

## Application of alum and chickpea (*cicer arietinum*) in removing color from leachate

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**Abstract.** Dual coagulant has the potential to improve the coagulation process. In leachate treatment coagulation/flocculation can be used as a main treatment method or as a polishing/tertiary treatment step. Application of natural coagulant as coagulant aids able to increase the formation of floc and the removal ability of the coagulation process. This study was focusing on the ability of dual coagulants made from chemical coagulant (Alum) and natural coagulant (Cicer Arietinum (CA)) in removing colour from leachate. Jar test was carried out to investigate the effect of dose and pH on the removal ability of the dual coagulant. The optimum pH and dose for dual coagulant were obtained at pH 6.0 with dose of Alum at 4 g/L and dose of CA at 0.6 g/L with 94% removal of colour. While the optimum removal of colour for single Alum (4 g/L) and single CA (1.4 g/L) were recorded as 88% and 22%, respectively. The removals obtained using single natural and chemical coagulants were not as good as those obtained by dual coagulant. Thus, addition of CA as a coagulant aid for alum, able to increase the removal of color from leachate and has the potential to be applied as a treatment method for leachate.

### 1. Introduction

Most of solid waste disposed through landfilling [1]. The negative outcomes of landfill is the production of leachate. Leachate is classified as highly polluted wastewater and its composition varied over period of time. Leachates contain large amounts of organic matter, humic-type constituents, ammonia-nitrogen, heavy metals, chlorinated organic/ inorganic, and dark in color [2]. The compound of leachate has turned into the subject of dirtied wastewater and causing pollution to surface water and groundwater [3]. Treatment of leachate consist of biological, chemical and physical method. Suitability of this treatment is depending on the composition of the leachate.

Coagulation and flocculation are categories as physical and chemical treatment method. This method is suitable for partially and stable leachate. Mixing intensity, coagulant type, pH, duration, and dose are amongst the factors that are considered in coagulation and flocculation. One of the main factors considered is type of coagulant. Coagulant is divided into chemical and natural coagulant. Chemical coagulant is the most commonly used coagulant in coagulation and flocculation treatment. To reduce



the use of chemical coagulants, natural coagulants are the best alternative. Natural coagulants are environmentally friendly materials that would not affect the health of humans and other living organisms. There is a variety of natural coagulants used around the world, depending on the suitability of the material as coagulant [4].

CA known as chickpea is the second most widely grown legume crop after soybean, accounting for a substantial proportion of human dietary nitrogen intake and playing a crucial role in food security in developing countries [5]. CA seeds are usually used for human consumption [6]. CA is the third most important pulse crop worldwide and South Asia alone contributes approximately 72% of the production [7]. CA seeds are rich in proteins but they also contain a substantial amount of free amino acids, especially arginine [8]. Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification [9]. The properties of CA is suitable to be used as coagulant aid [9]. However, the application of chickpea as coagulant aid is still at research stage. Thus, more study need to be carried out to fully utilized its potential. The objective of this study is to determine the ability of CA as coagulant aid for alum by assessing the percentage removal of color from leachate and to compare the removal of color of dual coagulant (alum+ CA) with single coagulant (alum and CA) under the influence of pH and dose.

## 2. Methodology

Samples of leachate were collected from Simpang Renggam landfill located in Johor, Malaysia. The sampling procedures and analytical test for leachate were conducted according to APHA 2005 [10]. The characteristics of raw leachate from Simpang Renggam landfill was shown in table 1. All coagulation experiments were carried out using leachate sample.

H<sub>2</sub>SO<sub>4</sub> and NaOH were used to adjust the pH of the leachate. 500 mL of raw leachate from Simpang Renggam was added to each of the jar test beakers. The stock solution of alum used in this study was 3% solution. The dose of alum was added to the leachate at the beginning of rapid mixing, while dose for CA was added at the beginning of slow mixing. The speeds of rapid and slow mixing were shown in table 2. The color of leachate was measured by using HACH DR6000 spectrophotometer (Method 8006) before and after treatment to determine the percentage removal. Optimum value was selected by selecting the highest removal of color obtained.

**Table 1.** Characteristic of raw leachate from Simpang Renggam landfill

Turbidity (NTU) *	Suspended Solids (mg/L) *	Colour (ptCo) *	pH*
44.55	146.25	37.5	8.25

\*Average value of 6 leachate samples

**Table 2.** Constant jar test factor [11]

Factor	Value
Rapid mixing (rpm)	200
Rapid mixing duration (minutes)	4
Slow mixing (rpm)	30
Slow mixing duration (minutes)	15
Settling time (minutes)	30

### 2.1 Preparation of CA.

The preparation of CA stock was adopted from Asrafuzzaman *et al* [12]. The CA powders were sieved (75 µm size sieved size). Sieved CA was added into distilled water to make 0.01 g/L CA solution. The

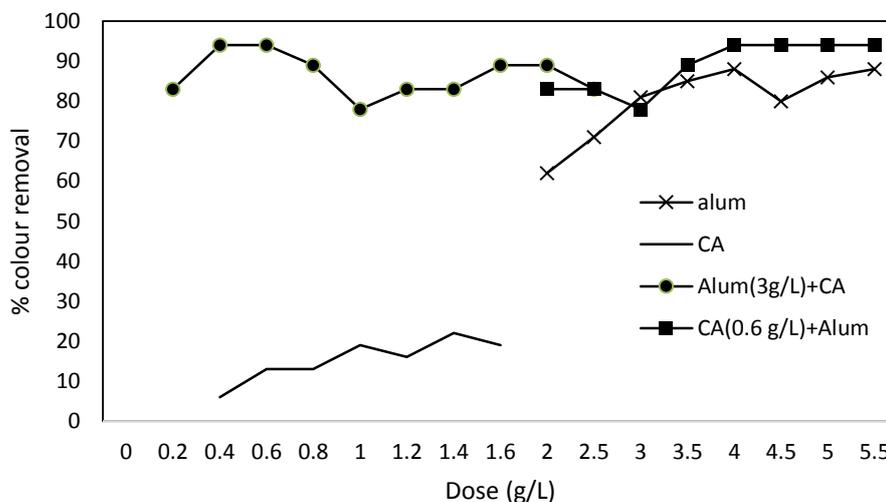
solution was vigorously mix for 45 minutes using a magnetic stirrer to promote water extraction of the coagulant proteins, and then filtered (Whatman no. 42, 125 mm dia.).

**3. Results and Discussion**

In this study, colour efficiency of leachate effluent treated by single alum coagulant, single CA coagulant and dual coagulant were compared in figure 1. As shown in figure 1, the colour removal ability of CA was the lowest and indicated that CA as single coagulant was not effective in removing colour. While alum, as single coagulant recorded 88% colour removal at 5.5 g/L. Application of dual coagulant increased the removal ability. Alum 3 g/L+CA and CA 0.6 g/L+alum, shown higher trends compared to single CA and alum. Thus, addition of CA improved the coagulation process. However, the doses of alum and CA should be kept sufficient and not overdosing to avoid re-stabilization [13].

At 2 g/L alum and 0.6 g/L CA, 83 % colour removal was achieved. At 2 g/L alum as single coagulant, just 62% colour removal was obtained. Therefore, addition of CA increased the colour removal ability compared to single alum. At optimum dose of single alum (5.5 g/L), the removal was increased from 88% to 94% after addition of 0.6 g/L CA. This data in in-line with the previous study [14].

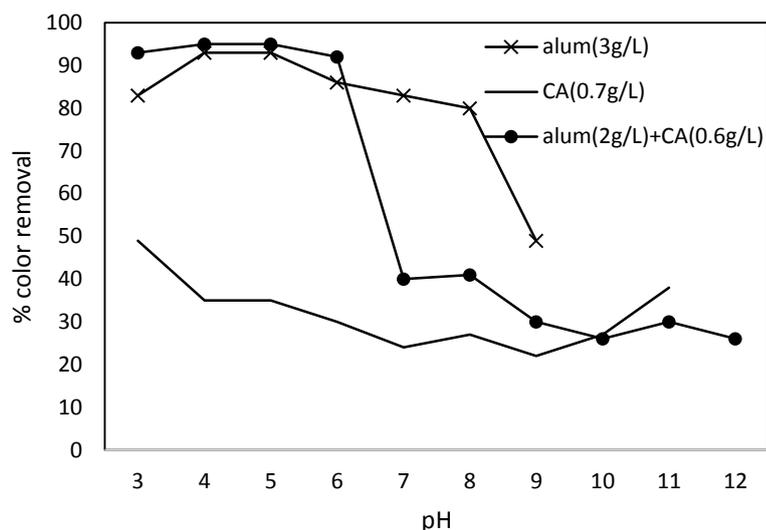
Based on figure 1 addition of CA as dual coagulant, had better colour removal compared to alum as single coagulant. Dual coagulant (alum 3.5 g/l and CA 0.6 g/L), achieved 89% colour removal with 36% less alum dose compared to single alum that required 5.5 g/L dose. Removal rate 94% was also achieved by dual coagulants at lower dose of alum (4 g/L) with the aids of 0.6 g/L CA. Addition of CA most likely increased the weight of floc and enhanced the colour removal. Based on the result, addition of CA able to reduce the dose of alum and enhanced the coagulation efficiency. It can be concluded that addition of CA resulted in possible reduction of treatment cost and health effect.



**Figure 1.** Removal of color under the influence of dose (leachate at pH 6)

The following experiments were designed to find the optimal pH of dual coagulant (alum 2 g/L+CA 0.6 g/L), single alum (3g/L) and single CA (0.7 g/L) as shown in figure 2. Performance of CA as single coagulant is still the lowest compared to alum and alum+CA. Removal of color from leachate under the influence of pH at acidic condition, resulted on similar trend for alum, CA and alum+CA. However, at pH 7 alum shows higher removal compared to CA and alum+CA. The amount of alum added was more than amount of CA, thus most of the coagulation optimum condition will favoured the optimum condition of alum as a single coagulant. The difference of percentage removal ability of alum and alum+CA were not too far.. However, at pH 3-6, alum+CA recorded slightly higher removal compared to alum and this indicates that the pH condition is suitable for alum and CA as dual coagulant.

Optimum pH for maximum colour removal efficiencies of alum+CA, alum and CA were at 4, 4 and 3, respectively. The colour removal recorded at this optimum pH for alum+CA, alum and CA were 95%, 93% and 35%, respectively. As shown in figure 2, reduction of removals were recorded at alkaline condition for all of the coagulants tested. This data was in good agreement with the previous finding [7]. The experimental data indicated that dual coagulant and single alum and CA performed better at acidic condition.



**Figure 2.** Removal of color under the influence of pH

#### 4. Conclusion

The application of Alum+CA as main coagulant and coagulant aid in leachate, enhanced the colour removal. Dual coagulation (Alum+CA) is more effective than a single coagulant. At pH 6 and dose of dual coagulant 4 g/L (alum) and 0.6 g/L (CA), 94% colour removal was recorded. The study has shown a good potential of CA to be used as natural coagulant aid in leachate treatment.

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#### References

- [1] Mohd-Kamil N A F and Abdul-Talib S 2010 Hazards due to Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals at the closed Kubang Badak landfill, Selangor *Sc. & Social R. (CSSR)* **1024**
- [2] Tatsi A, Zouboulis A I, and Samaras P 2003 Coagulation–flocculation pretreatment of sanitary landfill leachates *Chemosphere* **53** 737
- [3] Moraes P B and Bertazzoli R 2005 Electrodegradation of landfill leachate in a flow electrochemical Reactor *Chemosphere* **58** 41
- [4] Kukić D V, Šćiban M B, Prodanović J M, Tepić A N and Vasić M A 2015 Extracts of fava bean (*Vicia faba* L.) seeds as natural coagulants *Ecological Eng.* **84** 229
- [5] Varshney R K, Song C, Saxena R K, Azam S, Yu S, Sharpe A G and Cook D R 2013 Draft genome sequence of chickpea (*Cicer arietinum*) provides a resource for trait improvement. *Nature Biotech.* **31** 240

- [6] Sánchez-Vioque R, Clemente A, Vioque J, Bautista J and Millán F 1999 Protein isolates from chickpea (*Cicer arietinum* L.): chemical composition, functional properties and protein characterization *Food Chem.* **64** 237
- [7] Choubey S, Rajput S K and Bapat K N 2012 Comparison of Efficiency of some Natural Coagulants-bioremediation *Int. J. Emerging Tech. & Adv. Eng.* **2** 429
- [8] Cortés-Giraldo I, Megías C, Alaiz M, Girón-Calle J and Vioque J 2016 Purification of free arginine from chickpea (*Cicer arietinum*) seeds *Food Chem.* **192** 114
- [9] Patil C and Hugar M M 2015 Treatment of dairy wastewater by natural coagulants *Int. Research J. of Eng. & Tech.* **2** 1120
- [10] APHA AWW. WEF. 2005 Standard methods for the examination of water and wastewater (American Public Health Association, American Water Works Association, and Water Environment Federation, 2005)
- [11] Zin N S M, Aziz H A, Adlan M N, Ariffin A, Yusoff M S and Dahlan I 2014 Treatability Study of Partially Stabilized Leachate by Composite Coagulant (Prehydrolyzed Iron and Tapioca Flour). *Int. J. of Scientific Research in Knowledge* **2** 313
- [12] Asrafuzzaman M, Fakhruddin A N M and Hossain M 2011 Reduction of turbidity of water using locally available natural coagulants. *ISR N Microb*
- [13] Zin N S M, Aziz H A, Adlan N M, Ariffin A, Yusoff M S and Dahalan I 2013 Removal of Color, Suspended Solids, COD and Ammonia from Partially Stabilize Landfill Leachate by Using Iron Chloride through Coagulation Process *Int. J. of Eng. & Tech.* **5** 736
- [14] Aboulhassan M A, Souabi S, Yaacoubi A and Baudu M 2006 Improvement of paint effluents coagulation using natural and synthetic coagulant aids *J. of Haz. Mat.* **138** 40