Asia Pacific Environmental and Occupational Health Journal (ISSN 2462 -2214), Vol 4 (2): 16-20, 2018
Published Online © 2018 Environmental and Occupational Health Society

Characterization and Toxicity Study of Leachate from Closed Landfills in Selangor

Razi Ikhwan Md Rashid [1], Mohd Zikri Ibrahim [1,2], Mohd Azwat Abdullah [1], Ahmad Razali Ishak [1*]

[1]*Centre of Environmental Health and Safety, Faculty of Health Sciences, UiTM Puncak Alam, Malaysia*
[2]*Department of Municipal Waste Management and Public Cleansing, Kajang Municipal Council, Malaysia*

Corresponding author: Ahmad Razali Ishak; ahmadr2772@puncakalam.uitm.edu.my; Centre of Environmental Health and Safety, Faculty of Health Sciences, 42300, UiTM Puncak Alam Selangor; 03 32584509; 0332584599

ABSTRACT

Objective: The main objective of this study was to characterize the physicochemical characteristics of the closed landfill of Sungai Kembong and Ampar Tenang in Kajang, Selangor. The efficiency of leachate treatment was also evaluated. In addition, acute toxicity of the leachate effluent were tested using *Syprinuscarpio species.*
Method: The physicochemical parameters of leachate were determined according to APHA standard methods. The acute toxicity was conducted according to the OECD Guideline.
Result: The leachate from both landfill are categorized as stabilized landfill leachate. The treatment manage to significantly decrease the toxicity, BOD, COD and NH_3N concentration but the final concentration still above the allowable standard limit. **Conclusion**: Biological treatment is not sufficient to reduce the pollutants level below the discharge standard and require further additional treatment. However, the initiative to install the leachate treatment facility to the former open dumping site are commendable.

Keywords: *Leachate, closed landfill, toxicity*

1. Introduction

The population and economic growth have resulted in the increased of municipal solid waste (MSW) generation in many countries (Guerrero et al., 2013; Ishak et al., 2016). In Malaysia, the annual generation of MSW currently exceeds 11 million tons per year (Fauziah et al., 2012). Although various waste management strategies have been implemented to reduce the generation of MSW, landfilling remained the primary method of disposal due to the versatility and simplicity in terms of technical requirements and socio-economic aspects (Malek and Shaaban, 2008). Almost 95% of MSW is disposed in landfills in Malaysia (Moh and Manaf, 2014). However, only 23 out of 156 operational landfills are classified as sanitary (SWCorp, 2016). Most of the landfills were built without compliance according to the requirements of environmental impact assessment such as lack of monitoring and pollution control facilities including leachate collection & treatment system (Suratman et al., 2012).

The main problem associated with the landfilling is the substantial generation of landfill leachate (Ahmed and Lan 2012). Leachates are formed when liquid, usually water seeps through the landfill. As the water percolates through the MSW, waste products are leached into the water, forming the leachate (Gupta and Rajamani, 2015). Leachate contains numerous hazardous pollutants such as heavy metals which may seep from the landfill site into the surface and underground aquifers. The improper management of landfill leachate causes the detrimental impact on the environment and living organisms (Ishak et al., 2017). The regular leachate monitoring is needed to ensure the minimal risk to the nearby inhabitants. The main objective of this study was to characterize the leachate from two closed landfills in Selangor, Malaysia. The

efficiency of current leachate treatment method was also evaluated. Also, the acute toxicity of the landfill leachate was investigated using *Syprinuscarpio* species.

2. Materials and Method

2.1. Leachate sampling and characterization

The leachates were collected from Ampar Tenang and Sungai Kembong closed landfills in Selangor as shown in Figure 1. The raw leachate was collected directly from sedimentation pond before any treatment was applied, meanwhile the treated leachate was collected at the final discharge point of leachate treatment's facility. The physicochemical parameters of leachate were determined according to standard methods published by APHA et al. (2012). The percentage efficiency of the treatment method was calculated based on the different of parameters value before and after treatment.

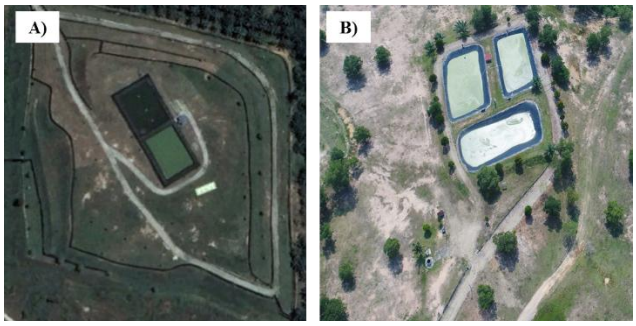

Figure 1. Aerial view of closed landfill A) Ampar Tenang B) Sungai Kembong

2.2 Acute toxicity determination

Acute toxicity of the raw and treated leachate was evaluated by using *Syprinuscarpio* species. The experiment was performed according to the OECD Guideline (OECD, 2004). 10 fishes of similar size were selected randomly and transferred into a 5 L container. Control was carried out without the addition of leachate sample. All experiments were conducted 96 h and no feeding were done during the experiment. The mortality of the fish for both control and exposed groups in triplicates were recorded for LC_{50} determination. 96h LC_{50} were converted to toxic unit values (TU) as illustrated in the Equation 1:

$$Toxicity\ Unit = \frac{100}{LC_{50}} \quad (2)$$

3. Results and Discussions

3.1. Landfill Background

Both Ampar Tenang and Sungai Kembong Landfill has been closed since 2010. However the safe closure of the landfills has only been implemented in 2016 and 2010, respectively. Previously, Ampar Tenang landfill received approximately 100 Metric tonnes of domestic waste per day. This landfill has been upgraded from open dump to controlled tipping waste disposal site. On the other hand, Sungai Kembong landfill had the capability to occupy 600 metric tonne waste per day and classified as a Type I Non-Sanitary Landfill. Both landfill doesn't have any liner installed to protect the ground water (Suratman et al., 2012). The information of the landfill are as shown in Table 1.

Table 1. Profile of closed landfill

Property	AMPAR TENANG	SUNGAI KEMBONG
Classification	Control tipping	Open dumping
Type	Non sanitary	Non sanitary
Size	10 acres	16 acres
Waste re-ceived/day	100 metric ton	600 metric ton
Nearest river	Sungai Labu	Sungai Kembong
Operating year	1995	1989
Year of closure	2010	2010
Type of closure	Safe closure (2016)	Safe closure (2010)
Landfill liner	None	None

3.2. Leachate Characteristics

Table 2 showed the physicochemical characteristics of the raw leachate obtained from Sungai Kembong and Ampar Tenang closed Landfills. The turbidity of raw leachate from both landfills were 409 and 547 NTU, respectively. The slight variation of the result might be due to the different landfill age. Sungai Kembong landfill is older and had undergo degradation and stabilization process phase at much earlier time as compared to Ampar Tenang Landfill (Zainol et al., 2012). Both landfill showed a slight alkaline condition with the pH of 8.01 for Sungai Kembong and 8.21 for Ampar Tenang. The result exhibited consistency with previous researches which state that the older landfill sites provides a more stable pH value between pH 7.5 - 9 (Renou et al., 2008). The stabilized pH condition is due to the equilibrium state between acid producing processes and acid consuming processes which usually displayed in matured landfill (Bhalla et al., 2013). Sungai Kembong Landfill contained a slightly higher concentration of Total

dissolved solid (TDS) (3446 mg/L) as compared to Ampar Tenang Landfill (3211 mg/L). TDS value is able to cause changes in the ionic composition of water and increased the toxicity of the leachate (Umar et al., 2010). High TDS is commonly influenced by the total amount of dissolved materials which occurred due to the decomposition of organic waste and thus demonstrates the degree of salinity and mineral contents of leachate (Fatima et al., 2012). Total Suspended Solids (TSS) is the portion of fine particulate matter that remains in suspension within leachate. TSS value for Sungai Kembong Landfill (14.42 mg/L) and Ampar Tenang Landfill (21. 22 mg/L) is below the discharged standard according to Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulation 2009. The decomposition and reduction of organic matter over time has resulted in low TSS value of landfills (Liu et al, 2018).

Ammoniacal nitrogen (NH_3N) is determined as a major and long term toxicant, as established by various toxicity analysis (Umar et al., 2010). The raw leachate from Ampar Tenang Landfill contains 1861 mg/L of NH_3N. This concentration was higher than Sungai Kembong Landfill which contains 1426 mg/L. This finding is in agreement with the finding by Umar et al (2010) that indicated the concentration of NH_3N persists within years which ranges between 500–1500 mg/L after a period of 3–8 years of waste placement and continues to be within this range over 50 years. The high concentration of NH_3N contributed significantly from the decomposition process of organic nitrogen and identified as a major long-term pollutant to the water bodies (Emenike et al., 2012).

Biochemical Oxygen Demand (BOD) is a measure of amount of oxygen used by various types of microorganisms as they feed upon organic matter. BOD is the most widely used parameter of organic pollution that commonly applied to leachate characteristic. The BOD of raw leachate from Sungai Kembong and Ampar Tenang closed Landfill is 249 mg/L and 265 mg/L, respectively. These value were much higher than allowable discharge standard (20 mg/L) as stipulated under Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulation 2009.The value of BOD is influenced by various factors which are mostly contributed from organic and inorganic compound that carried out by percolation through precipitation together with the leachate (Umar et al., 2010). High BOD level indicated the leachate contains high level of organic matter and have higher possibility to contaminate water body hence harmful to ecosystem (Lee & Nikraz, 2014). Chemical Oxygen Demand (COD) is an indirect measurement of organic matter concentration in landfill leachate. The average COD level of raw leachate from Sungai Kembong and Ampar Tenang Landfill contains 2936 mg/L and 3022 mg/L respectively. BOD/COD ratio shows a less than 0.1 indicated the leachate has low biodegradability (Ishak et al, 2016).

3.3. Leachate Treatment Efficiency

After Sungai Kembong and Ampar Tenang Landfill ceased its operation, this landfill is undergoing rehabilitation and the leachate treatment system was installed. The treatment will continue until the site is expected to be fully recovered. Both landfill uses biological treatment to treat the leachate. Table 2 showed the physicochemical characteristic of treated leachate and their performance efficiency. The results revealed that leachate treatment significantly reduce all the parameters. Turbidity showed the largest reduction with the percent of 82 and 77% in Ampar Tenang and Sungai Kembong, respectively. Higher COD and BOD removal efficiency after the treatment with more than 60% reduction were also achieved. However, the reduction of NH_3N were found to be less effective which indicated only 40 and 29% removal in Ampar Tenang and Sungai Kembong Landfill, respectively. Although the biological treatment manage to significantly reduced most of the parameters, the final discharge however still could not comply with the discharge standard. Inefficient reduction of most of the parameter by biological treatment in matured landfill leachate was reported by many studies (Amor et al., 2015). This is due to the presence of recalcitrant organic pollutant in the matured or stabilized landfill leachate.

Table 2. Raw Leachate Characterization of closed landfill

Parameter	Raw Leachate ± Standard Error	
	Sungai Kembong	**Ampar Tenang**
Turbidity (NTU)	409 ± 0.82	547 ± 0.69
Temperature (˚C)	33.81 ± 11	30.4 ± 0.84
pH	8.01 ± 0.02	8.21 ± 0.4
TDS (ppm)	3446 ± 0.47	3211 ± 8.18
TSS(ppm)	14.42 ± 0.33	21.22 ± 0.14
NH_3N (mg/L)	426 ± 121	861 ± 201
Dissolve Oxygen (mg/L)	0.56 ± 0.8	0.18 ± 0.004
BOD (mg/L)	249 ± 0.91	265 ± 0.79
COD (mg/L)	2936 ± 3.68	3022 ± 27.01
BOD/COD	0.08	0.09

Table 3. Treated Leachate Characterization and the removal efficiency

Parameter	Treated Leachate (% Efficiency)		*STD
	Sungai Kembong	Ampar Tenang	
Turbidity (NTU)	94 ± 6 (77%)	98 ± 9 (82%)	NA
TDS (ppm)	2744 ± 21 (20%)	2202 ± 12 (31%)	NA
TSS(ppm)	11.27 ± 0.02 (21%)	15.12 ± 0.05 (29%)	50
NH_3N (mg/L)	125.2 ± 0.2 (29%)	344.4 ± 0.2 (40%)	5
BOD (mg/L)	88 ± 0.82 (65%)	93 ± 0.47 (65%)	20
COD (mg/L)	1098 ± 247 (63%)	1220 ± 216 (60%)	400

* *Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulation 2009.*

3.4. Toxicity Analysis

Most of previous literature focused on the removal efficiency of the selected parameter according to national and international discharged standard without including the toxicity analysis. In this study, the acute toxicity of leachate was conducted using *Syprinuscarpio* species. The fish behaviour in this experiment demonstrated signs of restlessness, disorder swimming patterns and sudden quick movements. These behaviours were noticed gradually when leachate concentration increased. At high concentration of leachate, the fish became very weak and settled at the bottom. There was no change observed in the behaviour and swimming patterns of the control group. 96h LC_{50} was calculated using probit analysis. The relative toxicity of the leachate effluent before and after treatment were determined by converting the 96h LC_{50} to TU. Table 4 show the LC_{50} and toxicity unit (TU) of raw and treated leachate in Sungai Kembong and Ampar Tenang Landfill. The TU in raw leachate for both landfill were 6.94 and 9.12 respectively. The TU reduced 3 to 4 times lower after underwent the biological leachate treatment. The treated leachate Ampar Tenang was less toxic as compared to treated leachate from Sungai Kembong Landfill. The toxicity of the leachate is the result of high concentration of NH_3N, BOD and COD content in the final effluent (Emenike et al, 2012)

4. Conclusion

Ampar Tenang and Sungai Kembong landfill leachate were categorized as old and matured leachate which characterized by less biodegradability (BOD/COD < 0.1), moderate concentration of BOD, COD and NH_3N. The leachate treatment significantly reduced the pollution load in the leachate but still could not meet the minimum discharged standard as required by Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulation 2009. The toxicity testing on *Syprinuscarpio* species also revealed that treatment has reduced almost three to four times the toxicity of the raw leachate.

Table 4. Lethal Concentration (LC50) and Toxicity Unit (TU) of raw and treated leachate

Landfill	Raw		Treated	
	96h LC_{50}	Toxicity Unit (TU)	96h LC_{50}	Toxicity Unit (TU)
Sungai Kembong	14.40 %	6.94	44.67 %	2.24
Ampar Tenang	10.96 %	9.12	35.48 %	2.82

Acknowledgement

The authors would like to thank the Majlis Perbandaran Kajang, Selangor for cooperating in this study.

References

Ahmed, F. N., & Lan, C. Q. (2012). Treatment of landfill leachate using membrane bioreactors: A review. Desalination, 287, 41-54.

Amor, C., De Torres-Socías, E., Peres, J. A., Maldonado, M. I., Oller, I., Malato, S., & Lucas, M. S. (2015). Mature landfill leachate treatment by coagulation/flocculation combined with Fenton and solar photo-Fenton processes. Journal of Hazardous Materials, 286, 261-268.

APHA, A. W. W. A. (2012). WEF. (2012). Standard methods for the examination of water and wastewater, 22.

Bhalla, B., Saini, M. S., & Jha, M. K. (2013). Effect of age and seasonal variations on leachate characteristics of municipal solid waste landfill. International Journal of Research in Engineering and Technology, 2(8), 223-232.

Emenike, C. U., Fauziah, S. H., & Agamuthu, P. (2012). Characterization and toxicological evaluation of leachate from closed sanitary landfill. Waste Management & Research, 30(9), 888-897.

Fatima, S., Rafiq, S. K., & Hai, A. (2012). Effect of depth and age on leachate characteristics of Achan Landfill, Srinagar, Jammu and Kashmir, India. J. Environ. Sci. Tox. Food Technol, 2, 4-11.

Fauziah, S. H., & Agamuthu, P. (2012). Trends in sustainable landfilling in Malaysia, a developing country. Waste Management & Research, 30(7), 656-663.

Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste management*, *33*(1), 220-232.

Gupta, A., & Rajamani, P. (2015). Toxicity assessment of municipal solid waste landfill leachate collected in different seasons from Okhala landfill site of Delhi. Journal of Biomedical Science and Engineering, 8(06), 357.

Ishak, A. R., Hamid, F. S., Mohamad, S., & Tay, K. S. (2017). Removal of organic matter from stabilized landfill leachate using Coagulation-Flocculation-Fenton coupled with activated charcoal adsorption. Waste Management & Research, 35(7), 739-746.

Ishak, A. R., Mohamad, S., Soo, T. K., & Hamid, F. S. (2016). Leachate and surface water characterization and heavy metal health risk on cockles in Kuala Selangor. Procedia-Social and Behavioral Sciences, 222, 263-271.

Lee, A. H., & Nikraz, H. (2014). BOD: COD ratio as an indicator for pollutants leaching from landfill. Journal of Clean Energy Technologies, 2, 263-266.

Liu, Y., Sun, W., Du, B., & Liu, J. (2018). The Physical Clogging of the Landfill Leachate Collection System in China: Based on Filtration Test and Numerical Modelling. International journal of environmental research and public health, 15(2), 318.

Malek, M. A., & Shaaban, M. G. (2008). Landfill Common Method and Practices of Solid Waste Disposal in Malaysia. In ISWA World Congr.

Moh, Y. C., & Manaf, L. A. (2014). Overview of household solid waste recycling policy status and challenges in Malaysia. Resources, Conservation and Recycling, 82, 50-61.

OECD (2004) OECD 210 fish early life stage toxicity test. Oecd/Ocde 220: 1–22.

Renou, S., Givaudan, J. G., Poulain, S., Dirassouyan, F., & Moulin, P. (2008). Landfill leachate treatment: review and opportunity. Journal of hazardous materials, 150(3), 468-493.

Suratman, S., Tawnie, I., & Sefei, and A. (2012). Impact of Landfills on Groundwater in Selangor, Malaysia. ASM Science Journal, 5(2), 101–107.

SWcorp (2016). Statistik Tapak Pelupusan Sisa Pepejal yang beroperasi dan yang telah ditamatkan operasi mengikut negeri, 2016. Retrieved from http://www.swcorp.gov.my/index.php\

Umar, M., Aziz, H. A., & Yusoff, M. S. (2010). Variability of parameters involved in leachate pollution index and determination of LPI from four landfills in Malaysia. International Journal of Chemical Engineering, 2010.

Zainol, N. A., Aziz, H. A., & Yusoff, M. S. (2012). Characterization of Leachate from Kuala Sepetang and Kulim landfills: a comparative study. Energy and Environment Research, 2(2), 45.