Study on Treatment of Slaughterhouse Wastewater by Electro-coagulation Technique

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***Abstract* - Electro-coagulation (EC) is well known as a technique for removing suspended solids as well as oils and greases from wastewater. The aims of this research are to study the performance of the EC technique to treat a high strength wastewater from slaughterhouse in batchwise mode. The effect of various process variables such as number and electrode material, initial pH, suspended solid (SS) content, and operating time was investigated The electrolytic cell (electro-coagulator) used was a 600 ml cylinder glass reactor with working volume 400 ml and equipped by magnetic stirrer without temperature control. Cast iron (Fe) and aluminum (Al) cylinder were used as anode/cathode pair. The number of electrode was varied 1 and 2 pairs. The effective area of the electrode pair was 6.28 cm^2. The DC power supply was controlled by a voltmeter and be adjusted constant at 125 A/m^2 for each test runs. The initial SS concentration were varied from 1250, 2100, 3000, and 4000 mg/L by diluting wastewater. It is found that effluent temperature depends on SS and increases up to 98 °C when SS content was 4000 mg/L. One and two pairs of Fe-Al electrode will give SS removal efficiency are 97.2 and 99.6 %, respectively. However, the higher electrode number will need the shorter time to get certain removal efficiency of SS. Number of electrodes didn't give the significant impact to the final pHs. With initial pH 7.05 both two pair of electrode will give the final pH relatively constant to 7.80. Further work will be conducted to optimize the CD and charge loading to avoid the excessive temperature increase.**

Keyword: electro-coagulation, slaughterhouse, wastewater treatment

I. INTRODUCTION

Slaughterhouses are one of animal agricultural industry producing a wastewater with highly charged in soluble and insoluble organics. The slaughterhouse wastewaters (SWWs) contain high concenetration of organic materials, suspended solid, as well as colloidal from such as fat, proteins, and cellulose (Caiceta, et al, 2002; Masse, et al, 2001; dan Nunez, et al, 1999). Facing the increase of environmental problems and more stringent regulation in environmental, the new breakthrough in developing the technology for treating SWW is needed.

In general, the methods to treat the SWW are dominated by conventional methods such as biological wastewater treatment, either aerobic as well as anaerobic treatment. An aerobic treatment processes are limited by their high energy consumption needed for aeration and high sludge production. On the other hand, the anaerobic treatment of slaughterhouses wastewater often slowed or impaired due to the accumulation of suspended solids and floating fats in the reactor, which lead to a reduction in the methanogenic activity and biomass wash-out (Masse, et al., 2002; Rajehwari, et al., 2000). In adition, it is also reported that anaerobic treatment is sensitive to high organic loading rates, as a serious disadvantage (Nunez, 1999; Borja, et al., 1998). Both biological processes require long hydraulic retention time and large reactor volumes, high biomass concentration and controlling of sludge loss, to avoid the sludge wash-out (Rajehwari, et al., 2000).

The fairly new technology, EC technology offers an alternative to remove pollutants from wastewater especially wastewaters contain high suspended solid such as SWW. At this point, the EC process has attracted a great deal of attention in treating industrial wastewaters because of its versatility and environmental compatibility (Beagles, 2004). The EC has been applied to treat water containing foodstuff waste, oil wastes, dyes, suspended particles, chemical and mechanical polishing waste, organic matters from landfill leacheates, defluorination of water, synthetic detergent effluents, mine wastes and heavy metal containing solution. This method is characterized by simple equipment, easy operation, a shortened reactive retention period, a reduction or absence of equipment for adding chemicals, and decreased amount of precipitate or sludge which sediments rapidly. The process has been shown to be an effective and reliable technology that provides an environmentally compatible method for reducing a large variety of pollutants. Moreover, during EC, the salt content of the liquid salt content does not increase appreciably, as in the case of chemical treatment (Mollah, et al, 2001).

This process has proven satisfy able to treat several pollutant from wastewater (Chen, 2004; Mollah, et al, 2001; and Rajeshwari, 1994). Several wastewater successfully treated e.g textiles industrial effluent (Bayramoglu, et al., 2004; Kobya, et al., 2003; dan Lin, 1994), domestic wastewater (Pouet, et al., 1995), lecheate (Tsai, et al., 1997), and chemicaly industrial fiber (Lin, 1998). EC technique also has been developed to treat several food industrial wastewater such as olive oil (Adhoum, and Monser, 2004), restaurant (Chen, et al., 2000a dan 2000b), dan oily wastewater (Calvo, et al., 2003; Chen, 2002). However, antill at present, still litlle information can be obtained application of this technique to treat high strenght wastewater such as SWW. The aims of this research are to study the performance of the EC technique to treat a high strength wastewater from slaughterhouse in batchwise mode. The effect of various process variables such as number and electrode material, suspended solid (SS) content, and operating time was investigated.

II. MATERIALS AND METHODS

The SWW samples were obtained from a slaughterhouse at Ungaran Semarang (Central Java). At the slaughterhouse, the wastewater was screened to remove hair and solids larger than 1 mm. The electro-coagulation experimental apparatus is shown in Fig. 1. The effect of various process variables such as electrode material, current density (CD), suspended solid (SS) content, and operating time was investigated. The electrolytic cell (electro-coagulator) used was a 600 ml cylinder glass reactor with working volume 500 ml and equipped by magnetic stirrer without temperature control. Magnetic stirrer was set at 400 rpm. Cast iron (Fe) and aluminum (Al) cylinder (10 mm diameter and 100 mm length) were used as anode/cathode pair. The number of electrode was varied 1 and 2 pairs. The electrode pair was dipped in the SWW to a depth of 8 cm and was situated approximately 3 cm apart. The effective area of the electrode pair was 6.28 cm^2. The DC power supply was controlled by a voltmeter and be adjusted constant at 125 A/m^2 for most test runs. For each test run, 500 mL of SWW was put in the reactor. The initial SS concentration were varied from 1250, 2100, 3000, and 4000 mg/L by diluting wastewater. Wastewater samples were taken every 10 minutes experimental run and allowed settle during 10 minutes and filtered before analyzed. The water quality of SWW, such as the COD, pH, suspended solid, and turbidity, was measured in each experimental run by the standard methods APHA (1992).

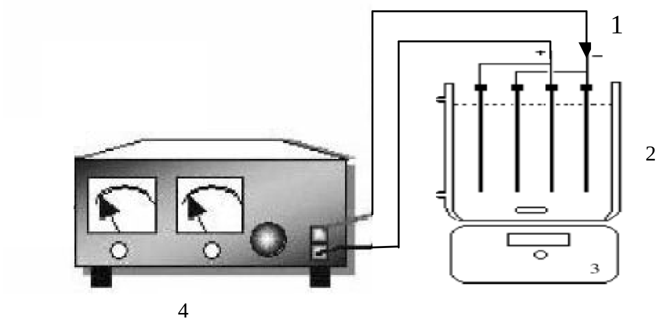


Fig. 1 The electro-coagulation experimental apparatus (1). Electrode; (2). Electro-coagulator; (3). Magnetic stirrer; (4). Power supply

III. RESULT AND DISCUSSION

A. Influence of initial suspended solid concentration on final temperature

The influence of initial concentration on final temperature was studied by varying initial suspended SWW concentration from 500, 1000, 2000, 3000, and 4000 (without dilution) mg/L.

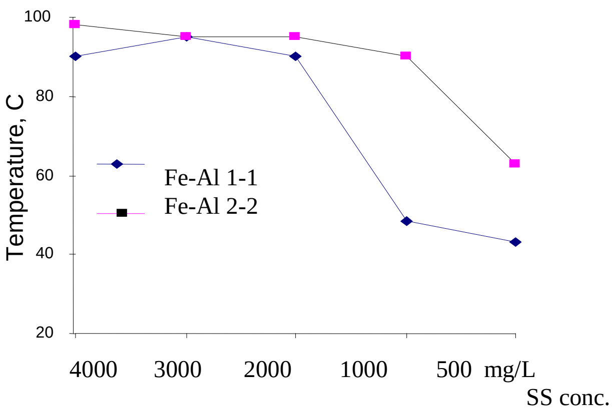


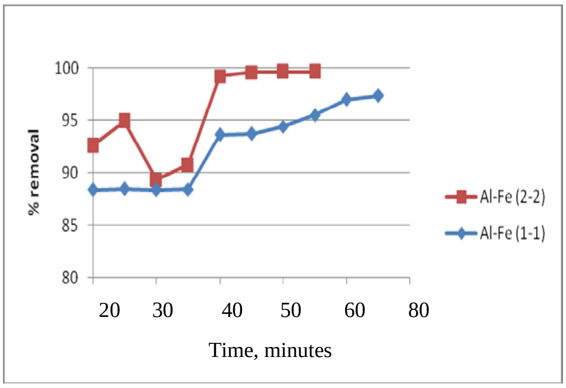
Fig. 2 Influence of initial SS concentration on final temperature

Fig. 2 shows that final temperature of effluent depends on initial SS concentration and increases from room temperature to 90 – 98 C with SWW without dilution (4000 mg/L). This is estimated due to the higher current dencity (CD) in supplied to the electrocoagulator. According to Chen (2004), when too large current is used, there is a high chance of wasting electrical energy in heating up the water. More importantly, a too large current density would result in a significant decrease in current efficiency. In order for the electro-coagulation system to operate for a long period of time without maintenance, its current density is suggested to be 20–25 A/m^2 unless there are measures taken for a periodical cleaning of the surface of electrodes. In this case, the CD was maintained to 125 A/m^2. Further work need to be conducted to optimize the CD and charge loading to avoid the excessive temperature increase.

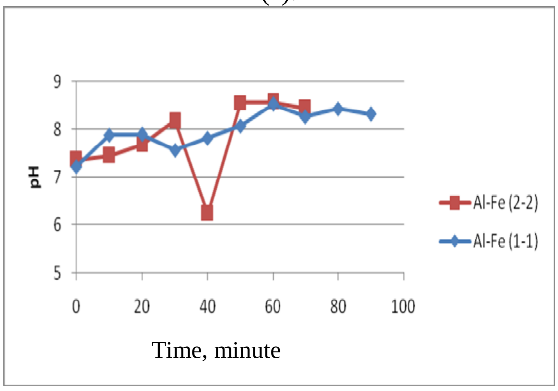
Effect of initial SS to temperature increase estimated due to the initial total dissolve solid (TDS) in SWW. TDS contributed by total anions and cations in wastewater in term of mg/L. The existence of the carbonate or sulfate ions would lead to the precipitation of Ca^{2+} or Mg^{2+} ions that forms an insulating layer on the surface of the electrodes. This insulating layer would sharply increase the potential between electrodes and result in a significant decrease in the current efficiency. The decrease in current efficiency will tend to increase the wasting energy and compensated in excessive temperature increase.

B. Effect of operating time to SS removal and final pH

To explore the effect of the operating time, the current density is kept constant at 125 A/m^2 and the pH of the wastewater is adjusted to 7. As seen in Figure 3(a), in general, the SS removal will increases with the increase of operating time and will remain constant after 40 minute observation. SS conentration will decrease from 6670 sampai 1510 mg/L with one pair of elctode while with two pair of electrode will decrase SS concentration from 3910 sampai 190 mg/L. In term of SS removal efficiency, one and two pairs of Fe-Al electrode will give SS removal efficiency are 97.2 and 99.6 % and respectively. However, with one pairs of electrode will need more time to obtain certain removal efficiency. Figure 4 shown that number electrode don't give the significant impact to the final pH. With initial pH 7.05 both two pair of electrode will give the final pH relatively constant to 7.80 after 50 minutes observation.



(a).



(b).

Fig. 3 Influence of operating time and electrode number to TSS removal (a); and final pH (b).

C. Influence initial pH to final pH

The influence of initial pHs to final pH of SWW effluent were explored by varying initial pH off SWW. Initial pHs of SWW were set bay adding NaOH or HCl solution. The graph resulted as shown in Fig. 4.

Fig. 4 show that, in general, the higher initial pH will exhibit the lower of final pH, either one or two pair of electrode Fe-Al. According to Chen (2004), the effects of pH of water or wastewater on electro-coagulation are reflected by the current efficiency as well as the solubility of metal hydroxides. When there are chloride ions present, the release of chlorine also would be affected. It is generally found that the aluminum current efficiencies are higher at either acidic or alkaline condition than at neutral. The treatment performance depends on the nature of the pollutants with the best pollutant removal found near pH of 7. The power consumption is, however, higher at neutral pH due to the variation of conductivity. When conductivity is high, pH effect is not significant. The effluent pH after electro-coagulation treatment would increase for acidic influent but decrease for alkaline influent. This is one of the advantages of this process. The increase of pH at acidic condition was attributed to hydrogen evolution at cathodes, reaction by Vik et al. (1984). In fact, besides hydrogen evolution, the formation of $Al(OH)_3$ near the anode would release H^+ leading to decrease of pH. In addition, there is also oxygen evolution reaction leading to pH decrease.

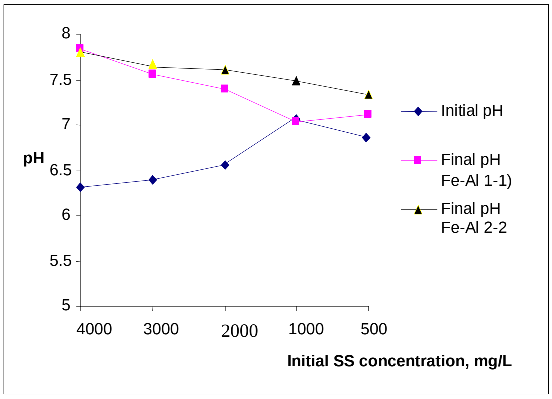


Fig. 4 The effect of initial pH of wastewater to final pH

IV. CONCLUSION

EC is found to be an effective method for the treatment of SWW. Effluent temperature depends on SS and increases up to 98 °C when SS content was 4000 mg/L. One and two pairs of Fe-Al electrode will give SS removal efficiency are 97.2 and 99.6 %, respectively. However, the higher electrode number will need the shorter time to get certain removal efficiency of SS. Number of electrodes didn't give the significant impact to the final pHs. With initial pH 7.05 both two pair of electrode will give the final pH relatively constant to 7.80. Further work will be conducted to optimize the CD and charge loading to avoid the excessive temperature increase. In addition, further works also need to be conducted at pilot plant scale in order to study the economic feasibility of the treatment of SWW by EC.

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