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Stabilized Leachate Treatment Using Aerated Electrocoagulation to Reduce Ammonia Nitrogen and Colour Removal

Muhamad Arif Syazwan Awang[1], Laila Wahidah Mohd Zailani[1], Nur Shaylinda Mohd Zin[2*], Nor Azliza Akbar[3]

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[2]Senior Lecturer, Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[3]Senior Lecturer, Center for Civil Engineering Studies, Universiti Teknologi MARA,
Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Bukit Mertajam, Pulau Pinang, Malaysia

*Corresponding Author

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Abstract: Landfill leachate is considered dangerous as it contains countless pollutants. Untreated landfill leachate will damage groundwater resources, the environment and human health. An appropriate treatment is necessary to treat leachate to prevent harm to the environment and humans. The objective in this research is to determine the optimum aerated electrocoagulation under the influence of current density, pH of leachate and aeration rate for ammonia nitrogen and colour removal. The efficiency of removal ammonia nitrogen and colour were compared with Environmental Quality (Control of pollution from solid wastewater transfer station and landfill) Regulation 2009. This research used leachate from Simpang Renggam Sanitary Landfill. In this experiment two electrodes of aluminium and ferum at anode and cathode respectively were used. The highest removal percentage were obtained at 84.93% and 58.82% for the colour and ammonia nitrogen at 200 A/m^2 of current density, 1.0 L/min of aeration rate and pH 5. The removal value was still insufficient to fit the environment quality standard. However, to meet the environmental quality standard, integration with other treatments method is suggested.

Keywords: Aerated electrocoagulation, leachate, ammonia nitrogen, colour

1. Introduction

Leachate is defined as the hazardous substances produced in the landfill due to the process of decomposing of solid waste [1]. As of being labeled hazardous, leachate contains various heavy metals, organic compounds and ammonia nitrogen which can potentially bring harms and pollution towards environmental [2]. The high rate of rainfall precipitation that permeates through the landfill will increase the generation of leachates. Precipitation and evaporation depend on the climatic factor which Malaysia is in the hot and wet tropical climate throughout the year [3]. Thus, encouraged the higher production of leachate in the landfill. Electrocoagulation (EC) is the method to treat polluted **water** involving the release of active coagulant precursors from the corroded sacrificial anodes while formation of hydroxyl ions and hydrogen gas at the cathode simultaneously [4]. The anode is oxidized when an electric current is applied, while the cathode undergoes a reduction of the elementary metals. The process was combined with aeration process as it stimulates the formation and growth of suspended biological flocs, breaking down and metabolizing

**Corresponding author: nursha@uthm.edu.com*

leachate pollutants [5] when supplying the oxygen. By adding aeration in the EC, it will enhance and improve the turbulence around the electrodes and allow the reactive species to escape from the anode [6].

Kobya *et al*. [7] mentioned that the efficiency of the aerated electrocoagulation process will be increased when aeration rates increase. The modification of aerated electrocoagulation was carried out to produce a better performance in order to achieve the target of removal value. Baiju et al. [13] stated that biological treatments are only effective in removing organic matters in the young leachate which is inefficient when it comes to use in old leachate treatment. Based on Wahidah [9], electrocoagulation process which a physical treatment reduced the colour and ammonia nitrogen content in the stabilize leachate. This study aims to remove the ammonia nitrogen and colour by using aerated electrocoagulation from stabilized leachate under the influence of current density, pH and aeration rate.

2. Materials and Methods

2.1 Sample Sampling

The raw leachate samples were collected from the Simpang Rengam sanitary landfill located at latitude 10 53'41.64 "22'34.68 North and longitude 1030" East in Kluang district, Johor, Malaysia. The raw leachate sample were tested at Environmental Laboratory in Faculty of Civil Engineering and Built Environment (FKAAB), University Tun Hussein Onn Malaysia (UTHM) to identify the characteristics based on chemical oxygen demand (COD), pH, temperature, suspended solids, colour, ammonia nitrogen and turbidity. Figure 1 shows the leachate pond at Simpang Renggam Sanitary Landfill.

Fig. 1 - Leachate pond at Simpang Renggam sanitary landfill

2.2 Apparatus and Chemical Reagent

Table 1 shows the apparatus and chemical reagents used in the experiment. The procedures were conducted based on American Public Health Association (APHA 2008) Standard Method [8].

Table 1 - Apparatus and chemical reagent

Parameter	Apparatus & Chemical reagent	Standard Method
pH	pH meter, beaker, sodium hydroxide, sulphuric acid	APHA (4500)
Colour	DR6000, pipette, conical flask	HACH Method 8025
Ammonia Nitrogen	Nessler reagent, mineral stabilizer, polyvinyl alcohol, pipette, conical flask	HACH Method 8038
COD	Potassium Dichromate, sulphuric acid, mercury sulphate, ammonium iron II sulphate 6-hydrate,	HACH Method 8000

	ferrion indicator, pipette, COD vials, DR6000, Spectrophotometer	
Suspended solids	DR6000, deionized water, cylinder	APHA 2540
Turbidity	Turbidity meter	APHA 2130
Aerated Electrocoagulation	Beaker, aluminium and ferum electrode, air pump, air flow meter, air diffuser, DC power, magnetic stirrer, sulphuric acid, sodium hydroxide, sodium chloride	

2.3 Experimental Work

The experiments were carried out in a 1000 ml beaker based on modification process by Wahidah [9]. 200x50x1mm of aluminum (anode) and iron (cathode) electrodes were used in this study while a DC power was used to supply electrical current directly to the electrodes. While in the same time, the oxygen was supplied from the air pump into the leachate. The air pump was connected to the air flow meter. 1.46 gram of sodium chloride was added during the process to improve the conductivity of sample. Figure 2 shows the experimental setup of the aerated electrocoagulation process.

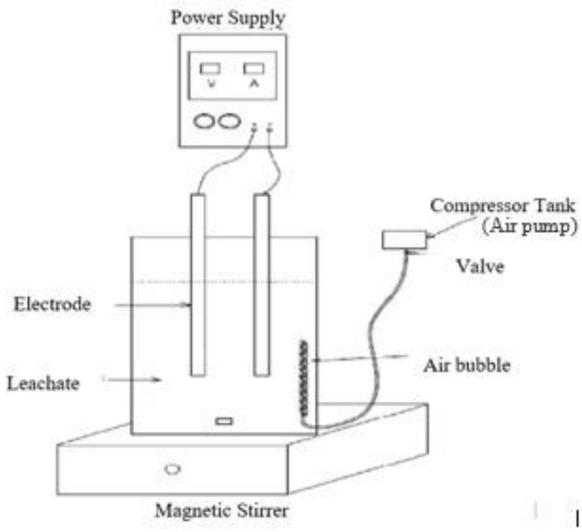

Fig. 2 - Aerated electrocoagulation process

3 Results and Discussion

3.1 Characterization of Leachate

The sample parameters which were pH, colour, ammonia nitrogen, COD, turbidity, suspended solids and temperature within 3 months [26]. Table 2 shows the leachate characteristics of Simpang Renggam Sanitary Landfill. Generally, the leachate from Simpang Renggam Sanitary Landfill was categorized as an old or stabilized leachate as the landfill had operated for over 10 years. As the landfill becomes older, the leachate was in phase of methagonic acid which has a low concentration of volatile fatty acid. This explains the increment of pH value and lower COD based on the characteristic such as ph value for young leachate <6.5, intermediate 6.5-7.5 and stabilized leachate .7.5 [10]. Value of ammonia nitrogen increases with the increment of leachate age [11]. The value for colour and turbidity was caused by the solid itself, the debris and food waste [12].–Leachate from different ages contains varies characteristics to another which also requires a different treatment to meet the required effluent level before discharged the leachate. Thus, explains why AEC was suitable to be used in treating leachate of Simpang Renggam Sanitary Landfill.

Table 2 - Leachate Characteristics of Simpang Renggam sanitary landfill

Parameter	Simpang Renggam Landfill Leachate	Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulation 2009
pH	7.86 – 8.23	6.0 – 9.0
Colour (ADMI)	1584.33 – 2922.23	100
Ammonia Nitrogen (mg/L)	708.65 – 2092.30	5
COD (mg/L)	691.33 – 714.67	400
Turbidity (NTU)	19.63 – 23.86	-
SS (mg/L)	67 - 88	50
Temperature	22 - 28	40

3.2 Effect of Current Density

Current density is one of the main parameters to control the reaction rate in the entire process [14]. In this study, six varied current density were choosing which 50, 100, 150, 200, 250, 300 A/m^2. Figure 3 shows the bar chart between the removal percentage of colour and ammonia nitrogen at different current densities. Nasrullah *et al*. [14] mentioned as the current density increases, the removal efficiency of biochemical oxygen demand, chemical oxygen demand and suspended solid also increases. The efficiency of ion creation in the anode and cathode increases as the current density rises, resulting in an increase in floc formation. This was due to the rise number of ions created on the electrodes, which promotes pollutant molecule destabilization [15]. Decomposition of the electrode material and an increase in pollutant removal are both caused by high current density [16]. The trend of the bar chart present upward at 50 A/m^2 to 250 A/m^2 then downward when continued at 300 A/m^2. G. Jing *et al*. [17] stated that the temperature increases as the current density increases over certain time. Thus, coagulation becomes unstable at high temperatures, resulting in low removal efficiency. The results of the study found that the highest removal percentage for colour and ammonia nitrogen were 23.85% and 58.81% respectively and the optimum removal percentage obtained at 200 A/m^2 of current density.

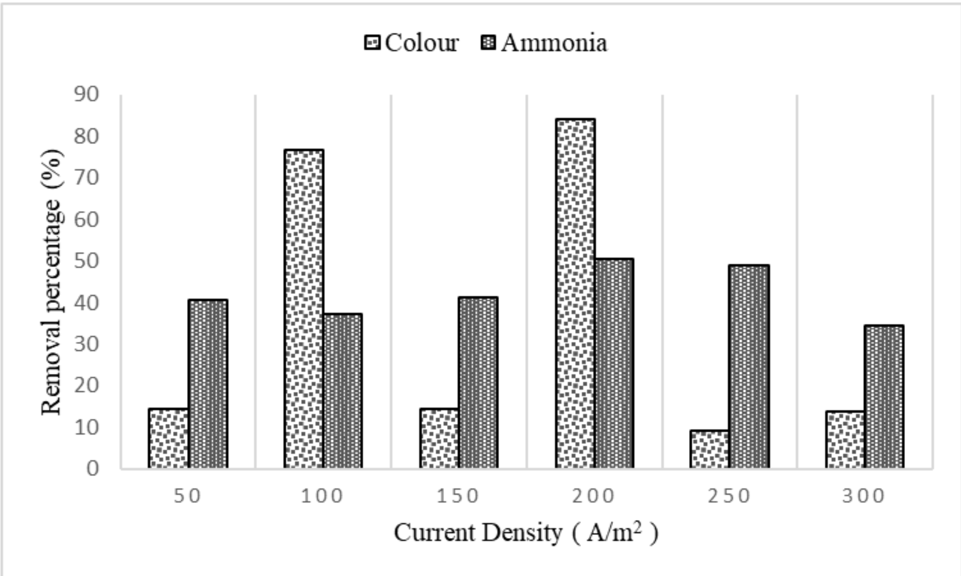

Fig. 3 - Removal percentage of colour and ammonia for AEC at different value of current density

3.3 Effect of Aeration Rate

Aeration rate is defined as the volume of air that is circulated through, mixed or dissolve in liquid or substance over time. Aeration rate can influence the removal of ammonia and effective microbes [18]. The efficiency of the aerated electrocoagulation process will be increased when aeration rates increase [7]. The collisions between the mixing solution and the contaminants increase when aeration is applied in the reactor, thus increasing the efficiency of removal in a wastewater treatment process. When the aeration was increased, high removals of BOD and total nitrogen were recorded. Some water pollutants, such as iron and manganese, become oxidized when air is mixed with it [19]. According to Ai *et al*. [20], the dissolved oxygen supply was insufficiently when the aeration rate was at 0.1 m^3/h and when the aeration rate was at 0.3 m^3/h, the dissolved oxygen supply was excessive. Due to the higher aeration rate, the turbulence was more intense that lead to break the distribution of oxygen. Thus, explains the downward trend after optimum value obtained. The possible reason would be that the aeration may increase the evaporation rate and sample loss. The evaporation rate increase may reduce the volume of sample and concentrate the contaminants and pollutants in the sample. The optimum removal percentage for colour and ammonia nitrogen were both obtained at 1.0 L/min of aeration rate.

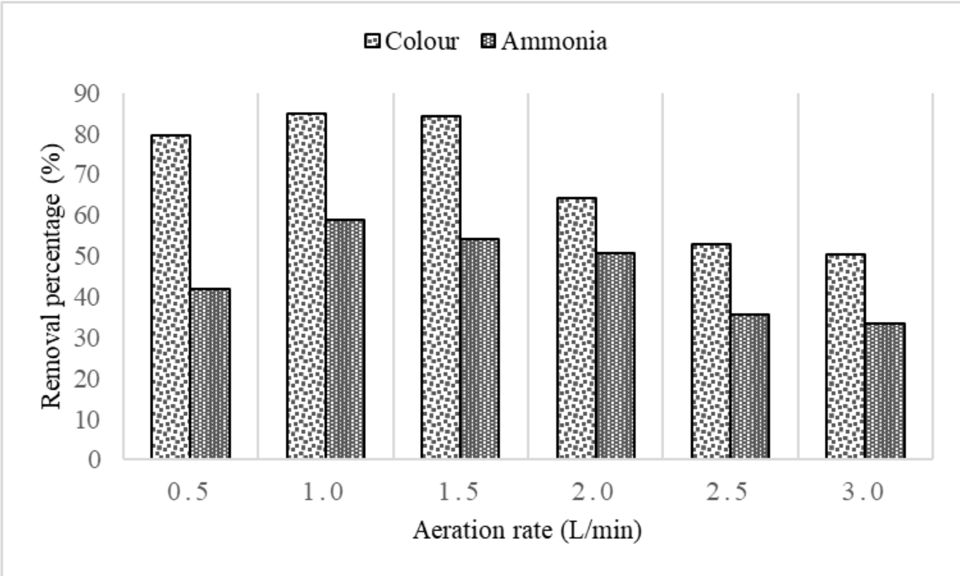

Fig. 4 - Removal percentage of colour and ammonia for AEC at different value of aeration rate

3.4 Effect of pH

Value of pH is an important variable which affects the process of electrocoagulation treatment [21]. According Taib *et al.* [22], the initial pH of 7 was used in his experimental of EC and carried on at different stage variable starting from pH of 3, 5, 7 and 10. Hence, the pH from range 4 to 9 were chose to be tested in this experiment. Figure 5 shows the bar chart between the removal percentage of colour and ammonia at different pH value. The trend of graph presents upward until pH 5 and started to go downward until pH 9. Naje *et al*. [23] mentioned that the removal efficiency is decreased at both low and high pH values from the optimal range. Wahidah [9] stated that as pH increases to alkaline, the ions will coagulate in a weaker state which reduce the removal performances. In general, the pH of the sample will be varied when the EC carried out depends on the electrode materials and initial pH [24], during the process as result of the H_2O oxidation reactions generated at the cathode, and successive OH^- ions are formed in the electrolytic medium [25]. The result of the study found the optimal removal of colour and ammonia nitrogen were 68.65% and 48.30% respectively and found the highest removal percentage both at pH 5.

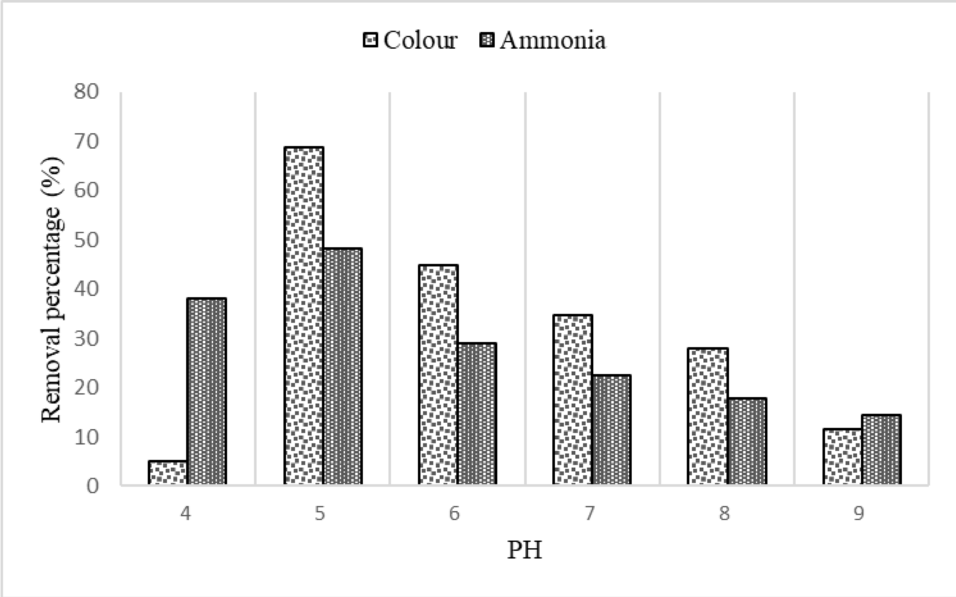

Fig. 5 - Removal percentage of colour and ammonia for AEC at different value of pH

4 Conclusion

As a conclusion, the leachate at Simpang Renggam Sanitary Landfill was categorized as a stabilized leachate based on the characterization obtained. This study found that the AEC achieved the highest removal percentage of colour and ammonia nitrogen in the leachate at 200 A/m^2 of current density, 1.0 L/min of aeration rate and pH 5. The percentage removal of colour and ammonia nitrogen were 84.93 % and 58.82 %, respectively. According to the Environmental Quality (Control of pollution from Solid Wastewater Transfer Station and Landfill) Regulation 2009, the removal value was still insufficient to fit the environment quality standard. However, this study shows a good sign in decreasing the colour and ammonia nitrogen in leachate.

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