

**THE MECHANISM OF MICROORGANISMS BIODEGRADATION
OF POLYETHYLENE PLASTIC AS FOOD PACKAGING
MATERIAL: A REVIEW**

***REVIEW MEKANISME BIODEGRADASI MIKROORGANISME
TERHADAP PLASTIK POLIETILEN SEBAGAI BAHAN PENGEMAS
MAKANAN***

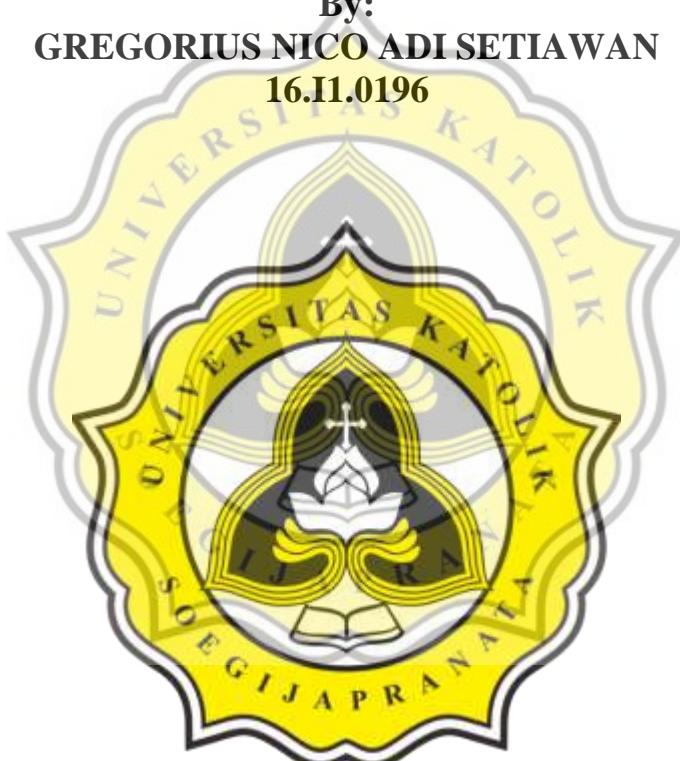
BACHELOR THESIS

Submitted in partial fulfillment of the requirements for a Food Technology
Bachelor's degree in Faculty of Agricultural Technology

By:

GREGORIUS NICO ADI SETIAWAN

16.II.0196



**DEPARTMENT OF FOOD TECHNOLOGY
FACULTY OF AGRICULTURAL TECHNOLOGY
SOEGIJAPRANATA CATHOLIC UNIVERSITY
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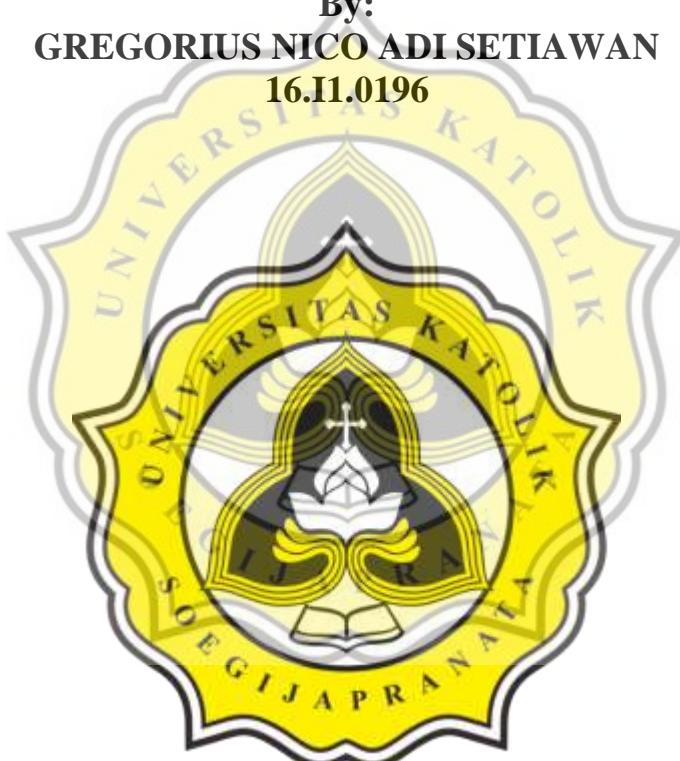
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2020

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SUMMARY

Plastic is one of the products derived from petrochemical industries that is synthetically made by combining the monomers and added chemical additives to make it into long polymeric chains. One example of plastics is polyethylene that is primarily used in the food packaging industry. Polyethylene is one type of plastic that is recalcitrant to degrade naturally; that is why many researchers are focusing on finding the potential microorganisms that are suitable to degrade polyethylene material. A number of bacterial species have been identified as having the ability to degrade polyethylene, namely *Proteus vulgaris*, *Pseudomonas putida*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Brevibacillus parabrevis*, *Brevibacillus borstelensis*, and many others. Also, there are some species from fungi that are able to degrade polyethylene material such as *Aspergillus niger*, *Aspergillus falgus*, *Aspergillus glaucus*, *Penicillium frequentans*, *Penicillium pinophilum*, *Mucor circinelloides*, etc. A few species from Actinomycetes are also known for their ability to degrade polyethylene such as *Streptomyces* and *Nocardia asteroides*. Those bacteria and fungi species, each of them has different ability in biodegradation depends on the supporting factor such as composition and structure of the polymer, molecular weight, crystallinity, hydrophobic character, environment condition, the ability of biofilm formation, additives, surfactant, and pretreatment to microorganism or polymer. However, the biodegradation mechanism from each microorganism will affect the effectiveness of the biodegradation process. The biodegradation mechanisms from bacteria are by forming a biofilm on the plastic surface and secreting the extracellular enzyme that will scrape the polymer surface, while the mechanism from fungi is by using their hyphae to penetrate the polymer matrix and destroy it from the inside. Another research has found that bacteria-fungi consortium effectively maximizes the biodegradation process. The reason is that fungi will grow the hyphae to damage the polymer structure to the inside, while bacteria can easily penetrate and secrete extracellular enzymes. However, until today it is hard to know or conclude the most efficient microorganism to degrade polyethylene because of the differences of factors and conditions that affect every research. There is a need for more research about the most suitable combination of biodegradation assessment to achieve the high accuracy result to calculate the biodegradation rate.

RINGKASAN

Plastik merupakan salah satu produk turunan dari industri pengolahan minyak bumi yang dibuat secara sintetis dengan menyatukan monomer- monomer dan menambahkan bahan kimia untuk membentuknya menjadi rantai polimer yang panjang. Salah satu tipe plastik yang paling banyak digunakan dalam industri pengemasan makanan adalah polietilen. Polietilen merupakan salah satu jenis plastik yang sulit untuk terurai secara alami, sehingga cukup banyak dilakukan penelitian untuk mencari potensi mikroorganisme yang paling sesuai untuk menguraikan polietilen. Cukup banyak spesies bakteri yang telah diketahui kemampuannya untuk dapat menguraikan polietilen seperti *Proteus vulgaris*, *Pseudomonas putida*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Brevibacillus parabrevis*, *Brevibacillus borstelensis*, dan masih banyak lagi. Selain itu cukup banyak kapang yang mampu mendegradasi komponen polietilen seperti *Aspergillus niger*, *Aspergillus falcus*, *Aspergillus glaucus*, *Penicillium frequentans*, *Penicillium pinophilum*, *Mucor circinelloides*, dan lainnya. Beberapa spesies dari actinomycetes juga ditemukan mampu mendegradasi polietilen seperti *Streptomyces* dan *Nocardia asteroides*. Dari sekian banyak spesies bakteri dan kapang, masing – masing memiliki kemampuan biodegradasi yang ditentukan dari beberapa faktor penunjang seperti komposisi dan struktur polimer, berat molekul, kristalinitas, kemampuan hydrophobic, kondisi lingkungan, kemampuan pembentukan biofilm, kandungan zat aditif, surfaktan, dan perlakuan awal terhadap mikroorganisme ataupun polimer. Selain dipengaruhi oleh berbagai faktor tersebut, mekanisme kerja dari mikroorganisme dalam mendegradasi juga turut mempengaruhi keefektifan biodegradasi. Mekanisme kerja dari bakteri dengan membentuk biofilm pada permukaan plastik dan mengeluarkan enzim ekstraseluler yang akan mengikis bagian permukaan dari polimer, namun mekanisme kerja dari kapang yang menggunakan pertumbuhan hifanya untuk dapat masuk lebih dalam ke struktur matriks dari polimer tersebut dan merusaknya dari dalam. Selain itu dalam penelitian lain telah ditemukan bahwa pembentukan konsorsium yang tepat antara kapang dan bakteri akan semakin memaksimalkan kinerja dari biodegradasi. Hal tersebut terjadi karena kapang menumbuhkan hifa untuk merusak hingga ke bagian dalam struktur polimer dan bakteri akan lebih mudah untuk masuk ke dalam struktur polimer serta melepaskan enzim ekstraselulernya. Namun hingga saat ini masih belum dapat diketahui atau disimpulkan mikroorganisme mana yang dapat mendegradasi polietilen secara lebih efektif karena adanya perbedaan faktor-faktor dan kondisi yang mempengaruhi dalam setiap penelitian. Selain itu juga perlu dilakukan penelitian lebih lanjut mengenai kombinasi metode pengujian yang paling tepat untuk dapat membaca hasil biodegradasi secara maksimal.

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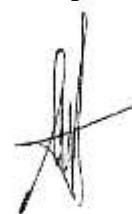
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The author realizes that there were unintended errors in writing this report. The author allows all readers to give suggestions to improve its content. However, the author hopes that this report can be an inspiration and provide useful information for others.

Semarang, 29 September 2020

Author,



Gregorius Nico Adi Setiawan

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