Sand screen width variation on water treatment (Case study of Wisolo river)

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Abstract. The safe and clean water is necessary to the most of rural community. Slow sand system was proven to be sustainable and reliable drinking water treatment. The majority of Sambo community using river as a source their daily activity. The water of the river containing a very high degree of contamination. The purpose of this study is to determine the model of Wisolo River Water treatment in order to obtain Clean Water in Sambo Village and then checked whether the physical content of the river water meets the water quality standard. From the results of the study using 3 (three) models of Wisolo River water filter processing layer variations, which are most ideal to use and meet the physical quality standards of clean water based on the Regulation of the Minister of Health of the Republic of Indonesia, the layer variations in model I, namely with successive material composition from bottom to top: gravel = 20 cm, palm fiber = 20 cm, and sand = 50 cm.

1 Introduction

Water is necessary for many purposes ranging from domestic uses, industrial water supply, and irrigation. The slow sand filter was proven to be sustainable and reliable drinking water treatment alternative for a small community like Sambo community, which can be beneficial for addressing the small systems challenges. River contamination threatens its sustainable use as the most significant reservoir of clean water. Slow sand filtration has been an effective water treatment process. In many regions in Indonesia especially Central of Sulawesi, most water supply source is water river especially in rural areas where the cost of treated water is unaffordable to low-income residents.

Filtration is the process of passing water through the material to remove particulate and other impurities, including floc, from the water being treated. These impurities consist of suspended particles (fine silts and clays), biological matter (bacteria, plankton, spores, cysts or other matter), and floc. The material used in filters for public water supply is usually a bed of sand, coal, or other granular substance. Filtration processes can generally be classified as being either slow or rapid [1].

Slow sand filtration is a technology that has been used for portable water filtration for hundreds of years. It is a process well-suited for small, rural communities since it does not require a high degree of operator skill or attention. As its name implies, slow sand filtration

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is used to filter water at prolonged rates. The typical filtration rate is at least fifty times slower than for rapid rate filtration. Due to this slow rate of filtration, a large land area is required for the filtration basins. Small communities that have plenty of available lands are often good candidates for slow sand filtration. Slow sand is a relatively simple filtration process. No chemical addition is required for proper filtration operation [2].

Many researchers have been interested in investigating the slow sand filtration. Febrina and Amdani [3] using water treatment with slow sand. The sand grain mesh 70 with the thickness 70 cm. This treatment process could reduce the turbidity and increasing pH water quality. Another researcher Makhmuddah and Notodarmojo [4] investigate the Cikapundung River. In this research, double stage slow sand filtration was operated in unsaturated flow condition. The objective of this research is to determine the performance of double stage slow sand filter during unsaturated flow condition in reducing iron, manganese, turbidity, and color that contained in Cikapundung river water.

Teena and Kani [5] evaluate the use of local sand for slow filtration and its eventual use in local water districts for water treatment is an essential contribution to water demand of the local population. Thus, this research investigates the efficiency of the slow sand filter in purifying well water using Achenkovil River sand as the filter medium. Turbidity and pH tests were done on a water sample before and after the filtration process to determine the percent efficiency of the slow sand filter to reduce turbidity and pH.

Daida et al. [6] investigate of experimental work is to identify the design parameters that affect the SF performance and impurity removal capabilities. Three different set up of the SF were installed. Each set up has three experiment units were installed. Since the other parameters have not that much significant effect on the efficiency of the SF, three parameters of great importance are selected. The three parameters are standing water height, filtration sand depth, and media sand effective size (ES).

Sand filter capping is the process in which the top portion of a rapid sand filter is replaced with anthracite coal to achieve the improved performance typical to sand/anthracite filter. If an increase in capacity is desired, a more massive amount of sand is replaced as such practice will increase filter run as well as it will increase the number of fines. This research aims to study this technology and to reveal some of the merits that can be gained if introduced in water treatment plants [7].

Meanwhile, Fadaei [8] investigate the third stage of water treatment after reservoir storage and rapid filtration, before disinfection. Slow sand filters can also provide a single-stage treatment for fresh waters within certain water quality limits of turbidity and algal content. Simplicity and low capital and operating costs are other principal advantages of SSF compared with more complicated methods of water treatment. SSF is utilized under several conditions and scales ranging from household level to the large scale at a potable water production plant. The purpose of this investigation is to compare the efficiency of physical and biological treatment of slow sand filter in Kakhkash.

Treatment of water for the rural community has been a very major problem culminating against the utilization of water for the domestic and drinking purpose for the entire rural community. The existing method used in the treatment of water for rural community seems very expensive and sometimes the chemical obtained directly from the stream is very harmful and deadly to the community. The water treatment process used in the supply of water to urban area seems very cumbersome and cannot be used in the small community. Then, the need arises to construct a slow sand filtration unit that is very efficient and cost-effective for a rural area. Ankidawa and Tope [9] research to constructing a slow sand filter with a filter aid filtration unit for rural water treatment using locally available materials.

Another researcher, Abdulkareem [4] studying the design of a filtration system of treatment plant consists of many processes, which can generally be subdivided into pre-treatment, and treatment. Some of these include screening, coagulation, flocculation,

characteristic. Besides, the bottle is easy to wash from the latest sample, easy to remove to another tank without no suspension residue, and also safety.

Experimental materials used are sand, gravel, and raw fiber. Sand is used not only to reduce silt and clay contamination but also filtering the solid material such as wood, leaves, and garbage. The sand grain diameter depends on pollutant material that filtered. For the dirty water, the fine sand with the diameter 0.2-1.5 mm is used. Gravel is a non-cohesion soil that forms the single structure with the grain diameter 5-150 mm. Gravel used to lift the sand, so the filtered water free flowing. The primary function of the gravel is to reduce the odor and color of the dirty water. Raw is natural fiber that produced by a coconut tree. The primary function of raw is to absorb water sediment that causes turbidity color of water. Other materials using are PVC pipe with a diameter of 6 inches, pipe glue, valve, mineral bottle 600 ml.

Water treatment method including 1) Experimental filtering. There is one of filtering experimental pipe prepared. The height of the pipe is 100 cm with the different width of sand. The sand grain diameter is uniform that is 0.2 mm; 2) Cloudy water storage. Cloudy water storage consists of four tanks with a capacity of 5 liters. The diameter of the water tank as the same as the capacity. Mesh of wire prepared to sieve grain sand; 3) Filter material consists of a) Sand with the grain diameter 0.2 mm is washing with the clean water until no residual material or garbage and then bask in the sun until precisely dry out, b) Gravel and rock determined from the less of sand material. Washing out until totally clean and dry out on basking in the sun, and c) The raw material was washing out until clean and dry out.

The water treatment method are as follows. Fill in the filtering tank storage with the three filter media: a) gravel on the bottom of tank, b) raw material is layering in the second layer after gravel, c) top of the layer is sand. Then, the contamination water river flowing from the top layer through the second and the bottom layer. The filtered water outing of the tank than pick up the basket and starting on the stop watch. The stop watch using to time counter the velocity of flowing water until fulling of the basket. Turn off the stop watch when the time filtering running until one hour as the same time the discharge recorded and noted. The running process doing the same step for another width of filtering material.

2.3 Research variables

There are two different type of variables involved in this research. The first, independent variables are variables that can affect bounding variables. In this study, the independent variable is the thickness of the filter media layer. Second, the dependent variable is the variable that is affected or the variable that results, in this case, is the physical quality of water.

3 Results and discussion

From the results of the physical quality examination of the water of Wisolo River, Sambo Village, District of South Dolo, the ideal material composition for obtaining clean water is sand, raw fiber, and gravel with a variety of different filter thickness models. Three variation models are used for each of the three times repeated filtering as follows. Model 1 consists of sand with thickness of 50 cm, raw fiber thickness of 20 cm, and gravel thickness of 20 cm. Model 2 consists of sand with thickness of 45 cm, raw fiber thickness of 20 cm, and gravel thickness of 20 cm. The last model is model 3 that consists of sand with thickness with 25 cm, raw fiber thickness of 20 cm, and gravel thickness of 20 cm. Table 1 shows the water condition with various thickness of layer. From the data tabulation above

than drew into the graphical below. The Fig. 2 shows that the correlation and comparison the water condition before and after the filtration treatment process.

Table 1. Water condition after filtering for model-1 filter sand.

Time (min)	Thickness 50 cm			
	Q (cm ³ /s)	T (°C)	V (m/s)	Turbidity (NTU)
60	14.472	28.700	2.041	9.900
120	28.389	27.000	1.963	9.010
180	40.829	27.500	1.755	5.450

Table 2. Water condition after filtering for model-2 filter sand.

Time (min)	Thickness 45 cm			
	Q (cm ³ /s)	T (°C)	V (m/s)	Turbidity (NTU)
60	14.618	27.900	2.062	16.780
120	28.813	28.000	2.002	12.500
180	41.340	28.900	1.767	10.800

Table 3. Water condition after filtering for model-3 filter sand.

Time (min)	Thickness 25 cm			
	Q (cm ³ /s)	T (°C)	V (m/s)	Turbidity (NTU)
60	14.992	27.300	2.114	18.820
120	29.450	27.900	2.039	16.450
180	43.474	28.000	1.978	12.400

Fig. 2 showed that the differences time with the turbidity of the three condition thickness of the layer. The trend line of the turbidity with the time is decreasing as long as the water flowing. It can be proven that as the longer time the water flowing filter that decreasing the turbidity and another material contamination of dirty water. The trend line suitable for the all experimental condition. Meanwhile, with the three states of the thickness filter layer showed that the 50 cm thick layer larger decreasing the turbidity of dirty water. It explains that thicker of the layer and longer time the water flowing the filtration process, the turbidity of water decreasing significantly.

Fig. 3 shows that the relationships between the velocity of water and time to flowing the filtration treatment process. Generally, the trend line of the figure shows that the velocity is decreasing along the time water flowing. It can be explained that as long as the time of water flowing the treatment process, the velocity of flowing through the filtration is slower. The differences between the three condition of layer thickness are not significant. It can be

proven that all state of thickness layer does not has a significant contribution to the velocity of water flowing in the filtration process.

Fig. 2. The correlation between turbidity and time.

Fig. 3. The correlation between time and velocity.

Fig. 4. The relationships between velocity and discharge.

The same condition occurred for Fig. 4 above. This figure showed that the trend line of the curve as the same as Fig. 3. It showed that the increasing discharge would be decreasing the water flow velocity through the filtration treatment process. There no significant differences between the three condition of thickness layer. It explained that the

thickness of the layer has no meaning contribution to water velocity of this treatment process.

Statistical analysis used is as follows. 1) Analysis of one-way variants of the thickness variations of the filtering model, 2) Statistical analysis of the mean sample variance. Statistical analysis was performed on temperature, discharge, and turbidity with the ANOVA analysis method. From the variations in the relationships calculated, there is only a significant relationship between thickness and turbidity variations as an example of ANOVA calculation for turbidity (NTU). The calculation is as follows.

$$S = \frac{1}{k-1} \sum (\bar{X}_i - \bar{X})^2 \bar{X} \tag{1}$$
$$= \frac{1}{3-1} [(8120-12.457)^2 + (13.360-12.457) + (15.890-12.457)^2]$$
$$= 20.705$$

$$nS^{2/x} = 3 \times 15.705 \tag{2}$$
$$= 62.115$$

$$S^2 = \frac{1}{n-1} \sum_i \sum_j (\bar{X}_{ij} - \bar{X}_j)^2 \tag{3}$$
$$= \frac{1}{3-1} \left[\frac{1}{3-1} (9900-8120)^2 + (9010-8120)^2 + (5450-8120)^2 + \right.$$
$$\left. (16.780-13.360)^2 + (12.500-13.360)^2 + (10.800-13.360)^2 + \right.$$
$$\left. (18.820-15.890)^2 + (16.450-15.890)^2 + (12.400-15.890)^2 \right]$$
$$= 0.333 \times 49.573 = 16.524$$

$$F_o = \frac{nS^{2/x}}{S^2} \tag{4}$$
$$= \frac{62.115}{16.524} = 3.759$$

Table 4. Data on the state of turbidity of the water after filtering the thickness variations of the filtering model.

Time (min)	Data			
	Model 1 (NTU)	Model 2 (NTU)	Model 3 (NTU)	Average
1	9900	16.780	18.820	8120
2	9010	12.500	16.450	13.360
3	5450	10.800	12.400	15.890
Average	8120 X ₁	13.360 X ₂	15.890 X ₃	12.457 X

From Table 4, by using the sample variance average statistical analysis, obtained $F_o = 3.759$ using the real level values (α) = 0.05, $V_1 = 2$, and $V_2 = 15$ from the distribution list F value $F(0.05)(2)(15) = 3.68$ because $F(0.05)(2)(15) = 3.68 < F_o = 3.759$ So H_o is rejected, which means having a meaningful relationship between thickness variance, filtering model and turbidity. Based on the results of the experiment and calculation of ANOVA analysis shows the relationship between the thickness of the sand media as a filter with the speed of the water produced after filtering.

The thicker the sand used in filtering the speed of the water will decrease. From the results of the experiment, it can also be seen that the longer the time used in filtering the discharge tends to decrease. From the results obtained in the study showed that the source of Wisolo river water in Sambo Village after filtering with 3 variations of filter thickness in the 1st model is more ideal to be used to produce water sources that comply with the physical quality standards of water based on regulations (Minister of Health Republic of Indonesia Number 492/Menkes/PER/IV/2010. In this study, it was found that turbidity parameters meet physical quality standards as clean water.

5 Conclusions

Based on the results, it can be concluded from the results of the study using 3 (three) models of Wisolo River water filter processing thickness variations, which are most ideal to use and meet the physical quality standards of clean water based on the Regulation of the Minister of Health of the Republic of Indonesia Number 492/Menkes/PER/IV/2010 are the thickness variations in model I, namely with successive material composition from bottom to top, gravel = 20 cm, palm fiber = 20 cm, and sand = 50 cm.

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