

Effects of Aluminium Sulfate and Klaraid during Wastewater Treatment Process at a Beverage Company in Phnom Penh, Cambodia

Chanreaksmey Taing, Pichmony Ek *, Fidero Kuok

*Department of Chemical Engineering and Food Technology, Institute of Technology of Cambodia,
Russian Federation Blvd., P.O. Box 86, Phnom Penh, Cambodia.*

Abstract: *Effects of aluminium sulfate and Klaraid on physico-chemical characteristics of wastewater and total phosphorous removal during wastewater treatment process at a local beverage company in Phnom Penh were investigated followed by the determination of the optimum application of aluminium sulfate and Klaraid for phosphorous flocculation. Aluminium sulfate versus total phosphorous at different ratios of 20:1, 21:1, 22:1, 23:1, and 24:1 were studied whereas Klaraid was studied at the concentration of 9 ppm, 11 ppm, 13 ppm, 15 ppm, and 17 ppm. Physico-chemical characteristics of wastewater viz pH, color, dissolved oxygen, total phosphorous, ammonia, and chemical oxygen demand (COD) before and after treatment were analyzed. Aluminium sulfate versus total phosphorous at ratio of 22:1 was the most effective in removing total phosphorous whereas the optimum value was at 13 ppm for the application of Klaraid. At these values, observed physico-chemical characteristics of the effluents were complied with the guideline limit of Ministry of Environment of Cambodia (MoE). By comparing the effectiveness of the two flocculants, application of aluminium sulfate was most effective in phosphorous removal while that of Klaraid was better in terms of color and ammonia removal.*

Keywords: Aluminium sulfate; Klaraid; Phosphorous Flocculation; Wastewater treatment

1. INTRODUCTION

Wastewater—i.e., a worldwide issue with adverse environmental impact and residential quality of life once it is not handled properly, is of great concern particularly in the case of Cambodia where industrial development has vigorously taken place with annual gross domestic product of about 7% according to National Small Flows Clearinghouse (NSFC) (NSFC, 1997; World bank, 2014). In fact, the composition of wastewater varies widely depending on the generation sources, e.g., household, industry, or hospital, from which wastewater generally presents more than 95% of water whereas the remaining 5% normally contains pathogens, soluble and insoluble organic/inorganic matters and gases (Tchobanoglous *et al.*, 2003). Given the vast difference in physico-chemical characteristics of wastewater, the *in-situ* wastewater treatment facility is commonly used in the case of either industry or hospital.

In the case of food industry, wastewater could contain different kinds of chemical substances, e.g., H_3PO_4 and Topax which have been used as sanitizer and cleaning agent; in particular, the defected products could significantly contribute to the increase of pollutants in wastewater. These excessive contaminants may include phosphorous, nitrogen, iron and aluminium. Therefore, it is necessary to remediate these pollutants prior to their discharge into the environment.

This study aimed to address the wastewater treatment issue at a local beverage company by investigating the effects of aluminium sulfate and Klaraid on physico-chemical characteristics and total phosphorous removal. Moreover, the optimum application of aluminium sulfate and Klaraid in phosphorous flocculation tank was determined at which the effluent quality was compared with the guideline limit of MoE.

2. METHODOLOGY

2.1 Experimental operation

A 30 L of wastewater sample was taken from aeration tank and then well mixed with the use of air pump VS-648. Sample was later separated into 6 different plastic tanks containing 5 L of wastewater. Aluminium sulfate was then added at different ratio versus total phosphorous—i.e., 0:1, 20:1, 21:1, 22:1, 23:1, and 24:1, respectively. To simulate the actual condition of wastewater treatment at this local beverage company, samples with addition of aluminium sulfate were subjected to aeration for 35 min and settling for 5 hours prior to physico-chemical analyses.

In the case of Klaraid, different concentrations of 9 ppm, 11 ppm, 13 ppm, 15 ppm and 17 ppm, were applied respectively to 6 different tanks containing 5 L of sample.

Similar experimental procedure to that of aluminium sulfate was conducted before subjecting to physico-chemical analyses.

2.2 Physico-chemical analyses

2.2.1 pH and color

pH value of wastewater sample was measured by using pH meter (827-pH-lab, Metrohm, Switzerland). pH measurements were performed in triplicate. On the other hand, samples were also subjected to color analysis during which sample was filtered by using cellulose nitrate filter paper. 10 mL of filtrate was then placed into the clean vial and measured in triplicate with the use of Photometer Multi-Direct (Lovibond, Tintometer GmbH Ltd., Dortmund, Germany). Color value of sample was determined and expressed in Pt-Co.

2.2.2 Dissolved oxygen

Concentration of dissolved oxygen presented in wastewater samples were analyzed with the use of dissolved oxygen meter (SensoDirect 150, Tintometer GmbH Ltd., Dortmund, Germany). Dissolved oxygen was then measured in triplicate and expressed in mg/L.

2.2.3 Ammonia

Ammonia test kit (Tintometer GmbH Ltd., Dortmund, Germany) was used to determine the concentration of ammonia. 10 mL of wastewater sample with ammonia tablets 1 and 2 were well-mixed and stood for 10 min. Triplicate samples were then measured with the use of Photometer Multi-Direct (Lovibond, Tintometer GmbH Ltd., Dortmund, Germany) and expressed in mg/L.

2.2.4 Total phosphorous

Total phosphorous concentration was determined with the use of phosphorous test kit (Tintometer GmbH Ltd., Dortmund, Germany). 10 mL of sample with the phosphate tablets 1 and 2 were mixed and stood for 10 min prior to its measurement by using Photometer Multi-Direct (Lovibond, Tintometer GmbH Ltd., Dortmund, Germany). Triplicate samples were then subjected to total phosphorous analysis and expressed in mg/L.

2.2.5 Chemical oxygen demand (COD)

Chemical oxygen demand test kit (Tintometer GmbH Ltd., Dortmund, Germany) was used to determine the concentration of COD in wastewater sample. 2 mL of

sample was added into the ready-made test tube with COD reagents and well mixed. Tubes were then heated for 120 min in a pre-heated COD reactor at a temperature of 150 °C. After it was cooled down to room temperature, tube was subjected to COD measurement with the use of Photometer Multi-Direct (Lovibond, Tintometer GmbH Ltd., Dortmund, Germany) and expressed in mg/L. Triplicate samples were used for each wastewater sample.

3. RESULTS AND DISCUSSION

3.1 Effects of aluminium sulfate and Klaraid on pH and color

Figures 1 and 2 present the effects of aluminium sulfate and Klaraid on pH and color of the effluent during the treatment course. A slight decrease of pH value was observed following the application of aluminium sulfate, from about 8.4 to the lowest pH value—i.e., about 7.9; this could be explained by the fact that the reaction of aluminium sulfate in wastewater could potentially release 2 moles of hydrogen ions which contributed to acidic condition in wastewater (Davis, 2010). In the case of Klaraid, no significant variation of pH was observed during the course of investigation (see Fig. 2). In both cases, pH values of the effluents were complied with the guideline limit of MoE in Cambodia—i.e., between 5.0-9.0 (MoE, 1999). As aluminium sulfate added, significant change of color was not observed despite its slight fluctuation in the range of 46—53 Pt-Co (See Fig. 1).

In contrast, color value of wastewater with the addition of Klaraid was drastically decreased from 112 to 59 Pt-Co suggesting that the capacity of Klaraid to remove color was higher than that of aluminium sulfate (See Fig. 2). This could be explained by the fact that pigments contained in wastewater decreased significantly with the addition of flocculant—i.e., Klaraid, during which the flocculant and pigments formed insoluble complexes that were gradually and gravitationally settled (Zhang *et al.*, 2012).

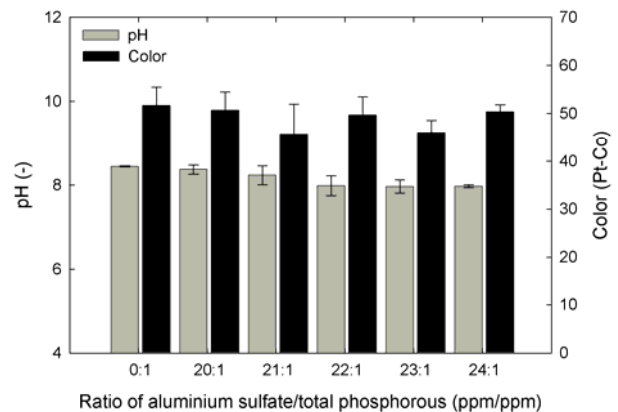


Fig.1. Effects of aluminium sulfate on pH and color.

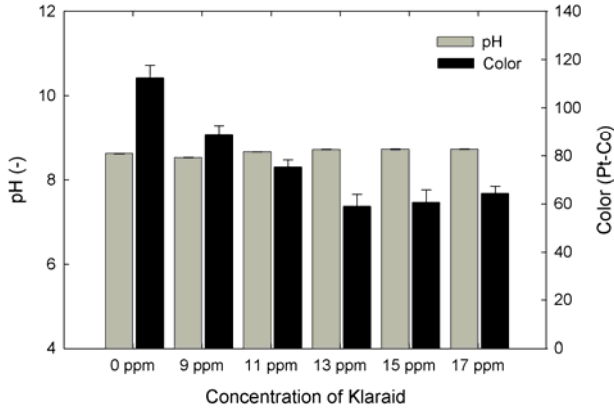


Fig.2. Effects of Klaraid on pH and color.

3.2 Effects of aluminium sulfate and Klaraid on ammonia and total phosphorous

Concentrations of ammonia and total phosphorous of the effluent after using aluminium sulfate as chemical coagulant with different ratios of aluminium sulfate versus total phosphorous are shown in Fig. 3. As flocculation progressed, no significant change in ammonia concentration—i.e., in the range of 0.05–0.07 mg/L, was observed in spite of different ratios of aluminium sulfate versus total phosphorous were added. In the case of Klaraid, NH_3 concentration slightly decreased to the lowest concentration of about 0.03 mg/L (See Fig. 4). Overall NH_3 concentrations in wastewater samples after the addition of either aluminium sulfate or Klaraid were complied with the guideline limit of MoE of Cambodia (MoE, 1999).

The higher the concentration of aluminium sulfate applied, the higher the total phosphorous removal was (See Fig. 3). Among different ratios, percentage of total phosphorous removal at the ratio of 24:1 was the highest—i.e., about 86.54% while the lowest was at the ratio of 20:1—i.e., about 72.62%. According to the study of phosphorous removal of municipal sewage wastewater in China, using aluminium sulfate as coagulant removed approximately 95.60% of total phosphorous under the pH of 6.9 (Wang *et al.*, 2005). Therefore, lower performance of aluminium sulfate— $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ in total phosphorous removal observed in the present study was probably due to the high pH of wastewater sample—i.e., about 7.98 while the effective range of pH for aluminium sulfate working condition was in the range of 5.5–6.3 (Droste, 1997). In the present study, concentrations of total phosphorous after the application of aluminium sulfate at different ratios of aluminium sulfate versus total phosphorous were complied with the guideline limit of MoE of Cambodia (MoE, 1999).

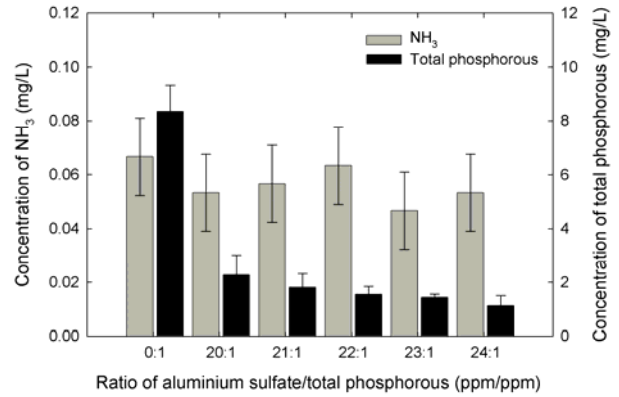


Fig.3. Effects of aluminium sulfate on ammonia and total phosphorous.

In the case of Klaraid, a slight decrease of total phosphorous concentration was observed; however, the removal efficiencies of phosphorous at different concentrations of Klaraid were not significantly different (See Fig. 4). Moreover, the remaining total phosphorous in the effluent at various Klaraid concentrations was higher than that of guideline limit of MoE of Cambodia (MoE, 1999) suggesting that additional phosphorous treatment is necessary once Klaraid is used. Therefore, comparing to aluminium sulfate, Klaraid had less effective performance in total phosphorous removal.

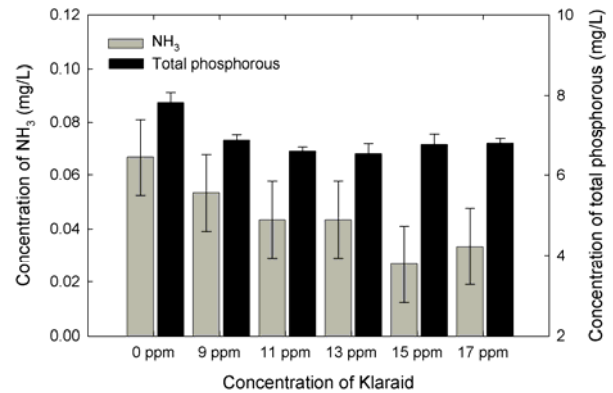


Fig.4. Effects of Klaraid on ammonia and total phosphorous.

3.3 Effects of aluminium sulfate and Klaraid on dissolved oxygen and COD

The effects of aluminium sulfate and Klaraid on dissolved oxygen and COD are presented in Fig. 5 and 6. Initial difference in the dissolved oxygen and COD concentrations between Fig. 5 and 6 could be attributed to the fact that two batches of wastewater samples taken at different times from aeration tank were subjected to two separated batches of investigations to determine the effects of aluminium sulfate and Klaraid; therefore, the observation mainly focused on

each batch of experiment. In the case of aluminium sulfate, despite the difference in aluminium sulfate concentration applied, concentration of dissolved oxygen slightly fluctuated in the range of 3.6–4.6 mg/L (See Fig. 5). On the other hand, the reduction of dissolved oxygen was relatively correlated with the increase of Klaraid concentration (See Fig. 6). As flocculation progressed, dissolved oxygen gradually decreased from the initial value of 6.5 mg/L to the lowest value of 5.1 mg/L. In accordance with the guideline limit of MoE in Cambodia (MoE, 1999), the amounts of dissolved oxygen in the effluent in both aluminium sulfate and Klaraid treatments, were much higher than the minimum required value to protect biota in the receiving water-body. At different applications of aluminium sulfate, removal efficiency of COD at the ratio of 24:1 was the highest—i.e., about 64.4% whereas the lowest was at the ratio of 20:1—i.e., about 29.9%. In contrast, COD concentration correlatively increased with the increase of Klaraid concentration (See Fig. 6). In the present study, COD concentrations in both applications of aluminium sulfate and Klaraid were within the allowable guideline limit of MoE of Cambodia (MoE, 1999).

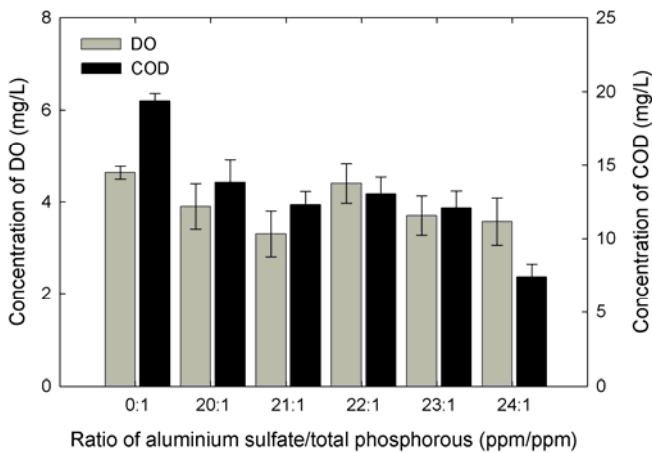


Fig.5. Effects of aluminium sulfate on dissolved oxygen and COD.

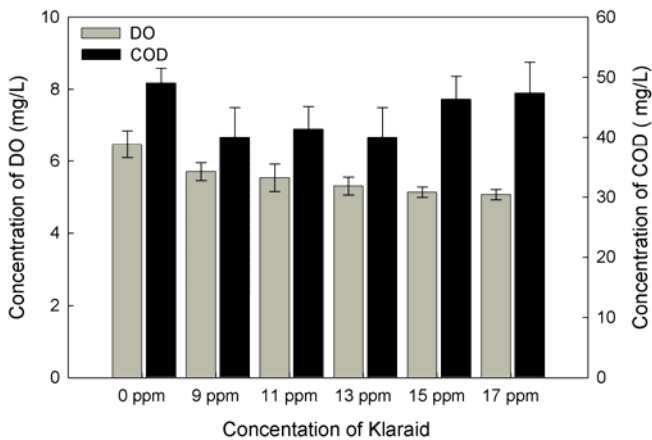


Fig.6. Effects of Klaraid on dissolved oxygen and COD.

3. CONCLUSIONS

The effects of aluminium sulfate and Klaraid on physico-chemical characteristics and total phosphorous removal were investigated at different concentrations of aluminium sulfate and Klaraid during wastewater treatment process at a local beverage company. With the use of both aluminium sulfate and Klaraid, physico-chemical characteristics of the effluents were complied with the guideline limit of Ministry of Environment of Cambodia. Similar effectiveness of phosphorous removal was observed when aluminium sulfate at the ratio of 22: 1 was used or Klaraid at the concentration of 13 ppm was applied. Based on their applicability, aluminium sulfate was most effective in phosphorous removal while Klaraid was best to remove color and ammonia.

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