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Landfills Leachates Quality and Quantity in Tidal Area in Banjarmasin Landfills, Indonesia

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Abstract The main issue in the perspective expectation of tidal landfill is about the big potential in polluting the environment. One of the pollutants which caused by the landfills is leachates. To prevent the leachates contamination around the environment, it is required to have a landfills leachates and cultivation management. Leachates quality and quantity data is required for the leachates cultivation. The leachates quantity of tidal landfills is determined with the water balance method (Thornthwaite). Leachates discharge which formed in landfills is in the range of 64-106 lt/s on wet months (Nov-April) and 18 - 40lt/s on dry months (May- Sept). The quality of tidal landfills Banjarmasin is based on the TDS, BOD, COD, Fe, NH_3N various parameters and there is a decrease of the pollutant concentration in the age of landfill zone of 1 year up to 10 years. The longer the age of the landfill zone, the smaller the leachates pollutant content.

Keywords Thornthwaite method, Tidal land area, Leachates

1. Introduction

Leachate generated from landfill, is an important source of environmental pollution around the landfill. The increase in municipal waste Banjarmasin reached 1019 m^3 per day and is likely to increase from year to year will increase the production of leachate and the more potential to pollute the environment. The presence of leachate from the landfill has a high risk of contaminating water and soil around the landfill [1]. Leachate contains dissolved organic material, inorganic compounds and metals [2]. The dump has been identified as one of the major threats to water resources and land [3].

Production of leachate coming from the liquid contents in the trash because of the decomposition process is also involved rain water into the garbage and litter decomposition dissolving material that accumulates at the bottom of the landfill and seeping through the ground [4]. Contamination occurs due to the continuous leachate seeping into the environment from time to time regardless of the environmental consequences [5]. Landfill conditions in the tidal area further increased the potential for leachate contamination of the environment. The existence of leachate at the landfill must be managed and processed so that it does not cause environmental pollution. To perform the processing, it needs accurate data such as quantities and quality of the landfill leachate.

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The leachates quantity of landfills is determined by the rain intensity, the landfills effective extensive, evaporation, infiltration/soil porosity and the moist level of the waste. While the leachates quality is determined by the waste composition, waste amount, water amount which dissolves the waste as well as the landfills operational system. Leachates quality and quantity is important to be examined in accordance with the leachates management including leachates collection, distribution, cultivation, and extrication to the environment.

The tidal condition of the environment affected the leachates amount and dissemination around the landfills environment. Tidal water caused the soil to be water-rich. The existence of tidal condition also affected the underground water flow which tends to be up and down/unstable which caused the leachates dissemination to be evenly spread. The dissemination of leachates could spread on the landfills surrounding area. This study was aimed to assess the quality and quantity of leachates in Basirih Landfill, Banjarmasin.

2. Leachates Assessment

The leachates which occurred on the operation could be determined by Water Balance Method [6]. This method is based on the assumption that leachates are only produced by rainfall that has successfully infiltrated into the heap of the waste (percolation). Some other sources such as the result of garbage decomposition, infiltration of the surface ground water, and other surface water flow could be ignored. The factors that influence the percolation quantity in Water

Balance Method are: Precipitation, Evapotranspiration, Surface run-off, and Soil moisture storage (Figure 1).

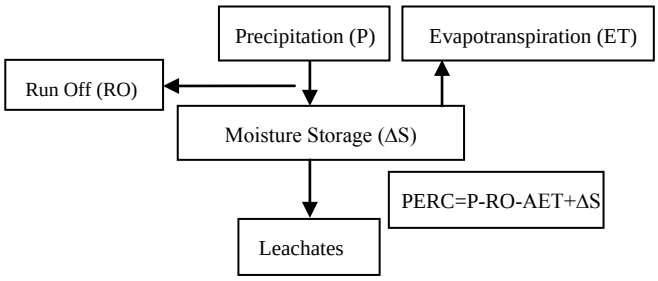


Figure 1. Input-Output System from the Water Balance [7]

With the equation [8]:

$$PERC = P - (RO) - (AET) - (\Delta ST) \quad (1)$$

$$I = P - (R/O) \quad (2)$$

$$APWL = \Sigma NEG\ (I - PET) \quad (3)$$

$$AET = (PET) + [(I - PET) - (\Delta ST)] \quad (4)$$

$$Q\ leachates = (A.\ (1\text{-}Cro).P)/\ 86400 \quad (5)$$

Description:

PERC : percolation, the water which comes out from the system and goes towards the layer underneath, eventually becomes a leachate.

P : the monthly average precipitation of the annual data.

RO : the monthly average of surface runoff which is calculated from the precipitation and the runoff coefficient.

AET : the actual evapotranspiration, indicated the amount of the missing water significantly from month to month.

ΔST : the changes of ground-water deposits from month to month, associated with the soil moisture storage.

ST : soil moisture storage, is the amount of water which stored in the soil at the time of balance.

I : infiltration, the amount of water which infiltrated into the ground.

APWL : accumulated potential water loss, is the negative value from (I-PET) which indicated the accumulation of water loss

I- PET : infiltration value minus the evapotranspiration potential; negative value indicated the amount of failed water infiltration to be supplied on the ground, while the positive value indicated the excess water during a certain period to fill the ground.

PET : evapotranspiration potential, calculated based on the monthly average value of the annual data.

A : the extensive area of the landfill.

3. Research Method

The method used in this study is a survey method. The survey was conducted to assess the physical aspects of the landfill as a waste processing infrastructure, assessing the number and characteristics of waste as a source of leachate. The quality of landfill leachate was measured in 1 year, 5 years and 10 years garbage zones. The total amount of leachate samples were 18 samples. Time of sampling is done on the terms of season, i.e. rainy season and dry season. Assessment quality of leachate consisted of the parameter Total Dissolved Solid (TSS), Biological oxygen demand (BOD), Chemical oxygen demand (COD), Iron (Fe), Ammonium (NH_3N) and pH. Measurements were also performed on the trash to determine the characteristics of the waste to produce leachate.

Leachate quantity measurements performed using water balance [8]. The calculation is done by using rainfall data for 10 consecutive years, e.g. evaporation, percolation and infiltration (the physical condition of the ground). Besides, the necessary data for the calculation of leachate quantity is the water content in the garbage and the amount of organic waste. Additional supporting data used in the calculation of the quantity of leachate is temperature and humidity. Landfills study area currently 39.5 hectares with an active area of the landfill 20 hectares, divided into 16 zones hoarding.

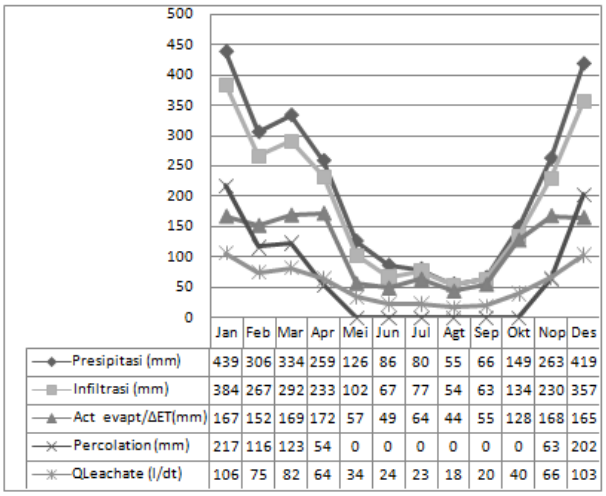
The collected data was in the form of primary and secondary data. Primary data were obtained from a direct interview with the Landfills manager, leachates water quality and quantity measurement and an interview with other relevant institution or agency. In the implementation of primary data collection, there was a direct field observation of the investigated variable through sampling which was conducted with standards and basic procedures. Secondary data was collected from Cleaning and Landscaping Department of Banjarmasin (*Dinas Kebersihan dan Pertamanan Kota Banjarmasin*), Environmental Department of Banjarmasin (*Badan Lingkungan Hidup Kota Banjarmasin*), BAPPEDA Banjarmasin, Kimpraswil Agency Banjarmasin, Climatology and Geophysics Station and other parties that relevant to the research plan. Primary or secondary data was analysed and formulated in order to determine the quantity and quality of the tidal landfill leachates.

4. Results and Discussion

4.1. Leachates Quantity

The leachates quantity which produced by Banjarmasin landfills is fluctuated depending on the precipitation of that area, the landfill extensive area and the waste water amount which entered the landfill. The average waste amount which entered the Landfills is 512 tons/days (Hygiene Department, Banjarmasin). The precipitation data was based on observation during the last ten years on 2003-2012. Figures rainfall ranges from 55 - 439 mm which is divided in 6 wet months and 6 dry months. Infiltration that occurs in the landfill area ranging from 54 mm 384 mm. Evaporation at

landfill sites ranged from 44 mm to 167 mm. While the numbers percolation is very low ranges from 0 mm to 217 mm. Low percolation was caused by the tidal soil conditions. Discharge leachate is formed, ranging from 64-106 l/sec in wet and 18-40lt / sec in the dry months. The leachate formed trend can be seen in Figure 2.



	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Agt	Sep	Okt	Nop	Des
Presipitasi (mm)	439	306	334	259	126	86	80	55	66	149	263	419
Infiltrasi (mm)	384	267	292	233	102	67	77	54	63	134	230	357
Act evapt/ΔET(mm)	167	152	169	172	57	49	64	44	55	128	168	165
Percolation (mm)	217	116	123	54	0	0	0	0	0	0	63	202
QLeachate (l/dt)	106	75	82	64	34	24	23	18	20	40	66	103

Figure 2. Leachates Quantity on Banjarmasin Landfills (Source: Data Analysis)

The amount of formed leachates is ranging from 18 lt/s up to 106 lt/s with the average of 55 lt/sec. The biggest leachates production occurred in January due to the high rain intensity. Whereas in August, the production of leachates is in the minimum level due to the small rain intensity. This leachates production is become a base for leachates cultivation planning. The data used in this leachates cultivation is the biggest leachates production which is in January and combined with a safety factor (1.5-2.5) [9]. The main source in this leachates formation is the infiltration of rain water. High rain intensity and the character of the heap which is not solid will accelerate the formation and increase the leachates water quantity [10].

Leachates quantity which formed on the wet months need to get more attention due to the capabilities of leachates cultivation. Leachates quantity on the tidal Landfills which acts as the dominant deciding factor is the rain intensity (precipitation). Infiltration factor becomes so small due to the soil condition of the landfill surrounding area. The condition of the soil in landfill area is a land with high water saturation level which has an up and down flow even stagnant. The leachates management on the wet months require a canalization, fencing, and cultivation which compatible with the amount of the leachates. Cultivation capacity should be in accordance with the amount of the leachates which compatible with the pump capacity, the ability of anaerobic, aerobic process and biofilter/land application.

4.2. Leachates Quality

The quality of leachates in the landfill is influenced with the waste composition, waste amount, rain intensity as well as the duration of the waste heap. After the test box sampling was conducted, the soil composition of Banjarmasin Landfill is in accordance with the SNI 19-3964-1994 and the results are as follows (Table 1). The waste composition of Banjarmasin Landfills is dominated by organic waste of 55.5%, plastic waste of 19.1% and the rest are paper, textiles, glass, wood, metal, rubber, bones, etc. This waste composition will affect the formation of leachates quality. These results are lower than in Jakarta, which are 64.07% of organic waste, while the inorganic waste which is dominated with paper waste of 15.97% and plastic waste of 14.83% [11]. Haitian city, Haiti has 65% of organic waste [12]. Chittagong Bangladesh has 62% of organic waste [13]. Based on that waste composition, the leachates concentration will also be dominated by organic biodegradable content and the rest is non biodegradable content which influenced the Landfills leachates quality. After the implementation of sampling and laboratory test, Banjarmasin Landfills leachates have the quality as follows (Table 2).

Table 1. Waste composition of Banjarmasin Landfills

Waste Types	Amount (kg)	%
Organic (leaves, vegetables, fruit, etc)	57.34	55.51
Plastic	19.73	19.10
Paper	10.66	10.32
Wood	1.90	1.84
Textiles	9.89	9.57
Metal	0.46	0.44
Glass	2.09	2.02
Rubber/Leather	0.56	0.54
Bones	0.30	0.29
Others	0.38	0.37
Total	103.30	100.00

Source: Field Assessment, 2014.

Table 2. Banjarmasin Landfills Leachates Quality and Other Cities in Indonesia

Parameters	Unit	The Age of Banjarmasin Landfill			The Age of Other landfill in Indonesia		
		1 year	5 year	10 year	1 year	5 year	10 year
pH	-	7,98	7,57	7,42	5,2-6,5	6,3	-
TDS	mg/liter	8.108	1.626	1.263	10.000-14.000	6.794	1.200
COD	mg/liter	6.518	1.138	585	10.000-40.000	8.000	400
BOD	mg/liter	423	127	62	7.800-28.000	4.000	80
Fe	mg/liter	141	78	80	210-325	6,3	0,6
NH_3N	mg/liter	257	129	125	56-482	-	-

Source: Secondary Data, 2014

From the table above, it can be explained that the pH parameters on the landfill at the age of 1 until 10 is relatively the same, which is 7.42-7.98. Parameter Total Dissolved Solid (TDS), Biological oxygen demand (BOD), Chemical oxygen demand (COD), Iron (Fe), Ammonium (NH_3N) decreased starting at age landfills 1 year to the life of the landfill 5 year and age of the landfill 10 year. Leachates quality which based on the parameters above is in accordance with the landfill leachates quality in other cities of Indonesia [9].

The leachates quality is caused by some organic content on the landfill which are susceptible (biodegradable) It is generally unstable and easy to rotten because of the degradation process which produce nutrients, toxic chemical substances and other simple organic contents, and then it would cause some inconvenience and unpleasant odour [14]. The high concentration of COD and BOD was due to the production of volatile fatty acids acetic anaerobic. At the stage of methane production, the acid is converted to CO_2 and CH_4 so that the content of organic material in the leachate becomes lower. The concentration of some inorganic components such as Fe and Ca remains the same as a result of changes in pH. While Ammonia show slow improvement on the landfills which have old age [15]. The leachates composition is not only influenced by waste characteristic (organic, inorganic), but also the easiness of decomposing (dissolved/not dissolved), the condition of waste heap (temperature, pH, moisture, duration/age), the water source characteristic (water quality and quantity which influenced by the climate and hydrogeological parameter), the cover soil composition, microbes and nutrients availability, and also the inhibitor availability [16].

Leachates quantity and quality which was formed in the landfill is the pollutants which will contaminate the environment [17]. Contamination/pollution could occur in the soil, ground water or surface water and the river in the surrounding area of landfill [18]. Leachates quality has a high COD and BOD content. Some inorganic concentration like Fe and Ca aligned as a result of the changes in pH. Ammonia indicated a slow enhancement with the age of landfill. In most cases, the content of heavy metals is lower than mg/1 [15]. The content of the leachate is Cl^-, NO^{3-}, SO_4^{2-}, and NH_4^+ which is found in high concentrations in groundwater samples, especially close to the landfill site. This condition indicates that the quality of ground water is being significantly affected by percolation of leachate. The presence of contaminants in groundwater, especially near the location of the landfill has contaminated the ground water even aquafier [19].

Therefore, there has to be a management towards the existence of leachates so it would be safe for the environment. The management can be done in the form of leachates collection, related to the leachates limitation so it would not be spread, distribution, cultivation and extrication into the environment. The main components that are necessary for the leachates management is the leachates quality and quantity, leachates cultivation methods/techniques, land availability, and the compatibility with the environmental condition [20].

5. Conclusions

Debit landfill leachate formed in Banjarmasin is averaged of 55 lt/sec. For the wet months (Nov - April) ranges from 64-106 lt/sec, while the dry season (May - Sept), between 18 – 40 lt/sec. The dominant factors which affected the leachates debit is the rain intensity (precipitation). Infiltration factor in tidal landfill area is very small due to the condition that the soil is very high saturated water and the flow that tends to be stagnant.

Banjarmasin landfill leachate quality parameters based on total dissolved solid (TDS) of 8,108 mg/lt at the age of landfill 1 year, 1,626 mg/lt at the age of landfill 5 year and 1,263 mg/lt at the age of 10 year landfill. Biological oxygen demand (BOD), 423 mg/lt at the age of landfill 1 year, 127 mg/lt at the age of landfill 5 year and 62 mg/lt at the age of 10 year landfill. Chemical oxygen demand (COD) of 6,518 mg/lt at the age of landfill 1 year, 1,138 mg/lt at the age of landfill 5 year and 585 mg/lt at the age of 10 year landfill. Iron (Fe) of 141 mg/l at the age of landfill 1 year, 78 mg/lt at the age of landfill 5 year and 80 mg/lt at the age of landfills 10 year. Ammonium (NH_3N) of 257 mg/lt at the age of landfill 1 year, 129 mg/lt at the age of landfill 5 year and 125 mg/lt at the age of 10 year landfill. Pollutant concentrations varied and decrease pollutants at the age of landfill zone 1th to 10th. This condition is based on the time processing of waste decomposition on the landfill area. We suggest to observe and examine the influence of leachates pollutants in Landfills towards the surrounding area and the socio-economic community on the subsequent research.

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