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Effectiveness of Local Waste Materials as Organic-Based Coagulant in Treating Water

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Abstract. The adequacy of chemicals as coagulants such as alum is all around perceived. Nevertheless, there are numerous drawbacks related with the use including high operational costs, impeding impacts on human wellbeing and generation of huge sludge volumes. In this manner, it is crucial to supplant these chemical coagulants with organic-based coagulants to minimize the downsides. Therefore, the aim of this study is to identify the suitability of selected local wastes in becoming organic-based coagulant as to treat raw water. Regarding choice of organic-based coagulants, this study focused on the local waste materials, which are chestnut peels, bagasse and maize cobs. These waste materials were prepared by washing, drying, grinding lastly sieving in obtaining powder of coagulants ready to be used. A jar test was then performed to decide the effect of individual characteristic coagulants on the effectiveness of turbidity removal under different working variables of pH and coagulant dosage. Based on the findings, bagasse contributed to the highest yield of 79.5% followed by chestnut and maize cob. From the jar test experiments, the optimum dosage of 90 mg/L and pH 7.5 was obtained. At these optimizations, highest turbidity removal of 97.3% was recorded by bagasse compared to the other tested natural coagulants. This showing that bagasse as one of the representatives of organic wastes has the potential to physically treat the water.

Keywords: Organic-based coagulant; Organic wastes; Coagulant dosage; Turbidity removal.

1. Introduction

In conventional water and wastewater treatment, coagulation and flocculation is one of the important processes [8]. Coagulation is a process whereby the particles adhered within each other thus, forming larger flocs which subsequently can easily settle at later stage. The addition of coagulant helps to destabilize the suspended colloidal particles hence, promoting subsequent coagulation [14]. In water, there is presence of colloidal particles which posing same negative charges. By adding coagulant, the neutralization process of these charges can be occurred.

Coagulation can be described as a complex chemical reaction that makes its dosing addition exhibits non-linear behaviour [2]. This makes the control of coagulation process in water and wastewater treatment is quite difficult. Uniform dispersion of coagulant in water or wastewater is important to increase particle-to-particle contact. Subsequent gentle and prolonged mixing times are among factors that are required to ensure uniform dispersion of coagulant. This is to encourage agglomeration of microscopic particles into larger flocs. Suspended polluting matter will adsorb to the large flocs. With more adsorption, the coagulated particles will increase in size and mass and finally will settle to the bottom of the tank once it is saturated with adsorbed suspended pollutants [12].

Until today, the conventional coagulant used is a chemical-based coagulant. There are various types of chemical coagulants such as aluminum sulfate (alum), ferric chloride, cationic polymers and



many others [1, 4, 6, 10]. Currently, in the water treatment process, compound that mostly used as a coagulant is the alum. Alum is capable in exhibiting good results for turbidity and color removal of raw water. In any case, there are numerous downsides related with the utilization of these coagulants. For example, high operational costs, inconvenient consequences for human wellbeing and the way that it is essentially influence pH of treated water. The utilization of chemical coagulants likewise will generally produce more end sludge product and for the most part, these sludge are harmful and danger. Due to such issue, legitimate treatment of the sludge before transfer is imperative. This sludge will be disposed at Secured Landfill, which at that point require more prominent expense [7].

The option of chemical coagulant, which is organic-based coagulant or also known as natural coagulant has been utilized in many countries as an effective coagulant. These coagulants were produced from different materials such as plant seeds, leaves and roots. Due to its promising results, a lot of developing countries are now using natural coagulant in their water and wastewater treatment on small scale. Among the common and established natural coagulants are *Moringa oleifera*, *Jatropha curcas*, *Strychnos potatorum*, and *Hibiscus sabdariffa* [11]. These coagulants are sustainable as there are less wellbeing risks and the expense of delivering these natural coagulants were more affordable than the chemical coagulants since it is locally accessible. The natural coagulants can also treat water of high turbidity and having remarkable removal proficiency [3, 5].

To date, the chemical coagulants are ending up less sustainable for coagulation of water and wastewater treatment due to different adverse impacts. It is currently crucial to supplant these coagulants with organic-based coagulants that can minimize the previously mentioned downsides. Therefore, the objective of this study is to identify the suitability of a selected local wastes in becoming natural coagulant as to treat raw turbid water. The feasibility analysis will look into the coagulant's physical characteristics and its potential in removing turbidity of a water.

2. Materials and Methods

2.1 Experimental procedure

In this study, raw water sample was collected from Water Treatment Plant, Taman Impian Emas, Skudai. The reason of this choice is that the water from this plant is a source of water supply to the consumers around Skudai area. The collected water sample has initial turbidity of 100 to 200 NTU. This water sample was treated using prepared organic-based coagulant and its effectiveness in terms of turbidity removal and coagulation activity is identified. For the preparation of natural coagulant, the chosen fruit seeds or fruit peels undergoes several preparation stages involving washing, drying, grinding, and sieving. These processes are conducted until final product in form of powder is obtained. The selected plant-based materials were bagasse, whole chestnut, maize cob and chestnut peel. The reason of these choices is that such materials are less likely been investigated until now. These materials were collected from the local markets and neighbourhoods. The prepared coagulant is then characterized for dry weight, yield and moisture content.

The study is the continued to determine the effect of pH and coagulant's dosage upon the efficiency of organic-based natural coagulants in reducing the turbidity. When the pH is constant at 7.5, the dosages were varied at 10 mg/L, 30 mg/L, 50 mg/L, 70 mg/L, 90 mg/L and 110 mg/L. This experiment resulted in an optimum dosage to be used at later experiment. Consecutively, the pH was varied at pH 2, 4, 7.5, 10 and 12 under the optimized dosage that obtained previously. In this study, sodium hydroxide (NaOH) of 2.0M was used to enhance the coagulant agent. The optimization of best dosage and pH for each of the prepared natural coagulants was determined based on the highest coagulation activity and turbidity removal.

2.2 Analytical methods

The prepared organic-based coagulants are characterized for yield and moisture contents. Yield is amount of the dry powder from the initial raw material of the selected organic-based natural coagulant. As for moisture content, it was analysed in order to determine how much water content in each prepared coagulant. The moisture content can be expressed in percentage as shown in Eq. (1).

$$\text{Moisture content (\%)} = \frac{(W_o - W_e)}{W_o} \times 100 \quad (1)$$

where,

W_o : Weight before drying (g)

W_e : Weight after drying (powder) (g)

Turbidity analysis was conducted by first preparing 500 mL of raw water sample prior and after the addition of coagulant of specified dosage. The sample was then placed in a glass cuvette of 10 mL and then measured using 2100P (HACH) Portable Turbidimeter. In order to investigate the potential of coagulation for the particles in turbid water under the effect of various natural coagulants, the parameter of coagulation activity is then conducted. The final turbidity of water sample after treated with respective natural coagulant of specified dosage (F_e) was taken during Jar Test. Additionally, the final turbidity of blank sample (without addition of natural coagulant) was as well recorded (F_o). The percentage of coagulation activity can be calculated using Eq. (2).

$$\text{Coagulation activity (\%)} = \frac{(F_o - F_e)}{F_o} \times 100 \quad (2)$$

where,

F_o : Final turbidity for blank water sample (NTU)

F_e : Final turbidity for natural coagulant (NTU)

3. Results and Discussions

3.1 Yield of the selected organic-based coagulant

Based on Figure 1, whole chestnut contributed to the highest yield with initial weight recorded as only 265g with resulted yield was 170g. This contributes to 64.2% of the whole prepared material in becoming an accessible organic-based coagulant. The second highest yield was contributed by maize cob. This particular material shows major difference of weight between initial weight, which was 345g and yield of 80g. This contributes to 23.2% of the whole prepared material in becoming the accessible organic-based coagulant. The percentage is quite low, thus showing that maize cob is a least preferable material to be chosen because the preparation of the initial material needs to be abundant with the final production of the coagulant is very least. Meanwhile, bagasse and chestnut peel resulted in a quite similar yield. Based on Figure 1, it can be seen that the weight of initial material for bagasse is 88g with its yield recorded as 70g. This contributes to 79.5% of the whole prepared material in becoming the accessible organic-based coagulant.

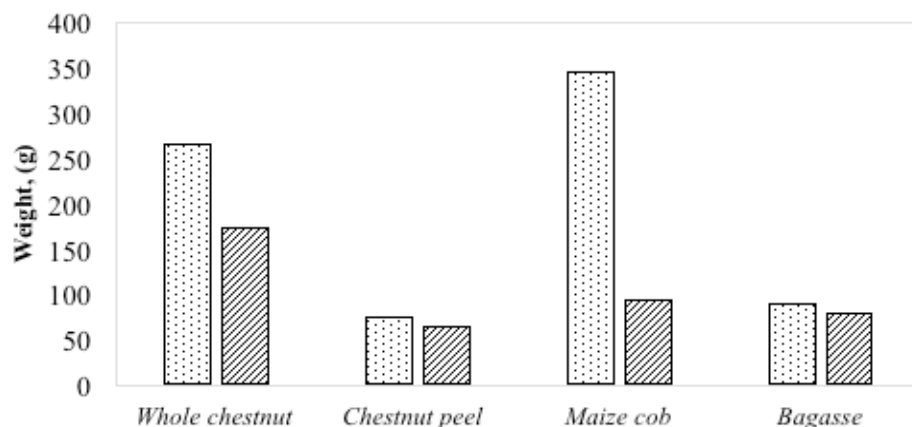


Figure 1. Experimental results of yield (□ Initial materials; ▨ Yield)

As for chestnut peel, the weight of initial material recorded as 74g with its yield of 58g thus, contributes to 78.4% of the whole prepared material in becoming the accessible organic-based coagulant. Highest percentage indicating that the final form of coagulants can be easily generated from the small batch of initially prepared materials. Overall, the findings concluded that bagasse and chestnut peel are among the feasible materials to work with in producing the final form of organic-based coagulant. This followed by whole chestnut and lastly, maize cob. Nevertheless, in terms of preparation of materials at initial stage, whole chestnut seemed to be easy to gather as greater weight can easily be obtained compared to bagasse and chestnut peel.

Table 1 shows the dry weight and moisture content for each of the prepared natural coagulants. Based on Table 1, the measured values of moisture content reveals variability with the range between 13 to 75%. The moisture content for maize cob is higher with 74.5% compared to the other natural coagulants. This is because the water content in the maize cobs evaporated quite slow during the prior drying process. Such high moisture contents resulted to a difficulty to obtain yield at the end of preparation process. This results supported the observation of yield for maize cob that is lesser than the other materials.

Table 1. Dry weight and moisture contents of the prepared organic-based coagulants

Natural Coagulants	Initial Weight (g)	Dry Weight (g)	Moisture Content (%)
Whole chestnut	265	173	34.7
Chestnut peel	74	61	17.6
Maize cob	345	88	74.5
Bagasse	88	76	13.6

On the other hand, chestnut peel and bagasse were both contained low moisture content of 17.6% and 13.6%, respectively. Too low moisture content is also not very good as most of the coagulant agent in the material will be dried, therefore might not be effective during coagulation process. According to Madukwe *et al.* [9], the moisture content for dry *Moringa oleifera* leaf powder was 7.1% which is very low and not suitable to become alternative for chemical based coagulant in water treatment. Meanwhile, Shilpa *et al.* [13] also reported that *Hyacinth* bean peels has lower moisture content of about 9.8% thus, showed less ability to be one of the best natural coagulant. The remaining material, which is whole chestnut containing a moderate moisture content of 34.7%, thus resulted in greater yield among all other natural coagulants.

3.2 Effect of dosage and pH of selected natural coagulant in treating water

As for coagulant's dosage and pH, Figure 2 and Figure 3 represents the profile of turbidity removal when various dosages and pH were experimented.

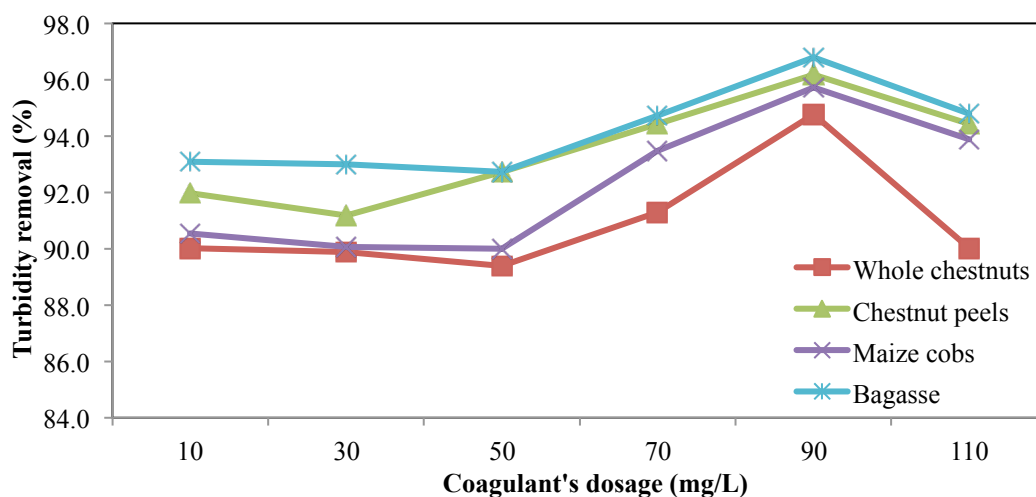


Figure 2. Turbidity removal of tested natural coagulants at different dosages (at pH 7.5)

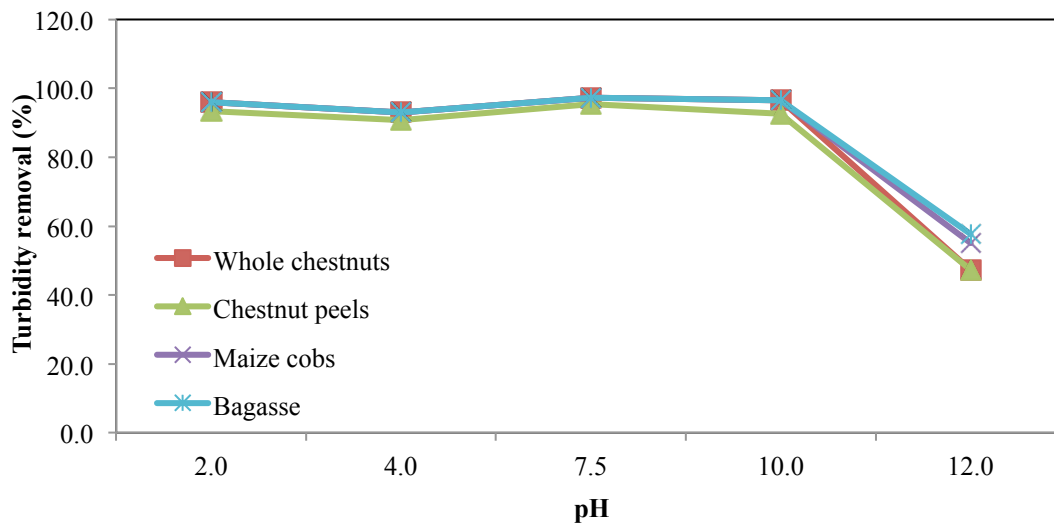


Figure 3. Turbidity removal of tested natural coagulants at different pH (at dosage 90 mg/L)

Based on Figure 2, it can be seen that the optimum dosage is 90 mg/L. Bagasse is recorded as the natural coagulant that resulted in higher percentage of turbidity removal of approximate 96.0%, followed by chestnut peel, maize cob and whole chestnut. Although, all natural coagulants resulted in almost similar range of turbidity removal at 90 mg/L, the starting percentage is rather high for bagasse compared to the other coagulants. Hence, makes bagasse as a feasible natural coagulant to be used in the treatment. Meanwhile, based on Figure 3, it can be seen that the optimum pH is 7.5. Yet again, bagasse is recorded as the natural coagulant that resulted in higher percentage of turbidity removal by 97.3%, followed by maize cob, whole chestnut and chestnut peel. Although all natural coagulants resulted in almost similar range of turbidity removal at pH 7.5, the starting percentage is rather high for bagasse compared to the other tested coagulants. This suggesting that bagasse is a feasible natural coagulant to be used in treating polluted river water.

Conclusions

Local waste materials are potential organic-based coagulants that can be used to treat water sustainably. On top of its significant effect on treatment removal performances, organic-based natural coagulants have also assembled great interests worldwide due to its ease of biodegradability and environmental friendly nature. Main contribution of this study focuses on the perspective that the organic-based coagulant can pose remarkable treatment performance, at par with chemical coagulant. Moreover, the uses of organic-based coagulants were all based from local plant wastes, which can help in reducing the amount of wastes to be disposed at sanitary landfill. Overall, the conclusions that can be drawn from this study are as the following below.

1. Bagasse is among the feasible materials to work with in producing the final form of organic-based coagulant, followed by chestnut and maize cob. However, in terms of preparation of materials at initial stage, whole chestnut is easy to gather as greater weight can be easily obtained.
2. Based on Jar Test experiments, the optimum dosage of 90 mg/L and pH 7.5 was obtained. At these optimizations, highest turbidity removal of 97.3% was recorded by bagasse compared to the other tested organic-based coagulants.

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References

- [1] Aboulhassan M A, Souabi S, Yaacoubi A and Baudu M 2006. Improvement of paint effluents coagulation using natural and synthetic aids. *Journal of Hazardous Materials*. **138** 40–45.
- [2] Adgar A, Cox C S and Jones C A 2005. Enhancement of coagulation control using the streaming current detector. *Bioprocess and Biosystems Engineering*. **27** 349–357.
- [3] Amran A H, Zaidi N S, Muda K and Loan L W 2018. Effectiveness of Natural Coagulant in Coagulation Process: A Review. *International Journal of Engineering & Technology*. **7(3.9)** 34-37.
- [4] Baptista A T A, Coldebella P F, Cardines P H F, Gomes R G, Vieira M F, Bergamasco R and Vieira A M S 2015. *Chemical Engineering Journal*. **276** 166-173.
- [5] Bhuptawat H, Folkard G K and Chaudhari S 2007. Innovative physico-chemical treatment of wastewater incorporating *Moringa oleifera* seed coagulant. *Journal of Hazardous Materials*. **142(1)** 477-482.
- [6] Chang Y S, Kim J H, Murugesan K, Kim Y M, Kim E J and Jeon J R 2009. Use of grape seed and its natural polyphenol extracts as a natural organic coagulant for removal of cationic dyes. *Chemosphere*. **77** 1090–1098.
- [7] Huang X, Bo X, Zhao Y, Gao B, Wang Y, Sun S, Yue Q and Li Q 2014. Effects of compound bioflocculant on coagulation performance and floc properties for dye removal. *Bioresource Technology*. **165** 116–121.
- [8] Jiang J Q 2015. The role of coagulation in water treatment. *Current Opinion in Chemical Engineering*. **8** 36-44.
- [9] Madukwe E U, Ugwuoke A L and Ezeugwu J O 2013. Effectiveness of dry *Moringa oleifera* leaf powder in treatment of anaemia. *International Journal of Medicine and Medical Sciences*. **5(5)** 226-228.
- [10] Okuda T, Baes A U, Nishijima W and Okada M 1999. Improvement of extraction method of coagulation active components from *Moringa oleifera* seed. *Water Research*. **33(15)** 3373–3378.
- [11] Pritchard M, Mkandawire T, Edmondson A, O’neill J G and Kululanga G 2009. Potential of using plant extracts for purification of shallow well water in Malawi. *Physics and Chemistry of the Earth, Parts A/B/C*. **34(13-16)** 799-805.
- [12] Ratnaweera H and Fettig J 2015. State of the art of online monitoring and control of the coagulation process. *Water*. **7(11)** 6574-6597.
- [13] Shilpa B S, Akanksha K and Girish P 2012. Evaluation of cactus and hyacinth bean peels as natural coagulants. *International Journal of Chemistry and Environmental Engineering*. **3(3)** 187–191.
- [14] Zueva S B, Ostrikov A N, Ilyina N M, De Michelis I and Vegliò F (2013). Coagulation processes for treatment of wastewater from meat industry. *International Journal of Waste Resources*. **3** 130.