ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Electrochemical Treatment Of Landfill Leachate: Optimization Of Cod Removal Using Charcoal- Graphite- Cobalt- Polyvinyl Chloride Electrode.

Majd Ahmed Jumaah[1]*, Mohamed Rozali Othman[1, 2] Muhammad Rahimi Yusop[1]

[1]School of Chemical Science and Food Technology, Faculty of Science and Technology, University Kebangsaan Malaysia, Bangi, Malaysia
[2]Centre for Water Research and Analysis (ALIR), Faculty of Science and Technology, University Kebangsaan Malaysia, 43600 Bangi, Malaysia

ABSTRACT

In this paper, several operating conditions such as treatment time, applied voltage, pH and Supporting Electrolyte concentration were tested on the treatment landfill leachate using electrochemical method. Results obtained show that electrochemical method can be used for the remove of chemical oxygen demand from landfill leachate by using proper operating condition. The best removal rates were obtained when charcoal- graphite- cobalt-polyvinyl chloride electrode was used as an anode, operating time is 120 min, voltage applied is 10 voltages, Supporting Electrolyte concentration is 1.5 % (w/v) and pH 4, 90% of chemical oxygen demand was obtained.
Keywords: electrochemical, landfill leachate, charcoal, COD.

***Corresponding author**

INTRODUCTION

Landfill leachate is a major source of pollution caused by the wastewater generated from solid waste buried underground [1]. It can readily pollute soil and penetrates into the underground layers of ground water resulting in severe underground water contamination which is one of the major water sources for human societies [2]. Leachate from landfills represents an extreme wastewater which requires intensive treatment before discharge [3]. Leachate can be categorized as a liquid waste that contains high chemical oxygen demand (COD) and other pollutants. In order to reach environmental friendly criteria for landfill leachate, these pollutants and COD level should be minimized to an acceptable discharge limit. Hence, landfill leachate must be collected and treated. Various methods of treating of landfill leachate have been reported and this process is divided into three, namely the process of chemical, physical and biological [4].The main aim of this study is to evaluate of the effectiveness of electrochemical oxidation technique for leachate treatment using charcoal- graphite- cobalt-PVC electrode in terms of COD removal.

MATERIAL AND METHODS

Leachate samples were collected from Jeram Sanitary Landfill, which is located in an oil palm plantation near MukimJeram, Kuala Selangor, Malaysia. The samples were collected in 1L amber glass bottles transported in ice cool container to the laboratory and stored at 4oC in order to keep the leachate characteristics unchanged.

The composite electrodes at the composition of charcoal 60%- graphite15%- cobalt10%-PVC15% were prepared[5], by mixing together a weighed portion of charcoal powder with PVC in 4 ml tetra hydrofuran (THF) solvent and swirled flatly to homogeneous followed by drying in an oven at 100˚ C for 3 h. The mixture was then placed in 1 cm diameter stainless steel mould and pressed at 10 ton/cm^2. The pellets were connected to silver wire with silver conducting paint prior covered with epoxy gum [6].The total weighed of pellet obtained is approximately 1 gm. The electrochemical system used is consisted of a DC power supply (CP x200 DUAL, 35 V 10A PSU) and a glass beaker (100 ml) completed with charcoal- graphite- cobalt-PVC composite electrode as an anode and stainless steel rod (d = 10 mm) as cathode. Known amount of solid supporting electrolyte (NaCl) was added to 50 ml of leachate. All experiments were carried out at lab scale

Optimization of Electrochemical Parameters for Landfill Leachate Treatment:

In order to treat leachate sample, several operational parameters (applied voltage, NaCl concentration, electrolysis time and pH) have been optimized to select the best conditions that can achieve better removal for color and COD using C60 CG15Co10PVC15 as a working electrode (anode).

The Effect of Applied Voltage on COD Removal:

Different applied voltage values were also used to investigate the effect of applied voltage on the COD removal of landfill leachate. Figure 1 shows that COD removal percentage was increased with the increasing of applied voltage .This can be explained that the rate of generation of hypochlorite ions increased with applied voltage which eventually increases the pollutant degradation [7]. The removal efficiency of COD was 63 %, 89 % and 92 % when applied voltage was measured from 5-15 V for 120 min electrolysis time. At the same time, more energy would be consumed at higher applied voltage, so the optimal voltage used for this study was 10 V as there was no significant different between 10 and 15 V.

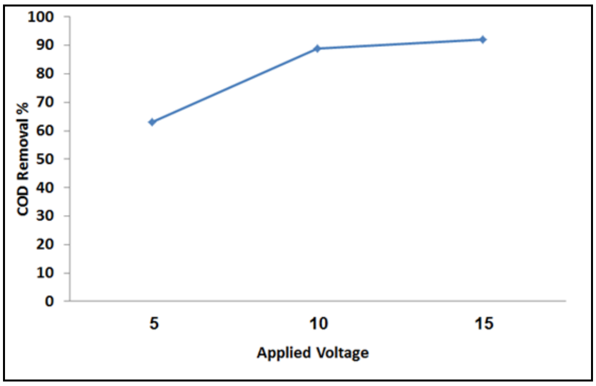

Figure 1: Effect of applied voltage on the removal of COD from leachate

Effect of Supporting Electrolyte on COD Removal:

The effect of NaCl concentration on COD removal was as shown in Figure 2. The results show increased the concentration of NaCl with improve the removal efficiency of COD. The removals of COD were 45 %, 69 %, 77 % and 83% with NaCl concentration added 0.5, 1, 1.5 and 2 % w/v respectively.

It is apparent that increasing the chloride concentration may increases the COD removal due to the increased mass transport of chloride ions to the anode surface and also increased diffusion in the diffusion layer of the anode (Figure 2). As a result, more amount of hypochlorite ion will be generated [8, 9]. Thus, higher concentrations of hypochlorite ion were able to oxidize more organic molecules in wastewater [10]. So far the final study, 1.5 (w/v) of NaCl was considered as an optimum electrolyte concentration due to higher COD removal in landfill leachate.

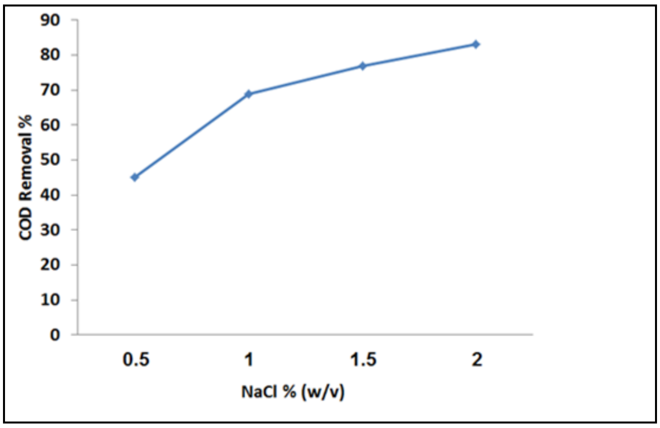

Figure 2: Effect of NaCl concentration on the removal of COD from leachate

Effect of Electrolysis Time on COD Removal:

Effect of electrolysis time on COD removal under the optimal conditions was investigated. As shown in Figure 3. The COD removal percentage rapidly increased with the increased of electrolysis time up to 90 min. After 90 min of electrolysis time, COD removal percentage was slowly increased until up to 89 %. The COD removal efficiency depends directly on the concentration of electrochemical generated hypochlorite. When the electrolysis time was longer, more hypochlorite ion will be produced in solution under fixed current density [11]. Therefore, COD value in the solution was reduced in higher concentration of hypochlorite. From the results, the electrolysis time at 120 min is considered as the optimal electrolysis time due to only slight different in COD removal percentage compared to after 150 and 180 min.

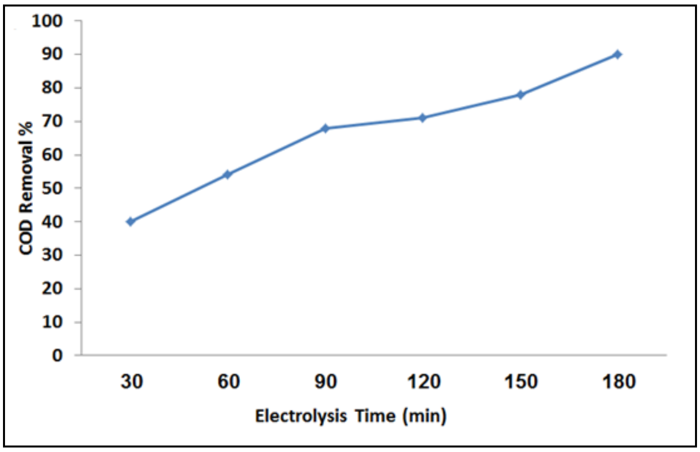

Figure 3: Effect of electrolysis time on COD removal from leachate

Effect of pH Value on COD Removal:

Figure 4 Shows that the COD removal decreased by increasing the pH value of the solution. The reason is in acidic condition presence of hypochlorous acid (HOCl) species which considered the most oxidizing agent compared to hypochlorite ion (OCl-). Anglada and Nordin[12, 13] found that low pH favored COD removal during electro-oxidation of landfill leachate. Therefore, pH 4 is the optimum pH value for treatment of landfill leachate based on Figure 4 with highest COD removal percentage compared to other pH values.

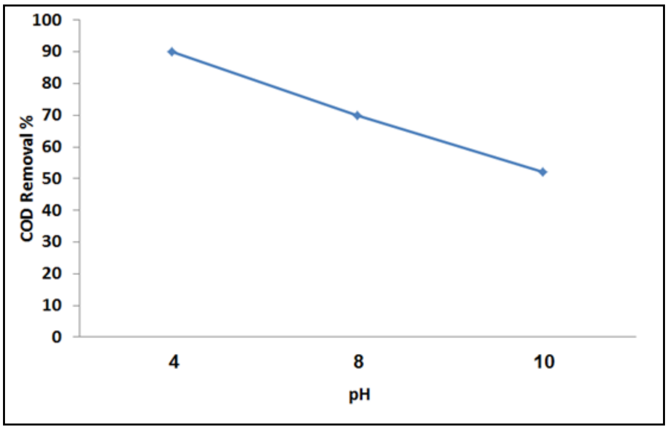

Figure 4: Effect of pH on COD removal from leachate

CONCLUSION

Based on the experiment of landfill leachate treatment by electrochemical oxidation, the results indicateelectrochemical oxidation technique can be used for COD removal from landfill leachate. Under conditions of charcoal- graphite- cobalt-PVC electrode, 10 V, 120 min electrolysis time, pH 4 and1.5% (w/v) NaCl concentration, the removal of COD was 90%.

ACKNOWLEDGMENT

The authors would like to thank University Kebangsaan Malaysia and Ministry of Higher Education, Malaysia through grants FRGS/2/2013/SG01/UKM/01/1 are gratefully acknowledged

REFERENCES

[1] Renou S J,Givaudan G, Poulain S,Dirassouyan F, Moulin P. J hazardous materials 2008;150: 468-493.

[2] Jumaah M A, Othman M R, ZakariaZ. International J Chemical Sciences 2015; 13: 943-954.

ISSN: 0975-8585

[3] Jumaah M A, Othman M R. International JChemTech Research 2015; 8: 604-609.
[4] Kjeldsen, Peter, Morton A. Barlaz, Alix P. Rooker, Anders Baun, Anna Ledin, Thomas H.Christensen. Critical ReviewsinEnvir Science & Tech 2002; 32: 297-336.
[5] Nordin, N, Amir, S F M, Yusop, Othman, M.R.ActaChimicaSlovenica 2015; 62: 642-651.
[6] JumaahMA, Othman M R.International Journal of ChemTech Research 2015; 8: 559-563.
[7] Jumaah, M A, Othman M R.International Journal of ChemTech Research 2015: 8: 783-787.
[8] Panizza, Marco, Carlos A Martinez-Huitle. Chemosphere 2013; 90: 1455-1460.
[9] Yang, C-H, C-C Lee, T-C Wen. Journal of Applied Electrochemistry 2000; 30: 1043-1051.
[10] Wang, Chih-Ta, Wei-Lung Chou, Yi-Ming Kuo. J Hazardous Materials; 2009; 164: 81-86.
[11] Jumaah, M A, Othman M R. Malaysian Journal of Analytical Sciences; 2015; 19:531-540.
[12] Anglada, Ángela, AneUrtiaga, Inmaculada Ortiz, DionissiosMantzavinos, Evan Diamadopoulos. Water Research 2011; 45: 828-838.
[13] Zakaria Z, Nordin N, Hasan S Z, Baharuddin N A, Jumaah M A, Othman M R. Malaysian Journal of Analytical Sciences 2015;19: 493-502.