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# Implementing a Simple Technology to Turn Greywater into Clean Water – A Solution for Solving Water Crisis in Bontang, Indonesia

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***Abstract***— *The water crisis in urban areas is getting more critical and demands a solution. On the other hand, water needs for various anthropogenic activities are increasing over time. One solution that has double benefits is wastewater treatment, which can provide clean water for human activities and at the same time lower the case of environmental pollution due to wastewater discharge. This study develops a simple technique for turning greywater into clean water by filtrating the pollutants using sand and neutralizing the pH level using PAC (poly aluminum chloride) and soda ash (sodium chloride). Observations were performed on water quality parameters consisting of pH and turbidity (NTU). Furthermore, primary data were analyzed using the linear regression method and descriptive statistics. Based on the results, it is confirmed that the sand filter is effective in decreasing the turbidity of greywater -indicating that suspended solids are successfully removed. In addition, PAC and soda ash can neutralize the pH level. This simple and affordable greywater treatment plant can produce output that meets the standard of grade II raw water according to government regulations. Output water is clean and can be reused for daily needs; washing vehicles, watering plants, laundry, cleaning the exterior of the house, etcetera. Wide replication of this technology can solve the water crisis in urban areas, but it also suggests further development. Therefore, future studies are expected to develop the technology of greywater treatment that can produce grade I raw water.*

***Keywords***— *Water treatment, urban, greywater, filtration, regression.*

## I. INTRODUCTION

The water demand increases following the rapid development and human population, especially in urban areas. One of the main and biggest uses of clean water is for domestic/household needs. Currently, water resources are managed by the local water companies by utilizing groundwater sources. In urban areas, however, groundwater sources are limited, or if there are many, the quality of the water is below the standard due to high pollution. This situation is worsened by the high production of domestic wastewater; greywater and blackwater. Greywater production is high due to the inefficiency of water use, where clean water is only used for only one purpose and then discharged directly into the sewage. Necessarily, the water can still be used for other purposes without having to be disposed of directly. This inefficiency exacerbates the crisis in water needs.

Greywater is one of the largest wastes that enter water bodies, such as rivers. Greywater is liquid waste originating from kitchens, laundry, and bathrooms [1]. Around 60-85% of the total volume of clean water needs will become domestic wastewater [2]. The share of greywater itself is about 75% of the total volume of domestic waste. This shows that the utilization of greywater has high potential [3]. In almost all regions in Indonesia, greywater enters river bodies without prior treatment, causing water contamination [4]. Greywater which is generally discharged directly into the drainage canal generally contains elements of nitrogen, phosphate, and potassium. These elements are nutrients for plants, so if greywater is simply dumped into water bodies, it can cause eutrophication [2]. Wastewater treatment is an obligatory program that must be executed as it is crucial for environmental sustainability and broadly affects many aspects [5].

Water pollution due to greywater contamination can be overcome by treating wastewater before disposal. However, recent research trends show that in addition to processing greywater for disposal, greywater can be reused as a source of clean water. In other words, greywater treatment must reach a point where the output meets clean water quality standards. So far, reuse has been limited to flush toilets, crop irrigation, and washing vehicles. However, the reuse of greywater can help reduce the use of available clean water sources. To improve the quality of treated water, as well as to support the adequacy of water raw materials, greywater can be mixed with rainwater. Arifin [6] explains that rainwater is a source of clean water that can be used as an alternative to meeting daily water needs.

Currently, the fulfillment of clean water in Bontang City is fulfilled by the local drinking water company; Perumdam Tirta Bontang City Park. The need for clean water in Bontang City is 632.10 liters/second, which is to meet the needs of a population of 185,251 people [7]. The raw water source utilized by the local drinking water company is a deep well, where the quality of the water decreases over time. The amount of water currently produced is 414.38 liters/second from 22 well units, so the total deficit of water demand is 217.72 liters/second. For this reason, an alternative source is needed to meet the need for clean water in Bontang City. Meanwhile, this condition is exacerbated by the limited reach of waterways. The high cost of transportation to the islands has resulted in around 500 households (KK) in four villages located in the Bontang waters archipelago which has become a challenge in itself and has contributed to difficulties in accessing clean water. There are at least four villages; Melahing, Tihi-tihi, Busung, and Selangan -with an average population of 140-150 households – that still do not receive clean water from the local drinking water company. So far, people in these villages buy water from PDAM customers in coastal areas for IDR 4,000 to IDR 5,000 per cubic meter. The



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price is certainly more expensive if added to the cost of transportation.

This research proposes a solution to overcome the shortage of clean water in Bontang City through the reuse of greywater. Briefly, the simple technology applied is filtration using sand media. Besides being simple, this technology is also inexpensive and does not require a complicated design, so it can be imitated by the local community to meet their household's clean water needs. Of course, this idea can not only be applied in Bontang City, but also in other areas that have limited clean water resources. Observations were made based on the parameters of pH and turbidity (NTU).

## II. Methods

This study implements quantitative methods with an experimental approach. Greywater was obtained from the channel of Gunung Elai Village, North Bontang District. Observations are based on pH and turbidity (NTU) parameters, namely based on the national standard for class II water issued by the Government Regulation of The Republic of Indonesia No. 82 of 2001 [8]. The required pH level is 6-9, while the maximum turbidity level is 5 NTU. The wastewater treatment design is explained in Figure 1. First of all, the greywater is treated with chemicals in the form of PAC (Poly Aluminum Chloride) and soda ash (Sodium Chloride) to help neutralize pH levels. Variations in the provision of PAC and soda ash (grams) trials were carried out to obtain the best pH levels; 10 grams, 20 grams, 30 grams, and 40 grams. Meanwhile, filtration with sand media is also applied with variations in thickness, namely 0 cm (without sand filtration), 10 cm, and 20 cm. The pH level was measured with a pH meter, while the turbidity level was measured with a nephelometer. Water quality data from the treatment combinations were then analyzed using descriptive and linear regression methods to determine the best results, which meet the criteria for class II raw water.

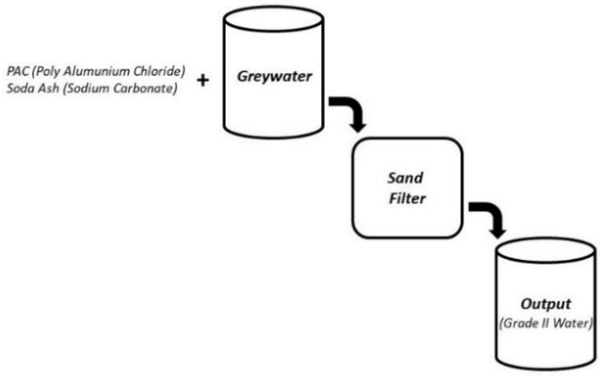


Fig. 1. The concept of the greywater treatment process

## III. Results and Discussion

### A. *Descriptive Analysis*

In this paper, the water quality parameters discussed are pH and turbidity (NTU). Descriptive analysis was carried out to find out the description of water quality improvement based on these two parameters. Before processing, the pH and turbidity levels of greywater were first measured, where the initial levels of each parameter were 5.2 and 12.8 NTU. pH is an important parameter in water quality analysis because it is closely related to biological and chemical processes [9]. pH states the intensity or concentration of hydrogen ion concentration in water, which in principle can control the balance of the proportion of carbon dioxide, carbonate, and bicarbonate content [10]. Meanwhile, turbidity represents the transparency of water, where the level decreases as the suspended matter content increases [11].

According to Government Regulation Number 82 of 2001, the recommended pH level for class II water is 6-9, while the standard for turbidity level is 5 NTU. The results of measuring pH and turbidity levels throughout the experimental process are presented in Table 1. Furthermore, the dynamics of water quality based on pH and turbidity parameters in each relevant treatment are explained visually in Figure 1 and Figure 2.

TABLE 1. pH and turbidity level of water on each treatment

| Greywater discharge (liter/minutes) | The thickness of the sand filter (cm) | pH neutralizing agent | pH | Turbidity (NTU) |
|---|---|---|---|---|
| 1 | 0 | PAC 10 grams + Soda ash 10 grams | 5.4 | 10.2 |
| | | PAC 20 grams + Soda ash 20 grams | 5.6 | 10.2 |
| | | PAC 30 grams + Soda ash 30 grams | 5.3 | 8.6 |
| | | PAC 30 grams + Soda ash 40 grams | 5.5 | 5.1 |
| 1.5 | 10 | PAC 10 grams + Soda ash 10 grams | 5.4 | 7.2 |
| | | PAC 20 grams + Soda ash 20 grams | 5.5 | 7.6 |
| | | PAC 30 grams + Soda ash 30 grams | 5.7 | 6.9 |
| | | PAC 30 grams + Soda ash 40 grams | 5.7 | 3.8 |
| 2 | 20 | PAC 10 grams + Soda ash 10 grams | 5.8 | 7.0 |
| | | PAC 20 grams + Soda ash 20 grams | 5.8 | 7.0 |
| | | PAC 30 grams + Soda ash 30 grams | 5.8 | 5.9 |
| | | PAC 30 grams + Soda ash 40 grams | 6.0 | 2.8 |

Based on the data presented in Table 1, it can be seen that the pH level tends to increase along with the increase in PAC and soda ash levels. This is in line with the theory that these two chemicals can neutralize pH which tends to be acidic [12, 13]. Visualization of an increase in pH levels -close to neutral- can be seen in Figure 1. The best pH levels are those that are included in the pH threshold range for class II water (6-9), which is found in the treatment of 20 cm sand thickness with 30 grams PAC and soda ash 40 grams. The best pH level is 6, and it meets the qualifications for class II water according to Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control. The thickness of the sand of 20 cm in the suspended solids filtration process is also more optimal in filtering out pollutants in the



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form of suspended solids, thereby contributing to an increase in pH levels.

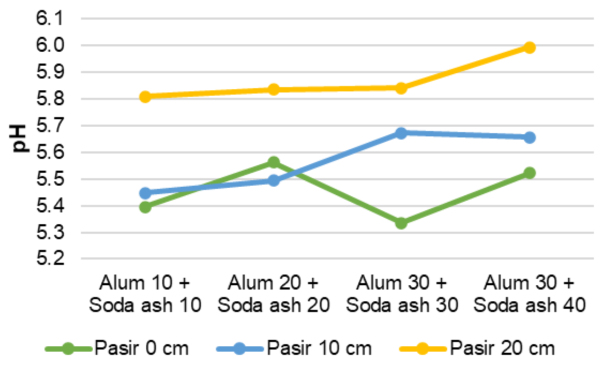


Fig. 2. pH level of water during treatment

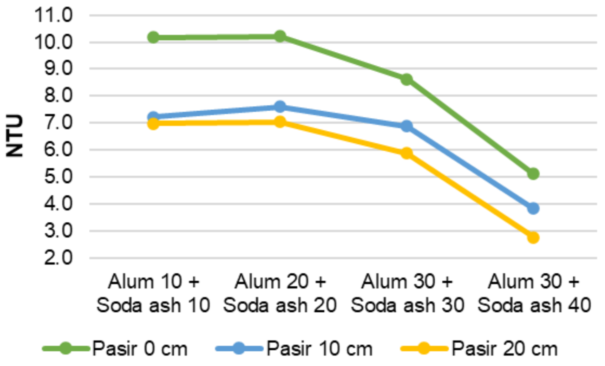


Fig. 3. Turbidity level of water during treatment

Regarding the turbidity parameter, Table 1 shows that the NTU value of greywater decreases throughout the processing process. The graph of decreasing turbidity level can be seen in Figure 2, where this condition is more related to the filtration process with sand media. In theory, sand has excellent potential to purify water [14, 15]. Suspended solids that have been lost in the filtering process will make the water clearer [16]. Based on the processing results, greywater has turned into class II water with a turbidity level of only 2.8 NTU. This value is below the turbidity threshold according to Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control, which requires a maximum level of 5 NTU.

*B. Regression analysis*

Regression analysis was performed to determine the significance of the treatment on water quality, which in this article is limited to the parameters pH and turbidity (NTU). The results of the analysis are declared significant if the significance value (p-value) is less than the significant level (α) of 0.05. Table 2 displays the results of the regression analysis of the pH parameter, while Table 3 displays the results of the regression analysis for the turbidity parameter data. Furthermore, the regression graph depicts the relationship between treatments; the application of PAC and soda ash, as well as variations in the thickness of the sand, on the quality of the treated water; pH, and turbidity.

TABLE 2. The results of regression analysis on pH parameter

| Variable | | Coef. | Sig. | Equation | $R^2$ |
|---|---|---|---|---|---|
| Constant | C | 5.316 | 0.000 | | |
| Sand thickness | X1 | 0.021 | 0.000 | Y = 5.316 + 0.021 X1 + 0.005 X2 + e | 55.9% |
| PAC + soda ash | X2 | 0.005 | 0.018 | | |
| pH | Y | | | | |

TABLE 3. The results of regression analysis on turbidity parameter

| Variable | | Coef. | Sig. | Equation | $R^2$ |
|---|---|---|---|---|---|
| Constant | C | 11.738 | 0.000 | | |
| Sand thickness | X1 | -0.144 | 0.000 | Y = 11.738 - 0.144 X1 - 0.138 X2 + e | 72.5% |
| PAC + soda ash | X2 | -0.138 | 0.000 | | |
| Turbidity | Y | | | | |

Table 3 demonstrates that the treatment applied has a significant effect on stabilizing pH levels, which is seen from a significance value that is smaller than or less than the significant level (α) of 0.05. In addition, it was seen that there was a linear relationship in a positive direction, where the addition of PAC and soda ash levels was able to increase the pH level which initially tended to be low (acid). This finding can be seen from the positive coefficient. The effect of giving PAC and soda ash, as well as the treatment of filtration with sand on pH levels, was 55.9%. Previous research conducted by Bacin and Nuzila [13] also reported that giving PAC and soda ash could improve water quality, namely stabilizing pH and reducing turbidity levels. Similar findings were also reported by Amri and Pasaribu [12] who had succeeded in clearing and stabilizing the pH of raw water for PDAM Tirtanadi Martubung Medan by providing PAC and soda ash. However, the water quality needs to be improved again by filtering treatment, which in this study was carried out with sand material.

Overall, table 4 explains the findings that the treatment of PAC and soda ash, as well as the treatment of variations in the thickness of the sand filter, proved to have a significant effect on reducing the turbidity of treated greywater (p-value < α 0.05). This is particularly related to the treatment of the sand filter. The thicker the sand filter layer that is applied, the more successful the turbidity level will be reduced. The thicker layer of sand in the filter box allows all suspended particles to be filtered out thoroughly. Statistically, this linear negative relationship can be seen from the negative coefficients. The treatment applied has a large effect of 72.5% on the decrease in water turbidity. In other words, filtration techniques are very effective in removing pollutant particles contained in greywater. This finding is in line with previous research conducted by Wulandari et al. [17] where sand material has great potential in filtering suspended pollutants contained in blackwater wastewater. He explained that sand not only has good pollutant filtering potential but is also easy to obtain at a relatively low cost. In addition, previous studies conducted by Coenraad et al. [14] and Artidarma et al. [15] are also in line with the results of this study, where sand is very effective in purifying water.

## IV. Conclusion

This study confirms that PAC and soda ash can neutralize the pH levels of greywater. In addition, the application of filtration techniques with sand material has also been shown to significantly reduce turbidity levels. Improving water quality based on these two parameters turns greywater into class II raw water. Based on the results of the experiment, the recommended use of PAC and soda ash is 30 grams and 40 grams, respectively. Furthermore, the recommended sand filter layer thickness is 20 cm. This study's best water treatment results had a pH level of 6 and a turbidity level of 2.8 NTU. This research can be further developed to reach a pH level of 7 and even lower levels of turbidity (class I water). Therefore, future researchers can apply a combination of various media filter techniques, with various thickness treatments. Observations can also be made on more complete water quality parameters to obtain measurement results that are representative of the actual output water quality.

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