

# Treatment of Phenolic Wastewater by Ozonation

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## Abstract

The effluent from product processing and refining plants contains phenol and phenolic compounds which are harmful and toxic in nature, requires a great attention in wastewater treatment. The study was focused on ozonation process for the reduction of phenolics and chemical oxygen demand (COD) at certain time interval by varying pH. Ozone is a strong oxidizing agent, the reaction of it with organic and inorganic ions in aqueous media has achieved a verity of treatment goals. Ozone is a safe alternative to chlorine products which performs the same functions without the undesirable side effects, it is not harmful to the environment since it is made from oxygen and decompose back into oxygen, no sludge disposal problem and increase the dissolved oxygen content of wastewater which helps further in the degradation of residual pollutant. Ozone generator was used for the treatment of phenolic wastewater. Experimental study was performed on synthetic wastewater which containing 200mg/l phenol concentration at different pH conditions for 6hrs of ozonation. The maximum 96.04% phenol removal was found after 4 hours of ozonation and maximum 65.08% COD removal was found after 6 hours of ozonation at pH11. The overall study showed that the alkaline pH was more favourable for better phenol and COD removal.

**Keyword- Chemical Oxygen Demand, Ozonation, Phenol, Synthetic Wastewater, Treatment**

## I. INTRODUCTION

In the current scenario several acute global issues came up like global warming, fresh water crisis, environmental pollution, dreadful diseases etc. In developing and developed countries environmental pollution is a major problem in recent years. [1] Due to the rapid industrialization increase in generation of waste streams which affects the environment and human health. [10]

The release of large amount of polluted industrial wastewater to the environment creates the need for improvement in existing technologies through developing and implementing green, suitable and sustainable treatment technologies, which removes hazardous contaminants present in many of these industrial streams.[5,10,16] India is a developing country, where industries are major contributors to the adverse effect on environment, where effluent contributes to major part of it, which content phenolic compounds.

Phenols, defined as hydroxyl derivatives of benzene and its condensed nuclei, may occur in domestic and industrial wastewater, natural water and potable water supplies. [18] The entry of phenolic compounds into the environment is the result of natural and anthropogenic activities. Natural sources of phenolic compounds in water pollution include decomposition of organic matter, synthesis by microorganisms and plant in the aquatic environment. Industrial, domestic, agricultural and municipal activities constitute the anthropogenic sources of water pollution with phenolic compounds. [19, 21]

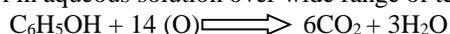
Phenol and phenolic compounds are common organic constituents of many industrial effluents because of it can be used as an intermediate chemical in a wide range of applications. [1]

These compounds are known to be toxic and inflict both severe and long-lasting effects on humans and animals. They act as carcinogens and cause damage to the red blood cells and the liver, even at low concentrations. [19, 21] The toxic levels usually range between the concentrations of 10-24mg/l for human and 9-25mg/l for fish. Lethal blood concentration of phenol is around 150mg/100ml.[16] The high toxicity of phenol is an alarming reason itself to purify and recycle phenolic effluent.

Phenolic compounds can be reduced or removed by various methods like stream gas stripping, biological treatment, adsorption/ion exchange, membrane based separation method, solvent extraction, oxidation processes etc.

The USEPA has listed phenol as priority pollutant and set a discharge limit of 0.1 mg/l of phenol in wastewater. According to Indian Standards for disposal of treated effluents (IS: 2490 Part A), the permissible limit for phenol for the discharge of effluent into inland surface water is 1.0 mg/l and in public sewer and marine disposal it is 5 mg/L. [3]

Due to high oxidation and disinfection potential of ozone, it is widely used for water and wastewater treatment. To improve quality of water as well as to remove organic and inorganic compounds from water and wastewater, ozone has been applied.[14] Ozone molecules break down toxic and recalcitrant organic compounds like phenol into smaller molecules. Ozonation process of phenol accomplished through direct ozone oxidation and indirect free hydroxyl radical oxidation.[17] In ozonation process some fundamental parameters are considered such as pH, required ozone dose, reaction time and feeding gas.[8] Ozone has been found to be highly reactive with phenol in aqueous solution over wide range of temperature. The reaction is,



4-6 moles of ozone are needed per mole of phenol for complete removal. The chemical oxidation demand reduction takes place in two stages- a sharp initial linear reduction followed by a relatively slower one. The changeover point may be used as an indicator of optimum ozone dose. [20]

The objective of the present study was to investigate the reduction of phenol and corresponding effect on COD at certain time intervals by varying pH in synthetic wastewater using ozonation.

## II. METHODOLOGY

To have a better understanding of the ozonation method and its efficiency to degrade the phenol and COD in synthetic wastewater, the experiments were conducted in a laboratory.

### A. Preparation of Synthetic Wastewater

0.38ml of laboratory grade phenol (99.5%) was diluted and makeup up to 2litre distilled water for preparing synthetic wastewater which contains 200mg/l phenol concentration. And then different pH (3,7,9,10, and 11) was adjusted with the help of NaOH and H<sub>2</sub>SO<sub>4</sub>.

### B. Phenolic Wastewater Treatment using Ozone Gas

Ozone generator was used for generation of ozone gas. The applied ozone dose was 2gm/hr. Ozone generator was attached with AC current and 40w power was used for appliances. Two litre wastewater was kept into ozone generator for ozonation. The ozonation of wastewater was performed in a plastic beaker. First the pH of Synthetic wastewater was adjusted with the help of NaOH and H<sub>2</sub>SO<sub>4</sub>. Ozone gas was passed through wastewater for 6 hrs. Appropriate NaOH was added to adjust the pH of wastewater after periodic time. Six samples were collected at each hour for analysis of phenol and every two hours samples were collected for analysis of COD.



Fig. 1: Ozonation of Synthetic Wastewater

### C. Analytical Methods

The pH meter was used for the analysis of pH according to the electrometric method. The phenol concentration was determined by the direct photometric method (4 – aminoantipyrine method) at a wavelength of 500nm, using spectrophotometer. Calibration curve was used for the estimation of the phenol concentration from photometric readings. The COD analysis of the synthetic wastewater was done by open reflux method.

## III. RESULTS AND DISCUSSION

The experimental study was performed on synthetic wastewater containing 200mg/l phenol concentration at different pH conditions (3,7,9,10 and 11) for 6hrs of ozonation to evaluate the effects of ozonation process on phenol and COD removal.

### A. Effect of Ozonation on Phenol Removal in Synthetic Wastewater at Different pH Conditions

– Phenol Concentration – 200mg/l

Different pH	Phenol Concentration : 200 mg/l					
	Contact Time ( Hours)					
	1	2	3	4	5	6
3	5.60	6.78	13.57	15.78	17.11	19.32
7	12.56	14.18	34.56	50.07	58.49	63.81
9	35.69	57.96	69.03	79.94	83.78	86.14
10	49.19	65.24	84.09	92.05	95.05	-

11	58.00	84.88	92.60	96.04	-	-
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Table 1: Phenol Removal % at Different pH

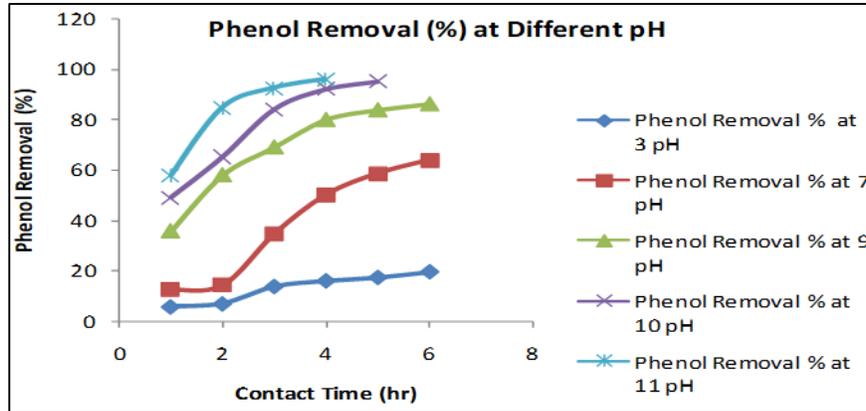


Fig. 2: Phenol Removal % at Different pH

Result of Table (1) and Figure (2) shows that with increasing time and pH, the phenol concentration of synthetic wastewater is gradually decreases. Results showed that 19.32%, 63.81% and 86.14% phenol removal was obtained at pH3, 7 and 9 respectively. At pH 10, 95.05% phenol removal was obtained after 5hrs of ozonation and maximum 96.04% phenol removal was found at pH 11 after 4hrs of ozonation, beyond that time phenol concentration was found below detection limit.

B. Effect of Ozonation on COD Removal in Synthetic Wastewater at Different pH Conditions

- Phenol Concentration – 200mg/l

Phenol Concentration : 200 mg/l			
Different pH	Contact Time (Hours)		
	2	4	6
3	3.17	4.76	6.35
7	9.52	12.70	26.98
9	15.63	28.13	48.44
10	27.42	40.32	56.45
11	41.27	50.79	65.08

Table 2: COD Removal % at Different pH

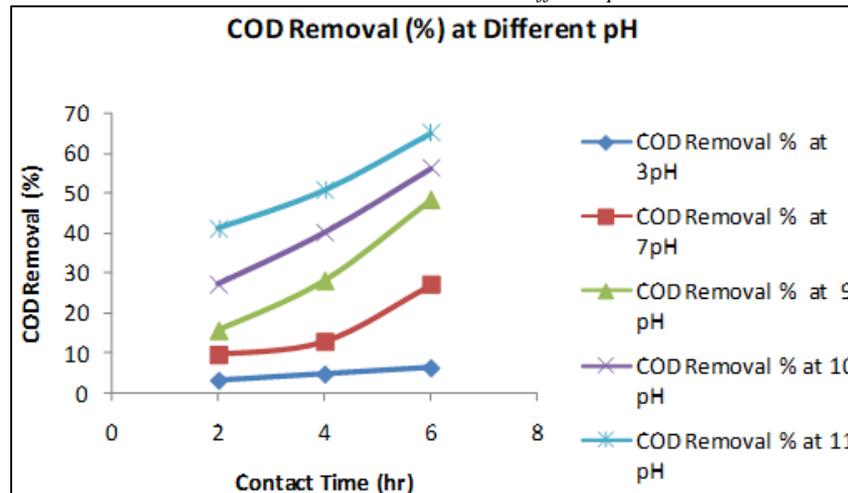


Fig. 3: COD Removal % at Different pH

Result of Table (2) and Figure (3) shows that with increasing time and pH, the COD concentration of synthetic wastewater is gradually decreases. After 6hrs of ozonation at pH 3,7,9 and 10, COD removal was found 6.35%, 26.98%, 48.44%, 56.45% respectively. Maximum 65.08% COD removal was found at pH11 after 6 hrs of ozonation.

## IV. CONCLUSION

The results of experimental study showed that the highest phenol and COD removal was found at pH 11 due to the free radicals of hydroxyl ions which is highly active at this pH. The overall study showed that phenol and COD removal efficiency gradually increases with increase in pH and the alkaline pH was more favourable for phenol and COD removal.

The results also indicated that phenol and COD removal increases with increase in contact time. Study also showed that better COD removal requires high ozone dose or more ozonation time in the treatment of synthetic wastewater.

From the results of the experimental analysis we can concluded that ozonation process is feasible method for removing phenol and COD from synthetic wastewater.

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