Treatability study on Dye Intermediates Wastewater Using Advanced Oxidation Processes.

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ABSTRACT

This paper describes about the treatability study carried out on dye intermediates wastewater with different methods of Advanced Oxidation Processes. The entire treatability study has been carried out to get significant reduction in wastewater parameters of dye intermediates such as COD and COLOR. Different experiments based on Advanced Oxidation Process have been carried out of the dye intermediates wastewater and it has been studied that 98% color reduction has been gained with the treatment of Calcium Hypochlorite, 40 % reduction in COD with the treatment of Hydrodynamic Cavitation and 42% reduction in COD with the treatment of Ozonation.

1. INTRODUCTION

The wastewater generating from industries manufacturing dye intermediates is increasing day by day. The wastewater containing dye intermediates causes a critical environmental problem because of the toxicity of color, very high COD, low biodegradability and fluctuating pH. As this wastewater contains high COD, which is carcinogenic in nature, its disposal will pose a great threat to aquatic environment. These effluents contain color as the major pollutant which is the major source of aesthetic pollution.

Due to the presence of refractory organics in the wastewater containing dye intermediates, they are resistant to biological degradation when treated by biological treatment such as conventional aerobic and anaerobic. The dyes are known to be largely non-biodegradable under aerobic biological conditions and could get converted to more hazardous intermediates under anaerobic conditions.[1] Approximately about 10-20% of the total dye intermediates used in the dyeing process is released into the environment.

Wastewater containing dye intermediates can be treated with conventional biological treatment (aerobic and anaerobic), adsorption, coagulation and flocculation but the problem associated with these methods is these methods cannot degrade dye intermediates wastewater because of the complex and refractory nature of the dye intermediate molecules. Secondary Problem is these methods, transfer waste components from one phase to another phase do not involve chemical transformation of the compounds which is done by Advanced Oxidation Processes. [1] So, the crucial need arises for the effective treatment which will degrade or break down the bio refractory molecules into end products with the help of Hydroxyl Radicals which is known as Advanced Oxidation Process (AOPs). AOPs include techniques such as Hydrodynamic Cavitation, Ozonation, treatment with Sodium Hypochlorite, Calcium Hypochlorite etc.

Materials and Methods

Treatability studies on dye intermediates wastewater based on different methods of Advanced Oxidation Processes have been carried out which are as follows:

1. Treatment with Sodium Hypochlorite and Calcium Hypochlorite.

In this treatment, sample of dye intermediates wastewater was taken in a beaker placed on magnetic stirrer so that continuous and uniform mixing can be provided. Color of wastewater has been measured before and after the treatment. Sodium Hypochlorite and Calcium Hypochlorite were separately added to the different samples of dye intermediates wastewater with different doses and allowed to mix for 10-20 minutes in the magnetic stirrer. After 20 minutes, reduction in color of the wastewater was observed and the precipitates which were formed got settle down. Figure1 shows sample of dye intermediates wastewater kept on magnetic stirrer in which Sodium Hypochlorite was added.

Figure1: Sample of dye intermediates wastewater in which Sodium Hypochlorite is added.

2. Treatment with Hydrodynamic Cavitation.

Hydrodynamic Cavitation is one of the AOPs (Advanced Oxidation Processes) which is used for the degradation of wastewater containing dye intermediates. Hydrodynamic Cavitation uses cavitating devices such as Venturi and Orifice in order to provide cavitation to wastewater. It works on the Bernoulli's Principle. When wastewater passes through the converging section of Venturi, its kinetic energy increases and at the same time pressure also increases.[3]

When wastewater passes through the point of vena contracta or throat of Venturi, throttling occurs which is sufficient to decrease the pressure at that point below the vapour pressure of wastewater and at that time cavities or bubbles form. Mechanism of Hydrodynamic Cavitation is shown in figure 2. Now when wastewater passes through the diverging section of Venturi, pressure increases and gets recovered and at that time bubbles gets collapsed. When the bubbles gets collapsed it generates hotspots with the temperature of the order of 10,000 K. and pressures of about 1000 atm. [2] Under these conditions water molecules get dissociated into $OH^{\bullet}$ and $H^{\bullet}$ radicals.These OH• radicals then diffuses into the wastewater of dye intermediates where they react with organic and dangerous pollutants and oxidize/mineralize them. The two main mechanisms which are responsible for the degradation of pollutants using hydrodynamic cavitation are as follows. Firstly the thermal decomposition/pyrolysis of the volatile pollutant molecules takes place which are entrapped inside the cavity at the time of collapse of the cavity. Secondly, the reaction of $OH^{\bullet}$ radicals which occurs with the pollutant at the cavity interface of wastewater. [2] Bubbles which gets collapsed are of the size of 2 to 10 µm, above which the bubbles do not get collapsed and below which the conditions which are required for the formation of radicals are not met. [4]

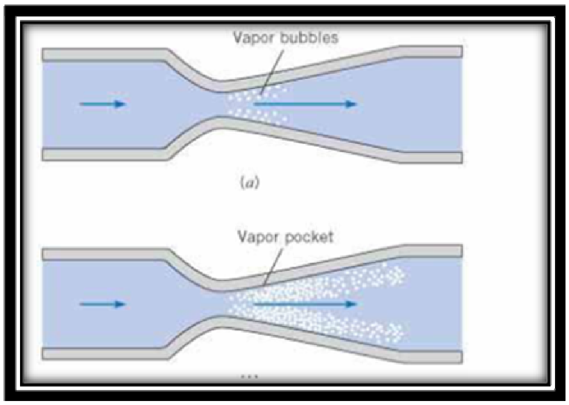

Figure 2: Mechanism of Hydrodynamic Cavitation

The hydrodynamic cavitation reactor used in the work (Fig.3) consisted of a Reactor of capacity 50 Litre which contained approximately 20 litres of dye Intermediate Wastewater. This reactor has been connected to a pump of capacity 1 H.P which pumped dye intermediates wastewater through pipe towards Venturi, a cavitating device and from the Venturi, wastewater flown back into the reactor which has been recirculated again. Pressure gauge has been attached for the regulation of pressure on the pipes which has been used to pump wastewater from pump to Venturi. Figure 4 shows wastewater resulting from the Venturi back into the reactor.

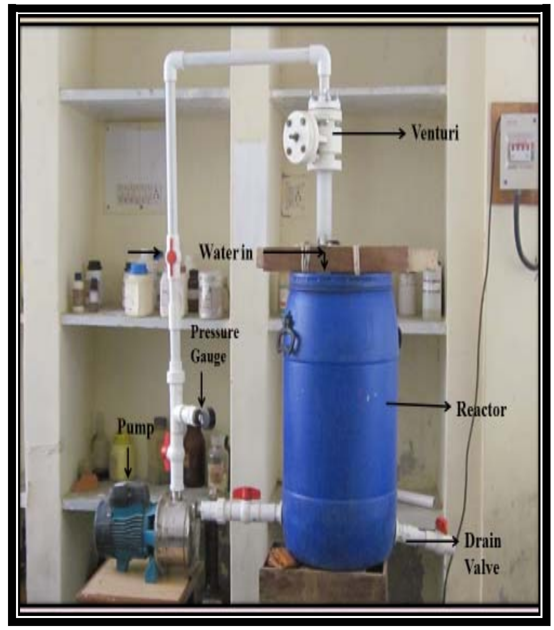

Figure 3: Hydrodynamic Cavitation Reactor

Figure 4: Wastewater resulting from Venturi back into the reactor.

3. Treatment with Ozonation

In this type of treatment, 1litre sample of dye intermediates wastewater has been taken in a beaker placed on ozonator and ozone has been supplied into the water for different interval of time. Figure 5 shows ozone supplied into the wastewater.

Figure: 5 Supply of Ozone into wastewater

Results and Discussion

1. Treatment with Sodium Hypochlorite and Calcium Hypochlorite

Different doses of Sodium Hypochlorite such as 10g/L, 20 g/L, 30g/L, 50g/L and 100 g/L were added to the dye intermediates wastewater having pH 9 and it has been observed as follows:

Sr. No.	Dose of Sodium Hypochlorite	Time	Reduction in COlOR
1.	100 g/L	24 h	96%

Different doses of Calcium Hypochlorite such as 10 g/L, 20 g/L, 30 g/L, 50 g/L, 100 g/L and 150 g/L were added to the wastewater having pH 9 and following results has been observed.

Sr. No.	Dose of Calcium Hypochlorite	Time	Reduction in COlOR
1.	150 g/L	24 h	98%

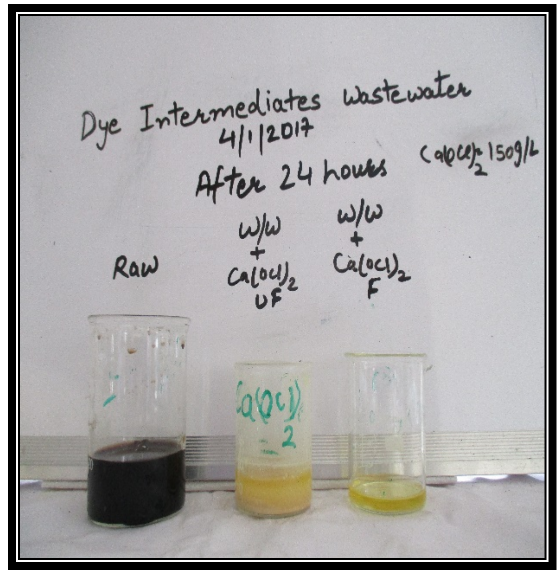

Figure 6: Color reduction on dosage of Calcium Hypochlorite

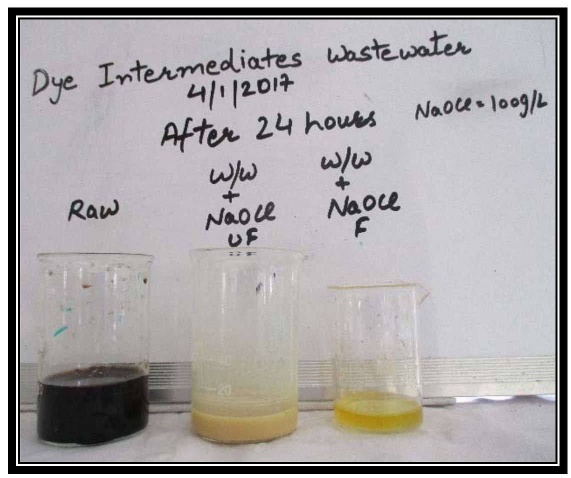

Figure 7: Color reduction on dosage of Sodium Hypochlorite

2. Treatment with Hydrodynamic Cavitation.

Dye intermediates wastewater having different pH was treated with Hydrodynamic Cavitation and the following results has been observed.

Sr.No.	pH	Time	Reduction in COD
1.	9	3 h	40%
2.	6	3 h	60%

1. **Treatment with Ozone**

Dye intermediates wastewater having different pH has been treated with Ozonation for different time interval and the following results has been observed.

Sr. No.	pH	Time	Reduction in COD
1.	9	1 h	20%
2.	6	3 h	42%

2. **Treatment with Hydrodynamic Cavitation followed by Ozonation.**

Sr.No.	Type of treatment	pH	Time	Reduction in COD
1.	Hydrodynamic Cavitation followed by Ozonation	6	3 h + 1h	50%

References

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