International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 16, Issue 1 (Jan. 2020), PP.52-58

Degradation Of Textile Dye By Using Advanced Oxidation Process

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ABSTRACT - *Textile industry is considered as one of the polluting and chemically severe industrial sectors which utilizes large quantity of water and chemicals for its various wet processing operations. The effluent consists of chemicals like acids, alkalis, colors, high BOD/COD concentration, surfactants, dispersing agents, soap and metals. Most of the textile wastewater are extremely colored as they are normally discharged with a dye and many dyes are visible in water at concentrations as low as 1 mg/L. There are many alternative treatments, have been considered in laboratory also in full scale, including physical, chemical, biological, Advanced Oxidation Process (AOP) and a combination of them. This paper aims to put together different AOPs such as UV/*H_2O_2*, UV/*TiO_2 *available for color and COD removal from dye solution. From the study it is concluded that AOPs can be effectively used as pretreatment process with a maximum COD removal of 95% and color removal of 64% by using UV/*H_2O_2 *Process.*

KEYWORDS*—Color, Textile industry, Dyes, AOP*

Date of Submission: 04-02-2020 Date of Acceptance: 20-02-2020

I. INTRODUCTION

The aim of any AOPs design is to “generate and use hydroxyl free radical as strong oxidant to destroy compound that cannot be oxidized by using conventional oxidizing agent” (5). Advanced oxidation processes are characterized by production of OH radicals and selectivity of attack which is a useful attribute for an oxidant. Hydroxyl radicals are highly reactive species; they attack the most part of organic molecules easily and also characterized by a little selectivity of attack which is a useful attribute for an oxidant used in wastewater treatment and for solving environmental pollution problems (7). The versatility of AOPs is also enhanced due to their different possible ways for hydroxyl radical production, allowing a better compliance with specific treatment requirements (1).

II. ADVANCED OXIDATION PROCESS

Advanced Oxidation Processes (AOPs) are defined as the processes which involve generation and use of powerful but relatively non-selective hydroxyl radicals in sufficient quantities to be able to oxidize majority of the complex chemicals present in the effluent water (2,6). Hydroxyl radicals (OH) has the highest oxidation potential (Oxidation potential, *E*0: 2.8 eV vs normal hydrogen electrode (NHE)) after fluorine radical. Fluorine, the strongest oxidant (Oxidation potential, *E*0: 3.06 V) cannot be used for wastewater treatment because of its high toxicity. From these reasons, generation of hydroxyl radical including AOPs have gained the attention of most scientists and technology developers (3,11,15).

AOPs can be classified in two groups: (1) Non-photochemical AOPs, (2) Photochemical AOPs. Non-photochemical AOPs include cavitation, Fenton and Fenton-like processes, ozonation at high pH, ozone/hydrogen peroxide, wet air oxidation etc. Photochemical oxidation processes include homogenous (vacuum UV photolysis, UV/hydrogen peroxide, UV/ozone, UV/ozone/hydrogen peroxide, photo-Fenton etc), and heterogeneous (photocatalysis etc) processes. Table 1 shows the Oxidation power of various Oxidants which can be used in AOPs (4,12,8).

Table 1: Oxidation Power of Various Oxidants in volts (V)

Oxidation species	Redox potential (eV)
Fluorine (F_2)	3.03
Hydroxyl radical ($^{\bullet}OH$)	2.80
Ozone (O_3)	2.07
Hydrogen peroxide (H_2O_2)	1.77
Potassium Permanganate	1.67
Chlorine dioxide (ClO_2)	1.50
Chlorine (Cl_2)	1.36

Oxygen(O_2)	1.23
Bromine (Br_2)	1.09

III. MATERIALS AND METHODOLOGY

The dyes selected are Acid Blue 29(AB29), Basic green 4(BG4) and Reactive Yellow 14(RY14). All the three dyes are supplied from local supplier (Trade Name: Novacron) and chemicals used for the analysis are of analytical grade. Characteristics such as toxicity, recalcitrant nature and higher solubility in water are the main criteria behind the selection of Dyes. All the three Textile Dyes (Acid Blue 29, Basic Green 4 and Reactive Yellow 14) used for the study are organic dyes, in which AB29 and RY14 belong to anionic dyes, whereas BG4 belong to Cationic dyes. and they were used in powdered form.

A. METHODS

Textile Dye solution was prepared by dissolving accurately weighed 1000mg of Textile dye in one litre of distilled water. 500ml of 100mg/L concentration was used as a working volume for the study. The following treatment methods such as UV + H_2O_2, UV + TiO_2 are adopted for the study to analyse the best suited method for color and COD removal for the Textile dye solution.

Ultraviolet and Hydrogen Peroxide

Dye solution with 100mg/L concentration was added with different dosages of H_2O_2 like 1ml, 2ml, 3ml, 4ml,5ml and 6ml.

Ultraviolet and Titanium Di-Oxide (TiO_2)

Different dosages of TiO_2 (98% pure) of 0.1gms, 0.2gms, 0.3gms, 0.4gms and 0.5gms (The dosages were selected based on the preliminary investigation) are added to the UV reactor for a working volume of 500ml with 100mg/l concentration.

Once the initial pH of samples were adjusted to 3,5,7 and 9 by adding 1N H_2SO_4 and/or 1N NAOH solution, the samples are fed into UV reactor, and analyzed for color and COD removal by drawing the samples at regular intervals of 10 minutes at each pH respectively for a period of 60 minutes. The study concludes with the optimum dosage of H_2O_2, TiO_2 and pH for the maximum removal of color and COD.

Analysis

The pH measurements were made by using Digital pH meter. Chemical Oxygen Demand was estimated by Closed Reflux Method by using COD digestor. The color of the dye solution was measured by using Double Beam Spectrophotometer.

IV. RESULTS AND DISCUSSION

This paper describes the degradation of Textile dyes and the results obtained during the process and their interpretations.

B. ACID BLUE 29

UV + H_2O_2

The experimental work has been conducted to study combined effect of UV/H_2O_2, UV/TiO_2 on the degradation of the Acid Blue 29 with 100 mg/L dye concentration and at different solution pH of 3,5,7 and 9 respectively.

At pH 3 maximum color and COD removal of 95% and 64% was achieved at 50min duration with 5ml H_2O_2 dosage.

At pH 5 maximum color and COD removal of 87% and 56% was achieved at 60min duration with 5ml H_2O_2 dosage.

At pH 7 and 9 maximum color and COD removal of 73%, 9% and 63%, 45% was achieved at 50min duration with 6ml H_2O_2 dosage, after that it starts decreasing.

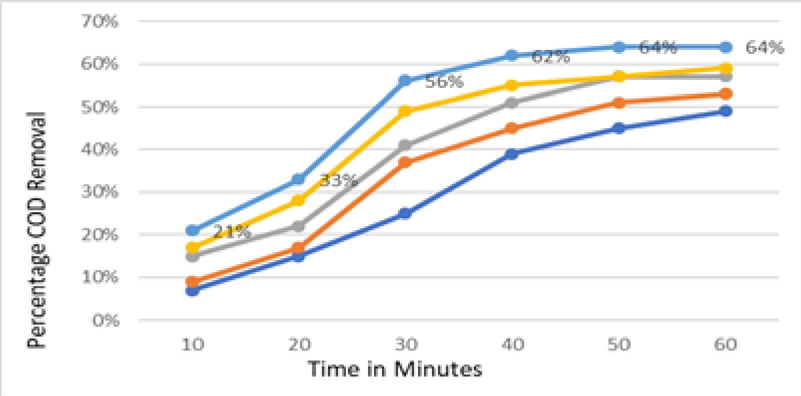
This may be due to H_2O_2 dosage, which plays a vital role in degradation process and removal efficiency increases as the H_2O_2 dosage increased, after which the efficiency starts to decrease or constant depending upon the type of dye and contact time (9,10). H_2O_2 in excess becomes a scavenger of hydroxyl radicals to form water and hydroperoxyl radicals (HO_2•), thus initiating other reactions that affect the oxidation process (14). Similar finding was reported from H. Amin et al,2008 that decolorization efficiency decreased from 90.69% to 82.3% when the dose was increased from $10cm^3$ to $12cm^3$.

Hence study concludes that 50min contact time, 5mL H_2O_2 dosage at pH3 was optimum for the degradation of AB 29 Dye.

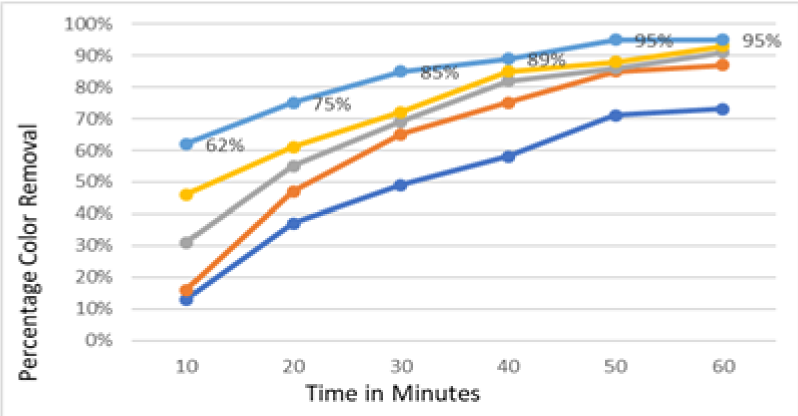
UV+TiO_2

At pH 3,5,7 and 9 the maximum COD removal achieved was 67%, 59%, 45% and 37% at 0.1 gm and at contact time of 50-60 minutes. Insignificant color removal was observed with all Ph. This is due to fact that over the

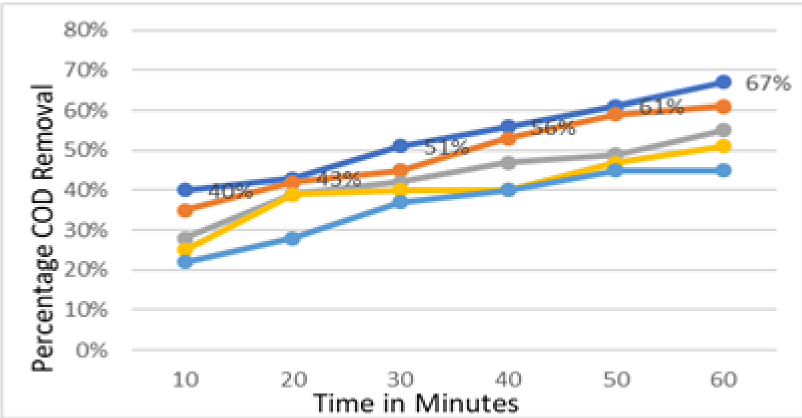
period of time, increase in TiO_2 dosage forms white precipitation leads to increase in color and COD. And the formation of precipitate depends on the contact time and dye composition.
Hence the study concludes that pH 3 is considered as optimum condition for the maximum COD removal of 67% at 60min duration with 0.1gm TiO_2 dosage.



Percentage COD removal for AB 29 at pH 3 by UV/H_2O_2



Percentage Color removal for AB 29 at pH 3 by UV/H_2O_2



Percentage COD removal for AB 29 at pH 3 by UV/TiO_2

C. Basic Green 4

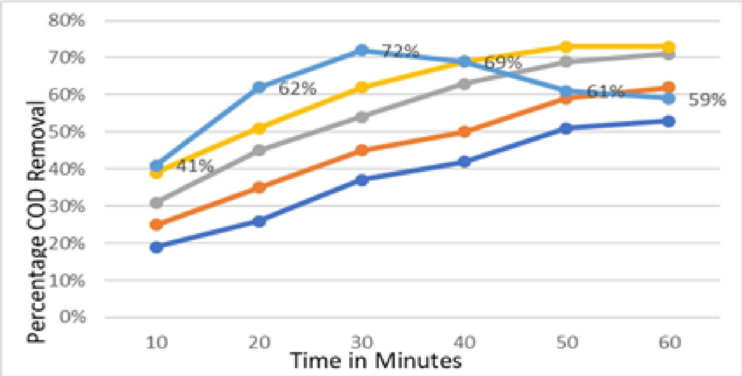
UV + H_2O_2

The experimental work has been conducted to study combined effect of UV/H_2O_2, UV/TiO_2 on the degradation of the Basic Green 4 with 100 mg/L dye concentration and at different solution pH of 3,5,7 and 9 respectively. At

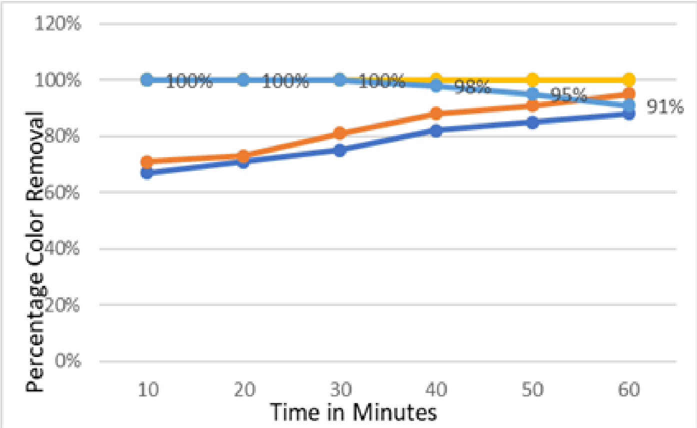
pH 3 maximum color and COD removal of 100% and 71% was achieved at 60min duration with 3ml H_2O_2 dosage, after that it starts decreasing.
At pH 5 maximum color and COD removal of 100% and 65% was achieved at 60min duration with 4ml H_2O_2 dosage, after that it starts decreasing.
At pH 7 maximum color and COD removal of 99% and 56% was achieved at 60min duration with 4ml H_2O_2 dosage, after that it starts decreasing.
At pH 9 maximum color and COD removal of 94% and 47% was achieved at 60min duration with 5ml H_2O_2 dosage, after that it starts decreasing.

UV + TiO_2

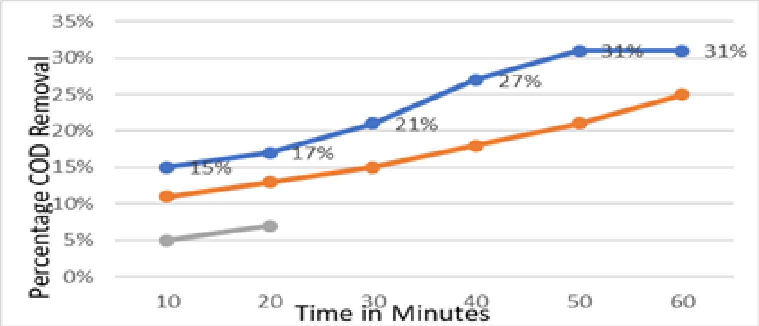
At pH 3,5 and 7 the maximum COD removal achieved was 31%, 17% and 8% at 0.1 gm for contact time of 50-60 minutes. And 39%, 26% and 14% of color removal was observed at 0.1gm TiO_2 dosage for 50-60 min duration. There was insignificant color and COD removal was observed at pH 9. Hence the study concludes that pH 3 is considered as optimum condition for the maximum color and COD removal of 39% and 31% at 60min duration with 0.1gm TiO_2 dosage.



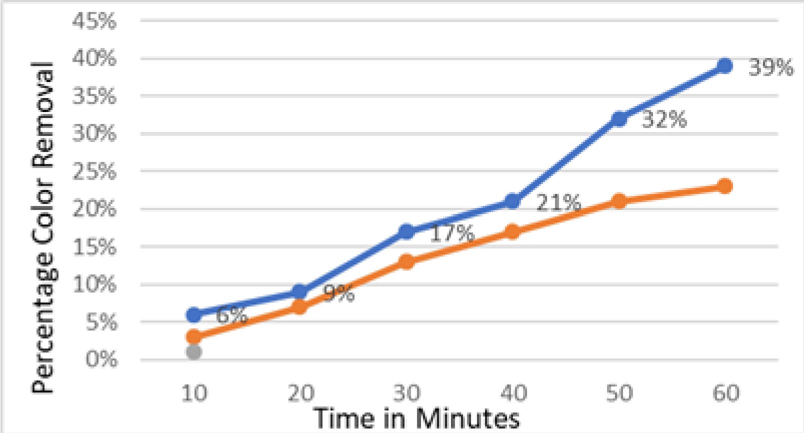
Percentage COD removal for BG 4 at pH 3 by UV/H_2O_2



Percentage Color removal for BG 4 at pH 3 by UV/H_2O_2



Percentage COD removal for BG 4 at pH 3 by UV/TiO_2



Percentage Color removal for BG 4 at pH 3 by UV/TiO_2

D. Reactive Yellow 14

UV + H_2O_2

The experimental work has been conducted to study combined effect of UV/H_2O_2, UV/TiO_2 on the degradation of the Reactive yellow 14 with 100 mg/L dye concentration and at different solution pH of 3,5,7 and 9 respectively.

At pH 3 maximum color and COD removal of 74% and 63% was achieved at 50min duration with 5ml H_2O_2 dosage.

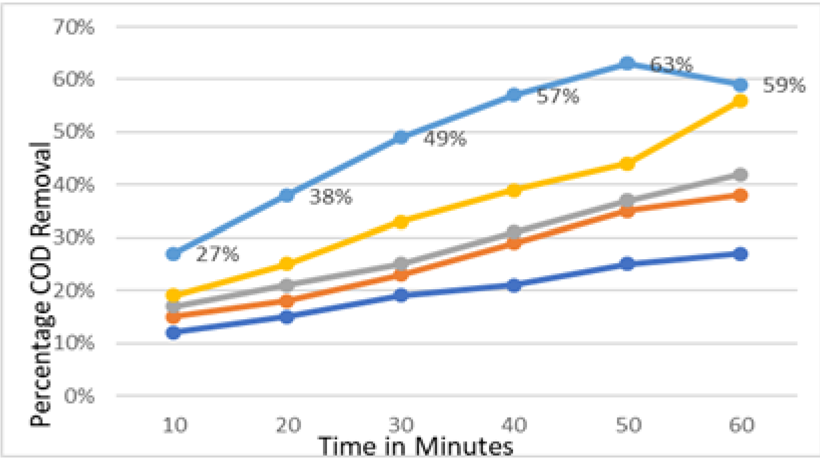
At pH 5 maximum color and COD removal of 59% and 45% was achieved at 60min duration with 5ml H_2O_2 dosage.

At pH 7 maximum color and COD removal of 21% and 19% was achieved at 60min duration with 6ml H_2O_2 dosage, after that it remained constant There was insignificant color and COD removal observed at pH 9.

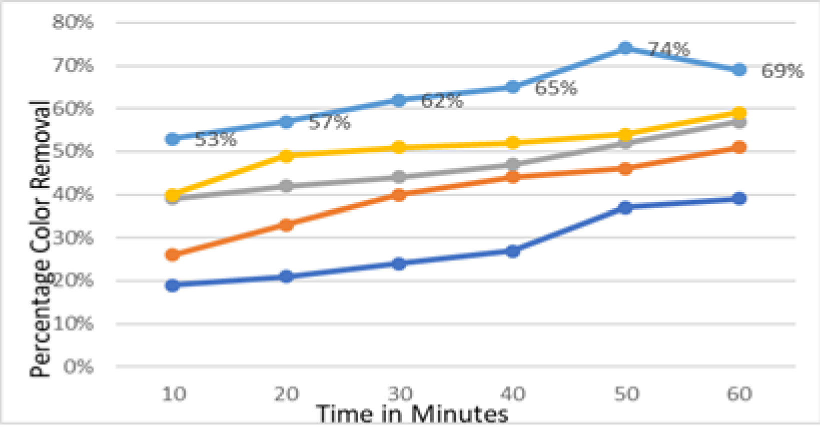
UV + TiO_2

At pH 3, the maximum COD removal achieved was 27% at 0.2 gm for contact time of 50 minutes. And 19% of color removal was observed at 0.2gm TiO_2 dosage for 50 min duration. There was insignificant color and COD removal at pH 5,7 and 9. This is due to fact that over the period of time, increase in TiO_2 dosage forms white precipitation leads to increase in color and COD (14). And the formation of precipitate depends on the contact time and dye composition (13).

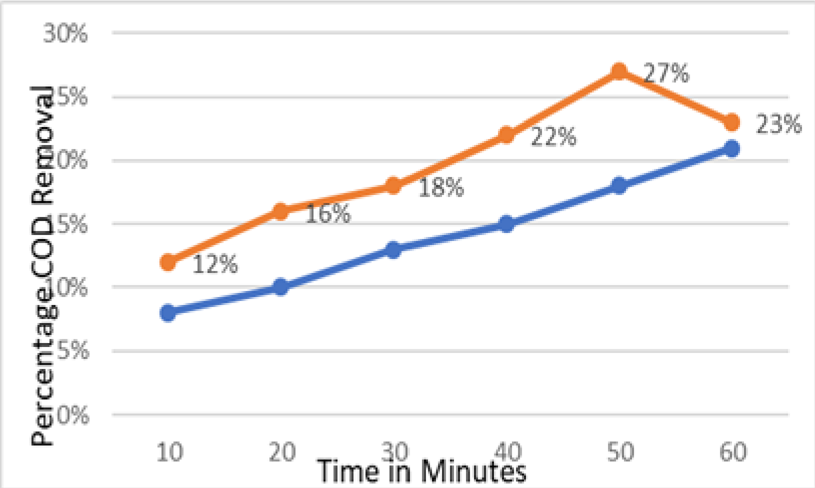
Hence the study concludes that pH 3 is considered as optimum condition for the maximum color and COD removal of 27% and 19% at 50min duration with 0.2gm TiO_2 dosage.



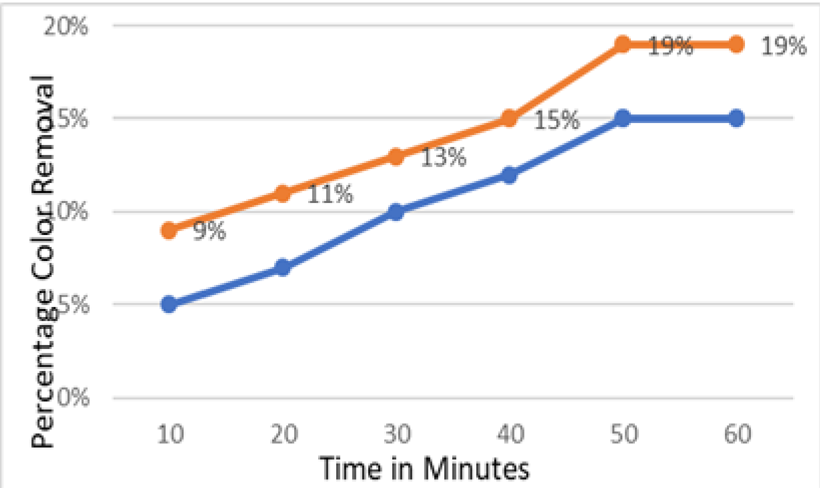
Percentage COD removal for RY 14 at pH 3 by UV/H_2O_2



Percentage color removal for RY14 at pH3 by UV/H_2O_2



Percentage COD removal for RY 14 at pH 3 by UV/TiO_2



Percentage color removal for RY 14 at pH 3 by UV/TiO_2

V. CONCLUSIONS

Advanced Oxidation process such as UV+H_2O_2 and UV+TiO_2 was used to degrade the Textile dyes such as Acid Blue 29, Basic Green 4 and Reactive Yellow 14, and each exhibit different removal characteristics in terms of color and COD removal for different treatment process.

ACID BLUE 29

At pH 3 a maximum color and COD removal of 95% and 64% was achieved at 50min for 5ml H_2O_2 dosage, for UV + H_2O_2 process.

At pH 3 maximum COD removal of 67% was obtained at 60min for 0.1gm of TiO_2 dosage, for UV + TiO_2 and shown insignificant color removal for the same dye.

BASIC GREEN 4

At pH 3 maximum color and COD removal of 100% and 71% was achieved at 60min for 3ml H_2O_2 dosage for UV + H_2O_2 process. At pH 3 maximum color and COD removal of 39% and 31% was obtained at 60min for 0.1gm of TiO_2 dosage, for UV + TiO_2.

REACTVE YELLOW 14

At pH 3maximum color and COD removal of 74% and 63% was achieved at 50min for 5ml H_2O_2 dosage, for UV + H_2O_2 process

At pH 3 maximum color and COD removal of 27% and 19% was obtained at 50min for 0.2gm of TiO_2 dosage, for UV + TiO_2.

By comparing all the process's for different dyes sch as AB29, BG4 and RY14, pH 3, contact time of 50-60min and H_2O_2 dosage of 5ml and TiO_2 dosage of 0.1gm is considered as optimum condition for maximum degradation of Textile dyes.

By comparing all the treatment process, UV + H_2O_2 was found to be most effective in degradation of all selected dyes in terms of color and COD removal.

Therefore, the study concludes that AOPs can be efficiently used for the degradation of the Textile dyes.

ACKNOWLEDGEMENTS

Author would like to thank Vision Group on Science and Technology, KSTePS, Governament of Karnataka for the financial support extended towards carrying out this project.

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Rekha H B"Degradation Of Textile Dye By Using Advanced Oxidation Process" International Journal Of Engineering Research And Development, vol. 16(1), 2019, pp 52-58.