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An evaluation of Wastewater Compounds Behavior to Determine the Environmental Impact Assessment (EIA) Wastewater Treatment Plant Technology Consideration: a Case on Surabaya Malls

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Abstract: Surabaya rivers are considered as the main source of water used by the citizens of Surabaya. Surabaya rivers are not only used for drinking materials, but also for industrial and mall sectors that produce wastewater. Thus, the existence of wastewater is an inevitable situation. Ensuring the sustainability of Surabaya Rivers is important to fulfill the minimum criteria set by the Indonesia Government. This research aims to evaluate the wastewater compounds behavior in Surabaya rivers in order to understand the characteristics and patterns of wastewater. Seven variables to include BOD, COD, NH3, O&G, PO4, TSS and a debit were assessed by structural equation modeling. The sampling data were taken from two malls in Surabaya. The analysis result describes one positive correlation and five negative correlations. The wastewater treatment plant technologies are expected to be able to accommodate the behavior patters of these wastewater compounds. Several recommendations from the analysis result can be used by mall owners, potential developers as well as the Environmental Impact Assessment related sectors to consider the characteristic of wastewater compounds and to use the appropriate wastewater treatment plant technology in order to ensure the sustainability of the river.
Keywords : Surabaya River, Wastewater Compounds, Wastewater Treatment Plant.

Introduction

Water is a fundamental compound needed by almost every living creatures to maintain the existence of life. There are many ways to obtain a water, such as from spring, rain, river, and some artificial processes. The compositions of water are not only formed by basic hydrogen (H) and oxygen (O2), but also a lot of attached minerals depending on its interaction. In some situation, the compounds are maintained to a pure substance while the others fused such as mineral water, solvent and wastewater. However, not all the materials are good for the sustainability living creatures, it sometimes contains toxic and chemical substance that could endanger the living beings. Thus, the approaches to ensure the quality of water are necessarily needed.

Many cities all over the world use the river as a main source of water including Surabaya. By more than 30 years[1], Surabaya rivers were used by more than 3 million population as drinking water as well as industries and malls. To ensure the quality of the river safe to be consumed, six drinking water treatment plants in

Surabaya are used. Furthermore, the proper wastewater treatment plants are also obliged to the industries and malls to ensure the output fulfilled the standard quality. All of the approaches were aimed to control the water quality. In Razif et al.,[2] research, six parameters were mentioned in the criteria of good water set by the government to include BOD, COD, NH3, O&G, PO4, TSS in a debit water. In order to meet the minimum standard quality, Razif et al.,[1] need to adjust the wastewater treatment plant in Surabaya mall as a case due to some parameters exceed the minimum standard quality in the first design and finalized it in the second design. A similar phenomena is also appeared in water treatment of Surabaya drinking water, which need a redesign of water treatment to fulfill the minimum criteria[3]. Both situations, perhaps, happened due to the behavior of each parameter that is not explored yet. Thus, this research aims to evaluate the behavior of the six parameters in a wastewater debit to better understand the characteristic of wastewater in malls.

Materials and Methods

Two qualitative data sampling were taken at two Surabaya malls in April 2014[1,2]. The sampling consists of BOD, COD, NH3, O&G, PO4, TSS in a debit water. The sampling time was recorded in each hour for 24 hours. The collected data were later analyzed in the laboratory and the details are shown in Table 1.

Table 1 Sampling of wastewater compounds.

Mall	Time (Hour)	BOD (mg/l)	COD (mg/l)	NH3 (mg/l)	O& G (mg/l)	PO4 (mg/l)	TSS (mg/l)	Debit (l/second)
D	1	344	584	103.33	64	13.12	772	0.51
	2	370	629	174.83	70	37.09	660	0.48
	3	356	595	157.06	66	25.75	676	0.53
	4	338	584	209.28	62	35.27	662	0.42
	5	332	550	28.06	60	17	706	0.15
	6	346	561	157.33	62	15.32	660	0.19
	7	274	450	150.9	34	17.19	346	1.31
	8	256	415	135.45	30	8.26	360	1.31
	9	178	292	157.06	22	19.7	166	1.02
	10	220	348	99.36	26	4.75	232	1.81
	11	352	606	74.05	68	5.79	638	3.73
	12	144	236	105.1	18	3.09	236	4
	13	192	314	103.19	24	3.97	214	4.05
	14	146	236	117.54	18	5.83	120	3.75
	15	204	326	87.33	36	3.16	480	2.28
	16	148	236	147.76	17	5.64	140	3.21
	17	144	225	134.77	17	5.17	148	2.42
	18	112	180	135.24	14	5.44	142	3.76
	19	151	236	124.24	20	6.33	172	3.54
	20	184	292	136.19	22	4.01	268	4.08
	21	178	281	155.01	21	6.95	138	3.92
	22	166	270	170.04	20	20.16	144	1.52
	23	488	764	145.4	84	12.28	852	0.39
	24	436	752	120.42	82	21.25	950	0.39
H	1	218	371	101.28	42	4.55	474	3.5
	2	240	415	97.45	46	3.86	534	3.69
	3	278	472	95.53	54	4.9	570	4.27
	4	262	460	107.97	53	5.21	510	1.94
	5	220	393	117.41	44	5.48	528	5.64
	6	224	370	105.79	40	5.71	480	4.67
	7	202	337	109.31	38	5.1	436	5.44
	8	206	348	115.36	39	5.48	466	6.03

	9	198	326	126.98	36	4.9	440	2.92
	10	246	404	119.46	46	4.67	416	4.08
	11	236	393	131.08	42	5.21	396	6.42
	12	230	393	125.06	43	5.44	420	2.72
	13	288	472	112.08	52	4.82	428	2.33
	14	256	415	112.21	47	5.71	504	1.36
	15	236	382	117.54	43	5.25	340	0.39
	16	132	213	103.74	24	6.84	284	0.19
	17	138	225	126.98	26	6.87	138	0.39
	18	112	180	238.92	20	10.84	72	0.39
	19	136	213	198.72	24	11.01	72	0.39
	20	190	326	170.29	37	8.65	420	0.19
	21	208	360	130.91	40	8.15	466	0.78
	22	192	326	103.33	34	5.83	558	2.72
	23	188	314	118.09	32	6.02	510	1.56
	24	178	303	105.92	33	6.25	620	0.77

Source : Razif et al (2015)[1]; Razif et al (2015)[2]

The collected data were evaluated by using structural equation model with AMOS software, which the constructed model is shown in Figure 1. The derivations of hypotheses are described at below:

H1: BOD has a positive/negative significant relation to a debit water
H2: COD has a positive/negative significant relation to a debit water
H3: NH3 has a positive/negative significant relation to a debit water
H4: O&G has a positive/negative significant relation to a debit water
H5: PO4 has a positive/negative significant relation to a debit water
H6: TSS has a positive/negative significant relation to a debit water

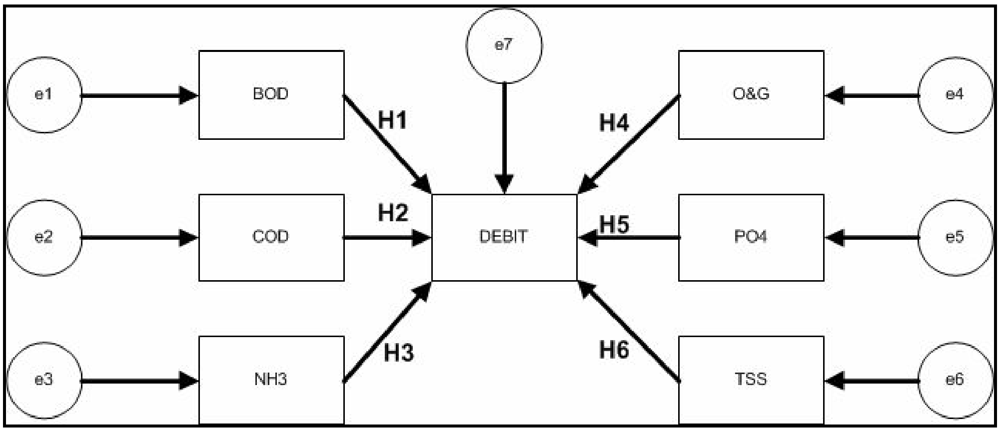

Figure 1. Evaluation model of wastewater compound behavior

Result and Discussion

The first evaluation was to conduct a descriptive statistical analysis of the sampling data, where several parameters were shown in Table 2(a) and 2(b). Furthermore, the descriptive statistical analysis reveals the mean, Q1, Q2, Q3, minimum value, maximum value, variance, standard deviation and data range.

Table 2 (a). Descriptive analysis

Variable	N	Mean	Q1	Q2	Q3	Minimum	Maximum
BOD (mg/l)	48	230.70	178	213	271	112	488
COD (mg/l)	48	382.80	283.80	354	457.50	180	764
NH3 (mg/l)	48	127.51	105.27	119.94	147.17	28.06	238.92
O&G (mg/l)	48	39.42	24	37.50	50.75	14	84
PO4 (mg/l)	48	9.36	5.12	5.81	10.97	3.09	37.09
TSS (mg/l)	48	415.90	218.50	432	552	72	950
Debit (l/s)	48	2.32	0.49	2.11	3.76	0.15	6.42

Table 2 (b). Descriptive analysis 2

Variable	Variance	Std Deviation	Range
BOD (mg/l)	7070.90	84.10	376
COD (mg/l)	20374.50	142.70	584
NH3 (mg/l)	1242.17	35.24	210.86
O &G (mg/l)	320.46	17.90	70
PO4 (mg/l)	60.14	7.76	34
TSS (mg/l)	46727.70	216.20	878
Debit (m3/s)	3.25	1.80	6.27

The following evaluation was to find the correlation between each variable to a wastewater debit represented in six hypotheses. As for the first correlation in Figure 2, it shows how BOD has a negative correlation to wastewater Debit with the value of -0.609. This situation could occur when a Debit increased by 1, a BOD value decreased in 0.609.

Figure 2. Correlation of BOD to Debit

The second correlation between COD and Debit in Figure 3 indicates the positive value by 0.76, which means in every 1 point debit increment the COD will increase by 0.76 points. This result has an interesting characteristic because normally a debit could decrease the compound in a wastewater.

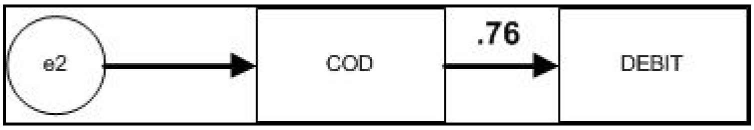

Figure 3. Correlation of COD to Debit

The third correlation between NH3 and Debit presented Figure 4 shows the negative points by -0.01, which indicates in every 1 value Debit elevation the NH3 will reduce by 0.01 values.

Figure 4. Correlation of NH3 to Debit

The fourth correlation from O&G to Debit displayed Figure 5 illustrates the negative relation by -0.10, which specifies in every 1 value Debit will reduce the NH3 by 0.10 values appropriately.

Figure 5. Correlation of O&G to Debit

The fifth correlation from PO4 to Debit shown in Figure 6 demonstrates the negative reflection by -0.11, which identifies in every 1 value Debit will diminish the PO4 by 0.11 values suitably.

Figure 6. Correlation of PO4 to Debit

The last sixth correlation from TSS to Debit revealed in Figure 7 demonstrates the negative likeness by -0.05, which detects in every 1 value Debit will weaken the TSS by 0.05 values suitably.

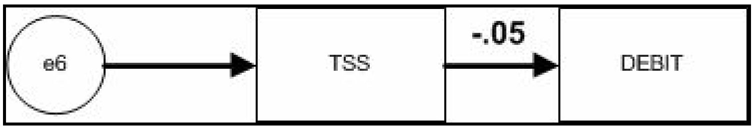

Figure 7. Correlation of TSS to Debit

The overall result of correlation model was shown in Figure 8. The model could explain the behavior characteristic of six parameters by the 98% R^2. However, exploring the significance of the correlation is important to determine the validity of simulation result. Since the sampling data is extremely small, a bootstrap approach will be used. Some research could explain the significance characteristic of a model in many cases of the small to moderate sample with bootstrap method[4,5,6]. The result of the bootstrap approach in this evaluation model is shown in Table 3.

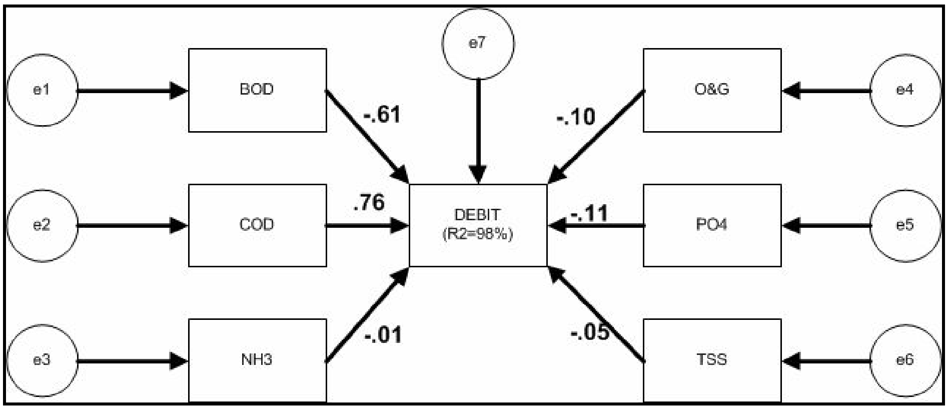

Figure 8. Wastewater compound behavior model result

Table 3. Significant correlation result

Parameter	Correlation	p-value	Note	Hypothesis
BOD (mg/l)	-0.61	0.012	Significant	H1:Accepted
COD (mg/l)	0.76	0.004	Significant	H2:Accepted
NH3 (mg/l)	-0.01	0.729	Insignificant	H3:Rejected
O&G (mg/l)	-0.10	0.342	Insignificant	H4:Rejected
PO4 (mg/l)	-0.11	0.003	Significant	H5:Accepted
TSS (mg/l)	-0.5	0.351	Insignificant	H6:Rejected

note: $p \leq 0.05$

Based on Table 3, 3 out of six correlations have significant value and validate 3 hypotheses. This result, however, is still relatively has a small to moderate accuracy because the sampling data are less than 40 (the minimum value for s normal distribution). A recalculation with a larger number of sampling data is suggested. Finally, this research describes how the behavior of six parameters could be described in the wastewater debit and the result can be used for EIA wastewater treatment plant technology consideration. A material selection of wastewater treatment plant that could reduce the COD value more than the other parameters is highly suggested.

Conclusions

The current research aimed to evaluate the behavior characteristic of wastewater compounds in Surabaya Malls. Six parameters include BOD, COD, NH3, O&G, PO4, TSS was evaluated. A sampling data were performed in two malls in Surabaya city. The collected data was measured by structural equation modeling and the result describes the behavior of each parameter to a debit water. Three out of six hypotheses were proven and the model could explain the 98% R^2.

The result indicates how the EIA evaluator and Mall owner should concern about COD parameter that is still occurring in the wastewater debit. Some limitations need to be evaluated such as the sampling data need to be added and further recalculation need to be performed to increase the accuracy of the evaluation model. A material selection of wastewater treatment plant that could reduce the COD value more than the other parameters is highly suggested to reduce the output that will flow into Surabaya river.

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