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New Approach of Municipal Solid Waste (MSW) Leachate Treatment using Hydrothermal Method

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Abstract:

Landfill is the most widely used and prevalent method for municipal solid waste disposal in Malaysia due to the cheap and simpler operational mechanism. However, leachate generation from MSW caused major pollution in the landfill due to it high toxicity. Current approach involving biological and physical/chemical leachate treatment are inadequate because of long processing time and/or relatively high-cost of processing. In this study, hydrothermal treatment at 150 °C under 0.15 MPa were investigated to treat MSW leachate. Laboratories studies were conducted to design the hydrothermal processing for leachate treatment and evaluate its process condition as well as to investigate the effect of parameters in the process for leachate treatment. Leachate characterization such as pH, chemical oxygen demand (COD), and ammonia nitrogen (NH3-N) was carried out before and after the treatment for comparison and recommendations. Result of characterization shows that in 2 hours of treatment, pH increased from 3.27 to 4.68, COD decreased from 51000 mg/L to 1100 mg/L and NH3-N decreased from 3496 mg/L to 152 mg/L. As such, hydrothermal treatment processing of MSW leachate is believed potentially as a leachate treatment process that is green and environmentally friendly technology that can shorter processing time and reduce operational cost.

Keywords: *Landfill leachate, MSW, Hydrothermal, Leachate characteristics*

I. INTRODUCTION

The world is facing a waste crisis from organic and toxic today. Every year the amount of those waste generated by industrial and domestic sources increase rapidly [1]. Malaysia has no exception with records of 33, 000 metric tons of waste generation every day [2]. The country is landfill dependent and almost 90% of collected waste being thrown into dumpsite with only about 10 % of the landfills are sanitized. The rest are still traditionally sent to landfills that fill with all sorts of waste without proper treatment and oxidation facilities [3].

As waste generation increase more waste has to be dump into landfill, simultaneously leads to the increase in landfill leachate generation. Landfill leachate has constantly been the most challenging issue in waste management [4]. This is because it is a complex liquid contains numerous biodegradable and non-biodegradable pollutants such as organics matter, phenols, ammonia nitrogen and etc. [5]. Leachate toxicosis may cause environmental hazard to surface and ground water pollution as it can percolate throughout soils and subsoils, causing adverse impacts to receiving water, if not properly treated and safely managed [6]. In other words, leachate have to be properly managed and treated for a clean and healthy lifestyle, before the surface water and groundwater get polluted and ruin the entire ecosystem nearby.

Many issues have been raised due to the improper

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leachate management in Malaysia. The Papan Landfill in Perak, Malaysia currently has no proper leachate treatment system [4]. A group of fishermen off the coast of Nibong Tebal claimed a foul discharge from a nearby landfill has resulted in "tonnes" of fish ending up dead near Pulau Burung Sanitary Landfill in Penang [7]. The Simpang Renggam Landfill in Johor had been identified as the source of pollution into Ulu Sungai Benut after a bund at the storage pond collapsed [8]. Six solid waste landfills are found to have serious and recurring leachate contaminant issues; the former ones at Taman Beringin Kuala Lumpur; and Pajam Negeri Sembilan as well as at Sungai Udang Melaka; Pulau Burung in Penang; Tanah Merah Estate in Negeri Sembilan and CEP Simpang Renggam Estate in Johor. The monitoring by the Department of Environment (DOE) revealed the pollution was due to the design of the landfill and existing leachate treatment system that was less efficient compared to the increasing volume of solid waste received [9].

Current approach of leachate treatment involves biological and physical/chemical leachate treatment required long processing time and/or relatively high-cost of processing since there's need of combination of several to make sure the effluent continuously meets a stringent quality standard. Many aqueous waste products cannot be destroyed by only biological treatment, and several industrial waste waters containing highly toxic substances are difficult to dispose of [10]. Biologically treated landfill leachate itself often inconvenience to fulfil the regulatory discharge standards. Thus, to prevent environmental pollution, many landfill leachate treatment plants involve multiple stages treatment process [4]. Biological treatment is the most common practice for leachate treatment worldwide including in Malaysia, but sometimes the remaining values of chemical oxygen demand (COD) and absorbable organic halogenated compounds (AOX) are still relatively high [11-12]. The major fraction of old or biologically treated leachate were large recalcitrant organic molecules that are not easy removed during biological treatment [13]. The leachate generation is increasing, while the process is time consuming. With increasing leachate effluent quality standards, the efforts for leachate treatment also increase [14]. Various types of treatment methods have been proposed to alleviate the risk of untreated leachate. However, most of the available techniques remain complicated, expensive and generally require definite adaptation during treatment process [5].

An ideal leachate treatment system should have the ability to treat a wide range of chemical constituents, accept varying quantities and concentrations of leachate, and be inexpensive to construct and easy to maintain with low energy and personnel requirements. In order to meet strict quality standards for direct discharge of leachate into the surface water, a development of integrated method of leachate treatment, is required. The present study aimed at designing the hydrothermal processing for leachate treatment and evaluate its process condition, as well as to investigate the effect of parameters in hydrothermal in the process. Hydrothermal is a rapid technology suitable for leachate treatment that can produce high quality of clean water. The process can stabilize the pH level, and reduce the amount of COD, NH_3-N composition of the leachate in a short time with relatively low cost of operation.

II. MATERIAL AND METHODS

A. Material

Fresh municipal solid waste (MSW) leachate for the sampling was collected from several garbage trucks own by *KDEB* Waste Management Sdn Bhd (KDEBWM) during the transportation to landfill. Collected MSW leachate was sieved using a 1.5 mm mesh to remove solid particles and stored at 4ºC before being used for leachate characterization and hydrothermal treatment processing which in accordance with the standard method for the examination of water and waste water [15].

B. Leachate characterization

Sample characterization was done in order to detect the water quality before and after the hydrothermal processing. Physio-chemical parameters was analyzed for leachate characterization such as pH, COD, NH3-N composition. pH was analyze using pH meter, COD was determined by the colorimetric method, and NH3-N concentration was measured by salicylate method (385 HACH DR/3900 Spectro-photometer). Result of obtained parameter were compared with the standard discharge limit by the Malaysian Environmental Quality Act 1974 (Act 127) [16].

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C. Hydrothermal treatment

Fig. 1 shows the laboratory-scale experiment for hydrothermal treatment utilization. The technology will employ the combination of heat energy and water, as a media to convert unutilized resources in various shapes and characteristics into a uniform product. A 150 ml of raw MSW leachate was placed into a reactor, the reactor was sealed and purged with nitrogen gas. Saturated steam about 150 ºC temperature and 0.5 MPa pressure was injected to the leachate in the reactor. The reactor was heated at a 2-hours holding time after reaching all the setup condition. In the reactor, heat energy and pressure within the steam reacted to destroy the bonding of organic component in the MSW leachate to become clean water. Inorganic particles in the reactor was discharged and finally, clean water was collected from condenser as product of the hydrothermal treatment process.

Fig. 1 Hydrothermal treatment utilization

III. RESULT AND DISCUSSION

Table 1 shows the characteristics of collected leachate sample before and after the hydrothermal processing. Fig. 2 shows the sample of MSW leachate before, and after hydrothermal MSW leachate treatment at 150 °C temperature, 0.5 MPa pressure, in 2-hours of operation. Fig. 3 shows the flow diagram and results for the MSW leachate characterization before and after hydrothermal MSW leachate treatment operation.

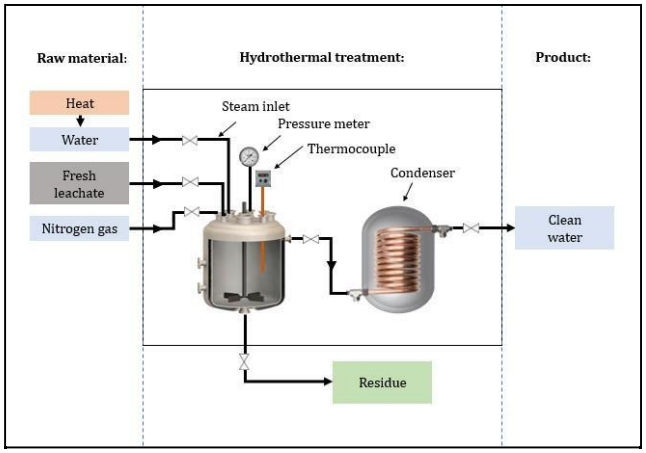
Table 1 The characteristics of raw MSW leachate before and after the hydrothermal processing (at 150°C, 0.15 MPa, 2-H treatment).

No	Parameter	MSW leachate		
		Raw	Treated	Standard*
1	pH	3.27	4.68	5.00-8.00
2	COD (mg/L)	51,000	1,100	100.00
3	NH_3-N (mg/L)	3,496	152	2.70

*Discharge standard at Class IV for irrigation [17].

The pH values varied at 3.00-3.54 and average of 3.27 for raw MSW leachate collected from several garbage trucks own by *KDEB* Waste Management Sdn Bhd (KDEBWM) during the transportation to landfill. After 2-hours of hydrothermal treatment processing, the pH values gave the range of 4.50-4.86 and with average of 4.68 which was remained in acidic form. The COD values for raw MSW leachate varied from 47000-55000 mg/L and the average of 51000 mg/L. The treated MSW leachate gave the COD in the range of 1000-1200 mg/L with average of 1100 mg/L. For NH3-N, ranges between 2950-4042 mg/L for raw MSW leachate with average value of 3496 mg/L. The treated MSW leachate gave NH3-N in the range of 150-154 mg/L with the average of 152 mg/L.

Through all the result of characterization, it can be noticed that although there is not much changes in pH, where it is still in acidic form, 4.68 is almost reach the discharge standard (5.00-8.00). As well as COD and NH3-N are not yet reach discharge standard, but it can be seen that there are so much reduction in COD and NH3-N of leachate after the treatment Could be a bit more changes on parameter level or by varying the process condition can improve



the quality of the water produced. The permissible pH, COD and NH3-N for treated MSW leachate to be discharge for irrigation at Class IV are; pH= 5.00-8.00, COD= 100.00, and NH3-N= 2.70 as according to the Malaysian Environmental Quality Act 1974 (Act 127) [16].

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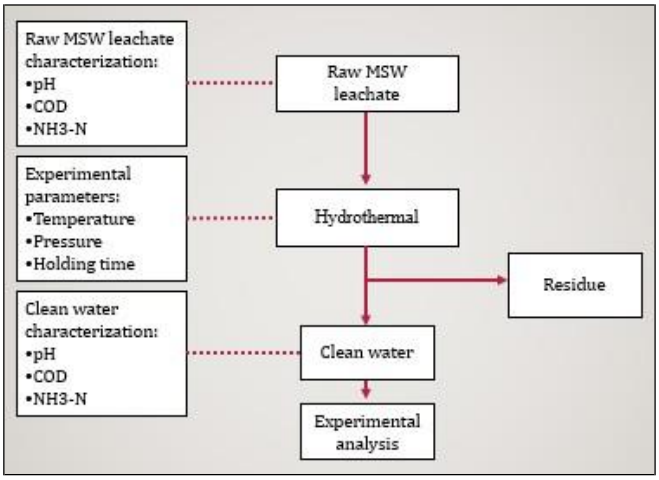
Fig. 2 Leachate before and after hydrothermal treatment processing

Fig.3 Hydrothermal treatment processing flow

IV. CONCLUSION AND RECOMMENDATIONS

In this work, MSW leachate treatment was conducted using hydrothermal treatment processing. Based on the experiments, all results were recorded and analyzed and the following



conclusions could be made;

- The pH value, COD and NH3-N for MSW leachate before treatment is 3.27, 51000 mg/L, and 3496 mg/L respectively.
- After 2-hours of hydrothermal treatment processing, the pH value, COD and NH3-N is 4.68, 1100 mg/L, and 152 mg/L in 2H respectively.
- It was found that, the pH value after MSW leachate undergo hydrothermal treatment processing were not much comparable with the raw MSW leachate which is still in acidic form, although the COD and NH3-N has drop considerably.
- It was observed that, although the COD and NH3-N has decrease considerably, still not yet reach the standard set by the Malaysian Environmental Quality Act 1974 (Act 127) [16].
- It is recommended that, more experiments of MSW leachate treatment using hydrothermal treatment processing should be done in order to find the best process conditions for leachate treatment.
- Another different series of temperature, pressure and holding time should be done to compare and produce better leachate treatment product.
- The higher temperature and pressure should be applied to have shorter holding time.
- As such, hydrothermal treatment processing of MSW leachate process that is green and environmentally friendly technology that can shorter processing time and reduce operational cost.

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