TREATMENT OF TANNERY EFFLUVIUM BY USING RADIANT-FENTON OXIDATION REACTOR

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ABSTRACT

Tannery industry is one of the forebearer industries in the world. The tanning process aims to transfigure skins in stable and non-perishable products namely leather. It is recognized as a serious environmental threat due to high chemical levels including salinity, organic loading (chemical oxygen demand or load, biological oxygen demand), inorganic, dissolved, suspended solids, ammonia, total nitrogen chromium chloride, sodium and other salt residues. The aim of the study is to determine the treatment of the tannery wastewater by using Radiant-Fenton oxidation reactor. To study the characteristics of the sample tannery wastewater such as pH = 10, colour = 600, BOD = 2066 mg/l, COD = 6200 mg/l, TSS = 1400 mg/l, Turbidity = 785 NTU, Chloride = 1000 mg/l were analyzed. Initially the treatment of tannery wastewater was carried out by Radiant-Fenton Oxidation Reactor at lab scale, the reactor having a volume of 2.35 litres with inner and outer dia of 2.54 cm and 5.08 cm fabricated with inner tube of height 1.5 feet and 2 feet with a breadth of 120 mm and 80 mm respectively with UV visible of 36 watts. The organic loading rate of 0.3 kg/COD/m³ with a flow rate of 8.6 l/min were applied to reactor. With the HRT as 8 hrs, COD and TSS removal was taken to be influencing parameter. The Photon-Fenton Oxidation Reactor was operated for 8 hours and gets the final output as COD = 700 mg/l, BOD = 200 mg/l, colour = 300, turbidity = 30 NTU, TSS = 95%, pH 5, Chloride 150 mg/l. It has achieved the maximum removal efficiency of 95%.

KEYWORDS: *Tannery wastewater, Photon-Fenton Oxidation Reactor, Hydraulic Retention Time (HRT), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) & Total Dissolved Solids (TDS)*

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1. INTRODUCTION

According to the India, about 1 to 2 million gallons of wastewater per day are generated by average dyeing facility in India, reactive and direct dyeing generating most of the wastewater. The tanning process aims to makeover the skins into stable and everlasting products namely leather. There are four main areas of sub-processes required to make finished leather, they are Beam house operation, Tanyard processes, Retanning and Finishing. Tannery industries generally causes pollutants which produce wide kind of high concentration toxic chemicals. It alters salinity, organic loading (chemical oxygen demand or load, biological oxygen demand), inorganic, dissolved, suspended solids, ammonia, total nitrogen chromium chloride, sodium and other salt residues of water sources [14]. Discharge of highly coloured dye effluents in natural water constitutes one of the most important problems of the surface water. Industrial dye, effluent is visible even at concentrations lower than 1 mg/L. The treatment of tannery wastewater is difficult due to complex nature of the industry and the number of chemicals employed in the leather

process [2]. The treatment of tannery wastewater is also very complex because the raw material processed and the intermediate products manufactured vary greatly in their nature and composition. There are many methods available to eliminate effluvia from water for instance ozonation process were used to remove calcitrant compound from effluvia [12]. Fenton process also avail to eliminate effluvia but removal efficiency was quite lesser [4]. Other oxidation methods were also faced the low efficiency rate [8]. Many technologies are there to breakdown the effluvia of tannery industries but their overall removal efficiency was lesser. Radiant-Fenton process is used to get more removal efficiency under various light sources [7]. It includes solar sources too [10]. $\text{Fe}^{2+}/\text{H}_2\text{O}_2$ UV irradiation accelerates the production of highly reactive species mainly hydroxyl radicals ($\text{OH}^\cdot$) [15]. An alternate pathway is through the generation of $\text{HO}_2^\cdot$, Which also absorb the UV radiation of 254nm wavelength and produce hydroxyl radicals [5]. It can oxidize organic compounds producing organic radicals (R). It has potential to initiate chain oxidation process, factors that influence the efficiency of Radiant-Fenton process include initial colour intensity, $\text{H}_2\text{O}_2/\text{Fe}^{2+}$ concentration were found [9]. Hence eliminating or reducing the wastage at the source of cleaner technological options of Radiant-Fenton process under UV irradiation was discussed.

2 MATERIAL AND EXPERIMENTAL SETUPS

2.1 Sample Collection

The effluent samples were collected from Rathinam tannery in Naripallam ($11^\circ 40' \text{W}$ and $77^\circ 65' 03'' \text{E}$). The effluent samples were collected from the all stages of tanning processing viz., soaking, liming, deliming, pickling, vegetable tanning and Retanning. The effluent was collected in polythene containers of 2.5 litres capacity and were brought to the laboratory with due care and was stored at 20°C for further analysis. Chemicals used for the analysis of spent liquor were analytical grade reagents. The physical and chemical characteristics of tannery effluents parameters viz. pH, total alkalinity, total acidity, COD, BOD, total solids (TS), total dissolved (TDS), total suspended solids (TSS), chlorides and sulphides were analyzed as per standard procedures [3].

Figure 1: Study area location

2.2 Experimental setup

Photo Fenton Reactor with Inner and Outer tube of diameter 2.54cm and 5.08cm respectively, connected with UV are used in the experiments [1]. It has a volume of 2.35 litres and fabricated with inner and outer tube of height 1.5 feet and 2 feet

with a breadth of 120mm and 80mm respectively. The Experimental work was carried out in order to evaluate the removal efficiency of the COD and TSS. During the Experimental work the organic loading rate of 0.3kg/COD/m³ with a flow rate of 8.6 l/min were applied to reactor with the HRT as 8hrs, COD and TSS removal was taken to be influencing parameter. The process usually involves the use of low-pressure UV lamps with a principal wavelength of 254nm [6][11]. Since the maximum absorption of ozone molecules is at 253.7nm. The light source commonly used is a medium –pressure mercury lamp wrapped in a quartz sleeve that can generate the UV light at wavelength of 200-280nm. They applied two different UV radiations 150W,15W to the synthetic tannery effluvia. The performance of the Reactor was evaluated at HRT (HRT=V/Q); V-Reactor volume; Q-effluvia flow.

Figure 2: Effluvia treatment setup

3 RESULT AND DISCUSSIONS

3.1 Removal of Cod

The effect of H₂O₂ and Fe²⁺ dosage ranging from 5ml to 60ml to 2gm to 8gm on the removal of COD efficiency was investigated while stabilizing all the conditions of the reaction and altering the H₂O₂ and Fe²⁺ doses. With the HRT of 8 hrs., but at time of 4hrs it reaches a maximum removal efficiency of 74% at concentration of 4gm of Fe²⁺ and 20ml H₂O₂.

Table 1: Removal Efficiency of COD for 8hrs

Duration(hr.)	Initial value of COD (mg/l)	Final value of COD (mg/l)	Removal efficiency of COD in %
1	1600	5428.57	12.44
2	1600	3333.3	46.80
3	1600	2900	53.22
4	1600	1600	74.19
5	1600	2100	66.18
6	1600	2100	66.18
7	1600	1123.9	45.46
8	1600	1432	30.68

There is no reaction during 5th and 6th hour of COD value but after that we can see reactions at low rate. This is shown in graph.

Figure 3: Graph of COD removal efficiency for 8 hrs.

3.2 Removal of TSS

The effect of H_2O_2 and Fe^{2+} dosage ranging from 5ml to 60ml to 2gm to 8gm on the removal of TSS efficiency was investigated while stabilizing all the conditions of the reaction and altering the H_2O_2 and Fe^{2+} doses.

Table 2: Removal Efficiency of TSS for 8 hrs

Duration(hr.)	Initial value of COD (mg/l)	Final value of COD (mg/l)	Removal efficiency of COD in %
1	1400	1034	34.87
2	1400	1038	47.8
3	1400	1045	38.9
4	1400	1065	85.43
5	1400	1055	85.43
6	1400	1055	74.73
7	1400	1080	91.6
8	1400	843	95

At the HRT of 8hrs, maximum Total suspended solids were removal of 95% was obtained. At this first HRT it was about 34% and then there is up and raise this is shown in the graph.

Figure 4: Graph of TSS removal efficiency for 8 hrs.

It can be observed that the removal efficiency of both BOD and TSS increases with increasing hydrogen peroxide dosage up to the point of maximum.

3.3 Effect of pH on COD removal

A series of batch experiments were conducted to investigate the effect of pH on COD removal by maintaining H_2O_2 concentration and catalyst (Fe^{2+}) dosage as 20ml/l and 5g/l respectively and UV power as 36 Watts. P^{H} values were varied in the range of 2 to 9.

Table 3: pH Effect on COD Removal

pH	Initial value of COD (mg/l)	Final value of COD (mg/l)	Removal efficiency in %
2	1600	2389	61.46
3	1600	876.4	80.1
5	1600	2867	53.75
7	1600	4986	19.58
9	1600	1976	8.87

It was observed that maximum COD of 80% was achieved at P^{H} at 3 and COD and BOD removal decreased with increase in pH. It can be attributed that in alkaline environment, H_2O_2 is unstable and easily decomposes to produce water and oxygen rather than forming hydroxyl radicals most directly however at values higher than 4 ferrous ions easily form ferric ions which have a tendency to produce ferric hydroxy complexes variation of percentage COD with respect to P^{H} is shown in figure.

Figure 5: Graph of pH effect on COD removal for 8 hrs.

3.4 Effect of pH on TSS Removal

The P^{H} during the experiment was 10 and it was adjusted to various pH condition. A series of batch experiments were conducted to investigate the effect of pH on TSS removal by maintaining H_2O_2 concentration and catalyst (Fe^{2+}) dosage as 20ml/l and 5g/l respectively and UV power as 36 watts. pH values were varied in the range of 2 to 9.

Table 4: pH Effect on TSS Removal

pH	Initial value of TSS (mg/l)	Final value of TSS (mg/l)	Removal efficiency in %
2	1400	1670	40.63

3	1400	1740	74.38
5	1400	1643	38.6
7	1400	1660	40.34
9	1400	1760	80.02

Similarly, on further process there was a greater TSS removal. Nearly 80% of total dissolved solids was removed in the wastewater by adjusting various pH

Figure 6: Graph of pH effect on TSS removal for 8 hrs.

3.5 Effluvium Characteristic before and after Treatment

Table 5: Effluvium Comparison

Property	Before	After
pH	10	5
Colour	600	300
BOD	2066mg/ litre	200 mg/ l
COD	6200mg /litre	700 mg /l
Turbidity	785 NTU	30 NTU
Total suspended solids	1400mg/litre	450mg/litre
chloride	1000 mg /litre	150 mg /litre

The comparison between Tannery effluvium has been analyzed before and after treatment it shows the drastic fall in its concentration after the treatment. From the graph we can see that the reactor has achieved the maximum tannery effluvium removal efficiency of 95%. It is greater than all other methods avail for the removal of tannery effluvium. [13]

Figure 7: Comparison of parameters

4 CONCLUSIONS

The Radiant- Fenton Reactor has established as a well proven compact reactor for effluvia treatment. It has been used for small as well as large plant. Radiant-Fenton Reactor are capable of removing COD effectively. The following conclusion might be drawn as a result of application of a Radiant-Fenton reaction which indicate that, the optimum irradiation time was a minute at P^H 3, the dose of 20 ml/l of H_2O_2 and 5g/l of Fe^{2+} . Under these conditions 80% COD removal was obtained. The application of Radiant-Fenton oxidation process in tannery effluvia treatment technology is an efficient method for the decomposition of pollutants present in it and can be used successfully as a preliminary stage preceding biological treatment. For higher removal efficiency one of the solutions is to use two stage process radiant Fenton reaction and biological methods. It is necessary to check the reaction with respect to the large amount of various type of effluvia and find proper relation which enables the quick optimization of the process with respect to the changing input parameters of the effluvia subjected to treatment. Thus, this type of advanced treatment consisting of Radiant-Fenton reactors is viable technique for treating industrial as well as domestic effluvia.

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