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Effect of Types and Depths of Media Filter to Reducing Turbidity Concentration

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Abstract

Rapid sand filter is used to decrease the turbidity consentration. This research purpose is find the comparation of variation media to reduced turbidity from Wonokromo River. Silica and zeolite are used to be the media of rapid sand filter with effective sizes of 0,20 mm and 1,40 mm. Variation that used in this research are rapid sand filter single media and dual media with depth of 60 and 80 cm in each variation. Rapid sand filter dual media uses silica and zeolite with the comparison of 50 : 50. The result showed that every variation has more than 50% removal of turbidity. Rapid sand filter single media with 60 cm of depth reach 84,35% of turbidity removal and with 80 cm of depth reach 92,22% of turbidity removal. Rapid sand filter dual media (silica and zeolite) with 60 cm of depth reach 73,48% and with 80 cm of depth reach 87,77%. Result showed that rapid sand filter single media with 80 cm of depth reach the highest removal in every variation. It's concluded that the media depth and sizes effect the effictivity of turbidity removal.

Keywords: *Sand Filter, Silica Sand, Zeolite Sand*

1. INTRODUCTION

Human life is depending on clean water existance. Clean water is a primary needs for human, started from daily consumption to economy growth (Reza & Singh, 2010). However, high population growth has an impact towards enviromental quality. Bad environmental quality happened because of population transmigration to big cities, industrialization, and bad waste treatment (C.Y.C. Chu & R. R. Yu, 2002). Bad environmental quality leads to bad water quality. One of the clean water sources is river. But, right now, there are a lot of rivers that are contaminated by chemical or waste. These thing make the river as the sources of clean water cannot be utilized (Mawaddati et al., 2021). One of method that can be used as water treatment is rapid sand filter. Rapid sand filter is water treatment that used sand as the media, and it can be varied to more than one media.

The research that been conducted by Sze et al. (2021), rapid sand filter can decrease turbidity to 77,3% and TSS to 91% with 90 cm of media variation depth. In other research that conducted by Maryani et al. (2014), rapid sand filter can decrease turbidity to 98,27% with 100 cm of media variation depth and decrease total coliform to 99% with 120 cm of media variation depth. Rapid sand filter is depending on media because commonly the media have different sizes, chemical structure, and form (Selintung & Syahrir, 2012). Rapid sand filter is commonly used as water treatment in Water Treatment Plant in Indonesia. Therefore, this research is conducted to compared between rapid sand filter single media and dual media in terms of effectivity.

2. MATERIAL AND METHODS

2.1 Rapid Sand Filter

This study used rapid sand filter as water treatment to show the effectiveness of rapid sand filter single media and dual media. The media filter that used in this study was silica sand and zeolite sand. The media is chosen because it is common in the water treatment, and it is inexpensive. The silica sand is screened to 20 – 40 mesh and the zeolite sand is a fine sand. Before starting the research, design calculations are conducted to calculate the flow of water that goes to rapid sand filter. Design calculations is shown in table 1.

Table 1. Design Calculations of Rapid Sand Filter

Descriptions	Calculation
Height	100 cm = 1 m
Diameter	10 cm = 0,1 m
Area	0,25 x π x d^2 = 0,25 x 3,14 x $0,1^2$ = 0,007 m^2
Silica Depth	*Single* Media: 0,6 and 0,8 m *Dual* Media: 0,3 and 0,4 m
Zeolite Depth	*Dual* Media: 0,3 and 0,4 m
Gravel Depth	0,1 m
Rate of Filtration	4 m/hour
Debit (Q)	a x V = 0,007 m^2 x 4 m/hour = 0,03 m^3/hour = 0,5 liter/minute
Rate of Filtration Check (V check)	Q/a = 0,03/0,007 = 4 m/hour
Numbers of Reactor (N)	12 x $Q^{0,5}$ = 12 x $0,0008^{0,5}$ = 0,5 unit ≈ 1 unit

Rapid sand filter is made by pipe with diameter of 10 cm and height of 100 cm equipped with ball valve and flowmeter to monitor water flow that has been planned. The reactor used a continous flow from ground basin to gravitation basin that pumped with submersible pump. If the water overflow from reactor, the overflow will goes to the ground basin. The filtration process is depicted in figure 1.

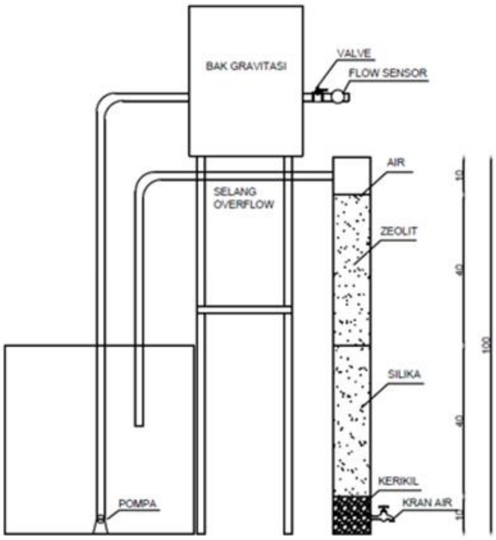

Figure 1. Rapid Sand Filter

2.3 *Pre – Treatment*

In this study, pre-treatment used with coagulation, floculation and sedimentation. Coagulation is used to destabilize the particle with rapid mixing added with coagulant so the spread to every spot on the basin. And after coagulation, floculation is used to form a bigger floc (Shammas & Wang, 2016). Then the sedimentation is used to sediment the floc to the lower side of the basin.

2.4 Turbidity Level in Sample

One of the physical parameters in water is turbidity. Turbidity is a measurement of impurity particle from clay, mud, and other organic and anorganic component in water (Letterman, 1999). The result of turbidity is written in Nephlometric Turbidity Unit or NTU (Metcalf & Eddy, 2014). The sample that used in this study were water from Wonokromo River. Turbidity level from raw water is shown in table 2 below.

Table 1. Turbidity Level from Raw Water

Parameter	Turbidity Level	Standard	Unit	Source
Turbidity	167	25	NTU	Ministry of Health Regulation Number 492/2010

3. RESULTS AND DISCUSSION

3.1. *Sieve Analysis*

Sieve analysis is use to determine effective size and uniformity coefficient (Selintung & Syahrir, 2012). Sieve analysis was carried out using mechanical sieve analyser and then the result showed in the graphic of media distrbution. Based on graphic, the d10 is effective size of the media filter and d60/d10 is the uniformity coefficient of media filter. The result obtained and shown in the table 3.

Table 3. Media Filter Properties

Media	Uniformity Coefficient	Effective Size (mm)	Porosity	Sr
Zeolite	1,00	1,40	51,5%	14,04%
Silica	1,60	0,20	31,7%	0,75%

3.2. *Jar – Test*

In this study, jar – test conducted to determine the right dose for coagulation and floculation. The coagulant used in the study was Poly Alumunium Chloride or PAC. The coagulant was chosen because it is common and inexpensive. Jar – test process is devided into 3 phases. First phase was rapid mixing (150 rpm) added with PAC for 1 minute. Second phase was slow mixing (30 rpm) for 10 minutes and then ended with sedimentation process for 30 minutes.

3.3 Effect of Types and Media Depth

Principles of rapid sand filter is to remove solid or liquid substance through media so the impurity particle will trapped in the media (Syahputra et al., 2022). Based on Schmitt and Shinault in (Sembiring et al., 2021), the basic principles of rapid sand filter is to trapped the suspension particles that have a bigger form into the media when passing through the media or it called as mechanical straining and the other principle is because of Van der Waals forces. The Van der Waals forces means that the smaller particles are attached to the surface of sand grains. Coagulant can help the process because it increase the adhesion force.

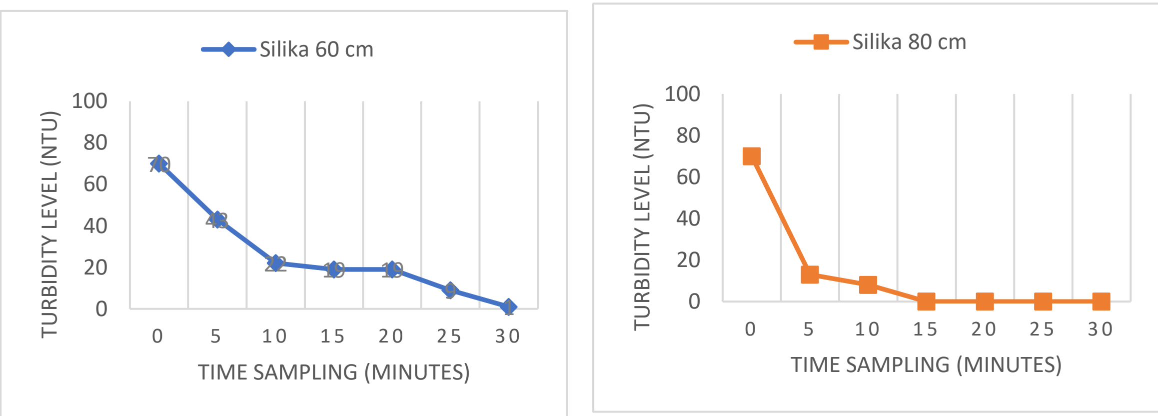

Figure 2. Relation Between Time Sampling and Turbidity Level in Single Media Variation

Graphic above showed the relation between time sampling and turbidity level in single media variation. Variation of depth in graphic is 60 and 80 cm. It is shown in these two graphics, turbidity level decrease slowly from time to time. In depth of 60 cm, shows that in 0^{th} minute turbidity level is 70 NTU, in 5^{th} minute it's 43 NTU, in 10^{th} minute it's 22 NTU, in 15^{th} minutes it's 19 NTU, in 20^{th} minute it's 19 NTU, in 25^{th} minute it's 9 NTU and in 30^{th} minute it's 1 NTU. Meanwhile variation of 80 cm depth, in 0^{th} minute turbidity level is 70 NTU, in 5^{th} minute it's 13 NTU, in 10^{th} minute it's 8 NTU, in 15^{th} minute it's 0 NTU, in 20^{th} minute it's 0 NTU, in 25^{th} minute it's 1 NTU and in 30^{th} minute it's 0 NTU.

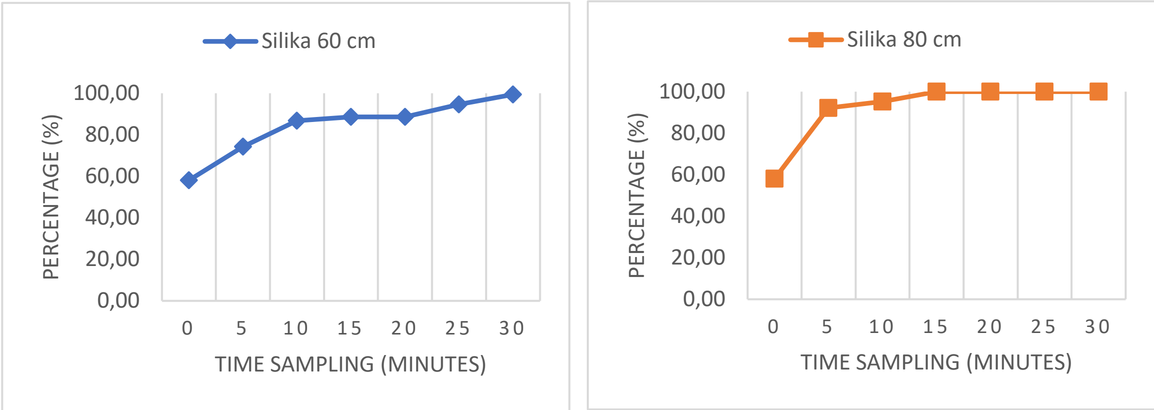

Figure 3. Relation Between Time Sampling and Removal Percentage in Single Media Variation

Graphic above showed the relation between time sampling and removal percentage of turibidity in single media variation. Variation depth in the graphics are 60 and 80 cm. In depth of 60 cm, shows that in 0th minute the percentage reach 58,08%, in 5th minute reach 74,25%, in 10th minute reach 86,83%, in 15th minute reach 88,62%, in 20th minute reach 88,62%, in 25th minute reach 94,61% and in 30th minute reach 99,40%. Meanwhile in depth of 80 cm, in 0th minute reach 58,08%, in 5th minute reach 92,22%, in 10th minute reach 95,21%, and from minute 15th to 30th the turbidity level is already reach 100%. Based on the graphic, the best variation for removal of turbidity is variation of 80 cm depth with a average percentage of 92,22% compared to 60 cm variation with average percentage of 84,35%. According to Duran-Ros et al. (2009), depth of media filter is effecting rapid sand filter to decrease turbidity level. It is because the deeper the media filter it will has a empty spaces for impurity particles to trapped between of it so it can increase the percentage of turbidity removal. Study that been conducted by Sze et al. (2021) and Pamularsih et al. (2013) showed that the depth of filter media is effecting the effectivity of turbidity.

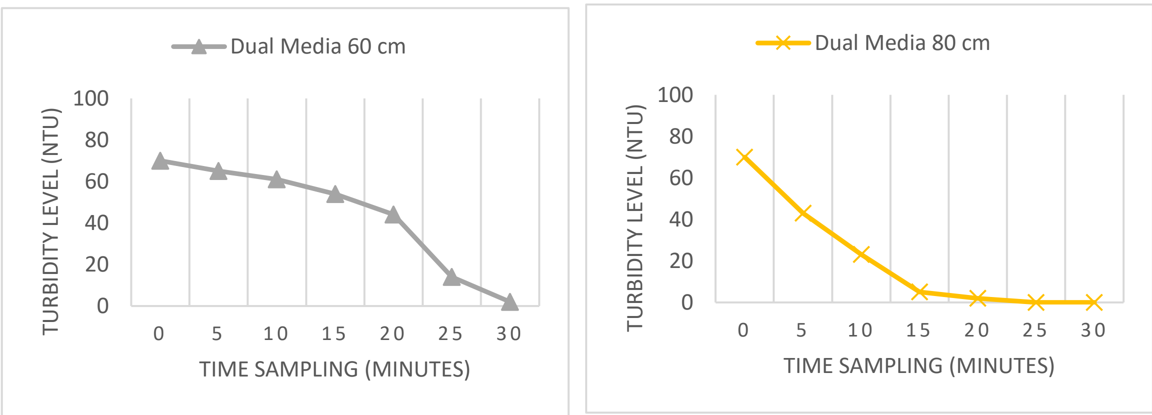

Figure 4. Relation Between Time Sampling and Turbidity Level in Dual Media Variation

Graphic above showed the relation between time samplinig and turbidity level in dual media variation. Based on graphic, turbidity level is slowly decreasing from time to time. In variation of 60 cm, the result showed that in 0th minute the turbidity level is 70 NTU, in 5th minute it's 65 NTU, in 10th minute it's 61 NTU, in 15th minute it's 54 NTU, in 20th minute it's 44 NTU, in 25th minute it's 14 NTU and in 30th minute it's 2 NTU.

Meanwhile in variaton of 80 cm, the result showed that in 0th minute the turbidity level is 70 NTU, in 5th minute it's 43 NTU, in 10th minute it's 23 NTU, in 15th minute it's 5 NTU, in 20th minute it's 2 NTU and from 25th to 30th minute the turbidity level is already reach 0 NTU. In this study, rapid sand filter dual media used silica and zeolite sand with comparison of 50:50 in each sand.

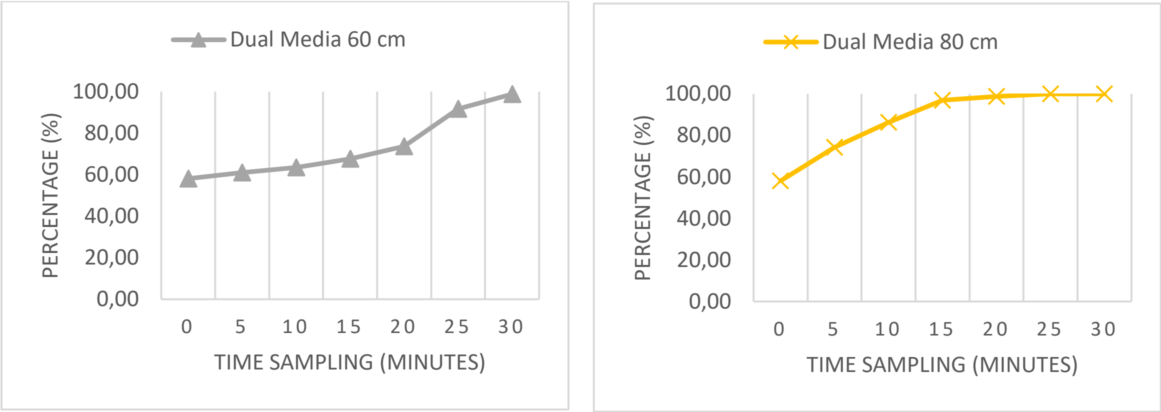

Figure 3. Relation Between Time Sampling and Removal Percentage in Dual Media Variation

Graphic above showed the relation between time sampling and removal percentage in dual media variation. Graphic showed that percentage increasing from time to time. Based on graphic, rapid sand filter dual media with depth of 60 cm showed that in 0th minute the turbidity removal percentage reach 58,08%, in 5th minute reach 61,08%, in 10th minute reach 63,47%, in 15th minute reach 67,66%, in 20th minute reach 73,65%, in 25th minute reach 91,62%, in 30th minute reach 98,80%. Meanwhile with depth of 80 cm showed that in 0th minute reach 58,08%, in 5th minute reach 74,25%, in 10th minute reach 86,23%, in 15th minute reach 97,01%, in 20th minute reach 98,80%, and from 25th to 30th minute the percentage of turbidity removal is already reach 100%. Based on the graphic shown, effectivity of turbidity removal in 80 depths has a higher removal percentage then 60 cm where the 80 cm variation reach average percentage to 87,77% and the 60 cm variation only reach average percentage to 73,48%.

Table 4. Effect of Media Filter Depth Towards Turbidity Removal Percentage in Single and Dual Media Variation

Types	Depth	% Removal of Turbidity
Single Media	60 cm	84,35%
	80 cm	92,22%
Dual Media	60 cm	73,48%
	80 cm	87,77%

Sizes of filter media is affecting removal efficiency. Efficiency will get higher if the filter media is smaller. This happen because smaller media filter increasing total area surfaces in filter media (Wegelin, 1996). Effective sizes of silica and zeolite sand are 0,20 mm and 1,40 mm. Because of the filter media effective sizes, the percentage of turbidity removal is affected. Based on the table above, rapid sand filter single media with depth of 80 cm has a highest turbidity removal percentage. There are two reasons, first one because silica has a smaller size with only 0,20 mm and second because the depth is deeper than 60 cm variation where there is 20 cm diffential. Based on research conducted by Nurmalia et al. (2019), smaller sizes give better percentage of turbidity removal. Besides of filter media size, depth of filter media also affected the percentage of turbidity removal where the deeper filter media the better percentage of turbidity removal (Duran-Ros et al., 2009). Based on research conducted by Pamularsih et al. (2013) it is shown that 60 cm of media depth have a percentage of 36% and the 100 cm of media depth have a percentage of 81%.

4. CONCLUSION

Rapid sand filter single media with depth of 80 cm has a highest average percentage of 92,22% and followed by rapid sand filter dual media with depth of 80 cm where the percentage of 87,77%. Based on these results, it showed that filter media depth is affected the removal of turbidity. It can be concluded that, rapid sand filter both single and dual media can reduce the turbidity up to 50%. In the next research, it can analyze other size and types of filter media with another sample.

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