TREATABILITY STUDY OF LEACHATE BY FENTON OXIDATION

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Abstract - *Leachate generation is a major problem faced by the landfill sites, also during collection and transport creating problem to public health and environment. In the present study, treatability study of fresh leachate by Fenton oxidation method was carried out. The optimum conditions were found at pH 2.5, $FeSO_4$ dosage 1.5 g/l, H_2O_2 dosage 3 ml/l and reaction time of 40 minutes with the best removal of about 99.1%, 86.3%, 85.1% and 99.3% for Turbidity, Hardness, COD and Colour were obtained respectively. Thus Fenton oxidation was proved to be a feasible and cost effective method to treat leachate.*

***Key Words*: Leachate, Fenton process, Hydrogen peroxide, Ferrous Sulphate, COD and Colour removal.**

1. INTRODUCTION

Urbanization, commercial and industrial magnification along with population growth has led to an increase in waste generation worldwide. Landfilling is the economical feasible method for the disposal of solid waste. The unpreventable drawback associated with landfill disposal is the generation of leachate an aqueous liquid with offensive odour and dark colour, produced due to physico-chemical and biological degradation of waste and seepage of precipitation through the compacted cells [1]. Leachate composition varies with time and area, also depends on the nature of waste disposed, landfill age, climate, infiltration rate. Leachate is also produced during collection and transfer of solid waste also from compost piles of waste. Leachate consist of organic and inorganic matter, heavy metals inorganic salts etc. leachate cause severe environmental impacts such as soil, ground and surface water contamination which directly or indirectly effect humans health and environment. Hence it is a major challenge to treat and dispose the leachate generated [2].

Young leachate usually have high biodegradability can be treated by biological process. The older leachate have lower biodegradability with high refractory compounds can't be treated using biological method [3]. Advanced oxidation process (AOP) is a better alternative for biological treatment. AOP is used widely wastewater where hydroxyl free radicals which act as strong oxidant, is used to destroy the impurities. The hydroxyl radicals once produced will vigorously attack the organic compounds. Fenton oxidation is one among the AOP which is very cost effective and easiest method. Fenton oxidation was invented by H.J.H Fenton in 1894. The Fenton's reagents used for oxidation process are hydrogen peroxide as a strong oxidant and ferrous ion as catalyst. Fenton oxidation is often used for industrial waste water which is highly toxic such as waste from dye, rubber chemical, pesticide, pharmaceutical etc [4]. The following reaction describes the Fenton oxidation mechanism:

$$Fe^{2+} + H_2O_2 \longrightarrow Fe^{3+} + {}^{\bullet}OH + OH \quad (1)$$

$$Fe^{3+} + H_2O_2 \longrightarrow Fe^{2+} + HO^{\bullet}_2 + H \quad (2)$$

$$^{\bullet}OH + RH \longrightarrow RH + H_2O \quad (3)$$

$$R^{\bullet} + Fe^{3+} \longrightarrow Fe^{2+} + R^{+} \quad (4)$$

Fenton oxidation is also used as an effective pretreatment for biological methods since it improves the quality of leachate. In the present work efficiency of Fenton oxidation to treat fresh leachate was studied.

2. MATERIALS AND METHODOLOGY

2.1 Sample Collection

The leachate for the present experimental study was collected from Pachchanady Compost Plant near Vamanjor in Mangalore. The sample was kept in refrigerator at about 4° C. The initial characterization of leachate was conducted as per standard method (APHA).

2.2 Materials and Reagents Used

The reagents used for Fenton oxidation are hydrogen peroxide and ferrous sulphate. HCL and NaOH were used for pH adjustment. Fenton oxidation was carried out in 1000 ml beaker using jar test apparatus.

2.3 Experimental Procedure

The oxidation process consists of four succeeding stages - pH adjustment, oxidation reaction, neutralization and coagulation and finally precipitation. The oxidation process was performed in glass beakers of 1 liter capacity. About 500 ml of sample was taken in the beaker and the pH of the sample was adjusted to acidic range using HCL. A weighed quantity of Fe^{2+} was added to the sample followed by the addition of required dose of H_2O_2. The sample was stirred using jar test apparatus at a constant speed. The pH was set to 7 after required time to initiate coagulation. The supernatant obtained was collected and taken for analysis.

Set of experiments was performed to obtain optimum pH, optimum concentration of Fe^{2+} and H_2O_2 and optimum reaction time.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Leachate

The initial characteristics of leachate used for experimentation is shown in Table 1 below. The leachate have high level of BOD/COD greater than 0.5. The reason behind higher biodegradability may be due to presence of dissolved organic and particulate matter present in the fresh waste than the older landfill leachate with stabilized and aged materials [5].

Table -1: Initial Characteristics of Leachate

Parameters	Value
pH	6.62
EC (ms/cm)	23.37
TDS (ppt)	12.97
Hardness (mg/l)	88000
Turbidity (NTU)	7860
BOD (mg/l)	88450
COD(mg/l)	128000
BOD/COD ratio	0.69
Colour (ptCo)	79980

3.2 Experimentation Results of Fenton Process

3.2.1 Optimization of pH

The first set of experimentation was performed to obtain the optimum pH. Fenton oxidation was effective under acidic pH, hence the pH was varied between 2 to 4.5 by maintaining 2.5 g/l of $FeSO_4$ and 20 ml/l of H_2O_2 and 2 hours reaction time. Too high or low pH is not suitable for Fenton reaction. The excess dosage results in the self-decomposition of H_2O_2 to H_2O and oxygen and deactivation of iron to ferric hydroxide and lower pH results in the less generation of hydroxyl radical also increases the scavenging $^{\bullet}OH$ by H^+ [6]. The maximum removal was obtained at pH of 2.5 hence taken as optimum pH.

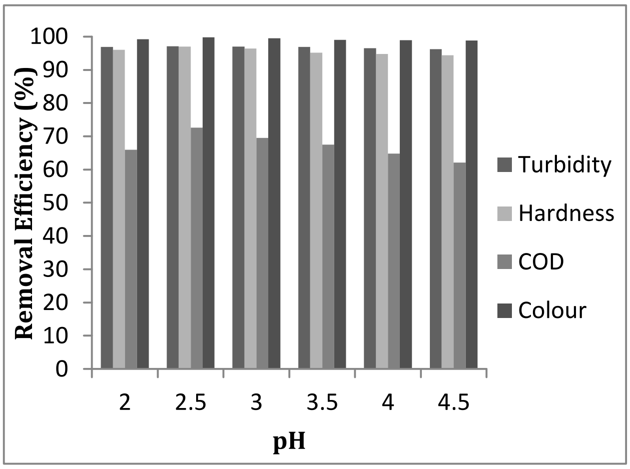

Fig -1: Effect on removal efficiency for varying pH

3.2 Optimization of $FeSO_4$ Dosage

The next step carried out was to determine the optimum $FeSO_4$ dosage. The $FeSO_4$ dosage was varied between 1 g/l to 3.5 g/l by maintaining 20m/l of H_2O_2, 2 hours reaction time and the optimum pH 2.5. The maximum removal was observed at an optimum dosage of 1.5g/l. In Fenton oxidation the initial reaction depend on the amount of Fe^{2+} dosage. The concentration of Fe^{2+} have a substantial effect on the reaction since it acts as catalyst to accelerate the generation of hydroxyl radical to deteriorate the pollutants. The lesser dosage effects less radical formation, reduce the speed and constrain the catalytic process. The excess dosage of Fe^{2+} causes increase in total dissolved solids and also extra sludge [7]. At 1.5 g/l maximum removal was observed hence it is taken as optimum dosage.

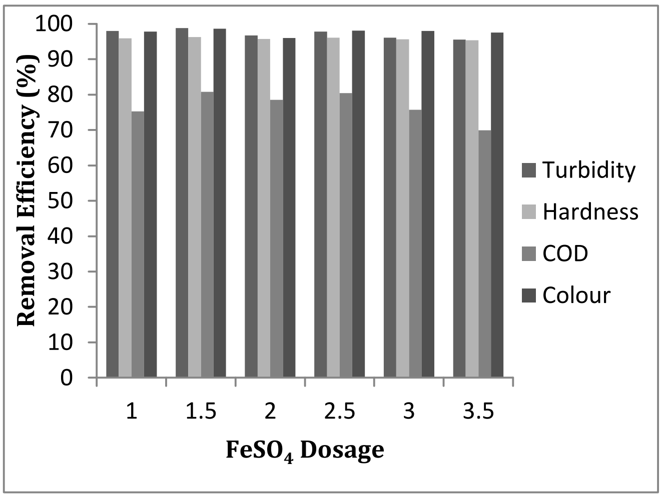

Fig -2: Effect on removal efficiency for varying $FeSO_4$ dosage

3.3 Optimization of H_2O_2 Dosage

The next variable to be optimized was H_2O_2 dosage, H_2O_2 was varied between 3 ml/l to 18 ml/l with n increment of 5 ml/l by maintaining 2 hours reaction time, optimum pH 2.5 and $FeSO_4$ 1.5 g/l. The surplus and scarcity of H_2O_2 dosage have significant on the reaction efficiency. Lower dosages of H_2O_2 do not produce ample hydroxyl radicals to attain thorough mineralization. High concentration results in the decomposition of H_2O_2 and the liberated oxygen hinder the removal efficiency. Excess dosage also causes iron sludge floatation or drops the sludge sedimentation as a result of O_2 off-gassing in reaction to the self-decomposition of H_2O_2 [7]. The maximum removal was obtained at 3ml/l.

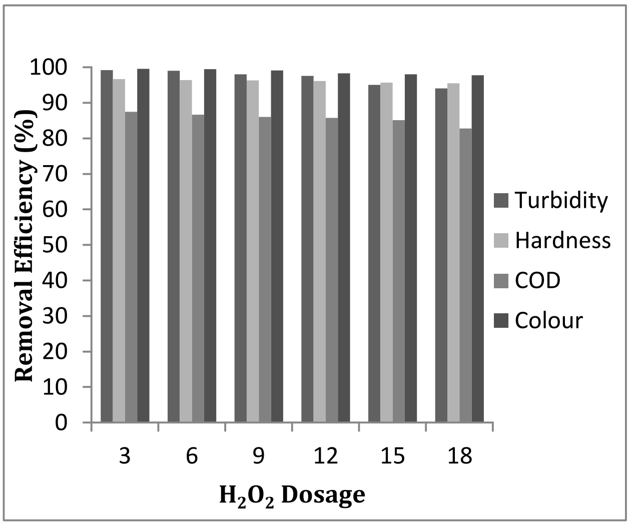

Fig -3: Effect on removal efficiency for varying H_2O_2 dosage

3.4 Optimization of Reaction Time

The reaction time was optimized by varying the reaction time between 20 minutes to 100 minutes with an increment of 20 minutes by maintaining the optimum pH, optimum $FeSO_4$ and H_2O_2 dosage. The hydroxyl radicals generation rate and organic matter reaction rate directly depends on the reaction time provided [8]. The utmost of the organic removal was observed at reaction time of 40 minutes than 60, 80 and 100 minutes. With an increase in reaction time only slight increase in the removal rate was found hence 40 minutes was taken as optimum.

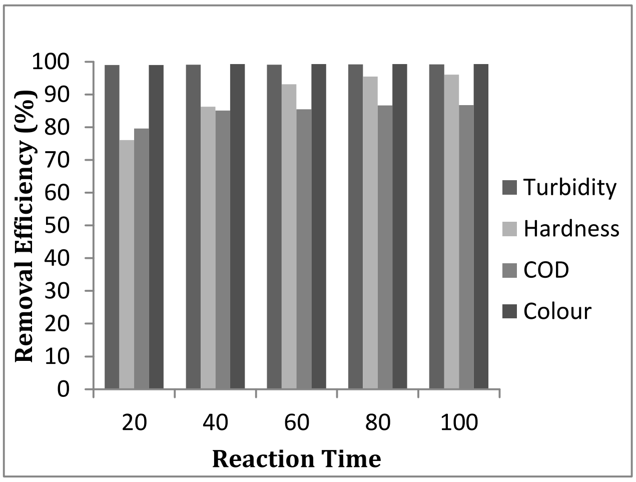

Fig -4: Effect on removal efficiency for varying Reaction Time

4. CONCLUSIONS

The set of experiments conducted proved Fenton oxidation was effective for the treatment of leachate. Great reduction in parameters such as COD, Colour, Turbidity etc were observed. The maximum removal efficiency of 99.1%, 86.3%, 85.1% and 99.3% for Turbidity, Hardness, COD and Colour were obtained respectively at optimum conditions viz pH as 2.5, $FeSO_4$ dosage as 1.5g/l, H_2O_2 dosage as 3 ml/l and 40 minutes reaction time.

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