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# Leachate Treatment by Photo-Fenton Process

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**ABSTRACT:** Advanced Oxidation Processes (AOPs) namely photo-Fenton has been investigated in the removal of organic matter and colour from landfill leachates. The leachate was characterized by high COD, low biodegradability and intense dark colour. An additional advantage of the photo-Fenton process is the ability to shorten the reaction time and reduce the dosage of iron, which can thus reduce the amount of deposits generated. Photo-Fenton process was performed in glass photo-reactor. Ozonation was done as a pretreatment to increase the efficiency of the process. It is found that the amount of iron over the optimum dosage had no effect with respect to time. In this study, the treatment efficiency of Photo Fenton, combination of ozone and Fenton, Fenton processes were 76.67%, 73.33% and 71.67% respectively. From the analysis, Photo Fenton process was efficient than other two processes.

## I. INTRODUCTION

**GENERAL:** Municipal and industrial wastes disposal in landfill remains a very important practice and it is an essential part of the worldwide waste management system. One of the most serious environmental problems related to landfill is the generation of leachate during the decomposition process by rainwater percolating through the waste layer in the landfill and the chemical and biological processes in the waste's cells. Leachate is a hazardous aqueous effluent which contains large amount of organic matter, ammonia-nitrogen, inorganic salts and heavy metals. As a result, one of the major issues to deal with at present is the collection, storage and suitable treatment of landfill leachate.

**FENTONPROCESS:** Biological, chemical or physical treatment and advanced technologies such as membrane applications, advanced oxidation techniques are required for the treatment of leachate. AOPs are sufficient treatment methods to convert refractory organics to simpler forms in leachate, so that chemical oxygen demand (COD) and color can be taken under control. In general, the effectiveness of an AOP is proportional with the ability to generate hydroxyl radicals. Direct oxidation processes were generally used to treat the sludge by degrading the bio refractory substances. But it has some problems such as generation of pollution load, process limitations and operating conditions. Fenton processes generally works with very less energy requirement comparing to the direct oxidation process. It works at near ambient temperature and pressure so that providing sufficient conditions to the treatment processes is not necessary. During Fenton process, the reaction between the iron and H<sub>2</sub>O<sub>2</sub> is encompassed and the hydroxyl radicals are generated which are extraordinarily reactive since they have very high oxidation potential (approximately 2.8V).

## NEED FOR STUDY

- The main need of the project is to treat leachate in an effective way.
- Leachate is the fluid percolating through the landfills and is generated from liquids present in the waste and from outside water, including rainwater, percolating through the waste.
- To treat the leachate using Fenton by optimizing the dosage of the oxidizing agent and concentration of catalyst.
- Photo-Fenton process is one of the Advanced Oxidation Processes (AOP's) and its removal efficiency is high.

## OBJECTIVES

- To study the effect of photo-Fenton process in the treatment of leachate.
- To optimize the dosage of Fenton's reagent.
- To determine the removal efficiency of the treated leachate.

## CONCLUSION

- In this chapter, the general study on the landfill leachate and photo-Fenton process was studied. The need of this study was determined.

## II. REVIEW OF LITERATURE

Jeremi Naumzyk et al., (2012) studied that Advanced oxidation processes (AOPs) such as H<sub>2</sub>O<sub>2</sub>/UV, O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub>, modified Fenton, and modified photo-Fenton processes have been investigated in terms of the treatment of landfill leachate with ratio of BOD<sub>5</sub>/COD in the range of 0.22 to 0.24. The modification of Fenton and photo-Fenton processes consisted in the inclusion of precipitation and separation of humid substances at pH 3. Due to the precipitation, the value of COD decreased by 39% and BOD<sub>5</sub> by 7.1%. The modification of the processes allowed us to improve the efficiency and to decrease the doses of reagents necessary to continue the process. Modified photo-Fenton process proved to be the most effective (92.7% COD

removal) of all processes investigated. Additionally, modified-Fenton process was much more effective than the other two processes when compared up to 120 min, while after longer times it gave the least satisfactory results. After 30 min of modified-Fenton process BOD<sub>5</sub>/COD ratio increased to 0.43. The parameter referred to as “efficiency of oxidants” was used to estimate the efficiency of all the processes—its value varied from 178 to 239%. Various substances including phthalates, hydrocarbons, silanes, and siloxanes were identified in raw and treated leachate. The efficiency obtained from m-photo-Fenton process is much higher regardless of the reaction period. The COD removal in the m-photo-Fenton process was 92.7%. Additionally, the “efficiency of oxidants” parameter is recommended to be used to assess the efficiency of AOP’s. Its value allows estimating the approximate amount of oxygen used in the oxidation process.

Zazouli et al., (2012) studied that advanced oxidation processes like Fenton and photo-Fenton have been effectively applied to oxidize the persistent organic compounds in solid waste leachate and convert them to harmless materials and products. However, there are limited data about application of Fenton-like process in leachate treatment. Therefore, this study was designed with the objective of treating municipal landfill leachate by Fenton, Fenton-like and photo-Fenton processes to determine the effect of different variables, by setting up a pilot system. The used leachate was collected from a municipal sanitary landfill in Qaem-Shahr in the north of Iran. Fenton and Fenton-like processes were conducted by Jar-test method. Photo-Fenton process was performed in a glass photo-reactor. In all processes, H<sub>2</sub>O<sub>2</sub> was used as the oxidant. FeSO<sub>4</sub>·7H<sub>2</sub>O and FeCl<sub>3</sub>·6H<sub>2</sub>O were used as reagents. All parameters were measured based on standard methods. The results showed that the optimum concentration of H<sub>2</sub>O<sub>2</sub> was equal to 5 g/L for the Fenton-like process and 3 g/L for the Fenton and photo-Fenton processes. The optimum ratio of H<sub>2</sub>O<sub>2</sub>: Fe<sup>2+</sup>/Fe<sup>3+</sup> were equal to 8:1 in all processes. At optimum conditions, the amount of COD removal was 69.6%, 65.9% and 83.2% in Fenton, Fenton-like and photo-Fenton processes, respectively. In addition, optimum pH was 3, 5 and 3 and the optimum contact time was 150, 90 and 120 minutes, for Fenton, Fenton-like and photo-Fenton processes, respectively. After all processes, the biodegradability (BOD<sub>5</sub>/COD ratio) of the treated leachate was increased compared to that of the raw leachate and the highest increase in BOD<sub>5</sub>/COD ratio was observed in the photo-Fenton process. The efficiency of the Fenton-like process was overall less than Fenton and photo-Fenton processes; meanwhile the Fenton-like process was at higher pH and did not show problems. The amount of COD removal was high at optimum conditions. The biodegradability (BOD<sub>5</sub>/COD ratio) of the treated leachate was increased compared to that of the raw leachate and the highest increase in BOD<sub>5</sub>/COD ratio was observed in the photo-Fenton process.

Tony et al., (2014) studied that establishing a treatment process for practical and economic disposal of car wash wastewater has become an urgent environmental concern. Photo-Fenton’s process as one of the advanced oxidation processes is a potentially useful oxidation process in treating such wastewater. Lab-scale experiments with UV source, coupled with Fenton’s reagent, showed that hydrocarbon oil is degradable through such a process. The feasibility of photo-Fenton’s process to treat wastewater from a car wash is investigated in the present study. A factorial design based on the response surface methodology was applied to optimize the photo-Fenton oxidation process conditions using chemical oxygen demand (COD) reduction as the target parameter to optimize. The reagent (Fe<sup>2+</sup> and H<sub>2</sub>O<sub>2</sub> concentration) and pH are used as the controlling factors to be optimized. Maximal COD reduction (91.7%) was achieved when wastewater samples were treated at pH 3.5 in the presence of hydrogen peroxide and iron in amounts of 403.9 and 48.4 mg/L, respectively.

### III. CONCLUSION

Based on the above literatures, it is studied that the Photo-Fenton process is effective among all AOP’s for the treatment of leachate.

### MATERIALS AND METHODS

#### GENERAL

There are various types of advanced oxidation Processes methods for the treatment of leachate. Out of the other methods photo-Fenton process is found to be more effective. Photo-Fenton process for the treatment of leachate is to be done by the following method.

#### MATERIALS AND CHEMICALS

Materials used for the study are beakers, conical flasks, measuring jars, stirrers, burette and pipette. The chemicals used are concentrated sulphuric acid (Conc. H<sub>2</sub>SO<sub>4</sub>), mercuric sulphate, ferrous ammonium sulphate (FAS), ferroin indicator, ferrous sulphate (Fe<sub>2</sub>SO<sub>4</sub>), hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>).

#### CLEANING OF GLASSWARE

To avoid unforeseen errors in the experiments due to process of chemicals and other foreign matters in the glassware such as beakers, Erlenmeyer flasks, burettes and pipettes used for experiments will be first cleaned with detergent and then soaked in chromic acid cleaning mixture (concentrated sulphuric acid 1000 mL) plus saturated sodium dichromate solution (35 mL).



## METHODOLOGY

The following figure represents the methodology of photo-Fenton process for the treatment of leachate

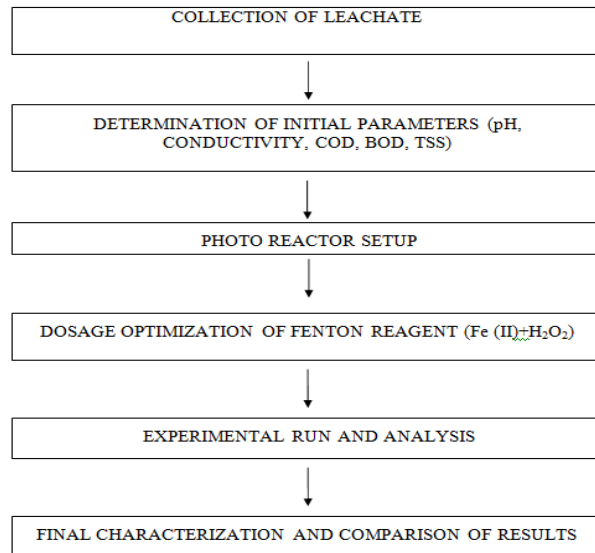


Fig 3.1 Methodology Flowchart

### COLLECTION OF SAMPLE

The leachate sample used for the project was collected from Ramayanpatti municipal wastes dump yard, Tirunelveli. The collected leachate was stored in the laboratory at 4°C for future studies. The photo view of the leachate collection site is given in the figure.

### DETERMINATION OF INITIAL LEACHATE PARAMETERS

The initial characteristics of leachate sample includes total chemical oxygen demand (TCOD), soluble chemical oxygen demand (SCOD), pH, conductivity, UV absorbance were analysed by using standard reference

#### pH

pH is a measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity, used to specify the acidity or alkalinity of an aqueous solution. It is the negative of the logarithm to base 10 of the concentration of the hydrogen ions. The pH of the sample is measured using digital meter.

Fig.3.3 pH meter



### CALIBRATION OF INSTRUMENT

In a 100 ml beaker, pH 9.0 buffer solution is taken. The pH electrode is dipped in the beaker containing buffer solution and the pH is checked. Make sure for the values if the instrument was not showing pH value 9.0, using the calibration knob adjust it till the reading becomes 9.0. The electrode is removed from the buffer solution and washed with the distilled water.

### PROCEDURE

The 10ml of Leachate sample was taken in three 100 ml conical flask labeled as Test1, Test2, and Test3. Simultaneously the distilled water was taken in three 100ml conical flask labeled as Blank1, Blank2 and Blank3. And 5ml of potassium dichromate solution was added in each of the six conical flasks. And 5ml of potassium iodide was added in each flask. And 10ml of sulphuric acid was added in each flask and pinch of mercuric sulphate was added in flask.

### DOSAGE OPTIMIZATION OF FENTON'S REAGENT

The  $\text{Fe}^{2+}$  catalyst for the Fenton's reagent is prepared by dissolving 69.50g of analytical grade ferrous sulphate ( $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ) in 500 ml of sterilized deionized water containing 5ml of concentrated  $\text{H}_2\text{SO}_4$ .

### EFFECT OF $\text{H}_2\text{O}_2$ DOSAGE

Hydrogen Peroxide dose is a critical variable in the process. A low concentration of  $\text{H}_2\text{O}_2$  did not generate enough  $\text{OH}^\bullet$  in solution. Addition of  $\text{H}_2\text{O}_2$  above optimum will lead to decrease in hydroxyl radical concentration due to free radical scavenging by the excess  $\text{H}_2\text{O}_2$ . So, there is an optimum,

### EFFECT OF $\text{Fe}^{2+}$ DOSAGE

The amount of ferrous ions is one of the primary parameters that influence the Fenton and photo-Fenton processes. It is observed that the extent of degradation increases with increasing initial  $\text{Fe}^{2+}$  concentration. Particular attention must be paid to  $\text{Fe}^{2+}$  dosage in order to avoid the following undesired  $\text{HO}^\bullet$  radicals scavenging reaction occurring in the presence of an excess of  $\text{Fe}^{2+}$ . Naturally, an excessive dosage of iron can contribute to a significant increase in total dissolved solids (TDS) and electrical conductivity in the effluent.

### EXPERIMENTAL RUN AND ANALYSIS

The container containing leachate sample is thoroughly shaken for resuspension of possibly settled solids and sample is transferred to the reactor. Then, the pH of the solution is adjusted by adding either  $\text{NaOH}$  or  $\text{H}_2\text{SO}_4$  solutions. The desired concentration of  $\text{Fe}(\text{II})$  and  $\text{H}_2\text{O}_2$  are added to the samples. Then the experiment is carried out.



**FINAL CHARACTERIZATION AND COMPARISON OF**

**RESULTS**

After completion of test, the treated sample is collected to determine the final leachate parameters. The initial and final parameters are to be compared for the final results.

**IV. RESULTS AND DISCUSSION**

**INTRODUCTION**

This chapter explains about the experimental outcome of study conducted. It includes initial characterization of leachate sample such as pH, TCOD, SCOD, TSS and the effect of TCOD at different Fenton reagent dosages and varying time.

**Table 4.1 Initial characterization of the leachate sample**

S.NO.	PARAMETER	MEASURED VALUE
1	pH	8.25
2	TOTAL SUSPENDED SOLIDS (TSS)	400 mg/l
3	TOTAL CHEMICAL OXYGEN DEMAND (TCOD)	6000 mg/l
4	SOLUBLE CHEMICAL OXYGEN DEMAND (SCOD)	4800 mg/l
5	BIOLOGICAL OXYGEN DEMAND (BOD)	60 mg/l
6	CONDUCTIVITY	4900 $\mu$ S/cm

**FENTON PROCESS**

Fenton’s reagent Fe<sup>2+</sup> was added at the rate of 1mM/l and H<sub>2</sub>O<sub>2</sub> at the rate of 10mM/l. The sample was collected at different intervals of time which is shown in the Fig.4.2. The removal of TCOD at 60 min was found to be 1700mg/l. the removal efficiency was 71.67%

**COMBINATION OF FENTON AND OZONATION PROCESS**

Fenton’s reagent Fe<sup>2+</sup> was added at the rate of 2mM/l and H<sub>2</sub>O<sub>2</sub> at the rate of 10mM/l. Before that Ozonation at 2.5l/min was done as pretreatment. The sample was collected at different intervals of time. It was shown in the fig. 4.3 The removal of TCOD at 60 min was found to be 1600mg/l. the removal efficiency was 73.33%.

**V. CONCLUSION**

In this report, a general study on the treatment of leachate by AOP is attempted. The various kinds of literature on the AOP were studied and photo-Fenton process was found more efficient among the other treatments. The laboratory experiments for the production of Fenton’s reagent and the treatment of leachate were carried out. Before that Ozonation process was done as the pretreatment. Then the leachate was treated with Fenton reagent, ozonation and Fenton reagent and photo Fenton process was carried out. A 5watts LED bulb was used for luminescence. After performing the experiments the TCOD for the treated sample was determined. The sample was collected 15minutes interval for 1hour. It was observed from the results that the efficiency was at PhotoFenton, combination of ozone and Fenton, Fenton processes were 76.67%, 73.33% and 71.67% respectively. From the



analysis, the treatment efficiency of leachate for PhotoFenton process was greater than Fenton and Fenton with ozonation process

#### REFERENCES

1. Agata Krzysztozek and Jeremi Naumczyk (2012), 'Landfill leachate treatment by Fenton, Photo-Fenton processes and their modification', *Journal of Advanced Oxidation Technologies*, Vol. 15, No. 1, pp.53-63.
2. Andreia Colombo, Aparecido Nivaldo Modenes, Daniela Estelita Goes Trigueros, Bruna L. de Medeiros, Pricila Marin, Silvia P.D. Monte Blanca (2018), 'Toxicity evaluation of the landfill leachate after treatment with photo-Fenton, Biological and photo-Fenton followed by biological processes'. *Journal of Environmental Health and science*, Vol. 54, No. 4, pp.269-276.
3. Andreia Colombo, Aparecido Nivaldo Modenes, Daniela Estelita Goes Trigueros, sabryna Isabelly Giordani da Costa, Fernando Henrique Borba, Fernando Rodolfo Espinoza- Quinines (2019), 'Treatment of sanitary landfill leachate by the combination of photo-Fenton and biological processes'. *Journal of Cleaner Production*, Vol. 214, pp.145-153.
4. Ardak Makhatova, Birzhan Mazhit, Yerboi Sarbassov, Kulyash Meiramkulova, Vassilis J. Inglezakis, Starvos G. Pouloupoulos (2020), 'Effective photochemical treatment of a Municipal Solid Waste Landfill Leachate', *Plos One*. DOI.10.1371/journal.pone.0239433.
5. Azhar Abdul halim, Noor Nazurah Zainal Abidin, Normah Awang, Anuar Ithnin, Mohd, Sham Othman, Mohd. Ikram Wahab (2011), 'Ammonia and COD removal from Synthetic Leachate using Rice Husk Composite
6. Apurva & J. Chavan studied on USE OF PLASTIC WASTE IN FLEXIBLE PAVEMENTS in volume 2, Issue 4, April 2013.
7. Chaudhary. A. K "Characterization of fly ash bituminous concrete mixes" *Journal of materials in civil engineering*.



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