Chapter 7
Performance of Chitosan and Polyglutamic Acid in Palm Oil Mill Effluent Treatment

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ABSTRACT

This chapter presents the study on pollutant removal efficiency in palm oil mill effluent using chitosan and polyglutamic acid (PGA). Up until today, palm oil mill effluent (POME) has been considered one of the significant sources of environmental pollution. The characteristics of POME include contaminating the source of drinking water, which is also harmful to the aquatic ecosystem by creating a highly acidic environment or causing eutrophication. With increasing public awareness of environmental pollution, it creates the need to address this issue. Both chitosan and PGA are non-polluting food-based anionic and biodegradable biopolymers that are environmentally friendly in wastewater treatment. The critical parameter to determine the effectiveness of pollutants removal is chemical oxygen demand, colour, and total suspended solids. In this aspect, this chapter also discussed some of the significant findings done in previous studies to provide proper understandings and implications on this topic.

BACKGROUND

Palm oil industry is a significant industry sector and plays a significant role in Malaysia's economy as one of the largest palm oil producers in the entire world (Liew, Kassim, Muda, Loh, & Affam, 2014). The palm oil industry in Malaysia contributes about 39% of the world palm oil production and also 44% of palm oil world export (Bello & Abdul Raman, 2017). Due to this importance, a large area of land

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has been converted into oil palm plantation estate. At the same time, more and more palm oil mill has been built to process the increasing amount of oil palm fresh fruit bunch (FFB) into crude palm oil. In Malaysia, there are 400 hectares land planted with oil palm in the year 1920, subsequently with 54,000 hectares in the year 1960, 2,692,286 hectares in the year 1996 and 5,229,739 hectares in the year 2013. At the year 2011, a record of total 426 palm oil mills is in operation in Malaysia with 250 mills in peninsular Malaysia and 176 mills in Sabah and Sarawak (Liew et al., 2014). The growth of the industry at the same time indicates the increase of wastewater or palm oil mill effluent (POME) produced and released into the watercourse, which will bring harm to the environment.

The process of extracting crude palm oil from the fresh fruit bunch consumes much water and therefore produces a large volume of wastewater. In Malaysia, a record of 0.67 cubic meters of POME generated in order to process one ton of FFB (Liew et al., 2014). Approximately 5-7.5 tons of water is required to produce one ton of crude palm oil. Eventually, more than 50% of these water would become POME which is shown in Figure 1 (Bello & Abdul Raman, 2017).

It is approximately 48-72 million tons, and 49-74 million tons of POME was generated in the year 2013 and 2014, respectively. In the year 2014, it estimated 19.66 million tons of crude palm oil produced with roughly 44 million cubic meters of POME generated (Parthasarathy, Mohammed, Fong, Gomes, & Manickam, 2016). In POME generated by processing 1 ton of FFB, it contains about 29-30kg of 30^{o}C, 3-days Biochemical Oxygen Demand (BOD_3) (Liew et al., 2014). From the data of POME produced in the year 2014, if the raw POME discharged into the environment without any further treatment, the BOD discharged is equal to the waste generated by 75 million people which is the 2.5 times of current Malaysia's population (Parthasarathy et al., 2016). POME is also said to be 100 times polluting than domestic sewage (Liew et al., 2014). According to the Department of Environment (DOE) practice, there are two ways of discharging treated POME, which are into water course or land. For the discharge into the watercourse, there are seven contaminants contained in the POME regulated. The regulated parameters are BOD_3, suspended solids (SS), oil and grease (O&G), ammoniacal nitrogen (AN), total nitrogen (TN), pH and temperature. For the discharge onto the land, the only parameter is BOD_3 which set at 5000mg/L. Table 1 shows the characteristic of raw and treated POME obtained from the discharge point of the local palm oil mill in Malaysia and DOE discharge limit (Bello & Abdul Raman, 2017).

The most popular method to treat the POME in Malaysia is the ponding system due to low equipment cost and the system is easy to operate. In Malaysia, there are more than 85% of palm oil mills that are currently adopting this method to reduce the BOD of POME into an acceptable limit which is less than 100mg/L in West Malaysia and 50mg/L in East Malaysia. In the ponding system, the POME undergoes biological treatments which include anaerobic digestion process followed by aerobic ponding with the hydraulic retention time of 40 days or above. However, the ponding system also causes some drawbacks which are long hydraulic retention time (HRT), vast land needed and the release of greenhouse gases (methane). There are also many palm oil mills which are unable to achieve the discharge limit only by using the ponding system (Parthasarathy et al., 2016).

If untreated POME discharge into the watercourse, it will undergo biodegradation process and consume dissolved oxygen in the water which eventually will kill the marine animals, especially fish in the river. The untreated POME, which is acidic, will cause the watercourse to turn acidic and affect the aquatic life. Moreover, the oil content in untreated POME tends to form a thick layer on the water surface that will prevent the absorption of oxygen. The dark brown colour and unpleasant smell of POME will turn the stream into brownish and unacceptable for public consumption (Bello & Abdul Raman, 2017). Apart from that, the high concentration of suspended solids will remain at the bottom of the river and

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