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# BTEX Compounds Removal from Waste Water by using UV&UV/$H_2O_2$ Process

Dhivakar[1], Dr.T. Vel rajan[2]
*P.G. Student, Department of Civil Engineering, Thiagarajar College of Engineering, Tiruparankundram, Madurai, India[1]*
*Professor, Department of Civil Engineering, Thiagarajar College of Engineering, Tiruparankundram, Madurai, India[2]*

***Abstract***

*Advanced oxidation processes refer to a set of oxidative water treatments that can be used to treat toxic effluents at the industrial level, hospitals, and wastewater treatment plants. The aim of this study wastewater treatment process of BTEX compounds presented sample; the use of$H_2O_2$ in combination with U.V. resulted in an enhanced extent of COD removal. The combination of several AOPs is an efficient way to increase pollutant removal and reduce costs. AOPs based on the UV/$H_2O_2$ system have shown high efficiency in reducing several organic compounds of environmental relevance. The UV/$H_2O_2$ process has additional advantages in that there is no sludge production and high rates of chemical oxygen demand (COD) removal by varying the operating parameters such as time, flow rate, P.H., hydrogen peroxide dosages. The COD removal efficiency of BTEX compounds decreased with increasing hydrogen peroxide dosages. When $H_2O_2$ concentration was increased, the COD removal efficiency also increased. The optimized condition for the $H_2O_2$/UV process was found at $H_2O_2$ dose of 0.5ml/L of wastewater, Toluene & Xylene concentrations maximum COD removal 77% achieved. At this same time, BTEX compounds the maximum COD removal 50% achieved when an $H_2O_2$ dose of 1ml/L is added within 60 minutes of the treatment time.*

**Keywords** - *Advanced oxidation processes, BTEX, UV/$H_2O_2$, COD Removal Efficiency, Wastewater.*

## I. INTRODUCTION

Most of the synthetic organic chemicals and naturally occurring substances enter the aquatic medium in several different ways and, according to their water solubility, can be transported and distributed in the water cycle. The effluents of urban wastewater treatment plants are among the significant responsibility for releasing this kind of contaminants into the environment.

BTEX is an acronym that stands for Benzene, Toluene, Ethylbenzene, and Xylenes. These compounds are volatile organic compounds (VOCs) found in petroleum and petroleum products such as gasoline. The xylene isomers are distinguished by the designations *ortho*(or *o* –), *meta*(or *m* –), and *para*(or *p* –), as indicated in the adjacent diagram.BTEX Components of gasoline in % weight of Benzene (11%), Toluene (26%), Ethylbenzene (11%), Xylene (52%). These compounds occur naturally in crude oil and can be found in seawater in the vicinity of natural gas and petroleum deposits. Other natural sources of BTEX compounds include gas emissions from volcanoes and forest fires. The primary human-made releases of BTEX compounds are through emissions from motor vehicles and aircraft and cigarette smoke.

Advanced oxidation processes (AOPs) refer to a set of chemical treatment procedures designed to remove organic (and sometimes inorganic) materials in water and wastewater by oxidation through reactions with hydroxyl radicals. AOPs involves two stages of oxidation 1) the formation of strong oxidants (e.g., hydroxyl radicals) and 2) the reaction of these oxidants with organic contaminants in water. However, the term advanced oxidation processes refer specifically to processes in which oxidation of organic contaminants occurs primarily through reactions with hydroxyl radicals. In water treatment applications, AOPs usually refers to a specific subset of processes that involve $O_3$, $H_2O_2$, and/or U.V. light. AOPs based on the UV/$H_2O_2$ system have shown high efficiency in reducing several organic compounds of environmental relevance. The UV/$H_2O_2$ process has additional advantages in that there is no sludge production, and high rates of chemical oxygen demand (COD) removal can also be achieved. The oxidation products are usually low molecular weight oxygenated compounds that are readily biodegradable or, in some instances, the organic compound reduces to carbon dioxide and water. In the U.V.–$H_2O_2$ process, the photolysis of hydrogen peroxide generates a significant oxidizing species hydroxyl radical (•OH). The oxidation potential of hydroxyl radicals is 2.8 eV, which can destroy the pollutants present in wastewater or convert them into simple harmless compounds.

## II. LITERATURE REVIEW

**Maria Cristina Collivignarelli. Et al. (2017)** investigated $H_2O_2$-based oxidation processes (namely $H_2O_2$/UV, photo-Fenton, and Fenton) to treat BTEX compounds. The $H_2O_2$/UV and photo-Fenton processes proved to be very useful in COD removal, the efficiency being more significant than 70%. The optimal treatment conditions for the $H_2O_2$/UV process were: 120 min reaction, $H_2O_2$/COD initial dosage ratio = 1/2; the radiation intensity revealed to be a crucial factor, especially in the earlier stage of the process (about 40 min): this aspect can be exploited to reduce the costs related to energy consumption.

**Mahmoud Bahmani. Et al. (2013)** stated the work mainly dealt with the UV-based advanced oxidation; UV/$H_2O_2$ were tested in batch reactor systems to evaluate the removal efficiencies and optimal conditions for the photodegradation of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) in order to treat the wastewater. The influences of operational parameters such as the initial concentration of $H_2O_2$, pH, temperature, initial concentration of BTEX, reaction time, and U.V. amount on the degradation of BTEX were studied. The obtained results showed that the highest degradation rate occurred during the first 30 min of the reaction time. The optimal conditions of the average and different BTEX concentrations with 0.421, 0.724, 1.11, 1.34, and 1.736 g/L initial concentrations of $H_2O_2$ and an acidic pH value of 3.1 were applied under three U.V. lights. Under the optimal conditions, for the average (550 mg/L) and the lowest (210 mg/L) concentration of BTEX, the chemical oxygen demand reduction reached about 90 and 98%, respectively, for the UV/$H_2O_2$ system during the first period of 180 min.

**Ebrahim E. Ebrahim. et al. (2013)**performed the study on evaluation of the possibility of applying advanced photo-oxidation technique (Fenton oxidation process) for removal of the residuals organic pollutants present in cosmetic wastewater. The different parameters that affect the chemical oxidation process for dyes in their aqueous solutions were studied using Fenton's reaction. These parameters are pH, hydrogen peroxide ($H_2O_2$) dose, ferrous sulfate ($FeSO_4$Æ$7H_2O$) dose, Initial dye concentration, and time. The optimum conditions were found to be: pH 3, the dose of 1 ml/l $H_2O_2$, and 0.75 g/l for Fe(II) and Fe(III) and reaction time 40 min. Finally, chemical oxygen demands (COD) before and after the oxidation process was measured to ensure the destruction of organic dyes during their removal from wastewater. The experimental results show that Fenton's oxidation process successfully achieved an outstanding removal efficiency of over 95%.

**Soon Chul Kwon. Et al. (2012)** addresses the effectiveness of different ozone-based advanced oxidation processes on treating 1,4-dioxane in aqueous solution was investigated in a lab-scale reactor. The removal efficiency of 1,4-dioxane was studied under different initial pH and $H_2O_2$ concentrations. Degradation (18%) of COD was observed with the application of UV-C alone, but the degradation of COD was greatly enhanced by a combined method, $O_3/H_2O_2/UV$ (94%). It appears, however, that an excess amount of hydrogen peroxide in the solution retards the decomposition of 1,4-dioxane. At pH 10 and an $H_2O_2/O_3$ ratio of 0.5, 1,4-dioxane in aqueous solution showed the highest degradation rate.

**Barbara Bianco. Et al. (2011)**described the need to remediate industrial wastewater for modern society, which requires particular understanding and ad hoc solutions. We observed a maximum COD % removal of about 80%, assessing the efficiency of the process. To understand the role of different reagents in the final yield, we performed a factorial experimental approach on the Fenton's reagents ($H_2O_2$ and $Fe^{2+}$) and analyzed the results developing a second-order analytical model. The model depends on three variables, namely: the initial [COD] of the sample, the [COD]/[$H_2O_2$] ratio, and [$H_2O_2$]/[$Fe^{2+}$] ratio. We obtained an accurate description of the COD % removal in different initial conditions, with an R2 = 0.85. In particular, we observed that optimal quantities of Fenton's reagents are a function of the initial COD of the treated wastes.

## III. METHODOLOGY AND MATERIALS USED

### *A. Sample preparation*

The following procedure prepared the stock solution from which the sample is to be obtained. 1ml of Benzene, Toluene, Ethylbenzene, Xylene was taken and made into 1000ml with distilled water. This is kept as a stock solution from which the required concentrations of the sample are obtained. Initially, 50 ml of stock solution was taken and made to 5000ml with distilled water, and this sample was used for other trails. The samples were prepared based on knowledge acquired from the literature review.

### *B. Experimental procedure*

The reactor setup consists of a round bottom glass vessel 1.1-liter volume with inlet and outlet arrangements. U.V. lamp of 11W is inserted inside the glass vessel. The experiment was conducted for the BTEX concentrations by adding various hydrogen peroxide dosages 0.5ml, 1ml, 2ml, 5ml. In the feed tank, hydrogen peroxide dosages were added to produce powerful hydroxyl radicals. The BTEX solution continuously flows through the reactor at a flow rate of about 16.6 ml/min for a detention time of 60 minutes, and it was irradiated with U.V. light inside the reactor. The reactor setup was kept inside the black box to avoid U.V. leakages. The treated sample is collected every 10 minutes for an hour. Then the collected sample was tested for COD concentrations.

### *C. Sample analysis*

For COD analysis using the method, samples were taken periodically from the UV/$H_2O_2$ reactor; the following procedure and apparatus have been used to examine how COD values were measured.

## IV. RESULTS AND DISCUSSION

### *A. Combination of Toluene and Xylene:*

The synthetically prepared solution containing Toluene and Xylene with an initial COD concentration of 140 mg/L was subjected to UV/$H_2O_2$ reactor with $H_2O_2$(0.5ml/L) dosage. The treated sample is collected every 10 minutes for an hour. The results of the study were given in table 1& 2.

Tables 1 &2 combination of Toluene and Xylene with an initial concentration of COD was about 140 mg/L. After the treatment process, COD removal increases with an increase in time. The maximum efficiency obtained without $H_2O_2$ dosage was upto57% for 1 hour time, and with the$H_2O_2$dosage, it was upto77% at 1 hour time. During the experiment, the dosage of $H_2O_2$was maintained at 0.5mg/L.

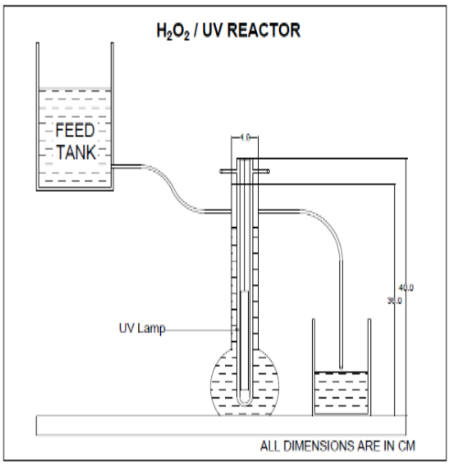


**Fig:1 schematic diagram of UV/$H_20_2$ reactor** **Fig:2 Laboratory experimental setup** **Fig:3 Reactor under UV**

**Table 1. COD removal efficiency without $H_2O_2$**

| TIME(min) | COD (mg/L) | Percentage of removal efficiency (%) |
|---|---|---|
| 10 | 100 | 28 |
| 20 | 80 | 42 |
| 30 | 80 | 42 |
| 40 | 70 | 50 |
| 50 | 70 | 50 |
| 60 | 60 | 57 |

**Table2. COD removal with 0.5ml/L $H_2O_2$ dosage**

| TIME(min) | COD (mg/L) | Percentage of removal efficiency (%) |
|---|---|---|
| 10 | 60 | 57 |
| 20 | 52 | 62 |
| 30 | 48 | 65 |
| 40 | 60 | 57 |
| 50 | 48 | 65 |
| 60 | 32 | 77 |

**Table 3. COD removal without $H_2O_2$**

| TIME(min) | COD (mg/L) | Percentage of removal efficiency (%) |
|---|---|---|
| 10 | 188 | 2 |
| 20 | 180 | 6 |
| 30 | 172 | 10 |
| 40 | 172 | 10 |
| 50 | 180 | 6 |
| 60 | 164 | 14 |

**Table 4.COD removal with 0.5 ml/L $H_20_2$dosage**

| TIME(min) | COD (mg/L) | Percentage of removal efficiency (%) |
|---|---|---|
| 10 | 168 | 12 |
| 20 | 160 | 16 |
| 30 | 160 | 16 |
| 40 | 152 | 20 |
| 50 | 144 | 25 |
| 60 | 140 | 27 |

**Table 5. Percentage COD removal with 1 ml/L $H_2O_2$dosage**

| TIME(min) | COD (mg/L) | Percentage of removal efficiency (%) |
|---|---|---|
| 10 | 156 | 18 |
| 20 | 140 | 27 |
| 30 | 128 | 33 |
| 40 | 132 | 31 |
| 50 | 108 | 43 |
| 60 | 96 | 50 |

### *B. BTEX Synthetic solution*

The synthetically prepared solution containing Benzene, Toluene, Ethylbenzene, and Xylene with an initial concentration of COD 192 mg/L was subjected to the UV/$H_2O_2$ experimental with $H_2O_2$ dosage and without $H_2O_2$ dosage. The treated sample is collected every 10 minutes for an hour. The results of the study were presented in tables 3, 4 &5.

From tables 3, 4,5, it is observed that with the combination of BTEX compounds, the concentration of COD obtained is 192 mg/L. Without $H_2O_2$ dosage, COD removal efficiency upto14%. The concentration of $H_2O_2$ was varied 0.5ml/L & 1ml/L and corresponding COD removal efficiency 27% & 50% respectively.The COD removal was based on the time and $H_2O_2$ dosage. As time and $H_2O_2$ dosage increases, COD removal efficiency also increased.

## V. CONCLUSION

In the wastewater treatment process of BTEX compounds presented sample, the use of$H_2O_2$ combined with the U.V. resulted in an enhanced COD removal. The COD removal efficiency of BTEX compounds decreased with increasing hydrogen peroxide dosages. When $H_2O_2$ concentration was increased, the COD removal efficiency also increased. The optimized condition for the $H_2O_2$/UV process was found at $H_2O_2$ dose of 0.5ml/L of wastewater, Toluene & Xylene concentrations maximum COD removal 77% achieved. At this same time, BTEX compounds the maximum COD removal 50% achieved when an $H_2O_2$ dose of 1ml/L is added within 60 minutes of the treatment time.

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