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Original Article

Biodegradation of Low-density Polyethylene (LDPE) Strips from Waste Plastic Bags Using Marine-derived Fungi

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Abstract

Introduction: Plastic in any form is harmful to the environment. Its non-degradable nature leads to plastic pollution. Various chemical and biological methods have been attempted to address this issue, but chemical approaches have often resulted in pollution due to the release of toxic gases. Biodegradation is one of the methods that has received much attention in recent years. This study focused on the biodegradation of plastic waste bags using five marine-derived fungal strains isolated from Red Sea.

Materials and Methods: The sediment samples were collected from the Red Sea. Samples were subjected to fungal isolation using the serial dilution and spread plate technique. Fungal species isolates were evaluated for degradation activity toward low-density polyethylene (LDPE) strip samples The degraded plastic strips were analyzed for weight loss, AFM, SEM, and GC-MS to identify degradation byproducts.

Results: The results showed that only two fungal strains (*Aspergillus terreus* (OQ271754) and *Alternaria alternata* (OQ282860)) exhibited significant degradation activity over 8 weeks, leading to a weight loss of 45.83% and 29.16% in the degraded plastic strips, respectively. AFM and SEM images of the degraded strips by these strains revealed a noticeable change in surface roughness and close attachment of spores compared to control strips. GC-MS analysis of degradation byproducts identified several compounds, with Bis(2-ethylhexyl) phthalate being the major compound. Toxicity testing of this compound on Wheat seeds showed a significant impact on seed germination.

Conclusions: This study demonstrates the potential of marine-derived fungi to degrade plastic materials through the action of their secondary metabolites, resulting in significant weight loss and changes in surface texture.

Keywords: LDPE Biodegradation, Marine-derived fungi, AFM, SEM, GC-MS, Byproducts Toxicity

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Introduction

Trillions of plastic bags are consumed annually,[1,2] and these packaging components are either wasted in landfills or thrown into the seas. These synthetic plastics represent an environmental contaminant and accumulate worldwide in marine waters.[3] Over 300 million tons of plastics are produced annually in various industries, with eight million tons of this production ending up as marine debris dumped into deep-sea sediments. Microplastic contamination caused by plastics affects human health and the environment.[4-6] The environmental concerns posed by plastic waste have recently gained prominence, prompting the use of different types of plastics, such as biodegradable plastics, as an appealing alternative to ordinary plastics. Studies on the microbial degradability of regular plastics have also been intensified.[7-8]

Plastic bags, along with other plastic materials, are widely used by customers worldwide due to their low cost and mass production. Plastic degradation indicates that the most significant impact is on the environment.[9] Plastic materials are disposed of using physical and chemical processes, which are both costly and produce hazardous byproducts, such as persistent organic pollutants, leading to soil infertility. Large polymer breakdown into carbon dioxide requires the involvement of multiple consortium species, with one breaking it down into monomers, another utilizing the monomers and producing simpler waste compounds as byproducts, and finally using the excreted wastes.[10,11]

The rising demand for and widespread usage of low-density polyethylene (LDPE) has made it increasingly important to discover an environmentally benign and safe technique for its degradation. Due to features such as cost-effectiveness, durability, energy economy, and lightweight nature, LDPE is used in various aspects of life, from packaging to toys.[12-15] LDPE waste accumulates in natural habitats and leads to various forms of pollution.[2] One of the most damaging impacts of LDPE accumulation can be seen in the marine ecosystem,[5,6] where it enters water bodies as micro- or nano-sized plastics, causing harmful effects such as neurotoxicity and an increase in cellular oxidative stress in marine species.[16,17] As a result, biodegradation is the only environmentally friendly approach to addressing the problem of plastic pollution. Plastic reacts with oxygen in the air during this process, and microorganisms aid in the

process by secreting polyethylene-degrading enzymes to oxidize the products for energy.[18] *Fusarium solani*[19] and *Penicillium simplicissimum* YK[20,21] have been found to use natural and synthetic polyethylene as their sole carbon source in the breakdown process.[22-24] According to the studies,[25] *Aspergillus fumigatus* and *Penicillium* sp. cause plastic material degradation, as weight loss analysis indicates.

Accordingly, this study focused on the biodegradation of plastic waste bags using marine-derived fungal strains isolated from Red Sea, Egypt.

Materials and Methods

Isolation of Fungal Isolates

The sediment sample was collected in sterilized bags from the Zafarana region (29°10'68.3"N 32°66'36.1"E), Red Sea, Egypt, and transported to the laboratory in an icebox. On Czapek Dox agar media, the sample was subjected to fungal isolation using the serial dilution and spread plate technique. HiMedia Pvt. Ltd provided the technique for preparing the media. Czapek Dox media contains 30 g sucrose, 2 g $NaNO_3$, 1g K_2HPO_4, 0.5 g $MgSO_4.7H_2O$, 0.5 g KCl, 0.01 g $FeSO_4$, and 15 g agar per liter.[26] Plates were incubated at 28 °C for 5-7 days.

Treatment of LDPE Strips

Square strips with a dimension of 3 cm2 were cut from bags made of low-density polyethylene. Forty polyethylene strips were weighed using a microbalance. Two types of Czapek Dox's broth media were used. One set of conical flasks contained normal Czapek Dox's media with complete composition and LDPE strips. The other flasks contained Czapek Dox's media with LDPE as a carbon source substitute to demonstrate whether the fungal isolates can utilize LDPE as a sole carbon source. The strips in both sets were disinfected and sterilized with 4% sodium hypochlorite and 70% alcohol before being aseptically transferred, with two strips in each flask. The fungal isolates were inoculated into the broth media (one disc in each flask) and incubated for 8 weeks at 28 °C. At the end of the incubation period, the strips were collected from the broth and washed vigorously with 2% sodium dodecyl sulfate to remove any attached fungal mycelium and then dried.[27] Biodegradation efficiency was measured by the weight loss method for each sample. The samples were then characterized using Atomic Force Microscope (AFM) and Scanning Electron Microscope (SEM). Gas Chromatography-Mass Spectrometry (GC-MS) was also used to determine the byproducts compounds produced by the biodegradation process.

Weight Loss Analysis

A microbalance was used to determine the initial and final weights of the polyethylene strips. The following formula was used to compute the percentage of weight loss for each sample[6]:

% weight loss = (Initial weight - Final weight / Initial weight) × 100

Atomic Force Microscope (AFM) Analysis

The Agilent 5600 LS AFM was used for the AFM analysis. In addition to the control strips, degraded strips were prepared for atomic force microscopy (AFM) to compare them with the control strips. All photos were captured at a resolution of 512x512 pixels and a scan speed of 1.0 Hz.

Scanning Electron Microscope (SEM) Analysis

The surface morphological changes of LDPE strips before and after microbial degradation were examined using a scanning electron microscope (SEM) (QUANTA FEG250). The biodegradable strips were examined by SEM along with a control strip.

GC-MS Analysis of Polyethylene Degradation Byproducts

After 8 weeks of incubation, the LDPE strips were removed from the fungal cultures via filtration using Whatman No.2 filter paper. Ethyl acetate was used as an organic solvent to collect the polyethylene breakdown products. Fifty milliliters of each filtrate were dissolved in 50 ml of ethyl acetate (EtOAc) using a separating funnel. Finally, 1 ml of the dissolved polyethylene degradation products was injected into an Agilent 7000 GC-MS-MS Triple Quad. A GC (Agilent Technologies 7890A) interfaced with a mass-selective detector (MSD, Agilent 7000) equipped with a polar Agilent HP-5ms (5% phenyl methyl polysiloxane) capillary column (30 m x 0.25 mm i.d. and 0.25 µm film thickness) was used for the analysis. Helium was used as the carrier gas, with a linear velocity of 1 ml/min and a column temperature of 38 °C. The compounds were identified by comparing their mass spectra and retention times to those of the authentic compounds, by computer matching with the NIST and Wiley libraries, and by comparing the fragmentation pattern of the mass spectral data to those reported in the literature.

Toxicity Assay of Polyethylene Degradation Products on Wheat Seeds

Wheat seeds were selected for the experiment based on their economic importance and availability. Wheat seeds (*Triticum aestivum* L.) were purchased from an agriculture research center with a purity and germination potential of 99%. The seeds were surface sterilized using a 4% sodium hypochlorite solution,[28] washed with sterile distilled water three times, and placed on sterile filter paper to dry at room temperature. The polyethylene degradation byproducts were diluted to form four concentrations (10%, 25%, 50%, and 75%) and used to assess their toxicity on the wheat seeds. Autoclaved and sterilized glass petri dishes with filter papers at the bottom were used. In each plate, wheat seeds were

sown in a laminar flow. Two ml of each concentration of dissolved polyethylene degradation products were applied to each plate. Two ml of the fresh byproduct solution were exchanged with the old solution every two days. Two ml of distilled water were added to the control plate. All treatments were performed three times, followed by room-temperature incubation under light conditions. The germination percentage (G%), germination index (GI), and percent elongation inhibition rate (EI%) of germinated seeds were estimated using the following formulas after three, five, seven, and nine days of incubation[29,30]:

G% = (Number of seeds germinated / total number of seeds) × 100
GI = (Gn ×Ln / Gc × Lc) ×100
Gn: mean value of germinated seeds.
Ln: mean value of root length.
Gc: mean value of germinated seeds in control.
Lc: mean value of root length in control.
EI% = (Lc – Ln / Lc) × 100.

Statistical Analysis

SPSS 15.0 for Windows, published by SPSS Inc. in 2007, was used for the analysis. means were compared using the least significant difference (LSD) test with a significance threshold of $p \leq 0.05$. Each test was repeated three times to ensure reliable results.

Results

Biodegradation Activity of the Isolated Fungal Species

Among the five fungal species isolated (*Aspergillus terreus*, *A. carneus*, *A. fumigatus*, *A. aculeatus*, and *Alternaria alternata*), only two species showed high degradation activity toward LDPE samples. Accordingly, after 8 weeks of incubation, good growth of fungal isolates occurred on the agar media with a carbon source. However, no reduction in the weight of the strips was noted, indicating the inability to degrade and utilize LDPE in the presence of a simple carbon source in the media. In the second set of media prepared with LDPE as the sole carbon source, only two isolates, *Aspergillus terreus* (OQ271754) and *Alternaria alternata* (OQ282860), were able to grow and utilize LDPE strips, resulting in weight losses of 45.83% and 29.16%, respectively (Table 1).

AFM Examination of the LDPE Degraded Strips

Images of AFM showed that LDPE strips degraded by *A. terreus* (Figure 1a) and *A. alternata* (Figure 1b) exhibited cracks, grooves, and high surface roughness with RMS roughness (Sq) of 161.911 and 210.095 nm, and mean roughness (Sa) of 121.177 and 128.800 nm, respectively, when compared with the control strips (Figure 1c) that had surface roughness with RMS roughness (Sq) of 59.2802 nm and mean roughness (Sa) of 46.7969 nm.

Table 1. Evaluation of Weight Loss of LDPE Samples by Isolated Fungal Species

Fungal species	LDPE weight (gm)		
	Before degradation	After degradation	Weight loss (%)
Aspergillus terreus	0.024	0.013	45.83
Alternaria alternata	0.024	0.017	29.16
Aspergillus carneus	0.024	0.024	--
Aspergillus fumigatus	0.024	0.024	--
Aspergillus aculeatus	0.024	0.024	--

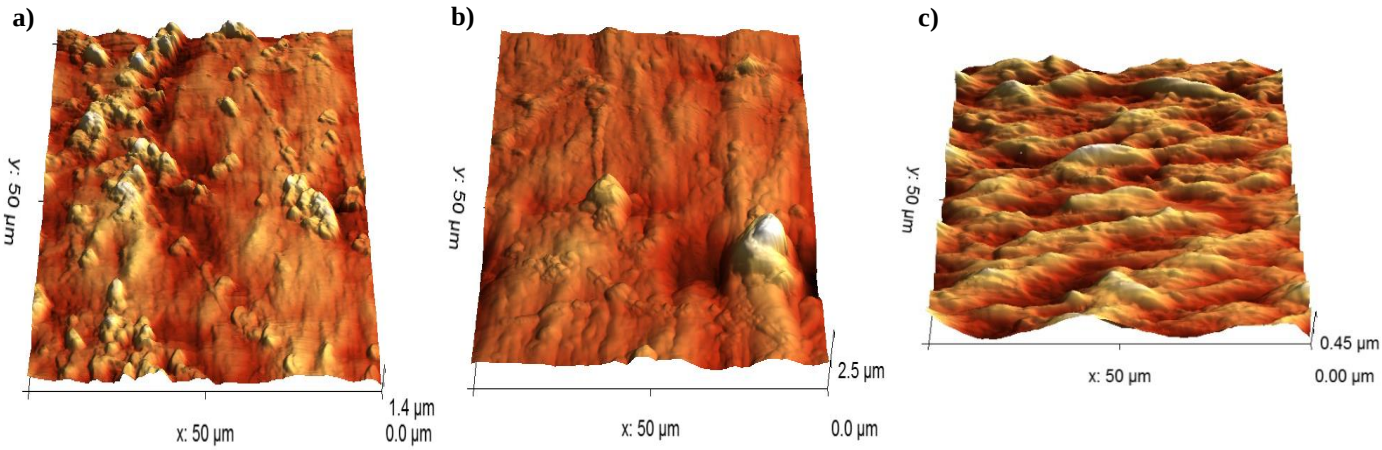

Figure 1. AFM Images of the LDPE Degraded Strips. **a)** LDPE Strip Degraded by *Aspergillus terreus*; **b)** LDPE Strip Degraded by *Alternaria alternate*; **c)** Control Strip.

SEM Analysis of the Degraded LDPE Strips

The broken LDPE strips were examined with a SEM to ensure that the fungus isolates had broken them down. Cracks, fragility, damaged layers, and surface roughness were shown in *A. terreus* (Figure 2a) and *A. alternata* (Figure 2b) degraded strips, with mycelia and spores

attached to their respective strips. The image of the control strip (Figure 2c) had a smooth surface view and showed no morphological alterations across all magnifications.

GC-MS Analysis of Polyethylene Biodegradation Products

GC-MS analysis of the byproducts resulting from fungal degradation of LDPE revealed different compounds. The action of *A. terreus* on LDPE strips leads to the formation of 7 compounds: Bis(2-ethylhexyl) phthalate, di(2-propyl pentyl) ester, Diisooctyl phthalate, di(6-methylhept-2-yl), di(oct-3-yl) ester, octyl 2-propyl pentyl ester, and Di-n-octyl phthalate, where Bis(2-ethylhexyl) phthalate represents the major compound at RT 54.494 (Figure 3). Concerning the action of *A. alternata*, it leads to the formation of 7 compounds as well: Bis(2-ethylhexyl) phthalate, 1,2-benzenedicarboxylic acid mono(2-ethylhexyl) ester, di(2-propyl pentyl) ester, Di-n-octyl phthalate, Diisooctyl phthalate, 2-ethylcyclohexyl octyl ester, and octyl oct-3-yl ester, where Bis(2-ethylhexyl) phthalate represents the major compound also but at RT 54.430 (Figure 4).

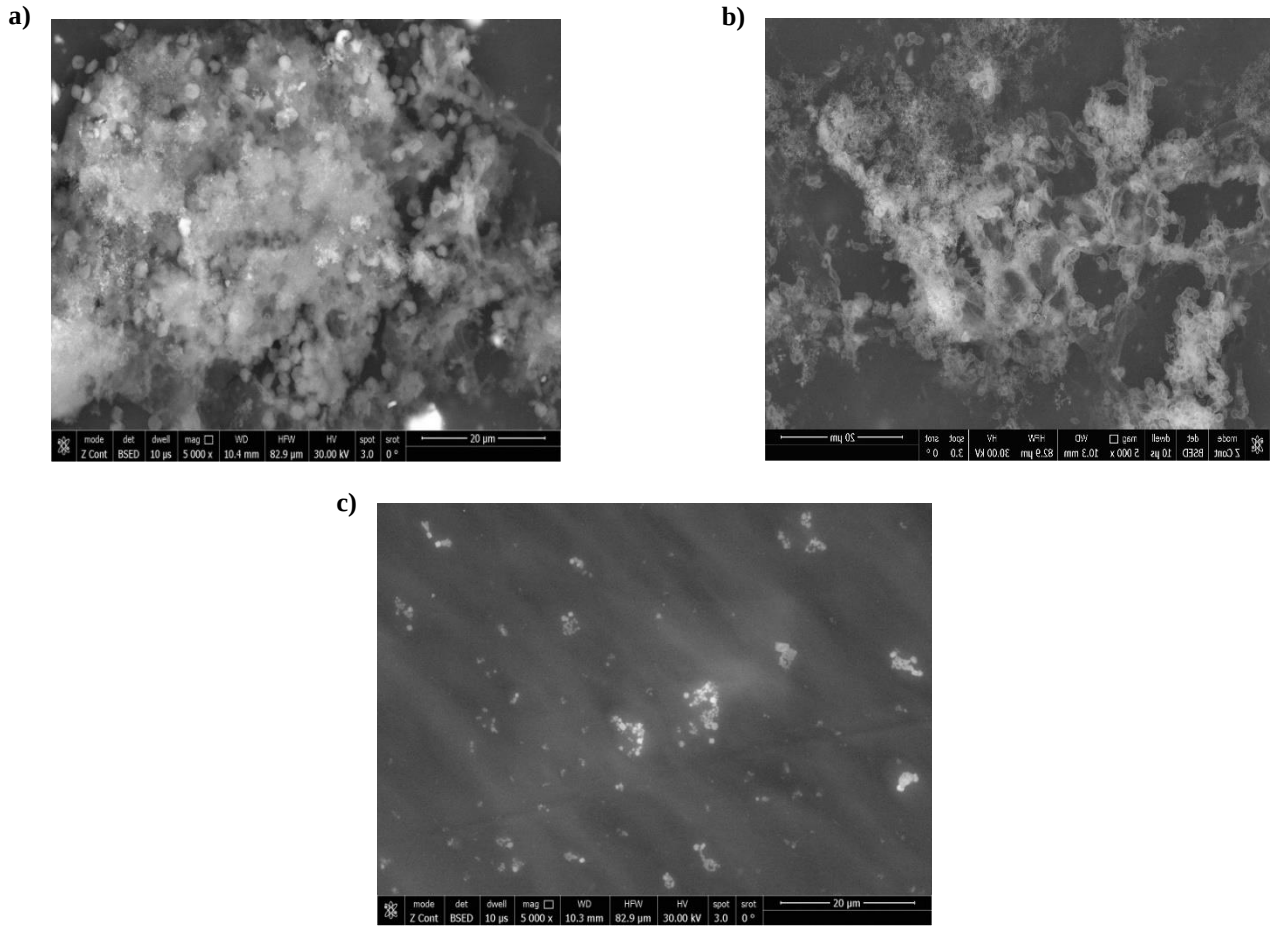

Figure 2. SEM Images of the LDPE Degraded Strips. **a)** LDPE Strip Degraded by *Aspergillus terreus*; **b)** LDPE Strip Degraded by *Alternaria alternate*; **c)** Control Strip.

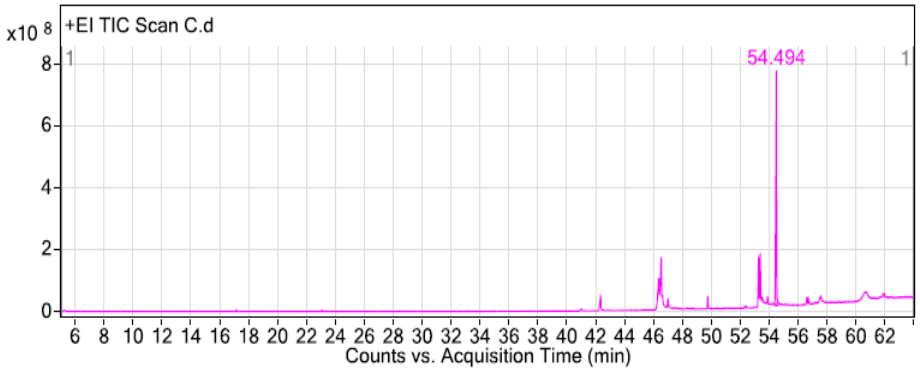

Figure 3. GC-MS Chromatogram of Polyethylene Degradation Products Produced by the Action of *A. terreus* on LDPE Strips.

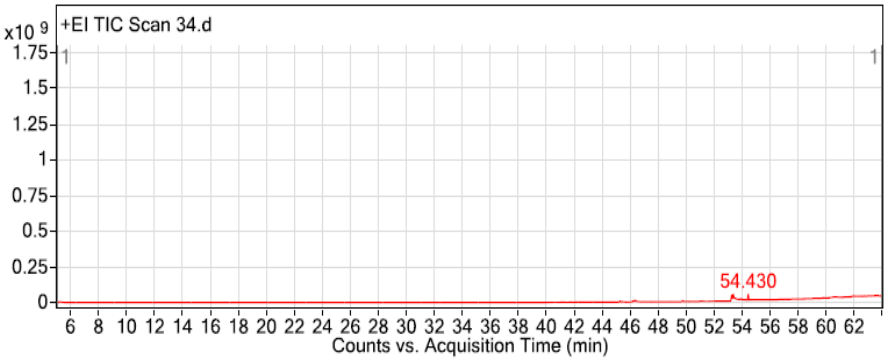

Figure 4. GC-MS Chromatogram of Polyethylene Degradation Products Produced by the Action of *A. alternata* on LDPE Strips.

Effect of Fungal Biodegradation Products on the Growth Parameters of the Wheat Plant

For this purpose, the germination percentage (G%), germination index (GI), and elongation inhibition rate (EI%) were evaluated. After 3, 5, 7, and 9 days of incubation at room temperature, the effect of polyethylene degradation products on the growth parameters of wheat seeds was measured at varied concentrations (10%, 25%, 50%, and 75%). In the control group, the seed germination percentage rate was reported to be 100% with a maximum GI (100 ± 0.0) and no elongation inhibition (EI%) (0.0 ± 0.0). The polyethylene degradation products produced by *A. terreus* caused a high decrease in seed germination (Table 2); as the concentrations of polyethylene degradation products increased, the germination percentage of wheat seeds decreased with a large decrease in the GI in each incubation period, while an EI% of 100 ± 0.0 was recorded after 3 days of incubation. On the other hand, the products produced from the degradation of polyethylene strips by *A. alternata* (Table 3) recorded a reduction in seed germination percentage and a decrease in GI, but less than that caused by the products of *A. terreus*, while the maximum EI% was recorded after 3 and 5 days of incubation (100 ± 0.0). The results of one-way ANOVA of G%, GI, and EI% reported a significant variation in seed germination compared to the control ($p \leq 0.05$).

Table 2. Effect of *A.terreus* Biodegradation Products on the Growth Parameters of the Wheat Plant

The concentration of degradation byproducts	Incubation periods											
	3 days			5 days			7 days			9 days		
	G%	GI	EI%	G%	GI	EI%	G%	GI	EI%	G%	GI	EI%
Control	$100^{c} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$	$100^{c} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$	$100^{d} \pm 0.0$	$100^{e} \pm 0.1$	$0^{a} \pm 0.0$	$100^{b} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$
10 %	$50.3^{b} \pm 0.33$	$5.5^{d} \pm 0.5$	$89.6^{b} \pm 0.6$	$100^{c} \pm 0.0$	$72^{d} \pm 0.6$	$4.3^{b} \pm 0.58$	$100^{d} \pm 0.0$	$87.5^{d} \pm 0.1$	$12.5^{b} \pm 0.1$	$100^{b} \pm 0.1$	$89.7^{d} \pm 0.1$	$10.2^{b} \pm 0.1$
25 %	$50^{b} \pm 0.57$	$4^{c} \pm 1.0$	$92.7^{c} \pm 0.6$	$75.3^{b} \pm 0.6$	$60^{c} \pm 0.57$	$40.3^{c} \pm 0.6$	$74.6^{c} \pm 0.6$	$46.9^{c} \pm 0.1$	$37.5^{c} \pm 0.1$	$99.9^{b} \pm 0.1$	$84.2^{c} \pm 0.1$	$15.8^{c} \pm 0.1$
50 %	$49.66^{b} \pm 0.88$	$1.7^{b} \pm 0.25$	$97^{d} \pm 1.0$	$74.3^{b} \pm 0.6$	$25.3^{b} \pm 0.6$	$59.6^{d} \pm 0.6$	$50.3^{b} \pm 0.6$	$20^{b} \pm 0.1$	$60^{d} \pm 0.1$	$75.03^{a} \pm 0.05$	$42.1^{b} \pm 0.1$	$43.9^{d} \pm 0.1$
75 %	$0^{a} \pm 0.0$	$0^{a} \pm 0.0$	$100^{e} \pm 0.0$	$25^{a} \pm 0.6$	$7.6^{a} \pm 0.6$	$67.6^{e} \pm 0.6$	$24.6^{a} \pm 0.6$	$5.6^{a} \pm 0.1$	$77.5^{e} \pm 0.1$	$75^{a} \pm 0.1$	$40.06^{a} \pm 0.05$	$46.7^{e} \pm 0.1$

G%: Germination percentage, GI: Germination index, EI%: Elongation inhibition percentage.

Table 3. Effect of *Alternaria alternata* Biodegradation Products on the Growth Parameters of the Wheat Plant

The concentration of degradation byproducts	Incubation periods											
	3 days			5 days			7 days			9 days		
	G%	GI	EI%	G%	GI	EI%	G%	GI	EI%	G%	GI	EI%
Control	$100^{c} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$	$100^{c} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$	$100^{b} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$	$100^{b} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$
10 %	$50^{b} \pm 0.1$	$7.5^{d} \pm 0.1$	$85^{b} \pm 0.1$	$50^{b} \pm 0.1$	$12^{d} \pm 0.1$	$76^{b} \pm 0.1$	$99.93^{b} \pm 0.05$	$95^{d} \pm 0.1$	$5^{b} \pm 0.1$	$99.93^{b} \pm 0.05$	$95.4^{d} \pm 0.1$	$4.6^{b} \pm 0.1$
25 %	$49.96^{b} \pm 0.05$	$6.5^{c} \pm 0.1$	$87^{c} \pm 0.1$	$49.96^{b} \pm 0.05$	$9.2^{c} \pm 0.1$	$81.6^{c} \pm 0.1$	$99.90^{b} \pm 0.1$	$84.2^{c} \pm 0.1$	$15.8^{c} \pm 0.1$	$99.90^{b} \pm 0.1$	$85^{c} \pm 0.1$	$15^{c} \pm 0.1$
50 %	$49.93^{b} \pm 0.12$	$5^{b} \pm 0.1$	$90^{d} \pm 0.1$	$49.93^{b} \pm 0.12$	$8^{b} \pm 0.1$	$84^{d} \pm 0.1$	$99.83^{b} \pm 0.15$	$72.5^{b} \pm 0.1$	$27.5^{d} \pm 0.1$	$99.83^{b} \pm 0.15$	$81.3^{b} \pm 0.1$	$18.7^{d} \pm 0.1$
75 %	$0^{a} \pm 0.0$	$0^{a} \pm 0.0$	$100^{e} \pm 0.0$	$0^{a} \pm 0.0$	$0^{a} \pm 0.0$	$100^{e} \pm 0.0$	$50^{a} \pm 0.1$	$20^{a} \pm 0.1$	$60^{e} \pm 0.1$	$75^{a} \pm 0.1$	$30.5^{a} \pm 0.1$	$59.3^{e} \pm 0.1$

G%: Germination percentage, GI: Germination index, EI%: Elongation inhibition percentage.

Discussion

With increasing attention on biological degradation of plastic materials as an alternative green method instead of chemical degradation, the bioactivities of marine-derived

fungi as a source of bioactive secondary metabolites have become one of the most important green methods for degradation. In this regard, several reports have pointed to the use of fungi, especially marine fungi, in degrading plastic materials. *Aspergillus* sp. (MH119104), isolated from marine waters near Sunderban, West Bengal, India, showed better degradation activity against polymer films obtained from waste plastic bottles.[31] In line with our results, previous studies have pointed to the significant role of media composition in biodegradation activity.[27] These studies reported that fungal isolates have been using sucrose as a carbon source, which is easier to break down than plastic. However, after 30 days of incubation, the weight of the LDPE had not decreased. This study also indicated that some fungal strains have grown on plastic materials as a carbon source. The hydrophobicity of fungi would be improved without a simple carbon source, increasing their attachment properties to plastic materials.[32]

Indeed, the high impact of biodegradation on plastic materials depends on the incubation period. As the incubation period increases, the biodegradation activity also increases. Aspergillus sp. showed a 22% weight loss in the plastic bottle samples after 6 weeks of incubation.[30] However, *Penicillium chrysogenum* showed weight loss of the LDPE sheets after 30, 60, and 90 days of incubation of 19.32%, 33.33%, and 34.35%, while *Penicillium oxalicum* reported weight loss of the LDPE sheets of 16.72%, 26.70%, and 36.60%, respectively. Both of them revealed, by AFM images, a change in surface roughness and fracture formation after 90 days of incubation. The scanning electron microscopy analysis of degraded LDPE films revealed spore and mycelium attachment with the appearance of cracks, grooves, fragility, damaged layer, pits, and surface roughness.[27] Furthermore, Dsouza et al.,[33] recorded a 26% weight loss of the LDPE samples after 55 days of incubation of an *Aspergillus consortium* in potato dextrose agar containing LDPE in substitution of dextrose, where SEM investigation of degraded polyethylene strips revealed morphological alterations such as bending, surface erosion, and pitting.

In close relation to our results, pits, grooves, and morphological changes on the plastic sheets were observed by AFM analysis conducted by Bonhomme et al.[34] The analysis also suggested that the fungal isolates secrete unique enzymes capable of degrading polyethylene even in the absence of oxidation, thus explaining the formation of grooves. These enzymes can oxidize alkene bonds into carbonyls and carboxylic acids.[35] Microorganisms can thrive in low-nutrient conditions and utilize solid substrates by synthesizing biofilms, which aid in their attachment to the surface.[36] Polymer hydrophobicity decreases, and breakdown is sped up by biofilm development.[37] Polyethylene samples treated by microbial biodegradation for a minimum of 20 days showed no evidence of exfoliation.[38]

Similar results were obtained by El-Sayed et al.,[39] who claimed that the GC-MS analysis of the biodegraded LDPE using a mixed culture of *A. carbonarius* and *A. fumigatus* revealed that the plasticizers Bis(2-ethylhexyl) phthalate, 1,2-benzenedicarboxylic acid, diisooctyl ester, diisooctyl phthalate, and tributyl acetyl citrate were produced. The ability of *Lysinibacillus* sp. JJY0216 in the biodegradation of polyethylene and polypropylene was examined by GC-MS analysis, and it was found that this species can degrade LDPE to various carboxylic acids of the hydrocarbon family.[40] However, Sangale et al., based on a GC-MS analysis reported that the fungal degradation of polyethylene revealed different compounds as byproducts. In the case of *A. sydowii* strain PNPF15/TS, four compounds were detected (7-methylene bicycle[3.2.0]hept-3-en-2-one, dibutyl phthalate, 1,4-benzenediol, and dodecahedron pyrido[1,2-b]isoquinoline -6-one), while *A. terreus* strain MANF1/WL produced six different compounds (2-naphthalenecarboxylic acid, dibutyl phthalate, 2-cyclohexen, 1,2-bis(trimethylsilyl)benzene, hexa siloxane, and hexadecanoic acid) and claimed no significant variation in the germination percentage of Sorghum seeds when treated with the degradation products of *A. terreus* MANF1/WL. However, similar to our results, there was a decrease in the germination index of seeds with an increase in concentration and duration period, and also showed a significant EI% of Sorghum seeds. While the products produced by *A. sydowii* PNPF15/WL showed no effect on the elongation inhibition rate of the Sorghum seeds.

Aswale[42] and Shahnawaz et al.,[43] studied plastic-degradation products toxicity of bacteria and fungi and reported moderate effect on seed germination of various tested plant seeds.[42] GC-MS analysis of bacteria-based polythene degradation products revealed 6 compounds formed due to the action of *Bacillus cereus* strain VASB1/TS (1-trime thylsilymethanol, 1,2,3, trimethylbenzene, 1-ethyl-3,5-dimethyl benzene, 1,4-dimethyl-2-ethyl benzene, dibutyl phthalate, and hexadecanoic acid) while, *Lysinibacillus fusiformis* strain VASB14/WL lead to the formation of 3 compounds (1-trimethylsilymethanol, 1,2,3,4 tetramethyl benzene, and hexadecanoic acid) and cause maximum EI% of tested plant seeds by (53.83 ± 15.71).

Conclusion

In conclusion, studies on marine-derived fungi have revealed their ability to degrade plastic materials such as waste plastic bags, which cause significant aquatic pollution. Two marine-derived fungi (*A. terreus* OQ271754 and *A. alternata* OQ282860) were found to be capable of degrading these plastic materials through the action of their secondary metabolites, resulting in a significant decrease in weight and changes in surface texture. This activity of marine fungi has a promising future in the field of plastic degradation,

potentially replacing traditional methods that contribute to various forms of environmental pollution.

Conflict of Interest Disclosures

The authors declare that they have no conflicts of interest.

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