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REDUCTION OF TSS AND COD IN RESTAURANT WASTEWATER USING NATURAL COAGULANT FROM KEPOK BANANA PEEL POWDER

Mutiara Fajar*, Iis Mulyani, Andika Munandar
Program Studi Teknik Lingkungan, Institut Teknologi Sumatera, Lampung Selatan, 35365, Indonesia
*Email: mutiara.fajar@tl.itera.ac.id

Abstract

Wastewater from restaurant activities contains organic compounds such as carbohydrates, proteins, fats, and oils that can pollute and damage the environment. Therefore, further research is needed to prevent this pollution. This study aims to analyse the characteristics of restaurant wastewater and utilise kapok banana peel waste as a natural coagulant to reduce TSS (total suspended solid) and COD (chemical oxygen demand) concentrations in the wastewater. Additionally, this study aims to analyse the correlation between the reduction in TSS and COD concentrations after the coagulation process. The results showed that kapok banana peel powder has polyelectronic properties and contains carboxyl, hydroxyl, and amide groups acting as active components in the coagulation-flocculation process. The coagulation-flocculation process was efficient at 400 mg biocoagulant, with reduction efficiencies of 92% for TSS and 73% for COD. Based on Pearson correlation analysis using SPSS, the reduction in TSS and COD concentrations had a very strong (r=0.954) and significant (Sig.=0.000) relationship.

Keywords: COD; Kepok banana peel; Natural coagulant; Restaurant wastewater; TSS

1. INTRODUCTION

The presence of water is a basic necessity for humans, both for conventional uses (drinking water, bathing, washing, and irrigation) and for improving the quality of human life by supporting industrial and technological activities. However, water pollution is increasing rapidly (Nafiadi, 2013). According to Zahra and Purwanti (2015), the most dominant pollution in water bodies is domestic waste, accounting for 60-70% of the pollution. Domestic wastewater originates from residential activities, restaurants, commerce, offices, and similar sources (Makbul et al., 2022). Domestic wastewater typically contains substances or materials that can endanger human health and life and disrupt environmental sustainability (Agustiani & Mirwan, 2024).

Modern society, a consumer society, often spends time gathering and eating out at restaurants. This can lead to increased waste produced by these restaurants, particularly wastewater. Restaurant wastewater contains high levels of organic materials such as oils and fats, as well as high levels of total suspended solids (TSS) and chemical oxygen demand (COD) (Bangun, 2018). Wastewater with a high organic content can cause microorganisms to require much oxygen to degrade the organic matter, indicated by a high COD concentration. In contrast, the TSS content in the wastewater can cause turbidity (Angrianto et al., 2021).

One wastewater treatment technology that can reduce the concentration of TSS and COD in restaurant wastewater is the coagulation-flocculation process. In the coagulation process, particles cannot be directly precipitated by gravity. Thus, an appropriate coagulant is added to cause destabilisation, and particles form microflocs, which are then precipitated. Coagulants can destabilise colloid charges by neutralising electric charges, allowing colloids to form easily precipitated clumps or flocs (Linggasari, 2023).

Coagulants are divided into synthetic and natural coagulants. Synthetic coagulants with chemical compounds such as PAC (poly aluminium chloride), alum, and ferrous sulfate can reduce pollutants, but this method has various drawbacks. Research shows that if aluminium content from water treatment is consumed by humans, it can lead to neurological diseases (Alzheimer's) (Hendrawati et al., 2016). Using chemical coagulants can produce sludge containing chemicals that may potentially re-pollute the environment (Kusniawati et al., 2023). Natural coagulants, such as moringa seeds, can be a safer alternative in wastewater treatment (Fajar, 2020). Natural coagulants have advantages such as being environmentally friendly, producing less sludge, and being biodegradable (Lafiyah et al., 2017).

Banana peels are relatively abundant waste products of bananas. Based on statistical data on banana production in Lampung Province in 2019, it amounted to 1,209,545 tons. Generally, banana peels are not utilised effectively and are only discarded as organic waste or used as animal feed for goats, cows, and buffaloes. Around 1/3 of the banana fruit are peels. Kepok banana peels contain several biochemical components, including the amino acid tryptophan, a serotonin precursor known as a pineal hormone. The mixture of amino acids bound to form peptide bonds into polymers. Protein is one type of natural polymer. Banana peels are also a waste product of the banana processing industry but can be used as a technology in water purification (Lubis, 2012). According to research by Hanifah et al. (2020) Anggraini in 2019, using kepok banana peel powder as a biocoagulant can reduce TSS by 83.2%.

Several other studies, such as those conducted by Qurbaniah (2017), Setyawati (2018), and Arifiyana and Devianti (2020), have proven that kepok banana peel is effective in reducing TSS and COD in wastewater. This study aims to observe the effects of kepok banana peel powder (Musa paradisiaca) as a natural coagulant to reduce the concentration of TSS and COD in restaurant wastewater treatment.

2. MATERIALS AND METHOD

2.1 Materials

Kepok banana peels (*Musa paradisiaca*) purchased from Way Huwi Village, South Lampung. Restaurant wastewater is obtained from local restaurants. COD reagents and distilled water are purchased from local chemical stores.

2.2 Method

2.2.1 Preparation of kepok bana peel coagulant

The kepok banana peels used are ripe and yellow-colored. It was cleaned of impurities and cut into small pieces. The pieces of the peels were sun-dried for two days. The peels were then oven-dried at 105°C for 30 minutes to reduce their moisture content. Afterwards, they were blended into powder, sieved through a 100-mesh sieve, and stored in a sealed container. The resulting product was kepok banana peel powder (biocoagulant). The biocoagulant was then analysed using FTIR (Fourier Transform Infrared).

2.2.2 Collection of liquid waste samples

Sampling in this study follows the Indonesian National Standard (SNI) 6989.59:2008 on wastewater sampling methods. A sample of wastewater from restaurant X was taken using the grab sampling method, where samples are collected directly at a specific time from a particular location (the restaurant's premises).

2.2.3 Coagulation and flocculation process

The coagulation-flocculation test was conducted using a jar test apparatus based on the Indonesian National Standard (SNI) 19-6449:2000 on the coagulation-flocculation testing method using jar test. The jar test was performed by pouring the restaurant wastewater sample into five glass beakers containing 500 ml of wastewater. Then, biocoagulant was added to each beaker at 200, 400, 600, 800, and 1000 mg/500 ml. The jar test apparatus is then operated with rapid stirring at 100 rpm for 1 minute, followed by slow stirring at 40 rpm for 3 minutes. After the flocculation, the jar test apparatus was turned off, the stirrer was removed, and the solution was left to settle for 60 minutes to allow sedimentation. Subsequently, the clear water from each beaker was collected, and testing was performed for TSS and COD parameters.

2.2.4 Measurement of TSS

TSS results from filtering dissolved solids in the form of colloidal particles, which settle gravitationally (Murdikaningrum et al., 2022). TSS is measured gravimetrically based on the Indonesian National Standard (SNI) 6989.3:2019 concerning gravimetric methods for testing total suspended solids (TSS). The stages in gravimetric measurements are weighing the filter paper (A). Set the funnel over the beaker. Place the weighed filter paper in the funnel. Pour 100 ml of the wastewater sample. After the sample was filtered, the filter paper was dried in an oven at 103-105°C for 1 hour. Filter paper dried in the oven was cooled in a desiccator for 15 minutes. Next, the filter paper is weighed using a digital analytical balance (B). The equation for calculating the TSS value can be seen in equation (1).

$$TSS\ (\frac{mg}{liter}) = \frac{(A - B)\ x\ 1000}{Test\ sample\ volume, mL} \quad (1)$$

Where A is the weight of filter paper + dry residue, mg; B is the weight of the filter paper, mg.

2.2.5 Measurement of COD

COD is an essential parameter in wastewater treatment because the higher the COD value in wastewater, the greater the amount of organic compounds it contains (Rahmi et al., 2023). COD measurements were carried out to determine the effect of adding a biocoagulant on changes in the COD value of restaurant wastewater. COD measurements were carried out based on the Hach 8000 Method. Each sample was put into a vial containing 0.2 mL of COD reagent and stirred gently to ensure a homogeneous mixture. The samples were heated using a HACH DRB 8000 at 150°C for 2 hours, then cooled to room temperature. Next, the COD parameters are analysed using a spectrophotometer, and the analysis results displayed on the screen are recorded. The percentage efficiency (Ef) of reduction COD is calculated using equation (2).

$$Ef = \frac{initial\ concentration - final\ concentration}{initial\ concentration}\ x\ 100\% \quad (2)$$

3. RESULTS AND DISCUSSION

3.1 Restaurant Wastewater Characteristics

The quality of restaurant wastewater is measured by testing physical (TSS) and chemical (COD) parameters. Physically, the characteristics of restaurant wastewater tend to be brownish and odour due to oil and fat residues, food scraps, and detergents. The initial characteristics of restaurant wastewater were determined before coagulation-flocculation treatment. The wastewater from dishwashing activities is analysed for TSS and COD concentrations and presented in Table 1.

Table 1. Initial concentrations of TSS and COD in restaurant wastewater

Parameter	Unit	Concentration	Water Quality Standard*
TSS	mg/L	267	30
COD	mg/L	500	100

*regulation of the Minister of Environment and Forestry number P.68 of 2016

Table 1 compares the TSS and COD concentrations in restaurant wastewater and the permissible standards for wastewater. The wastewater quality standards are based on the Minister of Environment and Forestry Regulation Number P68 of 2016 regarding domestic wastewater quality standards. The values of the restaurant wastewater parameters for TSS and COD concentrations have exceeded the permissible standards. Therefore, restaurant wastewater is not suitable for disposal in water bodies. Thus, treatment is required to reduce pollution levels in TSS and COD parameters.

3.2 Characteristics of Kepok Banana Peel Powder

The mixture of amino acids bound to form peptide bonds into polymers. Protein is one type of natural polymer. The active agent acting as a coagulant is a water-soluble, positively charged protein (Herawati et al., 2017). This solution has properties similar to alum polyelectrolytes and is a polymer that can bind colloidal particles and form precipitates (Ngili, 2013).

The functional group on kepok banana peel powder is analysed using Fourier Transform Infrared (FTIR). This analysis serves to identify chemical compounds that can be determined from the vibrational spectra produced by a compound at specific wavelengths (Silalahi et al., 2020). This analysis obtains information about functional groups composing compounds in kepok banana peel powder. Each functional group has characteristic vibrational regions (Beasley et al., 2014). Figure 1 shows the results of infrared spectrum analysis with FTIR of kepok banana peel powder.

Based on the observation of the waves in Figure 1, it can be seen that there is absorption at wave number 3272.6 cm^{-1}. According to Kurniasih and Kartika (2011), at this wavelength, there is overlapping absorption of hydroxyl (O-H) and amino ($-NH_2$) group vibrations. Furthermore, a carboxyl (-CH) functional group is also found at the wavelength of 2922.6 cm^{-1}. Other groups found are amide ($-CONH_2$) groups at the wavelength of 1595.3 cm^{-1} and primary amide ($-NH_2$) groups at 1028.7 cm^{-1}.

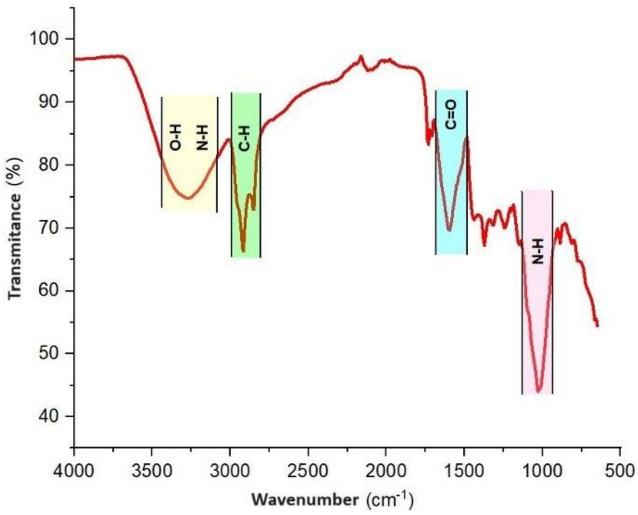

Figure 1. FTIR spectrum of kepok banana peel powder

Carboxyl, hydroxyl, and amide groups are constituent groups of organic polymers. These polymers are soluble in water and act as colloids because they are polyelectrolytes. In polar solvents such as water, these groups can dissociate, leaving charges on their polymer chains and releasing opposite ions in the solution (Mawaddah, 2014). These groups are the constituents of proteins. Protein molecules have amide ($-NH_2$) and carboxyl (-COOH) groups at the ends of their chains. This causes proteins to have many charges (polyelectrolytes) and amphoteric, meaning they can react with acids and bases. In acidic solutions or low pH, the amide groups on the protein will react with H^+ ions, positively charging the protein. Conversely, the carboxyl groups react with OH^- ions in basic solutions or high pH, making the protein negatively charged (Ulfa, 2022).

Proteins comprise polypeptide chains of 100 to 1000 amino acids joined by peptide bonds (Cakrawati & Mustika, 2012). In principle, peptide bond formation involves combining amino acids and carboxyl groups from two amino acids. This solution has properties similar to alum polyelectrolytes and is a polymer that can bind colloidal particles and form precipitates (Ngili, 2013). Based on the study by Herawati et al. (2017) using moringa seed extract as a natural coagulant, it is shown that the protein plays a role in the coagulation process.

Overall, the infrared spectrum results on kepok banana peel powder indicate the presence of polymers containing carboxyl, hydroxyl, and amide groups. These three groups are active components and play a role as coagulants. The polymer can bind colloidal particles and form precipitates. The active component that plays a vital role in coagulation is a natural polyelectrolyte composed of amide, hydroxide, and carboxyl groups (Octavianka & Purnomo, 2023).

3.3 The Effect of Biocoagulant Doses on TSS Reduction

Figure 2 shows the relationship between the dose of biocoagulant and the efficiency value of TSS reduction. It can be observed that both increases and decreases occur in the TSS parameter. The most efficient treatment occurs at a dose of 400 mg. In the 600 mg, the TSS concentration increases. This is because the concentration of the biocoagulant is not suitable. Excessive doses of biocoagulant cause the ability to reduce TSS levels to saturate. Inappropriate concentrations create repulsive forces and cause the formed flocs to break apart again. The breaking of the formed flocs due to excessive adsorption results in the re-suspension of organic matter and suspended particles.

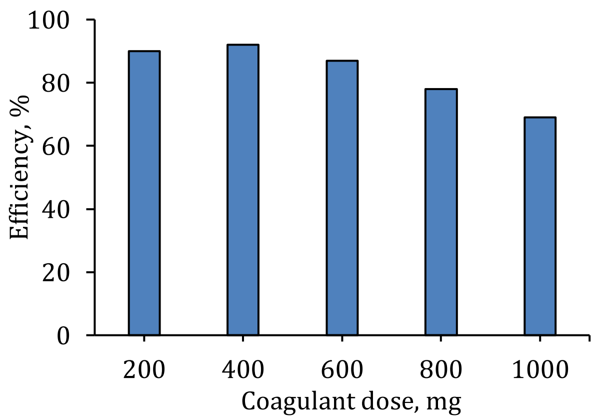

Figure 2. The relationship between biocoagulant dose and the TSS reduction efficiency

The reduction in TSS occurs due to the interaction of cationic polyelectrolytes found in the biocoagulant with colloidal particles in restaurant wastewater, forming easily precipitated flocs. When added to wastewater and followed by rapid stirring, the protein produced by the biocoagulant is distributed throughout the liquid part of the restaurant wastewater. Then, it interacts with negatively charged particles from organic material in restaurant wastewater.

Colloidal particles in wastewater undergo destabilisation and form microflocs through adsorption mechanisms. With slow stirring in the subsequent stage, these microflocs are brought into contact so they collide with each other. As a result, microflocs merge and adhere to each other, forming macroflocs that precipitate.

This study is consistent with research conducted by Hanifah et al. (2020), which found that using kepok banana peel powder can reduce TSS concentration in wastewater despite differences in wastewater types, doses, and banana peel processing methods. Hanifah et al. (2020) study used 300 to 700 g/500 ml of banana peel coagulant doses. The results showed that the optimum dose was 500 g, with a removal percentage of 83.2%. This study then expanded the variation in dose usage to 200 to 1000 g to find a more effective dose for removing wastewater. The optimum dose was 400 g, with a TSS removal percentage of 92%.

3.4 The Effect of Biocoagulant Doses on COD Reduction

Based on Figure 3, it can be observed that the efficient treatment for COD is the dosage of 400 mg/L. The fluctuations indicate that increasing the biocoagulant dosage added to the restaurant wastewater does not guarantee a proportional decrease in COD concentration in the wastewater. Several factors can cause an increase in COD value after reaching a minimum value post-treatment. This is due to saturation in the restaurant wastewater, wherein saturation caused by improper dosage addition will lead to the exhaustion of reduced flocs, and the remaining biocoagulant will contaminate the solution (Coniwanti et al., 2013).

Banana peel powder coagulant is added during coagulation, where the purpose is to reduce the stability of COD-causing particles by adding biocoagulant with opposite charges through rapid mixing. The ability of banana peel powder to reduce COD lies in its absorption capability and neutralisation of colloid charges. COD removal occurs due to the chemical process when the coagulant binds to COD-causing particles (coagulation process) and is also influenced by the flotation process (Nasrullah et al., 2021). The flotation process induces turbulence in the wastewater, increasing oxygen supply. Oxygen supply decreases COD concentration (Hertika et al., 2022).

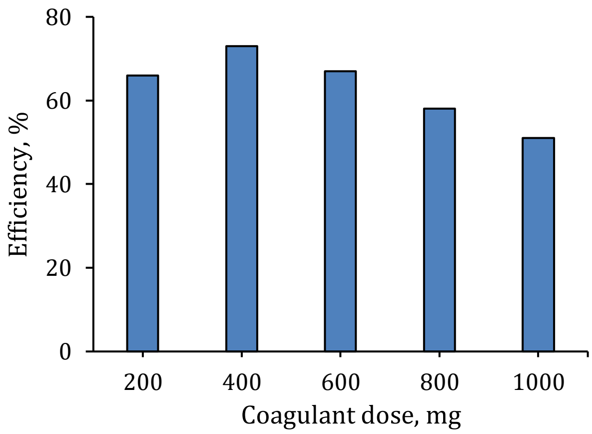

Figure 3. The relationship between biocoagulant dosage and the COD reduction efficiency

The decrease in COD concentration indicates that biocoagulants in the coagulation-flocculation process of restaurant wastewater can reduce COD concentration. However, although COD removal reaches 73%, the resulting COD value still exceeds the standard limits. This is due to the high organic content in restaurant wastewater. However, reducing the COD value in the coagulation-flocculation process can facilitate subsequent processes to achieve maximum

COD reduction. The decrease in COD concentration during coagulation-flocculation occurs because the formed polymer adsorbs organic compounds and captures colloidal particles, making it easier to separate. Decreased organic compound and colloidal particle content reduce COD (Bimantara, 2021).

4. CONCLUSION

The FTIR analysis of banana peel powder indicates the presence of active components acting as biocoagulants, namely carboxyl, hydroxyl, and amide groups. Banana peel powder biocoagulants can reduce TSS and COD parameters in restaurant wastewater, with an optimum dosage of 400 mg, resulting in an efficiency percentage of 92% for TSS concentration reduction and 73% for COD concentration reduction.

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