BOD, TSS and Colour Reduction of Palm Oil Mill Effluent Using Boiler Fly Ash

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ABSTRAK

Efluen dari kilang sawit perlu dirawat untuk mencapai piawaian yang ditetapkan oleh Jabatan Alam Sekitar. Walaupun beberapa sistem rawatan telah diperkenalkan dan berjaya mematuhi piawaian, tetapi masih terdapat kilang-kilang yang gagal mendapatkan kualiti yang dikehendaki. Kertas kerja ini melaporkan satu kaedah iaitu penyerapan menggunakan dandang abu terbang dari kilang sawit untuk mengurangkan benda-benda asing seperti warna, Permintaan Oksigen Biologi dan Jumlah Pepejal Terampai dari efluen sawit. Keputusan ujian menunjukkan dandang abu terbang berupaya melunturkan warna efluen dengan berkesan. Permintaan Oksigen Biologi dapat dikurangkan sebanyak 62% pada kuantiti 200 g l^{-1}. Penurunan maksimum Jumlah Pepejal Terampai didapati pada takat 100 g l^{-1}. Hasil ujian juga mendapati pH pada larutan hasil turasan meningkat apabila jumlah abu terbang bertambah.

ABSTRACT

Effluent from palm oil mill has to be treated to comply with the regulatory standards set by the Department of Environment (DOE). Even though several treatment systems have been introduced and successfully applied, there are still some mills which fail to obtain the required quality. This paper reports an adsorption method using boiler fly ash to reduce impurities such as colour, Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) from palm oil mill effluent. Results showed that boiler fly ash was able to decolourize effluent effectively. BOD was reduced about 62% at quantity of fly ash at 200 g l^{-1}. Maximum reduction of TSS was at 100 g l^{-1}. Results also showed that pH of the filtrate increased with an increase of boiler fly ash.

INTRODUCTION

As the country moves toward industrialization, the public has become more concerned about environmental quality, such as soil, water and air pollution. This pollution comes from various types of industries that discharge wastewater or effluent as well as emit pollutants into the air. The palm oil industry has been identified as one of the main contributors of organic pollution. The increase of palm oil mills to 308 in 1997 in Malaysia contributes significantly to the country's economy, but unfortunately, they also generate large volumes of effluent and solid waste.

Palm oil mills produce crude palm oil and palm kernel as their main products. The milling process also generates considerable amounts of co-product/waste such as empty fruit bunches (EFB), palm oil mill effluent (POME), palm fibre and palm shell. The quantity of POME produced is about 60% for every tonne of fresh fruit bunches (FFB) processed (Wood, 1977). Hence, an average of 30 t FFB hr^{-1} mill in the country will generate about 18 tonnes of effluent hr^{-1}.

Considering the seriousness of the pollution problems in the palm oil industry, the DOE has formulated several regulations for palm oil mills to treat POME to an acceptable level before allowing it to be discharged. Effluent has to be treated properly either for water-course or land application. A number of treatment systems have been successfully adopted by the industry and most of these systems are biological in nature. The most commonly used ones are ponding systems where effluent is discharged into a series of ponds before being discharged into the rivers. Aerobic and anaerobic microbial activities occur in the ponds to reduce the BOD. A survey by Teoh and Gee (1995) indicated that about 31% of the current

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systems were able to comply with the limit of 100 mg l^{-1} maximum all the time.

Fibre and shell are termed as by-products of the palm oil mill and they are used as boiler fuel to produce steam for electricity generation for the mill and domestic consumption within the mill complex. Boiler fly ash is produced in palm oil mills from the burning of fibre and shell. Every tonne of FFB produces about 4 kg to 6 kg of boiler ash. This porous ash which contains about 0.28% - 1.33% phosphorus, 1.02% - 4.31% potassium, 0.39% - 3.24% calcium and 0.29% - 2.60% magnesium (Rusnani and Ma, 1999) can be used as soil conditioner. Currently, this under utilized waste is mainly used as land fill.

Adsorption of heavy metals from aqueous solution by fly ash from palm oil mill and other sources have been reported (Theis and Wirth, 1977; Panday *et al.*, 1985; Mathur and Rupainwar, 1988; Weng and Huang, 1994 and Hashim *et al.*, 1996). In view of maximizing waste utilization and with the prospect of DOE imposing more stringent BOD limits on palm oil mill, an adsorption method using boiler fly ash was introduced. Therefore, the focus of this work is to provide information on the adsorption of impurities on boiler fly ash by using a stirred-method to further reduce BOD, TSS and colour in POME.

EXPERIMENTAL PROCEDURE

Samples of effluent with different concentrations were collected from a palm oil mill. Boiler fly ash used was also collected from the same mill.

The fly ash for the experiments was used as such without any grinding and drying. The particle size distribution was determined using a Fritsch sieve shaker. The surface area of the fly ash was determined by nitrogen adsorption method using a surface area analyzer (Model ASAP 2010, Micromeritics, USA). The moisture content of the sample was measured by heating the fly ash in an oven at 135°C for two hours.

The adsorption isotherm experiments were conducted by preparing various amounts of fly ash (15, 30, 45, and 60 g) in a series of 300 ml wastewater. The fly ash-wastewater mixtures were stirred at 150 rpm for 30 min in a temperature-controlled water bath. The temperature was kept constant at 25°C. After stirring, the fly ash was removed by vacuum filtration with Whatman #6 filter paper. A control sample was prepared by filtering the wastewater without fly ash.

The filtrates were analyzed for BOD, TSS, colour and pH. BOD and TSS were determined by using standard test methods (Zaid, 1985). Colour was measured by using a photometer (Model SQ300, Merck). The pH of the solutions was determined using a pH meter (Model 704, Metrohm, Switzerland).

Experiments on the optimum contact time between fly ash and wastewater to reach adsorption equilibrium were carried out by treating about 45 g of fly ash with several samples of 300 ml of wastewater. The samples were stirred at various intervals. The mixtures were then removed and filtered by vacuum filtration with Whatman #6 filter paper. The filtrates were analyzed for BOD, colour and TSS.

RESULTS AND DISCUSSION

The particle size distribution of the fly ash used is presented in *Table 1*. The fly ash contained various particle sizes ranging from less than 20 mm to more than 2000 mm. About 50% of the sizes were in the range of 70 mm to 320 mm. The surface area calculated from the Langmuir surface area plot was 199.3 m^2 g^{-1}. The fly ash contained 1.9% moisture content.

Figure 1 shows the pH in discharge samples after treatment with various amounts of fly ash. The results show that pH values of the filtrates were slightly increased with the increases in fly

TABLE 1. PARTICLE SIZE DISTRIBUTION OF FLY ASH

Size (μm)	Particle size distribution (%)
-20	0.04
+20 – 70	1.39
+70 – 320	50.42
+320 – 560	20.94
+560 – 2 000	23.50
+2 000	3.86

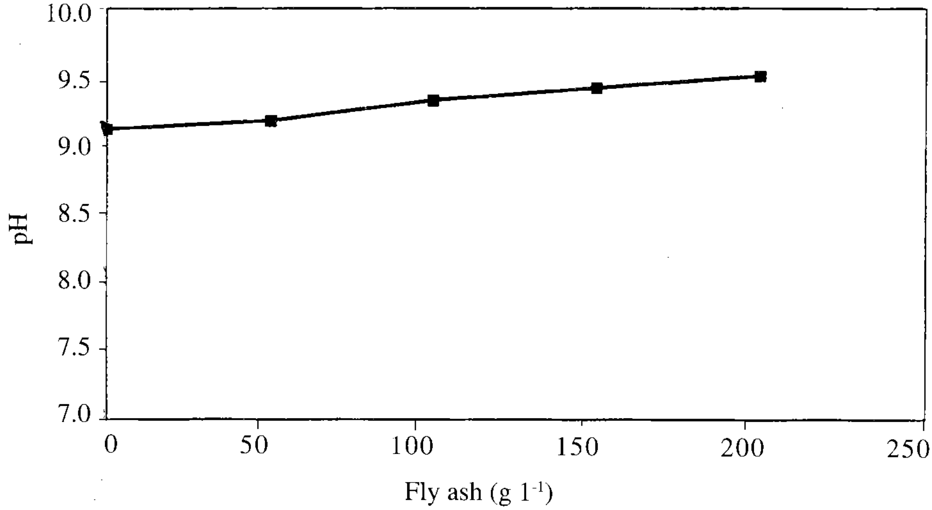


Figure 1. pH of filtrates treated with various fly ash dosages.

ash used. All the filtrates had a pH of more than 9. The high pH values in filtrates were expected as the pH in the control sample was also above 9. These results indicate that fly ash plays a fairly important role in making the waste become alkali. This observation agreed with a study by Behr-Andres and Hutzler (1994) that stated fly ash has an alkaline nature and can be an effective neutralizing agent. It was reported that the major alkalinity contributors in fly ash are CaO, K_2O and MgO (Weng and Huang, 1994). Hence, it is very important to determine the amount of fly ash to be used for palm oil mill effluent treatment so that the waste stream is not extremely alkaline.

The colour changes in POME after treatment with fly ash using the stirred-method were substantial as shown in *Figure 2*. The numbers in bracket indicate the amount of fly ash used in grammes. The method appears to be quite effective for colour removal. It was observed that a brownish colour still appeared in the effluent when 15 g of fly ash were used. A very light brownish colour was noted in the sample when treated with 30 g of ash. However, the colours of the filtrates were clear or colourless when 45 g and 60 g of fly ash were used.

Figure 3 illustrates the percentages of colour, BOD and TSS reduction with various

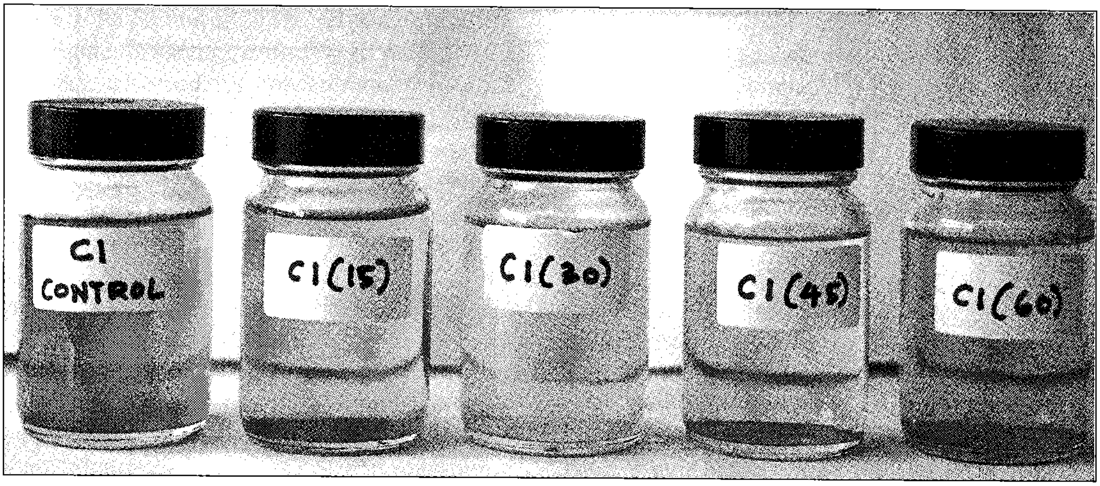


Figure 2. Colour changes on filtrates at various amounts of fly ash.

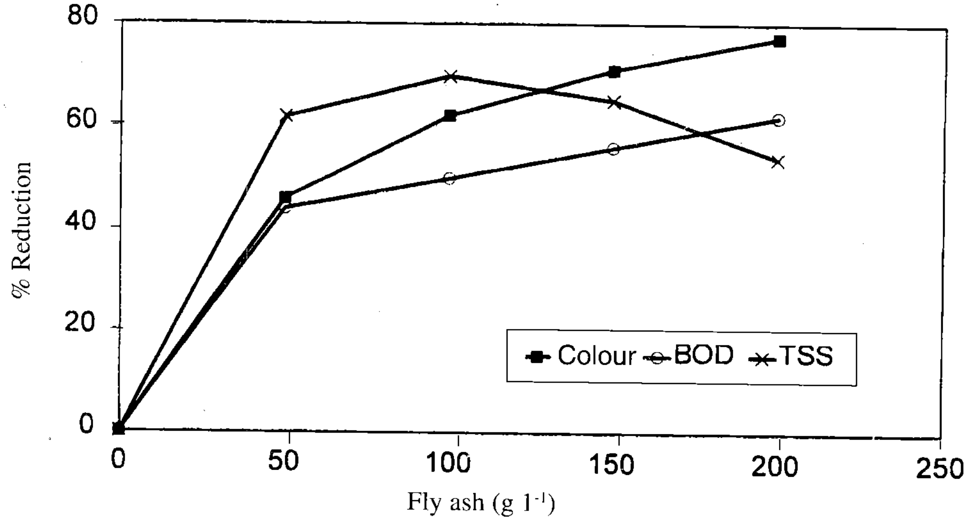


Figure 3. Impurities in filtrates treated with various fly ash dosages.

amounts of fly ash used. It is observed that about 42% of colour was removed at 50 g l^{-1} of fly ash dosage. When the dosages increased to 150 g l^{-1}, the colour was removed by about 70%. The results show that almost 80% colour removal could be achieved with 200 g l^{-1} fly ash. Initially there was a sharp reduction of BOD when 50 g l^{-1} fly ash was used. The percentage of reduction was then gradually increased when the fly ash dosage increased. About 62% of BOD was reduced at 200 g l^{-1} fly ash dosage. A similar trend was observed for TSS value during the initial stage. However, at 100 g l^{-1} fly ash dosage, percentage of TSS reduction started to decline. It declined further when 200 g l^{-1} fly ash was used. This may be caused by the various particle sizes of fly ash in the sample. Stirring at 150 rpm probably caused dispersal of some of the particles of the fly ash into fine particles. While it may be good to have small particle size that can adsorb more impurities, it will create more fine solids. These fine particles, trapped onto the glass fibre disc when conducting TSS analysis, will later affect the results.

Figure 4 shows the adsorption of colour by the fly ash after stirring continuously for a period

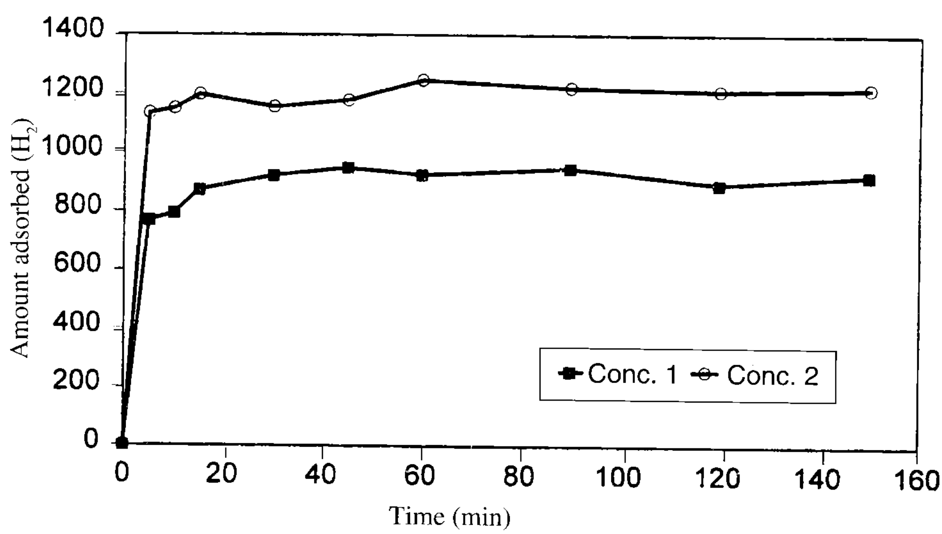
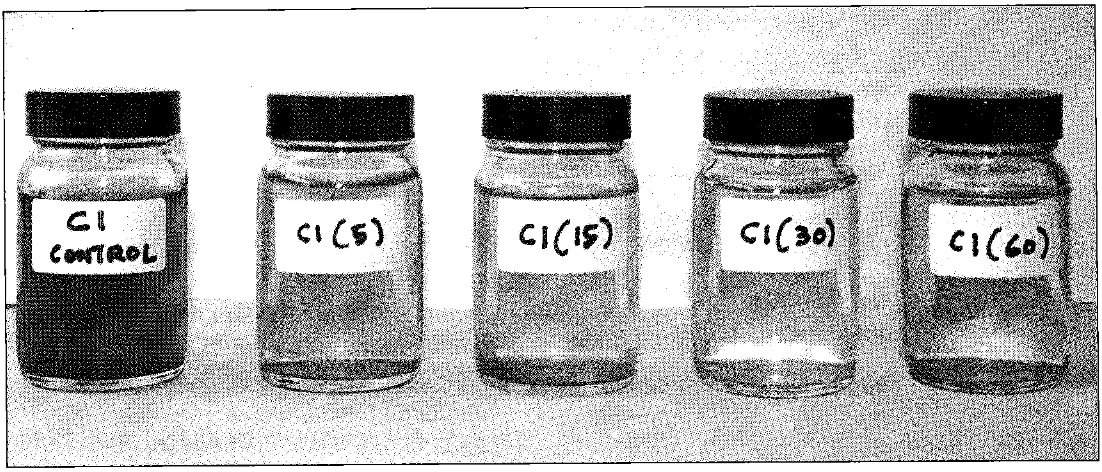
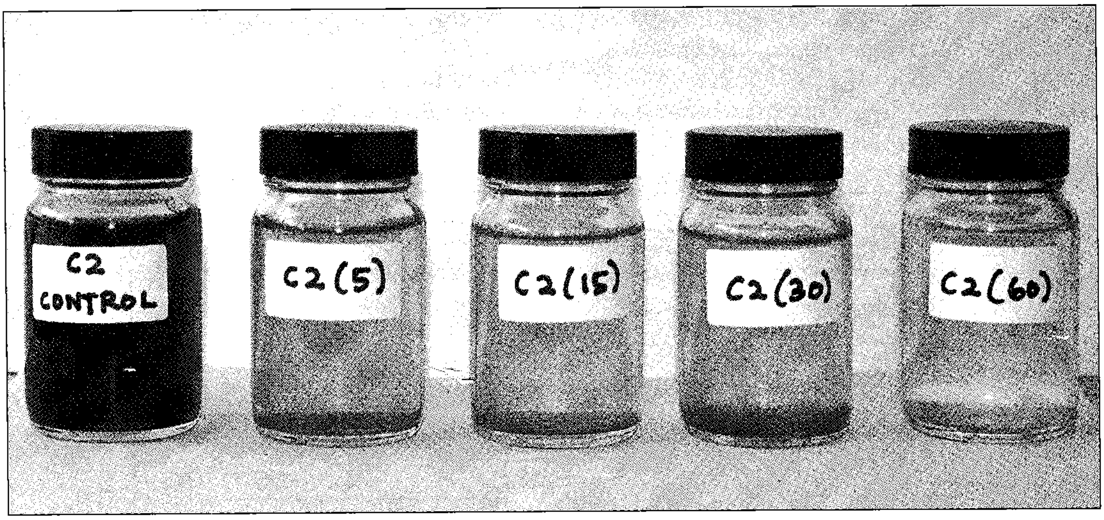


Figure 4. Adsorption equilibrium on colour by fly ash.





Figures 5. Colour changes in filtrates after stirring at various times: (a) Concentration 1 and (b) Concentration 2.

of time. The initial colour of concentrations 1 and 2 were 1096 Hz and 1424 Hz, respectively. After five minutes of stirring, about 768 Hz and 1134 Hz had been adsorbed for concentrations 1 and 2 respectively. It was noticed that concentration 1, being less than concentration 2, reached equilibrium in 45 min. Meanwhile, concentration 2 seemed to reach equilibrium in 60 min. Pictures of the colour changes for concentrations 1 and 2 at various times are shown in *Figures 5a* and *5b*. The number in bracket indicates the stirring time in minutes. It was observed that after five minutes of stirring, the colour changed to light brown (*Figure 5a*). A tint of brown colour still appeared in the sample at 15 min. At 30 min, the filtrates seemed to be colourless. In the case of concentration 2 (*Figure 5b*), it was noted that the filtrates turned colourless at 60 min.

Adsorption equilibria on BOD and TSS are shown in *Figures 6* and *7*. It was noted that the amount of BOD adsorbed was greater for concentration 2 when compared with concentration 1. Both concentrations seemed to show similar performances from 10 min to 60 min of stirring. By taking the best three points from the plotted graph, it could be said that each concentration would reach equilibrium at 30 min. Results for adsorption equilibrium on TSS (*Figure 7*) showed different phenomena where adsorption in concentration 1 was greater than concentration 2. At 30 min, concentration 1 had reached its equilibrium. For concentration 2, the adsorption remained constant for the first 15 min. Then the amount was increased to about 120 mg l^{-1} at 45 minutes. At 60 min, the adsorption became constant.

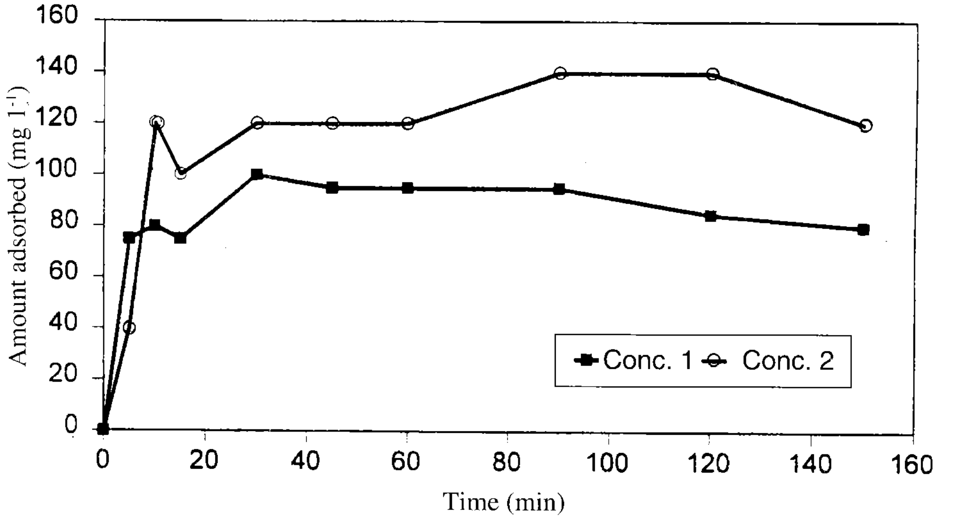


Figure 6. Adsorption equilibrium on BOD by fly ash.

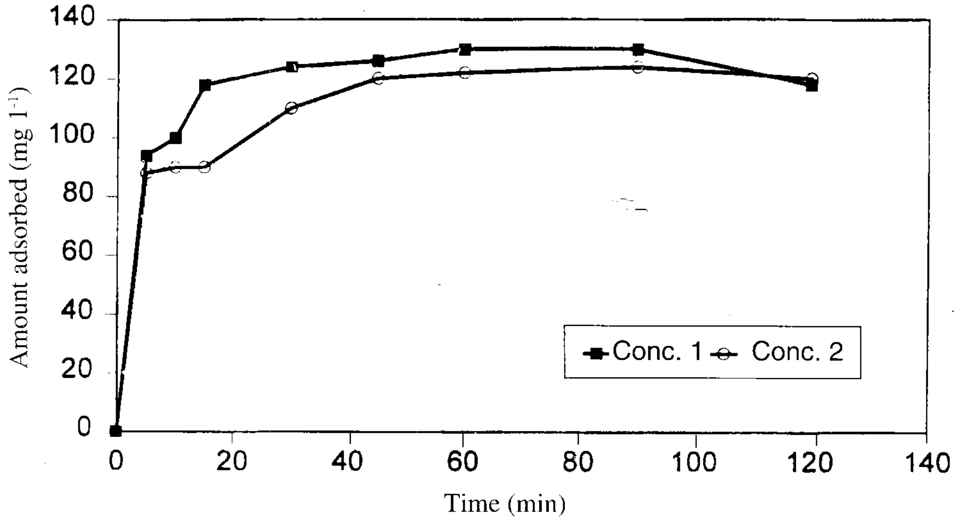


Figure 7. Adsorption equilibrium on TSS by fly ash.

CONCLUSION

Boiler fly ash from palm oil mill has been studied for its adsorption capability using the stirred-method. It has been demonstrated that the fly ash can be a potential adsorbent for BOD reduction and colour removal from POME. The fly ash has been able to remove nearly 80% of colour and 62% of BOD with 200 g l^{-1} fly ash dosage. The experimental results have indicated that TSS can be reduced effectively at 100 g l^{-1} fly ash dosage. However, with the increases of the fly ash dosage, the pH of the wastewater also increased. Therefore, it can be concluded from this study that the set standards for the quality parameters have to be established first in order to determine the amount of fly ash to be used for the treatment.

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