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Reduction of Chemical Oxygen Demand of the Industrial Effluent by Fenton Process, Fenton-UV Process, Fenton-Solar Process, Fenton-UV-Solar Process a Comparative Study

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***Abstract*: The industries are bearing with the high concentration of COD in the industrial wastewater, which is to be reduced within the acceptable limits given by the state pollution control board (SPCB). The Fenton process is a conventional process to reduce the COD of the effluent, but has a disadvantage of large production of ferric hydroxide during the Fenton Reaction. But to overcome the disadvantage of sludge formation of hydroxide, employment of the additional process of solar and photo Fenton. By employing the process COD reduction of the effluent is increased. This research presents a comparative study of the reduction of COD of the effluent taken from the industry, which was treated by Solar-Fenton process, Photo-Fenton process and Solar-Photo Fenton process. The experimental results revealed that compared with conventional Fenton process, reduction in Chemical Oxygen Demand (COD) increased by applying the Solar-Fenton as well as Photo-Fenton Process and both. The important conclusion from the research is that every Advance Oxidation Processes (including Fenton) dependent on many process parameters. Temperature effect, initial pH effect, H_2O_2 dose, Fe^{+2} concentrations, and most important reaction time were checked and analyzed for reducing the COD. The key point of this research is Reduction of COD using conventional Fenton process followed by UV/solar process. However, using solar energy (renewable source) in place of UV also give same results. It's a greener approach.**

Keywords—COD-Chemical Oxygen Demand, Advanced Oxidation Processes, Fenton, Photo Fenton, Solar Fenton;

I. INTRODUCTION

Advanced oxidation processes (AOPs) are frequently used to oxidize complex organic constituents found in wastewaters which are difficult to be degraded biologically into simpler end products. [9] Fenton oxidation is particularly attractive because of its simplicity without requirement for special equipment and high efficiency in organic pollutant removal. In Fenton reaction, highly reactive hydroxyl radicals (OH^0) are generated. [6]

$$OH^\circ + H_2O_2 \rightarrow \cdot O_2H + H_2O$$
$$OH^\circ + Fe^{3+} \rightarrow Fe^{2+} + OH^-$$

For the photo Fenton process, we employed UV light as it is capable of irradiating the effluent and more reduction and efficiency can be achieved by the process. In solar Fenton process, we have used the Natural source of constant energy- The sun for the same purpose.[4]

II. MATERIALS AND METHOD

Sample of the effluent with higher COD values was taken in a glass reactor (Fig.1) and pH of the sample was adjusted between 2 to 3. As a part of Fenton process calculated amount of $FeSO_4.7H_2O$ and H_2O_2 were added with continued aeration from one to two hours. Sample was drawn and analysed for COD. Above treated sample was divided into two batches, one for solar Fenton process and one for photo-Fenton process followed by solar process (Fig.4). Samples were drawn at every stage for analysing COD. [2]

III. EXPERIMENTAL SETUP

- The experimental setup for the Fenton process, Fenton+ UV process, Fenton+ Solar process is as shown in below figures:
  1. For the sample of effluent taken from the Effluent treatment plant:

Fig. 1 Glass Reactor with bubbler for Fenton process

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A) Color: Reddish- brown
B) Initial P^H: 6.48
C) Final P^H : 2.67(after adding 15 ml of 1 N HCL)
D) Volume of the effluent : 2000 ml
E) Capacity of the glass reactor : 3000 ml
F) Reaction time: 1 Hr.

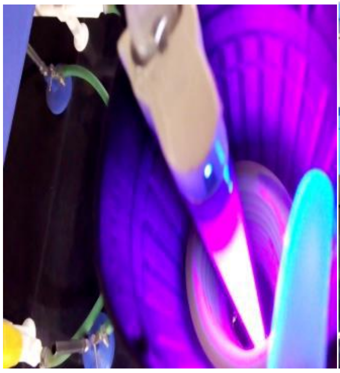


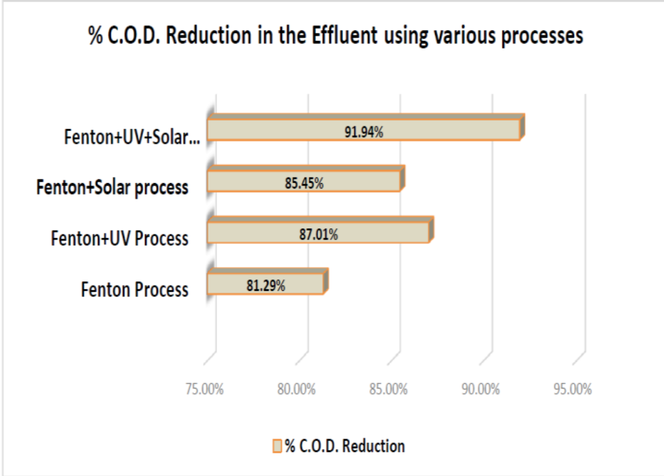
Fig. 2 Fenton UV

Fig. 3 UV light

Fig. 4 Solar Fenton setup

For the Fenton process: [2]
I. Amount of 2 % $FeSO_4.7H_2O$ added: 20 ml
II. Amount of 30 % H_2O_2 added: 40 ml
Observation:

Sr. No	Process	Reaction time	COD of the effluent	Final COD	%COD. Reduction
		(in Hours)	(in ppm)	(in ppm)	
1	Fenton	1 Hour	7700	1440	81.29
2	Fenton+UV	1 Hour	7700	1000	87.01
3	Fenton+Solar	1 Hour	7700	1120	85.45
4	Fenton +UV+ Solar	1 Hour	7700	620	91.94



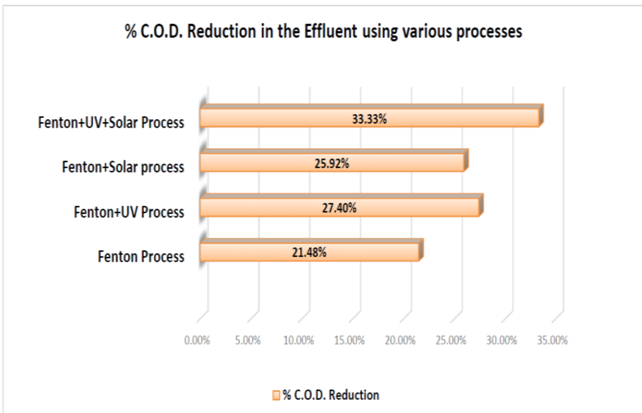
Graph (1) COD reduction for wastewater of Effluent treatment plant

2. For the sample of effluent taken from the Pharmaceutical industry:

A) Color: yellowish- orange
B) Initial P^H:8.211
C) Final P^H : 2.92(after adding 200 ml of 0.1 N HCL)
D) Volume of the effluent : 2000 ml
E) Capacity of the glass reactor : 3000 ml
F) Reaction time: 2 Hr.

Observation Table:

Sr. No	Process	Reaction time	COD of the effluent	Final COD	%COD. Reduction
		(in Hours)	(in ppm)	(in ppm)	
1	Fenton	2 Hour	27000	21200	21.45
2	Fenton+UV	2 Hour	27000	19600	27.40
3	Fenton+Solar	2 Hour	27000	20000	25.92
4	Fenton+UV+Solar	2 Hour	27000	18000	33.33



Graph (2) COD reduction for wastewater of pharmaceutical industry

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IV. RESULT AND CONCLUSION

1. Temperature effect

Fenton's oxidation studies reported that there is an optimum temperature before treatment efficiency drops. The optimum temperature is found at 45^0 C Most probably the generation rate of OH^0 is enabled at a high temperature but when the temperature approaches 60^0 C, hydrogen peroxide undergoes self-accelerating decomposition. Thus reduces the concentration of OH^0. [7]

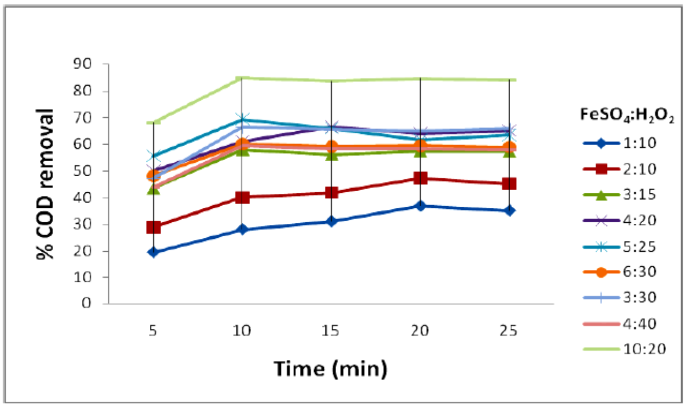
2. Initial pH effect

The reaction pH for Fenton's oxidation should in between 2 to 4. Some studies reported an optimum pH of 3. In this study, pH 2.5 is the optimum pH. [1]

3. Influence of H_2O_2 dose on COD

The presence of H_2O_2 in high quantity can act as a scavenger for the OH radicals. Also, additional H_2O_2 causes problem in downstream processes and will prevent waste water biological treatment. [3]

4. Effect of reaction time in reduction of COD



Graph (3). Initial Concentration optimization and feed ratio

Reaction time is an important factor. The reaction time for Fenton process in our study has been fluctuated between 30 min and 2 hour. [7]

5. Effect of Fe^{2+} concentration on COD

Based on operational cost and organic material removal efficiency, doses of Fenton reagents will be determined. (Graph (3)) Generally removal of organic matters improves with increasing concentration of iron salt. However, the removal increment may be marginal when the concentration of iron salt is high. [1]

❖ *Key points of the research study*

Reduction of COD using conventional Fenton Process is followed by UV/ solar process. However, using solar energy (conventional source) in place of UV also gave the same results. It's a greener approach. It's not clearly an advanced oxidation process but UV or solar process increases the mobility of free OH radicals ultimately increasing the efficiency of the process. Magnetic/Mechanical stirring is replaced by air bubbling (aeration) which helps in maintaining the DO level of the effluent helping in the secondary and tertiary treatments. Scale up of solar process may not be so difficult as UV process.

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