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Optimization of Operating Conditions for Landfill Leachate Treatment Using Electrochemical Oxidation Technique

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Abstract: Several operating conditions such as electrode material, treatment time, applied voltage and Cl^- concentration were tested on the treatment landfill leachate using electrochemical (EC) method. Results obtained show that EC method can be used for treatment of landfill leachate by using proper operating condition. The best removal rates were obtained when charcoal composite electrode was used as an anode, operating time is 120 min, voltage applied is 10 V, NaCl concentration is 1.5 % (w/v), 60% of color, 82% of COD and 69% of NH_3-N removal were obtained.
Keywords : decolorization, landfill leachate,charcoal composite electrode, electrochemical.

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), high levels of ammonia as well as elevated values of total dissolved solid (TDS)[4]. In order to reach environmental friendly criteria for landfill leachate, these pollutants 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 [13].The main aim of this study is to evaluate of the effectiveness of electrochemical oxidation technique for leachate treatment using charcoal composite electrode in terms of color removal.

Experimental

Analytical Methods

Raw leachate samples were collected from Jeram Sanitary Landfill, which is situated in an oil palm plantation near MukimJeram, Kuala Selangor. The samples were transported to the laboratory and stored in a refrigerator at 4˚C prior analysis. The characteristic of raw leachate was to determine the concentration of value selected parameters compared with standard discharge[12]and are summarized in Table 1.

Table 1. Characterization of raw leachate samples collected from Jeram Sanitary Landfill

Standard discharge	Value	Parameter
100	13200	Color Pt-Co
400	39000	COD mg/l
20	14790	BOD5 mg/l
5	3800	NH3-N mg/l
-	200	Total-P mg/l
6.0 – 9.0	8.65	pH
-	28.09	TDS ppt
-	29.67	Conductivity mS/cm

Preparation of Electrodes

The composite electrodes at the composition of C70-PVC30 were prepared accordingly as already discuss by other author elsewhere, by mixing together a weighed portion of charcoal powderwith PVC in 4 ml tetrahydrofuran (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[5].The total weighed of pellet obtained is approximately 1 gm. The ratio of Charcoalwith PVC in the prepared electrode is as summarized in Table 2.

Table 2. Ratio and composition metals powder and PVC for electrodes prepared

Electrode	Weight Ratio C:PVC	C (g)	PVC (g)
C:PVC	70:30	0.7	0.3

The Procedure

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 C:70-PVC:30 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. Color, COD, BOD_5 and NH_3-N of the leachate were measured by using standard method for the examination of water and wastewater [6]. TDS and conductivity were measured by using conductivity meter (Cond 610). The pH was measured using pH meter (Metrohm). The removal efficiency (%R) of landfill leachate was obtained at any time, with respect to its initial values using Eq. (1)[15].

$$R\% = [100(R_0 - R_t)]/R_0] \quad \ldots (1)$$

Were R% is the removal percentage, R_0 is initial value of parameters, R_t is the value of parameters at time t.

Results and Discussion

Effect of the Applied Voltage on Color Removal

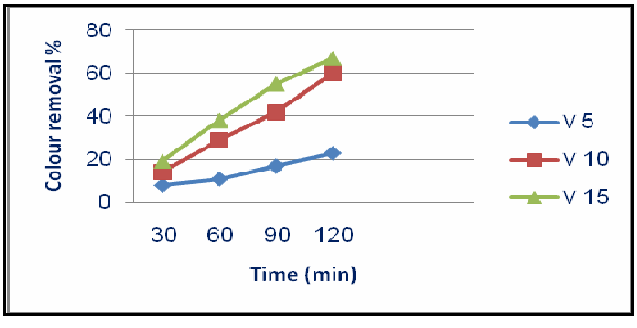

Figure1.Effect of Applied Voltage on Color Removal

Electrolysis was conducted using different applied voltage values to investigate the effect of applied voltage on the color removal of landfill leachate. Figure 1 shows that color removal percentage for5, 10 and 15 V determined were to be 23, 60and 67 % respectively, for the 120 min electrolysis time and1.5 % (w/v) concentration of NaCl. This is due to production of oxidant, hypochlorite ion in the bulk solution. Increasing generation of oxidant is proportional to current density, which is eventually increases the pollutant degradation. The increase in hypochlorite ion approaches equilibrium with degradation of organics present in the effluent [7]. Increasing the applied voltage of the electrochemical cell followed by the production of more electron, which results in increasing the rate of overall reaction [8]. Figure1 shows applied voltage at 10 V is the optimal electrical potential for the electrochemical oxidation process. Because it ensures the removal rate accompanied with reducing the electrical energy to reach desired color removal, Therefor, 10 V of applied voltage has been selected for the further experiments.

Effect of Cl^- concentration on color removal

The electrical conductivity of the solution is an important parameter for saving electric energy. To increases the electric conductivity of the solution, NaCl was used as the supporting electrolyte due to its capability not only as a conductor but also able to enhance the degradation efficiency and shortened the reaction times due to the formation of hypochlorite ion OCl^-[9]. It is apparent that increasing the Cl^- may increase the color 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 [10]. Thus, higher concentrations of hypochlorite ion were able to oxidize and degrade more organic molecules in landfill leachate. A percentage of 1.5 % (w/v) of NaCl concentration was considered as an optimum electrolyte concentration due to highest color removal in landfill leachate.

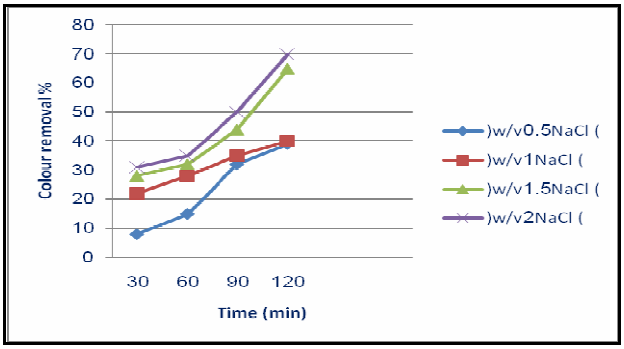

Figure 2.Effect of Cl^- concentration on color removal

Electrolysis Time

The effect of electrolysis time on color removal was studied in the range from 30 min. to 120 min using this optimum condition; applied voltage 10V, NaCl concentration 1.5% (w/v) and raw pH. The results obtained are as tabulated in Figure 3.

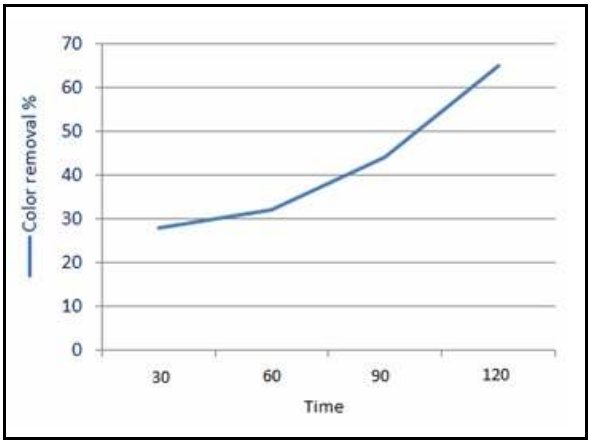

Figure 3. Effect of electrolysis time on color removal

The color removal percentage increases with the increasing of electrolysis time. This is due to the increased generation of hypochlorite ion in bulk solution as a result of oxidation process, thus increased the oxidation processes of organic and inorganic pollutants [14]. In other words, the efficiency removal of pollutants depends on the concentration of hypochlorite ion generated electrochemically in bulk solution[11].

The results obtained show that the electrochemical oxidation process is able to reduce the color, COD and NH_3N values in landfill leachate. From those three parameters under studied (color, NH_3N and COD), the removal percentage were not less than 60, 69 and 82% respectively (Figure 4).

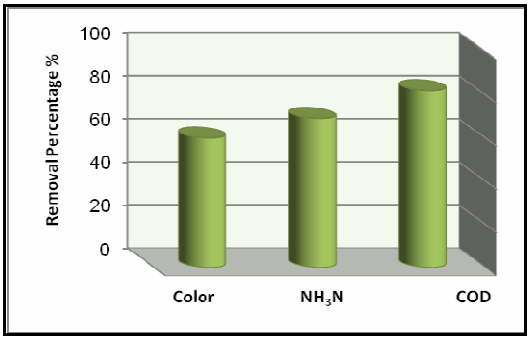

Figure 4. Removal percentage of pollution

Conclusion

Based on the experiment of landfill leachate treatment by electrochemical oxidation, the results indicate electrochemical oxidation technique can be used for the leachate treatment. Under conditions of $C_{70}PVC_{30}$ electrode, 10 V, 120 min electrolysis time and1.5% (w/v) NaCl concentration, the removal of color, COD and NH_3N was 60, 82 and 69 % respectively.

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