Removal of Iron and Total Chromium Contaminations in Landfill Leachate by Using Electrocoagulation Process

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Abstract.

This research work involves the study removal of Iron and Total Chromium by electrocoagulation process. This project focused on leachate landfill from Pulau Burung, Nibong Tebal, Penang as an electrolyte solution. These heavy metals are the main factor contributing to pollution in leachate landfill. Types of electrodes used in this study were Aluminium (grade 5052) and Stainless Steel (grade 316). The ranges of initial pH applied were pH (3, 4, 5, 6 and 7) and voltages applied were 1.5V, 2.0V and 2.5V. These three parameters were evaluated and the operation time was 60 minutes. At the end of electrocoagulation process, the solutions were stored and analysed using AAS to determine the final concentration of electrolyte solution.

Introduction

The increasing amount of wastes that are being produced every day usually will be sent to landfill. Leachate is the main pollution factors from landfill sites and must be treated before it is released into the environment [1]. Landfill leachate contain high amount of heavy metals that can cause serious health problems to human, if the wastewater that contained heavy metals is not treated properly [2]. This project will try to reduce and treat the heavy metal that contain in the landfill leachate.There are three kinds of outputs for landfills, example. gas, liquid (leachate) and inert solids [3]. Commonly, leachates may contain organic contaminants in large amounts and can be measured as Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), ammonia and high concentration of heavy metals. It contained a high concentration of pollutants which can have adverse effects on the environment [4].Various methods have been proposed to remove heavy metal such as ion exchange resins adsorption [5], chemical precipitation, membrane filtration [6], and electrocoagulation [7].

Materials and Methods

Sampling Location. The sampling site for this research work is Pulau Burung Landfill Site (PBLS). PBLS is located in Nibong Tebal, Penang, Malaysia. The coordinates of PBLS are 5°12'02.9"N, 100°25'30.2"E. Its altitude is 5.61 above sea level and is located near the sea. PBLS operational area is around 33 hectares and it is semi-aerobic landfill. This landfill functions as a disposal area for domestic non-hazardous and individual wastes. Waste from both Penang Island and Seberang Perai are disposed to this landfill. There is no landfill gas collection at PBLS. PBLS constructed leachate treatment facilities and a linear system to avoid leachate from infiltrating the ground. Daily cover is used to avoid infiltration of storm water into the waste layer, and to minimize odour release from the dumping site to the environment [8].

Sampling. The leachate that was collected from Pulau Burung Landfill Site was kept in the cold room and used without any pre-treatment. The samples were collected from Mac until May 2014. The samples were immediately transported to the laboratory, and were stored in a cold room at 5˚C prior to use for experimental purposes to minimize chemical biological and reactions. All samples were taken from the Aeration Pond PBLS that are close to the dump area.

Results and Discussions

Effect of pH on removal of Iron and Total Chromium. This experimental work used ranges, pH 3, 4, 5, 6 and 7. The pH 7.73 is for the control experiment and it is a raw leachate sample with addition chemical such as acid. These ranges will give the data about how acidic pH will affect the electrocoagulation efficiency in the removal of heavy metal that contain in the leachate samples.

Removal of Iron. As shown in Fig. 1, the removal of Iron is very efficient at pH 5, the percentages of Iron removal achieved 96.81% at voltages 2.5V and other applied voltages shown the same pattern when using Aluminium electrodes and as shown in Fig. 2 removal of Iron are efficient at pH 4 the percentages of removal Iron that been achieved is 94.30% at voltage 2.5V when using Stainless Steel Electrodes. This result shown that pH 5 is the optimum condition for removal of Iron using Aluminium electrodes and pH 4 is the optimum condition for removal of Iron using Stainless Steel electrodes. The result act as support to prove Hariz et al., (2013) [9] work, pH has a significant effect on the efficiency of the electrocoagulation treatment process. The initial pH that has been used in this experiment give a variant results depend on the heavy metal that want to be removed. In electrocoagulation process using stainless steel the removal are clearly not good. This is because the Stainless Steel might dissolve during the electrocoagulation process because the amount of Iron are increased after been analyze using AAS and Fig. 2 shown that in acidic pH the electrode is attacked by H^+ and enhances Fe dissolution [10], shown by eq. 1:

$$Fe + 2H^+ \longrightarrow Fe^{2+} + H_2 \qquad (1)$$

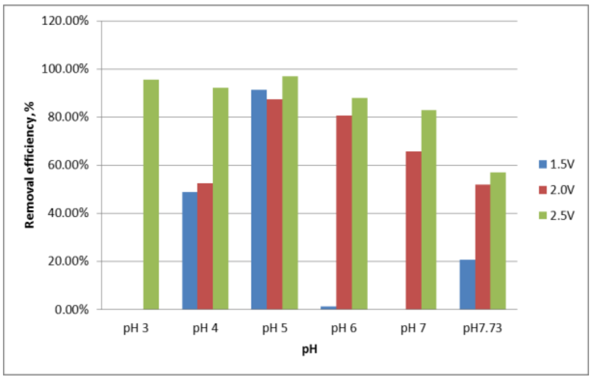

Fig. 1. Comparisons percentages removal Iron using Aluminium electrodes at differences applied voltages and at differences pH

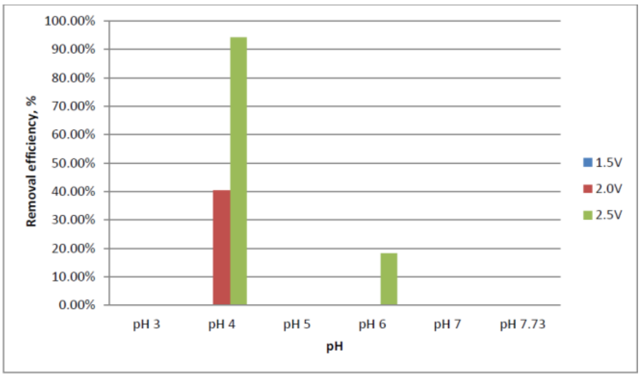

Fig. 2. Comparisons percentages of removal Iron using Stainless Steel electrodes at differences applied voltages and at differences pH

Removal of Total Chromium. As shown in Fig. 3, the removal of Total Chromium using Aluminium electrodes very efficient at pH 3 it about 72.65% at voltage 2.5V and slightly different with removal of Total Chromium using stainless steel electrodes at voltage 2.5V that are efficient at pH 7 from Fig. 4, it about 88.35%. At pH 3 and pH 4, the removal is 44.55% and 15.17% respectively. At other pH, there is no removal of Total Chromium. These result shown that the optimum condition for removal of Total Chromium. That is at pH 3 when using Aluminium electrodes at voltage 2.5V and at pH 7 is the optimum condition for removal Total Chromium using Stainless Steel electrodes at voltage 2.5V. The consequences of this result may cause by the influence of ion that has been release from different electrodes. According to Parga et al., (2005) [11] the Chromium ion that has been released during electrocoagulation are depending on pH and the ion that has been released by the types of electrodes that are being used.According to Rezaee et al., (2011) [12] when using Aluminum electrodes, Chromium removal increase during electrocoagulation while pH decreasing, when the initial pH is increasing, a decrease in the removal efficiency of chromium is observed. In acidic solution, Cr^{+6} ions are reduced to Cr^{+3} ions. Therefore, the removal efficiency of Chromium is significant.

According to Khandegar and Saroha, (2013) [13], they found that the pH of the solution has significant effect on the Chromium removal efficiency. They has done the experiments at different pH of the synthetic solution and achieved the maximum Chromium removal efficiency at the acidic pH. They have reported that the pH of the synthetic solution after the electrocoagulation process increased with an increase in the electrolysis time due to the generation of OH^- in the electrocoagulation process.From this experiment, effect of the pH on removal similar to the work of Anbari et al., (2012) [14] for using Stainless Steel electrodes. It can be observed that the removal efficiency of all studied ions decreased considerably upon decreasing initial pH and there is maximum removal efficiency at the pH of 7, which is almost neutral. Consequently, it can be decided that when pH is 7, the majority of iron complexes (coagulants) are formed and it's the optimum pH for carrying out the electrocoagulation.

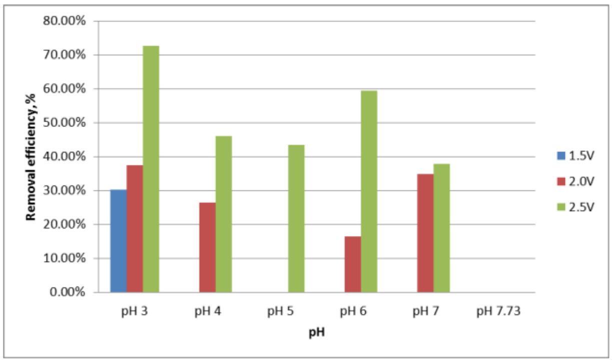

Fig. 3. Comparisons percentages of removal Total Chromium using Aluminium electrodes at differences applied voltages and at differences pH

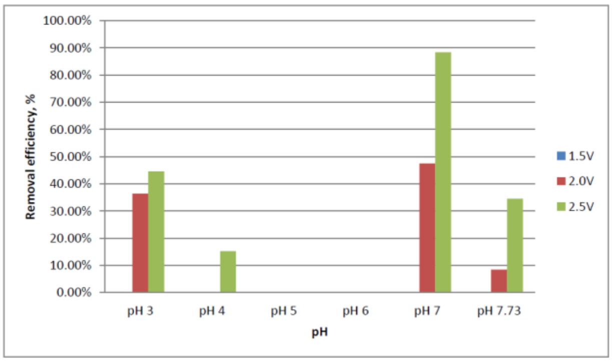

Fig. 4. Comparisons percentages of removal Total Chromium using Stainless Steel electrodes at differences applied voltages and at differences pH

Effect of Voltages Applied on Removal of Iron and Total Chromium. The voltages that had been applied are the lowest and in the range of 1.5V, 2.0V and 2.5V. The minimum range of applied voltage will give the benefit of reducing operating cost.As shown in Fig. 1 until Fig. 4 before, it showed the same pattern of removal when the applied voltages are increase in every pH that been applied. The removal is higher or maximum when the applied voltages are 2.5V and lower at 1.5V.

From the experiment, it was found that the maximum voltage give higher removal of heavy metal. For all removal of heavy metals that involved Iron and Total Chromium. The increase of voltage is influencing the rate of removal heavy metal. The removals are increased by voltages applied for this experiment. Bouhezila et al., (2011) [15] also reported that increase the voltage may increase the removal of heavy metal. In this experiment, it was found that the result for different electrodes shown different in removal efficiency achieved. It depends on the conductivity of the materials that has been used as electrodes. The Aluminium give a better result for removal of heavy metal instead Stainless steel electrodes but reliant on the heavy metal that has been removed.

Effect Types of Electrodes Material on Removal of Iron and Total Chromium. As shown in Table 1, the highest removal of Iron is recorded when using Aluminium electrodes higher than using Stainless Steel electrodes, are 96.81% and 94.30% respectively. But for removal of Total Chromium, the Stainless Steel electrodes were more effective than Aluminium electrodes as shown in Table 1.

Table 1**.** Comparison percentages removal of heavy metals with differences electrodes from this research work

Types of Removal	**Types of Electrode**	**Optimum percentage Removal, %**
Iron, Fe	Aluminium	96.81
Iron, Fe	Stainless Steel	94.30
Total Chromium, Cr	Aluminium	72.65
Total Chromium, Cr	Stainless Steel	88.35

Conclusions

Electrocoagulation studies conducted on the leachate from the Pulau Burung Landfill Site in Penang, Malaysia shown the positive result in removal of Iron and Total Chromium. It was found that the best electrodes for removal Iron is Aluminium electrodes with 96.81% at voltage 2.5V while for removal of Total Chromium the best electrode are the Stainless Steel. The Stainless Steel electrode is more effective than Aluminium electrodes at voltage 2.5V. The removal using Stainless Steel is 88.35%. For removal using Aluminium electrodes are 72.65%. The maximum voltages give higher removal of heavy metal for all removal of Iron and Total Chromium. The initial pH applied

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