RESEARCH ARTICLE OPEN ACCESS

Study on Treatment of Leachate from Landfill

Ravi M Soni[1], Dr. Shina Gautam[2]
[1]*(student M.E chemical engineering, Shroff S. R. Rotary institute of chemical technology, at. Vataria, Vali road, Ankleshwar, Gujarat)*
[2]*(Associate professor of chemical engineering, Shroff S. R. Rotary institute of chemical technology, at. Vataria, Vali road, Ankleshwar, Gujarat)*

ABSTRACT
A study was the investigated based on the leachate treatment which one of the apply to the coagulation-flocculation and Fenton process in the sequences of our process. Two types of the coagulant used: (i) aluminum sulphate (alum) (ii) ferric chloride were using standard jar test apparatus. Result indicated that which one of the best removal of the process so that alum was the 60.44% removal of the organic efficiency at pH 4.5 and alum dosages 7000 mg/l and ferric chloride was the 58.21% of the removal of organic efficiency at pH 5 and ferric chloride dosages 6000 mg/l. Further treatment of the sequential process is the Fenton process. Fenton process is exhibit at pH 3-3.5 and optimized parameter of the Fenton process for the Fe^{+2} dosages 15000 mg/l and H_2O_2 dosages 30000 mg/l, H_2O_2/Fe^{+2} = 2.0, total reaction time 1 hr. After the Fenton process was the 82.54 % removal of the COD, and overall % of the COD removal efficiency is 92.0% removal.

Keywords – Coagulation, Fenton process, Landfill leachate, Hydrogen peroxide, Ferrous sulphate.

Date of Submission: 21-02-2018 Date of acceptance 8-03-2018

I. INTRODUCTION

Day by day increases to the industrialization area so high amount of the waste water are generated and that can be directly affected to the environment. However, the high amount of landfill leachates is generated in industrialization [1]. A leachate is any liquid that, in the course of passing through matter, extracts soluble or suspended solids, or any other component of the material through which it has passed [1]. Leachate sample is depended upon the age, BOD, COD value, etc. leachate age is less than 5 years is called stabilized leachate. The leachate usually contains high concentrations of ammonium, organic matter, toxic compounds and heavy metals [2]. Thus, landfill leachate must be treated properly and efficiently, after the processes effluent that can be discharged in to the environment. Since landfill leachate contains wide range of organic contaminates present so that cannot be easily treated by the conventional methods [3-4]. Most of the researcher has focused on the advanced oxidation process or combination of the physico-chemical and advanced oxidation processes for the effective reduced to the organic contaminates and colour from the leachate [3].

Coagulation – flocculation method has been proposed mainly as a pre-treatment technique for removing non-biodegradable organics and heavy metals from fresh leachate [4]. It is widely used as pre-treatment, prior to biological or other physical-chemical techniques. Aluminum sulfate ($Al_2(SO_4)_3$), ferrous sulphate (Fe_2SO_4), ferric chloride ($FeCl_3$) and polyaluminium chloride (PACl) were commonly used as a coagulant. There should be optimized parameter such as coagulant dosages, optimum pH so which coagulant should be highest amount of the organic content removal [6].

Advanced oxidation processes (AOPs) are defined as the oxidation processes to generate effectively hydroxyl radicals in sufficient quantity to effect waste water treatment. Most of the advanced oxidation process use a combination of the strong oxidizing agents like ozone, oxygen or hydrogen peroxide [7-8]. The catalyzation of hydrogen peroxide by ferrous sulfate. Fenton published a descriptive study describing how ferrous iron in the presence of certain oxidizing agents yields a solution with powerful oxidizing capabilities, is called the fenton reagent. Fenton reagent is defined as the catalytic generation of hydroxyl radicals (•OH) [9] resulting from the chain reaction between ferrous ion and hydrogen peroxide, and the oxidation of organic compounds (RH) by Fenton's reagent can be proceed by the following chain reactions [11-12-13]:

$$Fe^{+2} + H_2O_2 \longrightarrow Fe^{+3} + OH^- + \bullet OH$$
$$Fe^{+2} + \bullet OH \longrightarrow Fe^{+3} + OH^-$$
$$RH + \bullet OH \longrightarrow H_2O + R\bullet$$
$$R\bullet + Fe^{+3} \longrightarrow R^+ + Fe^{+2}$$

Hydroxyl radicals are rapidly generated through the first step of the reaction and the iron cycles between

Fe^{+2} and Fe^{+3} and the plays the role of catalyst [15].

In the presences of organic compound, hydroxyl radicals can attack to the organics by the four ways like radical addition, hydrogenation abstraction, electron transfer and radical combination. In this current study the comprehensive of the review and statically analysis of optimum condition of Fenton oxidation of landfill leachate.

Last decade, the research based on advanced oxidation process is very few research so this method in the Fenton process with Nano zero valent iron is very effective method [16]. In this method developed an alternative Fenton system involving the oxidation of iron metal sheets (Fe^0) at acidic conditions generating in situ Fe^{2+} which will promote hydrogen peroxide decomposition into hydroxyl radicals [16-17]:

$$Fe^0 + 2H^+ \longrightarrow Fe^{+2} + H_2$$

II. MATERIALS AND METHODS

1.1 Characteristic of leachate

Landfill leachate was collected from the BEIL company from the Ankleshwar city. The landfill is about the young leachate and after collected to the leachate sample analysis was taken and obtained to the initial COD = 49955 mg/l, initial pH = 8.1, TDS = 70000 mg/l.

1.2 MATERIALS

All chemicals employed in the study were analytical grade. All solution was prepared in only for distilled-deionized water. Coagulation process in the 10% alum and 10% ferric chloride making in the distilled water. pH maintains in the whole process with the help of H_2SO_4 and NaOH. All glassware's washing by the H_2SO_4, by washing agent. Mainly chemicals in this process such as H_2O_2, $FeSO_4.7H_2O$ is the Fenton regent. In this process pH adjustment with the help of NaOH and H_2SO_4. In this process 10% (w/v) $FeSO_4.7H_2O$ and 30% (v/v) H_2O_2 that can be used.

1.3 Coagulation-flocculation method: -

Coagulation-flocculation method is the successfully stabilized leachate treatment and it's a physical treatment method. In this method the different types of coagulants used and which one is better removal of the organic component. However, using the jar test experiment for the treatment of leachate as shown in fig-2.1. In this jar test experiment, 200 ml sample to be taken in jar beaker and simply added to the coagulant and stirring to the first 25 min at 100 rpm and slow at 70 rpm. In this process optimized parameter such as pH, coagulant dosages so however, the first optimized to the coagulant dosages. Which coagulant dosages for the different coagulant simply added to each beaker. After the coagulation process measured to the COD and which point Should be the maximum amount of the % removal of COD. After optimized to the pH value because pH was the mainly affected to the removal of organic contamination. When pH value optimized in the coagulant dosages same in each beaker but pH value is different with the help of H_2SO_4 and NaOH.

Fig: - 2.1 Jar tests apparatus

1.4 Fenton process: -

The Fenton process was carried out by the following of the three stages in the batch mode of operation for the following stages: (1) leachate sample was 300 ml taken either in beaker and reactor (2) pH is maintain at 3 to 3.5 pH after the addition of the Fenton reactant dosages or during operation period. (3) which amount of the $FeSO_4$ dosages should be added and after the process to the maximum amount of the organic component removal. (4) and other chemical which one of the H_2O_2 dosages and that can be optimize parameter. (5) the mixtures were allowed to the mixing at 2000 rpm. (6) and after the process pH was also the adjusted at 7 pH with the help of NaOH. In this process more amount of the hydroxyl radicals is generated are very important. Most of the researchers in the Fenton process based on the continues mode of operation and few view based on the batch process mode. This all the process at room temperature and determine to the Fenton dosages parameter.

III. RESULTS AND DISCUSSION

1.5 Coagulation process:

The leachate treatment of the coagulant was separately treated by the alum and ferric chloride and both are making 10% (w/v). the coagulation process was optimized parameter such as coagulant dosages and pH and which one of the highest amount of the removal of the COD as shown in below.

3.1.1 Effect of the coagulant on COD removal

The effect of various dosages of alum and Ferric - chloride on COD removal as shown in figure-3.1.

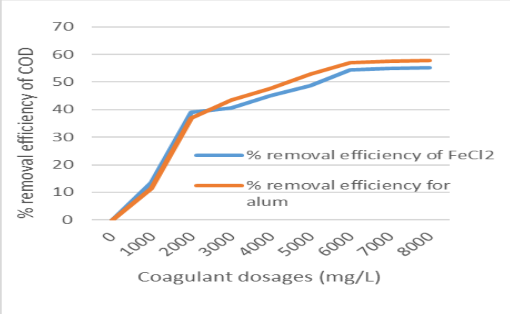

Fig: 3.1 Dosages vs. % removal efficiency of COD without pH adjustment

In figure-3.1, the graph shows the removal for all studied parameters which increases to a great extent with an increases alum dosages until it reached its optimum dosage. It is clearly indicated that the coagulant dosages increase to the highest amount of the COD removal to reached the optimum point for the alum for 7000 mg/l at 57.56% COD removal and ferric chloride for 6000 mg/l at 54.83% COD removal. Therefore, the maximum COD removal with the help of alum so it is the best coagulant and this coagulant is cheap as the cost point of view.

3.1.2 Effect of pH on COD removal

The removal efficiency in terms of COD by alum and ferric chloride with various pH values are shown in figure-3.2. From the figure-3.2 it is clearly indicate that pH 4.5 has slightly higher tendency for the removal of COD. This is mainly due to reasons that alum tends to hydrolyze at pH 4.5 to form Al^{+3}, $Al(OH)_2$+, and $Al(OH)_4^-$ ions to adsorb colloidal particle on its surface and precipitated as $Al(OH)_3$ which is the solid form sludge. pH 4.5 is selected as optimum pH for alum coagulant because at pH 4.5 is the highest amount of the COD removal (60.44%). As referred to figure-4.1, it can be observed that there is a peak at pH 4.5-5 which indicates the highest removal of COD between pH 4.5-5 with 6000 mg/L of $FeCl_3$ added. pH 5 is selected as optimum pH for the $FeCl_3$ due to less pH adjustment is needed because the at pH 5 is the highest amount of the COD removal (58.21%).

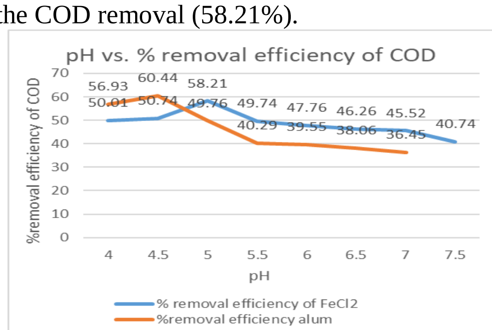

Fig: 3.2 Fig: 4.1 pH vs. removal efficiency of COD with pH adjustment

Acidic condition such as pH 4-5 facilitate the ferric ion hydrolyze in to polynuclear cations in order to destabilize those negative charge colloids in the leachate sample.

1.6 Fenton process:

The effects of the initial pH, $FeSO_4$ dosages, H_2O_2 dosages, temperature on the effectiveness of the Fenton oxidation process were studied.

1.6.1 Effect of H_2O_2 dosages

The H_2O_2 plays an important role in the Fenton oxidation process because the main cost of the Fenton process is the cost of the H_2O_2 so it is very important parameter optimized of the H_2O_2 dosages. It is clearly as shown in fig-3.3 that increasing the concentration of H_2O_2 leads to increasing the removal efficiency up to 72.88% at a dose of 30000 mg/l of H_2O_2. It is clearly indicated that the increases the H_2O_2 dosages to decreases to the % removal of efficiency. However, at a high dosage of H_2O_2, the removal efficiency decreased due to the •OH scavenging effect of H_2O_2 and recombination of the •OH. Therefore, the not required for the high amount of the H_2O_2 dosages so that the optimal concentration of H_2O_2 was obtained as 30000 mg/l for the Fenton oxidation process.

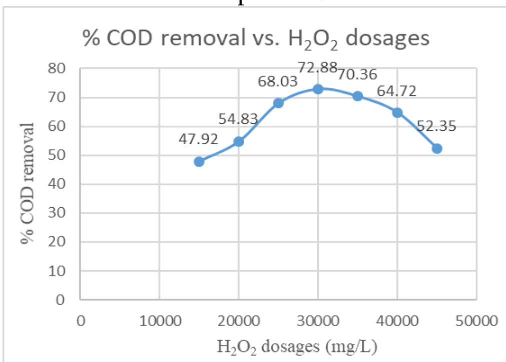

Fig: 3.3 %COD removal vs. H_2O_2 dosages at pH = 3 and $FeSO_4$ = 10000 mg/l

1.6.2 Effect of Fe^{+2} dosages

The effect of Fe^{+2} concentration is directly related to the % removal efficiency as shown in fig-4.4. It can be shown that the Fe^{+2} dosages increase to greatly improved to the removal efficiency up to critical Fe^{+2} concentration. It achieved 82.54% of the highest amount of the COD removal efficiency at 15000 mg/l of $FeSO_4.7H_2O$. This is due to very fact that Fe^{+2} plays a very important role in initiating the decomposition of H_2O_2 to generate •OH. A further increase in Fe^{+2} concentration that it should be Fe^{+2} recombines with •OH as scavenging. Hence, the excess ferrous ion consumed •OH with a high oxidation potential. This caused a decrease in the efficiency of COD removal so that the optimum condition of $FeSO_4.7H_2O$ is 15000 mg/l for the Fenton process due to the high amount of Fe^{+2} concentration that caused the generate to the high amount of sludge and it is the major problem of the Fenton process.

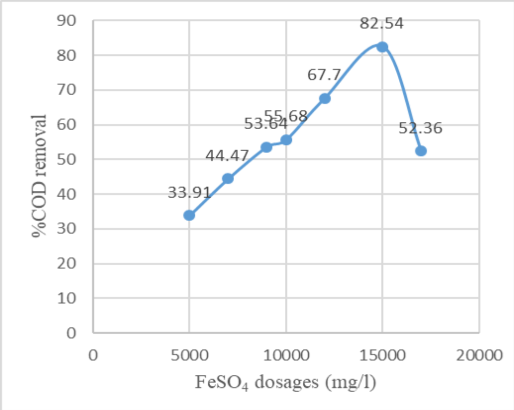

Fig: 3.4 % COD removal vs. $FeSO_4$ dosages at pH 3 and H_2O_2 = 30000 mg/l

1.6.3 Effect of the initial pH

The effect of the initial pH is very important parameter because it is directly affected to the % COD removal. The effect of the initial pH on COD removal efficiency was as shown in fig-4.5. It is clearly indicated that the graph is based on the 15000 mg/l $FeSO_4$ and 30000 mg/l H_2O_2 to the maximum COD oxidation based removal efficiency at that pH should be 3 to 3.5 pH means that pH between 3 to 3.5 should be maximum amount of the % COD removal of 80.39%. At an extremely low pH (<3) the COD removal efficiency decreased sharply, due to the low reaction rate $[Fe(H_2O)]^{+2}$ and H_2O_2, increased scavenging of pH by H^+ at low pH (<3). If pH should be exceeding to the 3.5 (>3.5) that sometimes due to the increasing rate of auto decomposition of H_2O_2, deactivations of irons ions in to the oxyhydries and decreased to the oxidation potential of •OH. Therefore, the COD removal efficiency is the directly related to the effect of the initial pH. The pH of the landfill leachate after the coagulation process was about the pH 6.5 and it dropped to the pH between 3-3.5 when the addition of the $FeSO_4$ (10% w/v) and H_2O_2 (30% v/v). Then, the pH value is consistent throughout the whole Fenton oxidation process. During the process pH values of leachate were adjusted to different values and the $FeSO_4$ 15000 mg/l and 30000 mg/l H_2O_2 were added in each beaker.

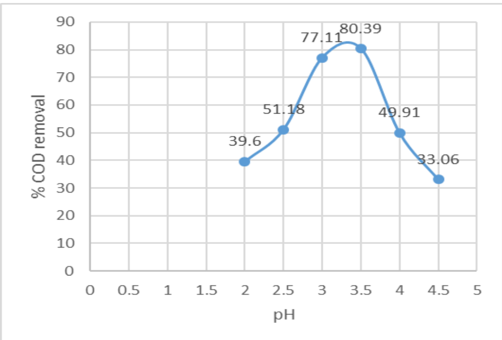

Fig: 3.5 % COD removal vs. pH at $FeSO_4$ = 15000 mg/l, H_2O_2 = 30000 mg/l

1.6.4 Effect of the temperature

Temperature is one of the important factors influencing catalytic oxidation reaction rates. In this process temperature range 20 to 40 ^{0}C should check to the which amount of the COD removal. Fenton process in the heat removed through the process because it is the exothermic reaction so that the temperature is high during the process [8-9]. During this our experimental temperature at 37 ^{0}C should be the highest amount of the COD removal but exceeding the temperature 40 ^{0}C now required to the cooling jacket. Higher temperature was beneficial for Organic removal, even though the increase of organic removal is relatively small.

IV CONCLUSION

(i) A combined process that includes coagulation and Fenton process were excellent removal efficiency for the leachate treatment.
(ii) Two types of coagulant should be used and alum is the best coagulant as a dosages of alum 6000 mg/l at pH = 4.5 and also a cost point of view is better as compare to the ferric chloride.
(iii) After coagulation process applied to the Fenton process and it is excellent work for this leachate treatment and optimized parameter like Fe^{+2} = 15000 mg/l and H_2O_2 = 30000 mg/l and operating temperature 40 ^{0}C.

Acknowledgements

"A little progress every day, adds up to a big result", the famous proverb holds true in the development of our project. But this project wouldn't have been developed up to this extent without the immense help of several people working behind the screen with me. I express my sincere thanks to internal guide Dr. Shina Gautam (Associate Prof. of Chemical Department), for her motivational support and continuous flow of encouragement while working in the direction of preparing of the project. I would like to appreciate the guidance given the judging panel especially in our project presentation that has improved our presentation skills by their comment and tips.

REFERENCES

[1]. Tatsi, A., Zouboulis, A., 2002. A field investigation of the quantity and quality of leachate from a municipal solid waste landfill in a Mediterranean climate (Thessaloniki, Greece). Adv. Environ. Res. 6, 207–219.
[2]. A. Tatsi, I. Zouboulis, K.A. Matis, P. Samaras, Coagulation–flocculation pretreatment of sanitary landfill leachates, Chemospher 53 (2003) 737–744.

[3]. Zi jun Young, Mohammed J.K Bashir, Choon Aun Ng, a sequential treatment of intermediate tropical landfill leachate using a sequencing batch reactor (SBR) and coagulation.

[4]. K.J. Kennedy, E.M. Lentz, Treatment of landfill leachate using sequencing batch and continuous flow up flow anaerobic sludge blanket (UASB) reactors, Water Res. 34 (2000) 3640–3656.

[5]. Hui Zhang, Xiaogang Wu, Xianwang Li, Oxidation and coagulation removal of COD from landfill leachate by Fered–Fenton process, Chemical Engineering Journal 210 (2012) 188–194.

[6]. Wei Li, Tao Hua, Qixing Zhou, Shuguang Zhang, Fengxiang, Treatment of stabilized landfill leachate by the combined process of coagulation/flocculation and powder activated carbon adsorption, Desalination 264 (2010) 56–62.

[7]. Xiaojun Wang, Sili Chen, Xiaoyang Gu, Kaiyan Wang, Pilot study on the advanced treatment of landfill leachate using a combined coagulation, fenton oxidation and biological aerated filter process, Waste Management 29 (2009) 1354–1358.

[8]. Y.W. Kang, K.-Y. Hwang, Effects of reaction conditions on the oxidation efficiency in the Fenton process, Water Res. 34 (2000) 2786–2790.

[9]. I. Monje Ramirez, M.T. Orta de Velasquez, Removal and transformation of recalcitrant organic matter from stabilized saline landfill leachates by coagulation–ozonation coupling process, Water Res. 38 (2004) 2605–2613.

[10]. R. Zamora, A. Moreno, M. Orta de Velasquez, I. Ramirez, Treatment of landfill leachates by comparing advanced oxidation and coagulation–floculation processes coupled with actived carbon adsorption, Water Sci. Technol. 41 (2000) 231–235.

[11]. F. Wang, D.W. Smith, M.G. El-Din, Application of advanced oxidation methods for landfill leachate treatment, J. Environ. Eng. Sci. 2 (2003) 413–427.

[12]. J.-S. Kim, H.-Y. Kim, C.-H. Won, J.-G. Kim, Treatment of leachate produced in stabilized landfills by coagulation and Fenton oxidation process, J. Chin. Inst. Chem. Eng. 32 (2001) 425–429.

[13]. A. Papadopoulos, D. Fatta, M. Loizidou, Treatment of stabilized landfill leachate by physico-chemical and bio-oxidation processes, J. Environ. Sci. Heal. A33 (1998) 651–670.

[14]. A. Lopez, M. Pagano, A. Volpe, A.C. Di Pinto, Fenton's pre- treatment of mature landfill leachate, Chemosphere 54 (2004) 1005–1010.

[15]. A review on Fenton and improvements to the Fenton process for wastewater treatment Arjunan Babuponnusami, Karuppan Muthukumar. Journal of Environmental Chemical Engineering.

[16]. K.D. Warren, R.G. Arnold, T.L. Bishop, L.G. Lindholm, E.A. Betterton, Kinetics and mechanism of reductive dehalogenation of carbon tetrachloride using zero-valence metals, J. Hazard. Mater. 41 (1995) 217–227.

[17]. A. Babuponnusami, K. Muthukumar, Removal of phenol by heterogenous photo electro Fenton-like process using nano-zero valent iron, Separ. Purif. Technol. 98 (2012) 130–135.

[18]. Y. Segura, R. Molina, F. Martinez, J.A. Melero, Integrated heterogeneous sono-photo-Fenton processes for the degradation of phenolic aqueous solution, Ultrason. Sonochem. 16 (2009) 417–424.

Ravi M Soni "Study on Treatment of Leachate from Landfill "International Journal of Engineering Research and Applications (IJERA) , vol. 8, no. 03, 2018, pp. 22-26