UNIVERSITI TEKNOLOGI MARA

BIODEGRADATION OF MICROPLASTIC IN BATCH CULTURE AND CONTINUOUS REACTOR FOR BIO-DIVERSITY CONSERVATION

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science
(Civil Engineering)

College of Engineering

September 2022

ABSTRACT

Currently, microplastic is considered a major concern worldwide and noteworthy among the researcher and authorities. Microplastic has spread ubiquitously in the environment, particularly in the aquatic system, due to its smaller size (size less than 5mm). This tiny microplastic adversely affected the environment, notably aquatic life via ingestion, choking, and entanglement. This microplastic is arduous to degrade as it takes a thousand years due to the properties of plastic itself and consequently remains in nature. This research study aims to investigate the performance of four (4) types of microplastics in a closed system: polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS). This microplastic has been biodegraded in the batch culture system using a colony of bacteria acquired from landfill leachate as a carbon source. The percentage of microplastic removal after the incubation period (7, 14, and 21 days) in batch culture was determined. In addition, the analysis of chemical properties, morphology surfaces of the microplastic, and ammonia-nitrogen for each batch culture were evaluated. The findings revealed that all microplastic could be degraded based on the percentage weight loss, chemical structure changes, surface morphology, and ammonia-nitrogen removal under the nitrification process after the incubation period. PE microplastic showed the highest percentage weight loss (8.8%) compared with other microplastic. Analysis by Fourier-transform infrared spectroscopy (FTIR) demonstrates that the chemical structure of each polymer has changed, which involved the formation of a new peak after the incubation periods. The chemical bond of C=O has formed in PP and PE, C-H has been developed in PS, and O-H has emerged in PET. The observation by scanning electron microscope (SEM) indicated the alteration on the surface in each microplastic, such as fractures and rough surfaces. Besides that, PP microplastic indicated the maximum ammonia-nitrogen removal after 16 days incubation period (97.41%). Next, the performance of the continuous reactor of continuous culture in removing the PE microplastics and ammonia nitrogen with different dilution rates was evaluated. The findings based on FTIR analysis show the absorption peaks at 1540 and 1635cm^{-1} attributed to C=C has experienced elongation after the changes of flow rate of 20 rpm to 30 rpm due to the exposure and interaction between microorganism colony and microplastic. This research study indicates that microplastics could be reduced in the batch culture using leachate inoculum and the continuous culture reveals a capability in degrading PE microplastic with the changes of chemical structure. This study also found that the activity of the microorganism's population plays a significant role in the degradation of microplastic. Furthermore, extending the incubation period for microplastic biodegradation can attain better optimal results in further research.

Keywords: batch culture, biodegradation, continuous culture, environment, incubation, microplastic

ACKNOWLEDGEMENT

Alhamdullilah, I am very grateful to Allah SWT for his Grace and Mercy for giving me this chance, strength, and opportunity to complete this research study. This study certainly will not be completed without constant and never-ending support, guidance, and contribution from many people that I have encountered during completing this study. I would like to express my appreciation to my supervisor, Dr Norhafezah Kasmuri for her invaluable ideas, encouragement, guidance, and constructive comments from the beginning until the end of preparing this research study. I am also wished to express my gratitude to the environment laboratory technician (UiTM), En Hazri Othman for helping me during the experiments of this research study. I would like to deliver my special thanks to my family and friends who give support during the completion of this research.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Municipal solid waste is one of the agendas under sustainable development goals (SDGs) categorized under goals 11 and goals 12 which are sustainable cities and communities, and responsible consumption and production (Figure 1.1). SDGs agenda that will be emphasized before 2030 and officially adopted by United Nations members stated (Unilever, 2019). It is a necessity for all country includes developed countries, to take appropriate action to achieve these sustainable development goals (SDGs). Municipal solid waste (MSW) is called garbage or trash that consists of daily items that are thrown away by the public, for example, food waste, construction waste, industrial waste, plastic, paper, and building waste (Hong et al., 2017). Municipal solid waste becomes one of the critical issues and challenges to the environment due to the amount municipal of solid waste generation around the world were increasing day by day. The estimation throughout main metropolitan cities worldwide shows about 69% of municipal solid waste will be generated within 13 years, starting from 2012 to 2025 (Gu et al., 2018). Currently, the generation of municipal solid waste (MSW) globally is about 2.01 billion tonnes per year and is predicted will rise to 3.40 billion tonnes by 2050. It shows, as much as 0.11 to 4.54 kg of waste was produced per day by an individual worldwide (Kaza & Woerden, 2018). The rising of solid waste generation around the world is due to several factors such as rapid population growth, urbanization, continuing industrial and economic activities, and increasing the standard of living in the developing country (Tiseo, 2020). The impact of the increasing amount of municipal solid waste will cause an adverse effect on water, public health, ecosystem, soil, and our environment if these municipal solid wastes are not handling well (Gu et al., 2018).

Since the introduced mass production of plastic products over the past 50 years, plastic products have become one of the main contributors to municipal solid waste (MSW) generation. Plastics have been found in significant MSW categories, with the containers and packaging category having the most plastic volume in 2018, with over 14.5 million tonnes (EPA, 2021). Plastic is a synthetic polymer derived from organics products such as coal, natural gas, salt, cellulose, and crude oil (Baheti, 2022). The