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Characterization of Leachate from Jeram Sanitary Landfill-Malaysia

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Abstract : Landfill leachate is the most common way of handling solid waste in Malaysia, due to high cost involved with advanced technologies for landfilling, lack of technical capacity, lack of knowhow to manage landfill sites. Landfill leachate generated from the MSW landfill sites must be treated before dispose into the environment as it creates many social and environmental problems. Characterization of landfill leachate is important to identify the most critical pollutants present in the leachate and thereby to introduce suitable and applicable treatment technologies such as in-situ permeable reactive barrier technologies for contaminant remediation. Therefore, the objective of this research is to characterize landfill leachate collected from Jeram landfills in Malaysia. The results of the leachate samples showed the concentration of organic compounds, expressed as COD, were 49000 mg/L; the proportion of easily biodegradable organics (BOD5) was 14790 and the total nitrogen concentration was 4500 mg/L. The ammoniacal (NH_3-N) concentration in the leachate studied was about 3800 mg/L and the color values for biological treated samples were (10200 Pt-Co) indicating the biological treatment system alone would not be effective in reducing the color. The results of this study will be used in developing site specific remediation technologies in landfill leachate treatment.
Key words: Landfill leachate, Characterization, Jeram, Malaysia.

Introduction

Prosperous lifestyles and continuing industrial and commercial growth in many countries around the world during the past decades have been accompanied by rapid increases in both municipal and industrial solid waste production [1]. Municipal Solid Waste (MSW) generation continues to grow both in per capita and overall terms. Many alternative methods of leachate treatment are available nowadays. Methods such as recycling, composting and incineration are promoted as alternatives to landfill method. However, even the most encouraged method (incinerations) creates residue of approximately 10-20 % that must be ultimately landfilled [2]. Currently, modern landfills are complex engineered facilities designed to eliminate or minimize the adverse impact of the waste on the surrounding environment. However, the generation of contaminated leachate remains an inevitable consequence of the existing waste disposal practice and future landfills.

In spite of the fact that many alternative methods of MSW treatment, sanitary landfilling is currently the most common municipal solid waste disposal method in many countries due to its relatively simple procedure and low cost [3, 4]. Up to 95 % of the total MSW collected worldwide is being disposed of in landfills [5]. After landfilling, solid waste undergoes physico-chemical and biological changes. Consequently, the degradation of the organic fraction of the wastes in combination with percolating rainwater leads to the production of a dark colored, highly polluted liquid called "leachate" [6].

Leachates may contain large amounts of organic matter (biodegradable, but also refractory to biodegradation), where humic-type constituents consist an important group, as well as ammoniacal nitrogen, heavy metals, chlorinated organic and inorganic salts. Characteristics of a landfill leachate can be represented by chemical oxygen demand (COD), biochemical oxygen demand (BOD), pH, total dissolved solid (TDS) and heavy metals [7, 8]. In order to reach environment friendly criteria for landfill leachate, these values should be carried out to an acceptable discharge limit. Hence, landfill leachate must be collected and treated. Since the variation in volume and composition, the conventional treatment method is inadequate and rarely meets the discharge standard. Various methods of treating landfill leachate have been reported and these processes are divided into three, namely the process of chemical, physical and biological [9].

Material and Methods

Leachate samples were collected from Jeram Sanitary Landfill, which is located in an oil palm plantation, Kuala Selangor, Malaysia. The physico-chemical characteristics of landfill leachate were determined on the basis of common physico-chemical properties according to the standard methods for analysis of wastewaters and surface water developed by the American Public Health Association[10]. Parameters analyzed include chemical oxygen demand (COD), color, biochemical oxygen demand (BOD), total-P, total-N and ammoniacal nitrogen (NH_3-N) were measured by HACH spectrophotometer (Hach Odyssey, DR/2400). The pH was measured by a pH meter (PH700 EUTECH Instruments, Singapore). Total dissolved solids (TDS) and conductivity (cond.) were measured by using a conductivity meter (cond. 610). The total suspended solids (TSS) were measured by using Filter with Vacuum. The concentration of some heavy metals such as copper (Cu), cadmium (Cd), zinc (Zn), barium (Ba), and lead (Pd) were measured using inductively coupled plasma optical emission spectrometry (ICP-OES optima 4300DV), chloride ion was measured using Metrohm 850 professional Ion Chromatography (IC). Two replicates were evaluated for each analysis from three sampling.

Results and Discussion

Characterization of Leachate from Jeram Sanitary Landfill

Physico-Chemical and Biological Characteristics of Raw Leachate

Physico-chemical characteristics of the landfill leachate depend primarily upon the waste composition and water content in total waste. The characteristics of the leachate samples collected from Jeram landfill site has been presented in Table 1.1 as an average for all three sampling. For the leachate studied, the concentration of organic compounds, expressed as COD, was 49000 mg/L; the proportion of easily biodegradable organics (BOD5) was 14790 and the total nitrogen concentration was 4500 mg/L. The ammoniacal (NH_3-N) concentration in the leachate studied was about 3800 mg/L. Leachate is rich in ammonia nitrogen as a result of the hydrolysis and fermentation of the nitrogenous fractions of the biodegradable substrates[11] and the release of soluble nitrogen from municipal solid waste into the leachate is slow and may continue over a long period.

The dark brown color of the leachate is mainly attributed to the oxidation of ferrous to ferric form and the formation of ferric hydroxide colloids and complexes with fulvic/ humic substance[12]. The pH value of the collected sample was found to be 8.65. The relatively high values of conductivity (29.67 mScm-1) and TDS (28.09 ppt) indicate the presence of inorganic material in the samples. TDS comprises mainly of inorganic salts and dissolved organics. The other major component present in the landfill leachate is Cl^- anions with the concentration of about 2017 mg/L. Total phosphorus values for leachate at landfilling site were 200 mg/L. The measured total phosphorus values were considerably higher than the standard limit. Phosphorus is one of the key elements necessary for growth of plants and animals and is a backbone of the Kreb's Cycle and Deoxyribonucleic acid (DNA) [13]. TSS value of leachate samples of the landfill were 5348 mg/L.

Characterization of Biological, Physico-Chemical Treated Leachate from Jeram Sanitary Landfill

In the Jeram Sanitary Landfill the leachate produced from landfill is pumped into treatment system that consists of three main stages; primary stage, secondary stage and the tertiary stage. During the primary stage the leachate is passed through three equalizations ponds (also referred to as Sequential Batch Reactors). The same process is repeated in the secondary stage but with only two Sequential Batch Reactors. Once the secondary stage is completed the remaining liquid is subjected to physical and chemical treatments tertiary stage to ensure compliance with standards [14]. Generally, the potential methods for leachate treatment are biological, physico-chemical, and the combination of biological and physico-chemical treatment processes[15]. The characteristics of the biological, physico-chemical pretreated leachate are as shown in Table 1.1. As it can be seen, the biological process proved to be inefficient to remove the color of leachate. The generated effluent, with a concentration of COD (5600 mg/L), NH_3-N (600 mg/L) and color (10200 Pt-Co) is above the disposal limits. However, the chemical and physical treatment process has been found to be very effective in reducing pollutants from the stabilized leachate where COD concentration is 680 mg/L, ammonia 400 mg/L and color 280 Pt-Co.

Table 1.1 Characterization of leachate samples collected from Jeram Sanitary landfill and standard discharge

Parameter	Raw leachate Mean ± SD(n=3)	Biological Treated Leachate	Chemical Treated Leachate	Physical Treated Leachate	Standard discharge
Color Pt-Co	14960 ± 5780	10200	290	280	100
COD mg/L	49000 ± 5543	5600	800	680	400
BOD_5 mg/L	14790 ± 2860	-	-	-	20
NH_3-N mg/L	3800 ± 2600	600	400	400	5
Total-P mg/L	200 ± 40	140	120	90	-
Total-N mg/L	4500 ± 3080	-	-	-	-
pH	8.65 ± 0.4	7.98	7.58	6.81	6.0-9.0
TDS mg/L	28095 ± 3824	18.00	17.61	13.51	-
TSS mg/L	5348 ± 2435	-	-	-	50
Conductivity mS/cm	29.67 ± 4	14.84	14.39	11.04	-
Cl^- (mg/L)	2017*	-	-	-	-
Pb (µg/L)	16 ± 5	-	-	-	100
Cu (µg/L)	31 ± 23	-	-	-	200
Zn (µg/L)	487 ± 80	-	-	-	2000
Cd (µg/L	6 ± 2	-	-	-	10
Ba (µg/L)	93 ± 52	-	-	-	1000

Note: n= number of samples during three months, Pt-Co= color unite, SD= Standard Deviation, *only one month sampling

Conclusion

Characterization of landfill leachate is important to identify the most critical pollutants present in the leachate and thereby to introduce suitable and applicable treatment technologies such as in-situ permeable reactive barrier technologies for contaminant remediation. The results of the leachate samples showed the concentration of organic compounds, expressed as COD, were 49000 mg/L; the proportion of easily biodegradable organics (BOD5) was 14790 and the total nitrogen concentration was 4500 mg/L. The ammoniacal (NH_3-N) concentration in the leachate studied was about 3800 mg/L, exceeded the maximum tolerance limits in Malaysia Standards. The color values for biological treated samples were (10200 Pt-Co) indicating the biological treatment system alone would not be effective in reducing the pollutants especially for color.

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