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The Fluctuation Impacts of BOD, COD and TSS in Surabaya's Rivers to Environmental Impact Assessment (EIA) Sustainability on Drinking Water Treatment Plant in Surabaya City

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Abstract: Surabaya's rivers have been used for 30 years by 3 million citizens of Surabaya as the raw material for the drinking water treatment plant. Currently Surabaya city has 6 drinking water treatment plants with the total of 6 m3/s debit water collections. Concurrently, Surabaya's rivers have been polluted for 30 years by domestic, farming and industrial waste. The aims of this research are to assess the fluctuation effects of biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids (TSS) in Surabaya's river to Environmental Impact Assessment (EIA) sustainability on 6 drinking water treatment plants in Surabaya city. A series of sampling data collections in year 2010, 2011, and 2012 were used and the site location was at Gunungsari Dam, which were near with both 3 drinking water treatment plants in Karangpilang and 3 drinking water treatment plants in Ngagel. The entire drinking water treatment plants have the EIA documents. By using a system dynamic simulation, a 5 year projection was performed to predict the percentage of the exceeding drinking raw water standard quality. A 5 year projection was based on the assumption that both environmental management plan (EMaP) and environmental monitoring plan (EMoP) can be reviewed in every 5 years if it is needed. The projected results of the parameters show that the exceeding the standard quality in pre-treatment filter were 1.32%BOD, 0%COD, and 92.82%TSS by using a singlepre-treatment filter and 0% of all parameters by using double pre-treatment filters. The results indicate the potential evaluation on reviewingthe EIA documents on 6 drinking water treatment plants. The debit value was still okay because the Surabaya's rivers have the continuous safety water quality byGunungsari and Jagir Dam. A period of checking is needed to maintain the parameter's quality according to the Ministry of Health's regulation threshold. The threshold is being set to anticipate the low quality parameters that potentially affect the 60% of the total population in Surabaya City. The EIA review in every 5 years needs to be focused on the attempt of process improvement of drinking water in 6 drinking water treatment plants by the adequate technology to produce the good water and fulfill the standard quality set by Ministry of Health's regulation.
Keywords : BOD, COD, TSS, Surabaya River.

Introduction

The utilization of water in Surabaya river has been performed for more than 30 years as a raw material of drinking water for citizens of Surabaya. Currently, Surabaya city has 3 million populations and own 6 drinking water treatment plants. The entire drinking water treatment plants are derived into 3 units in Karangpilang and 3 others in Ngagel. The drinking water treatment plants are operated with 6 m3/s total debit taken from the Surabaya rivers. According to LPPM-ITS's study in 2008[1], the load of contamination in Surabaya rivers caused by industrial waste was BOD = 25336.54 kg/day, by domestic and farming waste were BOD = 65496.69 kg/day. These values indicate that the major contributors which dump the waste into Surabaya rivers were from farming and domestic sectors. In accordance with the development of Surabaya city, the farming activity has significantly reduced. Thus, the biggest contributors of waste arefrom domestic and industrial waste and it has the majority of organic and anorganic materials. Because the rivers play the role as a raw material of the drinking water treatment plant, the bad water river will affect the process and quality of the resulted water. Furthermore, the entire 6 drinking water treatment plants use the conventional system. This situation, often, contributes the bad result water and it harms to the citizens' health. Moreover, the contamination of the river in the city are not only occurring in a metropolitan Surabaya city, but also occurs in many cities globally.

Garcia *et al* [2], in their research, evaluated the effectivity of wastewater control program in Indonesia, which the total of BOD and COD were reduced in approximation 32%. Fulazzaky[3] wrote an article that the reduced of Citarum's river quality because of the increased of contamination load was dumped without a proper process from Bandung's headwaters. Burroughs[4] explained that the contaminations in New York in 1664 was because of the citizens' activity, which throw their wastewater to drainage and flow to river and sea. In concurrent of domestic wastewater in city, wastewaters from hospitals are also contributing to the environment in many cities widely. This fact was revealed by Kotzamanidis *et al* [5].Morihama [6] also wrote how bad the river water quality in Brazil's city. Lin *et al*[7], in Taiwan case, concluded that the Houjing river was polluted from point source and non-point source originated from wastewater in city, farming, and an environmental degradation due to inefficient of water utilization. Cha *et al*[8] explained that BOD in river of Yeongshan, Korea, was very high during the dry season (April-June) and was reduced in winter season (July-September) because of the dilution rainfall effect. O'Donnell & Galat [9] wrote an article that the water river in Mississipi, USA had been degraded due to farming activity and urban sprawl for more than 200 years and it increased the sediment and nutrient to the river.

Currently, the river standard quality for drinking water raw-material in Indonesia is based on Government Regulation No.82/2001[10], which for class-1 river category the parameters are BOD = 2 mg/l, COD = 10 mg/l, and TSS = 50 mg/l. Furthermore, the requirements of drinking water in Indonesia are also based on Ministry of Health Regulation No.492/MENKES/PER/2010[11]. This research, therefore, will explore the potential exceeding value of BOD, COD and TSS from standard quality that will be processed into drinking water by a 5 year projection as well as suggests the appropriate way to improve the situation.

Materials and Methods

For the purpose of this research, a qualitative data sampling from Gunungsari Dam[12] was used. Dam of Gunungsari was selected because it served as a long storage for the intake of Karangpilang drinking water treatment plants 1,2 and 3. Furthermore, the Gunungsari Dam also flows the water to Dam of Jagir, which is the main intake of Ngagel drinking water treatment plants 1,2 and 3. Based on the water river monthly analysis, it has a fluctuation for key parameters that describe the contamination level such as BOD, COD, and TSS. The fluctuations of key parameters for Gunungsari Dam are shown in Table 1.

Table 1Water river quality in Gunungsari Dam.

Year	Month	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	Debit (m3/s)
	January	5.76	12.40	102.90	31.97
	February	4.85	11.00	216.00	16.75
	March	3.19	13.56	114.60	31.84
	April	3.07	9.26	88.00	35.26
	May	6.03	28.37	793.30	25.09

2010	June	3.47	13.27	85.30	15.86
	July	3.91	12.75	70.00	13.26
	August	4.18	16.13	87.00	14.26
	September	4.45	14.22	110.00	26.27
	October	9.02	46.50	813.30	19.65
	November	5.39	30.19	290.00	9.95
	December	6.47	28.72	314.00	11.90
2011	January	6.47	38.62	608.30	11.16
	February	3.38	15.58	59.00	25.11
	March	4.77	19.31	149.00	16.76
	April	4.95	20.06	118.70	8.25
	May	4.18	18.10	104.00	11.15
	June	3.41	14.05	46.70	11.33
	July	3.18	10.32	38.00	33.08
	August	2.93	11.59	25.00	12.70
	September	2.30	9.86	34.70	8.02
	October	2.31	10.16	26.50	14.49
	November	2.47	11.66	35.00	11.82
	December	3.88	14.09	52.00	38.51
2012	January	4.36	18.01	187.00	9.45
	February	2.42	8.19	57.00	8.18
	March	5.31	15,92	139.00	26.92
	April	2.86	11.81	106.00	18.80
	May	4.29	21.41	254.00	55.50
	June	11.94	32.00	32.00	27.51
	July	2.52	7.59	32.00	9.48
	August	2.38	5.41	18.00	46.63
	September	2.05	9.05	14.70	18.71
	October	3.10	13.19	20.50	64.08
	November	3.90	15.66	23.50	40.11
	December	3.41	16.75	1000.00	35.28

Source : Nugroho (2014)[12]

By using the sampling of data fluctuation every month for the year 2010-2012, a 5 year projection of System Dynamics with STELLA software is performed. A projection models are developed for every parameters and the example model of BOD is shownin Figure 1. In the developed model, it consists of 3 flows from the source and 2 flows to the destined output. The 3 flows from the source are consist of the material waste from domestic, industrial and farming. The wastewater source will mix together in the Gunungsari Dam denoted by Total Concentration of material (BOD) in DAM level. At DAM level, a random sampling collection was gathered by the research team to be used as the primary data. The formula of this level is denoted in random value between the minimum and maximum of sampling parameters (function= Random (nMin,nMax)).The DAM level, furthermore, flows the wastewater parameter to pre-treatment filter in drinking water treatment plants. At the filtering level, the river water will be processed with filter at some degree of the coefficient. A common filter method in developing country, especially in South East Asia, is Sasse method[13]and this method was validated with a 90% coefficient by Razif et al.'s research in Indonesia [14,15]. The filtered water, furthermore, will be distributed to the Citizens of Surabaya. A periodic sampling can be performed to control the water quality according to the Indonesia Government Regulation No.82/2001 as well as the Indonesia Ministry of Health Regulation No 492/MENKES/PER/IV/2010.

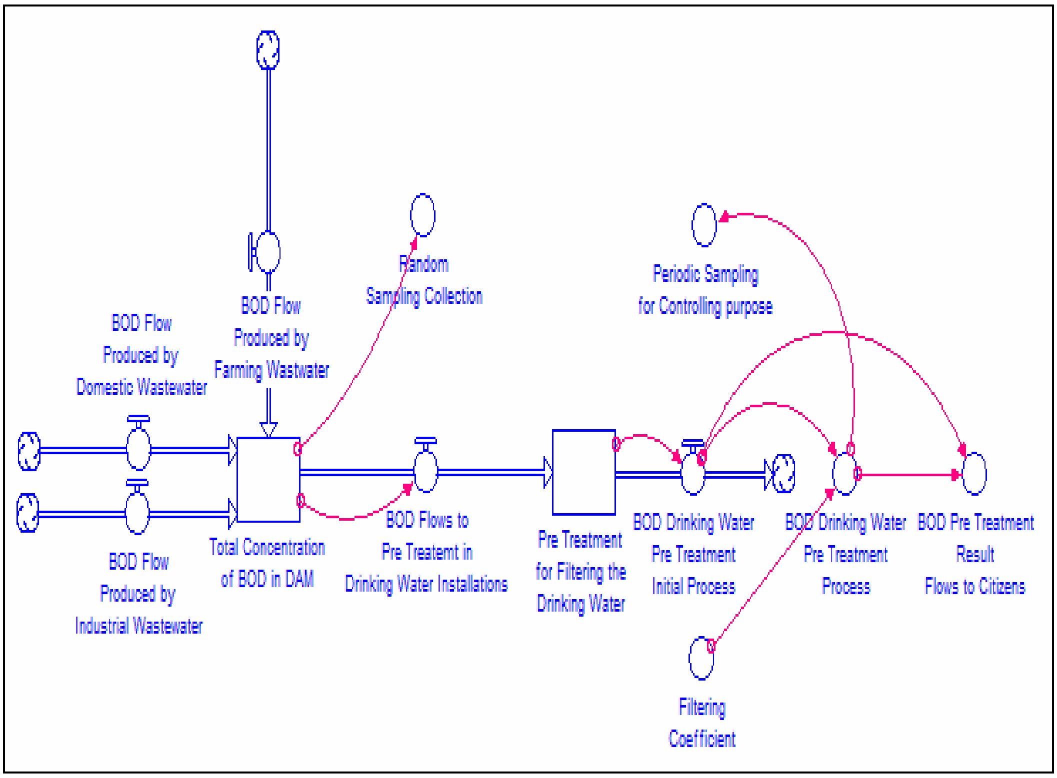

Figure 1. Example projection of wastewater for BOD parameter

Result and Discussion.

A descriptive statistical analysis is performed to analyze the 2010-2012 sampling data and the outcome is presented in Table 2(a) and 2(b). The descriptive statistical analysis consists of mean, minimum value, quartile 1, median, quartile 3, maximum value, standard deviation, variance, coefficient of variance and the range of the data.

Table 2 (a). Descriptive statistical analysis result

Variable	N	Mean	Minimum	Q1	Median	Q3	Maximum
BOD (mg/l)	36	4.24	2.05	2.97	3.89	4.93	11.94
COD (mg/l)	36	16.80	5.41	11.15	14.07	19.01	46.50
TSS (mg/l)	36	174.00	14.70	34.80	87.50	177.50	1000.00
Debit (m3/s)	36	13.98	8.02	11.45	17.73	31.94	64.08

Table 2 (b). Descriptive statistical analysis result 2

Variable	StDev	Variance	CoeVar	Range
BOD (mg/l)	1.99	3.943	46.86	9.89
COD (mg/l)	9.00	81.00	53.58	41.09
TSS (mg/l)	242.6	58877.50	139.43	985.30
Debit (m3/s)	13.98	195.33	61.73	56.06

The utilization of System Dynamics has been performed in prior research regarding wastewater treatment plant for Mall case[14]. In this research, a prediction is performed on Surabaya rivers with pre-treatment filtering for drinking water treatment plants, which the qualities are fluctuating in between 41 km caused by industrial, domestic and farming wastewater.The projection results of System Dynamic with STELLA software are shown in Figure 2-5 as well as Table 3 and 4.

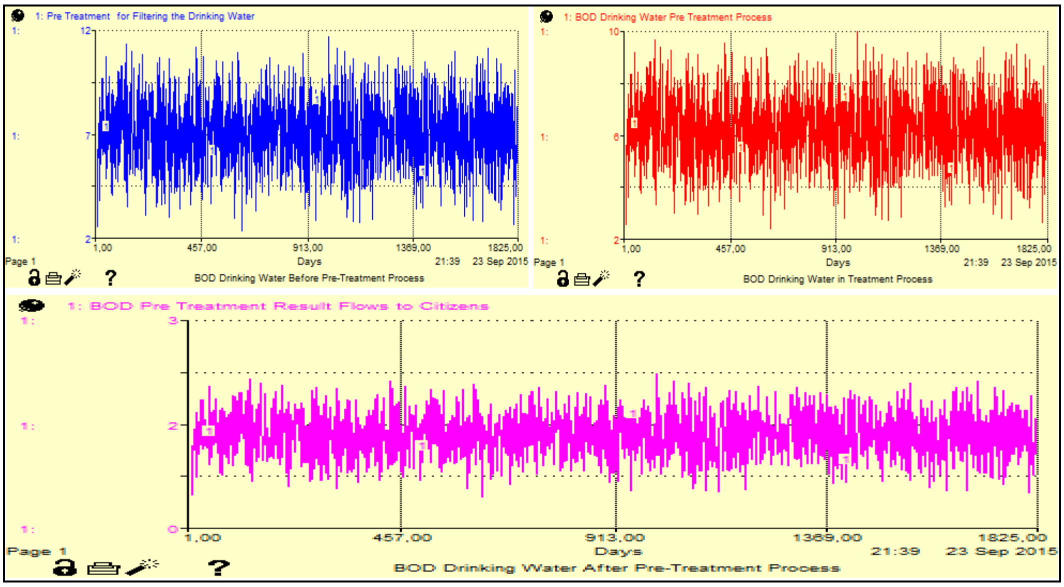

Figure 2. Five year projection of BOD parameter

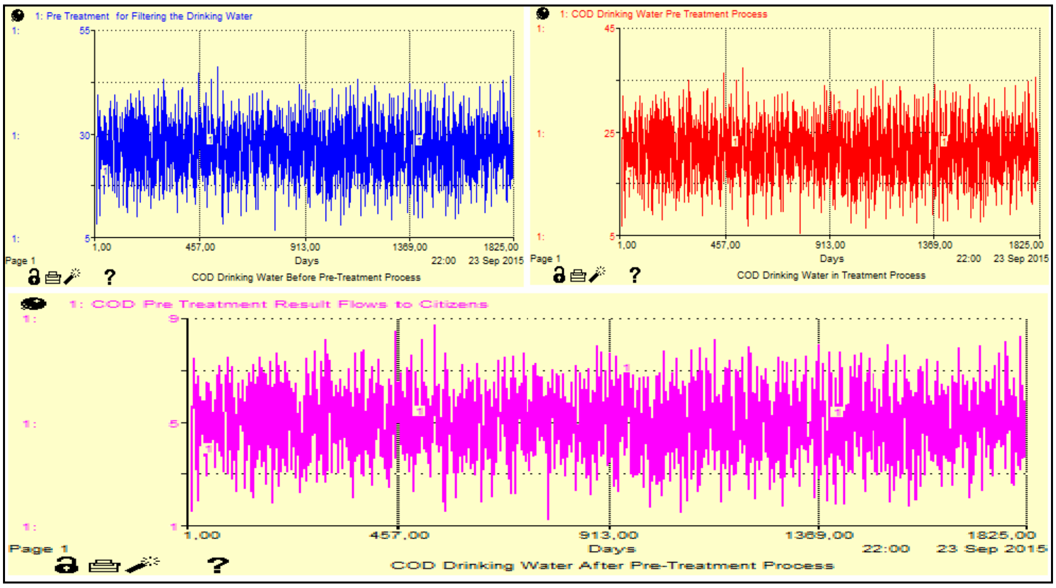

Figure 3.Five year projection of COD parameter

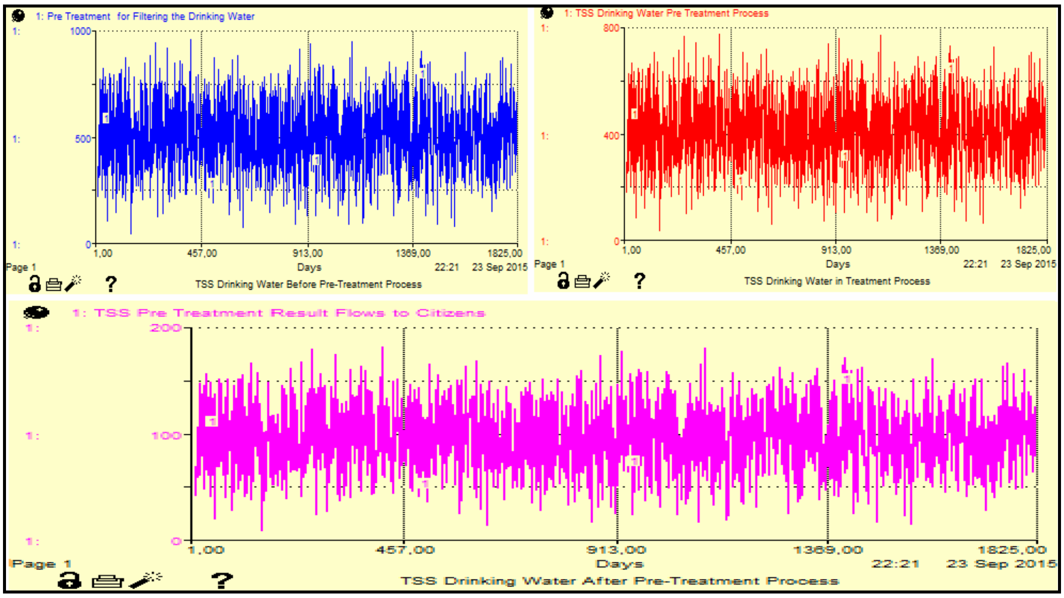

Figure 4 Five year projection of TSS parameter

Table 3. Five Year Projection of Water Quality in Surabaya River

Time (days)	Drinking Water Before Pre-Treatment Process			Drinking Water in Pre-Treatment Process			Drinking Water After Pre-Treatment Process		
	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)
1	2.47	8	216.14	2	6.48	175.07	0.47	1.52	41.07
2	2.47	8	216.14	2	6.48	175.07	0.47	1.52	41.07
3	5.01	28.75	226.73	4.06	23.28	183.65	0.95	5.46	43.08
4	7.51	30.03	492.25	6.08	24.32	398.72	1.43	5.7	93.53
5	5.84	39.24	555.84	4.73	31.79	450.23	1.11	7.46	105.61
6	6.62	32.17	469.04	5.36	26.06	379.92	1.26	6.11	89.12
7	7.32	35	307.96	5.93	28.35	249.45	1.39	6.65	58.51
8	5.77	23.15	318.91	4.67	18.75	258.32	1.1	4.4	60.59
9	5.74	32.45	668.61	4.65	26.29	541.57	1.09	6.17	127.04
10	3.76	33.92	773.41	3.04	27.47	626.46	0.71	6.44	146.95
::	::	::	::	::	::	::	::	::	::
1820	3.93	28.23	477.5	3.18	22.86	386.77	0.75	5.36	90.72
1821	5.74	33.71	332.42	4.65	27.31	269.26	1.09	6.41	63.16
1822	4.58	18.86	595.61	3.71	15.28	482.44	0.87	3.58	113.17
1823	4.58	25.14	618.96	3.71	20.36	501.36	0.87	4.78	117.6
1824	8.29	30.48	540.8	6.71	24.69	438.05	1.57	5.79	102.75
1825	5.57	24.94	659.66	4.51	20.2	534.32	1.06	4.74	125.33

Table 4. The projection record of parameters that exceed the minimum standard quality

Parameter	Threshold	Highest value gathered	Total Exeeding Occurance (in days)	Percent over threshold
BOD (mg/l)	2	2.23	24	1.32%
COD (mg/l)	10	8.5	0	0%
TSS (mg/l)	50	182.2	1694	92.82%

As it was shown in from Table 3, the information gives a projection on how pre-treatment with 90% coefficient will work in every day for five years. In the Table 4 result, some parameters exceed the minimum standard. It can be said that the 90% coefficient able to reduce both BOD and COD parameters in accordance with Government Regulation No.82/2001 with a 5% error tolerance.The TSS parameter, however, cannot be reduced significantly by using 1 filter with a 90% coefficient. The addition of 1 filter with a 90% after the first filter process is suggested, which needs 2 filters in total to handle the TSS problem. The simulation for 2 filters with a 90% coefficient is shown in Table 5.

Table 5. The result2 filters with both 90% coefficient

Parameter	Threshold	Highest value gathered	Total Exeeding Occurance (in days)	Percent over threshold
BOD (mg/l)	2	0.22	0	0%
COD (mg/l)	10	0.85	0	0%
TSS (mg/l)	50	18.22	0	0%

Furthermore, if Table 1 isanalyzed by multiplying the debit with concentration, we will get the load contamination value of each parameter as shown in Table 6.

Table 6. Contamination load calculation in Gunungsari Dam (Year 2010-2012)

Parameter	BOD (kg/day)	COD (kg/day)	TSS (kg/day)
Averageconcentration (mg/l)	4.24	16.8	174.03
Averagedebit (m3/s)	22.64	22.64	22.64
Conversion Factor	86.4	86.4	86.4
Load (kg/day)	8293.85	32862.41	340419.39

This load, later, can be compared with the previous research related to Surabaya's rivers contamination in year 2008[1, 15] as shown in Table 7.

Table 7. Contamination load calculation in Gunungsari Dam/Reach 5 (Year 2008)

Reach	Source	BOD (kg/day)	COD (kg/day)	TSS (kg/day)
5	Industrial	3660.87	10817.45	9249.71
5	Non Industrial	10435.27	34449.98	76220.64
	Total load	14096.14	45267.43	85470.35

If both Table 6 and 7 are compared, it can be seen the reduction of contamination of BOD and COD parameters from year 2008 to 2010-2012. However, the contamination value of TSS has increased. Furthermore, although the reduction of BOD and COD were occurring, the entire parameters were still exceeding the standard quality. The fluctuations of quality in raw-material drinking water and it still over the standard quality require the proper improvements by performing a review in EIA for 6 drinking water treatment plants that use Surabaya rivers. Because the 6 drinking water treatment plants are in current active, according to regulation, it needs an environmental audit. A suggested environmental audit shall contain:

1. An immediate evaluation on 6 drinking water treatment plants in Surabaya City by checking each of the water quality based on Ministry of Regulation No 492/MENKES/PER/IV/2010. In more detail, it contains 10 parameters that directly influence health. Furthermore, it has 16 parameters that indirectly influence to health, 9 additional parameters anorganic, 21 additional parameters organic, 22 pesticide parameters, 14 disinfectant parameters and its side effects, and 2 radioactive parameters.
2. If the environmental audit, mentioned in section a, has found many parameters that have not fulfilled the requirement, then the technological approach for adding the building filter units to elevate the current conventional 6 drinking water treatment plants' performance are needed
3. Considering the current condition, where Surabaya's rivers still taking the industrial, domestic and few farming wastewater, a checking on quality of the produced water such as anorganic, organic and

pesticide parameters becomes important to be performed internally by each treatment plant to ensure the quality meets the health (about 60% citizens of Surabaya in total of 3 million, or 1.8 million in precise, still consuming the drinking water from 6 drinking water treatment plants).

4. The checking report of raw drinking water quality in Surabaya's rivers along with the result of 6 drinking water treatment plants checking are important to be shown in public at Surabaya City in accordance with the principles of openness information related to EIA process.

Conclusions

1. The projection of raw water quality parameters describes how the exceeding parameters, with a single filter, are 1.32%BOD, 0%COD, and 92.82%TSS and 0% of all parameters by using double filters. These findings show how the reviews of EIA documents of 6 drinking water treatment plants are important and immediately needed.
2. The debit value, however, still okay because Surabaya's rivers have the continuous safety-water quality by Gunungsari and Jagir Dam.
3. A routine check on drinking water from 6 treatment plants is immediately needed to ensure the produced parameters did not surpass the Ministry of Health regulation. To ensure the produced water meets the standard quality is important to keep the health aspect of 60% citizens of Surabaya.
4. A review on EIA documents with an environmental audit in every 5 years need to be focused on technological approach to ensure the produced water meets the standard quality set by Ministry of Health.

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