Chapter 6
Applications of Advanced Oxidation Processes in Palm Oil Mill Effluent Treatment

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ABSTRACT

This chapter presents a review on limited studies that have been conducted using advanced oxidation processes (AOPs) in treating biologically treated palm oil mill effluent. Palm oil mill effluent is the by-products of palm oil production that is normally treated using a series of biological processes. However, despite being treated for a long period of retention time, the effluent still possesses high concentration of organics, nutrients, and highly colored, and will pollute the environment if not treated further. Advanced oxidation processes that utilized hydroxyl radicals as their oxidizing agents have the potential of further treating the biologically treated POME. Fenton oxidation, photocatalysis, and cavitation are the main AOPs that have been studied in polishing the biologically treated POME. Depending on the experimental conditions, the removal of organics, in terms of COD, TOC, and color, could reach up to more than 90%. Nevertheless, each of this process has its own limitations and further studies are needed to overcome these limitations.

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INTRODUCTION

Palm oil is a major industry in Southeast Asia and its production is increasing rapidly with the growth of plantation areas across the countries including Malaysia, Indonesia and Thailand (Aris et al., 2008). In 2014, 62.34 million tonnes of palm oil were traded globally with Malaysia producing 20 million tonnes of them (Ng and Cheng, 2015). The trend of palm oil production in Malaysia is also increasing; the exports of palm oil, palm kernel oil and other relating products have increased to 16.2 million tonnes in 2016 (Din, 2017). This can also be witnessed by the increase in oil palm plantation area from 320 ha in 1970 to 5.74 million ha in 2015 (Din, 2017; Rupani et al., 2010). Additionally, the number of mills has grown from 10 in 1960 to 407 in 2008 (Wu et al., 2010) and 453 in 2016 (Din, 2017).

Unfortunately, the expansion of the oil palm industry comes with its environmental cost. The current extraction process of palm oil includes wet process and dry process. The wet process, which is used in Malaysia requires a large volume of water (Wu *et al.,* 2009). It is estimated that the production of one-tonne crude palm oil utilises 5 to 7.5 tonnes of water (Rupani *et al.,* 2010). Consequently, more than 50% of the water becomes palm oil mill effluent (POME). It has been estimated that the quantity of POME generated annually in Malaysia is almost 2.2 x 10^7 m^3. With such amount, the wastewater will pollute the environment if adequate treatment is not provided.

CHARACTERISTICS OF PALM OIL MILL EFFLUENT

The characteristics of raw POME are dependent on several factors such as harvesting period, raw material quality (FFB) in terms of age and type, extent of the milling process, activities being conducted at the respective mill, processing technique, the discharge limit set by the factory as well as climate or weather (Irenosen *et al.,* 2014). Besides, the wastewater quality may differ according to batch, day and mills (Madaki & Seng, 2013).

Fresh POME is usually a viscous brownish colloidal mixture of water, oil and fine cellulosic fruit residue (Mat Rani, 2014) with unpleasant odour (Azuar *et al.,* 2015; Irenosen *et al.,* 2014). Some physicochemical properties of raw POME are shown in Table 1. Generally, raw POME is high in temperature, organics, solids, oil and grease as well as nutrients. The high temperature of POME, ranging from 80 – 90 °C is mainly due to the use of large amounts of steam and hot water in sterilization process. The pH for raw POME is slightly acidic in nature because of the organic acids content in complex forms (Madaki & Seng, 2013).

An important characteristics of raw POME is that it has a high concentration of organics. This is due to the fact that POME has a high amount of protein, carbohydrate, nitrogenous compounds, lipids and minerals which partly contributed to organic contents of the wastewater (Rupani *et al.,* 2010). Additionally, the high organic matters in POME is also contributed by the presence of different sugars such as arabinose, xylose, glucose, mannose and galactose (Ujang *et al* 2010). The solids in raw POME mainly come from oil-bearing cellulosic materials of the oil palm fruit (Ujang *et al.,* 2010). A variety of suspended components ranging from cell walls, organelles, short fibres, a spectrum of carbohydrates and nitrogenous compounds, free organic acids as well as mineral constituents also can be found in POME (Kanu & Achi, 2011).