

Optimization of Biological Oxygen Demand Reduction from Textile Effluent by Oxidation

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Abstract: The textile dyeing and printing units in Sanganer town, Jaipur, Rajasthan, India. Discharge a huge volume of mostly untreated textile dye wastewater (10,000-15,000kl/day) into various pools and drain adjoining the textile printing units. A number of azo dyes are used in textile printing industries, As a result. The textile waste waters are loaded with them, along with other chemicals used during printing and fixing of dyes on cloth. The main cause of generation of this effluent is the use of huge volume of water either in the actual chemical processing or during re-processing in preparatory, dyeing, printing and finishing, which is responsible for higher biological oxygen demand(BOD), so currently these industries facing significant challenges, associated mainly with Environmental legislation because BOD removal reduction of could not be achieved, discharge effluent's concentration is too high from discharge limit prescribed by Rajasthan State Pollution Control Board, The objective of study is physiochemical analysis of water in study area and the BOD reduction in textile wastewater. For BOD reduction three oxidizers Hydrogen peroxide, Calcium hypochlorite, Potassium dichromate was used to compare their treatment efficiency at different temperature, dosages and retention time.

Keywords: Textile industry, Textile effluent, BOD reduction, Oxidizing reagents, Discharge limit.

I. Introduction

Textile is an important industry for Rajasthan, representing over 20 percent of the investment made to the state. Sanganer is located about 15 km out of Jaipur, the state capital population of more than two million people. The famous art of printing developed in Sanganer during the 18th century and attained its peak in the 19th century. There lent less efforts and innovative techniques established this art over the world. Until the latter half of the 19th century, with the exception off new mineral colors like Nilathotha (CuSO₄) and tin chloride (SnCl₂), all dyes used was vegetable or animal in origin .Now-a-days, this natural dyes to have been almost completely replaced by synthetic dyes. There are estimated to be around 500 block and screen printing units in Sanganer. According to be port of United Nations industrial development organization, the export from this sector is of Rs200-300 cores per annum. Thousands of local people are employed in these industries, and their whole families are dependent upon this trade. Environmental problems within the textile industry are mainly caused by discharges of waste water. Textile industry is categorized as a red industry, Textile processing employs a variety of chemicals, depending upon the nature of the raw material and product .Textile finishing industry uses amounts of water, mainly because of washing operations, fig 1. Shown the % water consumption in textile industry.

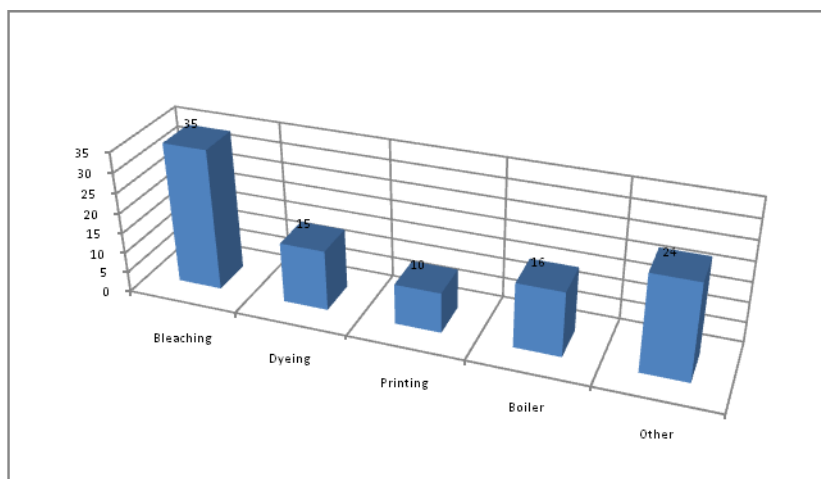


Fig. 1. % water consumed during wet processing in textile industry

Therefore, processing waste water have high- flow rates textile waste water contains substantial pollution loads in terms of COD, BOD, TSS, TDS and heavy metals. The value of these parameters is very high as compared against the values in Bureau of Indian standards (BIS) set by the government of India.

Characteristics of textile waste water are prerequisite for the investigation of treatment options. Ecological and toxicological problems due to the discharge of waste water from Sanganer textile industries in local drainage (Amani Shah Ka Nallah) have been one of the most important water pollution problems within this area. Studies have clearly indicated that the industrial effluents, which are directly discharged into the Amani Shah Ka Nallah, drainage contained highly mutagenic compounds. These compounds also contaminate the surface and even ground water, thereby, making it unfit for irrigation and drinking, Sanganer, a suburb of Jaipur is no exception to this. Direct dumping of industrial waste water in and around industrial areas causes the transfer of pollutants into the environment (Baslas and Singh, 1984). It can also lead to significant deterioration in the aesthetic value of down stream waters. The disposal fun treated textile waste water in Sanganer has contaminated ground water with heavy metals such as Zn,Ni,Cr,Cd,Pb,Cu, and Fe, which is reported in more than permissible limits by the Rajasthan State Pollution Control Board, Jaipur and other workers (Manivasakam, 1987; Usha,1989; Khanetal.,1995;Sharmaetal.,1999). The objectives of this study are to analyze the physicochemical properties of water (adjoining the textile effluent) which will help in identification of environmental impacts due to release of effluents and other wastes and treatment methods .In this study, we used three different Oxidants Hydrogen peroxide (H_2O_2), Calcium Hypochlorite [$Ca(OCl)_2$], potassium dichromate ($K_2Cr_2O_7$) to reduce the BOD of industrial waste water.

II. Study Area And Sampling

Sanganer town ($26^{\circ}49'$ - $26^{\circ}51'$ N latitude and $75^{\circ}46'$ - $75^{\circ}50'$ E longitude) lies about 16 km south of Jaipur city, the Rajasthan state capital in India that has a population of more than two million people. The total area of Sanganer is about 635.5 Sq. km out of which 12.9 Sq. km comprises the urban area.

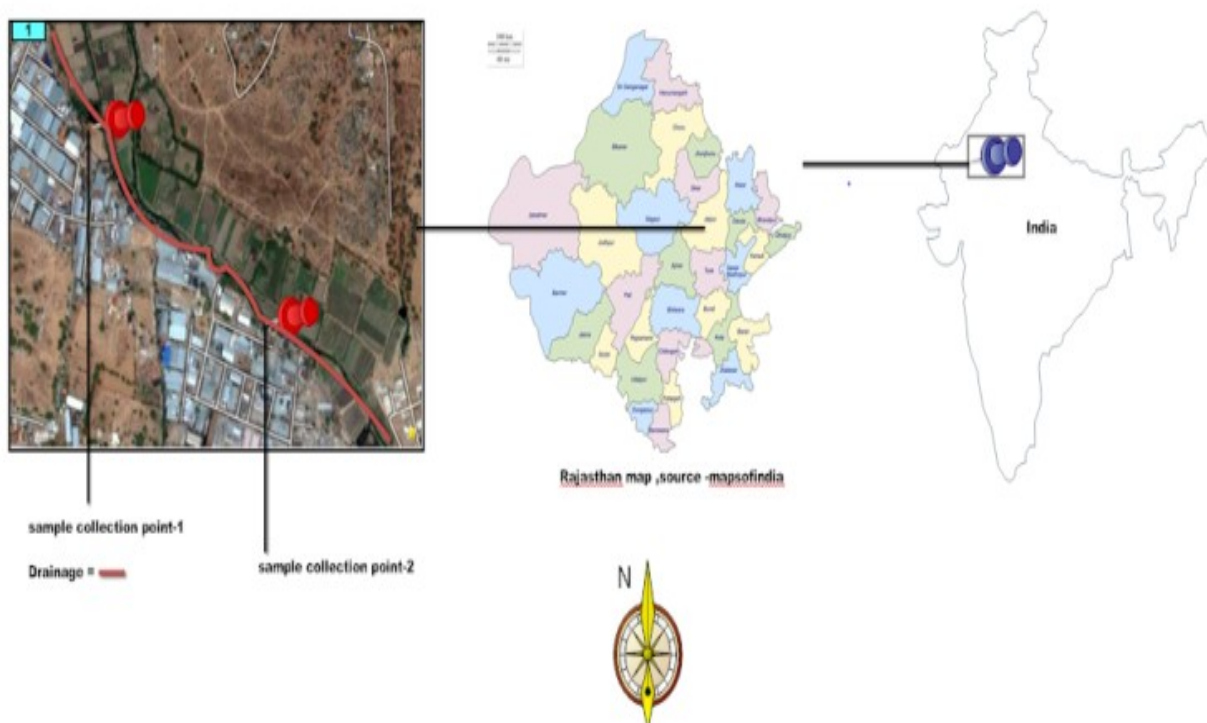


Fig. 2. Satellite view of sanganer textile industry area and effluent drainage (Jaipur, Rajasthan.)Indicating sampling points (post monsoon August 2012)

For this purpose two samples were collected during March 2012 (pre-monsoon) to August ,2012(post-monsoon)in good quality polyethylene bottles of one-litre capacity. Sampling has been carried out without adding any preservatives in well-rinsed bottles from different area of Sanganer and compares the BOD with the standards of water prescribed by state pollution and central board of Jaipur, Rajasthan, (India) as shown in fig.3

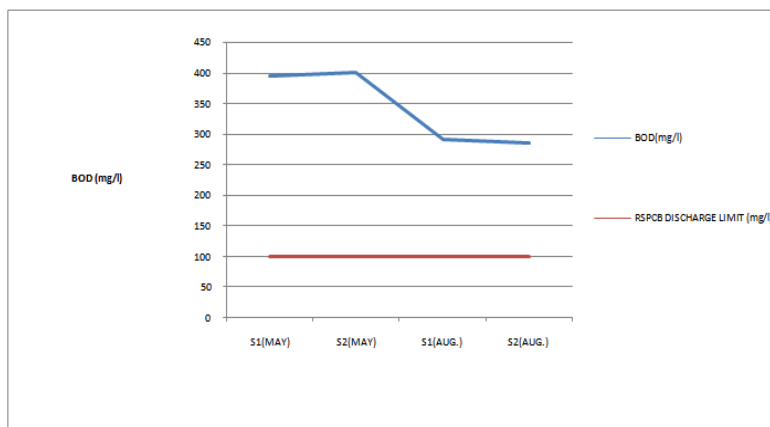


Fig.3. BOD analysis of sample (S1 and S2 collected during pre-monsoon and post monsoon), shown higher than the RSPCB (Rajasthan state pollution control board) discharge limit for textile and dyeing industry.

III. Material And Method

3.1 Physico-chemical analysis of sample water

The effluent samples were analyzed for pH, electrical conductivity (EC), total dissolved solids (TDS), biological oxygen demand (BOD), calcium and magnesium hardness, cations (Na^+ , K^+) and anions (Cl^-). Physicochemical Parameters of water were analyzed by standard methods (APHA, 1992).

Table 1: Physico-chemical properties of various effluent samples

Period	Sample No.	pH	E.C. (mmhos/ cm)	BOD (mg/L)	TDS (mg/L)	Cations (mg/L)		Anions (mg/L)
						Na+	K+	Cl-
May- 2012	S1	8.6	3.50	395	915	380	2.4	170
	S2	8.7	3.50	400	740	216	1.56	285
August-2012	S1	7.6	3.84	290	705	305	3.12	128
	S2	7.9	4.55	285	585	595	1.1	135

3.2 Physico-chemical analysis of soil adjoining area.

The samples of soil (adjoining the textile effluent) and effluent were collected from various sites of Sanganer region during different periods of the year (August and May 2012). The effluent samples were dark brown to black in colour and were giving pungent smell.

Table 1: Physico-chemical properties of various effluent soil samples

Period	Sample No.	pH	E.C. (mmhos)/cm	% O.M.	CF (mg/ 100g)
May 2012	S1	9.2	0.78	2.02	57
	S2	8.8	1.03	0.89	35
	S3	9.2	0.83	1.90	66
August 2012	S1	7.6	0.84	0.62	40
	S2	8.1	1.20	0.40	38

Here: EC= Electrical conductivity; OC= Organic carbon; OM= Organic matter.

3.3 Determination of biological oxygen demand

The BOD tests were carried out using standard procedure using a five-day BOD test. The method consists of filling with diluted and seeded sample, to overflowing, an airtight bottle of specified size and incubating it at the specified temperature for five days. Dissolved oxygen is measured initially and after incubation, and the BOD is computed from the difference between initial and final DO. Because the initial DO is determined shortly after the dilution is made, all oxygen uptake occurring after this measurement is included in the BOD measurement. Samples were diluted 15 times before the test followed by aeration to make sure enough dissolved oxygen (7.5 mg/l) will remain after five days of the test. 300 ml standard BOD bottles were used in these tests which were incubated at 20 °C in a dark incubator. After five days, the difference in oxygen consumption was measured to estimate BOD_5 .

3.3 Reduction of BOD by oxidizing reagents

All chemicals employed in this study were analytical grade. All solutions were prepared in distilled-deionized water made on each experimental day. Glassware used in this work was soaked with HNO_3 (~10%)

for 24 h, and rinsed with distilled-deionized water prior to drying. Batch experiments were conducted in the laboratory. In these experiments different types of oxidants such as (33%) Hydrogen peroxide (H_2O_2), Calcium Hypochlorite [$Ca(OCl)_2$] [MERCK, MB0M 600436, 30% Cl_2] and Potassium dichromate ($K_2Cr_2O_7$) [GR,MERCK,MC1M 610500] were used. Eight bottles were used in these tests having two of them without oxidants to check the initial BOD values, and for each oxidant, two bottles were used to check the accuracy of measurements. The pH of the aqueous solutions was adjusted with 1M H_2SO_4 or 1M NaOH solutions. Exact concentration was determined by standardizing them against a 0.1N sodium thiosulphate solution. 50ml of the sample was taken in a 250mL borosilicate flask, and the known amount of oxidant's solution was added. The flask contents were heated at 25°C,50°C, 100°C and then solution was left for 60 minutes, after words the BOD of this treated sample was determined. Once suitable oxidant was identified, the same dosage was used with variations of pH from 2 to 8 and retention time in order to check the effect of pH and the retention time 30 and 10 minutes in BOD removal.

IV. Experimental Result Analysis

4.1. Effect of Retention time and temperature

The experiments were carried out with the fixed dose of oxidants and pH whereas the retention time and temperature were varied from 10 to 60 min and 25°C to 100°C respectively, to determine the optimum value of retention time and temperature for BOD removal. The effects of different time and temperature is shown in figure 4 to 6, the removal of BOD increase with an increase the retention time and temperature with the same amount of oxidants and pH. It can be seen that the optimum BOD reduction at 100°C, when temperature increased, the rate of BOD reduction is increased because the higher temperature facilitated the high rate of reaction, and maximum BOD reduction were Obtained at lesser retention time.

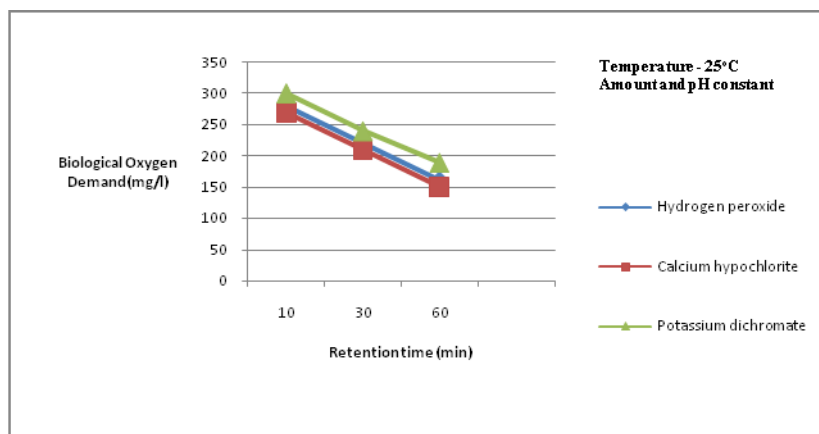


Fig. 4. Biological oxygen demand reduction at different retention time while temperature, amount and pH are constant (pH-3 to 6, temperature -25°C, amount-100 mg/l)

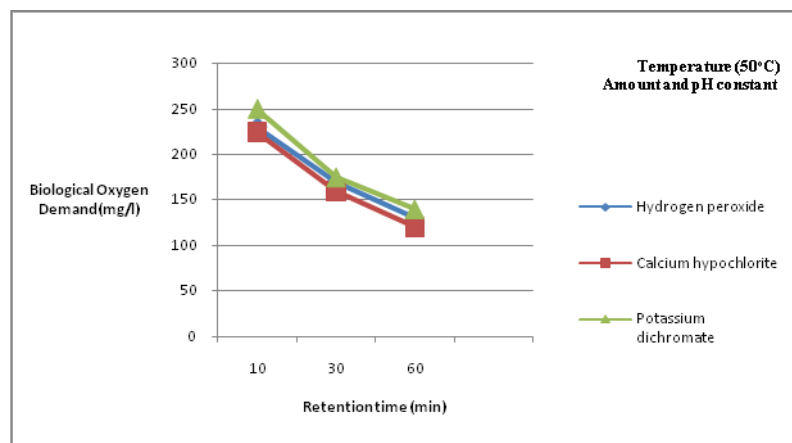


Fig. 5. Biological oxygen demand reduction at different retention time while temperature, amount and pH are constant (pH-3 to 6, temperature -50°C, amount-100 mg/l)

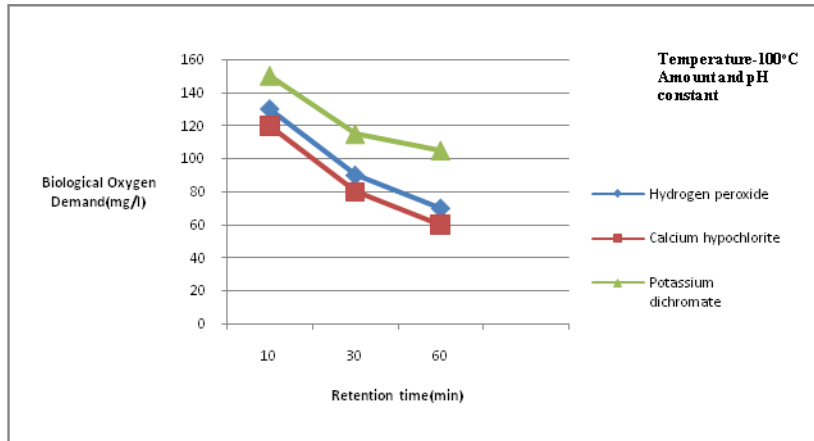


Fig. 6. Biological oxygen demand reduction at different retention time while temperature, amount and pH are constant (pH-3 to 6, temperature -100°C, amount-100 mg/l)

4.2 Effect of amount of oxidants

The effect on the amount of oxidants is shown in figure 7 to 9, at constant temperature (50oC) and retention time (30min) with the varied amount of oxidants. Removal of BOD increased in a dose of oxidants increased the optimum dose caused the substantial removal of the BOD, maximum BOD reduction observed at 300 to 400mg/l for Calcium Hypochlorite

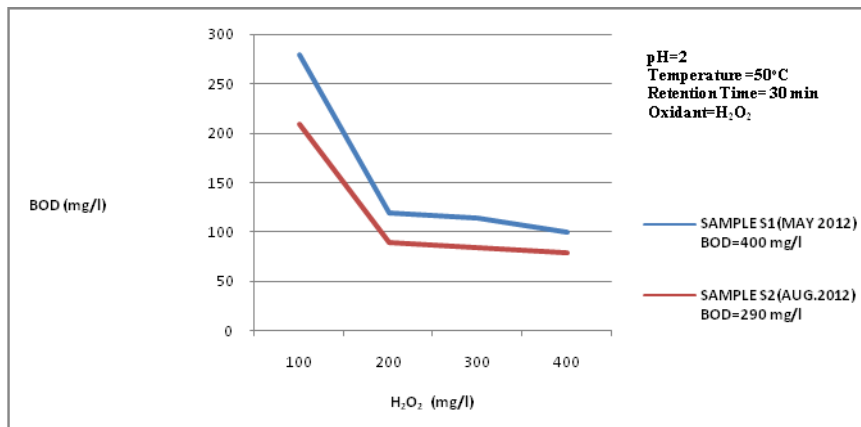


Fig. 7. H₂O₂ dosages effect on BOD reduction while other parameters (pH, retention time, temperature) are constant.

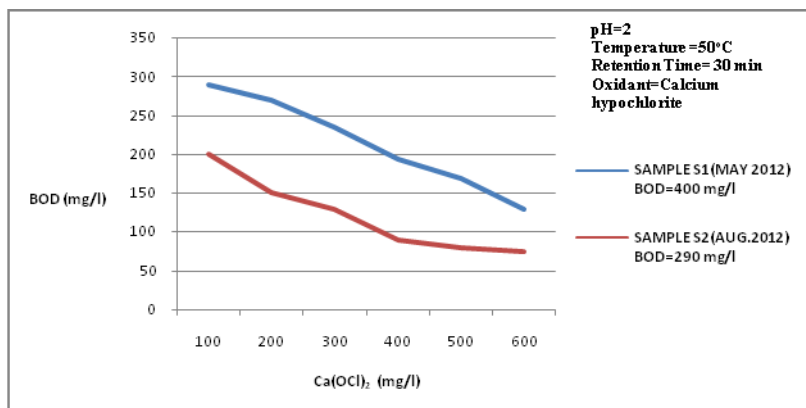


Fig. 8. Ca (OCl)₂ dosages effect on BOD reduction while other parameters (pH, retention time, temperature) are constant.

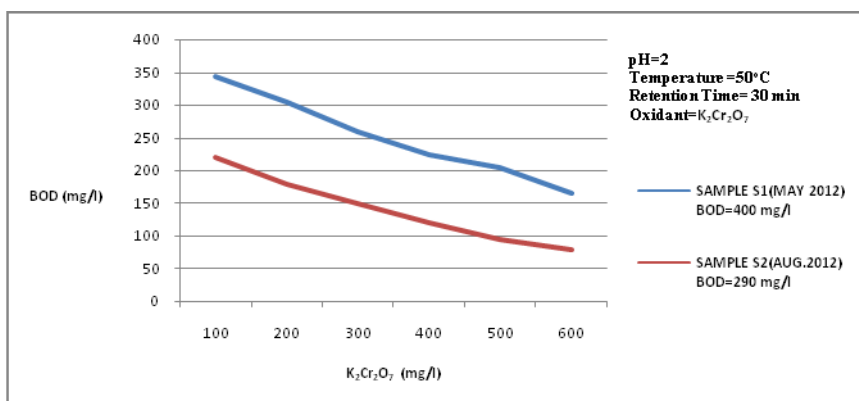


Fig. 9. K₂Cr₂O₇ dosages effect on BOD reduction while other parameters (pH, retention time, temperature) are constant.

4.3 Effect of pH on BOD reduction

To determine the optimum pH, pH was changed to 2-6 as shown in figure 9 at constant value of other variables (time, amount, temperature), the maximum BOD removal was observed at 4 for Hydrogen peroxide, 8 for Calcium Hypochlorite and Potassium dichromate.

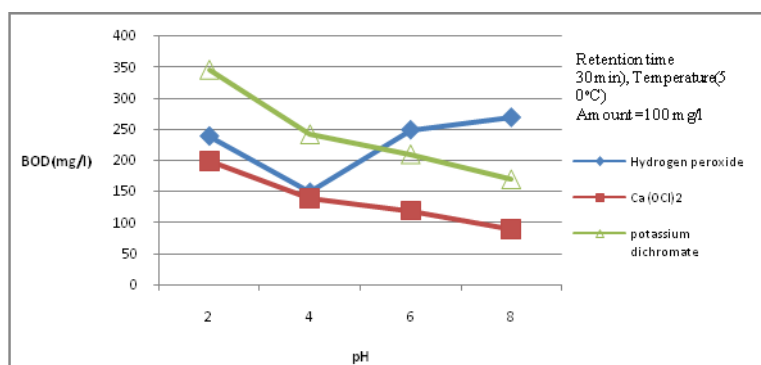


Fig. 10. effect of pH on BOD reduction while other parameters (retention time, temperature, and amount) are constant.

V. Conclusion

In the present investigation the Sanganer area was surveyed to assess the problem of textile industry pollution. The optimal physiological conditions were determined at lab scale that can be further scaled up and used for effluent treatment at industry level. In this study reduction of BOD of textile effluent was studied using three oxidants Hydrogen Peroxide, Calcium Hypochlorite and Potassium Dichromate, and study of physicochemical analysis of sample soil and water, the important parameters for oxidation process by the oxidants are retention time, the amount of oxidants and pH, results from the study show that following results:

1. Different samples of soils and water from the Sanganer area showed differences in the physico-chemical characteristics from one another with respect to chemical characteristics, as expected due to a relatively wide spectrum of dye manufacturing sources and due to presence of dyes and various types of organic and inorganic chemicals in the textile effluent.
2. The soil samples adjoining the textile effluent collected from agricultural region of Sanganer also showed great variation in the physico-chemical properties. The pH of the soil samples ranged from 7.6-9.2 and EC from 0.83-1.20 mmhos/cm and % organic matter (OM) of the soil samples ranged from 0.40-2.02. The Cl⁻ content in soil varied from 35-66 mg/100g of soil.
3. The pH of the effluents ranged from 7.6-7.9, electrical conductivity (EC) from 3.5-4.55 mmhos/cm and temperature between 25.0-29.0°C. Total dissolved solids were between 465-905 mg/L. Cation (Na⁺ and K⁺) and anion (Cl⁻) concentration in the effluent also showed wide variation. The results exhibited that cations ranged from Na⁺(216-595 mg/L) and K⁺(1.1-3.12 mg/L) and Cl⁻ ranged from (105-285mg/L). The calcium hardness (12-36 mg/L) and magnesium hardness (18-38 mg/L) also showed significant variation.
4. BOD concentration of discharge effluent in the drainage higher than the prescribed limit by Pollution-Control Board, Rajasthan (India).

5. When temperature increased than higher BOD reduction seen at lesser retention time, at 10 min retention time, 100°C BOD reduction similar to 50°C at 60 minute retention time.
6. Calcium hypochlorite reduced maximum BOD at given temperature and retention time compare to others due to availability of two (OCl⁻) per formula of Ca (OCl)₂ for oxidation.
7. Optimum pH, temperature and amount for Calcium hypochlorite are 4, 100°C, and 300-500 mg/l respectively.

The results obtained this study are expected to contribute to control the textile industry, Wastewater pollution and to protect aquatic environment.

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