxygen increased up to 8.1%, 54.1% and 36% respectively after ozonation and the odour of wastewater does not change in all investigations. Thus, this study might offer an effective way for wastewater treatment of soap and detergent industry.

INTRODUCTION

The Present studies include the characterization of wastewater, containing impurities generated in the industry from different processing steps and units of eff1uent treatment plant. Performance appraisal of each unit of effluent treatment and possibility of augmentation. Final attention is given on treatability study of various parameters like COD, BOD TDS, Colour etc. and compares the effect of Ozone doses with different reaction contact time. Due consideration is also given to the comparison of effluent characteristics parameters of effluent treatment plant with the State Pollution Control Board Effluent Quality standards discharged in different receiving bodies as per IS: 2490 (Part-I) 1974 and standards for liquid effluent for Soap and detergent Industries. Toxicity tests are also done on treated effluent to study the effects of treated waste effluent on ecological environment before disposal.

Soap and detergent industry consumes considerable volume of water for various manufacturing

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processes of Soap and detergent production. Water is also used and required for steam generation and other general purposes. The wastewater discharged is highly polluted in nature with highly variable characteristics such as temperature, colour, total solids, BOD, chemical oxygen demand, anions, cataions, surfactants. Due to highly polluting nature, it is not possible to discharge treated and untreated waste either into water course or on land without causing great damage. They pose a great problem for environmental engineers.

Ozonation processes have been found to be cost effective, easy to operate, and energy saving treatment alternatives. Ozonation processes have been mainly used for wastewater treatment to decolourisation, COD removal and separate suspended and/or fatty particles. The main function of Ozone is to flocculate colloidal particulates into larger particles that can be removed by sedimentation or flotation. The mode of action is generally explained in terms of two distinct mechanisms: 1) neutralization of negatively charged colloids by cationic hydrolysis products and 2) incorporation of impurities in an amorphous hydroxide precipitate, so-called sweep flocculation. The relative importance of these mechanisms depends on factors such as contact time and Ozone dosage. Ozonation has been used for the treatment of wastewater discharged from Soap and detergent industry.

The objective of the experiments is to investigate Ozonation followed by disinfection using Ozone doses with different reaction time for pretreatment of Soap and detergent industry effluent. The optimum reaction time values and Ozone dose were determined for each coagulant. Emphasis will be afforded to the removal efficiency of the COD, BOD5, TSS, TDS, alkalinity and Colour. Moreover, characteristics of the floated and settled sludge were assessed. Initial investments as well as the operational cost of the treatment process were estimated.

MATERIALS AND METHODS

Wastewater and analytical methods

The source for the collection of wastewater samples throughout the present studies is the soap and detergent industry situated in Ujjain city, Madhya Pradesh (India). The main surfactant used in this factory, is the anionic surfactant. This factory use the simple process for manufacturing of white and black Soap by caustic soda, glycerine and fetty acids, vegetable, and animal oils all these are makeup in a big pot. Physico-chemical analyses of 24h composite samples were carried out according to APHA. The analysis covered chemical oxygen demand (COD), biochemical oxygen demand (BOD5), total suspended solids (TSS), suspended solids (SS), total dissolved solid(TDS), Acidity , Turbidity etc. All the parameter was determined according to APHA. In this study, we compare the effect of different Ozone doses like 19 mg/L, 21.58 mg/L and 30.70 mg/L ozone on wastewater parameter.

Treatment processes

The formation of oxygen into ozone occurs with the use of energy. This process is carried out by an electric discharge field as in the CD-type ozone generators (corona discharge simulation of the lightning), or by ultraviolet radiation as in UV-type ozone generators (simulation of the ultraviolet rays from the sun). In addition to these commercial methods, ozone may also be made through electrolytic and chemical reactions. In general, an ozonation system includes passing dry, clean air through a high voltage electric discharge, i.e., corona discharge, which creates and ozone concentration of approximately 1% or 10,000 mg/L. In treating small quantities of waste, the UV ozonators are the most common, while large-scale systems use either corona discharge or other bulk ozone-producing methods.

Experimental setup

The ozonation studies are conducted in a 28 cm long bubble column reactor of 6 cm diameter by varying the contact time at different ozone rates at room temperature. Ozone gas is generated by using Ozone Generator. The generator produced ozone by the corona discharge method using the oxygen as feed gas from an oxygen concentrator. The schematic of the experimental setup is shown in Figure a. Ozone generation is determined by measuring the gas flow rate after calibration. Ozone is supplied at the bottom of the reactor through a gas diffuser. One ozone trap containing 2% potassium iodide solution is connected in series with the reactor in order to collect unreacted ozone.

Ozonation Studies

The ozonation studies are conducted by varying the contact time at different ozone rate. All the studies are conducted in the laboratory at room temperature. 500 mL sample of the soap and detergent wastewater is filled in the borosil glass bubble column reactor, which

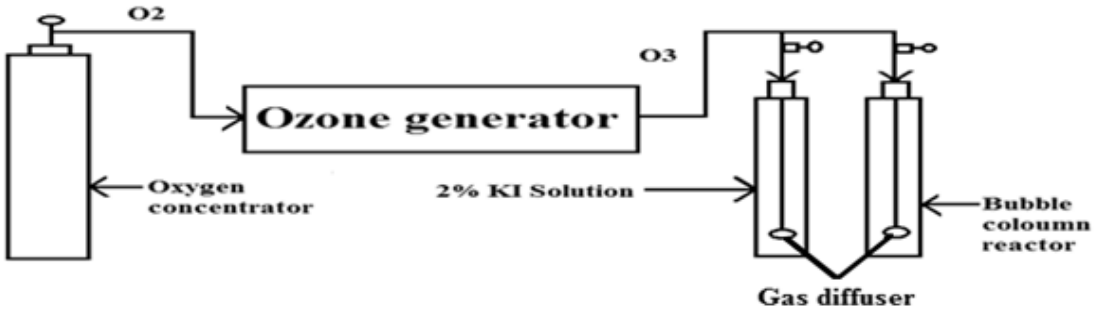

Fig. a. Schematic of the experimental setup.

are connected serially with one ozone trap containing 500 mL of 2% solution of aqueous potassium iodide. Ozone is bubbled through the aeration port of the reactor with the help of gas diffuser. The ozone gas is allowed to react with the sample for a specific time interval and 10 mL sample is withdrawn at every 2 minutes. The samples are analyzed for COD, BOD, TDS, TSS, DO and other parameters. The potassium iodide solution from the ozone trap is titrated with sodium thiosulphate to determine the amount of unreacted ozone in the outlet stream. Knowing the amount of ozone concentration in the feed gas stream, the amount of consumed ozone in the reactor is calculated. pH of wastewater is neutralized by addition of sulfuric acid to the wastewater and the applied ozone dose is kept constant at 30.70 mg/L. Wastewater parameters are measured at every 2 minutes. The ozonation reaction is conducted with different ozone dosing contact time to know the effect of ozone dose on wastewater parameter removal. The ozonation reaction is conducted at 19 mg/L, 21.58 mg/L and 30.70 mg/L to know the effect of ozone dose on wastewater parameters.

RESULTS AND DISCUSSION

Studies are carried out in order to investigate the effect of ozone on the COD, BOD, DO, TDS, TS, suspended solid, color and Alkalinity reduction of soap and Detergent industry wastewater and results obtained are discussed in following sections. Here all subsequent studies are done without any pH correction.

Influence of reaction time is studied for maximum reduction of effluent parameters of Soap and detergent industry wastewater. At neutral pH, ozone exclusively react with compounds with specific functional groups through selective direct reactions such as electrophilic, nucleophilic or dipolar addition reactions. Under neutral pH, the hydroxide ions catalyze the decomposition of ozone to yield highly reactive and nonselective hydroxyl radicals, which have an oxidation potential higher than that of ozone. The reaction time is varied between 2 to10 min in different experiments to study the influence of initial reaction time. Figure 1 to 9 shows effluent parameter's reduction at different reaction time with different Ozone doses. The All effluent parameter reduction at time 10 min was faster than those at other reaction

Table 1. Variation of ozone reaction time and COD reduction using 19, 20.58 and 30.7 mg/L ozone dose.

Ozone Reaction time (min)	COD Reduction with 19 mg/L ozone dose	COD Reduction with 21.58 mg/L ozone dose	COD Reduction with 30.70 mg/L ozone dose
0	2122.3	2122.3	2122.3
2	1910	1888.8	1697.84
4	1663	1599.7	1379.4
6	933.8	870	764
8	466.9	382	254.6
10	297	212.2	63.6

Table 2. Variation of ozone reaction time and turbidity reduction using ozone doses.

Ozone Reaction Time (min)	Turbidity reduction with19 mg/L ozone dose	Turbidity reduction with 21.58 mg/L ozone dose	Turbidity reduction with 30.70 mg/L ozone dose
0	873	873	873
2	715.86	663.4	488.8
4	619.8	550	428
6	454	358	262
8	297	209.5	174.6
10	87.3	78.5	35

Table 3. Variation of ozone reaction time and colour reduction using ozone dose.

Ozone reaction time (min)	Color reduction with 19 mg/L ozone dose	Color reduction with 21.58 mg/L ozone dose	Color reduction with 30.70 mg/L ozone dose
0	40.3	40.3	40.3
2	35.4	34.2	31.8
4	29.8	28.6	25.7
6	16.9	15.7	14.1
8	8.4	5.6	4.4
10	4.8	1.6	0.8

Table 4. Variation of ozone reaction time and increased total Solids using ozone doses.

Ozone reaction time (min)	Total Solids reduction with 19 mg/L ozone dose	Total Solids reduction with 21.58 mg/L ozone dose	Total Solids reduction with 30.70 mg/L ozone dose
0	1680.4	1680.4	1680.4
2	1693	1700	1732
4	1740	1784	1810
6	1768	1792	1888
8	1815	1881	1915
10	1888	1898	1963

Table 5. Variation of ozone reaction time and suspended solids reduction using

Ozone reaction time (min)	Suspended solids reduction with 19 mg/L ozone dose	Suspended solids reduction with 21.58 mg/L ozone dose	Suspended solids reduction with 30.70 mg/L ozone dose
0	684.2	684.2	684.3
2	574.7	554.2	465.2
4	431	396.8	355.7
6	294.2	212	191.5
8	157.3	82	60.4
10	75	27.3	13.6

time.

Effect of Ozone dose

Ozone application rate are varied at 19, 21.58 and 30.70 mg/L to assess the effect of the applied ozone dosage on COD, BOD and other parameters removal.

COD Reduction

Table 6. Variation of ozone reaction time and increased Total dissolved Solids using ozone doses.

Ozone reaction time (min)	TDS increase with 19 mg/L ozone dose	TDS increase with 21.58 mg/L ozone dose	TDS increase with 30.70 mg/L ozone dose
0	996.2	996.2	996.2
2	1118.3	1145.8	1266.8
4	1309	1387.2	1454.3
6	1473.8	1580	1696.5
8	1657.7	1799	1845.6
10	1813	1870.7	1949.6

Table 7. Variation of ozone reaction time and BOD reduction using 19, 20.58 and 30.7 mg/L ozone dose, Reaction time versus BOD.

Ozone reaction time (min)	BOD reduction with 19 mg/L ozone dose	BOD reduction with 21.58 mg/L ozone dose	BOD reduction with 30.70 mg/L ozone dose
0	709.2	709.2	709.2
2	652.4	624	581.5
4	539	510.6	461
6	319	297.8	248.2
8	141.8	127.6	99.2
10	99.2	85.1	28.3

The COD reduction of Soap and detergent industry wastewater as a function of the ozone reaction time for various ozone doses is present in Fig. 1. The doses of 19, 21.58 and 30.70 mg/L ozone gives overall percentage of COD reduction of 50.8%, 53.4% and 60.3% respectively at optimum ozone reaction time. The Ozone dose kept constant of 30.7mg/L.

Turbidity reduction

The turbidity reduction of Soap and detergent industry wastewater as a function of ozone reaction time for various ozone doses is presented in Fig (2). A dose of 19mg/L, 21.58mg/L and 30.70mg/L ozone has gives overall percentage of turbidity reduction is 50.2%, 57.4% and 68.2% respectively at optimum ozone doses.

Colour reduction

The colour reduction of Soap and detergent industry wastewater as a function of the initial ozone reaction time for various ozone doses is present in Fig. (3). A dose of 19, 21.58 and 30.70 mg/lit gives overall percentage of colour reduction of 52.6%, 57.4% and 61.8%

Table 8. Variation of ozone reaction time and increased alkalinity using ozone doses.

Ozone reaction time (min)	Alkalinity increase with 19 mg/L ozone dose	Alkalinity increase with 21.58 mg/L ozone dose	Alkalinity increase with 30.70 mg/L ozone dose
0	7000	7000	7000
2	7006	7119	7345
4	7119	7232	7541
6	7232	7684	8249
8	7458	7910	8588
10	7541	8249	9040

Table 9. Variation of reaction time and increased DO using ozone doses.

Ozone reaction time (min)	DO increase with 19 mg/L ozone dose	Do increase with 21.58 mg/L ozone dose	Do increase with 30.70 mg/L ozone dose
0	3.4	3.4	3.4
2	3.6	3.8	4.2
4	3.8	4.0	4.8
6	4.0	4.2	5.6
8	4.2	4.8	6.0
10	4.4	5.4	6.6

respectively at optimum ozone doses.

Total solids increase

The total solids increase of Soap and detergent industry wastewater as a function of the initial ozone reaction time for various ozone doses is present in Fig. (4). A dose of 19, 21.58 and 30.70 mg/L gives overall percentage of increased total solids of 6%, 7.7% and 10.6% respectively at optimum ozone doses. These percentage values of total solids are increased values after ozone treatment of untreated wastewater total solids value.

Suspended solids reduction

The suspended solids reduction of Soap and detergent industry wastewater as a function of the initial ozone reaction time for various ozone doses is present in Fig. (5). A dose of 19, 21.58 and 30.70 mg/L gives overall percentage of suspended solids reduction of 55.2%, 62.8% and 68% respectively at optimum ozone doses.

Total dissolved solids increase

The total dissolved solids increase of Soap and detergent industry wastewater as a function of the initial ozone reaction time for various ozone doses is present in Fig. (6). A dose of 19, 21.58 and 30.70 mg/L gives overall percentage of increased Total dissolved solids of 47.88%, 56% and 64.8% respectively at optimum ozone reaction time. These percentage values of total dissolved solids are increased values after ozone treatment of untreated wastewater total solid value.

BOD Reduction

The BOD reduction of wastewater as a function of the ozone reaction time for various ozone doses is present in Fig. (7). The doses of 19, 21.58 and 30.70 mg/L ozone gives overall percentage BOD reduction of 50.6%, 55.2% and 60.4% respectively at optimum ozone reaction time. The ozone doses kept constant of 30.70 mg/L.

Alkalinity increase

The alkalinity increase of Soap and detergent industry wastewater as a function of the initial ozone reaction time for various ozone doses is present in Fig. (8). A dose of 19, 21.58 and 30.70 mg/L ozone gives overall percentage of alkalinity reduction of 35.6%, 32.4% and 27.8%.

Dissolved oxygen increase

The dissolved oxygen increase of Soap and detergent industry wastewater as a function of the initial ozone reaction time for various ozone doses is present in Fig. (9). A dose of 19, 21.58 and 30.70 mg/L ozone gives overall percentage of increased dissolved oxygen of 17.6%, 30.5% and 60% respectively at optimum ozone doses. These percentage values of dissolved oxygen are increased values after ozonation process.

CONCLUSION

1. The Ozonation process for the treatment of Soap and detergent industry wastewater is effective. A dose of 19, 21.58 and 30.70 mg/L gives overall percentage of COD reduction of 50.8%, 53.4% and 60.8% respectively at optimum ozone reaction time respectively. COD reduction is found to extremely depend on ozone doses and reaction time. The total COD reduction is depending on ozone concentration and functional groups present in wastewater.
2. The overall percentage of Colour reduction of 52.6%, 57.4% and 61.8% are measured for 19, 21.58

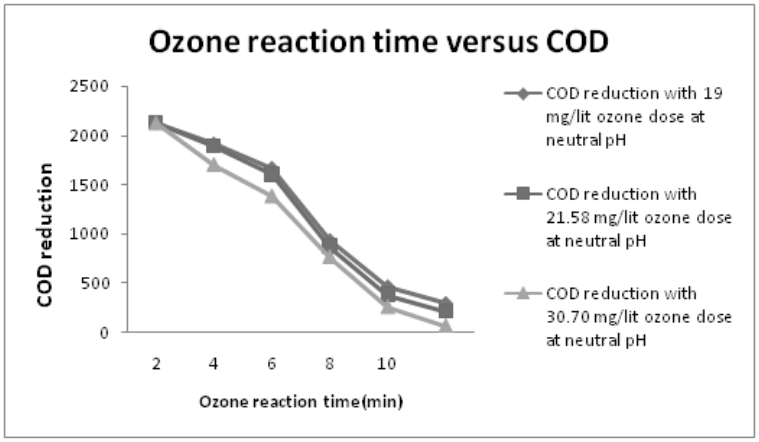

Fig. 1 Effect of ozone reaction time on COD reduction of Soap and detergent industry wastewater during ozonation. Ozone doses are 19mg/L, 21.58mg/L and 30.70 mg/L.

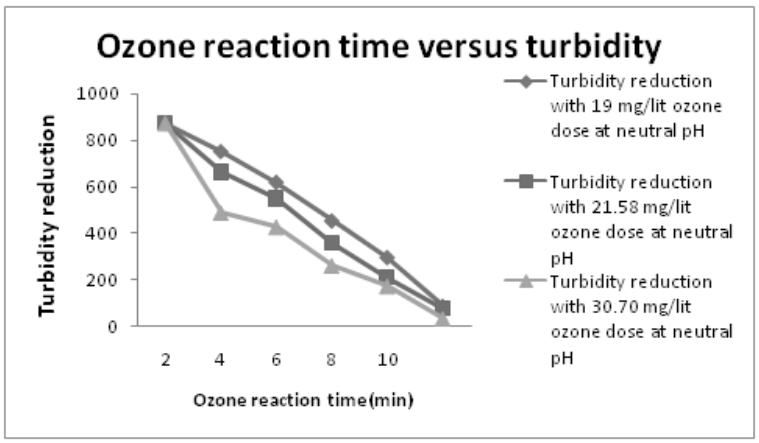

Fig. 2 Effect of ozone reaction time on Turbidity reduction of Soap and detergent industry wastewater during ozonation. Ozone doses are 19mg/L, 21.58mg/L and 30.70 mg/L.

Fig. 3 Effect of ozone reaction time on color reduction of Soap and detergent industry wastewater during ozonation. Ozone doses are 19mg/L, 21.58mg/L and 30.70 mg/L.

and 30.70 mg/L ozone doses respectively.

3. The overall percent of BOD reduction of 50.6%, 55.2% and 60.4% are measured for 19, 21.58 and 30.70 mg/L ozone doses respectively.
4. The overall percent of Turbidity reduction of 50.2%, 57.4% and 68.2% are measured for 19, 21.58 and 30.70 mg/L ozone doses respectively.
5. The overall percentage of alkalinity increase of 35.6%, 32.4% and 27.8% are measured for 19, 21.58, 30.70 mg/L ozone doses respectively.
6. The overall percentage of total solid of wastewater are increased from our actual value up to 6%, 7.7% and 10.6% are measured for 19, 21.58and 30.70 mg/L ozone doses respectively.
7. The overall percentage of dissolved oxygen are increased from our actual value up to 17.6%, 30.5% and 60% are measured for 19, 21.58 and 30.70 mg/L ozone doses respectively.
8. The overall percentage of total dissolved solids are increased from our actual value up to 47.88%, 54.86% and 64.8% are measured for 19, 21.58 and 30.70 ozone doses respectively.
9. The overall percentage of suspended solid reduction of 55.2%, 62.8% and 68% are measured for 19, 21.58 and 30.70 mg/L ozone doses respectively.

Based on all the experimental results it is concluded that the 30.70 mg/L ozone doses gives the good results as compared to the 19 mg/L and 21.58 mg/L ozone doses.

FUTURE SCOPE AND WORK

Industrial wastewater treatment generally has choice between biological and physico-chemical treatment technology, whereas, if the industries generate same characteristics of waste, then the treatment trains are also almost same (e.g. Sugar, Dairy, Distillery, Fertilizer and Textile Industries etc.). However, this does not hold good for Soap and detergent industrial waste. This is due to vary-

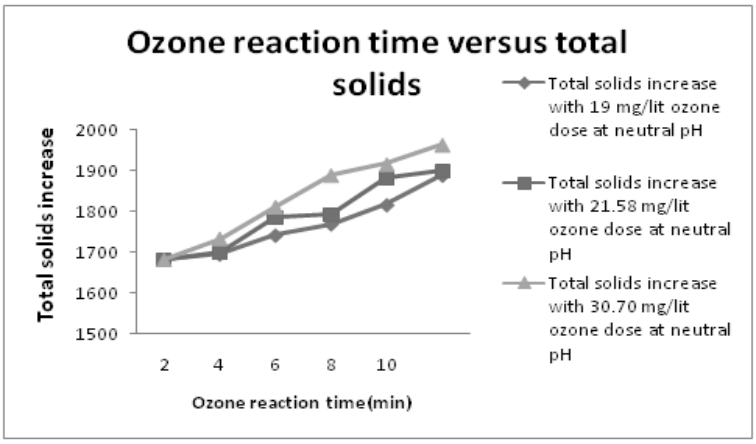

Fig. 4 Effect of ozone reaction time on total solids increase of Soap and detergent industry wastewater during ozonation. Ozone doses are 19, 21.58 and 30.70 mg/L.

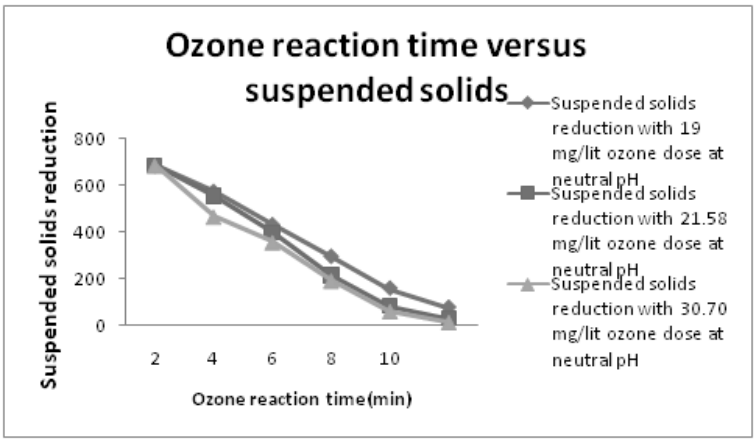

Fig. 5 Effect of ozone reaction time on suspended solids reduction of Soap and detergent industry wastewater during ozonation. Ozone doses are 19, 21.58 and 30.70 mg/L.

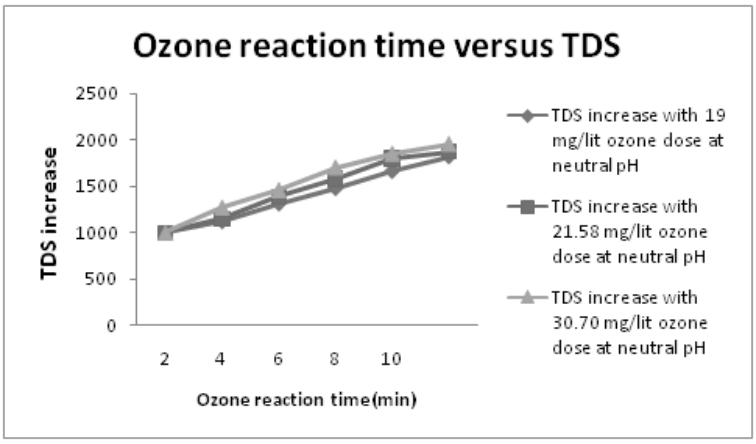

Fig. 6 Effect of ozone reaction time on Total dissolved solids increase of Soap and detergent industry wastewater during ozonation. Ozone doses are19, 21.58 and 30.70 mg/L.

ing type of Soap and detergent manufacturing units in different Soap and detergent industries and therefore, the waste generated is varying in quantity and quality.

1. The ozonation process has COD removal capacity hence pre or post ozonation along with ozonation process can be used for increasing the removal efficiency.
2. Ozonation process combined with Fenton, photo-Fenton, and H2O2/UV processes are effective for wastewater treatment of Soap and detergent manufacturer and Soap and detergent industry.
3. After treatment slight yellow color remains in the sample, it can be removed in the ozonation process.
4. BOD removal rate can be increased by addition of sewage sludge in the wastewater.
5. The combined ozonation and catalyst ozonation process for disposal of Soap and detergent industry wastewater is much easier to operate and costs much lower than other processes such as physical adsorption, chemical oxidation and conventional biological process.
6. Ozone as a standalone system or with UV/H_2O_2 can remove COD, BOD from water up to 90%. It also removes various dyes from the water effectively up to 99%. Additionally ozone can be used for cyanide removal from waste water. Pesticide industry also finds a wide application of ozone for breaking down the harmful chemicals in their wastewater and they are Reduces Chemical Oxygen Demand, Reduces Biological Oxygen Demand, Removes Colour, Reduces Oil and Grease, Removes Detergents, Reduces Pesticide, Reduces usage of Harmful Chemicals and Ecofriendly.

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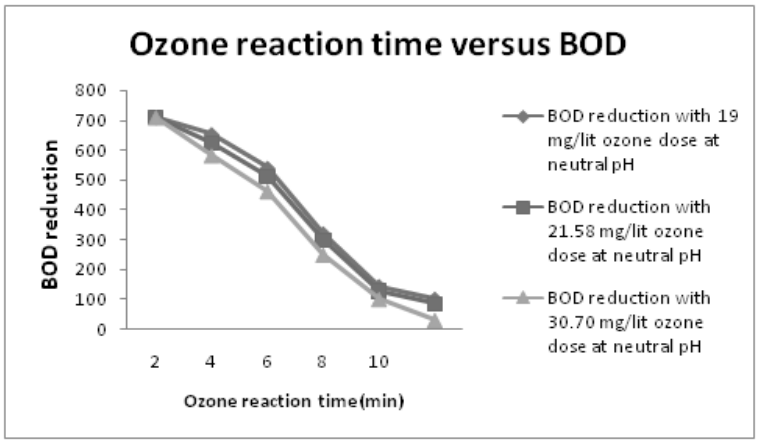

Fig. 7 Effect of reaction time on BOD reduction of soap and detergent industry wastewater during ozonation. Ozone doses are 19 mg/L, 21.58 mg/L and 30.70 mg/L.

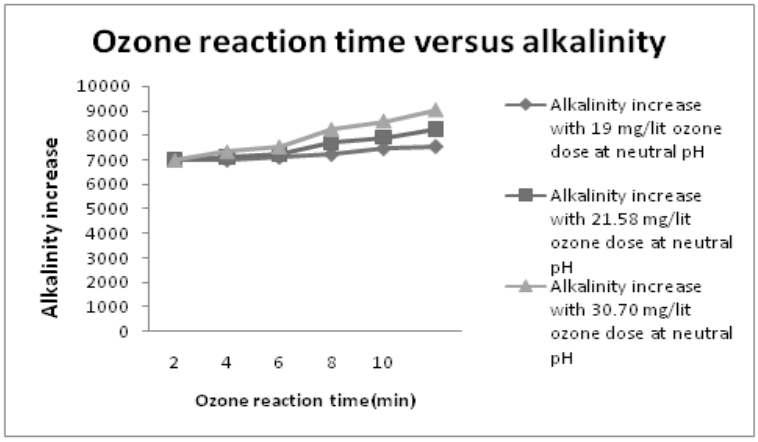

Fig. 8 Effect of ozone reaction time on Alkalinity increase of Soap and detergent industry wastewater during ozonation. Ozone doses are 19, 21.58 and 30.70 mg/L

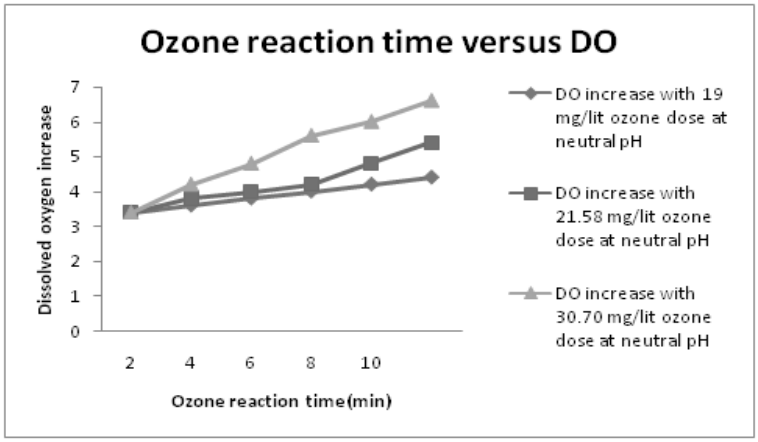

Fig. 9 Effect of ozone reaction time on DO increase of Soap and detergent industry wastewater during ozonation. Ozone doses are 19, 21.58, 30.70 mg/L ozone dose.

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