Characterization of Leachate and Its Sources – A Case Study in Johor, Malaysia

Muhammad Akmal Harith Saifull Bahri, Filzah Anisah Jeffril, Nur Fhatin Hidayah Mat Azalan, Mohd Zaki Sukor

Faculty of Chemical Engineering, Universiti Teknologi MARA Cawangan Johor Kampus Pasir Gudang, Johor, Malaysia

Abstract

Leachate samples were collected from two landfills in the state of Johor, Malaysia that contained municipal solid waste (MSW). Leachate were collected at three different checkpoints for each landfills. The aim of the study was to determine the chemical characteristics of different concentration of leachate with total of six different checkpoints from a sanitary and non-sanitary landfill. The samples were collected from Seelong sanitary landfill and Simpang Renggam non-sanitary landfill. This study examined the leachate samples for its significant parameters such as pH, Chemical Oxygen Demand (COD), Aluminium (Al), Magnesium (Mg), Nickel (Ni), Lead (Pb), Zinc (Zn), Cadmium (Cd), Chromium (Cr) and Copper (Cu). Aluminium has the highest reading of concentration meanwhile cadmium has the lowest level of concentration in both landfills. From the analysis of data, it is confirmed that leachates from both landfills are contaminated with heavy metals and organics constituents. The leachates have high chemical oxygen demand with readings between 4000 and 5000 mg/L and are alkaline with pH values of 7 to 9.

Keywords: COD, Heavy metals, Leachate, Sanitary Landfill, Solid waste

1. Introduction

Johor Bahru is a state in Malaysia which is located at the south of Peninsular Malaysia. Basically, the sanitary landfill located in Seelong and non-sanitary landfill located in Simpang Renggam are chosen to collect the samples of leachate. In addition, the sanitary landfill in Seelong is the biggest sanitary landfill in Johor, Malaysia and has been operated since year 2004. Also, sanitary landfill is the most efficient and cost-effective method of waste disposal. The sanitary landfilling is the primary method of disposal of municipal solid waste (MSW) in Johor. As in Malaysia, the availability of land is not a real issue, thus sanitary landfilling is the ideal method of solid waste management. The sanitary landfill is the dispose of waste from various places in Johor which including the disposal waste taken from authority board such as Majlis Bandaraya Johor Bahru (MBJB), Majlis Perbandaran Johor Bahru Tengah (MPJBT), Majlis Perbandaran Kulai (MPKu) and Majlis Daerah Kota Tinggi (MDKT). In contrast, the non-sanitary landfill in Simpang Renggam is a dump site which has been in operation since year 1995 and no longer suitable as it has exceeded its capacity. Furthermore, the management of non-sanitary landfill is not efficient compared to sanitary landfill. However, the climate in Johor Bahru is oppressive, hot and overcast which can affect the characteristics of leachate.

The Oxford dictionary (2012), leachate is defined as water that has percolated through a solid and leached out some of the constituents. Leachate is however starts off as rainfall on the top of the landfill. This is the largest contributor for modern sanitary landfills which do not accept any liquid waste. The discharge of leachate without treatment can cause adverse effects on environmental and public health Neczaj et al., (2008). Leachate is likely to contain various types of pollutants that may enter the groundwater aquifers in the surrounding areas stated by Al-Yaqout (2003) which is contaminated with organics, heavy metals and salts. In addition, it also contains high concentrations of ammonia and chemicals of emerging concern. The landfill leachate has to be treated properly as it contains a lot of amounts of organic matter in biodegradable and refractory forms. Thus, it is vital to treat the leachate first and meet the standards of discharge before it is being discharged to the groundwater. The treatment of leachate based on the parameters itself such as pH, chemical oxygen demand

(COD), metals components and organic matters in which these are usually related to the "age" of the leachate Kieldsen et al., (2002). There are two types of leachates which are from young and old landfills. The young landfills operated for less than 10 years meanwhile the old landfills operated for more than 10 years stated by Oiuyan Yuan (2016). The concentration of organics which is also referred as COD from young landfills is above 10 000mg/l meanwhile the leachate at landfills older than 10 years is below 3 000mg/L Chang, 1989; Chen, (1996). Later studies show that leachate from younger landfills also have low organic concentration Aziz et al., 007). These facts indicate that the concentration of organics may be varies with time and places.

Currently, a range of physical and chemical pre-treatment options are presented and the study has become very numerous for the leachate landfill Kurniawan et al., (2006). Nevertheless, leachate is becoming less contaminated with difficult substances as time goes by through public awareness, recycling and industrialization that make the leachate less harmful to the environment. Thus, the current study focuses on the characteristics of leachate generated from landfill site in sanitary landfill which is located in Seelong and non-sanitary landfill in Simpang Renggam, Johor.

2. Methodology

2.1 Sample Collection

The leachate samples were collected from one of the sanitary landfills which is located in Seelong, Johor. In this sanitary landfill, there were three different checkpoints of leachate sampling collection. Sample one was taken at a checkpoint located at the main pond of the landfill and labelled as SE 1. The next checkpoint was at the sampling pond which was connected with the landfill and labelled as SE 2. The last checkpoint was collected from the pipeline that was connected with the management building and labelled as SE 3. The structural building in the sanitary landfill was well organized and the entries of garbage lorries were scheduled from time to time. Figure 1 illustrates the location of each leachate samples collection.

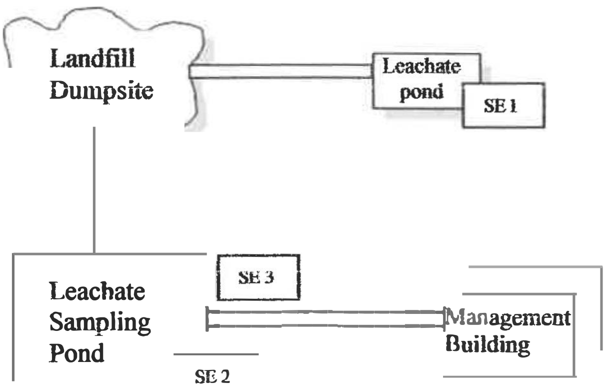

Figure 1: Layout of the study area in Seelong sanitary landfill site

The second place of leachate collection was at a non-sanitary landfill located in Simpang Renggam, Johor. At this landfill, the samples were also collected from three different checkpoints. Sample one of leachate was collected from the pipeline which was connected from the landfill and labelled as SR 1. The second sample was collected from the pond full of floating rubbish and labelled as SR 2. This pond was connected with the pipeline where the SR 1 was taken. The last sampling collection was located at the drainage which was connected with the landfill and labelled as SR 3. This non-sanitary landfill has quite poor environment as it did not have an organized management. Figure 2 illustrates the location of each leachate samples collection.

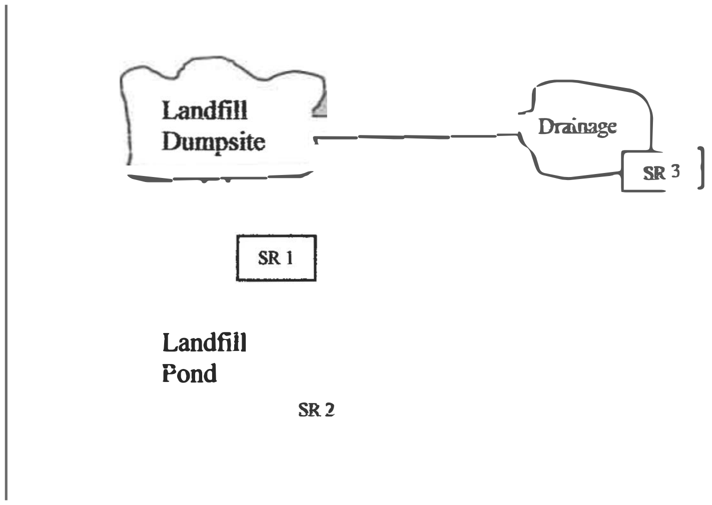

Figure 2: Layout of the study area in Simpang Renggam non-sanitary landfill site

In both places, the leachate samples were collected in bottles, labelled and handled properly. Throughout the sample collecting, proper Personal Protective Equipment (PPE) was emphasized as the leachate itself contains high concentration of organic matter and inorganic ions including heavy metals.

2.2 Storage of Leachate

Leachate samples were transported to a cold storage with temperature of 6°C in the laboratory refrigerator. This method is vital in order to preserve the characteristics of the leachate.

2.3 Analytical Method

Few parameters of the leachate were studied during the laboratory sessions. The parameters included were pH and concentration of organic compounds such as Chemical Oxygen Demand (COD). Other leachate constituents that also being measured were heavy metals namely copper (Cu), chromium (Cr), cadmium (Cd), nickel (Ni), zinc (Zn), lead (Pb), aluminium (Al) and magnesium (Mg). The device that was used to identify the contents of heavy materials was Inductively Coupled Plasma (ICP-OES).

The analysis of heavy metals was conducted using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES, Perkin Elmer, Optima 8000, USA). The device utilizes a vertical plasma and was used to handle the most difficult, high-matrix samples, delivering productivity, and performance. The digestion stepwise initially was prepared with 100mL amount of leachate samples. After that, an amount of nitric acid with volume of 2.5mL was prepared using 5mL micropipette to get a precise reading. Next, both of the amounts of 100mL of leachate samples and 2.5mL of nitric acid were mixed together in a 250mL beaker to get a digested leachate. Then the mixture was heated up to 2 hours on the hot plate with temperature of 180°C and was left for 20 minutes for cooling. The samples were filtered with membrane filter to get a clear solution from small particles. The samples were then poured into 50mL bottle samples. Lastly, the sample of digested leachate was safe to be measured in the ICP-OES device. The results of the analysis were taken and recorded.

Table 2: Characteristics of Non-Sanitary Landfill Leachate

Parameters	Leachate Samples		
	SR 1	SR 2	SR 3
pH	8.50	8.56	8.48
COD (mg/L)	4690	3690	4070
Al (mg/L)	61.87	49.58	17.11
Mg (mg/L)	Not in range	Not in range	Not in range
Ni (mg/L)	0.148	0.133	0.136
Pb (mg/L)	0.156	0.114	0.099
Zn (mg/L)	Not detected	Not detected	0.219
Cd (mg/L)	0.002	0.002	0.002
Cr (mg/L)	0.557	0.492	0.425
Cu (mg/L)	0.110	0.078	0.281

In Table 1 and Table 2, similar results were obtained stated by Al-Yaqout, (2003) that the leachate samples have a slightly high pH and remained in range between 7.78 to 8.6. The high alkalinity concentrations in leachate samples causes the pH values to be high. Maiti, (2016) stated that the value of pH represents the biological stabilization of the organic components. Moreover, the pH value increases with the age of the landfill. Malyuba Abu-Daabes, (2013) stated that new landfills have pH values between 4.5 to 7.5 while for old mature landfills, the pH values increases up to 9. The sanitary landfill in Seelong and non-sanitary landfill in Simpang Renggam have operated for more than 10 years. This shows that the age of a landfill affects the increasing alkalinity in the pH value of leachate samples.

The presence of high values of chemical oxygen demand (COD) in the samples is a clear indication of severe contamination. This is due to the decomposition of organic waste and pose direct threats of groundwater pollution with landfill materials stated by Al-Yaqout, (2003). The result shows the highest COD values which is 4850 mg/L indicates that it has very high levels of complex organic content. The high COD values indicate the high amount of pollution in the leachate samples. The sources of waste in Seelong sanitary landfill are mostly coming from industrial, restaurants and factories. This is because Seelong is an urban area. Hence, it has high density population with 223, 306 people as stated in year 2010. They contributes in high disposal of solid waste. Meanwhile, in non-sanitary landfill located in Simpang Renggam has the lowest COD values of 3690 mg/L. This is because the sources of waste they gathered are coming from rural and residential areas. The waste is mainly domestic rather than industrial waste. In addition, the population in Simpang Renggam is estimated around 49,780 people. The low population contributes minimum disposal of solid waste in the landfill compared to Seelong. The low COD values shows that it has low levels of complex organic content and less amount of pollution in the leachate samples.

Moreover, in this study (Table 1 and Table 2), the concentration of magnesium (Mg) levels in leachate is high and are not in range because of the presence of industrial waste such as cosmetics, cement and textile are being dumped into the landfill stated by McBean et al., (1995). Aluminium (Al) contains high concentration level because it was found in domestic waste such as raw municipal solid waste (RNSW), car engines and body parts, frozen food trays, cigarette and candy wrappings. The nickel (Ni) concentration ranged between 0.186 mg/L to 0.263 mg/L in Seelong sanitary landfill and 0.133 mg/L to 0.148 mg/L in Simpang Renggam, the non-sanitary landfill. The concentration of nickel (Ni), chromium (Cr) and cadmium (Cd) in leachate are mainly produce from electroplating household batteries and tannery industry stated by Z. Gotvajn, (2009). In addition, lead (Pb) was also found in the leachate with readings of 0.026 mg/L to 0.066 mg/L in Seelong and 0.099 mg/L to 0.156 mg/L in Simpang Renggam. The readings of lead (Pb) may be caused of some contamination such as batteries, photography, old lead-based paints and lead pipes disposed at the landfill which are toxic waste.

Besides that, zinc (Zn) with concentration of 0.125 mg/L to 1.28 mg/L shows that there are toxic wastes such as fluorescent light bulb and batteries. Magda M. Abd El-Salam, (2014) states that the high concentrations of zinc (Zn) can be attributed to disposal of large quantities of industrial wastes within landfills.

4. Conclusion

The landfill wastes in Seelong and Simpang Renggam are mainly come from various sources and including hazardous materials. The heavy metals that have been analyzed are aluminium (Al), magnesium (Mg), nickel (Ni), lead (Pb), zinc (Zn), cadmium (Cd), chromium (Cr) and copper (Cu). Aluminium (Al) and magnesium (Mg) have the highest concentrations level because of the industrial and domestic waste. The sanitary landfill in Seelong has the technology for wastewater and solid waste treatment, while non-sanitary landfill in Simpang Renggam does not have the technology to treat the wastewater. The characteristics of leachate show a specific trend with age of landfills. It is characterized by its high organic strength and heavy metal concentrations. Other than that, young landfills may have lower pH values and low heavy metals concentration while for old mature landfills, higher pH values and high heavy metals concentrations. The concentration of various organic metals as determined by ICP-OES, however, were not statistically different between the sanitary and non-sanitary landfill. The findings of this study which including pH, COD and heavy metals concentrations shows that the importance to have a better understanding of the complex conditions that will influence the leachate industry. It is necessary to understand the characteristics of the leachate such as the pH values that probably change after the landfill is being capped and closed. Hence, the rainfall will no longer play a dominant role in the generation of leachate.

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