Efficiency of Natural Plant-Based Coagulants for Water Treatment

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Abstract. Natural plant-based coagulant is a natural based coagulant that can be used in coagulation process of water treatment. This study was conducted to investigate the potential of plant-based materials as coagulants for surface water treatment. Two types of locally available plant-based materials were selected as natural coagulants in this study are soybean and banana peel. Their efficiency in removing turbidity and color from raw surface water were analysed. Findings from the present study showed that the coagulation efficiency using soybean and banana peel were comparable to conventional chemical coagulants. The treatment of surface water using soybean and banana peel coagulant were found to be the most effective at dosage of 120 mg/L. The turbidity removal efficiency for soybean and banana peel are 23.2% and 15% respectively. In present works, both plant-based coagulants were found to be a suitable coagulant for surface water on the basis of removal of turbidity and color, respectively.

1. Introduction

Water treatment is any method that improves the quality of water to make it more acceptable for a particular end-use. The end use may include drinking, industrial water supply, irrigation, river flow conservation, recreation of water, or many other uses, including safe return to the ecosystem. In conventional water treatment processes, many coagulants and flocculants are widely used. Coagulation is an effective, simple, and widely practiced water treatment method. Conventional chemical coagulants, such as aluminum sulfate and ferric chloride are the most widely used coagulants with greater benefits but still cannot prevent the negative side, commonly referred to as lack of green chemistry [1]. In addition, the use of chemical coagulants will give risks to human health and living organisms, including intestinal constipation, seizures, gastrointestinal colic and energy loss [2]. As there are human health and environmental problems regarding on the chemical’s usage, there are ways to develop cost-effective, easier, and environmental friendly coagulant process.

The development and application of natural coagulants in water treatment has been given great importance nowadays [3]. These natural coagulants can be formed or extracted from animal, microorganisms and plant. Plant extracts from seeds, leaves, root, barks, and fruits have been used in the water purification system since ancient times [4]. These natural coagulants are used in environmentally friendly engineering because they are renewable resources and are particularly achievable in remote areas [5]. Furthermore, natural coagulants have various benefits, including reductions in sludge production, lower costs, limits on the pH of treated water, protection, and improved biodegradability [6]. The coagulants used in this study are a plant-based coagulant, namely...
soybean and banana peel. This study was carried out to investigate the efficiency of natural plant-based coagulants to treat the surface water by varying coagulant dosage.

2. Experimental

2.1. Material
Soybean and banana peel used in this study were obtained from local market. While the surface water sample was obtained from detention pond located nearby the laboratory. This study was conducted to investigate the potential of plant-based materials as coagulants for surface water treatment. The different coagulant dosages were varied for identifying the optimum dosage and removal performance of the natural coagulants in treating the surface water.

2.2. Preparation of natural coagulants
Soybean and banana peel were prepared by drying and powdering method. Soybean and banana peel were washed with distilled water several times to remove dirt and contaminants, followed by drying in oven at 105°C for 24 hours to ensure the water content in the beans is absorbed fully. The dried samples were then blend using domestic blender until it turned into powder. Then, the soybean and banana peel powder were sieved using 0.063mm sieve to remove large size particles to make a good natural coagulants solution.

2.3. Experimental run
A conventional jar test apparatus was used in the experiments to coagulate, flocculate and makes sedimentation of surface water sample using natural plant-based coagulants namely soybean and banana peel. One beaker of raw surface water without the addition of natural coagulant was prepared as a control and the initial turbidity and colour were measured. Different dose of natural coagulant extract was added into each beaker of raw surface water. The natural coagulant concentration used in this experiment are 40 mg/L, 80 mg/L and 120 mg/L respectively. The mixtures were rapidly stirred at 140 rpm after the addition of the coagulant for three (3) minutes duration. Then, the mixture was stirred slowly at a speed of 20 rpm to allow it to flocculate for 30 minutes. The flocs then undergo sedimentation process for 30 minutes. Subsequently, the sample was taken for turbidity and color removal analysis as follows:

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Removal\ Efficiency = \frac{(\text{Initial \ value} - \text{Final \ value})}{\text{Initial \ value}} \times 100(\%) \quad (1)
\]

3. Results and Discussions

3.1. Turbidity removal
The turbidity value was measures before and after the treatment. Results of turbidity reduction with different dosage of natural coagulants in jar test experiments can be shown in the figure 1. From figure 1, it is found that the raw surface water turbidity is 22 NTU. The turbidity reduced to 20.8 NTU, 19.0 NTU and 18.7 NTU corresponding to 40 mg/L, 80 mg/L and 120 mg/L of banana peel dosage, respectively. While for the same dosage of soybean, the turbidity also reduced to 21.5 NTU, 20.4 NTU and 16.9 NTU respectively. This showed that the turbidity reduction is increase with increasing dosage of natural coagulants.
Figure 1. Turbidity reduction at different natural coagulants dosage.

3.2. Color removal

Reduction analysis of color are observed too. Results of color reduction with different dosage of natural coagulants in jar test experiments can be shown in the figure 2.

Figure 2. Color reduction at different natural coagulants dosage.

As can be seen in the figure 2, the raw surface water color is 194 Pt/Co. At 40 mg/L, 80 mg/L and 120 mg/L of banana peel doses, the color reduced to 171 Pt/Co, 148 Pt/Co and 136 pt/Co respectively. While for soybean, the color reduced to 188 Pt/Co, 147 Pt/Co and 135 pt/Co corresponding to 40 mg/L, 80 mg/L and 120 mg/L of soybean dosage, respectively. This showed that the increment of natural coagulants dosage will increase the color reduction.
3.3. Removal efficiency

Based on the previous result, the turbidity and color reduction are directly dependent on the increment of natural coagulants dosage which is at 120 mg/L. In addition, the different dosage of natural coagulants will influence the removal efficiency. Based on the equation (1), the removal efficiency of turbidity and color were shown in figure 3 and figure 4, respectively.

Both figures show linear removal efficiency with the increment of coagulant dosage. From figure 3, it is shown that the highest percentage of turbidity removal for banana peel and soybean are 23.2% and 15% respectively corresponding to 120 mg/L of coagulant dosage. While, for color removal (figure 4) shows nearly same removal efficiency for both coagulants.
4. Conclusions
The jar test experiments were performed on raw surface water. The coagulation experiments using soybean and banana peel indicated that coagulation process effectively removed turbidity and color from surface water sample using 40 – 120 mg/L of the natural coagulants. For future work, the optimum method of coagulation process can be done with high turbid water. The removal efficiency of turbidity and color due to effect of pH and temperature can also be found experimentally, which may further improve the removal efficiency by using these natural coagulants. Application of natural plant-based coagulants have demonstrated their efficiency in water treatment and are a reference for other new natural coagulants in Malaysia in reducing chemical coagulants usage. It is proven that natural plant-based coagulants have bright future and can minimize the chemical depending products in water purification process.

References
[1] Choy S Y, Prasad K M N, Wu T Y, Raghunandan M E and Ramanan R N 2014 J. Environ. Sci. (China) 26 2178–89
[2] Subramonian W, Wu T Y and Chai S P 2014 Ind. Crops Prod. 61 317–24
[3] Salleh S N M, Zin N S M and Othman N 2019 Sains Malays. 48 155–64
[4] Pritchard M, Mkandawire T, Edmondson A, O’Neill J G and Kululanga G 2009 Phys. Chem. Earth 34 799–05
[5] Yin C Y 2010 Process Biochem. 45 1437–44
[6] Kansal S K and Kumari A 2014 Chem. Rev. 114 4993–10