# Treatment of Dye Wastewater by Sonolysis Process

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**Abstract:**
*In a laboratory study, treatment of dye wastewater having high chemical oxygen demand (COD) in the range of 12000 to 13000 mg/L. by sonolysis was examined. Batch experiments were conducted to determine optimal sonolysis time (with and without dipping) to obtain the best results. In Sonolysis without dipping, the optimal time was 90 mins and 71.45% COD removal is obtained at pH 6. In Sonolysis with dipping, the optimal time was 90mins and 82.18% of COD removal is obtained at the same pH. These results suggest that, the Sonolysis (with dipping) process proved to be more efficient for removal of COD from the dye wastewater.*

**Keywords:** *Advanced oxidation process, COD removal, Dye wastewater, Sonolysis*

## 1. Introduction

The wastewater from dye manufacturing industry causes serious impact on natural water bodies and land in the surrounding area. High values of COD and BOD, presence of particulate matter and sediments, chemicals which are dark in color leading to turbidity in the effluents causes depletion of dissolved oxygen, which has an adverse effect on the marine ecological system. The improper handling of hazardous chemicals in waste water also has some serious impact on the health and safety of workers putting them into the high-risk bracket for contracting skin diseases like chemical burns, irritation, ulcers, etc.

Dye wastewater contains high organic loading, due to the high organic load, toxicity, biological processes cannot be used, since no COD removal is achieved biologically. Thus, a biological treatment is not feasible. In these cases, chemical pretreatment can adequately reduce the COD prior to biological treatment Sonication has been widely known to induce radical reactions. This useful property has found its applications in sonolysis of water, sonolytic degradation of aqueous organic pollutants, and sonochemical synthesis of chemicals. The underlying phenomena include cavitation, microstreaming, and localized supercritical conditions. These phenomena lead to sonolytic splitting of water as well as pyrolysis of a vaporized molecule.

In aqueous phase sonolysis, there are three potential sites for Sonochemical activity, namely:

1. The gaseous region of the cavitation bubble where volatile and hydrophobic species are easily degraded through pyrolytic reactions as well as reactions involving the participation of hydroxyl radicals with the latter being formed through water sonolysis:
   $H_2O \rightarrow H^{\cdot} + OH^{\cdot}$
2. The bubble–liquid interface where hydroxyl radicals are localized and, therefore, radical reactions predominate although pyrolytic reactions may also, to a lesser extent, occur and

3. The liquid bulk where secondary sonochemical activity may take place mainly due to free radicals that have escaped from the interface and migrated to the liquid bulk. It should be pointed out that hydroxyl radicals can recombine yielding hydrogen peroxide which may, in turn, react with hydrogen to regenerate hydroxyl radicals:

$$OH\cdot + OH\cdot \rightarrow H_2O_2$$

$$H_2O_2 + H\cdot \rightarrow H_2O + OH\cdot$$

**Table 1. Advantages of Sonication**

| No. | Advantage |
|---|---|
| 1 | Able to treat very toxic wastes at mild conditions. |
| 2 | Environmentally friendly technology using only electricity as a reactant. |
| 3 | The energy consumption depends on the chemical oxygen demand (COD). |
| 4 | The sonolysis - treatment can be simply stopped by switching the power off. |
| 5 | Cost effective and safe. |
| 6 | Fully-controlled by a computer. |
| 7 | Even effluents with low conductivity can be treated. |

## 2. Materials and Methods

### *2.1 Dye Wastewater*

The untreated wastewater samples were collected from the collection basin of an ETP of a Reactive dye manufacturing industry near Baroda, Gujarat. The sampling bottle was cleaned and rinsed carefully with distilled water and then with the effluent. About 2.5 cm air space is left in the bottle to facilitate mixing by shaking. Then samples were stored at 4°C within one to two hours of sample collection.

### *2.2 Experimental Procedure*

The experiments were performed in a round-bottomed flask. Thereafter, For Sonication, ultrasound stirrer is used with a frequency of 20 kHz for different time interval. Sample was kept for quiescent condition for 2 hours for the settlement of the precipitate. All experiments were carried out in batch mode. Several set of experiments were carried out to check the optimum range of sonication time.

**Fig. 1. Sonication Apparatus**

### *2.3 Sample Analysis*

pH of the sample is adjusted by using NaOH and measured by pH meter from the company EI products, Parwanoo (H.P), India. pH meter is calibrated by using commercially available Thallate buffer. Waste water sample is mixed with the help of Magnetic Stirrer from the company Remi Scientific Instruments ltd., Mumbai, India. Raw and treated waste water sample is analyzed for COD according to the methods summarized in the standard methods for the analysis of wastewater.

## 3. Results and Discussion

The wastewater characteristics play a significant role on its treatment. Raw wastewater parameters were measured and listed in Table 2. These results indicate that this wastewater contains high load of organic and inorganic matter. Therefore, this wastewater can cause damage to the environment when discharged directly without proper treatment.

**Table 2. Range of Characteristics of Raw Wastewater**

| Sr. | Characteristics | Values |
|---|---|---|
| 1 | Chemical Oxygen Demand | 12000-13000mg/l |
| 2 | pH | 5.9-6.5 |

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**Fig. 2. Raw Dye Wastewater**

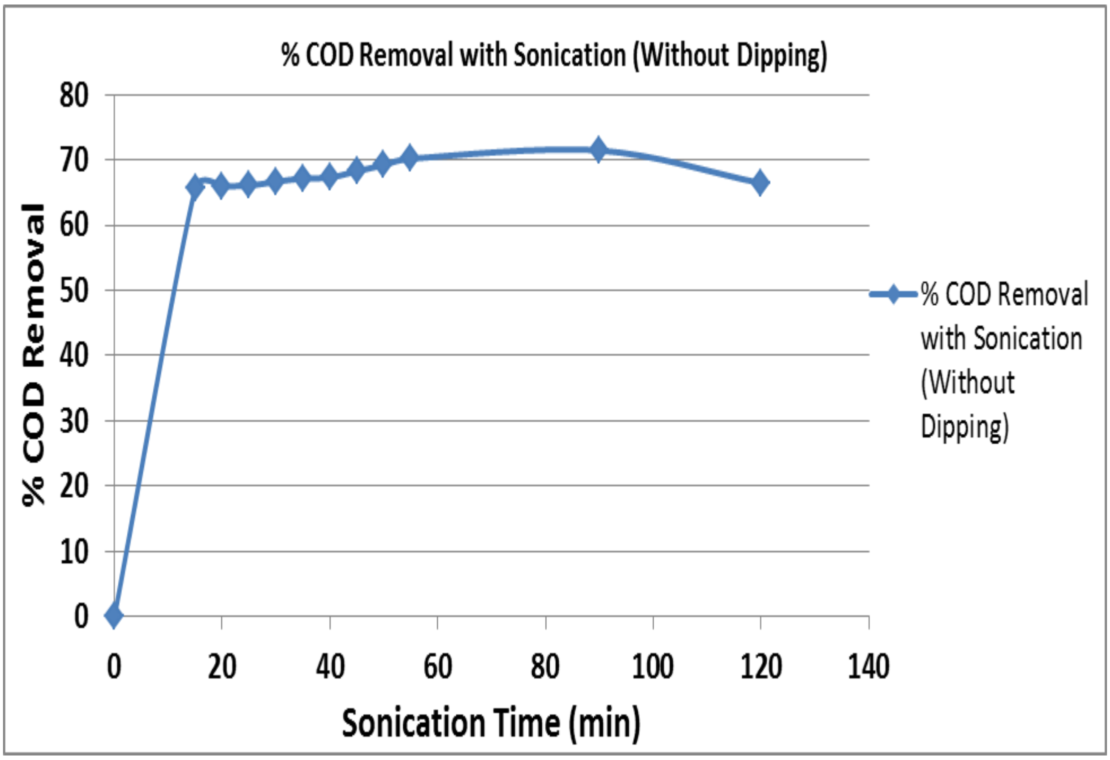


**Fig. 3. % COD Removal with Sonication (without dipping)**

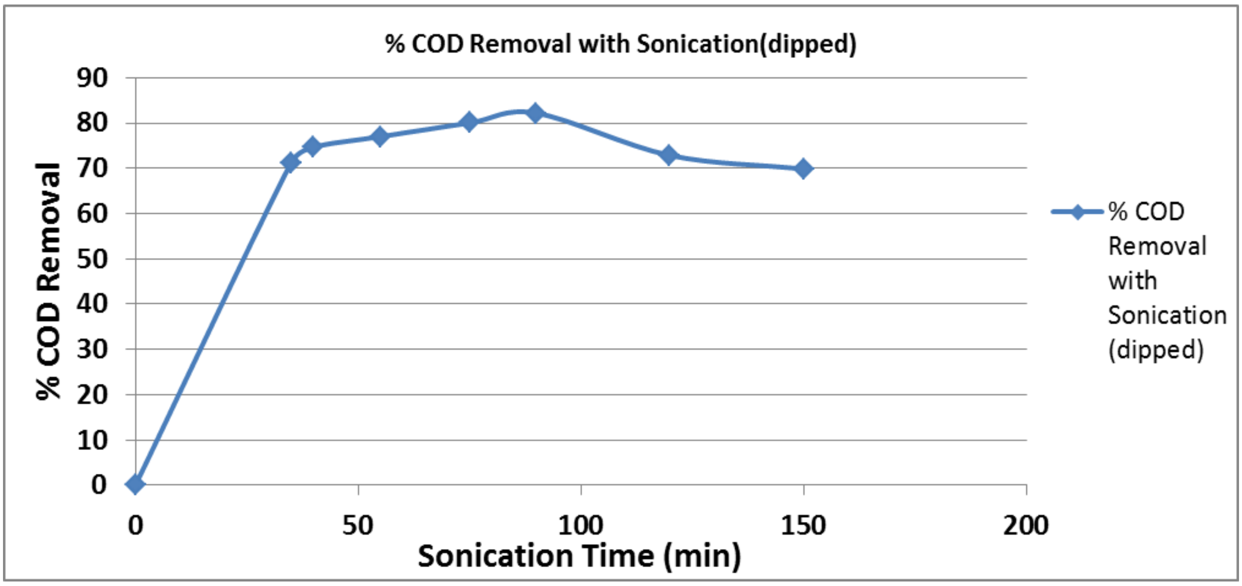


Fig. 5. % COD Removal with Sonication (dipped)

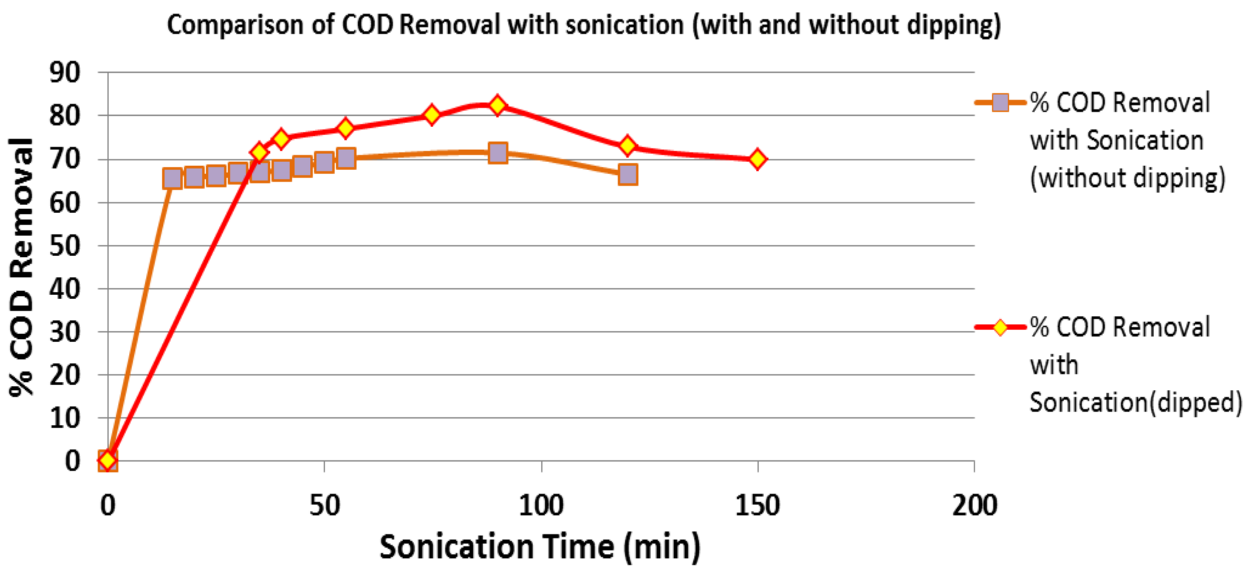


Fig. 4. Comparison of COD Removal with Sonication (with and without dipping)

Figure 6 Treated Dye Wastewater by Sonication

In this study, the effect of sonolysis was examined for the different time intervals from 0 to 120mins. The Sonication apparatus used was of 500W. With Sonication (without dipping), maximum COD removal achieved was 71.45% in 90mins as shown in Fig. 2 and for Sonication (with dipping), maximum COD removal achieved was 82.18% in 90 mins as shown in Fig 3. After 90 mins the degradation efficiency decreases as shown in the comparative Fig 4.

## 4. Conclusion

The degradation of wastewater from dye wastewater was investigated by the Sonication process. The Sonication process was done in two ways (with and without dipping). Therefore, maximum efficiency of COD removal is achieved at 90 mins, 82.18% with sonication dipped.

Sonophotocatalysis are eco-friendly way to reduce the pollution load of wastewater. These processes differ from the other treatments processes because wastewater compounds are degraded rather than concentrated or transferred into a different phase and secondary waste materials are not generated. Sludge generation is very less compare to other processes.

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