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The Ability of Alum to Reduce Color in Sasirangan Home Industry Wastewater

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Abstract: Water is the main need of living things in the world. Water determines the sustainability of living things. Humans, animals, and plants depend on water for their survival. Therefore, water should always meet the standards that have been set. Wastewater from the home-based sasirangan industry has distinctive characteristics in the form of the color of wastewater that has not been managed properly. The purpose of this study was to determine the ability of alum to reduce the color of home-based sasirangan industry wastewater. The type of research is a true experiment, with the population being all home-based sasirangan industry wastewater in Atun Sasirangan Cempaka. The sample is part of the wastewater. The wastewater was put into 25 containers for 5 treatments of alum addition with concentrations of 40%, 80%, 160%, 240%, and 320%. Each treatment was repeated 5 times. The results showed that the average value of wastewater color after treatment ranged from 140.5 to 179.2 Pt-Co. The lowest average value was in the treatment of adding alum with a concentration of 160%. It is concluded that alum is able to reduce the color of home-based sasirangan industry wastewater. It is recommended that the handling of wastewater color problems in the sasirangan fabric home industry use alum as a coagulant in the treatment method.
Keywords: Alum; home Industry; sasirangan; wastewater.

INTRODUCTION

Water is the main need of living things in the world. Water determines the sustainability of living things. Humans, animals, and plants are highly dependent on water for their survival (Mawardi, 2014). The factors of quantity, quality, continuity, and affordability are important in providing water for daily life (Muslimin, 2022). If these factors are in good condition, it will be a good support, but otherwise, it can be a threat to the lives of living things.

In terms of quality, water used for daily human life must meet Environmental Health Quality Standards (Menkes, 2023). Water quality that does not meet the standards can be affected by the distance between the water source and the source of contamination (Budhiawan et al., 2022). The disposal of wastewater to the land surface can cause pollution of soil and surface water sources. The presence of wastewater can have an impact on groundwater sources (Widiyanto et al., 2015).

Humans can generate waste in their daily activities. Waste in liquid form is called wastewater. If wastewater is discharged into waters, it can result in increased levels of heavy metals (Ariyanto & Indrowuryatno, 2008), increased water temperature, and low salinity (Dzikrillah et al., 2022). Therefore, before being discharged into waters, wastewater must be treated first so that it meets predetermined standards.

In 2018, the textile industry in Indonesia grew faster than the food and beverage industry, chemical industry, automotive industry, and electronics industry (Pratiwi,

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2020). However, this creates a side problem. The textile industry is one of the producers of wastewater. In the textile industry, various coloring materials are used, some natural coloring materials and some chemical coloring materials. Coloring using chemicals is more common because it is easy, cheap, and fast to work with. Chemical dyeing also gives satisfactory results in the brightness of the textile color. Dyes in water can interfere with aesthetics and penetration into water bodies, thereby disrupting the photosynthesis process of aquatic plants (Agustina & Amir, 2012). Disposal of textile industry waste into the surrounding environment without special treatment first will pollute the ecosystem (Andriani, 2017; Paramnesi & Reza, 2020; Zammi et al., 2018).

In South Kalimantan, the textile processing industry that continues to grow in the community is the home-based sasirangan fabric industry. The development of this home-based sasirangan industry provides benefits for the community in the form of job opportunities. The home-based sasirangan fabric industry in South Kalimantan Province spreads to various regions. However, the distribution of the industry is most prevalent in Banjarmasin City, Banjarbaru City, and Banjar Regency (Noraida & Khair, 2024). As much as 80% of the industry uses synthetic or chemical dyes, including Na2SO4, SLS, caustic soda, indanthren dyes (specifically for hot dyeing), indigosol dyes (hot dyeing), naphthol dyes (specifically for cold dyeing), freeze/frosi dyes (cold dyeing). The sasirangan industry mostly uses indanthren dyes and naphthol dyes (Nasruddin et al., 2018). Wastewater generated by the industry is then discharged into the surrounding environment. Some are discharged into the waters, and some are discharged onto the ground surface. Therefore, prevention and countermeasures as an effort to prevent pollution control due to the sasirangan industry wastewater need to be carried out.

The most distinctive characteristic of sasirangan wastewater is the color parameter. There are two kinds of color in water, namely apparent color and true color. Apparent color is the color that arises due to various objects or suspended substances from organic matter, while true color is the color that arises due to non-organic substances. The color that occurs in sasirangan wastewater is in the true color category. Synthetic dyes in the textile processing process will produce liquid waste that is harmful to the environment (Handayani & Yuliasni, 2020). The color parameter value of the sasirangan wastewater has exceeded the predetermined standards. It is known that the color parameter value of sasirangan wastewater is 2704.5 Pt-Co (Noraida & Khair, 2024), which is much greater than the wastewater color standard of 200 Pt-Co (MenLHK, 2019).

Some studies related to reducing water color include research on reducing water color using chitosan derived from shrimp skin. Chitosan has free amino groups that can bind colloidal particles contained in wastewater to form flocs that can settle. The binding of these particles will reduce the values of pollutants contained in textile wastewater, so that the water can be discharged into public waters without polluting the environment (Prayudi & Susanto, 2000). There is also research on reducing water color using the coagulation-flocculation method, namely by adding coagulants or chemicals to a solution with the aim of conditioning suspensions, colloids, and suspended matter in preparation for the advanced process of flocculation. Flocculation is the process of collecting particles with unstable charges that then collide with each other to form a collection of particles with a larger size, also known as flocculant particles or flocs (Rusydi et al., 2017). Another study was conducted on peat water using alum. Peat water is characterized by its yellowish color. The use of alum can reduce the color of peat water (Trimaily et al., 2017).

Research on the use of alum coagulant to reduce the color value of liquid waste, especially waste from the home-made sasirangan cloth industry, is still limited. The purpose of the study was to determine the ability of alum to reduce the color of home-based sasirangan industry wastewater. Alum concentrations of about 4% are used to solve the color problem in water and reduce turbidity (Crittenden et al., 2012).

MATERIALS AND METHODS

This research is pure experimental research, which is research conducted by controlling all variables that are not studied. In this type of pure experimental research, samples for treatment and control are taken randomly. The population in this study was all wastewater from the home-based sasirangan cloth industry. The research sample was part of the wastewater taken from the coloring process unit of the home-based sasirangan fabric industry in Banjarbaru City, South Kalimantan Province. The tools used include pipettes, measuring cups, plastic containers, InScienPro ZE-200 Photometer. The materials used included distilled water and sasirangan wastewater samples. Preparation of the study was carried out by preparing 25 plastic containers and placing samples into each plastic container. In the implementation of the study, alum was used for 5 treatments with concentrations of 40%, 80%, 160%, 240%, and 320%. The concentration of alum in percent means that in 100 ml of solution, there are alum in grams. There were 5 replications of each treatment. Alum, as required, was added to the plastic containers randomly. Then stir quickly to dissolve the alum for 2 minutes. Stir gently to form a flog for about 5 minutes. Let stand for about 30-60 minutes for the flogs to settle to the bottom so that the top of the container is colorless water. The data obtained is displayed using a frequency distribution table and analyzed descriptively. Furthermore, anova test on SPSS Tools was used to compare whether there was a difference between the treatments given. The Ethics Commission of Politeknik Kesehatan Kemenkes Banjarmasin No.208/KEPK-PKB/2023 approved this study.

RESULTS AND DISCUSSION

Descriptive Analysis

Handling the wastewater problem of the Sasirangan fabric home industry is necessary. This will certainly have a good impact on the environment without having to eliminate the sasirangan home industry. The best design must be made while still benefiting the craftsmen in the home industry.

Table 1. Alum Concentration Variations and Color Values of Sasirangan Wastewater after Treatment

Alum (%)	Color (Pt-Co)				Effectiveness (%)
	Min	Max	Average	SD	
40	177.9	182.0	179.2	1.63	93.37
80	158.7	162.1	160.1	1.46	94.08
160	135.0	144.4	140.5	3.64	94.80
240	143.2	148.7	145.1	2.13	94.64
320	148.7	152.4	150.9	1.37	94.42

Understanding the industry processes can help create a wastewater treatment design. Furthermore, it conducts sampling and parameter checks according to applicable regulations. Currently, regulations related to Wastewater Quality Standards for Textile Industry Businesses and/or Activities are listed in the appendix of the

Minister of Environment and Forestry Regulation No.P.16/MenLHK/Setjen/Kum.1/4/2019. Table 1 shows the average color value of sasirangan wastewater before treatment, which is 2704.5 Pt-Co, and after treatment.

Table 1 shows the results of descriptive data processing of 25 data points consisting of 5 treatments and 5 replications. It is known that the average value of the color parameter for the addition of Alum to the wastewater sample is 179.2, 160.1, 140.5, 145.1, and 150.9 Pt-Co. The lowest average value of the color parameter is in the treatment of adding Alum with a concentration of 160%. If the color value of sasirangan wastewater with the addition of various concentration variations is compared with the initial color value of 2704.5 Pt-Co, the effectiveness of reducing the color value of water ranges from 93.37 to 94.8 percent.

When compared with the wastewater color standard listed in the Minister of Environment and Forestry Regulation No.P.16/MenLHK/Setjen/ Kum.1/4/2019, which is 200 Pt-Co, it can be said that all treatment groups adding Alum to each wastewater sample with concentrations of 40%, 80%, 160%, 240%, and 320% are below the predetermined standard. The color parameter value with a concentration of 160% alum has an average of 140.5, with the highest effectiveness value of 94.8. Table 1 shows that with the addition of Alum at concentrations of 40%, 80%, and 160%, the actual color of the water has begun to decrease. However, with the addition of concentrations of 240% and 320% of Alum, the value of the water color parameter began to increase again. The image of wastewater samples before and after treatment can be seen in Figure 1.

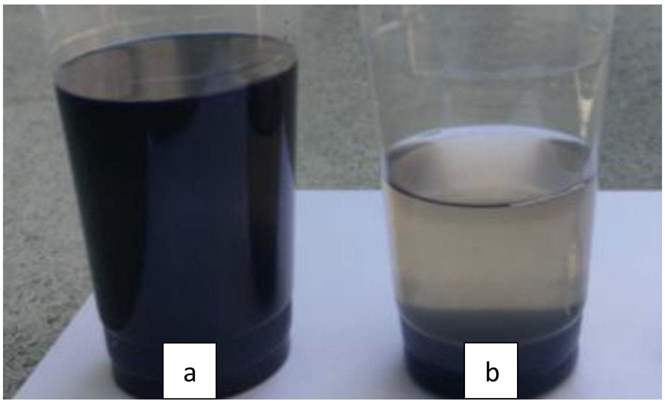

Figure 1. Sasirangan wastewater samples before and after treatment.
a) Before treatment, b) After treatment, adding alum with concentration of 160%

Comparison Test

To determine whether there is a difference in the average values of the 5 treatments that have been examined, the appropriate comparison test is carried out. The results of the comparison test using the one-way ANOVA test can be seen in Table 2. Table 2 shows the results of adding alum to home-made sasirangan wastewater, where the color of the wastewater is in the range of 0.156 to 0.768. This value is greater than the alpha value set at 0.05, indicating that the data from all treatments have a normal distribution. This normality test is important because the requirement for performing parametric statistical tests, such as one-way ANOVA, is that the data follow a normal distribution. The normality test indicates that the data from all treatments follow the expected distribution, meaning that the variation within the data is within reasonable bounds and can be further analyzed using more advanced statistical methods.

Table 2. Results of One-way ANOVA Test

Alum (%)	Normality*	Homogenity	ANOVA p value**
40	0.640	0.197	0.000
80	0.396		
160	0.768		
240	0.156		
320	0.542		

*Shapiro-Wilk Normality Test
**There is a difference at 0.05

Next, a homogeneity test was conducted to determine the consistency or homogeneity of variance within the data across treatment groups. The results showed a value of 0.197, which is greater than the alpha value of 0.05, meaning that the data tested is homogeneous. This homogeneity ensures that the data variability across groups is uniform, meaning any variations in the results between treatment groups are not due to large differences in variability. With the normality and homogeneity requirements met, a one-way ANOVA test can be conducted. One-way ANOVA is a statistical analysis method used to determine whether there are significant differences between several treatment groups in terms of the color of sasirangan wastewater with various concentrations of alum addition in the sample. This test is conducted to evaluate whether the addition of alum has a significant effect on the color change of sasirangan wastewater.

The results of the ANOVA test showing significant differences in the color change of sasirangan wastewater after the addition of alum align with research by Rusydi et al. (2017), which states that color intensity in wastewater can be reduced using coagulants. Coagulants work by coagulating color-causing substances in wastewater so that they can be separated from the water, ultimately reducing the color of the wastewater and making the water clearer. Another study (Putri & Soewondo, 2010) also supports these findings, showing that coagulants are effective in reducing color in textile wastewater. In this context, alum acts as a coagulating agent that accelerates the settling process of colored particles and reduces the turbidity of wastewater. The coagulation process with alum is optimal at a pH range of 6 to 8, although it can still occur at a pH of 4 to 8 (Babu et al., 2007). This pH range is important because coagulation depends on the chemical interaction that occurs between alum ions and particles in the water; at the optimal pH, the surface charge of particles and alum ions more easily attract each other, making the formation of flocs or clumps more effective.

Since the one-way ANOVA results show a significant difference, further testing is carried out using the Least Significant Difference (LSD) method to determine which groups show a significant difference in wastewater color reduction. The LSD results show that there are significant differences between treatments in the average value of color reduction, meaning that each treatment produces a different effect on reducing the color of sasirangan wastewater.

Alum (aluminum sulfate) has been proven effective as a coagulant to reduce the color intensity of home-made sasirangan waste through the mechanism of destabilization and aggregation of dye particles. This study strengthens previous findings while providing empirical data on simple and affordable textile waste processing. The sasirangan industry that produces dye waste has the potential to pollute water sources and aquatic ecosystems, but the use of alum can overcome this environmental problem. This coagulant is especially suitable for small industries because of its effectiveness in handling the unique characteristics of sasirangan waste, which is rich in dye pollutants.

Table 3. Results of LSD Test

LSD Multiple Comparison				
40%	80%	160%	240%	320%
	*	*	*	*
*		*	*	*
*	*		*	*
*	*	*		*
*	*	*	*	

*There is a significant results

In recent studies, alum has demonstrated optimal performance in color reduction when used at concentrations suitable for maintaining pH levels between 6 and 8, as this range enhances its coagulation efficiency (Abba et al., 2015; Setiawan et al., 2021). This pH-sensitive nature of alum means that its coagulation capacity is highly effective in neutralizing charges on dye molecules within this range, enabling the particles to clump together and be removed as sludge. According to Sibiya et al. (Sibiya et al., 2021), alum is also often combined with natural coagulants like chitosan or Moringa oleifera to increase efficiency, lower residual aluminum levels, and decrease the amount of sludge produced, making it a more environmentally friendly choice for wastewater treatment.

Further supporting this, research by Kumar et al. (Kumar et al., 2008) found that alum treatment can significantly reduce the color intensity of textile wastewater, thereby enhancing water quality and reducing environmental impacts. Internationally, wastewater studies have focused on reducing the dependency on single chemical treatments, exploring alum’s synergy with other coagulants, such as ferric chloride, and investigating its effectiveness in combination with adsorbents like activated carbon. These approaches not only maximize color removal but also help mitigate potential health risks associated with residual aluminum.

For the Sasirangan industry, alum provides an accessible and cost-effective solution to wastewater treatment, especially for small-scale operators who may lack advanced water treatment facilities. As research continues to emphasize sustainable practices, there is a push for integrating alum with other natural agents to ensure that wastewater treatment methods remain both effective and environmentally sound. This aligns with the goals of the textile industry worldwide to meet rising environmental standards and reduce pollution outputs in a cost-efficient manner (Sibiya et al., 2021).

Addressing the wastewater problem from the Sasirangan fabric home industry is essential for environmental protection without disrupting the industry itself. Effective wastewater treatment must consider both environmental benefits and economic feasibility for the artisans. This approach begins with a clear understanding of the processes involved in Sasirangan textile production, followed by sampling and parameter checks in alignment with established standards. Currently, the regulations for textile wastewater quality are stipulated in the Minister of Environment and Forestry Regulation No.P.16/MenLHK/Setjen/Kum.1/4/2019.

The impact of alum as a coagulant in treating Sasirangan wastewater has been studied, with results summarized in Table 1. This descriptive analysis indicates that adding alum to samples of wastewater leads to significant reductions in color intensity, achieving up to 94.8% reduction at a concentration of 160%. Alum coagulates dye particles, allowing them to be removed more efficiently from the water. Studies like those by Ahmad Hussaini Jagaba et al. (2018) highlight alum's high efficacy in textile wastewater treatment. Notably, alum's effectiveness is optimized within a pH range of 6 to 8, enhancing the coagulation process as supported by research from Setiawan et al.(2021) and Abba (2015).

Further analysis (Table 2) includes a comparison test using ANOVA, confirming alum's ability to reduce color intensity. This statistical validation, which indicates normality and homogeneity across treatment groups, allows for meaningful comparisons and supports alum's role in decreasing color intensity. The findings are consistent with Kumar et al. (2008), which showed alum's effectiveness in lowering dye concentrations, reducing turbidity, and improving water clarity. Alum's positively charged ions neutralize negatively charged dye particles, leading to coagulation and reducing chemical oxygen demand (COD), a critical pollutant measure.

However, alum's limitations, such as residual aluminum and sludge production, require careful management. Recent research advocates combining alum with natural coagulants like chitosan or Moringa oleifera, which can enhance coagulation, lower residual aluminum, and reduce sludge production. These combinations align with global environmental goals, offering Sasirangan artisans a cost-effective, efficient solution that balances pollutant reduction and environmental safety.

Alum effectively reduces the color intensity of Sasirangan liquid waste while meeting the standard for liquid waste disposal, with the advantages of accessibility and affordable costs. The development of methods through a combination of alum with natural coagulants is still needed to improve the sustainability of waste management, in line with regional regulations and global goals in creating an environmentally friendly and economical textile wastewater treatment system for traditional industries.

CONCLUSION

The addition of alum with a range of concentrations from 40% to 320% has been proven to be able to reduce the color of sasirangan waste below the 200 Pt-Co quality standard (PermenLHK No. P.16/2019), where the optimal concentration of 160% shows the highest effectiveness, reaching 94.8%. This solution not only meets environmental standards but is also economical for home industries, so it is recommended as a priority action for pollution control.

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CONFLICT OF INTEREST

The authors declare no conflict of interest for this research and publication.

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