Chapter 11
Comparative Study of Advance Oxidation Processes for Treatment of Pesticide Wastewater

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ABSTRACT

This study compared the amount of catalyst and energy efficiency required for operation of five advanced oxidation processes (Fenton, UV photo-Fenton, solar photo-Fenton, UV/TiO2/H2O2, and FeGAC/H2O2) for degradation of the pesticides chlorpyrifos cypermethrin and chlorothalonil wastewater. Under optimum operating conditions, degradation in terms of COD and TOC removal and biodegradability (BOD5/COD ratio) index (BI) were observed to be (1) Fenton – 69.03% (COD), 55.61% (TOC), and 0.35 (BI); (2) UV photo-Fenton – 78.56% (COD), 63.76% (TOC), and 0.38 (BI); (3) solar photo-Fenton – 74.19% (COD), 58.32% (TOC), and 0.36 (BI); (4) UV/TiO2/H2O2 – 53.62% (COD), 21.54% (TOC), and 0.26 (BI); and (5) FeGAC/H2O2 – 96.19% (COD), 85.60% (TOC), and 0.40 (BI). The cost was $39.9/kg TOC (Fenton), $34.1/kg TOC (UV photo-Fenton), $30.1/kg TOC (solar photo-Fenton), $239/kg TOC (UV/TiO2/H2O2), and $0.74/kg TOC (FeGAC/H2O2). The FeGAC/H2O2 process was found to be most efficient and cost effective for pretreatment of the pesticide wastewater for biological treatment.

INTRODUCTION

There is a very high interest in the surface water usage and protection in Malaysia. This is because it provides about 98% of the water needs of various communities in the country (Azhar, 2000). Therefore, contamination could be very dangerous as it would cause a critical health risk to the entire population. The Department of Environment (DOE), under the Ministry of Natural Resources & Environment,

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Malaysia is charged to monitor river water quality annually. However, pesticide contamination and its concentration in rivers are not documented in the water quality reports (DOE, 1998 and 2010; National Water Quality Index of Malaysia (DOE, 2017), whereas the pesticide industry is about the top supporting sector for the agricultural industry which brings in high income revenue to the economy. According to Sime Derby updated annual reports, the total land bank covered by their plantation is approximately 1,000,000 hectares. This includes over 602,000 ha planted with oil palm, over 13,400 ha planted with rubber, over 5,600 ha planted with sugar cane and close to 9,000 ha is used as grazing pastures (Sime Darby Annual reports, 2017) as seen in Figure 1. This shows an increase in use of pesticides due to the huge increase in planted hectares from 200 until 2017.

On the one hand, the documented pesticide concentration detected in soil residue, waterways, rivers and crop fields (Abdullah, 2002) calls for strict and improved monitoring and/or alternatives in the eventual wastewater treatment process before discharge into the inland waterways and rivers (Naubi et al., 2016). On the other hand, treatment of the pesticide wastewater requires to be complete in order to degrade active ingredients or the organic bonds of parent compounds used in the formulation and production of the pesticide. In other to accomplish this, the use of economical treatment methods which are sustainable irrespective of the concentration of pesticide wastewater at any given treatment plant is imperative.

Pesticides are grouped into various unique classes including organochlorine, organophosphorus, carbamate, pyrethroid, etc. The organochlorine pesticide (OCPs) is about the most common. It is one of the pesticides categorized as persistent organic pesticide (POP). A revised version of POPs were added to the archive during the Stockholm Convention in year 2009 listed additional pesticides and Malaysia is signatory to this treaty (Qiu & Cai, 2010; Martins et al., 2013; Pariatamby & Kee, 2016). In addition, some pesticides numbering up to 40 and chosen by the Malaysian Ministry of Agriculture are still being

Figure 1. Oil palm plantation in terms of planted hectares
(Sime Darby, 2017)