A PRELIMINARY EVALUATION OF *ALOE VERA* RIND AS NATURAL COAGULANT FOR WATER TREATMENT

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ABSTRACT

Aloe vera is a species of Aloe, native to northern Africa. It is a stemless or very short-stemmed succulent plant. *Aloe vera* is now widely used in cosmetic and alternative medicine industries. In this study, the coagulation performance of rind from *Aloe vera* was investigated for the first time. Rind of *A. vera* was evaluated for turbidity removal from synthetic turbid water samples by using jar test. *A. vera* rind coagulant was extracted with different concentration of sodium chloride (*Av*C-SC) from ground rind shows high turbidity removal up to 90%. The effects of coagulant concentration, pH and initial turbidity on coagulation performance were also investigated. The results showed the combination of *Av*C-SC and alum significantly increased the removal of turbidity and water with 7.7 NTU could produce from 204 NTU of synthetic turbid water. Thus, *Av*C-SC could be used effectively as aid to alum as well as reduce cost of treatment and use of alum by about 50%. This readily available rind from *A. vera* plant may offer an appropriate solution for producing potable water in some developing countries.

KEYWORDS

***Aloe vera*, Turbidity removal, Natural coagulant, Water treatment, Coagulation.**

1 INTRODUCTION

Water quality is very important to measure and secure our daily routines and commercial activities. It is excruciatingly essential to have access to clean water supply thus, in order to meet the demand of clean water supply, researchers, governments and public has given a lot of attention to water treatment process.
The best immediate option in treating water is to use simple and relatively cost effective technology such as coagulation and flocculation process. Coagulation is a common process in water treatment for destabilizing colloid impurities and producing large floc aggregates which can be removed from the water in subsequent clarification / filtration process. Conventional chemical-based coagulant commonly used, can be classified into inorganic coagulant namely aluminium chloride, Ferric chloride, polyaluminium chloride (PAC) (Philips et al., 2003; Renault et al., 2009) and synthetic organic polymers such as polyacrylamide (PAM) (Li et al., 2006; Šćiban, 2009). However, the most widely practiced in water treatment all over the world is aluminum salts because it is cheaper. The effectiveness of these chemicals as coagulant is well recognized. Disadvantages associated with the usage of these coagulants are such as produce large Aluminium sludge volumes, affect the pH of the treated water, bring detrimental effect to human health and can develop Alzheimer disease in human being (Madrona et al., 2010; Sanghi et al., 2002). Therefore, it is desirable to replace or minimize the usage of Aluminium salts (Alum) by developing the alternative natural or plant-based coagulants to counteract the undesirable chemical sludge from water treatment process.

Natural coagulant has many advantages compared to Alum. Natural coagulant is biodegradable, mostly has natural pH and can significantly reduce the cost of water treatment (Pritchard et al., 2009; Santos et al., 2009). *Aloe vera* is a plant that has potential to be used in the water treatment because its characteristic is quite similar to cactus which has proven as good coagulant. *Aloe* is a genus of succulent plants, meaning that it exhibits a high rate of water retention. There are some 400 species of *Aloe* worldwide. The genus *Aloe* belongs to the family Liliaceae, including the species *Aloe barbadensis* Miller, commercially known as ''*Aloe vera*'' (Vega et al., 2007). This specie is believed to originate in northern Africa; like other species, nevertheless, it lacks a definitive area of origin, given the wide geographic range in which the plant can grow and thrive. Nowadays, *Aloe vera* also can be found in Asia pacific. *Aloe vera* plant is widely used in food, cosmetic and alternative medicine industries.
In this study the coagulation performance of *Aloe vera* rind as natural coagulant in water treatment been investigated. Determine the effect of salt concentration on natural coagulant extraction, the effects of coagulant concentration, pH and initial turbidity on coagulation performance were also investigated as well as the application of *Av*C-SC in river water treatment.

2 METHODS

2.1 EXTRACTION OF COAGULANT *AV*C-SC

Harvested *Aloe vera* leaf was washed and cleaned then rind was removed from the leaf and cut to the size of 2 cm and 5g of the dried *Aloe vera* rind was grinded and added into 100 mL of 0.5M Sodium Chloride. The suspension was mixed well for 30 minutes and filtered. The filtrate was ready to be used as coagulant stock (*Av*C-SC).

2.2 EXPERIMENTAL SET-UP

Synthetic turbid water was prepared with different kaolin clay concentration and deionized water to provide turbidity of 50–500NTU and pH was adjusted to 4 by 1 M of NaOH and HCl. Jar test analysis (JLT6, VELP SCIENTIFICA, Italy) was being conducted in order to find the optimum pH and to determine the optimum dosage of coagulant to function effectively in treating water. Synthetic turbid water samples (200 ml) were stirred at 100 rpm for 3 min and coagulants were added into the samples during this time. Then the samples were stirred at 30 rpm for 30 min. After the mixing, the samples would stand for 30 min and then the turbidity of the supernatant liquors was measured by a turbidity meter (2100N, HACH, USA).

3 RESULTS AND DISCUSSION

3.1 EFFECT OF SODIUM CHLORIDE CONCENTRATION ON NATURAL COAGULANT (*Av*C-SC) EXTRACTION

Fig. 1 showed the effect of different concentration of Sodium chloride solution on *Av*C-SC extraction. Sodium chloride was prepared with different concentrations of 0.05 to 3 M as extraction solution, used to determine the highest extraction of active agent coagulant (AvC-SC) from *Aloe vera* rind. In general, *Av*C-SC extracted by different concentrations of sodium chloride was able remove more than 75% of turbidity from synthetic turbid water with initial 400 NTU at pH 4. The lowest turbidity removal it was recorded when 0.05 M of sodium chloride was used to extract the active agent of *Av*C-SC. Because the lowest removal of turbidity, means the lowest concentration of active agent extracted (*Av*C-SC) by sodium chloride. The *Av*C-SC extraction increased slightly as the sodium chloride increased and the highest extraction was by 1.5 M as the final turbidity was 38.5 NTU. Beyond this concentration of salt the turbidity removal decreased which shows sodium chloride with concentration higher than 1.5M reduced or effected the extraction of *Av*C-SC, thus 1.5 M of sodium chloride was chosen for the next experiments.

3.2 EFFECT OF *Av*C-SC CONCENTRATION ON TURBIDITY REMOVAL

Different concentrations of *Aloe vera* rind were used to prepare *Av*C-SC coagulant solution to study the effect of coagulant dosage on turbidity removal (Fig. 2). Study showed the turbidity removal increased as the *Av*C-SC coagulant increased. *Aloe vera* rind 375 mg/L reduced the turbidity of synthetic turbid water from 208 to 37.4

NTU. Further increasing in *Aloe vera* rind concentration (overdosage) decreased the turbidity removal (Ndabigengesere et al., 1995). Study shows the concentration of *Av*C-SC used in this experiment was quite high in comparison with concentration of common chemical coagulant used in water treatment. Therefore, for better understanding of *Av*C-SC coagulant, more study in the future need to be done in *Av*C-SC active agent purification, chemical composition and zeta potential.

3.3 EFFECT OF pH ON TURBIDITY REMOVAL

Fig. 3 showed the effect of pH on *Av*C-SC coagulation performance. Synthetic turbid water with different pH 4 to 9 were used to study the effect of pH on coagulation process. Results showed the *Av*C-SC perform highly at acidic pH than neutral, final turbidity with 46.9 NTU could be obtained from initial turbid of 207 NTU at pH 4. While 50% was the lowest turbidity removal recorded by *Av*C-SC at pH 9. Generally, the coagulation efficiency of *Av*C-SC was increased as the pH decreased. That because the low pH of kaolin suspension (acidic condition) has more positive H^+ ion, which help to neutralize the negative charges of kaolin particles and influenced flocs formation. *Av*C-SC could be an alternative natural coagulant use to remove Alizarin Violet 3R dye and acid dyes from aqueous solutions as the highest removal of these dyes could be achieved at acidic pH 4 (Beltrán-Heredia et al., 2011; Zonoozi et al., 2011).

3.4 EFFECT OF INITIAL KAOLIN CONCENTRATION ON TURBIDITY REMOVAL

The study investigated the effect of kaolin particles concentration on *Av*C-SC coagulation efficiency (Fig. 4). Experiments showed the turbidity removal was increased as the initial turbidity increased (Katayon et al., 2006; Nkurunziza et al., 2009). The results showed that turbidity removal influenced by the initial turbidity as the highest turbidity removal was 92% when the initial turbidity 400 NTU and the lowest was 51.4% when the initial turbidity 50 NTU.

3.5 EFFECT OF MIXED COAGULANT (*AVC-SC* WITH ALUM) CONCENTRATION ON TURBIDITY REMOVAL

However, the *Av*C-SC showed a good turbidity removal, but couldn't reduce the turbidity of water to lower than 5 NTU (drinkable water) and no significant results were recorded at neutral pH. Therefore the study investigated the effect of mixed coagulant (*Av*C-SC + alum), mixing ratio 1:1, used to treat turbid water with initial turbidity 204 NTU at pH6 (Fig. 5). Experiments showed the turbidity removal was increased dramatically and final turbidity close to 5 NTU could be obtained as the mixed coagulant dosage reached to 20 gm/L, then removal of turbidity decreased slightly as the mixed coagulant increased (over dosage). The same phenomena was observed when mixed coagulant cactus with $AlCl_3{\cdot}6H_2O$ recorded highest turbidity removal than cactus only (Zhang et al., 2006). Thus, *Av*C-SC could be used effectively as aid to alum as well as reduce cost of treatment and use of alum by about 50%.

3.6 EFFECT OF pH ON WATER TREATED BY MIXED COAGULANT

The effect of pH on coagulation using mixed coagulant 20mg/L to treat synthetic turbid water with initial turbidity 203 NTU was investigated. Fig. 6 showed the mixed coagulant was quite efficient and turbidity of 7.5 NTU could be produced at pH 6. However, mixed coagulant showed insignificant removal of turbidity at pH range 3 to 5 and pH 8. This result shows mixed coagulant could be potential coagulant that can used in real water treatment plants.

3.7 COAGULATION EFFECT OF MIXED COAGULANT ON RIVER WATER

Sample of river water was taken from Sungai Langat at the Latitude of 2°57'56.90"N and Longitude 101°47'8.33"E, Selangor, Malaysia. The initial turbidity was 110 NTU, TSS 240 mg/L, COD 70 mg/L and pH 6.3. Table 1 showed three coagulants were used to treat river water. The results were that the maximum turbidity removal was 96.1 % (final 4.3 NTU) recorded by alum then mixed coagulant was able to produce water with low turbidity close to that produced by alum. While *Av*C-SC showed insignificant removal of turbidity of 78.6 %. The final total suspended solids of river water treated by alum, mixed coagulant and *Av*C-SC were 25, 45 and 65 mg/L, respectively. In addition, the study was investigated the reduction of COD by these coagulants and results showed the final COD were 10, 20 and 40 mg/L of water treated by alum, mixed coagulant and *Av*C-SC, respectively. In general, results showed the mixed coagulant was able to treat the river water efficiently and cost effectively.

Table 1:Different types of coagulants used to treat river water

Coagulant	Final Turbidity NTU	Turbidity Removal %	TSS (mg/L)	COD (mg/L)
Alum	4.30	96.1	25.0	10.0
Mixed coagulant (*Av*C-SC + alum)	7.7	92.6	45.0	20.0
*Av*C-SC	23.5	78.6	65.0	40.0

4 CONCLUSIONS

Natural coagulant extracted from *Aloe vera* rind by sodium chloride showed coagulation properties through the jar test by using kaolin suspension as module of synthetic turbid water. The *Av*C-SC did not record any desirable result as principle coagulant. In addition, *Av*C-SC showed low coagulation performance at neutral pH, which most of surface water in range of 6 to 9. More importantly, *Av*C-SC showed excellent results when used in mixed coagulant (alum + *Av*C-SC) with ratio of 1:1 and water with low turbidity close to turbidity of standard drinking water could be achieved. Thus, *Av*C-SC could be used effectively as aid to alum as well as reduce cost of treatment and use of alum by about 50%.

Figure 1: The effect of Sodium chloride concentration on AvC-SC extraction

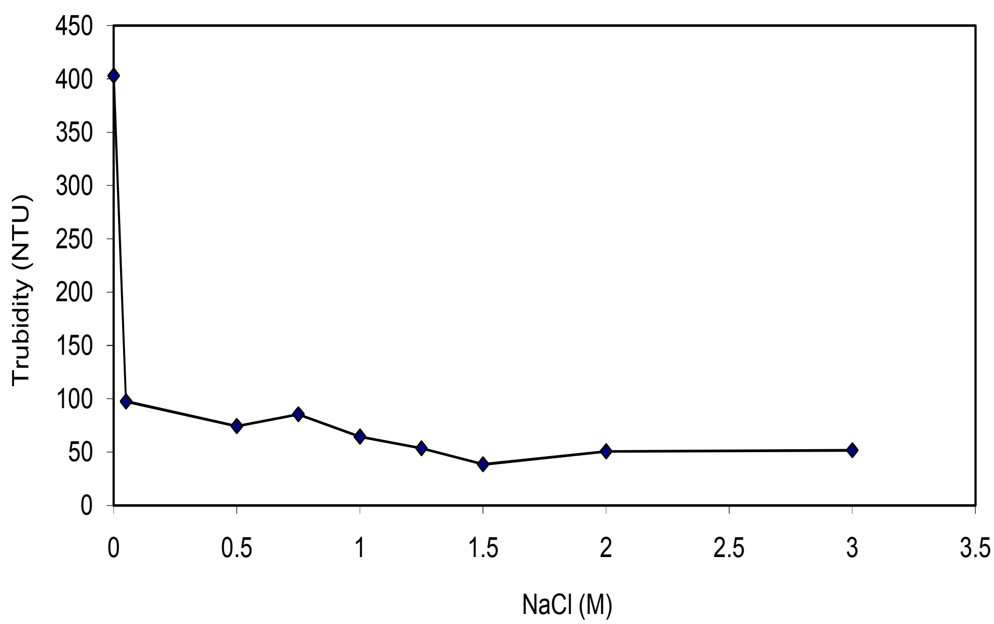


Figure 2: The effect of AvC-SC concentration on turbidity removal

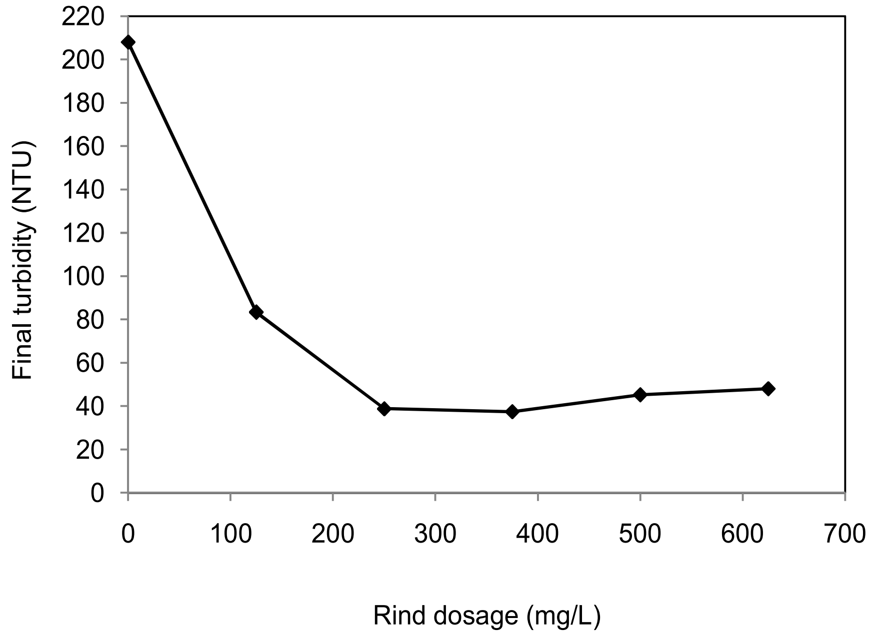


Figure 3: The effect of pH on turbidity removal using AvC-SC coagulant initial turbidity 207 NTU

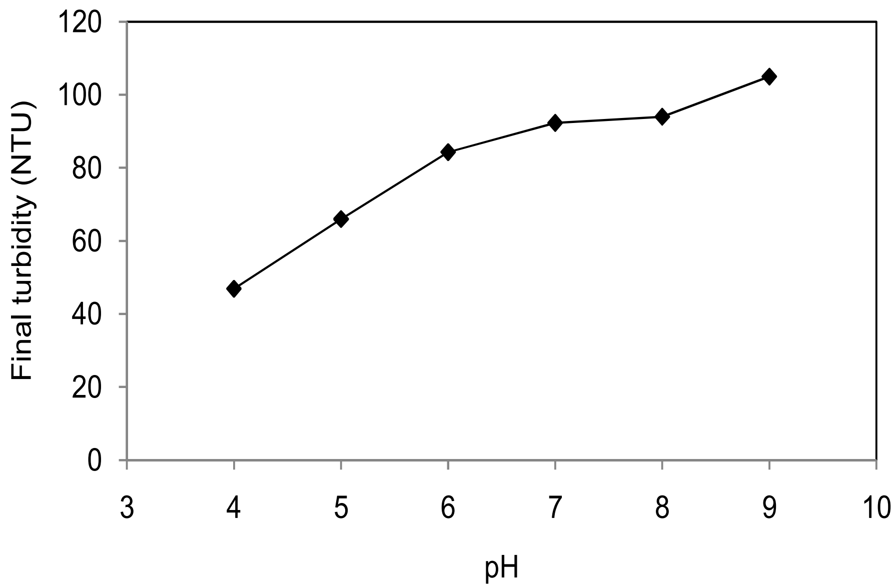


Figure 4: The effect of initial turbidity on turbidity removal using AvC-SC coagulant

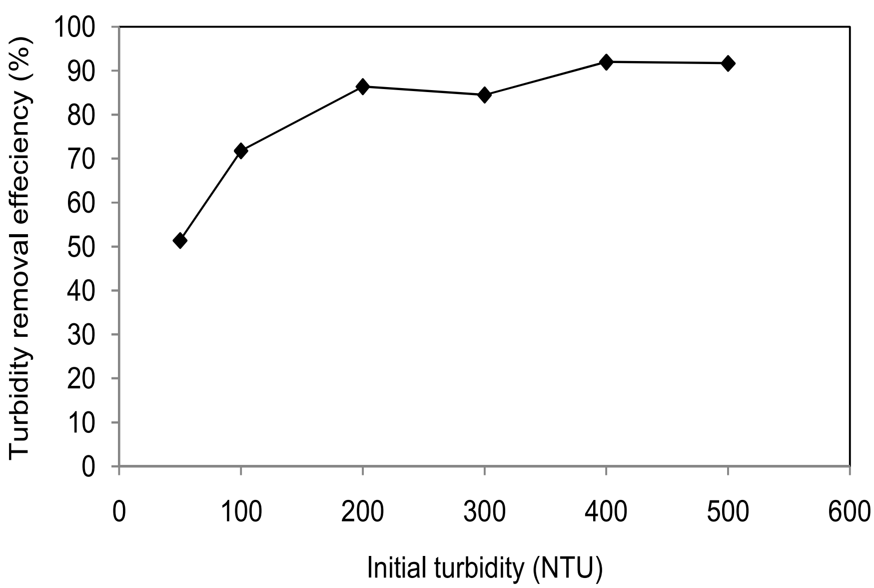


Figure 5: The effect of mixed coagulant concentration on turbidity removal at pH 6

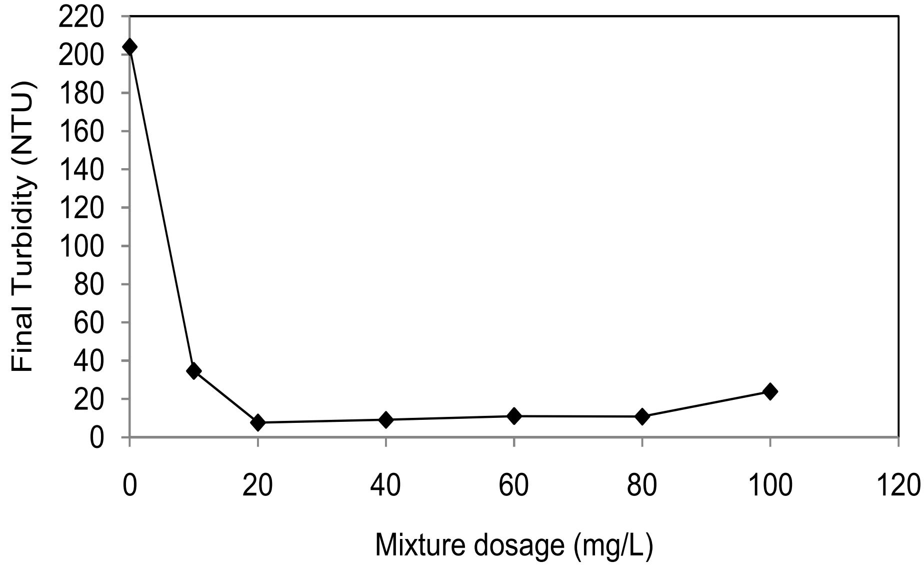
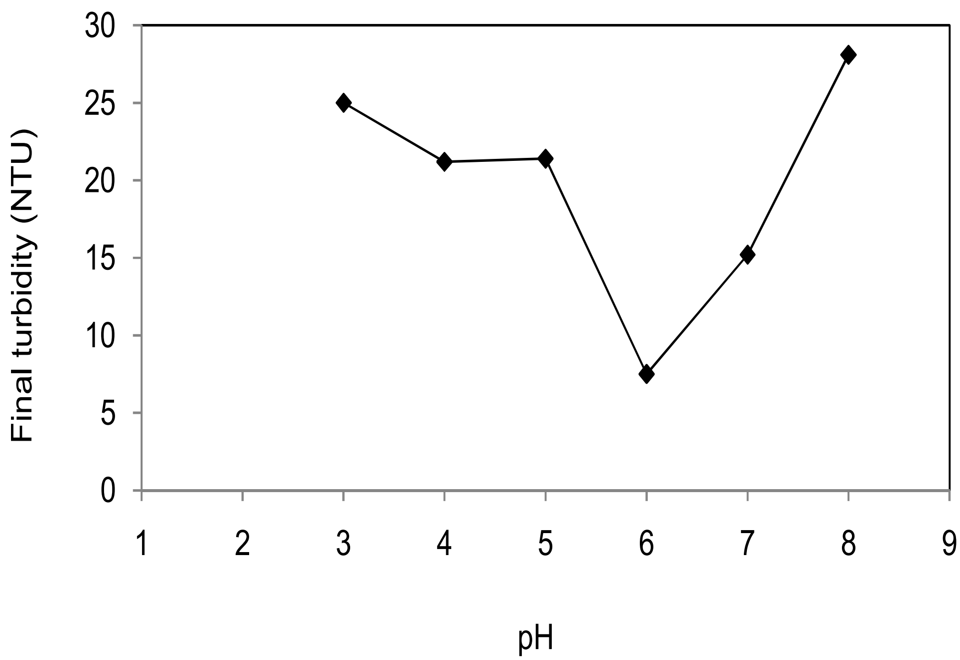


Figure 6: The effect of pH on turbidity removal using mixed coagulant



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