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Original Article

Physicochemical properties and heavy metals concentration in crude leachate samples from municipal solid waste in tropical country

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Abstract

Landfill leachate contains many contaminants and it has been a concern due to its toxicity to the environment. This study aims to measure the heavy metals concentration (Cu, Cd, Pb, Ni and As) and physicochemical characteristic of the crude leachate discharged from municipal waste landfill. Leachate samples from a young landfill (less than five years old) and old landfill (10 years of age) were analysed for its physicochemical properties and heavy metals to the Malaysian wastewater standards and other international standards. Samples were analysed for heavy metals analysis using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) Optima 8300. The physicochemical characteristics of the leachate in young landfill were significantly higher ($p< 0.05$) than the old landfill. Cu (0.0265 ± 0.0007 mg/l) and Ni (0.1773 ± 0.0004mg/l). Significant relationship between physicochemical characteristic with Pb. From the results it was concluded that physicochemical characteristics and heavy metals showed that both landfill leachates had significant difference except for Cd, Pb and As.

Keywords: Municipal solid waste, Leachate, Landfill, Physicochemical properties, Heavy metals

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Introduction

Rapid urbanization and economy growth leads to the continuity of waste generation (Ismail, 2013). Landfilling is the only way of disposing all kind of solid waste materials and this method poses the simplest and cheapest method to dispose solid waste compared to other method such as incineration. It is the common method of waste disposal especially in low and middle income countries (Ismail, 2013). The average amount of MSW produced in Malaysia was 0.5-0.8 kg/ person/ day in 2003 and increased to 1.7 kg/ person/ day in major cities (Abd Manaf et al., 2009). In 2012, overall waste generation in urban and rural area was 33,130 metric tonnes per day with 1.17 kg/ capita/ day (National Solid Waste Management Department, 2013). Large amount of municipal and industry wastes are produced due to the increment of population size, rapid industrialization and the changes of consumption pattern among citizens

(Zainol et al., 2012). Malaysian produced over 23 000 tonnes daily and the amount is expected to rise to 30 000 tonnes in 2020 due to the increase of population number and development (Zainol et al., 2012).

There are five type of waste landfill in Malaysia, classified as Level 0 (open dumping), Level 1 (controlled tipping), Level 2 (controlled landfill with bund and cover soil), Level 3 (Sanitary landfill with leachate recirculation system) and Level 4 (Sanitary landfill with leachate treatment system) (Fauziah and Agamuthu, 2012; Suratman et al., 2011). Landfill received various types of waste from food waste, plastics, paper, mixed organic compounds, wood and others (Tarmudi et al., 2009; Budhiarta et al., 2012). Other types of wastes included were household waste, industrial or electric and electronic waste.

Landfill leachate occurs when water percolates the landfill, leach through the waste, and carry along contaminants compound in the landfill (Mohd Zin et al., 2012). Aziz et al. (2004) stated that production of leachate is because of the moisture that enter the landfill, extract the contaminants and discharged from the landfill in liquid phase when the moisture produced is sufficient to initiate a liquid flow. Landfill leachate is one of the environmental concern as it is toxic the environment. It is one of the source of contamination for groundwater aquifers as well as for adjacent soil and surface waters (Yi et al., 2011; Mor et al., 2006). Leachate may leach out and pollute the nearest water sources because of improper leachate management system in landfill.

Various types of contaminants detected in leachate and they are highly variable (Mohd Zin et al., 2012). Contaminants level are varies with the landfill age, decomposition of solid waste, precipitation rates, site hydrology, landfill compaction and cover design, sampling procedure, interaction of leachate with the environment and landfill design and operation (Bhambulkar, 2011; Kjeldsen et al., 2002). Leachate composition is determined by many factors such as waste composition, landfill age, hydrogeology, climate conditions, moisture that enter the landfill, landfill design and landfill operation (Ghafari et al., 2010; Aziz et al., 2004). Heavy metal is one of the hazardous substances detected in the landfill leachate (Slack et al., 2005). Heavy metals pollution in the aquatic food chain can cause severe health effects via food consumption to human (Sivaperumal et al., 2007; Ozuni et al., 2010). Quality of leachate produced was different by local climatic condition even the landfills have the same type of waste (Mohd Zin et al., 2012), different in volume of leachate produced (Isma, 2013), the rainfall index in the landfill and the landfill age (Ogundiran and Afolabi, 2008). For example, a landfill with high rainfall intensity might have lower contaminants in the leachate produced due to dilution factor compared to a landfill with low rainfall intensity. Leachate production is usually higher in warm climate compared to the colder climate (Ismail, 2013). Besides, after two or three years, leachate quality for the landfill has reached its maximum level then it will decline subsequently (Lee et al., 2010). For example, BOD and COD of young landfill will be high and it will decrease consequently after 10 years.

A young landfill is considered a landfill with less than five years old whereas an old landfill is defined as a landfill with more than 10 years of age (Zainol et al., 2012). The strength of organic and inorganic contaminants is inversely proportionate to the landfill age where the strength of contaminants is high in the young landfill (Bhambulkar, 2011). Leachate is generated for a long time even though after the landfill closed (Jones et al., 2006). Leachate from a young landfill usually detected as acidic and has high BOD5, COD, BOD5/ COD ratio and moderately high in ammonia (Zainol et al., 2012; Rivas et al., 2004). In contrast, leachate from an old landfill, which is more than 10 years of age is more matured and stable with high level of ammonia, moderately concentration of BOD5 and COD and low ratio of BOD5/ COD (Zainol et al., 2012; Rivas et al., 2004).

This paper highlights the comparison of physicochemical properties and heavy metals concentration (Cu, Cd, Pb, Ni and As) between leachate from young and old landfill obtained from municipal solid waste landfill in a tropical country during dry season. This is to serve as reference information for future research in leachate treatment technique. Limited studies found to compare the characteristic of leachate by landfill age. For example, previous study by Fauziah et al. (2013) compared the landfill leachate characteristics between an active and a closed sanitary landfill in Selangor, study by Zainol et al. (2012) was compared between two semi-aerobic sanitary landfill in northern part of Malaysia and other studies only focuses on one landfill such as in Emenike et al. (2011) and Mohd Zin et al. (2012). This study provide a baseline information on leachate study between landfill leachate ages in a tropical country.

Material and Methods

Material

Leachate was collected from Tanjung 12 landfill (young landfill) and Bukit Beruntung landfill (old landfill) in Selangor. Tanjung 12 landfill is the young landfill and has been operating for 5 years while Bukit Beruntung Landfill is the old landfill which has been operating for 17 years. These landfills were selected in this study as they fulfilled the age criteria for young and. Both landfills are municipal solid waste landfill operated in Selangor. Raw landfill leachate was collected from the inlet point of the leachate pond in both landfills. Leachate was collected using high-density polyethylene (HDPE) plastic bottles with well-sealed cap. The samples were stored in 4◦C until being used to prevent any contaminants disturbance or reaction changes to the samples.

Methods

Sample analysis

The laboratory analysis was performed following United States Environmental Protection Agency (USEPA) standard procedure. Heavy metals were analysed by using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) Optima 8300. ICP-OES was calibrated before metal analysis. Multi-element calibration was used in the calibration process by using calibration solutions of 0.05 mg/l, 1.0 mg/l, 5.0 mg/l and 10.0 mg/l. The calibration process will produce the calibration curves and the linearity was close to 1.000.

Physicochemical characteristics and heavy metals standards

Leachate samples in the study was analysed for its physicochemical properties including heavy metals concentration presence in the leachate. The values were compared with Malaysian wastewater standards as well as other countries standards which were Singapore, Thailand and United State of America. This is to see the difference since there is differences on MSW landfilling practice between developing and developed country (Ismail, 2013). Table 1 shows the Malaysian standards and other country standards for physicochemical properties and heavy metals in landfill leachate.

Statistical Analysis

All the statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) Version 21.0. Independent t-test (parametric) and Mann-Whitney U test (non-parametric) were used to compare physicochemical characteristics and heavy metals between both leachate samples.

Table-1: Standards of physicochemical properties and heavy metals

Parameter	Std. (a)	Std. (b)	Std. (c)	Std. (d)
Colour	NA	7 LV	NA	NA
Odour	NA	NA	NA	NA
pH	5.5-9.0	6.0-9.0	5.5-9.0	6.5-8.5
Turbidity (NTU)	NA	NA	NA	NA
Conductivity (mS)	NA	NA	NA	NA
TDS (ppt)	NA	2000	5000	NA
DO (mg/l)	40	NA	NA	NA
BOD (mg/l)	50	50	60	110-400
COD (mg/l)	100	100	400	250-1000
Oil and grease (mg/l)	10	10	5.0-15.0	NA
Cu (mg/l)	0.20	0.10	2.00	1.3
Cd (mg/l)	0.01	0.10	0.03	0.05
Pb (mg/l)	0.10	0.10	0.20	0.015
Ni (mg/l)	0.20	1.00	0.10	NA
As (mg/l)	0.05	1.00	0.25	0.01

Std. (a): Standard EQA B for Wastewater (Malaysian Environmental Quality Act Standard B 1974) and Standard Guideline for Landfill Development Reports by Ministry of Housing and Local Government, (2004),
Std. (b): Singapore Code of Practice on Pollution Control (2000 Edition),
Std. (c): National Environmental Quality Act B.E.2535 (1992), Thailand,
Std. (d): United State Environmental Protection Agency (USEPA) (2006).

Results and Discussion

Physicochemical characteristic of crude landfill leachate from young and old landfill

Figure 1 shows the colour of both crude leachate. Crude leachate from young landfill has black colour with a strong odour whereas the old landfill was light brown with less odours. Table 2 shows the physicochemical characteristics of crude leachate from the young and old landfill. The young leachate is black with a strong odour whereas leachate from the old landfill is light brown with less odours. Leachate in both landfills was alkaline with the mean ± SD pH of 8.50 ± 0.01 (young landfill) and 7.96 ± 0.03 (old landfill). The turbidity of young leachate was 20 times higher (207.00 ± 3.00 NTU) than the old leachate landfill (9.99 ± 0.49 NTU). The conductivity level of the young leachate was 7 times higher (12.46 ± 0.02 mS) than the old landfill (1.76 ± 0.01 mS).

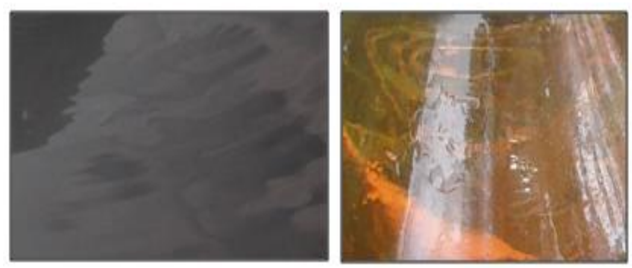
The young leachate also contains significant higher total dissolved solid (TDS) (12.29 ± 0.02 ppt), biological oxygen demand (BOD) (27,000 ± 458.26 mg/l) and chemical oxygen demand (COD) (51,133 ± 305.5 mg/l) as compared to the old leachate. The mean ± SD of the TDS, BOD and COD of the old leachate was 1.73 ± 0.01 ppt, 867± 12.53 mg/l, and 5,028 ± 20.13 mg/l respectively. The oil and grease level of the young leachate was higher (2.64 ± 0.02 mg/l) than the old leachate (0.52 ± 0.03 mg/l). The dissolved oxygen (DO) values had slight variation with the mean ± SD of 8.49 ± 0.09 mg/l for young leachate and 9.87 ± 0.03 mg/l for old leachate. All parameter (i.e. pH, turbidity, conductivity, TDS, DO, BOD, COD and oil and grease) were significantly difference between young and old landfill ($p<0.05$).

Visual appearance of both leachate shows crude leachate from young landfill has a black colouration while the old landfill leachate was light brown in colour. Differences in waste composition between both landfills lead to the differences in the leachate colour (Emenike et al., 2011). Generally, leachate composition depends on the nature of landfill, waste composition and the age of the landfill (Ismail, 2013). The crude leachate from the young landfill in this study had strong ammoniac odour compared to the old landfill leachate. The ammoniac odour of crude leachate was due to the ammonia level because of the biodegradation of amino acids and other nitrogenous organic matter in the landfill (Emenike et al., 2011). Strong ammoniac in the young landfill shows that the landfill are not stabilized yet and slightly ammoniac in the old landfill indicated the landfill was in the early stage of stabilization.

The pH value in crude leachate from young landfill was slightly alkaline than the old landfill. The pH of the leachate is varied depending on the landfill ages (Kulikowska and Klimiuk, 2008; Zainol et al., 2012). Generally, old landfill has a higher pH value of leachate compared to the young landfill (Umar et al., 2010). However, it depends on the alkalinity of the municipal waste.

Young leachate has higher turbidity, TDS and conductivity value compared to old leachate. This is because the presence of dissolved organic matters was high in young landfill than the old landfill. High concentration of dissolved organic matters lead from the deposition of waste in the landfills reflected the high concentration of TDS and turbidity value (Emenike et al., 2011). Umar et al. (2010) also stated that the main source of high TDS was from inorganic salts and dissolved organics in the landfill.

Figure-1: Colour of crude leachate samples from young landfill (a) and old landfill (b).



(a) (b)

Table-2: Physicochemical characteristics of crude leachate from young and old landfill

Physicochemical characteristics	Young Landfill [a]		Old Landfill [b]		*Z*-score	*p*-value
	(Mean ± SD)	Range	(Mean ± SD)	Range		
Colour	Black	NA	Light brown	NA	NA	NA
Odour	Strong ammoniac	NA	Slightly ammoniac	NA	NA	NA
pH	8.50 ± 0.01	8.50-8.51	7.96 ± 0.03	7.94-7.99	-2.023	0.043*
Turbidity (NTU)	207 ± 3.00	204-210	9.99 ± 0.49	9.50-10.48	-1.964	0.05*
Conductivity (mS)	12.46 ± 0.02	12.44-12.48	1.76 ± 0.01	1.75-1.77	-1.993	0.046*
TDS (ppt)	12.29 ± 0.02	12.28-12.32	1.73 ± 0.01	1.72-1.74	-2.023	0.043*
DO (mg/l)	8.49 ± 0.09	8.42-8.55	9.87 ± 0.03	9.85-9.89	-1.964	0.05*
BOD (mg/l)	27 000 ± 458.26	26,500-27,400	867 ± 12.53	855-880	-1.964	0.05*
COD (mg/l)	51 133 ± 305.5	50,800-51,400	5028 ± 20.13	5,010-5,050	-1.964	0.05*
Oil and grease (mg/l)	2.64 ± 0.02	2.62-2.65	0.52 ± 0.03	0.50-0.54	-1.964	0.05*

NA= Not available, [a] less than 5 years operation, [b] more than 10 years operation

*Significant difference at the 0.05 level (two-tailed) of Mann Whitney test.

Young leachate also has higher BOD and COD than the old leachate in this study. Young landfill usually has high BOD5 and COD (> 5 g/l), high NH3-N, low nitrogen concentration (< 400 mg/ L) and low pH value (Kulikowska and Klimiuk, 2008; Zainol et al., 2012; Yilmaz et al., 2010; Rivas et al., 2004). BOD and COD are generally represent the concentration of degradable organic matters in the leachate (Emenike et al., 2011). Acidogenic biodegradation stage that initially occurs in the landfill is characterized in the leachate by high BOD and COD. BOD and COD are usually decreased with the increase of the landfill age (Umar et al., 2010). This explains why BOD and COD were high in young leachate. In contrast, an old landfill was more matured and stable than the young landfill that these landfills usually has high level of ammonia, moderate concentration of BOD5 and COD and low ratio of BOD5/ COD (Zainol et al., 2012; Rivas et al., 2004). Other factors also influence the findings such as the composition of solid waste, precipitation rates, interaction of leachate and environment, and also the landfill design and operation (Zainol et al., 2012). Leachate composition also depends on the site hydrogeology, climate conditions, moisture that enter the landfill, landfill compaction, surface cover design and interaction of leachate with the environment (Bhambulkar, 2011; Kjeldsen et al., 2002; Ghafari et al., 2010; Aziz et al., 2004).

Comparison between physicochemical characteristic of crude landfill leachate with the standards

All of the parameters in physicochemical characteristic of landfill leachate were within the Standard Environmental Quality Act B for Wastewater (Malaysian Environmental Quality Act Standard B 1974) except for BOD and COD where both leachate samples were exceeded the standard guideline value. No standard guideline value for colour, odour, turbidity, conductivity and TDS.

The comparison with other parameters also were compared to other standards of wastewater globally includes Singapore Code of Practice on Pollution Control (2000), National Environmental Quality Act B.E.2535 (1992), Thailand, and United State Environmental Protection Agency (USEPA) (2006). The physicochemical properties also were within the global standard guideline as shown in Figure 2 except for BOD and COD. Despite the guideline value has slight variations compared to the Malaysia standard.

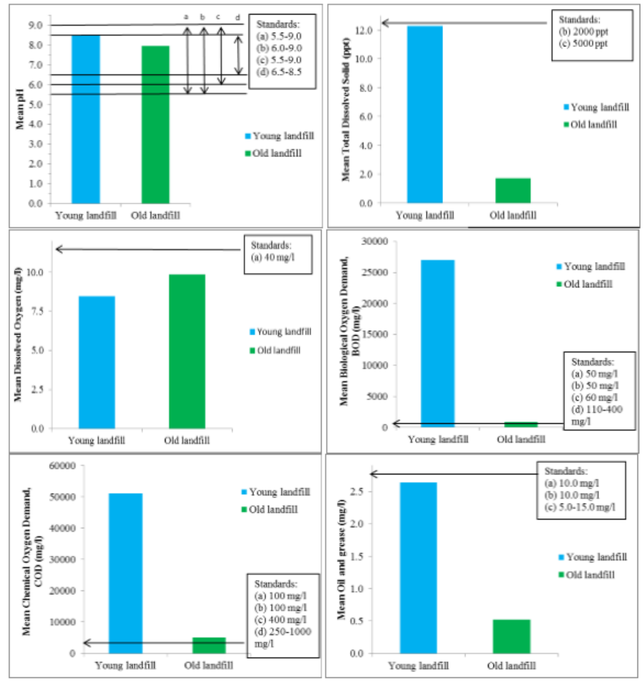


Figure-2: Comparisons of physicochemical characteristics of landfill leachate with Malaysia and other global standards

(a) Standard EQA B for Wastewater (Malaysian Environmental Quality Act Standard B 1974);
(b) Singapore Code of Practice on Pollution Control (2000 Edition), (c) National Environmental Quality Act B.E.2535 (1992), Thailand, (d) United State Environmental Protection Agency (USEPA) (2006).

Only 3 of the parameters (i.e. pH, DO and oil and grease) were within the Environmental Quality Act B for Malaysian Wastewater standard (Malaysian Environmental Quality Act Standard B 1974). These parameters also within the standard value in Singapore Code of Practice on Pollution Control (2000), National Environmental Quality Act B.E.2535 (1992) Thailand, and United State Environmental Protection Agency (USEPA) (2006). Whereas BOD and COD values were higher than all the standards limit in this study.

All of the parameters in physicochemical characteristic of landfill leachate were within the Malaysian Standard Environmental Quality Act B for Wastewater (Malaysian Environmental Quality Act Standard B 1974) except for BOD and COD. Comparison between the physicochemical properties with other standards from other countries such as Singapore, Thailand and United States of America also produced the similar results where only BOD and

COD values were exceeded the standards limit. Although the limitation of standard was not the same for each country, but the range between the standards values were not far between each other. According to Robinson (2005), although there are differences between each landfill sites, the remarkable consistency of the leachate generated in the landfill are still present. The differences between leachate characteristic was due to the composition of wastes in individual countries, the climate of the country, the varied rainfall patterns and rates as well as the quality of landfill management of each landfill site (Robinson, 2005).

Heavy metals concentration in crude leachate from young and old landfill

Table 3 shows the concentration of heavy metals in leachate samples from the old and young landfill. Generally, all heavy metals were higher in young leachate. However, only Cu (t= 10.07, p=0.037) and Ni (Z=-1.96, p=0.05) were significantly higher in young leachate. The mean ± SD of Cu and Ni in young leachate was 0.03 ± 0.0007 mg/l and 0.17 ± 0.0004 mg/l respectively. Cd was only detected in young leachate with the mean ± SD of 0.006±0.00017 mg/l whereas Pb was not significantly difference between the young (0.003 ± 0.0007 mg/l) and old leachate (0.002 ± 0.0007 mg/l). Arsenic (As) was not detected in both leachate in this study.

All heavy metals in young crude leachate were slightly higher than the old crude leachate. According to Umar et al. (2010), young landfill has high heavy metals concentration due to high metal solubility caused by low pH produced by organic acids similarly found in most of the literature articles. For example, high Cu in the young leachate in this study was consistent with Zainol et al. (2012) where high Cu was recorded in the 14 years old landfill (0.08 mg/l) compared to 16 years old landfill (0.03 mg/l). High Cu level ranged between 1.0-7.0 mg/l also were recorded in landfill leachate in Bukit Tagar and Panchang Bedena, in Selangor, Malaysia (Fauziah et al., 2013).

Pb concentration in this study was lower compared to Fauziah et al., (2013) a study in Bukit Tagar and Panchang Bedena, in Selangor Malaysia (between 13.0 to 41.7 mg/l). Pb in the leachate was possibly from the Pb batteries, pipe, Pb-based paint and also chemical for photograph processing (Mor et al., 2006).

Cd in this study was detected in the young leachate only. It is consistent with previous study where Cd was not detected in a 28 years old landfill but was high in a 6 years old landfill (7 mg/l) (Fauziah et al., 2013). High Cd in the leachate was possibly related to waste from PVC products which Cd was used as the stabilizers, colour pigment, alloys, Ni-Cd batteries and fertilizers (Castro-gonzalez and Mendez-Armenta, 2008; Jarup, 2003).

Ni concentration in this study present at a similar range as determined in Zainol et al., (2012) where high Ni was determined in the 14 years old landfill (0.16 mg/l) compared to the 16 years old landfill (0.07 mg/l). Emenike et al., (2011) also reported high Ni in the landfill leachate (19.5 mg/l) in Jeram sanitary landfill in Malaysia.

Singh and Mittal, (2009) determined high Cu (0.2-1.5 mg/l), Cd (0.2-0.4 mg/l), Pb (0.9-1.5mg/l) and Ni (1.0-5.0 mg/l) in open dumping landfill in Okhla, Delhi. This landfill generates 7000 metric tonnes of MSW per day with high construction and destruction waste and inert waste (1200 kg/m3) (Singh and Mittal, 2009). Cu (0.2 mg/l), Cd (0.001 mg/l), Pb (0.11 mg/l) and Ni (0.07 mg/l) also were detected in an open dumping landfill in Olusosun landfill in Nigeria (Ogundiran and Afolabi, (2008). Olusosun Landfill, Nigeria received more than 25 000 tonnes of wastes per year and the landfill waste was dominated by solid wastes from domestic sources as well as industrial wastes because the landfill was surrounded by some industrial factories, workshop, gas station, and road network (Ogundiran and Afolabi, 2008).

Mor et al., (2006) found high concentration of Cu (0.93 mg/l) and Cd (0.06 mg/l) in a non-sanitary landfill in Delhi, India. Pb (1.54 mg/l) and Ni (0.41 mg/l) also were detected in the leachate. Landfill studied in Mor et al. (2006) contain various type of wastes including domestic wastes, construction wastes such as sands, bricks and concretes, and also other wastes from near areas such as poultry market, fish market, slaughtering house and dairy farm. Non-infectious waste from hospitals was also being dumped in the landfill (Mor et al., 2006).

In Cartagena City, Colombia, a research was done to detect the amount of heavy metals tested in the sanitary landfill. Based on the report, the amount of Cu was found to be <0.053 mg/l, and Cd value was recorded in range between 0.039 - 0.295 mg/l. Pb was found to be less than <0.137 mg/l and lastly Ni was found in range between 0.173 - 0.359 mg/l (Olivero-Verbel et al., 2008). The study was conducted in the landfill after 36 years of operation.

Table-3: Heavy metals concentrations in crude

leachate from young and old landfill

Heavy metals (mg/l)	Young landfill (Mean±SD)	Old landfill (Mean±SD)	*t-value / Z-score*	*p-value*
Cu	0.0265 ± 0.0007	0.0200 ± 0.0014	10.07[b]	0.037 *
Cd	0.0061± 0.0001	ND	NA	NA
Pb	0.0025 ± 0.0007	0.0020 ± 0.0014	0.78[b]	0.490
Ni	0.1773 ± 0.0004	0.0225 ± 0.0007	-1.96[a]	0.05*
As	ND	ND	NA	NA

ND = Not detectable, NA= Not available, significant at the 0.05 level (two-tailed),
[a] *Z*- score, [b] *t*-value.

Difference level of heavy metals obtained in various research was due to several reasons. According to Yi et al., (2011), the composition, volume and toxicity of leachate produce are vary depending on the nature and age of wastes, the disposal method, the depth of the site, and climate. The characteristics of leachate varies from time to time and the main leachate production was from the waste degradation process in the landfill (Fauziah et al., 2013).

Local climate such as the intensity of rainfall also contributed to the differences in leachate characteristics for both young and old landfill. Besides, nature of waste disposed, the rainfall index in the landfill and age of the landfill influenced the differences in the leachate characteristic (Ogundiran and Afolabi, 2008; Ismail, 2013). The level of toxicants in leachate was different by local climatic condition even the landfills have the same type of waste (Mohd Zin et al., 2012), different in volume of leachate produced (Ismail, 2013), the rainfall index in the landfill and the landfill age (Ogundiran and Afolabi, 2008). For example, a landfill with high rainfall intensity might have lower contaminants in the leachate produced due to dilution factor compared to a landfill with low rainfall intensity. Leachate production is usually higher in warm climate compared to the colder climate (Ismail, 2013). Besides, after two or three years, leachate has reached its maximum level then the toxicants level will decline subsequently (Lee et al., 2010) [Table 3]

Comparison between heavy metals in crude leachate with the standards

All of these heavy metals were within the Standard Guideline for Landfill Development Reports by DOE Malaysia (2004) and other global standards as shown in Figure 4. However, Ni was found exceeded about 1.7 times the standard value of National Environmental Act (1992) Thailand (0.1 mg/l) and Singapore Code of Practice on Pollution Control (0.1 mg/l).

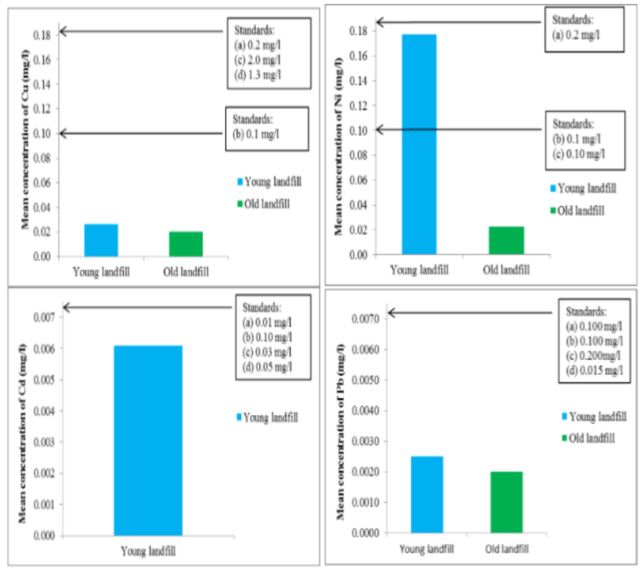


Figure-2: Comparison of Cu, Cd, Pb and Ni of landfill leachate with Malaysia and other standards

(a) Standard Guideline for Landfill Development Reports by DOE, 2004;
(b) Singapore Code of Practice on Pollution Control (2000 Edition);
(c) National Environmental Quality Act B.E.2535 (1992), Thailand;
(d) United State Environmental Protection Agency (USEPA) (2006).

According to Umar et al. (2010), heavy metals presence in landfill leachate was low. In order, heavy metals concentration in crude leachate from young landfill was Cu > Ni > Cd > Pb whereas in crude leachate from old landfill Cu > Ni > Pb. All of these heavy metals were within the Standard Guideline for Landfill Development Reports by DOE, (2004). However, Ni was found exceeded the standard value of National Environmental Act (1992) Thailand (0.1 mg/l). The other standards show slight variation to the Malaysia standard. Study by Emenike et al., (2011) also reported similar result where the Ni value was exceeded the standard limitation with 19.5 mg/ l of Ni. Previous study by Zainol et al. (2012) also stated that Cu and Ni values of their leachate samples were below the allowed limit (0.20 mg/L) set in the Environmental

Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulations 2009, Malaysian Environmental Quality Act 1974 (Act 127).

Conclusion

All the physicochemical characteristics tested in this study showed that leachate from young landfill were significantly higher than leachate from old landfill. Comparing with the Malaysian standards and other standards, all of the physicochemical characteristics were below the standard limitation except BOD and COD. Among all heavy metals tested, only Cu and Ni were significantly higher in leachate from young landfill compared to old landfill. Concentration of As was not detected in both leachate samples and Cd only being detected in young landfill. Comparing with standards, all heavy metals tested (Cu, Cd, Pb and Ni) were below the standard limitation. Thus, the leachate release to the environment was not considered harmful to the environment. This is exceptional for Ni where its concentration was exceeded Thailand standard of limitation.

Contribution of Authors

Rahman URA: Conceived idea, conducted experiment and write up of article
Ismail SNS: Helped in experiment and article write up
Abidin EZ: Article write up
Praveena SM: Article write up

Disclaimer: None.
Conflict of Interest: None.
Source of Funding: None.

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