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LEACHATE CO-TREATMENT OF LANDFILL WITH MUNICIPAL WASTE WATER USING BIOLOGICAL AND ADVANCED OXIDATION PROCESS

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ABSTRACT
Attempts were made to treat landfill leachate with municipal wastewater using aerobic column type sequencing batch reactor and advanced oxidation process. Sequential batch reactor was fabricated with Perspex material column of 5 cm diameter. The height of the reactor was 100 cm resulting in a volume of 2.0 litres. One air blower EK 8000 was used for supplying diffused air to the reactor. The entire experimental set up was automated with solenoid valves, timers, gate valves etc. The reactor was seeded with aerobic sludge of municipal sewage treatment plant. The reactor was operated on a 24 hour cycle consisting of 20 minutes of fill, 22 hours of react, 1hour of settle, 10 minutes of decant and 30 minutes of idle phase. Leachate was mixed with municipal wastewater at different dilutions. The reactor system was properly acclimatised by gradually increasing the fraction of leachate with municipal wastewater. Initially 5% of leachate was mixed with municipal wastewater and the reactor was operated for 30 days. After achieving substantial degradation of leachate at 5% dilution, the fraction of leachate was increased to 10%, 15% and 20%. The reactor was operated until steady state conditions were achieved under each phase. The performance of the reactor was monitored for the removal of BOD, COD, Ammonia and Total Kejeldahl Nitrogen (TKN). The maximum COD removal efficiencies of 81%, 78%, 79% and 74% respectively was achieved at 5%, 10%, 15% and 20% leachate fraction. The maximum BOD removal under each feeding conditions was around 78%. Ammonia, nitrate and nitrites were also monitored in the influent and effluent of the reactor. It was observed that 98% removal of ammonia nitrogen was achieved in the reactor. The effluent of the biological reactor was subjected to post treatment using Fenton's reagent and Ozonation. It has been observed that ozone was effective in reducing COD further and overall 85% removal efficiency was achieved after treatment whereas 81% removal efficiency was achieved after treating with Fenton's reagent.

INTRODUCTION
Continuous industrial and commercial growth in the past decades has resulted in a rapid increase in the generation of both industrial as well municipal solid wastes. Landfilling of municipal and industrial solid wastes is among the most widespread and economical method of waste disposal. Disposal of solid waste in landfills results in generation of a toxic liquid termed as leachate. Landfill leachate is extremely polluted wastewater rich in biologically recalcitrant organic matters, ammonia nitrogen, heavy metals, pathogens and inorganic salts (Kjeldsen 2002 and Deng 2007). Chemical composition of leachate changes with the time span of landfill operation. Typical leachate COD for the transient landfills (2–5 years of operation) is about 500–10000 mg/L, while COD for old landfill leachate is less than 500 mg/L (Kim and Lee 2009). Leachate may endanger aquatic environment due to uncontrolled overflow, subsidence, and infiltration (Isidori et al. 2003). A number of physical chemical and biological treatment methods have been used for the treatment of landfill leachate. Biological treatment has generally been the most preferred method owing to its effectiveness in removing organic matter and nitrogen (Abbas et al. 2009). However, as the biodegradation of solid waste progresses the efficiency of biological process reduces because of the increasing amount of generation of refractory compounds namely fulvic and humic acids constituents in leachate (Renou et al. 2008). Advanced

oxidation processes (AOP) have been recognised as an attractive means to remove colour, reduce the organic load andimprove the biodegradability of recalcitrant contaminants of mature leachates (Deng and Englehardt, 2006; Kochany and Lipczynska-Kochany, 2009; Renou et al., 2008). AOPs involve the production of free radical species, mainly the hydroxyl radical (OH). The hydroxyl radical may be produced from single oxidants such as ozone (O_3), or from a combination of strong oxidants such as O_3 and hydroxide (OH^-), O_3 and hydrogen peroxide (H_2O_2), or ferrous ions (Fe^{2+}) with H_2O_2 (Renou et al., 2008; Rosenfeldt et al., 2006). The combination of Fe^{2+} and H_2O_2 is called Fenton oxidation. Fenton oxidation has been extensively studied for the treatment of mature landfill leachates. In Fenton's oxidation, under optimum pH, ferrous ions react with hydrogen peroxide to generate the hydroxyl radical in a very simple and cost-effective manner (Deng and Englehardt, 2006). Ozone (not decomposed, pH < 6) is a strong oxidiser having high reactivity and selectivity towards organic pollutants such as aromatic compounds (Lucas et al., 2010; Lin et al., 2009). Ozone alongwith H_2O_2 at high pH is very effective in removing recalcitrant compounds. AOPs are generally used as either pre treatment or post treatment techniques alongwith biological oxidation (Lin and Kiang, 2003). Neczaj et al., (2008) studied the co-treatment of landfill leachate and the wastewater from industrial milk factory in two laboratory-scale aerobic sequencing batch reactors (SBR). During co-treatment process of landfill leachate the best effluent quality was observed under organic loading of 0.8 kg BOD_5/m^3 d and HRT of 10 days. Kalka (2012) studied the co treatment of landfill leachate with sewage and observed the decrease in toxicity of leachate. He concluded that the toxicity was not decreased to a significant level. Zeng et al. (2015) worked on the effect of the mixing ratio during co-treatment of landfill leachate and sewage with a combined stripping and reversed A2/O process. He observed that stripping, as pre-treatment, could significantly remove ammonia nitrogen (NH_3-N) and total nitrogen (TN) by 55% and 52%, respectively.

It has been observed that a variety of reactor configurations have been used for the biological treatment of wastewater. Among the various biological treatment processes sequencing batch reactor (SBR) has gained popularity owing to ease in operation, maintenance and less space requirement. Recent researches in the SBR technology has led to the development of column type sequencing batch reactor wherein strong aeration force results in the development of aerobic granules which can handle higher organic load and can degrade toxic compounds as well. Column type SBR requires less space and less aeration cost and can handle high organic load. Going through the literature it has been observed that a number of studies have been performed on the co-treatment of leachate and municipal wastewater. However, the fraction of leachate was not significant. The present study was focussed on a two stage co treatment of leachate and sewage at a higher dilutions i.e. upto 20%. The first stage treatment was focused on the column type SBR. The effluent of the SBR was subjected to advanced oxidation process using ozone and Fenton's reagent. The parameters analysed were BOD, COD ammonia nitrogen, nitrite and nitrate.

MATERIALS AND METHODS

The leachate used in the study was collected from a landfill site in Ghazipur, Delhi (India). Ghazipur landfill site spread over an area of 72 acres is adjacent to proposed project site. Thesite receives MSW from North and South Sahadara. The landfill site on an average receives about 2000 TPD of MSW.
The experiments were carried out in a laboratory scale Sequencing Batch Reactor System (SBR) fabricated with Perspex material and had a total volume of 2.0 liters. The dimensions of the reactor were 5 cm in diameter and 100 cm in height and the working H/D (Height/Diameter) was about 20, fine air bubbles for aeration and mixing were supplied by diffusers placed at the reactor bottom. One air pump system, model EK- 8000, 6.0 W, was used for supplying diffused air to the reactors. The entire experimental setup was automated with Solenoid valve, Gate valves followed by automatic on-off timers. The reactor was operated on a 24 hour cycle consisting of 20 minutes of fill, 22 hours of react, 1hour of settle, 10 minutes of decant and 30 minutes of idle phase. A tank of 12 liter capacity

was provided for the influent to the SBR. Figure 1 shows the diagram of the reactor set up.

Table 1. Characteristics of Raw Lechate and Sewage

S.No	Parameters	Lechate	Sewage
1.	pH	8.16	7.5
2.	Alklanity (mg/L)	150	85
3.	COD(mg/L)	4,900	150
4.	BOD(mg/L)	3000	90
6.	Nitrate(mg/L)	21	7
7.	Nitrite(mg/L)	6.7	0
8.	Ammonia(mg/L)	280	15
9.	TKN(mg/L)	1400	36

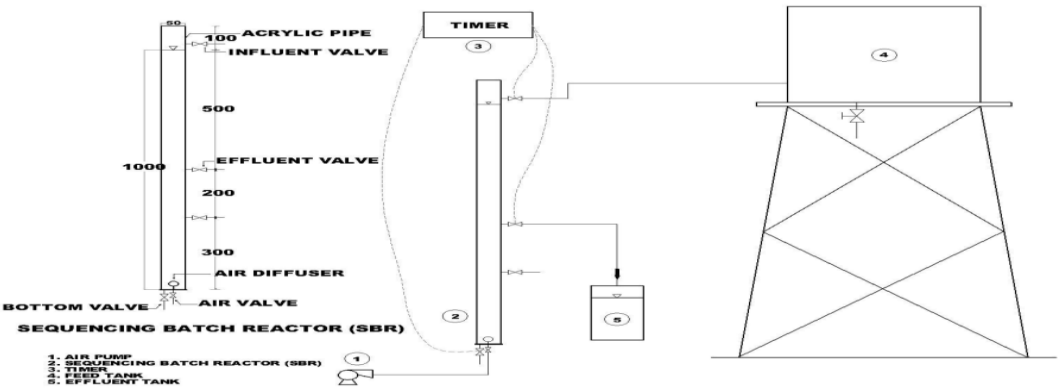

Figure 1: Reactor set up used for the Study

The reactor was seeded with sludge obtained from the municipal wastewater treatment plant, Okhla, New Delhi, India. Initially the reactor was fed with sewage in order to activate the microorganisms. Once the microorganisms were acclimatised to sewage landfill leachate was introduced to the reactor along with sewage. Initially 5% of the leachate was mixed. Subsequently the percentage of leachate was increased to 10%, and finally 20% after achieving significant COD removal in each stage. Once the reactor achieved steady state at maximum dilution of 20%, the effluent of the reactor was post treated with Fenton’s reagent and ozone.

Experiments for Fenton reagent were performed in a Jar test assembly. 500 mL of leachate was taken in five beakers of 1 L each and gentle mixing was done for 30 minutes. The dose of $FeSO_4$ was kept at 1 mg/L while the dose of hydrogen peroxide was varied from 2 mL to 10 mL. The pH was reduced to 3.5 as Fenton’s reagent works best around this pH. The dose of $FeSO_4$ was kept constant as it acts as catalyst for the liberation of .OH radical .After mixing the sample was settled, filtered and analysed. Post treatment with ozone was performed at elevated pH around 8.5 and for different exposure time. Ozonation experiments were performed in a 1.0 L beaker using ELTECH oxygen concentrator followed by ELTECH ozone generator. The concentration of ozone was kept constant and was 2.5 g/hr and contact time was varied as 10 minutes, 20 minutes, 30 minutes and 40 minutes.

The pH, alkalinity, COD, ammonia nitrogen and nitrite were monitored in the influent and effluent reactor volatile suspended solids were monitored on a routine basis. COD was monitored using Hach COD digester. TKN was measured using Hach TKN digester. Hach spectrophotometer DR 5000 was used for the analysis of COD, TKN etc. All chemical analyses were performed using standard Methods (AWWA 2010).

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OBSERVATIONS AND DISCUSSIONS

The present investigation was carried out to assess the performance of column type SBR for the co treatment of leachate with municipal sewage. After acclimatization of microorganisms 5% of leachate was introduced along with sewage and the COD removal was observed. COD removal increased with time. The fraction of leachate was increased to 10%, 15% and 20% after achieving significant COD removal in each phase. As shown in fig 2 the maximum COD removal efficiencies of 81%, 78%, 79% and 74% were achieved at leachate fractions of 5%, 10%, 15% and 20% respectively. At 20% leachate concentration the COD removal efficiency achieved was only 73 %. Studies on co treatment of leachate with sewage have been done by Kalka, (2012), Zeng et al. (2015), Berry (1997) and Rahat et al. (2008). However, these investigators did not attempt such a high fraction (20%) of leachate with sewage.

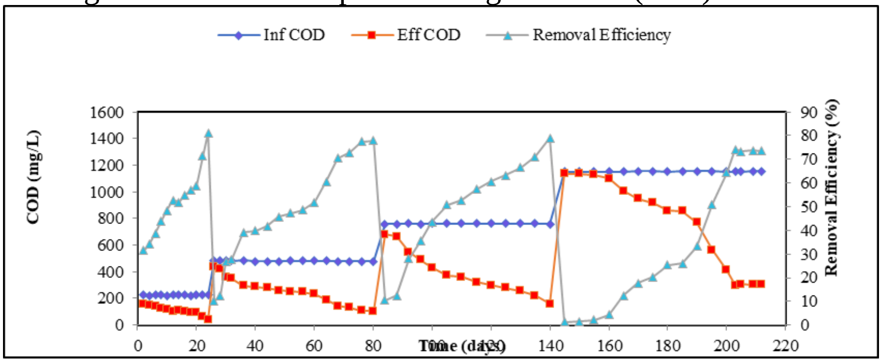

Fig 2 Variation of COD with Time for 5%, 10%, 15% and 20% leachate concentration

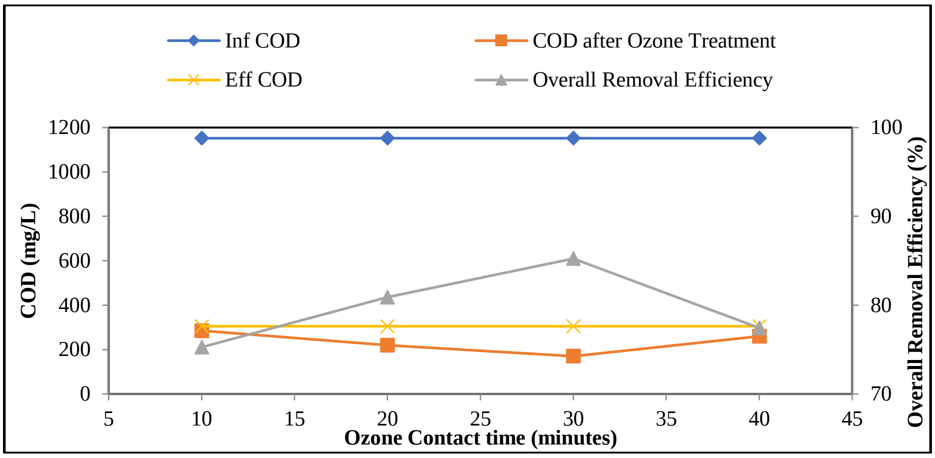

Fig 3 Variation of COD at different ozone contact time.

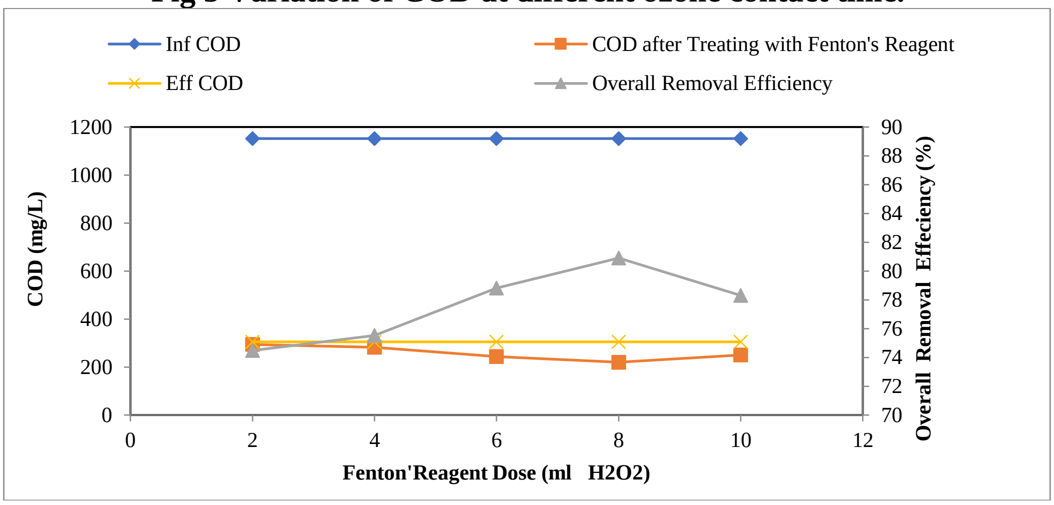

Fig 4 Variation of COD with dosages of Fenton Reagent

Apart from monitoring COD, nitrogen removal was also monitored in the present study. TKN removal efficiency of 66%, 66.5%, 69% and 62% were achieved and ammonia removal efficiencies of 94%, 97% 96% and 97.5 % were obtained at 5%, 10%, 15% and 20% fraction of leachate in sewage respectively. The higher removal of ammonia was because of air stripping through the reactor. The effluent from biological reactor was subjected to post treatment using advanced oxidation processes.

Separate studies were performed for finding the effect of ozone and Fenton's reagent on the post treatment of biologically treated effluent. Fig. 3 shows the results of variation of ozone exposure times on the COD removal. It was observed that COD removal efficiency increased with increase in exposure time. The maximum COD removal efficiency of 85% was achieved at 30 minute exposure time. Fig. 4 shows the variation of doses of hydrogen peroxide on COD removal efficiency. It was found that COD removal efficiency increased with the doses of H_2O_2 and the maximum COD removal efficiency of 81% was found at 4 ml dose of H_2O_2. The concentration of $FeSO_4$ was kept constant at 1 mg/L. Susana et al. (2011) evaluated the effect of Fenton's reagent and ozone on the pre treatment of leachate. However not much work is done on the post treatment of leachate using advanced oxidation processes.

CONCLUSIONS

The co treatment of landfill leachate with sewage was found efficient till 10% fraction of leachate with effective removal of nitrogen and COD. At 20% fraction of leachate the COD removal efficiency dropped. The post treatment of biologically treated effluent was successfully done using ozone and Fenton's reagent. Ozone was found more effective than fenton's reagent. It can be concluded that co treatment of leachate with sewage can be managed at a ratio of 20% using sequential biological and advanced oxidation process with effective removal of COD and nitrogen.

References

[1] Abbas AA, Jingsong G, Ping LZ, Pan YY, Al-Rekabi WS. Review on landfill leachate treatments. J Appl Sci Res. 5:534–545, 2009.

[2] Berry R.C. & Lin K.C., "Experimental studies on the co-treatment of landfill leachlate and sewage in Fredericton, N.B., Canada" Transactions on Environment and Environment. 14: 1997.

[3] Deng Y, Englehardt JD. Electrochemical oxidation for landfill leachate treatment. Waste Manage. 27:380–388, 2007.

[4] Deng, Y., Englehardt, J.D. Treatment of landfill leachate by the Fenton process. Water Res. 40: 3683-3694. 2006.

[5] Englehardt JD, Deng Y, Meeroff D, Legrenzi Y, Mognol J, Polar J. "Options for managing municipal landfill leachate: year 1 development of iron-mediated treatment processes". Gainesville (FL): Hinkley Center for Solid and Hazardous Waste Management; (Final Report Year 0432024–06), 2006.

[6] Hassen A, Belguith K, Jedidi N, Cherif A, Cherif M, Boudabous A. "Microbial characterization during composting of municipal solid waste". Bioresource Technol. 80:217–225, 2001.

[7] Isidori.M, Lavorgna. M, Nardelli.A, and Parrella.A, "Toxicity identification evaluation of leachates from municipal solid waste landfills: amultispecies approach," *Chemosphere*, 52(1): 85–94, 2003.

[8] Guo. J, Abdulhussain A, Abbas, Chen.Y, Liu. Z, Fang.F, Chen. P, "Treatment of landfill leachate using a combined stripping, Fenton, SBR, and coagulation process" J.Hazardous Mater. 178 (1-3): 699-705, 2010.

[9] Kim Y.D. and Lee D. G., "Comparative study on leachate in closed landfill sites: focusing on seasonal variations," J. Hazard. Mater. 11(3):174–182, 2009.

[10] Kjeldsen P, Barlaz MA, Rooker AP, Baun A, Ledin A, Christensen TH. "Present and long-term composition of MSW landfill leachate: a review". Crit Rev Env Sci Tec. 32: 297–336, 2002.

[11] Kochany, J., Lipczynska-Kochany, E., "Utilization of landfill leachate parameters for pretreatment by Fenton reaction and struvite precipitation e a comparative study". J. Hazard. Mater. 166: 248-254, 2009.
[12] Lin, S.H., Kiang, C.D., "Combined physical, chemical and biological treatments of wastewater containing organics from a semiconductor plant". J. Hazard. Mater. 97: 159-171.
[13] Lin, A.Y-C., Lin, C.F., Chiou, J.M., Andy Hong, P.K., (2009). O3 and O3/H2O2 treatment of sulfonamide and macrolide antibiotics in wastewater. Journal of Hazardous Materials, 171: 452-458, 2003.
[14] Lucas, M.S., Peres, J.A., Li Puma, G."Treatment of winery wastewater by ozone based advanced oxidation processes (O3, O3/UV and O3/UV/H2O2) in a pilot-scale bubble column reactor and process economics". Sep. Purif. Technol. 72: 235-241,2010
[15] Neczaj E, Małgorzata K, Tomasz K, Joanna L, Ewa O, **"**Sequencing batch reactor system for the co-treatment of landfill leachate and dairy wastewater" Desalination, 222(1-3): 404-409, 2008.
[16] Rahat Jahan Chaudhari, Farrukh Basheer and I.H. Farooqi "Combined Treatment of Landfill Leachate and Domestic Wastewater in Submerged Aerobic Fixed Film Reactor (SAFF)", Asian Journal of Water Environment and Pollution, 5(2), pp. 97 – 101, 2008.
[17] Renou S, Givaudan J, Poulain S, Dirassouyan, Moulin P "Landfill leachate treatment: review and opportunity".J Hazard Mater 150:468–493, 2008.
[18] Rosenfeldt, E.J., Linden, K.G., Canonica, S., von Gunten, U., 2006. "Comparison of the efficiency of OH radical formation during ozonation and the advanced oxidation processes O_3/H_2O_2 and UV/H_2O_2". Water Res. 40: 3695-3704, 2006.
[19] Susana. C, Teixeira.P, Oliveira.R, Mota.M , "Evaluation of Fenton and ozone-based advanced oxidation processes as mature landfill leachate pre-treatments". Journal of Environmental Management" 92: 749-755, 2011.
[20] Kalka J, "landfill leachate toxicity removal in combined treatment with municipal wastewater". The Scientific World Journal, volume 2012.
[21] Yang.Z, Zhou.S, "The biological treatment of landfill leachate using a simultaneous aerobic and anaerobic (SAA) bio-reactor system" Chemosphere 72 (11): 1751-1756, 2008.
[22] Zeng ,X, Ding.W, Zhang. Z, Wan.P, Yang. D & Wang.S , "Effect of the mixing ratio during co-treatment of landfill leachate and sewage with a combined stripping and reversed A2/O process". 2015