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Decolourisation of Anaerobic Palm Oil Mill Effluent via Activated Sludge-Granular Activated Carbon

A.Y. Zahrim, F.M. Rachel, S. Menaka, S.Y. Su, F. Melvin and E.S. Chan

Chemical Engineering Program, School of Engineering and Information Technology,
Universiti Malaysia Sabah, Locked Bag 2073, 88999 Kota Kinabalu, Sabah, Malaysia

Abstract: Eradication of colour from industrial effluent such as palm oil mill industry is becoming increasingly important from environmental and aesthetic point of view. In this study, decolourisation of anaerobic palm oil mill effluent (AnPOME) by means of suspended activated sludge (SAS) and activated sludge-granular activated carbon (ASGAC) was conducted in lab scale sequencing batch reactor. During the period of treatment, colour removal for the SAS and ASGAC was about 0-14% and 41-28% respectively. The organic matter removal (measured as COD) for the SAS and ASGAC was about 27-39% and 70-59% respectively. This study showed that activated sludge-granular activated carbon (ASGAC) was superior to suspended activated sludge (SAS) for treatment of AnPOME.

Key words: Palm oil mill effluent, Activated sludge, Granular activated carbon, Sequencing batch reactor

INTRODUCTION

The palm oil industry has become one of the largest revenue earners and has contributed much toward Malaysia's development and improved standard of living. However, the palm oil mills also have generated enormous amounts of highly polluting effluent. In Malaysia, more than 85% of the mills have adopted the conventional ponding system that based on suspended growth activated sludge due to inexpensive cost [1]. However, there are many processing plants failed to comply with the standard discharge limits [2] as well as colour. In this study, the efficiency of colour and organic removal of AnPOME using suspended activated sludge (SAS) was compared with activated sludge-granular activated carbon (ASGAC).

Nowadays, removal of colour from industrial effluent is becoming increasingly important from environmental and aesthetic point of view. Coloured effluents will inhibits the growth of the desirable aquatic biota necessary for self purification (re-oxygenation) by reducing the penetration of sunlight, with a consequent reduction in photosynthetic activity and primary production. The colour compounds also have a tendency to chelate metal ions (formation of ring structure with metal ions) and thus become directly toxic to aquatic biota [3]. Though less toxic, coloured effluents are often objected by the public on the assumption that colour is a sign of pollution. Colour removal, in particular, has recently become an area of major scientific interest as indicated by the multitude of related research reports. During the past two decades, several decolourization techniques have been reported, few of which have been accepted by some industries [4]. There is a need to find alternative treatments that are effective in removing colouring agents from large volume of effluents, which are cost-effective, like the biological or integrated systems [4].

Due to the fact that there is no chemical addition during palm oil processing, the colour causing from this effluent appear from plant constituents such as lignin and phenolics [5] as well as repolymerization of colouring compounds after anaerobic treatment [6]. It has been reported that, phenolics (tannic and humic acids) from the feedstock and melanoidins from Maillard reaction of sugars (carbohydrates) with proteins (amino groups) might contribute to the colour of the sugar processing effluent [7]. Effluent containing lignin and its degraded are chemically stable, resistant to biological degradation and are intractable to separation by conventional methods [3]. From previous study, immobilised activated sludge had

Corresponding author: Abu Zahrim Yaser, L4 Lab, Department of Chemical and Environmental Engineering, University of Nottingham, University Park, Nottingham NG72RD, UK
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successfully treated various types of industrial effluent; both with high degradation efficiency and good operational stability [8-11]. Several media to enhanced performance of activated sludge such powdered activated carbon, granular activated carbon, sand, zeolite, rice husk etc. has been reported [8, 12].

MATERIALS AND METHODS

AnPOME and activated sludge: The effluent was collected from the final anaerobic pond effluent, Lumadan Palm Oil Mill, Sabah, Malaysia and brought back to laboratory for analysis. Activated sludge with settling velocity of 10 m/hr was obtained from anaerobic and facultative pond. After undergone centrifugation, the activated sludge was seeded to reactor.

Sequencing Batch Reactor (SBR): SBR is a simple operation, has a compact design and is cost saving (capital and running cost). In this work, three lab scale sequencing batch reactors (SBR) were set up:

- Control - contained neither granular activated carbon nor seeded with activated sludge
- SAS - initially was seeded with 2 g/l of activated sludge
- ASGAC - contained 200 g/l granular activated carbon and seeded with 2 g/l of activated sludge. The average particle size of GAC was 1.7 mm.

All three reactors were made of plastic cylinders with a diameter of 10.5 cm and a height of 22 cm. Dissolved oxygen was maintained at 2 mg/l in the reactors using an aquatic pump (Blue Sky BS410). The reactor working volume was 1 L. The reactor operates based on 96 hours of operation. The cycle consisted of fill (5 min), reaction and aeration (95 h), settle (15 min) and draw periods (10 min).

Analysis: The COD was tested using the Spectrophotometer HACH DR 2010. Colour reduction was determined using the HACH DR890 Colorimeter via APHA Platinum-Cobalt Standard Method. The nitrogen ammonia content was tested with using the HACH Model 2010AN via the Nessler Method [13]. The dissolved oxygen was determined using the TOA-DKK (brand) Water Quality Checker (WQC-model 22A). The mean particle size of GAC was determined using the SigmaScan Pro5.

RESULTS AND DISCUSSION

Characteristics of the Anaerobic Palm Oil Mill Effluent: Table 1 shows that after the anaerobic ponding systems, the discharge effluent was high in colour (dark brownish). Moreover, it also contains high organic matter as well as nutrient (Table 1). Therefore the following treatment was done without any additional nutrient.

Colour and Organic Removal: During the first 40 days of experiment, the colour removal for the AnPOME at average influent of 4438 PtCo for control, SAS and ASGAC was 4838, 4664 and 2632 PtCo respectively (Figure 1). After 40 days of experiment, no colour removal was observed for control reactor as expected because of no added of activated carbon as well as activated sludge. In this study, SAS only able to remove colour after about

Table 1: Characteristics of anaerobic POME

Parameter	Unit	Anaerobic POME
pH		7.7-8.3
Total COD	mg/L	1003-1279
Apparent Colour	PtCo	3816-6994
Total Suspended Solids	mg/L	290-350
Ammonia Nitrogen	mg/L	50-100
Total Phosphate	mg/L	28-85

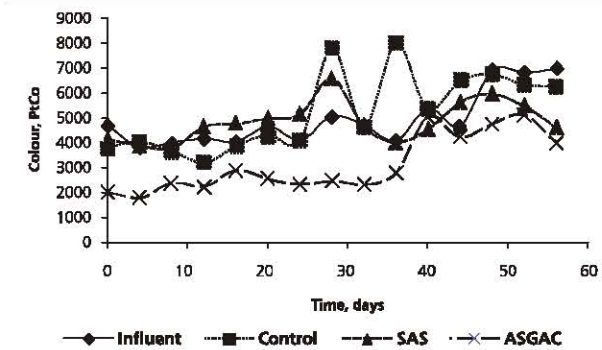

Fig. 1: Colour removal of AnPOME by activated sludge

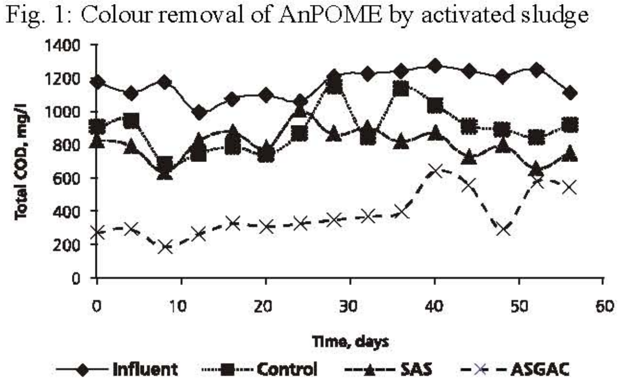

Fig. 2: COD removal of AnPOME by activated sludge

Table 2: Colour and COD removal for AnPOME during period of treatment

	Average percentage of colour removal (before 40 days)	Average percentage of colour removal (after 40 days)	Average percentage of COD removal (before 40 days)	Average percentage of COD removal (after 40 days)
Control	No removal	No removal	22	26
SAS	No removal	14	27	39
ASGAC	41	28	70	59

40 days of treatment period (Table 2) due to well adaption of indigenous microorganism to the environment. Sevais *et al.* [14] stated that about three months were required for bacteria to colonize the GAC in pilot plant for treatment of drinking water. Similar trend of evolution for organic removal is shown in Figure 2. Organic removal is due to settling of suspended solid and biodegradation (Table 2). Settling of suspended solid contribute about 66% of organic removal after 40 days of treatment.

Higher percentage of colour removal in ASGAC system i.e. 41% might be due to adsorption into the fresh GAC pore [9]. Then gradually the pores start to be filled with the recalcitrant organic compound. At about 40 days, as the GAC become saturated and eventually the colour removal decreases. Despite that, the microorganisms begin to oxidise the colour compound. Assuming that the mechanism for colour removal is due to biodegradation and adsorption [15]; both of the mechanisms contribute for 50% each of colour removal. From aesthetic point of view, the colour after ASGAC treatment is still not acceptable. Thus, further research should be done in this area such as prolong the reaction time and pre-treatment of ASGAC in order to improve the decolourisation. Moreover, colour causing compound after anaerobic effluent such as lignin, tannin, melanoidin etc. should be quantified to understand the process.

CONCLUSION

Decolourisation performances of suspended activated sludge (SAS) and activated sludge-granular activated sludge (ASGAC) were compared using anaerobic palm oil mill effluent (AnPOME) using sequencing batch reactor experiments. From this preliminary study, it can be concluded that ASGAC outperformed SAS regarding colour and organic removal.

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