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ISOLATION AND QUANTITATIVE ASSESSMENT OF POLYETHYLENE-DEGRADING MICROBIAL ISOLATES FROM PLASTIC-CONTAMINATED SOIL

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ABSTRACT
The increasing accumulation of polyethylene in terrestrial environments has become a major ecological concern due to its high chemical stability and resistance to natural degradation processes. Conventional disposal practices such as landfilling and incineration are insufficient to address the growing burden of plastic waste and often lead to secondary environmental impacts. In this context, microbial degradation offers a sustainable and environmentally compatible alternative for polyethylene remediation.

In the present investigation, polyethylene-degrading microorganisms were isolated from plastic-contaminated soil samples using selective enrichment techniques. The isolates were screened for their ability to utilize polyethylene as a sole carbon source, and their biodegradation efficiency was quantitatively evaluated through time-dependent weight-loss analysis under controlled laboratory conditions. Inoculated polyethylene samples exhibited a progressive reduction in weight, whereas no measurable change was observed in uninoculated controls, confirming the biological nature of the degradation process. Among the isolated strains, isolate F3 demonstrated the highest degradation efficiency, achieving a maximum polyethylene weight reduction of 3.84% after 60 days of incubation.

The findings of this study emphasize the biodegradation potential of indigenous soil microorganisms and highlight their possible application in the development of eco-sustainable strategies for polyethylene waste management.

KEYWORDS: Polyethylene biodegradation, Plastic-degrading bacteria, weight-loss analysis, soil microorganisms, Environmental sustainability.

INTRODUCTION

The widespread production and consumption of synthetic plastics have resulted in their extensive accumulation in natural ecosystems worldwide (Geyer et al., 2017; Andrady, 2011). Among various plastic polymers, polyethylene is one of the most abundantly manufactured materials due to its durability, flexibility, and low production cost (Hopewell et al., 2009). However, these same properties contribute to its persistence in the environment, where it remains largely resistant to physical, chemical, and biological degradation processes, leading to long-term accumulation in soil and landfill environments (Restrepo-Flórez et al., 2014; Barnes et al., 2009).

Conventional plastic waste management practices, including landfilling and incineration, are increasingly regarded as unsustainable solutions due to land scarcity and the release of toxic emissions during disposal processes (Hopewell et al., 2009; Ojeda et al., 2009). Consequently, alternative approaches that minimize environmental impact and promote sustainable waste treatment are urgently required. In this context, biological degradation using microorganisms has gained recognition as a promising and environmentally safe strategy for plastic waste remediation (Shah et al., 2008; Sivan, 2011).

Microbial biodegradation of plastics involves the colonization of polymer surfaces by microorganisms, followed by enzymatic and metabolic processes that lead to polymer fragmentation and partial mineralization (Orr et al., 2004; Tokiwa et al., 2009). Several studies have reported the capability of soil-derived microorganisms to initiate polyethylene degradation under controlled laboratory conditions, indicating that natural environments harbor microbial communities with inherent plastic-degrading potential (Hadad et al., 2005; Kathiresan, 2003; Kyaw et al., 2012). However, the efficiency of degradation varies significantly among microbial strains, making the isolation and screening of effective degraders an essential step in polyethylene biodegradation research (Sivan, 2011; Roy et al., 2011).

Quantitative evaluation of polyethylene degradation is critical for assessing microbial performance and degradation efficiency. Among the available assessment methods, weight-loss analysis remains a reliable and widely applied technique for determining polymer degradation over time, as it provides direct evidence of material utilization during microbial incubation (Hadad et al., 2005; Pramila & Ramesh, 2011). Therefore, the present study focuses on the isolation of polyethylene-degrading microorganisms from plastic-contaminated soil and the quantitative evaluation of their degradation potential using time-dependent weight-loss analysis, with the aim of identifying efficient microbial isolates for environmentally sustainable plastic waste management strategies.

MATERIALS AND METHODS

Sample Collection

Soil samples were collected from plastic-contaminated dump sites for the isolation of polyethylene-degrading microorganisms. Samples were collected aseptically in sterile containers and transported to the laboratory for further processing.

Enrichment and Isolation of Microorganisms

Enrichment of polyethylene-degrading microorganisms was carried out using mineral salt (MS) medium supplemented with polyethylene as the sole carbon source. Soil samples were inoculated into the medium and incubated at 30 ± 2 °C under shaking conditions. After successive enrichment cycles, microbial isolates were obtained by sub-culturing in LB broth and MS medium, followed by streaking on LB agar plates. Distinct colonies were purified and designated as F2, F3, and B13.

Screening Of Polyethylene Degrading microorganisms

Preliminary screening of the isolated microorganisms was conducted to evaluate their polyethylene degradation potential. Selected isolates were inoculated into MS medium containing pre-weighed polyethylene samples and incubated under controlled conditions. Uninoculated flasks containing polyethylene were maintained as controls.

Time-Dependent Weight-Loss Analysis

Polyethylene degradation was quantitatively assessed using a time-dependent weight-loss method. After incubation, polyethylene samples were recovered, washed thoroughly to remove adhering biomass, dried to constant weight, and weighed. The percentage degradation was calculated using the formula:

Percentage degradation (%) = [(Initial weight − Final weight) / Initial weight]× 100

Control Setup

Control experiments were conducted using MS medium containing polyethylene without microbial inoculation. These controls were maintained under identical experimental conditions to confirm that observed weight loss was due to microbial activity and not abiotic factors.

Preliminary Screening of Microbial Isolates

Preliminary screening of microbial isolates was carried out to evaluate their polyethylene degradation potential based on weight loss. Among the tested isolates, F2, F3, F4, and F5 showed varying degrees of polyethylene weight reduction during the initial screening phase.

Time-Dependent Polyethylene Degradation by Selected Isolates

Based on preliminary screening, selected isolates were further evaluated for polyethylene degradation over a period of 20 days. A gradual decrease in polyethylene weight was observed for all tested isolates, indicating active biodegradation

Comparison of Control and Inoculated Samples

To confirm that polyethylene degradation was biologically mediated, weight changes in inoculated samples were compared with uninoculated control samples over 60 days. No weight loss was observed in the control, whereas inoculated samples showed measurable degradation.

Table 1. Preliminary screening of microbial isolates based on polyethylene weight change.

Isolate	Initial Weight (g)	Final Weight (g)
F2	0.0361	0.0360
F3	0.0334	0.0328
F4	0.0305	0.0304

F5	0.0287	0.0285

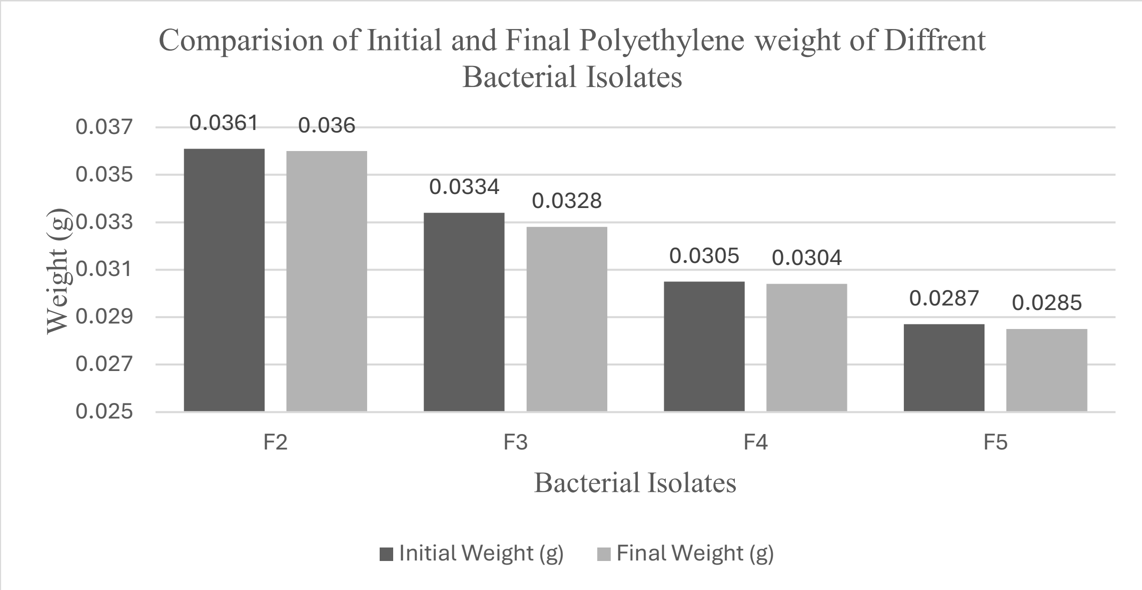

Figure 1. Comparison of initial and final polyethylene weights of bacterial isolates (F2, F3, F4 and F5).

Table 2. Time-dependent polyethylene degradation by selected isolates (secondary inoculation).

Isolate	0 Days (g)	10 Days (g)	20 Days (g)
F2	0.0361	0.0352	0.0351
F3	0.0334	0.0319	0.0310
B13	0.0343	0.0331	0.0329

Table 3. Comparison of polyethylene weight change in control and inoculated samples Isolate F3, which showed the highest degradation potential, was further evaluated over an extended incubation period of 60 days. Time-wise analysis demonstrated progressive polyethylene degradation with increasing incubation duration.

Sample	Initial Weight (g)	Final Weight (g)	% Change
Control (60 days)	0.0466	0.0466	0.00
F3 (60 days)	0.0469	0.0451	3.84

Table 4. Time-wise polyethylene degradation by isolate F3 during extended incubation.

Duration (Days)	Initial Weight (g)	Final Weight (g)	% Degradation
10	0.0475	0.0469	1.26
20	0.0474	0.0463	2.32
30	0.0468	0.0456	2.56
40	0.0489	0.0474	3.07
50	0.0470	0.0452	3.83
60	0.0469	0.0451	3.84
60 (Control)	0.0466	0.0466	0

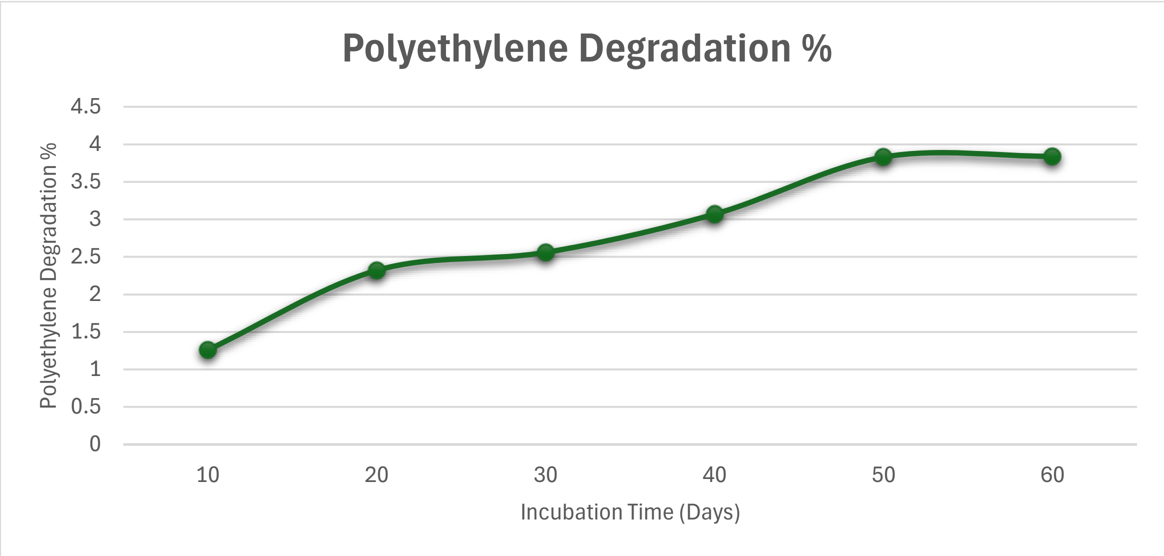

Figure 2. Time-dependent polyethylene degradation (%) by isolate F3 during 10–60 days of incubation.

DISCUSSION

The present study demonstrates the potential of indigenous microbial isolates to degrade polyethylene under controlled laboratory conditions. Time-dependent weight-loss analysis confirmed that polyethylene degradation was biologically mediated, as no significant weight reduction was observed in uninoculated control samples while inoculated samples showed measurable degradation. Among the isolates tested, F3 exhibited the highest degradation efficiency, indicating superior adaptability and metabolic capability for polyethylene utilization.

Extended incubation further enhanced degradation efficiency, suggesting that prolonged microbial–polymer interaction plays a critical role in effective polyethylene breakdown. The observed progressive reduction in polyethylene weight over time highlights the significance of microbial activity in polymer degradation processes. Overall, the findings of this study suggest that isolate F3 holds promise for application in biological plastic waste management strategies. Future studies involving molecular identification, enzymatic profiling, and large-scale validation are recommended to better understand the degradation mechanisms and enhance practical applicability.

CONCLUSION

This study demonstrates the potential of soil-derived microorganisms for the biodegradation of polyethylene under laboratory conditions. Microbial isolates obtained from plastic-contaminated soil showed measurable polyethylene weight loss, confirming biologically mediated degradation. Among the tested isolates, F3 exhibited the highest degradation efficiency during both short-term and extended incubation periods, indicating superior metabolic adaptability to polyethylene utilization.

The absence of significant weight loss in uninoculated control samples further validates that the observed degradation was due to microbial activity rather than abiotic factors. Time-dependent weight-loss analysis revealed progressive degradation with increasing incubation duration, highlighting the importance of prolonged microbial interaction for effective polymer breakdown.

Overall, the findings suggest that isolate F3 holds promise for application in environmentally sustainable plastic waste management strategies. Further studies involving molecular identification, enzymatic characterization, and optimization of degradation conditions are recommended to enhance its applicability at a larger scale.

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