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Analysis of the Prasedimentation Buildings Performance on BOD and COD Levels at Siwalan Panji Sidoarjo Water Treatment Plant

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Abstract— *Afoer River in Buduran Sub-District of Sidoarjo City is one of the rivers as a source of raw water by Siwalan Panji Water Treatment Plant, this study aims to analyze the capabilities of alternative biofilters in the decline of BOD, and COD in prasedimentation buildings, analyzing the most economical and effective costs of the biofilters used. This research method is an experimental study of planned biofiltration alternatives such as River Rock, Crossflow, Bio-Ball with data testing using the Anova Two Way test. Observation data shows raw water does not meet class I standard of raw water quality, as a solution in improving the performance of Prasedimentation buildings, used River Rock, Crossflow, and Bio-Ball Biofilters. Statistic test results showed decreased organic substance efficiency in River Rock BOD biofilters 87.05%, COD 84.61%, Crossflow BOD biofilters 97.73%, COD 95.35%, and Bio-Ball BOD biofilters 97.64%, and COD 95.26%. The most economical and effective cost analysis result is crossflow biofilter with BOQ value of Rp 383,240,648,- and OP cost per month Rp. 16,545,490,-.*

Keywords— *Raw Water Quality, Prasedmentation, Biofilter.*

I. INTRODUCTION

Water is an essential compound for the life of all living things; its availability is abundant where 70% of the water covers the earth's surface, the amount can reach 1.368 million cubic kilometres [1], if the availability of water cannot be met it can be assured there will be no life [2]. The declining environmental condition has an impact on the reduced potential of groundwater, to meet water needs, a clean water supply system that uses rivers as a source of raw water [3]. Over time, many industrial activities, households, and human populations, impacting on the environmental conditions of the waters become polluted due to the lack of human awareness not to dump waste directly into the river without the absence of first storage, as a result of various diseases that interfere with health [4–6].

Siwalan Panji Water Treatment Plant which is an agency owned by Sidoarjo Drinking Water Regional Company (PDAM) which utilizes the Afoer River in Buduran sub-district as raw water, IPA Siwalan Panji is responsible for the treatment of raw water into clean water that is feasible for the consumption of Sidoarjo people. IPA Siwalan Panji can produce clean water 165 l/s. However, because the quality of raw water every year has a decrease in the effect on the performance of the pretreatment process in prasedimentation buildings.

Water or river is said to be polluted if the water cannot be used following standard water quality. Good river quality can be done through integrated water quality management [7]. The decrease in water quality of the Afoer river has an effect on the non-maximal performance of pre-existing buildings in the process of decommenting dissolved organic matter, based on early observations of 2020 the level of noise reached 35.60 NTU, BOD 19.5 mg/l, and COD 9.84 mg/l, from those parameters the condition still exceeds the standard stipulated in Government Regulation No. 82 of 2001 for standard water class I.

From this problem, researchers are working on alternative solutions to improve the performance of pre-existing buildings by using biofilters such as River Rock, Crossflow, and Bio-ball, expected from these alternative solutions the quality of raw water used following government regulation No. 82 of 2001 [8], which is based on the economic and effective cost aspect.

II. LITERATURE REVIEW

A. *Raw Water*

Raw water for household drinking water, starting now called raw water is water that can come from a surface water source, groundwater basin and or rainwater that meets specific quality standards as raw water for drinking water [9]. The source of raw water consists of several water sources, that is [10]:

1. Surface water: rivers, natural, and artificial lake water, seawater
2. Groundwater: shallow groundwater, deep groundwater, spring water
3. Sky water: Rainwater

B. *Raw Water Classification*

The quality and characteristics of raw water have been regulated in Government Regulation No. 82 years. 2001, Based on this Government Regulation, water quality is classified into four groups [11]:

1. Class I : Water is used as raw water for drinking water,
2. Class II: Water designated as infrastructure or facilities recreation, fresh fish cultivation, livestock, and water for watering plants,
3. Class III: Water is used for freshwater fish cultivation, animal husbandry, and water for watering crops

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4. Class IV: The water it uses is used for water that irrigates plants

C. *Wastewater Treatment According to its Characteristics* [12], namely:

1. Physical processing: Processing with the gravitational separation process
2. Chemical Processing: Processing by neutralization, precipitation, oxidation, reduction, and ion exchange
3. Biological processing: Processing by utilizing the activity of microorganisms

D. The Building of Raw Water Treatment

Pra sedimentation is one of the units in drinking water treatment buildings that are used as water treatment in the preliminary process. This building functions as a place for the deposition of discrete particles such as sand, clay, and other solid substances that can precipitate by gravity [13].

E. Biofilter Theory

A biofilter is a place for microorganisms to grow to carry out their biological functions. Biofilters are used to condition and maintain water quality in a closed or open circulation system [14]. Biofilters comparison based on biofilters surface area [15]:

1. River rock Biofilters Surface area: 100-200 (m2/m3)
2. crossflow biofilters Surface area: 150-240 (m2/m3)
3. Net Type Biofilters Surface area: 50 (m2/m3)
4. Biological Structure Rotation Biofilters Surface area: 80-150 (m2/m3)
5. Random Biofilters Packing Surface area: 200-200 (m2/m3) Factors Affecting The Efficiency Of Biofilters [16]: Hydraulic Retention Time, Temperature, COD concentration enters with COD allowance, surface areas, an efficiency ratio of BOD reduction to COD removal.

III. Research Methodology

This research is a qualitative descriptive study, conducted observationally-based on experimental studies. The goal is to determine alternative solutions for the treatment of improving the quality of raw water using alternative biofilters. This research process is located at Siwalan Panji Water Treatment Plant in Buduran District, Sidoarjo City. IPA Siwalan Panji can produce clean water of 165 l/s or 14,256,000 L/day, and operational IPA lasts for 24 hours.

The first stage of this study is the collection of data on the condition of raw water used. The data retrieved is primer and secondary data. The second stage is the statistical analysis of bod reduction capability efficiency, and COD in alternative biofilters, the third stage is the economical and effective cost analysis of alternative biofilters. So came the conclusion of biofilters that has an economical and effective cost in the reduction of bod and COD organic substances.

In the statistical test of data processing using SPSS 32, with the method used by the Anova Two Way test, the variables used include:

a. Free variables consist of BOD levels, and COD before processing
b. Bound variables consist of River Rock biofilter media, Crossflow, Bio-Ball, BOD content, and COD after processing
c. Control variables are hydrolysis stay time of 35 hours, 48 hours, 61 hours, 74 hours, and 87 hours.

IV. Results and Discussions

A. Raw Water Quality Conditions

TABLE I. Raw Water Quality Evaluation Results

Parameters	Unit	Standard	Evaluation value	Description
Raw Water Quality In:				
a. BOD	mg/l	2	19,5	Exceed
b. COD	mg/l	10	9,84	Threshold
c. Turbidity	NTU	5-25	30	Exceed

Source: observation data

Based on the observation results (Table I) some parameters exceed the standard of raw water quality class I Government Regulation No. 82 of 2001. To maximize raw water quality is used alternative biofilters such as River Rock, Crossflow, and Bio-Ball [15].

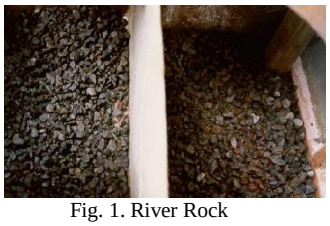

Fig. 1. River Rock

Fig. 2. Crossflow

Fig. 3. Bio-Ball biofilters

B. Performance Improvements using Alternative Biofilters

TABLE II. Bod Reduction Efficiency, and COD, on Alternative Biofilters against Hydrolysis Time

Biofilters	Parameters	Total Decrease Efficiency (%)				
		35 hours	48 hours	61 hours	74 hours	87 hours
River rock	BOD	75,19%	80,58%	84,84%	86,12%	87,06%
	COD	67,94%	72,11%	76,28%	80,44%	84,61%
Crossflow	BOD	84,94%	86,33%	88,11%	92.92%	97,73%
	COD	76,57%	81,26%	85,96%	90,65%	95,35%
Bio-ball	BOD	84,91%	86,31%	88,02%	92,83%	97,64%
	COD	76,49%	81,18%	85,88%	90,57%	95,26%

Source: Calculation Results

From the results of the study (Figure 4), that hydrolysis stay time (35 hours, 48 hours, 61 hours, 74 hours, and 87 hours) has an influence on the efficiency of bod reduction, and COD, on alternative biofilters used. The longer the contact time between raw water or liquid waste with media will affect the more significant the efficiency rate of the reduction of organic substances [17].

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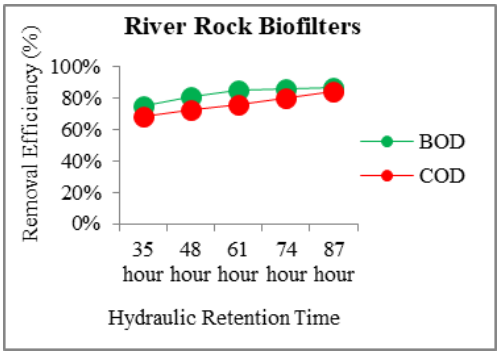
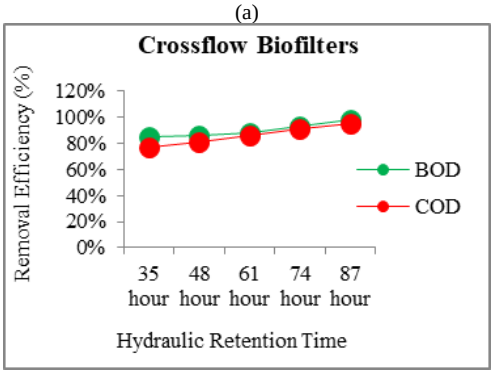
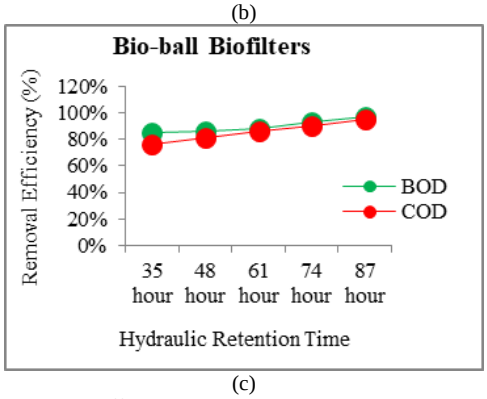


(a)



(b)



(c)

Fig. 4. (a),(b),(c) Efficiency graph (%) Decreased BOD, and COD on alternative biofilter media against hydrolysis time

C. *Improved Performance of Prasedimentation Building on The Effectiveness of Hydrolysis Time*

Removal Efficiency (%) BOD

Duncan[a,b]

Hydraulic Retention Time (hours)	N	Subset 1	2	3	4
35 hours	9	81.67978			
48 hours	9	84.07433	84.07433		
61 hours	9		86.98800	86.98800	
74 hours	9			90.62244	90.62244
87 hours	9				94.14089
Sig.		.198	.119	.054	.062

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 15.076.

a. Uses Harmonic Mean Sample Size = 9.000.

b. Alpha = .05.

(a)

Removal Efficiency (%) COD

Duncan[a,b]

Hydraulic Retention Time (hours)	N	Subset 1	2	3	4
35 hours	9	73.66744			
48 hours	9	78.18511	78.18511		
61 hours	9		82.70233	82.70233	
74 hours	9			87.21944	87.21944
87 hours	9				91.73689
Sig.		.070	.070	.070	.070

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 26.465.

a. Uses Harmonic Mean Sample Size = 9.000.

b. Alpha = .05.

(b)

Fig. 5 (a),(b) The Annova Two Way test output hydrolysis time capability at efficiency (%) decrease in BOD organic matter, and COD against alternative biofilters

Statistical test results (Figure 5) can be concluded that bod reduction efficiency, and COD affect the length of time of the hydrolysis process. The longer the hydrolysis process, the greater the decreased efficiency of organic matter [17].

D. *Prasedimentation Building Performance Improvement Solution with Best Biofilter*

Removal Efficiency (%) BOD

Duncan[a,b]

Biofilters	N	Subset 1	2
River Rock	3	87.055000	
Bio-ball	3		97.637667
Crossflow	3		97.730000
Sig.		1.000	.846

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = .311.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

(a)

Removal Efficiency (%) COD

Duncan[a,b]

Biofilters	N	Subset 1	2
River Rock	3	84.608000	
Bio-ball	3		95.256333
Crossflow	3		95.346333
Sig.		1.000	.928

Means for groups in homogeneous subsets are displayed.

Based on observed means.

The error term is Mean Square(Error) = 1.357.

a. Uses Harmonic Mean Sample Size = 3.000.

b. Alpha = .05.

(b)

Fig. 6. The Annova Two Way test output determines the best biofilter media at 87 hours hydrolysis time on efficiency (%) decrease in BOD organic matter, and COD

In statistical testing (Figure 6) with the Annova Two Way test, that the surface area of the biofilter has an influence on the amount of efficiency (%) decrease in organic matter. It can be inferred from the results of these tests crossflow media is the best and effective in the reduction of organic substances.

E. Cost Analysis

TABLE III. Bill of Quantity Biofilter River Rock

Cost Type	Amount	Unit	Unit Cost (Rp)	Cost (Rp)
Media Installation	1	set	15,896,345	15,896,345
Pipe Installation	1	set	132,715,290	132,715,290
Root Blower Foundation	9	m3	22,797,778	22,797,778
			Sub Amount	171,409,413
Finishing				
Pipe Painting	108	m	8,500	918,000
Installation of Root Blower Diffuser and Ecorator	1	set	210,004,790	210,004,790
Sub Amount				210,922,790
Total				382,332,203

Source: Calculation Results

TABLE IV. Bill of Quantity Biofilter Crossflow

Cost Type	Amount	Unit	Unit Cost (Rp)	Cost (Rp)
Media Installation	1	set	16,804,790	16,804,790
Pipe Installation	1	set	132,715,290	132,715,290
Root Blower Foundation	9	m3	22,797,778	22,797,778
			Sub Amount	172,317,858
Finishing				
Pipe Painting	108	m	8,500	918,000
Installation of Root Blower Diffuser and Ecorator	1	set	210,004,790	210,004,790
Sub Amount				210,922,790
Total				383,240,648

Source: Calculation Results

TABLE V. Bill of Quantity Media Biofilter Bio-ball

Cost Type	Amount	Unit	Unit Cost (Rp)	Cost (Rp)
Media Installation	1	set	265,745,531	265,745,531
Pipe Installation	1	set	132,715,290	132,715,290
Root Blower Foundation	9	m3	22,797,778	22,797,778
			Sub Amount	421,258,598
Finishing				
Pipe Painting	108	m	8,500	918,000
Installation of Root Blower Diffuser and Ecorator	1	set	210,004,790	210,004,790
Sub Amount				210,922,790
Total				632,181,388

Source: Calculation Results

Based on a cost analysis comparison of the bill of quantity (Table III to V), crossflow media is the most economical and effective media. With a BOQ value of Rp. 383,240,648,-, then for OP costs (Table VI), Crossflow media has an operational cost and more economical maintenance of Rp. 16,545,490,-/month.

TABLE VI. Operational and Maintenance Costs on Each Biofilter

Description	Biofilter Alternatives		
	River Rock (Rp)	*Crossflow* (Rp)	Bio-Ball (Rp)
Treatment			
Flashing tub	1,500,000	1,500,000	1,500,000
Flashing Biofilters	6,000,000	2,400,000	6,000,000
Root Blower Repair	2,000,000	2,000,000	2,000,000
Pipe repair	1,000,000	1,000,000	1,000,000
Biofilter damage replacement	500,000	250,000	150,000
Diffuser repair/replacement	12,000,000	12,000,000	12,000,000
Amount	23,000,000	19,150,000	22,650,000
Operational			
Power	178,982,784	178,982,784	178,982,784
Fuel pump	413,100	413,100	413,100
Amount	179,395,884	179,395,884	179,395,884
Total Cost per Year	202,395,884	198,545,884	202,045,884
Total Cost per Month	16,866,324	16,545,490	16,837,157

Source: Calculation Results

V. CONCLUSION AND SUGGESTIONS

A. Conclusion

Based on the observation of raw water quality used is not classified as class I raw water following with Government Regulation No. 82 of 2001, seen from parameters such as water noise reaching 35.60 NTU, BOD 19.5 mg/l, and COD 9.84 mg/l. From raw water quality results that do not meet government standards, solutions are done using alternative biofilters such as River Rock, Crossflow, and Bio-Ball. The level of alternative biofilter capability in bod reduction and COD in prasedimentation buildings is very influential in the length of stay in the hydrolysis process, the success of organic substance reduction occurred during the 87-hour hydrolysis time wherein river rock biofilters can decrease bod levels 87.05%, COD 84.61%, Crossflow BOD 97.73%, COD 95.35%, Bio-Ball BOD 97.64%, and COD 95.26%. In terms of the cost of using alternative biofilters that have an economical cost, the level is the Crossflow biofilter, with a BOQ value of Rp. 383,240,648,- and cost and maintenance of Rp. 16,545,490,-/month.

B. Suggestions

The advice that researchers can give is to follow:

1. Biofilter bio-ball has almost the same organic substance reduction capability as Biofilter Crossflow, but biofilter selections need to be considered from aspects of deficiency and excess in their use and placement.
2. For further research, it is necessary to research on the reduction of bod organic matter, and COD, on advanced processing systems.

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