

Identification of Important Parameter from Leachate Solid Waste Landfill on Water Quality, Case Study of Pesanggrahan River

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Abstract. Cipayung Landfill takes waste generation from Depok City approximately ± 750 tons/day of solid waste. The south and west boundaries of the landfill is Pesanggrahan River which 200m faraway. The objectives of this study are to indicate an important parameter which greatly affects the water quality of Pesanggrahan River and purpose the dynamic model for improving our understanding of the dynamic behavior that captures the interactions and feedbacks important parameter in river in order to identify and assess the effects of the treated leachate from final solid waste disposal activity as it responds to changes over time in the river. The high concentrations of BOD and COD are not the only cause significantly affect the quality of the pesanggrahan water, it also because the river has been contaminated in the upstream area. It need the water quality model to support the effectiveness calculation of activities for preventing a selected the pollutant sources the model should be developed for simulating and predicting the trend of water quality performance in Pesanggrahan River which can potentially be used by policy makers in strategic management to sustain river water quality as raw drinking water.

1. Introduction

Population increase and urbanization are challenging municipal authorities to manage solid waste. Landfill, one of several components of the waste management chain that needs more attention to reduce its environmental impact. Eventhough landfill is less expensive than other forms of waste treatment but it has make environmental problems. [1]. The leachate that produced by solid waste landfilling can caused surface water pollution because of the organic concentration.

Pesanggrahan River is a strategic river which 7.7 km length for Banten Province, DKI Jakarta, and also West Java Province in Indonesia. It is located within Kabupaten Bogor, Depok City, and Tangerang City in west Java Province, flow to South Jakarta, West Jakarta, and to the North Jakarta in DKI Jakarta Province, and flows to the estuary.

Depok City, West Java Province, Indonesia extends from longitude 106°43'00"-106°55'30" E and latitude 6°19'00" 6°28'00"S has an solid waste final disposal landfill (6°25'19.08"S 106°47'16.48"E) with an area of 11.6 Ha, which located in the sub-district of Cipayung. Cipayung Landfill takes waste generation from Depok City approximately ± 750 tons/day of solid waste. It has been operationalized since 1992. The south and west boundaries of the landfill is Pesanggrahan River which 200m faraway.



Based on those condition above, it need a identification the parameter which has a negative impact on the water quality of river pesanggrahan.

The objectives of this study are: (1) identification an important parameter which greatly affects the water quality of Pesanggrahan River (2) purpose the dynamic model for improving our understanding of the dynamic behavior that captures the interactions and feedbacks important parameter in river in order to identify and assess the effects of the treated leachate from final solid waste disposal activity as it responds to changes over time in the river.

2. Method

2.1 Study area

Pesanggrahan river in Depok City, West Java Province, Indonesia extends from longitude $106^{\circ}43'00''$ - $106^{\circ}55'30''$ E and latitude $6^{\circ}19'00''$ - $6^{\circ}28'00''$. To identify the water quality parameter, water samples were taken at 1 point before the landfill location and 3 points after the landfill location which is still within the administration area of Depok city. They are sampling location (SL) H which has 848 m before landfill area, SL B before the leachate outlet and SL_X and SL_W which located after landfill location, and the distance around 0.53 and 5.792 km from landfill location. (see figure 1).

Selected sampling stations located in Depok City, Indonesia. The water samplings were conducted in April and May 2017 by analyzing in situ for the parameter of DO, pH and temperature, and 23 parameters that are in accordance with raw water standards, by ex situ analysis to determine whether the Pesanggrahan River can still be used as a raw drinking water. The parameters analyzed are all physical and chemical parameters in raw water standard are color odor, taste turbidity and conductivity and TDS, TSS organic permangant, alkalinity, hardness, COD, BOD, Ca, Mg, CO₂, Fe, Mn, Nitrat, Nitrit, Sulfat, BOD and COD.

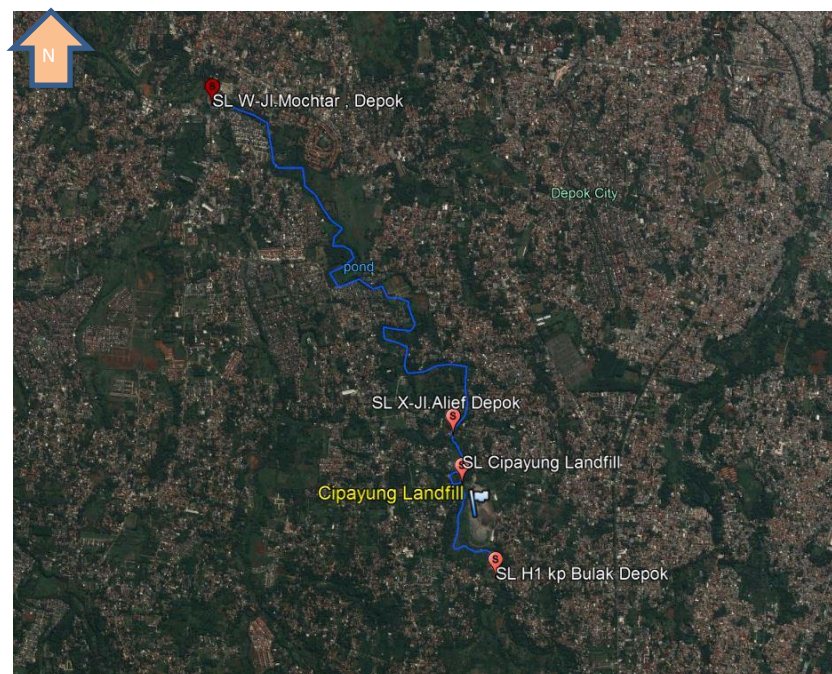


Figure 1 Water quality sampling location in Depok City Area

2.2 Statistical data analysis for proposing mechanistic water-quality model.

The data processing and statistical analysis for the parameters which exceed the class II standard were conducted using SPSS (ver. 23.0). Multivariate Analysis of Variance (Manova) analyzed the significance water quality parameters differences between four (4) sampling locations. Before running the Manova, the multivariate data must be normally distributed assumptions and independently sampled recommendation. The Kolmogorov-Smirnov and Levene's Test was applied to check the

normality and verify homogeneity of variance across samples which explain the suitability and validity of the parameters being addressed through the Manova. The null hypothesis (H_0) of the Manova is the equality of variation mean for each parameter.

The results of Manova are presented as a basic to propose mechanistic water-quality model. To recognize the effects of leachate discharge into the river, the principle of mass balance was used because it is basic principle of water quality models [2]. It suggests using different loads from natural and anthropogenic pollutant that are contributed by the area between the upstream and downstream of the landfill location to build the water quality model.

3. Results and discussion

The results of the discharge and velocity measurements in sampling locations can be seen in Table 1 and the illustration of the transfer of water carrying leachate is illustrated in the chart in figure 2. Furthermore, the discharge measurements at the time showed a value of 3,59-3,95 m^3/sec (Table 1). This is not a measurement that can show the amount of real discharge, because the discharge will be affected by the rain fall. Moreover, it need time series data debit to further analyze in detail.

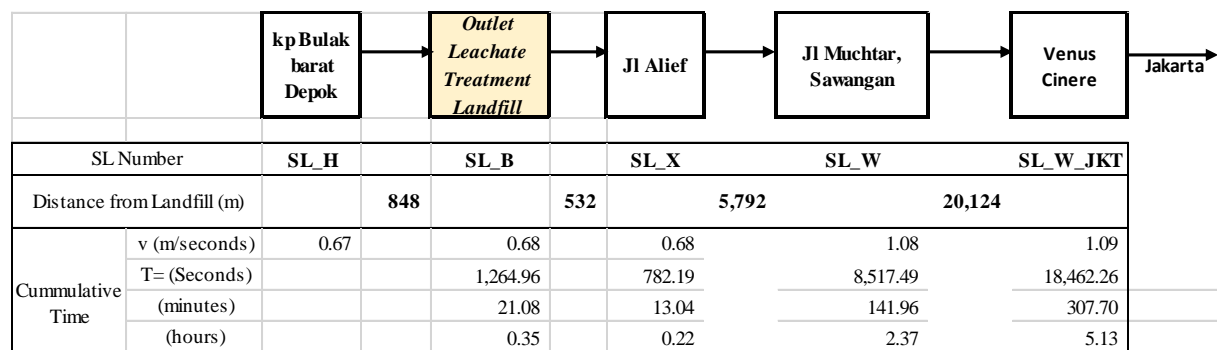


Figure 2. Distance and velocity sampling location pesangrahan river from Cipayung landfill in Depok City

Table 1. The results of the river's discharge and velocity measurement

Sampling Location (SL)	GPS	River's Width (cm)	Distance between SL (m)	Velocity (m/s)	Debit (m^3/s)
Kampung Bulak barat Depok	6°25'32.10"S 106°47'20.1"E	8.2	850	0.67	3.59
Outlet Leachate Treatment	6°25'19.08"S 106°47'16.48"E		-	0.68	3.95
JI Alief	6°25'01.20"S 106°47'10.8"E	11	540	0.68	3.6
JI Muchtar, Sawangan	6°23'50.1"S; 106°46'18.4"E	8.2	5,260	1.08	

The water quality in table 2 shows almost all parameter meet the standards class II for raw drinking water standard, unless total suspended solid (TSS), and the organic parameters; BOD, COD and organic permanganate exceed the standards, therefore that 4 parameters can be regarded as an important parameter. The excessive BOD and COD loads indicate the level of water pollution which could damage the quality of river water. It causes low DO (dissolved oxygen) concentration and unsuitable life conditions in the river. Water quality assessments generally use the Biochemical Oxygen Demand (BOD) which is one of the most widely used criteria because it delivers information about the fraction of the organic load which is ready biodegraded in water. Especially, it indicates as

the biodegradable fraction of an effluent as the ratio between BOD₅ and COD (chemical oxygen demand) in the water treatment plant [3].

Table 2. The results of the river's water quality

No	PARAMETER	Unit	STANDARD	Mean	Mean	Mean	Mean
			Raw water	SL_H	SL_B	SL_X	SL_W
			Class II	Kp.Bulak	Landfil Loc.	Jl.Aliief	Jl.Sawangan
Phisics Parameter							
1	Color	Pt-Co	50	5.0	5.0	4.7	5.0
2	Odor	-	-				
3	Taste	-	-				
4	Turbidity	NTU	25	15.5	20.0	15.4	14.6
5	Conductivity	µS/cm	-	107.0	195.4	168.4	137.2
Chemistry Parameter							
6	pH	-	6,5 - 9,0	8.2	7.7	7.7	7.7
7	TDS	mg/L	1000	51.5	97.7	83.7	66.3
8	Organic Permanganat	mg/L KMnO ₄	10	91.7	58.4	86.5	103.2
9	CO ₂	CO ₂	-	0.0	0.0	0.0	0.0
10	Alkalinity	mg/L CaCO ₃	-	85.3	137.6	103.5	129.1
11	Hardness	mg/L CaCO ₃	500	136.0	117.3	174.7	130.7
12	Ca	mg/L Ca ²⁺	-	38.4	32.0	36.3	29.9
13	Mg	mg/L Mg ²⁺	-	9.5	9.1	20.4	13.6
14	Cl	mg/L Cl ⁻	600	10.5	36.0	54.1	14.0
15	Fe	mg/L Fe	1.00	0.6	0.4	0.4	0.5
16	Mn	mg/L Mn	0.50	0.0	0.1	0.0	3.0
17	Nitrat	mg/L NO ₃	10.0	0.1	0.1	0.1	0.2
18	Nitrit	mg/L NO ₂	1.00	0.1	0.1	0.1	0.2
19	Sulfat	mg/L SO ₄ ²⁻	400	29.1	31.8	28.8	30.6
20	TSS	mg/L	50	78.0	72.3	69.7	90.3
21	BOD	mg/L	3	78.1	65.3	87.2	54.9
22	COD	mg/L	25	111.6	93.7	133.5	170.0
Insitu Parameter							
23	pH	-	6,5 - 9,0	7.6	6.7	6.7	6.7
24	DO	mg/L	4	6.9	6.2	4.8	5.4
25	Temperatur	°C	-	27.0	25.3	27.4	26.6

It needs to detect a main or interaction effect significantly for each concentration of parameters among sampling locations. The probabilities from the kolmogorov-smirnov test (table 3) below are greater than 0.05 (the typical alpha level) except the DO (see table 3). They indicate that the data are multivariate normally distributed. The results of Levene's Test also show homogeneity of variance across samples (table 4). Because of their cause, the Manova is suitable to check differences mean significantly for each parameter among sampling locations.

Table 3. The Kolmogorov-Sminorv Test for normality

		Organic permanganat (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	DO (mg/L)
N		12	12	12	12	12
Normal Parameters ^{a,b}	Mean	84.955	77.583	85.074	127.201	6.915
	Std. Deviation	43.077	37.366	43.784	68.462	.438
Most Extreme Differences	Absolute	.138	.132	.155	.164	.353
	Positive	.130	.132	.105	.140	.353
	Negative	-.138	-.097	-.155	-.164	-.170
Test Statistic		.138	.132	.155	.164	.353
Asymp. Sig. (2-tailed)		.200 ^{c,d}	.200 ^{c,d}	.200 ^{c,d}	.200 ^{c,d}	.000 ^c

Table 4. Lavene's Test of homogeneity of variance across samples

	F	df1	df2	Sig.
BOD (mg/L)	3.358	3	8	.076
COD (mg/L)	4.538	3	8	.039
Organic permanganat (mg/L)	.741	3	8	.557
TSS (mg/L)	2.520	3	8	.132
DO (mg/L)	3.223	3	8	.082

Table 5. The output of Manova Tes

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^d	
Intercept	Pillai's Trace	1.00	2881.63 ^b	5.0	4.0	0.00	1.000	14408.13	1.000
	Wilks' Lambda	.00	2881.63 ^b	5.0	4.0	0.00	1.000	14408.13	1.000
	Hotelling's Trace	3602.03	2881.63 ^b	5.0	4.0	0.00	1.000	14408.13	1.000
	Roy's Largest Root	3602.03	2881.63 ^b	5.0	4.0	0.00	1.000	14408.13	1.000
SL	Pillai's Trace	1.57	1.32	15.0	18.0	0.28	.524	19.83	.528
	Wilks' Lambda	.03	2.05	15.0	11.4	0.11	.699	26.55	.554
	Hotelling's Trace	16.69	2.97	15.0	8.0	0.06	.848	44.52	.690
	Roy's Largest Root	15.70	18.84 ^c	5.0	6.0	0.00	.940	94.19	.999

a. Design: Intercept + SL

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Computed using alpha = .05

Table 5 indicate that $p > 0.0005$, therefore, It accepts Hnull, that the means are equal for each response variable. It means there are not interaction effect of TSS and organic pollutant concentration (Organis Permanganate, BOD and COD) and sampling locations or differences of the concentration of parameters significantly among sampling location. This results describe that high concentrations of BOD and COD from leachate treatment plant from landfill are not the only cause significantly affect the quality of the pesanggrahan water. The BOD and COD concentration in LS before the landfill location showed a high value of 78.1 mg/L BOD and 111.6 mg/L COD. BOD mixture between BOD leachate and BOD river based on the mas balance principle is 78,5 mg/litre. Since the leachate discharge (0,35 litre/seconds) is not significant compared to the large river flow (3,7m/seconds). Pollution occurs not only because of the leachate, but the river has been contaminated with garbage in the upstream area. Besides when water sampling was conducted, there were many garbage on the river that also play a role in pollution water of Pesanggrahan River.

Reaeration is the major source of oxygen supply for BOD assimilation in streams, and assuming a balance of other sources (of oxygen supply) and decline (for oxygen demand) [4] [5]. This manova result, which there are not significant differences between the upstream and downstream points, leads to conjecture an indication that there is no self-purification process or the incidence of pollutant loads along the Pesanggrahan River, and another contaminant besides treated leachate landfill.

To know the effect of BOD leachate load on Pesanggrahan River is need model for developing understanding of the dynamic behaviour BOD dan DO parameter in River. The Biological Oxygen Demand (BOD) parameter is generally used to indicate the level of waste water pollution. BOD is quantified using dissolved oxygen (DO) (in mg/L) as the common, but it is not a constituent. Instead, it is a surrogate considered to quantify the potential of oxygen consumption by bacteria to break down organic carbon in the water. [6]. Therefore the Biochemical Oxygen Demand (BOD) typifies more precisely water and the biodegradable organic quality of the hydro system. Determination of BOD concentration is significant to trace the pollution flow from the upper to lower reach in the river [7]

Effluent dischargers from leachate landfill is an important issue in river water quality management. It is considering the role played in the decision-making process and in the implementation of any proposed waste load allocation program in Depok and DKI Jakarta region therefore Environmental management need model to predict the fluctuations river water quality.

The population growth and their activities makes the threat solid waste and leachate that related with polluted water more and more serious. A proper water resources management is important because water is a transportation medium for many pathogens that can make health risk seriously. Consequently, it needs a tool to simulate the temporal and spatial progress of pollutant concentrations in the surface water. The water quality model supports to calculate the effectiveness of activities to prevent a selected the pollutant sources, not only in defining the necessities for meeting the water quality standards [8]

There are various water quality models which use reaeration as the major source of oxygen supply for BOD assimilation in streams, and assuming a balance of oxygen supply and decline (for oxygen demand) enthusiastically, which the rate of DO deficit expressed as dD/dt . Water quality data can be projected by modeling which were simulated to understanding of the dynamic behavior the BOD and DO concentration as an impact of solid waste landfill to pesanggrahan River as the equation (1) and (2) following :

$$\frac{dBOD}{dt} = A - k_1 \cdot BOD(t) \dots(1) \quad [4]$$

$BOD_{out}(t)$ = the rate of BOD decrease (mg/litre /days)

k_1 = deoxygenation coefficient (/days)

$BOD(t)$ = BOD concentration at time t (mg/litre)

$$\frac{dDO}{dt} = k_r [DO_{sat} - DO(t)] - k_1 \cdot BOD(t) \dots(2) \quad [4]$$

k_a = reoxygenation rate (/days)

DO_{sat} = DO saturated (mg/L)

Every model has its boundaries and advantages for detailed conditions. The data availability for the accurate model application as well as research goal are basic to choose the appropriate modelling approach [9]. It will proposed conceptual river water quality system dynamics model System dynamics modelling (SDM) is a computer-based method which is well balanced and sensible in the modern theory of non-linear dynamics and feedback control concept. [10]. This model starts with the development of a dynamic hypothesis which will build qualitative and quantitative model, generally mentioned as a Causal Loop Diagram (CLDs) (see figure 3), nonlinear systems and analyst the internal relation of systems [11]. The discrete concept of time is based upon the discrepancy between

time-points and fixed time intervals, while the continuous concept deals with changes over time, based on infinitesimal mathematics [12].

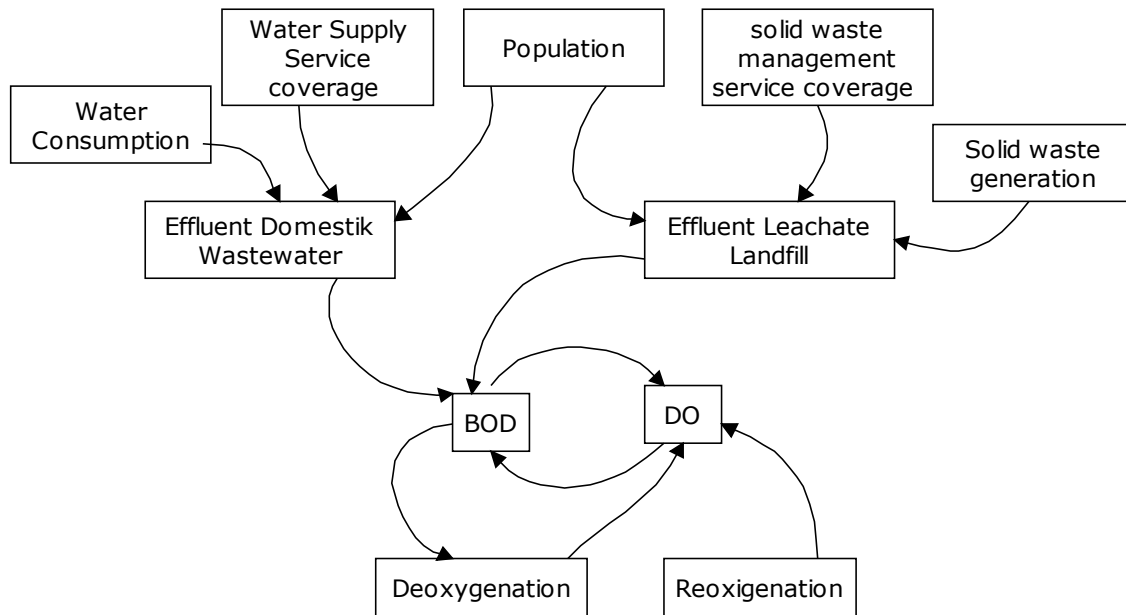


Figure 3. Causal Loop Diagram BOD and DO model.

The assumption of a river is made up by sequence of several reaches, according to scheme originally proposed by Thommann (1963), which the differential equations can be transformed into finite expressions [5]. To simplify the problem, it could be approached by developing a one-dimensional BOD-DO model with cross-sectional averaged and time-dependent assumption. The dynamic and quality terms are assumed to be constant over the entire cross section. It is only the longitudinal side is importance [5]. It is assumed sufficient because the river's lateral and vertical scale is much smaller than longitudinal ones [8]. The BOD and COD modeling can be disregarding some other aspects that can be pertinent to the problem of the approximating the river behavior. This assumption may be inconsistent with the natural behavior of the river and does not consider that pollutant concentration can vary within the length of each reach. Nevertheless, the approach of modelling can adopt for a first-glance estimation through considering the time effortlessly as a sequence of several steady state situation. It can simulate to describe any possibility how the pollutant behaves after being discharged in the stream

4. Conclusions

The high concentrations of TSS and Organic parameters occur not only because of the leachate, it also because the river has been contaminated by garbage in the upstream area. It needs the water quality model to support the effectiveness calculation of activities for preventing a selected the pollutant sources. The future study will build the BOD-DO system dynamics model. It should be developed for simulating and predicting the trend of water quality performance in Pesanggrahan River which can potentially be used by policy makers in strategic management to sustain river water quality as raw drinking water.

5. References

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