UNIVERSITI TEKNOLOGI MARA

BIODEGRADATION OF PHARMACEUTICAL COMPOUNDS CAFFEINE AND CARBAMAZEPINE USING GRAM-POSITIVE BACTERIA

NAJIHAH BINTI MOHAMAD NASIR

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ABSTRACT

This study aims to evaluate the potential of selected bacteria in caffeine and carbamazepine degradation. The objectives of this study are to screen potential bacteria in degradation of caffeine and carbamazepine, to optimise degradation parameters of caffeine and carbamazepine as well as to evaluate degrading enzymes for prediction of degradation pathways. Methodologies included screening of bacteria resistance towards caffeine and carbamazepine and optimisation parameters of initial concentrations, initial pH and temperature for degradation of caffeine and carbamazepine. Then, mixed culture study was conducted at the selected optimum condition. At the same time, bacteria growth for *Rhodococcus zopfii* and *Leifsonia shinshuensis* was determined to support the degradation result. In addition, enzyme assays for oxygen oxidoreductase, aldehyde oxidase, catechol 1,2 dioxygenase and catechol 2,3 dioxygenase were also conducted. The result demonstrated that bacteria *R. zopfii* and *L. shinshuensis* were selected due to growth and potential in utilising caffeine and carbamazepine as nutrient source for degradation. For single culture degradation study, the 10 mgL^{-1}, pH 7 and 40 °C were selected as optimum condition for degradation of caffeine and carbamazepine. Optimum normalised degradation percentage of caffeine by *R. zopfii* was 72.53 ± 0.10 and *L. shinshuensis* was only 38.49 ± 0.01. For carbamazepine, both *R. zopfii* and *L. shinshuensis* achieved high normalised degradation percentage of 99.99 ± 0.00. Degradation of caffeine was not correlated to bacteria growth meanwhile, degradation of carbamazepine was linearly correlated to the bacteria growth. The result also revealed antagonistic interaction between *R. zopfii* and *L. shinshuensis* in mixed culture. Furthermore, enzyme assay for bacteria in caffeine showed presence of enzymes oxygen oxidoreductase and aldehyde oxidase, meanwhile, oxygen oxidoreductase, aldehyde oxidase, catechol 1,2 dioxygenase and catechol 2,3 dioxygenase were determined during carbamazepine degradation. The presence of enzymes elucidated degradation mechanisms and pathways prediction of caffeine and carbamazepine. Such study gained an insight into the reuse of intermediates and end products as resources for application in industries. In conclusion, the integration of degradation trend, bacteria growth and enzyme production provides database for modelling, information for large scale study and industry application. This sustainable bacteria degradation technology not only transforms waste to valuable products but also, safeguards the environment and human health.

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CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Over recent decades, negative effects of uncontrolled development through human activities such as agricultural, industrial and urbanisation have resulted in disposal of various pollutants into environment (Gavrilescu et al., 2015). Contamination of water due to inadequate waste facilities has threatened human health since human utilise water in everyday life. Hence, various research and advancement of technologies in improving water quality are conducted. This leads to discovery of emerging micropollutants in water bodies. Emerging micropollutants become a worldwide concern due to the behaviours, biological and toxicological effects to human health (Liu et al., 2019; Srikanth et al., 2019).

In accordance with the concern on emerging micropollutants issue, Contaminant Candidate List (CCL) and Watch List for European Union are being regularly updated in the United States and European Union, respectively. These lists include the unregulated emerging micropollutants and provide information to determine research and data collection that need to be prioritised (European Parliament, Council of the European Union, 2013; Garcia-Becerra & Ortiz, 2018). In Malaysia, emerging micropollutants issue is addressed by government agencies, such as Ministry of Health and Academy of Sciences. The conducted initiatives include emerging micropollutants monitoring programmes and research (Abdullah et al., 2016). Emerging micropollutants have been highlighted in Malaysia for study and review of regulation implementation, especially for river and coastal-based projects (American Chemical Society Malaysia Chapter, 2018).

Emerging micropollutants comprise of pharmaceutical compounds, personal care products (PCPs), detergents, fragrances, steroid hormones, industrial chemicals and pesticides (Wanda et al., 2017). One of the most commonly reported emerging micropollutants groups in water bodies is pharmaceutical compounds group (Lapworth et al., 2012). Pharmaceutical compounds are released into environment on regular basis