Effectiveness of Mushroom (Pleurotus Pulmonarius) Waste as Natural Coagulant for Kaolin Synthetic Water via Coagulation-Flocculation Process

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Abstract. Coagulation-flocculation process is a widely used method in water treatment. In this study, mushroom waste was selected as natural coagulant to treat kaolin synthetic water via coagulation-flocculation process. Rotten mushroom and mushroom spent were evaluated separately. Functional group of mushroom wastes were analyzed using Fourier Transform Infrared Spectroscopy. Optimum dosage and pH of mushroom wastes and aluminium sulphate in kaolin synthetic water treatment were examined through jar testing. A comparative study on the effectiveness of mushroom wastes and aluminium sulphate in kaolin synthetic water treatment was evaluated in terms of turbidity removal percentage and sludge volume index. Results obtained from jar testing show rotten mushroom and mushroom spent achieved turbidity removal efficiency of 99.73% and 99.25% respectively at optimal pH of 4 and optimal dosage of 5 mg/L whereas 99.91% of turbidity was eliminated by alum under optimum condition of pH 9 and dosage 25 mg/L. Under optimized condition, sludge volume index value obtained by rotten mushroom, mushroom spent and alum were 37.38 mL/g, 40.34 mL/g and 51.58 mL/g respectively. Overall, the finding indicated that mushroom waste could be a potential alternative to chemical coagulant since they are environmentally friendly, effective in turbidity removal, producing less sludge and pH independent.

1. Introduction
Rapid industrialization all over the world causes the increase in the amount of wastewater generated during the process for the production of desired products to occur. Hence, wastewater treatment has to be introduced in order to remove impurities, toxic substance and microorganisms in the wastewater so that the treated water is suitable for beneficial reuse [1]. In general, wastewater treatment can be categorized into three major types of treatment which are physical treatment, chemical treatment and biological treatment with the aim to remove particular form of impurities in the wastewater. Coagulation is a crucial physicochemical process that normally apply as a pre or also post step of process in wastewater treatment plant to remove any substances that its size is in the range of 0.1 µm to 10 µm [2].
In the midst of all the wastewater treatment methods, coagulation-flocculation process is preferred since it is reliable, cost-effective, easy operation and low energy consumption [3]. Efficacy of coagulation can be determined by various circumstances such as pH condition, coagulant dosage, retention time, mixing speed, temperature and wastewater types [2].

Generally, there are two types of coagulants which are chemical coagulants and natural coagulants. Chemical coagulants are the conventional type of coagulants that involve in water and wastewater treatment. Most common chemical coagulants used are aluminium-based like aluminium sulphate and iron-based like ferric sulphate [1]. On the other hand, natural coagulants are an alternative option for chemical coagulants since chemical coagulants produce large amount of sludge and are non-biodegradable. Natural coagulants can be derived from animal, plant, fungi and microorganisms to improve quality of [4].

In this study, mushroom waste is used as a natural coagulant to replace the usage of chemical coagulant in the coagulation-flocculation process of wastewater treatment. Mushroom waste is used in this study since recent published research reports that chitosan extracted from mushroom is an effective coagulant, safe to the environment, easily obtained and sustainable [2]. Effectiveness of mushroom waste as a type of natural coagulants to treat kaolin synthetic water is analyzed and its efficiency is compared with one of the chemical coagulants, aluminium sulfate. Jar test is conducted in order to identify the efficiency of coagulants on reducing the turbidity and sludge volume index (SVI) ratio of the kaolin synthetic water under optimum conditions of pH and coagulant dosage.

2. Methodology

The experimental work started with the preparation of mushroom waste and kaolin synthetic water. Functional group and chemical compound analysis of mushroom waste was done via FTIR technique. The jar test was conducted to determine the optimum pH and coagulant dosage for turbidity removal of kaolin synthetic water. Percentage of removal was calculated in order to obtain the removal efficiency of turbidity. Sludge volume index (SVI) for mushroom waste and alum under optimum conditions were determined by considering the mixed liquor suspended solids (MLSS) value obtained.

2.1. Materials and Equipment

2.1.1. Materials. Summarized list of materials and chemicals utilized throughout the experimental work is presented in Table 1.

| Materials/ Chemicals | Molecular formula | Purpose                                |
|----------------------|-------------------|----------------------------------------|
| Whatman filter paper  | -                 | To filter supernatant                  |
| 1.0 M Sodium hydroxide| NaOH              | pH adjustment                          |
| 1.0 M Hydrochloric acid| HCl               | pH adjustment                          |
| Kaolin powder         | Al₂Si₂O₅(OH)₄ or Al₂H₄O₇Si₂ | To produce kaolin synthetic water     |
| Rotten Mushroom       | -                 | Coagulant                              |
| Mushroom Spent        | -                 | Coagulant                              |
| Aluminium sulfate     | Al₂(SO₄)₃         | Coagulant                              |

2.1.2. Equipment and Apparatus. List of equipment and apparatus used throughout the experimental work is summarized in Table 2.
Table 2. List of equipment and apparatus used for the experiment.

| Equipment/ Apparatus                                      | Purpose                                                                 |
|-----------------------------------------------------------|-------------------------------------------------------------------------|
| 500 ml Beaker                                             | To hold sample for jar test                                             |
| Volumetric flask                                          | To prepare NaOH and HCl                                                 |
| Sieve shaker                                              | To determine particles size                                             |
| Analytical balance                                        | To determine weight of materials used                                   |
| Oven                                                      | Drying                                                                  |
| Grinder                                                   | To ground mushroom waste into powder form                               |
| Jar test equipment equipped with stirring blades (Model SW6)| Jar test                                                                |
| pH meter                                                  | To measure pH of the kaolin synthetic water                            |
| HACH TL2300 Turbidity meter                               | To determine turbidity                                                 |
| PerkinElmer Fourier Transform Infrared (FTIR) Spectrometer| To determine functional group                                          |

2.2. Preparation of Coagulant

Mushroom wastes include rotten mushroom and mushroom spent from *Pleurotus pulmonarius* was collected from mushroom farm near UniCITI Alam Campus. Firstly, the mushroom wastes were cleaned and rinsed with tap water followed by distilled water to remove the dust and contaminants. After rinsing, the mushroom waste was cut into small pieces and dried in an oven at 60 °C for 6 hours. Subsequently, the dried pieces were then ground into fine powder using grinder [5]. Lastly, the powder was passed through sieve shaker in order to gain uniform particle size of 0.5 mm [5]. The mushroom waste powder prepared was ready to utilize as coagulant for kaolin synthetic water treatment. On the other hand, aluminium sulfate solution was prepared by dissolving 10 g of the powdered form aluminium sulfate in 1 litre of distilled water. The solution can be directly used as coagulant without the need of further dilution [6].

2.3. Functional Group Analysis of Mushroom Wastes using FTIR Spectroscopy

Functional groups of mushroom waste powder that played important role in adsorption of pollutants or contaminants was identified via PerkinElmer Fourier Transform Infrared (FTIR) analysis. Prior to this analysis, the mushroom waste powder was dispersed in potassium bromide, KBr in order to form tablet [7]. Additionally, FTIR spectra recorded was in the range of 4000 to 650 cm\(^{-1}\) with a resolution of 4 cm\(^{-1}\) at room temperature [2]. The spectrum obtained was displayed in the computer screen and the desired peak selected was properly labelled and analyzed.

2.4. Preparation of Kaolin Synthetic Water

In this study, kaolin was used as a synthetic water. The stock kaolin solution was prepared by dissolving 10 gram of kaolin powder in 1 litre of distilled water [2, 6]. The suspension was then gradually combined at 200 rpm for 1 hour with the aid of a jar test device to ensure a standardized dispersion of kaolin particles [2]. After that, the suspension produced was left for 24 hours for complete hydration of kaolin [2]. Samples with initial turbidity around 2500 NTU was prepared for the coagulation-flocculation process by adding stock kaolin suspension of 70 ml into 430 ml tap water [2]. Apart from this, the initial pH of the synthetic turbid water was regulated by 1 M sodium hydroxide (NaOH) or 1 M hydrochloric acid (HCl) to get the required pH [2].

2.5. Jar Test

Coagulation-flocculation experiments were carried out by using jar test apparatus. Jar testing was the primary method for assessing coagulant efficiency [1] and identifying optimum operating conditions of coagulant in coagulation-flocculation process.

For every batch, six 1 litre beakers were filled with 500 ml kaolin synthetic water which its pH was maintained at constant around 7 for experimental work [2]. One beaker of kaolin synthetic water with no adjustment of pH or addition of coagulant was prepared as a control to the experiment. For jar testing,
the pH and dosage of mushroom waste and aluminium sulfate was altered so that optimum conditions for the highest possible efficiency of coagulation-flocculation process could be obtained [8]. All experiments were carried out at an average temperature of 26-30 °C.

Apart from this, the procedures for coagulation consist of three steps which were: (1) intense stirring after coagulant introduction (rapid mixing speed), (2) gentle stirring (slow mixing speed) and (3) sedimentation (settling time) [8]. The rapid mixing speed in this study was set as 150 rpm for 4 minutes while the slow mixing speed was set at 40 rpm for 25 min [2]. Additionally, the settling time for this jar test was fixed at 30 minutes. Lastly, 20 ml of treated sample was taken from the middle part of the solution (2 cm below the sample surface) with the aid of pipette and was put in the turbidity cuvette in order to calculate final turbidity using HACH Turbidimeter Model 2100 N [2].

2.6. Experiment Matrix

The experimental matrix set up for mushroom waste and aluminium sulfate coagulant are as shown in Table 3. The effect of pH on the coagulant performance was evaluated by altering the pH and fixing the dosage of coagulants. The pH of both mushroom waste and aluminium sulfate coagulant was calibrated into the range of 4, 5, 6, 7, 8, 9, 10, 11 and 12 by using 1 M of sodium hydroxide (NaOH) and 1 M of hydrochloric acid (HCl). In this experiment, the pH which contributed the highest percentage of turbidity was selected as optimum pH. The effect of dosage on the coagulant effectiveness in this experiment was obtained by altering the dosage and fixing the pH of the kaolin synthetic water at 7. The dosage values set for the run was 5, 10, 15, 20, 25, 30 and 35 mg/L. In this experiment, the dosage which contributed the highest percentage of turbidity was selected as the optimum coagulant dosage.

| Sample                  | pH | Dosage used (mg/L) (Mushroom waste) | pH | Dosage used (mg/L) (Alum) | Contact time (min)               |
|-------------------------|----|-------------------------------------|----|--------------------------|----------------------------------|
| Kaolin Synthetic Water  | 7  | 5                                   | 7  | 5                        | Rapid mixing speed and time = 150 rpm for 4 mins |
|                         | 10 | 10                                  | 10 |                          | Slow mixing speed and time = 40 rpm for 25 mins |
|                         | 15 | 15                                  | 15 |                          |                                   |
|                         | 20 | 20                                  | 20 |                          |                                   |
|                         | 25 | 25                                  | 25 |                          |                                   |
|                         | 30 | 30                                  | 30 |                          |                                   |
|                         | 35 | 35                                  | 35 |                          |                                   |
| 4                       |    | Optimized dosage                    | 4  | Optimized dosage         |                                   |
| 5                       |    |                                      | 5  |                          |                                   |
| 6                       |    |                                      | 6  |                          |                                   |
| 7                       |    |                                      | 7  |                          |                                   |
| 8                       |    |                                      | 8  |                          |                                   |
| 9                       |    |                                      | 9  |                          |                                   |
| 10                      |    |                                      | 10 |                          |                                   |
| 11                      |    |                                      | 11 |                          |                                   |
| 12                      |    |                                      | 12 |                          |                                   |

2.7. Analytical Procedures

2.7.1. Turbidity. Turbidity test was performed by using HACH TL2300 Turbidity meter in accordance with APHA Method 2130B. Prior to usage, the meter was adjusted with variety of turbidity standards [1]. Principle of turbidity measurement was based on the comparison of intensity of light released by the sample. Turbidity was measured in the unit of Nephelometric Turbidity Units (NTU). Removal efficiency of turbidity was calculated using Equation 1 as follow:
\[ \text{Turbidity removal efficiency} = \frac{A - B}{A} \times 100\% \]

\( A \), initial turbidity of sample (NTU) and \( B \), turbidity after treatment (NTU).

2.7.2. Sludge Volume Index. Sludge produced after coagulation-flocculation experiment under optimum conditions was used to indicate the sludge volume index (SVI) measurement. It is the volume (in millimeter) that occupied by 1 g of suspension after settling time of 30 minutes. Equation 2 was used to analyzed the SVI.

\[ \text{SVI} = \frac{\text{settled sludge volume after 30 mins} \left( \frac{\text{mL}}{L} \right)}{\text{mixed liquor suspended solids, MLSS} \left( \frac{\text{mg}}{L} \right)} \times \frac{1000 \text{ mg}}{g} \]

3. Results and Discussion

3.1. Functional Group Analysis of Mushroom Wastes and Alum using FTIR Spectroscopy

Based on Figure 1 and Figure 2 which shows the FTIR spectra analysis of rotten mushroom and mushroom spent, functional groups present within both types of mushroom waste are almost the same since most of the absorption peaks showed up are with the same intensity. Absorption band appeared with a peak at 3316.8 cm\(^{-1}\) in Figure 1 and in Figure 2 with peak at 3348.3 cm\(^{-1}\) and 2343.9 cm\(^{-1}\) indicate the vibrational stretching of O–H group (hydroxyl group) [9] which implies the presence of lignin, pectin and cellulose [5]. Free hydroxyl groups found within the spectrum can also correlate with the presence of alcohols, phenols and carboxylic acids. Symmetric stretching of C–H group like methylene groups at the peak of 2926.4 cm\(^{-1}\) in Figure 1 may due to the increase in C–H bond formation after amidation reaction [10]. Absorption peak at 1629.2 cm\(^{-1}\) (Figure 1) and 1632.3 cm\(^{-1}\) (Figure 2) could be associated to C=O (carbonyl group) stretching vibration in the amide bonds (amide-I band), the C=O and C=C stretching vibration in amino acids, deformation of aromatic ring and the N–H bending occurs in flavonoids [2]. Absorption band at 1364.7 cm\(^{-1}\) from rotten mushroom FTIR spectra can be attributed to stretching vibration of carbonyl group (-COOH) which plays important role in flocculating mechanism whereas peak at 1314.3 cm\(^{-1}\) from mushroom spent FTIR spectra correspond to amide III region [7]. Carbonyl compound such as ester and alkyl carbonate may exist in mushroom spent based on the absorption band at 1736.2 cm\(^{-1}\). Intense peak at 1037.3 cm\(^{-1}\) (Figure 1) and at 1056.2 cm\(^{-1}\) (Figure 2) are involved in the internal vibration of chitin cycle that correspond to C-O-C group. This absorption band also indicates the possible presence of methoxy group (CH stretch) and primary amine (CN stretch) [9].

On the contrary, four main peaks appear with different intensity are determined from alum spectra analysis in Figure 3. Absorption peaks at 3256.84 cm\(^{-1}\) and 2134.28 cm\(^{-1}\) are both attributed to the stretching vibration of O-H group (hydroxyl group). The band at 1636.34 cm\(^{-1}\) in alum FTIR spectra may assigned to the presence of carbonyl compound, for instance, amide [9]. Absorption peak observed at 588.68 cm\(^{-1}\) is associates with the composition of sulfonate salt or sulfate ion that exist in alum. Generally, alum hydrolyze rapidly once it is added to a solution in order to form numerous cationic species adsorbed by negatively charged particles and leads to charge neutralization [3].

Previous published study stated that the existence of hydroxyl, carbonyl, carboxylic, methoxy and amino groups as the main functional groups that contribute to coagulation-flocculation process. When carboxyl group and hydroxyl group present in wastewater treatment, the electrostatic attraction can be increased to provide a stronger bridging mechanism which eventually enhances the water treatment efficiency [10]. Mushroom wastes are made up of large amounts of natural polymer, for example protein, chitin, chitosan, cellulose and hemicelluloses rich in hydroxyl, carbonyl and amide functional groups.
[5]. A coagulant could be able to provide active binding sites for pollutants when all these functional groups are added in wastewater treatment process [5].

![Figure 1. FTIR spectra analysis of rotten mushroom.](image1)

![Figure 2. FTIR spectra analysis of mushroom spent.](image2)

![Figure 3. FTIR spectra analysis of alum.](image3)

3.2. Effect of Coagulant Dosage on Coagulation-Flocculation Process

Figure 4 illustrated the turbidity removal efficiency against the coagulant dosage utilized in jar testing for rotten mushroom, mushroom spent and alum at constant pH. Based on the results obtained in Figure 4, it was noticed that the optimum dosage for rotten mushroom and mushroom spent were 5 mg/L with the turbidity removal efficiency of 99.67 % and 98.94 % respectively while alum achieved its maximal turbidity removal efficiency of 99.65 % at the dosage of 25 mg/L. After the highest peak was achieved at 5 mg/L dosage, the turbidity removal efficiency of rotten mushroom and mushroom spent were found to be gradually decreased with the increase in dosage. Reduction in efficiency of turbidity removal was
shown after dosage increment may signify that the presence of coagulant was in excess as all suspended particles may already be bound to the coagulant. Due to the nature of rotten mushroom and mushroom spent with long high molecular weight chain, overdosing of coagulants in kaolin synthetic water causes the surfaces of colloids to be saturated [4]. This situation minimizes the sites available for polymer bridging formation [3].

According to Figure 4, the turbidity removal efficiency of alum was increased consistently with the addition of alum dosage initially until its optimum dosage reached at dosage of 25 mg/L. The increase in removal efficiency was due to the increase in the active sites available for the interaction with colloidal particles [5]. When the active sites available was sufficient for all the colloidal particles to interact with, the effective removal of turbidity can be achieved. The turbidity removal efficiency started to decline after the maximum removal of turbidity occurred with dosage of 25 mg/L as overdose of coagulant may leads to the charge reversal and restabilization of particles in kaolin synthetic water.

Optimum dosage was crucial to be determined since overdosing of coagulants will results in a substantially increase in the amount of sludge generated after the wastewater treatment process [11]. Coagulants added to the wastewater treatment process must be at its optimum level so that highest removal efficiency can be achieved. This is because inadequate coagulant dosage may fail to destabilize and promote the aggregation of colloidal particles for flocs formation whereas coagulants may had reached its saturation level under overdose condition.

![Figure 4](image)

**Figure 4. Percentage of turbidity removal with different types of coagulant.**

### 3.3 Effect of pH on Coagulation-Flocculation Process

Since pH of solution greatly affects the degree of stabilization of colloidal suspension and surface charges of the coagulant, thus optimum pH of kaolin synthetic water during coagulation-flocculation process was identified to ensure the efficiency of turbidity removal. During pH optimization via jar testing, optimum pH obtained through jar testing for rotten mushroom (pH 4), mushroom spent (pH 4) and alum (pH 9) were applied.

Figure 5 demonstrated the effect of pH on the percentage of turbidity removal by using rotten mushroom, mushroom spent and alum. From Figure 5, rotten mushroom and mushroom spent both achieved its highest turbidity removal efficiency at pH 4 with the turbidity removal of 99.73 % and 99.25 % respectively while maximum turbidity removal efficiency for alum was obtained at pH 9 with 99.91 % turbidity removed. Kaolin synthetic water treatment was found to be favourable in acidic condition when rotten mushroom and mushroom spent were used as coagulant since biopolymer recovery through hydrolysing the insoluble biopolymer constituents into soluble biopolymer occurred [10]. By utilizing rotten mushroom and mushroom spent as coagulant, the percentage of turbidity removal decreased with the increase in pH of kaolin synthetic water when the pH of water went beyond pH 4. This may due to the decrease in charge attraction between positively charged coagulants and negatively charged contaminants when the pH of kaolin synthetic water was increased. The efficiency of turbidity removal for rotten mushroom, mushroom spent and alum were found to be relatively high.
at pH 10 – pH 12 due to the possible reaction that occur between alumina in kaolin and sodium hydroxide to form sodium aluminate before coagulant was added in for coagulation-flocculation process.

Based on Figure 5, percentage of turbidity removal by using alum was gradually increased initially from pH 4 until a peak was appeared at pH 9 and gradually decreased from pH 9 to pH 12. Alum was able to remove the highest possible turbidity at pH 9 due to chemical reaction between colloids and alum [6].

![Figure 5. Percentage of turbidity removal with different types of coagulant.](image)

**3.4 pH Analysis Before and After Kaolin Synthetic Water Treatment**

pH analysis before and after the kaolin synthetic water treatment with different dosages of rotten mushroom, mushroom spent and alum were done. pH of kaolin synthetic water was adjusted to pH 7 before treatment of water. According to results, pH value obtained after kaolin synthetic water treatment using rotten mushroom, mushroom spent and alum were within the range of 7.18 - 7.46, 7.33 – 7.48 and 5.38 – 7.11 respectively. By the utilization of mushroom waste which were rotten mushroom and mushroom spent, there was only slight increase in pH value after treatment. On the other hand, significant decrease in pH value with the increase in dosage of alum added was found when alum was applied as coagulant in wastewater treatment. This is due to the reaction between alum and bicarbonate by which the bicarbonate will then reacts with calcium ion, $Ca^{2+}$ for charge neutralization. During this reaction, carbonic acid ($H_2CO_3$) will be formed when carbon dioxide released from the reaction reacted with water. pH of kaolin synthetic water will decrease when more alum is added to it since carbonic acid formed will partially dissociated to produce acidic compounds or elements like carbonate, bicarbonate and $H^+$ [12].

**3.5 Sludge Volume Index Analysis**

Sludge Volume Index (SVI) is a useful parameter utilized to measure and describe the settling characteristic of sludge in wastewater treatment process. Through calculation, SVI obtained for alum was found to be the highest with 51.58 mL/g, followed by mushroom spent with 40.34 mL/g and rotten mushroom with the lowest SVI value of 37.38 mL/g. This means the sludge produced after kaolin synthetic water treatment by using chemical coagulant, alum produced more sludge compared to mushroom spent and rotten mushroom which are natural coagulant. Excess volume of sludge produced by alum may induce detrimental issues to operator that responsible in handling the disposal and discharge of sludge. Since SVI value obtained for rotten mushroom, mushroom spent and alum are less than 80 mL/g, thus the sludge produced was attributed to an old, over-oxidized sludge that is dense and comes with the rapid settling characteristics.

**3.6 Comparison on Effectiveness of Rotten Mushroom, Mushroom Spent and Alum**
A comparison study on the effectiveness of rotten mushroom, mushroom spent and alum in treating kaolin synthetic water had been evaluated and illustrated in Table 4. From table, higher dosage of alum (25 mg/L) at pH 9 is required to remove 99.91 % turbidity in kaolin synthetic water while only 5 mg/L of rotten mushroom and mushroom spent at pH 4 is needed to achieve nearly the same turbidity removal efficiency which is 99.73 % and 99.25 % respectively. Alum is found to produce higher sludge volume of 51.58 mL/g compared to rotten mushroom that produced 37.38 mL/g sludge and mushroom spent which contributed 40.34 mL/g sludge after kaolin synthetic water treatment. In terms of pH, alum causes the treated kaolin synthetic water to be in acidic condition since the pH decreased with the increased in dosage added. Extra treatment may require to implement in order to adjust pH of treated effluent back to neutral. Rotten mushroom and mushroom spent are more recommended to be utilized as coagulant as they are cheap, environmentally friendly, effective in turbidity removal, produce less sludge and causes no change in pH although an additional physical separation method may need to be implemented after coagulation-flocculation process to enhance removal efficiency. This can be supported by numerous published studies that promoting the application of natural coagulants in wastewater treatment instead of chemical coagulants because they require lesser coagulant dosage, generate lesser sludge after treatment and pH independent [11]. For mushroom waste, rotten mushroom is found to be more efficient that mushroom spent since it removes higher efficiency of turbidity with less sludge produced after treatment.

Table 4. Comparison study on effectiveness of rotten mushroom, mushroom spent and alum.

| Coagulant Characteristic | Rotten Mushroom | Mushroom Spent | Aluminium Sulfate (Alum) |
|-------------------------|----------------|---------------|-------------------------|
| Optimum pH              | 4              | 4             | 9                       |
| Optimum dosage (mg/L)   | 5              | 5             | 25                      |
| Turbidity removal efficiency (%) | 99.73         | 99.25        | 99.91                   |
| SVI (mL/g)              | 37.38          | 40.34         | 51.58                   |
| pH changes after treatment | (Slightly increased) | (Slightly increased) | (Significantly decreased) |

4 Conclusion

This study had successfully examined and evaluated the treatment of kaolin synthetic water by using mushroom wastes which are rotten mushroom and mushroom spent as natural coagulant and alum as chemical coagulant. Characterization of rotten mushroom and mushroom waste via FTIR analysis confirms the presence of hydroxyl group, carbonyl group, carboxyl group and amine group that contribute to coagulation-flocculation process in wastewater treatment. Rotten mushroom and mushroom spent were found to have potential as coagulant since vast amount of effective functional groups were present within them. Under the same optimum conditions of pH 4 and dosage of 5 mg/L, rotten mushroom showed its highest turbidity removal efficiency of 99.73 % and mushroom spent removed up to 99.25 % turbidity via jar testing. In comparison to alum as chemical coagulant, nearly the same percentage of turbidity removal which was 99.91 % at optimal pH value of 9 and optimal dosage of 25 mg/L. Results obtained indicates that mushroom wastes were capable to be an alternative coagulant to alum due to its high efficiency in turbidity removal. The experimental results showed that sludge generated by rotten mushroom and mushroom spent comes with SVI value of 37.38 mL/g and 40.34 mL/g respectively under optimum conditions (pH 4 and 5 mg/L dosage). By comparison, alum was found to produce more sludge than rotten mushroom and mushroom spent since its SVI value was 51.58 mL/g under optimum condition of pH 9 and with dosage of 25 mg/L. Larger volume of sludge generated will cause problematic issues to operator that deals with the sludge disposal and may cause harm to the environment.
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