TIK-243 Effectiveness Of Chitosan To Reduce The Color Value, Turbidity, And Total Dissolved Solids In Shrimp-Washing Wastewater

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EFFECTIVENESS OF CHITOSAN TO REDUCE THE COLOR VALUE, TURBIDITY, AND TOTAL DISSOLVED SOLIDS IN SHRIMP-WASHING WASTEWATER

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ABSTRACT
This research aims to identify the optimum concentration of chitosan solution and the effectiveness of chitosan as a biocoagulant in shrimp-washing wastewater on three types of water quality parameters, i.e., color, turbidity, and total dissolved solids (TDS). By employing the jar test method, the coagulation-flocculation test was performed by adding chitosan doses of 0 ppm (control), 50 ppm, 100 ppm, 150 ppm, 200 ppm, and 250 ppm, respectively. The effectiveness of chitosan was measured by calculating the percentage decrease in color, turbidity, and TDS parameters in the treated shrimp-washing wastewater samples. The statistical analysis results indicated that the treatment had a significant effect on the three types of parameters, with the obtained optimum concentration of chitosan solution of 200 ppm. The effectiveness of chitosan in reducing color (84%), turbidity (83%), and TDS (54%).

KEY WORDS
Chitosan, biocoagulant, coagulation-flocculation, optimum dose.

Indonesia is a country with the second-longest coastline globally, which becomes a supporting factor for Indonesia's fishery industry development. In addition to the positive impacts on the food sector and economy, the fishery industry development also negatively impacts the environment. According to Basuki & Sanjaya (2009), Indonesia has approximately 170 shrimp processing industries with a built-in production capacity of around 500,000 tons/year. The amount of liquid waste generated from the freezing industry of fishery products, including frozen shrimp processing, reaches 14.9 m^3/ton of product (Ibrahim, 2005). Meanwhile, clean water in large quantities utilized as the primary input in the production process of the fishery product processing industry reaches 20 m^3/ton of product. Additionally, water is used in almost all relatively complex production processes, one of which is in the raw materials washing process. The raw materials washing process is generally conducted repeatedly to avoid bacterial contamination. The raw material washing wastewater is a liquid waste source from the fishery industry, including the frozen shrimp processing industry.

Chitosan is poly-(2-amino-2-decks-β-(1-4)-D-glucopyranose) with the molecular formula $(C_6H_{11}NO_4)$n obtained from the chitin deacetylation (Sugita *et al.*, 2009). Chitosan refers to an eco-friendly (Wardhani *et al.*, 2014), non-toxic, biodegradable, renewable, and reactive natural biocoagulant (Ihsani & Widyastuti, 2014). Chitosan is helpful in various fields, contributing to reducing environmental pollution since it is effectively applied in water and wastewater purification. The optimum concentration of chitosan solution utilized as a biocoagulant varies in each type of treated water or wastewater. As a coagulant in the wastewater treatment of the fishery industry, chitosan functions well in the concentration ranging from 175 – 225 ppm with an optimum dose of 200 ppm (Ibrahim *et al.*, 2009). Chitosan is effective in water purification, reduction of color value (Purwaningsih *et al.*, 2020), turbidity (Nugraheni *et al.*, 2014), and TDS (Nuralam *et al.*, 2012). This research aims to analyze the optimum concentration of chitosan solution as a biocoagulant and its effectiveness in reducing color, turbidity, and TDS parameters in shrimp-washing wastewater.

MATERIALS AND METHODS OF RESEARCH

The materials used in this research included the samples of shrimp-washing wastewater obtained from the shrimp processing unit of PT Kalimantan Fishery in Banjarmasin, South Kalimantan, commercial chitosan, 2% acetic acid, distilled water, and filter paper. The instruments utilized included a portable flocculator, magnetic stirrer, turbidity meter, portable data logging spectrophotometer, TDS meter, Beaker glass, Erlenmeyer, pipette, volumetric flask, and funnel.

The design used in this study was a completely randomized design (CRD) with six treatments and 4 replications, namely: Shrimp-washing wastewater chitosan solution 0 ppm; Shrimp-washing wastewater + addition 50 ppm of chitosan solution 1%; Shrimp-washing wastewater + addition 100 ppm of chitosan solution 1%; Shrimp-washing wastewater + addition 150 ppm of chitosan solution 1%; Shrimp-washing wastewater + addition 200 ppm of chitosan solution 1%; Shrimp-washing wastewater + addition 250 ppm of chitosan solution 1%.

The preparation of 1% chitosan solution referred to the Prayudi & Susanto (2000). The preparation was performed by dissolving 1 gram of chitosan powder into 20 mL of 2% acetic acid. Afterward, it was continued by adding 100 mL of distilled water and stirring the solution using a magnetic stirrer to ensure that the chitosan was well-dissolved.

The stages of coagulation-flocculation in this research referred to Ratnawulan *et al.* (2018). The samples of 1,000 mL shrimp-washing wastewater were prepared in 6 Beaker glasses, while the coagulation-flocculation test was executed by employing the jar test method. Chitosan solutions 1% with concentrations of 0 ppm (control), 50 ppm, 100 ppm, 150 ppm, 200 ppm, and 250 ppm were added to the samples while mixing the solution at 200 rpm 1 minute. The process was followed by slow mixing at 50 rpm in 30 minutes. After the mixing process, the samples were deposited for 30 minutes before they were filtered. The sample parameters, including color, turbidity, and TDS, were measured after the treatment.

The effects of the treatment provided, in this case, the amount of chitosan solution concentrations on the shrimp-washing wastewater, could be determined using the Kruskal-Wallis method of data analysis at a 95% confidence level. The normality of data was analyzed using the Shapiro-Wilk test, while the homogeneity of data was analyzed using Levene's test. The Mann-Whitney U test was conducted to determine the treatments of chitosan solution concentrations resulting in significant differences. The statistical test tool employed was IBM SPSS version 25.0. The percentage calculation of the decrease in color, turbidity, and TDS parameters was performed to determine the effectiveness of chitosan as a biocoagulant in shrimp-washing wastewater using the formula: $Ef = (A - B)/A\,x\,100\%$, where A represents the initial value of the parameters. In contrast, B represents the final value of the parameters after the treatment.

RESULTS OF STUDY

Color, turbidity, and TDS parameters were tested after the samples were treated with coagulation-flocculation using the jar test method. The research results suggested that 200 ppm was the optimal concentration of chitosan solution to reduce the color value, turbidity, and TDS in shrimp-washing wastewater samples.

Table 1 – Results of the Control and Treatment of Various Chitosan Solutions Concentrations

Chitosan solution concentrations (ppm)	Parameters					
	Color (TCU)	Decrease (%)	Turbidity (NTU)	Decrease (%)	TDS (mg/L)	Decrease (%)
0 (Kontrol)	278	-	54.6	-	572	-
50	207	25.5	29.4	46.2	413	27.8
100	133	52.2	18.9	65.4	399	30.2
150	90	67.6	15.9	70.9	378	33.9
200	46	83.5	9.0	83.4	264	53.9
250	54	80.6	13.8	74.7	279	51.2

Note: The data obtained from four repeated treatments

Table 2 – Results of Statistical Analysis using Kruskal-Wallis Test

	Color (TCU)	Turbidity (NTU)	TDS (mg/L)
Kruskal Wallis H	22.410	22.332	22.400
df	5	5	5
Asymp. Sig.	0.000	0.000	0.000

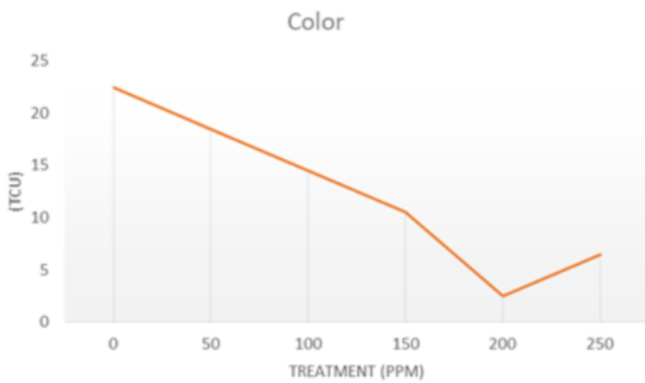

Figure 1 – Chitosan Concentration Effects on the Color Value

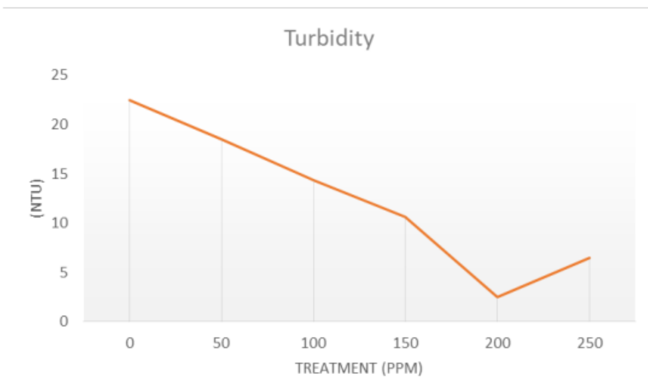

Figure 2 – Chitosan Concentration Effects on the Turbidity Value

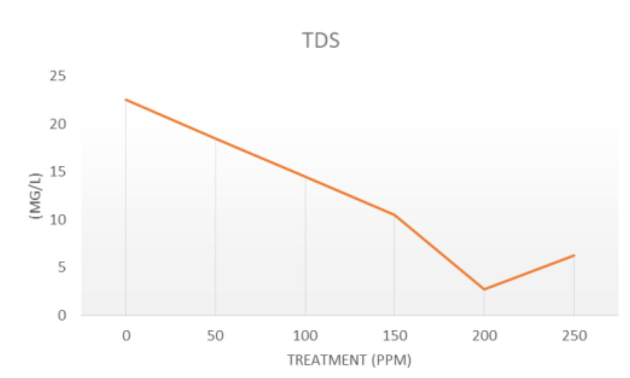

Figure 3 – Chitosan Concentration Effects on the TDS Value

Based on the statistical analysis results, it can be concluded that the treatment of the various concentrations of chitosan solutions caused significant effects on color, turbidity, and TDS parameters. The Mann-Whitney U test results that significantly different treatment for color, turbidity, and TDS was between 0 ppm and 200 ppm, 0 ppm and 250 ppm, 50 ppm and 200 ppm.

DISCUSSION OF RESULTS

There have been many studies on the application of chitosan coagulants in reducing pollutants in wastewater. The optimum concentration of chitosan solution utilized as a biocoagulant varies in each type of treated water or wastewater. Chitosan coagulant worked optimally at a concentration of 20 ppm in improving lake water quality (Hendrawati *et al*., 2015). The use of chitosan as a water purification coagulant with an optimum dose of 4 ppm for river water (Mustafiah *et al*., 2018) and 150 ppm effectively reduced 68% of turbidity in reservoir water (Amalia, 2018). The optimum dose of chitosan as a coagulant in laundry wastewater treatment was 200 ppm (Joko *et al*., 2016), while the optimum dose of chitosan for textile wastewater treatment varied depending on the dye used.

Additionally, chitosan as a coagulant in the processing of fishery industry wastewater functioned properly within the concentration, ranging from 175 - 225 ppm with an optimum dose of 200 ppm (Ibrahim *et al*., 2009). The results of the previous studies suggested that the use of chitosan with concentrations exceeding the optimum limit would raise back some water quality parameters, such as color and turbidity. It confirmed that optimizing the coagulant concentration was crucial to run the coagulation process effectively.

The jar test is the most common method to evaluate and optimize the coagulation-flocculation process (Muruganandam *et al*., 2017). The jar test works to determine the optimum dose of the coagulant used in water processing or wastewater treatment. Chitosan contains several intrinsic characteristics that make it a coagulant and/or flocculant, which effectively removes contaminants in the dissolved conditions (Renault *et al*., 2009). The addition of chitosan as a biocoagulant in the coagulation-flocculation process helps accelerate the formation of larger, stronger, and more stable flocs (Joko *et al*., 2016). The flocculation-coagulation process aims to remove non-precipitating particles or colloids by adding a coagulant to the raw water followed by rapid stirring or coagulation and slow stirring or flocculation. It results in colloidal particle agglomeration, which then can be separated mainly in the sedimentation process. The coagulation aims to destabilize colloidally and suspend solid particles, while the purpose of flocculation is to accelerate collisions that induce the formation of unstable colloid particles so that they can be deposited (Nugraheni *et al*., 2014).

Table 1 displays the treatment through the coagulation-flocculation process with the addition of the most suitable chitosan concentration at 200 ppm with the color value of 46 TCU, turbidity value of 9.0 NTU, and TDS value of 264 mg/L. Based on the Kruskal-Wallis test results, the p-value was less than 0.05 for the color, turbidity, and TDS parameters. It means there were statistically significant differences in pH, color, turbidity, and TDS values due to the treatment of adding various concentrations of chitosan solutions. Kruskal-Wallis is an omnibus test that can only detect significant differences statistically without knowing which treatments are different. Therefore, a post-hoc test is required. The Mann-Whitney U test was carried out to identify the difference between one treatment and another.

Visually, the shrimp-washing wastewater had a slightly muddy brown color. The color of the wastewater indicated its quality. The new wastewater would be gray, while the stale or foul wastewater would have a darker color (Mahida, 1984). The addition of chitosan solution reduced the color value from 278 TCU to 46 TCU or 83.5% at a concentration of 200 ppm, as indicated in Table 1. The reason was that the higher the coagulant dose, the more dye molecules were trapped along the chitosan polymer chains and eventually agglomerated to form flocs. Increasing the coagulant dose resulted in more floc formation, significantly decreasing the color value (Tchobanoglous & Eddy, 1991). The addition of chitosan solution at a concentration of 250 ppm increased the color value back to 54 TCU or 80.6%. The reason was, with excessive agitation, the destabilized particles forming flocs turned back stable, and the flocs in the wastewater disunited. Consequently, the dye molecules trapped in the flocs unraveled (Purwaningsih *et al.*, 2020).

Turbidity is the parameter that should be measured to check the efficiency of the flocculation-coagulation process (Hendrawati *et al.*, 2009). Turbidity may be caused by organic and inorganic suspended solids in water. The statistical analysis results stated that the concentration of chitosan solution had various actual effects on wastewater turbidity. Table 1 presents that the most suitable turbidity value of 9.0 NTU was generated at a concentration of 200 ppm. According to Nugraheni *et al.* (2014), the higher the coagulant dose, the greater the turbidity removal efficiency in wastewater. The increase of turbidity removal efficiency value was caused by coagulant addition at an optimal dose that helped bind the contaminant and then turned the stable turbidity-causing fine particles into unstable. Therefore, it creates an attractive force that deposits the fine particles, forming flocs on the floor. In this case, the attractive force is greater than the repulsive force, resulting in a smooth deposition process of colloidal particles in turbid water (Tarigan, 2011). The reduced turbidity content was also induced by coagulants that help the floc formation (Kalpikawati, 2006). The chitosan concentration increase to 250 ppm was found to increase the turbidity value back to 13.8 NTU. Hendrawati *et al.* (2015) reported that the addition of a coagulant exceeding the optimum limit would cause an increase in the value of turbidity due to excessive solutes. The result of a similar study was also reported by Mustafiah *et al.* (2018) that the addition of 2 ppm and 4 ppm chitosan solution in samples of river water could reduce the turbidity respectively 88.84% and 98.63%. The addition of a higher concentration of the coagulant caused the turbidity to increase.

Total Dissolved Solids contains various solutes, including organic, inorganic, and other materials, with a diameter less than 10^{-3} μm in the solution dissolved in the water (Mukhtasor, 2007). The TDS analysis is required to determine the pollution load and design the biological wastewater treatment system (Ilyas *et al.*, 2013). The changes in the TDS concentration can be dangerous since they cause changes in salinity, ion composition, and toxicity of each ion. Changes in salinity can disturb the aquatic biota and biodiversity, generate less tolerant species, and cause high toxicity on an organism's life cycle (Weber-Scannell & Duffy, 2007). The results of the Kruskal-Wallis analysis test suggested that the treatment of given variations in chitosan concentration significantly influenced the value of the TDS samples. Table 1 presents that the addition of chitosan solution could reduce the TDS level in the shrimp-washing wastewater up to 53.9% (264 mg/L) in the concentration of 200 ppm and 51.2% (279 mg/L) in the concentration of 250 ppm. According to Hatma *et al.* (2021) suggested that the addition of chitosan made the solid content in the lake water decrease. The TDS analysis conducted by Nuralam *et al.* (2012) also indicated that the TDS level in the river water samples with 61.88% – 79.38% and swamp water with 78.24% – 88.05% decreased with the addition of a 3 gram chitosan dose. As a biocoagulant, chitosan is passable to be used as an alternative to improve water quality in reducing solid content.

The results of comparison between control and the samples treated with the optimum chitosan concentration of 200 ppm could reduce the color value to 84%, turbidity to 83%, and TDS to 54%. Chitosan in the optimum concentration of 200 ppm could contribute as a biocoagulant in the shrimp-washing wastewater in the frozen shrimp processing industry. Compared to synthetic coagulants, chitosan is a non-toxic, biodegradable, polyelectronic, and reactive coagulant, such as protein. The coagulant of chitosan is eco-friendly material since it does not contain hazardous materials and has high added value (Mustafiah *et al.*, 2018).

CONCLUSION

The addition of chitosan as a biocoagulant is considered effective in reducing the color value, turbidity, and TDS in shrimp-washing wastewater with an optimum chitosan concentration of 200 ppm. Chitosan effectively reduces the color value to 84%, turbidity to 83%, and TDS to 54%.

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