DEGRADATION OF A TEXTILE REACTIVE AZO DYE BY A COUPLED CHEMICAL-BIOLOGICAL PROCESS: OPTIMIZATION OF PROCESS PARAMETERS – STATE OF THE ART

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Abstract

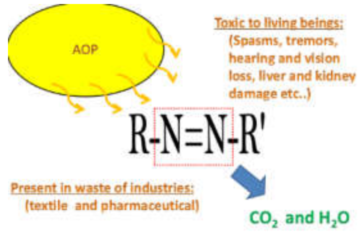
Advanced oxidation processes (AOPs) offer a highly reactive non-specific oxidant called hydroxyl radicals (HO), capable of destroying a wide range of organic pollutants in water and wastewater. Therefore, the Fenton's reaction was employed in the current work as a pre-treatment for further aerobic treatment with the microbes of Reactive black 5 dye. This work is, to the best of our knowledge, the first study that combines Fenton's reagent, as a pretreatment, with biological treatment using sludge as a secondary treatment.

1.0.INTRODUCTION

Textile wastewaters are strongly colored and contain high amounts of organic matter depending on forms of dyes and auxiliary chemicals. Effluent of textile industry contains high content of dyestuffs, surfactants and additives, which generally are organic compounds of complex structures.

Among 20–30 different chemical or chromophore structure dye groups, anthraquinone, phthalocyanine, triarylmethane and azo dyes are quantitatively the most important groups. Azo dyes are synthetic organic compounds widely used in textile dyeing, paper printing and other industrial processes such as the manufacture of pharmaceutical drugs, toys and foods

The reactive azo dyes are highly recalcitrant to conventional wastewater treatment processes. In fact, as much as 90% of reactive dyes can remain unaffected after activated sludge treatment. The traditional treatment techniques applied in textile wastewaters, such as chemical coagulation/flocculation, membrane separation (ultrafiltration, reverse osmosis) or activated carbon adsorption only does a phase transfer of the pollutant. Therefore, alternative methods should be implemented for effective pollution abatement of dyed effluents.



2.0.LITERATURE REVIEW – SUMMARY

It was realized that Azo dye contamination is a serious concern locally as well globally which warrants effective steps to prevent the attendant problems of contamination/pollution. Various technologies such as thermal treatment, soil washing, bioventing, air sparging, adsorption, electrochemical oxidation, electrokinetic remediation, biodegradation and AOPs have been reported effective for decontamination of petroleum hydrocarbons. But before applying any technology estimation of dye contamination level and depth should be done. Various estimation theories, methods and softwares are available but most of them are mathematical models and show some limitations when applied in reality. Therefore, there is a need for development of an accurate and practically applicable estimation method.

Advanced Oxidation Processes such as: Fenton, photo-Fenton and photocatalytic processes, in combination with biological treatment are the treatment technologies which fulfill the requirements of 21st century's waste treatment. These processes using hydroxyl radicals degrade a large variety of petroleum hydrocarbons. Moreover they can be performed in presence of sunlight, both in situ and ex situ, which reduces the need of energy. This method has been worked upon by various researchers; therefore, more and more inventions are being made to further increase its practical applicability.

3.0.RESEARCH GAPS

1. Inconsistencies reported in the optimized values of process parameters, used in Fenton mediated AOP treatment, depict that research is still required in this direction.

2. Optimization of process parameters using multivariate statistical approach has not been studied widely in AOP mediated treatment, therefore in this Box Behnken approach will be used for optimization of process parameters

3. Complete treatment of Azo dye using coupled AOP and Biological treatment has not been studied widely.

4. Synergy effect of different AOPs: Fenton, Photofenton and Photocatalytic processes has been not been studied for the treatment of Azo contaminated waters

4.0.OBJECTIVES

1. Evaluation of AOPs for the treatment of the azo dye contaminated water

2. Evaluation of the bio-compatibilty (biodegradability) of the photochemically pretreated solution.

3. Proposition of a general strategy to develop combined photochemical and biological system for the treatment of azo contaminated water and textile industry waste water.

4. Evaluation of the performance of coupled chemical-biological treatment system at lab scale for treatment of azo contaminated water and textile industry waste water.

5. Evaluation of the effects of UV in enhancement of treatment of dye contaminated water.

5.0.STATISTICAL ANALYSIS

For Fenton

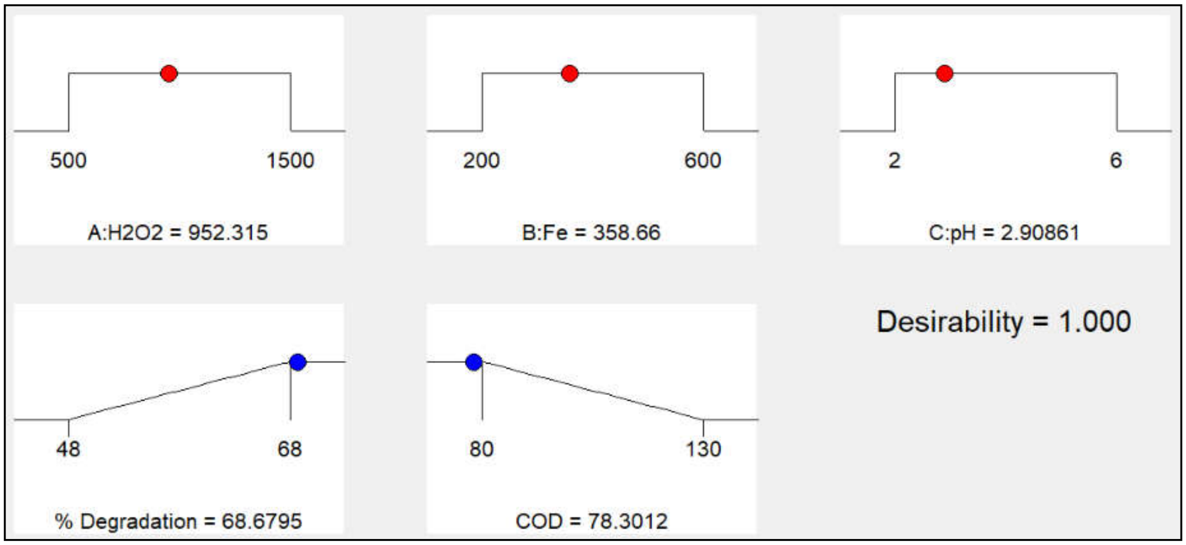
$$X_1 = 68 + 0.88\,Y_1 + 0.13Y_2 - 5Y_3 - 0.25Y_1Y_2 - 0.50Y_1Y_3 + 1.50Y_2Y_3 - 7.38\,Y_1^2 - 4.38Y_2^2 - 6.13Y_3^2$$

$$X_2 = 80 - 2.19Y_1 - 0.31Y_2 + 12.50Y_3 + 0.62\,Y_1Y_2 + 1.25Y_1Y_3 - 3.75Y_2Y_3 + 18.44Y_1^2 + 10.94Y_2^2 + 15.31Y_3^2$$

5.1.Maximum values of responses at optimum condition in Fenton treatment

S.No.	Control Parameters	Symbolic representation	Maximum values for Responses
			% degradation ($X_1 = 68.68$)
1	$FeSO_4.H_2O$	Y_1	358.66
2	H_2O_2	Y_2	952.32
3	pH	Y_3	2.9

5.2.Results of optimization



5.3.Effects of H_2O_2 concentration in Fenton

From the results, it can be interpreted that up to certain concentration of H_2O_2, the COD removal and % degradation increased with increase in concentration of H_2O_2. Beyond this concentration of H_2O_2 increase in COD degradation is only marginal, in case of Fenton process. In case of photo Fenton process, the COD degradation increases with the increase in H_2O_2 concentration. Therefore, 952 mg/L of H_2O_2 concentration was chosen as the optimal concentration for Fenton process At these optimal concentrations of H_2O_2, about 68.68% of % degradation was reported for Fenton.

Being an oxidizing agent, H_2O_2 reduces the COD of the leachate by organic and inorganic compounds present in leachate, into free radical molecules. These free radicals react with oxygen available in the reaction mixture and yield peroxyl radicals (Kang, 2000). When the concentration of H_2O_2 exceeds its optimal value, the oxidizing effects might have decreased due to the radical scavenging. In the process of radical scavenging, the excess H_2O_2 present reported to react with OH radicals to produce HO_2 radicals and in turn both HO_2 and OH radicals react to form H_2O molecules (Primo, 2008; Talini, 1992). Thus, an ultimate reduction in the concentration of OH radicals was reported, which resulted in lesser COD removal (Talini, 1992).

5.4.Effects of FeSO4.7H2O concentration in Fenton

Being an oxidizing agent, H_2O_2 reduces the COD of the leachate by organic and inorganic compounds present in leachate, into free radical molecules. These free radicals react with oxygen available in the reaction mixture and yield peroxyl radicals (Kang, 2000). When the concentration of H_2O_2 exceeds In case of Fenton process, initially by increasing concentration of Fe^{2+} up to 358.66 mg/L, the COD degradation rate increased, beyond which decrease was reported.

$FeSO_4.7H_2O$ when introduced in reaction mixture produces Fe^{2+} ions that act as oxidizing agents in Fenton and photo Fenton processes. But when introduced in excess, Fe^{2+} ions lead to formation of Fe^{3+}, on reacting with OH radicals. These Fe^{3+} molecules further react with OH^- ions to produce FeOH. Hence, excess Fe^{2+} ions reduce the concentration of OH radicals (Walling, 1970; Deng and Englehardt, 2006).

6.0. RESULTS

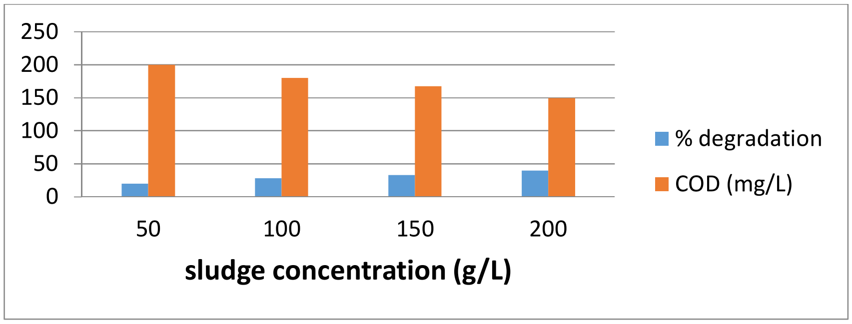


Fig 1.1: Optimum sludge concentration for Dye removal

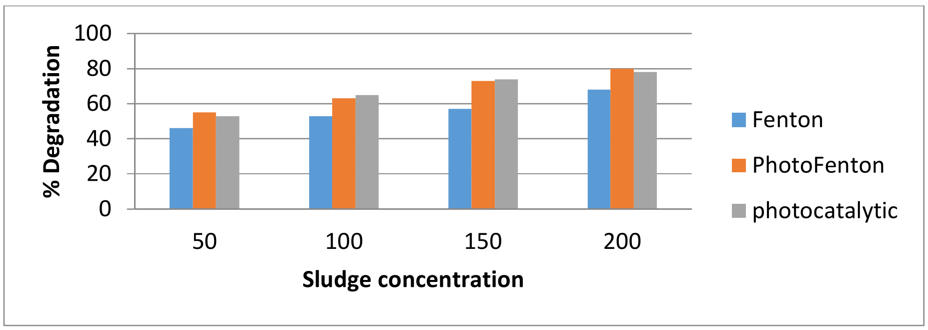


Fig – 1.2: Combined biological-chemical treatment of reactive azo dye

Table - 1.3: Characteristics of textile wastewater

PARAMETER	UNIT	MEAN VALUE ± STD. DEV.
pH	-	9.3 ± 0.7
Temperature	^0C	23 ± 5
COD	mg/L	3500 ± 409
TDS	mg/L	2133 ± 523
TSS	mg/L	1245 ± 320

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