

Chapter 16

Classical Fenton and Sequencing Batch Reactor Treatment of Pesticide Wastewater

Augustine Chioma Affam

University College of Technology Sarawak, Malaysia

Ezerie Henry Ezechi

 <https://orcid.org/0000-0003-4968-5541>

Universiti Teknologi Malaysia, Johor Bahru, Malaysia

Malay Chaudhuri

Independent Researcher, Malaysia

ABSTRACT

*This chapter examined Fenton and sequencing batch reactor (SBR) treatment of pesticide industrial wastewater. The optimum operating conditions for Fenton pretreatment of the pesticide wastewater were H₂O₂/COD molar ratio 3.0, H₂O₂/Fe²⁺ molar ratio 10, pH 3 and reaction time 60 min. The COD and TOC removal were 58.51 and 39.76%, respectively and biodegradability (BOD₅/COD ratio) increased from 0.02 to ~ 0.30 after 60 min reaction time. The reaction followed pseudo-first order kinetics with a rate constant (*k*) of 0.0083 min⁻¹. In the post-treatment by aerobic SBR, five different Fenton operating conditions were investigated and H₂O₂/COD molar ratio 3.0, H₂O₂/Fe²⁺ molar ratio 25, pH 3 and reaction time 60 min appeared to be the most significant (*p* < 0.05) operating conditions. The Fenton–SBR treatment at 12 hr HRT achieved COD, TOC and BOD₅ removal efficiency of 96.7, 97.7 and 93.3%, respectively. The Fenton-SBR process was effective for the treatment of pesticide wastewater.*

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INTRODUCTION

Extensive use of pesticides and their contamination potential have become a major concern. Although the benefits of pesticide application are evident in terms of increased agricultural productivity, the presence of pesticide residues in the soil, water and air has created potential risks to the natural environment (Barron et al., 2003). Major sources of pesticide in the water stream include wastewater from agricultural industries and pesticide formulating and manufacturing plants, rinsing and washing of spray equipment and run off during application in crop fields. Wastewater from these sources may have pesticide contamination levels as high as 500-1000 mg/L (Malato et al., 2000). Pesticide active ingredients have been reportedly found in inland waterways and rivers in Malaysia. Organophosphate pesticides (chlorpyrifos and diazinon) and organochlorine pesticides (lindane, heptachlor, endosulfan, dieldrin, endosulfan sulfate, DDT and DDE) have been detected in the Selangor river (Leong et al., 2007). The presence of pesticide active ingredients in surface water is presumably due to the inability of conventional wastewater treatment plant to completely remove them. Organochlorine pesticides such as heptachlor, dieldrin and pp-DDT (52–159 mg/kg) have been detected in sewage sludge in three locations in South Johore, Johor State (Ahmad et al., 2004). Pesticides in the sewage sludge may be incorporated into agricultural lands during application (Tadeo et al., 2010).

Advanced oxidation process (AOP) is a promising technology whereby chemical reactions produce hydroxyl radical (OH[•]) which oxidizes the organic contaminants in wastewater under mild operating conditions (Zhou et al., 2001). Oxidation with Fenton's reagent is based on ferrous ion, hydrogen peroxide (H₂O₂) and OH[•] produced by the catalytic decomposition of hydrogen peroxide in acidic solution (Chamarro et al., 2001). Sequencing batch reactor (SBR) is based on the principles of the activated sludge process. The wastewater is treated in batches, with aeration and settlement both occurring in the same tank. The SBR process consists of several phases: filling, aeration-reaction, settling, decant and idle phase. With respect to application, SBR has been successfully used in both municipal and industrial wastewater treatment (Mohan et al., 2005). SBR has several advantages such as combining the reactor and the setting tank in the same vessel and this easily controls performance with respect to reaction time and sludge solids maintenance. Aeration of the mixed liquor occurs in the second stage, sludge is formed and ammonia is oxidized to nitrites and nitrates. In the settling stage, settlement of the sludge takes place and denitrification process may occur due to continuous consumption of nitrogen (Neczaj et al., 2008). The SBR process is easy to operate and the process saves more than 60% of the expenses when compared with the conventional activated sludge process (Chang et al., 2000). Recalcitrant organics such as pesticides may be toxic to the microorganisms of the activated sludge process. Hence, the use of Fenton pretreatment to produce non-toxic and biodegradable intermediates that could be treated in a biologically has been recommended. Complete mineralization of the contaminants may be achieved with partial use of Fenton pretreatment and complementary SBR treatment (Farré et al., 2007). Chlorpyrifos and chlorothalonil were removed from aqueous mixture in constructed wetlands (Sherrard et al., 2004), and cypermethrin and chlorfenvinphos residual water by microwave-assisted photo-Fenton process (Gromboni et al., 2007).

For a complete treatment of industrial pesticide wastewater that would meet effluent discharge standard as required by Malaysia (EQA, 1974), there is a need to combine Fenton and SBR treatment of a chlorpyrifos, cypermethrin and chlorothalonil pesticide wastewater. The purpose of this study was to examine Fenton–sequencing batch reactor (SBR) treatment of a chlorpyrifos, cypermethrin and chlorothalonil pesticide wastewater. The first phase of this study examined the effect of operating conditions

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