DAVAO RESEARCH JOURNAL
https://davaoresearchjournal.ph

ORIGINAL RESEARCH ARTICLE

Evidence of Plastic Biodegradation Potential by a Fungal Isolate from a Sanitary Landfill in Davao Oriental

Eunice M. Gavilo[1,2], Phoebe Nemenzo-Calica[1]

[1]Master of Science in Environmental Science Program, Faculty of Advanced and International Studies, Davao Oriental State University, Mati City, Davao Oriental, 8200 Philippines, ORCID: Eunice M. Gavilo https://orcid.org/0009-0002-9004-5183; Phoebe Nemenzo-Calica https://orcid.org/0009-0004-7987-3951
[2]Governor Generoso College of Arts, Science and Technology, Governor Generoso, Davao Oriental, 8210 Philippines, ORCID: Eunice M. Gavilo https://orcid.org/0009-0002-9004-5183

*Corresponding author: *eunicegavilo1@gmail.com*

ABSTRACT

Plastic pollution, particularly from low-density polyethylene (LDPE), remains a major environmental concern due to its resistance to natural degradation. This study aimed to isolate and characterise microorganisms associated with highly degraded LDPE plastic litter collected from the sanitary landfill in Barangay Anitap, Governor Generoso, Davao Oriental, Philippines, and to evaluate their potential to biodegrade LDPE. Five highly degraded LDPE samples were collected and used for microbial isolation. A total of 10 isolates were recovered, comprising 5 bacterial isolates (BS1–BS5) and 5 fungal isolates (FS1–FS5). Morphological characterization was performed using Nutrient Agar for bacteria and Potato Dextrose Agar for fungi. Screening assays identified fungal isolate FS3 as exhibiting the highest LDPE biodegradation potential. Visible changes in FS3-treated LDPE included surface roughening, thinning, deformation, fragmentation, and extensive fungal colonization. Stereomicroscopic examination revealed dense fungal hyphae attached to and penetrating the plastic surface. Scanning Electron Microscopy (SEM) confirmed significant surface deterioration characterized by cracks, pits, grooves, erosion patterns, and fungal penetration compared with the smooth surface of uninoculated controls. Based on morphological and microscopic characteristics, FS3 was tentatively identified as a *Fusarium* species, with molecular confirmation through Internal Transcribed Spacer (ITS) sequencing currently ongoing. The findings demonstrate that sanitary landfill environments harbor indigenous microorganisms capable of degrading LDPE. This study provides preliminary evidence supporting the use of landfill-derived fungi as promising biological agents for sustainable plastic waste bioremediation and environmentally friendly waste management strategies.

Keywords: *Biodegradation, Fusarium solani, Low-density polyethylene (LDPE), plastic pollution, sanitary landfill*

Submitted: 18 May 2026
Revised:
Accepted:
Published:

OPEN ACCESS

How to cite: Gavilo, E. M., and Nemenzo-Calica, P. (2026). Evidence of Plastic Biodegradation Potential by a Fungal Isolate from a Sanitary Landfill in Davao Oriental *Davao Research Journal*, 17(2), 97-109. https://doi.org/10.59120/drj.v17i2.587

INTRODUCTION

Plastic pollution has become a major global environmental challenge due to the accumulation of non-biodegradable synthetic polymers in terrestrial and aquatic ecosystems. Since their introduction in the 1850s, plastics have become indispensable because of their durability, versatility, low cost, and resistance to degradation (Zhuang, 2022; Mnyango and Hlangothi, 2024). Among the various plastic types, low-density polyethylene (LDPE) is one of the most widely used materials in plastic bags, food packaging, wrappers, sachets, and other single-use products because of its flexibility, light weight, and moisture resistance (Andrady, 2017; Gong et al., 2023). However, its extensive use and improper disposal have significantly contributed to the global plastic waste crisis.

Approximately 430 million tons of plastic are produced annually worldwide, much of which eventually becomes waste (Vasquez, 2024). Due to its highly recalcitrant polymer structure, LDPE persists in the environment for decades and degrades very slowly under natural conditions (Gajendiran et al., 2016). Conventional waste management approaches, including landfilling, recycling, and incineration, have not been sufficient to address the growing volume of plastic waste. Landfills accumulate large quantities of plastics, while incineration may release harmful gases and toxic compounds (Al-Salem et al., 2009; Hopewell et al., 2009; Gan et al., 2019). In addition, plastic fragmentation generates microplastics that contaminate soils, freshwater systems, oceans, and food chains, posing risks to ecosystems and human health (Obebe and Adamu, 2020; Galloway, 2015).

The problem is particularly significant in the Philippines, which has been identified as a major contributor to marine plastic pollution due to inadequate waste management systems and improper disposal practices (Jambeck et al., 2015; Meijer et al., 2021). More than 2.7 million tons of plastic waste are generated annually, with a considerable proportion entering marine environments (Climate Change Commission, 2024). These concerns highlight the need for sustainable and environmentally friendly approaches to plastic waste management.

Microbial biodegradation has emerged as a promising alternative because microorganisms can colonize plastic surfaces and utilize enzymatic processes to break down polymer chains

(Qin et al., 2021; Ullah et al., 2025). During biodegradation, microorganisms form biofilms, secrete extracellular enzymes, fragment polymers, and ultimately convert degradation products into simpler compounds, including carbon dioxide, water, methane, and biomass (Zeenat et al., 2021). Numerous bacterial and fungal species have demonstrated the ability to degrade polyethylene and other synthetic polymers under laboratory conditions (Shankar et al., 2019; Gorish et al., 2024).

Among these microorganisms, filamentous fungi are considered particularly promising because of their extensive hyphal networks, adaptability to harsh environments, and production of oxidative and hydrolytic enzymes, including laccases, lipases, esterases, and peroxidases (Ekanayaka et al., 2022; Chigwada et al., 2025). Previous studies have reported polyethylene degradation by fungal genera including *Alternaria*, *Penicillium*, *Aspergillus*, and *Fusarium* (Spina et al., 2021; Srikanth et al., 2022). In particular, *Fusarium* species have demonstrated the ability to colonize and degrade LDPE through enzymatic depolymerization and biofragmentation (Zahra et al., 2010; Omidoyin et al., 2025), thereby using complex polymers as alternative carbon sources under nutrient-limited conditions (Kamil et al., 2025). Recent studies further emphasize the role of oxidative enzymes, including laccases, manganese peroxidases, lignin peroxidases, and cutinases, in initiating the breakdown of chemically stable polymer chains (Ameen et al., 2025; Qin et al., 2021; Bautista-Zamudio et al., 2023; Chigwada et al., 2025).

Landfill ecosystems are considered valuable reservoirs of potentially plastic-degrading microorganisms because they harbor diverse microbial communities that are continuously exposed to plastic-rich environments (Munir et al., 2024). Such exposure may promote adaptation to synthetic polymers and enhance biodegradation capabilities (Awasthi et al., 2023). Several studies have successfully isolated plastic-degrading bacteria and fungi from landfill environments, demonstrating their potential for bioremediation applications (Lamela et al., 2023; Gong et al., 2023). Accurate identification of these microorganisms is essential, and Internal Transcribed Spacer (ITS) sequencing is widely recognized as the universal DNA barcode for fungal identification due to its high taxonomic resolution and reliability (Schoch et al., 2012). Combining morphological and molecular approaches has therefore become the preferred strategy for characterizing fungal biodegraders (Chigwada et al., 2025; Ameen et al., 2025).

Despite growing international interest in microbial plastic biodegradation, studies on indigenous fungal degraders in the Philippines remain limited, particularly those derived from sanitary landfill environments. Existing local research has focused primarily on plastic-associated bacteria (Lamela et al., 2023), while information on landfill-derived fungi capable of degrading LDPE is scarce. Furthermore, little is known about plastic-degrading fungal communities in Mindanao, especially in Davao Oriental. Addressing this knowledge gap is important for developing locally adapted bioremediation strategies that utilize indigenous microorganisms already acclimatized to plastic-contaminated environments.

Therefore, this study investigated microorganisms associated with highly degraded LDPE plastic litter collected from the sanitary landfill of Barangay Anitap, Governor Generoso, Davao Oriental, Philippines. Specifically, the study aimed to isolate and characterize microbial communities associated with degraded LDPE, evaluate their biodegradation potential, and identify the isolate exhibiting the greatest LDPE biodegradation activity through morphological and microscopic characterization. The findings provide localized evidence of native microbial resources with potential applications in LDPE biodegradation and contribute to the development of sustainable biological approaches for plastic waste management in the Philippines.

MATERIALS AND METHODS

Description of the study area

The study was conducted using plastic waste samples collected from the sanitary landfill in Barangay Anitap, Governor Generoso, Davao Oriental, Philippines, located at 6˚37'55.36"N and 126˚06'49.08E (Figure 1). Barangay Anitap is one of the coastal, rural barangays in the municipality, characterized by agricultural lands, residential areas, and patches of secondary vegetation. The barangay is influenced by a tropical climate with relatively high humidity, warm temperatures, and considerable year-round rainfall, creating environmental conditions conducive to microbial survival and growth.

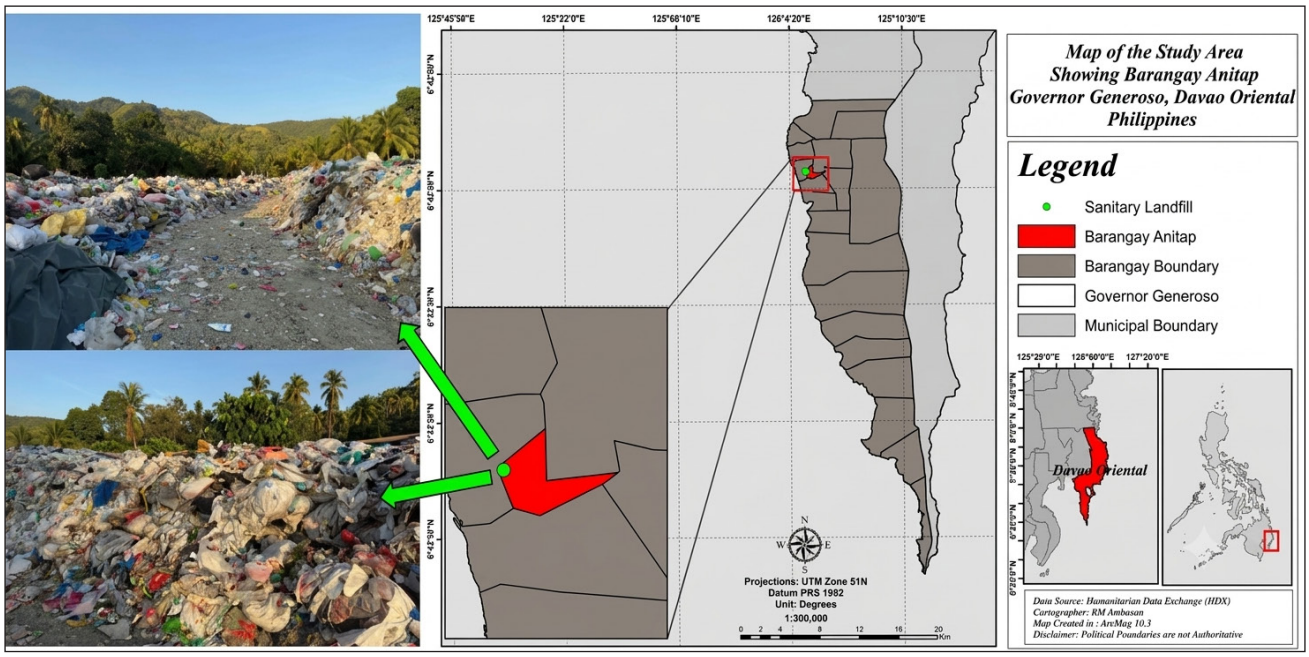

Figure 1. Location map of the study area in Barangay Anitap, Governor Generoso, and actual view of the sanitary landfill showing the sampling site for highly degraded low-density polyethylene (LDPE) plastic litter collection.

Topographically, Barangay Anitap consists of gently rolling to moderately sloping terrain, with low-lying areas extending toward the coastal portions of the municipality. The area comprises mixed soil types commonly associated with agricultural and landfill environments, which can support diverse microbial communities. The surrounding environment is continuously exposed to sunlight, fluctuating moisture levels, and organic waste accumulation, all of which contribute to the physical weathering and degradation of plastic materials.

The sanitary landfill in the barangay serves as a disposal site for mixed municipal solid wastes, including domestic, commercial, and agricultural refuse. The landfill was selected as the sampling site because of the visible accumulation of highly degraded plastic wastes and the prolonged environmental exposure of the materials to heat, ultraviolet radiation, rainfall, and soil microorganisms. These environmental and topographical characteristics provide favorable conditions for microbial colonization and adaptation, thereby increasing the potential to isolate indigenous microorganisms capable of degrading low-density polyethene (LDPE).

Sample sollection

Five highly degraded low-density polyethylene (LDPE) plastic litter samples were randomly collected from different areas within the landfill using sterile gloves and forceps. Only plastic materials exhibiting advanced stages of environmental degradation were selected for sampling. These samples were characterized by visible physical deterioration, including discoloration, brittleness, surface cracks, fragmentation, thinning, a roughened texture, and the presence of adhering soil particles or biofilm-like microbial growth. The selection of severely weathered plastic litter was based on the assumption that prolonged environmental exposure increases the likelihood of microbial colonization and adaptation to plastic substrates. The collected samples were individually placed in sterile zip-lock bags, properly labeled, and transported to the Microbiology Laboratory at the Davao Oriental State University in the Mati City, Davao Oriental, for microbial isolation and characterization. Care was taken to minimize contamination during collection and handling to preserve the naturally occurring microorganisms associated with the degraded LDPE surfaces.

A limitation of this preliminary study is the relatively small number of LDPE samples collected (n = 5), which may not fully represent the microbial diversity associated with degraded plastics across the entire landfill. Nevertheless, the selected samples provided an initial basis for isolating and screening microorganisms with potential to degrade LDPE. Future studies involving a larger number of samples and multiple sampling periods are recommended to capture greater microbial diversity and strengthen the ecological representativeness of the findings.

Isolation and characterization of microorganisms from degraded LDPE plastics

Microbial isolation was conducted in accordance with standard microbiological procedures. Each of the five degraded LDPE plastic litter samples was rinsed with sterile distilled water to remove loosely attached debris. The individual plastic litter sample was then immersed in sterile saline solution and vortexed to detach surface-associated microorganisms. For bacterial isolation, a loopful of each diluted suspension was streaked onto Nutrient Agar (NA; HiMedia Laboratories Pvt. Ltd., Maharashtra, India), while fungal isolates were cultured on Potato Dextrose Agar (PDA; HiMedia Laboratories Pvt. Ltd., Maharashtra, India). The inoculated plates were incubated at room temperature for 24–48 hours for bacterial growth and 5–7 days for fungal growth. Distinct microbial colonies that developed on the culture media were repeatedly sub-cultured until pure isolates were obtained. Each colony exhibiting distinct morphological characteristics was considered a separate isolate. The purified bacterial isolates were coded as BS1–BS5, where "B" represented bacteria and "S" represented sample, while fungal isolates were coded as FS1–FS5, where "F" represented fungi and "S" represented sample. The purified isolates were subsequently maintained on Nutrient Agar (NA) slants for bacteria and Potato Dextrose Agar (PDA) slants for fungi for further characterization and biodegradation screening.

Morphological characterization of the bacterial and fungal isolates was performed based on colony appearance and cultural characteristics. Bacterial isolates grown on Nutrient Agar plates were examined for colony color, shape, margin, elevation, opacity, and surface texture. Fungal isolates cultured on Potato Dextrose Agar plates were characterized according to colony color, texture, sporulation pattern, pigmentation, and hyphal appearance.

Screening of LDPE biodegradation activity

The biodegradation potential of the microbial isolates was evaluated using sterile blue LDPE plastic substrates. Commercial LDPE plastics were cut into uniform 1 cm^2 pieces, surface-sterilized with 70% ethanol, and then rinsed with sterile distilled water. For bacterial isolates, a loopful of a 48-hour pure culture was uniformly streaked over the entire surface of Nutrient Agar (NA) plates to establish confluent growth. For fungal isolates, a uniform mycelial plug (approximately 5 mm in diameter) obtained from the actively growing margin of a pure culture was aseptically transferred onto Potato Dextrose Agar (PDA) plates. The bacterial cultures were incubated for 48 hours, whereas the fungal cultures were incubated for 5 days at room temperature to ensure sufficient microbial growth before LDPE exposure. Subsequently, one sterile LDPE plastic strip (1 cm^2) was individually placed on top of each established bacterial or fungal culture.

The inoculated setups were then incubated at room temperature for 18 days and regularly monitored for visible signs of biodegradation. Changes observed on the LDPE surfaces included discoloration, thinning, surface roughening, fragmentation, fungal colonization, and deformation. Uninoculated LDPE substrates served as the control treatment for comparison.

After the incubation period, all LDPE samples were examined under a stereomicroscope at 40× magnification to assess microbial attachment and surface alterations. The plastic surfaces were observed under a stereomicroscope to detect bacterial interaction, fungal hyphae penetration, biofilm formation, surface erosion, and structural deterioration. Photographic documentation of the observed changes was conducted for comparative analysis between inoculated and uninoculated LDPE samples.

Scanning Electron Microscopy (SEM) analysis

Scanning Electron Microscopy (SEM) analysis was performed to confirm further the biodegradation effects of the most active isolate on LDPE surfaces. The LDPE samples were carefully removed from the culture setups and gently rinsed with sterile distilled water to eliminate loosely attached microbial biomass. The samples were air-dried before SEM preparation. The prepared LDPE samples were subjected to SEM examination at different magnifications (500x, 1000x, and 2000x) at Ateneo de Davao University, Davao City, Philippines, to observe microstructural changes on the plastic surfaces. Surface characteristics such as cracks, pits, grooves, erosion patterns, and fungal penetration

were analyzed and compared with those of uninoculated control samples. The SEM analysis provided detailed evidence of physical deterioration associated with microbial biodegradation activity.

Identification of the potential LDPE-degrading isolate

The isolate demonstrating the highest biodegradation activity was identified by its morphological and microscopic characteristics. Colony morphology, pigmentation, hyphal structures, and spore characteristics were examined and compared with standard fungal identification references and published descriptions. Based on these characteristics, the isolate was tentatively assigned to the genus *Fusarium* and provisionally identified as *Fusarium solani*.

Because the identification was based solely on morphological observations, it should be regarded as preliminary. Morphological traits may vary with culture conditions and may not be sufficient to distinguish closely related fungal species with certainty. Therefore, definitive species-level identification requires molecular confirmation. Molecular characterization of isolate FS3 is currently being conducted at the Philippine Genome Center Mindanao, University of the Philippines Mindanao, using amplification and sequencing of the Internal Transcribed Spacer (ITS) region of ribosomal DNA, the widely accepted DNA barcode for fungal identification (Schoch et al., 2012). The ITS region is being targeted using the universal fungal primers ITS1 and ITS4. The final taxonomic identity of FS3 will be confirmed upon completion of these analyses. Meanwhile, isolate FS3 is being maintained as a pure culture under laboratory conditions for preservation and future studies. Deposition of the isolate in an appropriate microbial culture collection repository will be pursued following molecular confirmation to ensure long-term preservation, accessibility, and reproducibility of the research findings.

RESULTS

Isolation of potential plastic-degrading microorganisms from the sanitary landfill

Five highly degraded LDPE plastic litter samples collected from the sanitary landfill of Barangay Anitap, Governor Generoso, Davao Oriental served as sources of microbial isolation. The samples consisted primarily of weathered plastic bags, sachet wrappers, and thin plastic films that exhibited discoloration, brittleness, fragmentation, thinning, and surface roughness (Figure 2). These materials were partially buried within landfill soil and continuously exposed to moisture, heat, organic wastes, and microbial activity. Figure 2 shows the actual degraded LDPE plastic litter samples collected from the sanitary landfill and utilized for the isolation of bacterial and fungal strains in this study.

Figure 2. Highly degraded LDPE plastic litter samples collected from the sanitary landfill of Barangay Anitap, Governor Generoso, Davao Oriental used for microbial isolation.

Microbial isolation from the sanitary landfill yielded 10 isolates: 5 bacterial and 5 fungal. The bacterial isolates were coded as BS1, BS2, BS3, BS4, and BS5, while the fungal isolates were designated as FS1, FS2, FS3, FS4, and FS5. The coding system represented the microorganism type, wherein "B" denoted bacteria, "F" denoted fungi, "S" denoted the sampling site, and the numerical value corresponded to the isolate number. As summarized in Table 1, the bacterial isolates cultured on nutrient agar exhibited generally consistent colony characteristics across replicates.

Table 1. Description of the five bacterial isolates cultured on Nutrient Agar (NA).

Isolate	Colony color	Form/Shape	Elevation	Margin	Surface/Texture	Opacity	General Observation
BS1	Cream to pale yellow	Irregular streak growth	Slightly raised	Entire to slightly undulate	Smooth, moist	Opaque	Moderate bacterial growth observed along streak lines
BS2	Creamy to pale yellow	Irregular to filiform streaks	Slightly raised to convex	Entire to undulate	Smooth, glistening, slightly mucoid	Opaque	Dense streak development with some mucoid portions
BS3	Yellowish cream	Irregular streak growth	Slightly raised	Entire to slightly undulate	Smooth, moist	Opaque	Moderate to dense bacterial growth across the agar surface
BS4	Pale cream to yellowish	Irregular to circular	Slightly raised to convex	Entire	Smooth, shiny, slightly mucoid	Opaque	Moderate colony growth with isolated mucoid colonies
BS5	Creamy yellow	Irregular	Raised	Slightly lobate to undulate	Smooth, moist	Opaque	Moderate to dense colony formation observed on nutrient agar

In addition to the bacterial isolates obtained from degraded LDPE plastic litter samples, five distinct fungal isolates were successfully isolated from the sanitary landfill environment. These isolates were designated as FS1, FS2, FS3, FS4, and FS5, where "F" represented fungi, "S" referred to the sampling site, and the numerical value corresponded to the isolate designation. The fungal isolates were cultured on Potato Dextrose Agar (PDA) to evaluate their colony morphology, mycelial texture, pigmentation, sporulation, and growth characteristics. Fungi are recognized as important biodegrading microorganisms due to their ability to produce extracellular enzymes capable of degrading complex organic compounds, including synthetic polymers such as low-density polyethylene (LDPE). Thus, the successful isolation of multiple fungal strains from the landfill environment suggests that these microorganisms may have adapted to plastic-rich conditions and may be capable of biodegrading plastics. Table 2 presents a summary of the morphological characteristics of the fungal isolates, highlighting variations in colony appearance and growth behavior that may reflect differences in fungal diversity, physiological adaptation, and biodegradation potential.

Table 2. Description of the five fungal isolates cultured on Potato Dextrose Agar (PDA).

Fungal isolate	Colony color	Mycelial texture and appearance	Growth characteristics	Sporulation/Pigmentation Observed	Overall Observation
FS1	Whitish to pale cream	Smooth to slightly cottony; sparse and circular colonies	Limited radial expansion; moderate fungal development	Small dark-centered sporulating portions observed in some replicates	Early fungal sporulation with moderately established colonies
FS2	White to grayish with dark centers	Dense, cottony, and opaque mycelia	Rapidly spreading colonies with moderate to dense mycelial growth	Dark green to black pigmentation indicating active sporulation	Mature fungal growth with extensive colony development
FS3	White to creamy	Cottony and filamentous texture; thick and opaque colonies	Moderate radial spreading with active proliferation	Isolated pigmented portions observed in some replicates	Well-established fungal colonies with vigorous growth
FS4	Pale white to translucent	Thin, smooth, and slightly cottony mycelia	Moderate radial expansion with relatively uniform surfaces	Minimal pigmentation observed	Less dense fungal growth compared to other isolates
FS5	Creamy white	Filamentous and cottony; moist and opaque colonies	Moderately spreading colonies with consistent fungal development	Yellowish portions observed in some replicates	Moderate fungal growth with stable colony morphology

Morphological characteristics of the isolated microorganisms

The bacterial isolates (BS1–BS5) exhibited generally uniform colony morphology on Nutrient Agar, characterized by cream-to-yellowish pigmentation, smooth, moist surfaces, an opaque appearance, and slight elevation. Differences among isolates were limited to colony form, margin configuration, and the extent of mucoid growth (Table 1). The colony morphology characteristics presented in Table 1 were recorded from direct observations of pure bacterial cultures during the isolation and characterization phase of the study. Although photographic documentation of isolated colonies is unavailable, the reported morphological descriptions were documented contemporaneously during laboratory observations. The fungal isolates (FS1–FS5) displayed greater morphological variability than the bacterial isolates, with differences in pigmentation, mycelial texture, sporulation, and radial expansion on PDA (Figure 3). Among the isolates, FS2 and FS3 showed dense cottony mycelia and pronounced sporulation, whereas FS4 exhibited relatively sparse growth. A detailed summary of fungal characteristics is provided in Table 2.

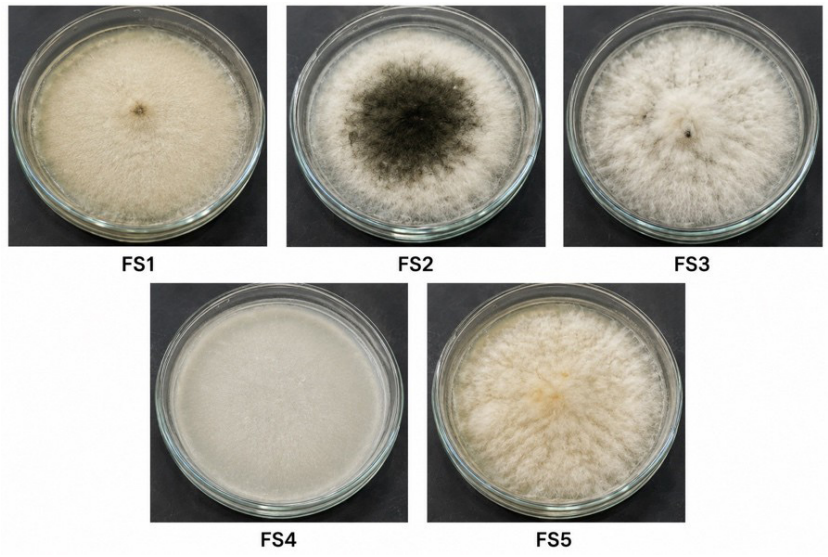

Figure 3. Colony morphological characteristics of fungal isolates cultured on Potato Dextrose Agar (PDA).

Screening of microbial isolates for LDPE biodegradation

As shown in Figure 4, the blue low-density polyethylene (LDPE) plastic substrates, each measuring approximately 1 cm², initially exhibited a smooth, intact, uniformly square morphology with no observable tears, cracks, perforations, or surface deformations before incubation. Following 18 days of incubation with the different microbial isolates, most LDPE substrates remained morphologically unchanged, indicating minimal or no visible biodegradative activity on the polymer surface. However, the LDPE substrate inoculated with isolate FS3 exhibited pronounced physical deterioration characterized by severe surface deformation, irregular edges, loss of the original square structure, and visible fungal colonization. Dense fungal hyphae were observed attached to and penetrating the LDPE surface, suggesting active colonization and biodegradation of the polymer.

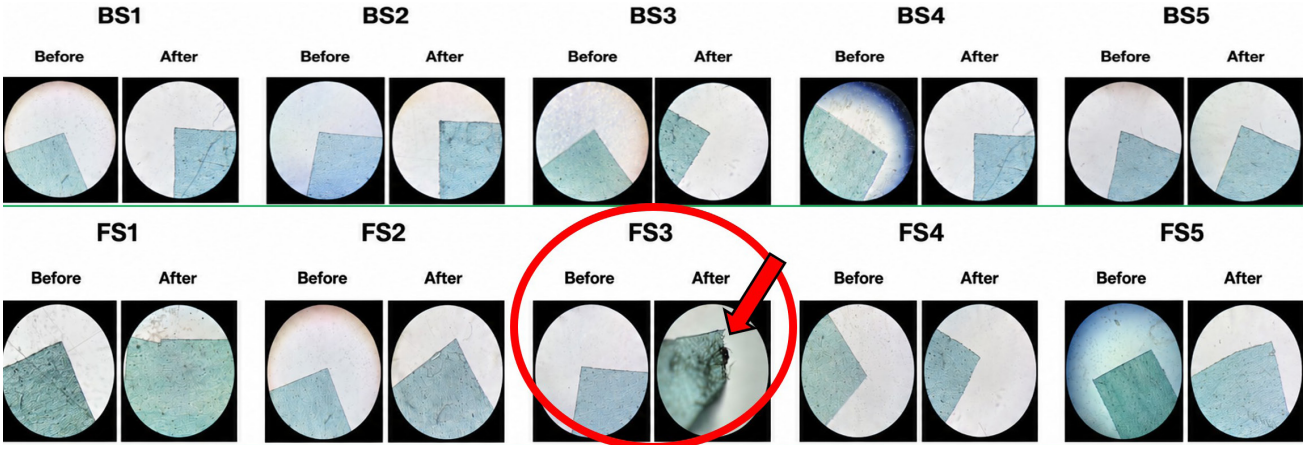

Figure 4. Morphological appearance of blue low-density polyethylene (LDPE) plastic substrates (≈1 cm²) before and after the 18-day biodegradation assay following inoculation with bacterial and fungal isolates under the stereomicroscope (40x).

A closer look at FS3 under the stereomicroscope, as shown in Figure 5, reveals that FS3 exhibited the most visible LDPE deterioration among all isolates tested, providing qualitative evidence of potential polyethylene biodegradation activity. The observed morphological changes suggest that FS3 possesses enzymatic mechanisms capable of altering the structural integrity of LDPE, highlighting its potential application in microbial-based plastic waste bioremediation strategies.

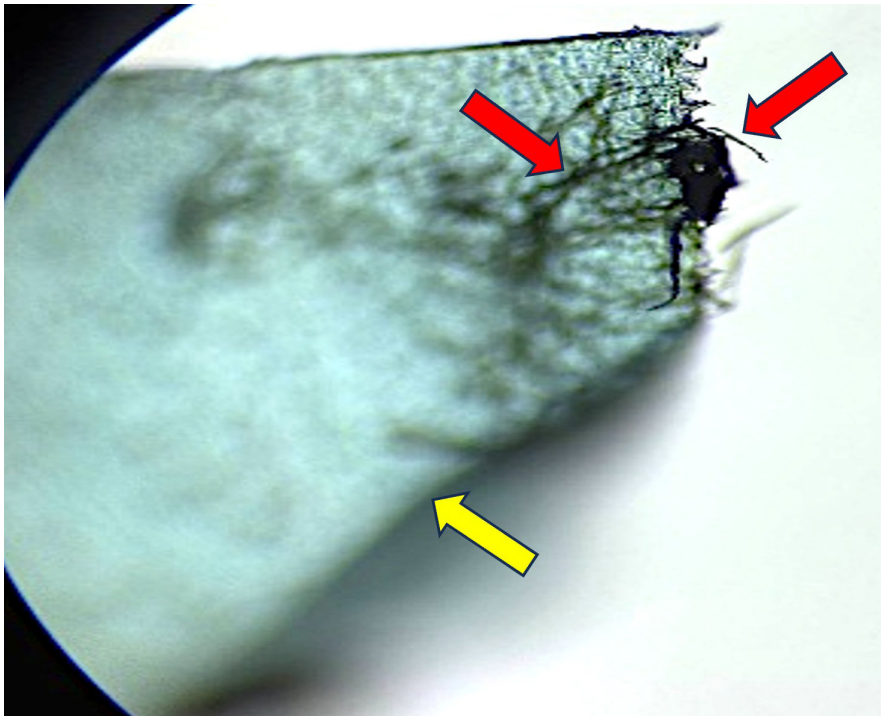

Figure 5. Zoomed stereomicroscopic image (40× magnification) of the blue low-density polyethylene (LDPE) plastic substrate inoculated with fungal isolate FS3 after the 18-day biodegradation assay, showing visible fungal hyphae attached to the plastic surface (red arrows) and the blue LDPE plastic substrate (yellow arrow).

Scanning Electron Microscopy (SEM) analysis of LDPE-degradation

Scanning Electron Microscopy (SEM) analysis was conducted to confirm the biodegradation activity of FS3 on LDPE surfaces compared with the uninoculated control. SEM examination revealed substantial deterioration of LDPE surfaces exposed to FS3, including pits, cracks, grooves, erosion patterns, and fungal attachment. In contrast, uninoculated controls retained smooth and intact surfaces, indicating minimal structural alteration (Figure 6).

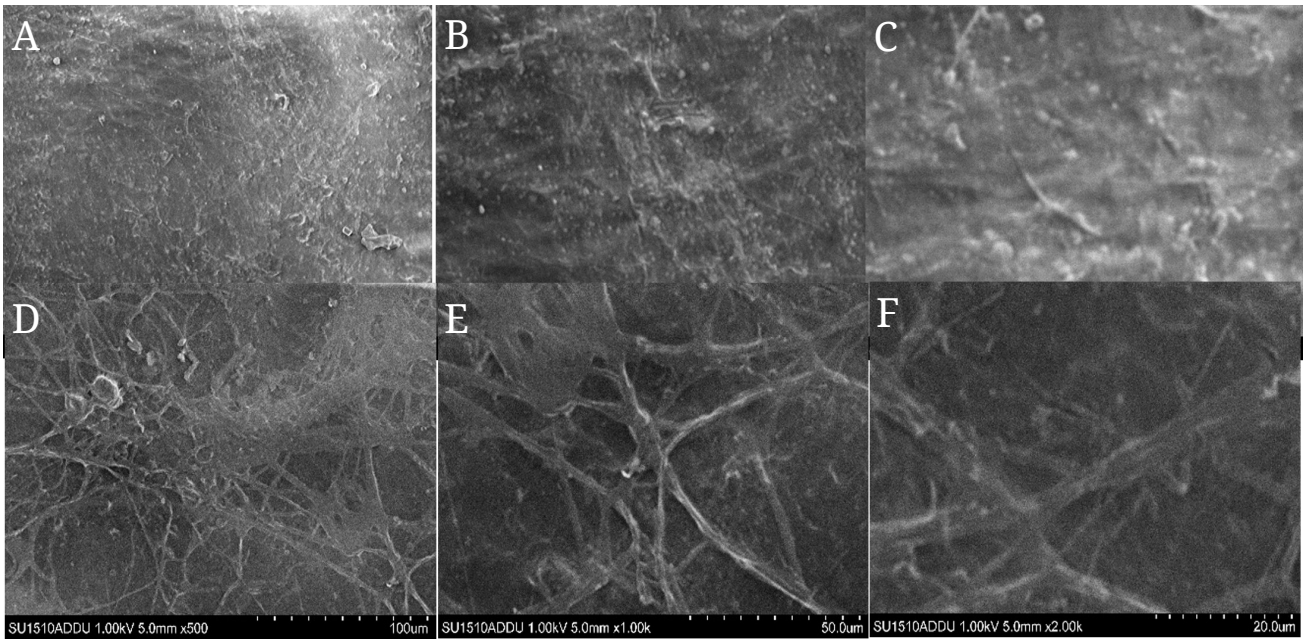

Figure 6. Scanning Electron Microscopy (SEM) images showing the surface morphology and degradation of low-density polyethylene (LDPE) plastics inoculated with fungal isolate FS3 after 18 days of incubation, compared with the uninoculated control. Panels A–C show the morphology of the uninoculated control LDPE plastic at (A) 500×, (B) 1,000×, and (C) 2,000× magnifications, respectively, exhibiting a relatively smooth and intact surface. Panels D–F show the morphology of LDPE plastic inoculated with isolate FS3 at (D) 500×, (E) 1,000×, and (F) 2,000× magnifications, respectively, revealing visible surface deterioration, erosion, cracks, pits, hyphal penetration, and fungal colonization, indicating the biodegradation or "plastic-eating" effect on the LDPE plastic surface.

Identity of the Best Plastic-Degrading Fungus (Isolate FS3)

Among all the microbial isolates evaluated in this study, fungal isolate FS3 exhibited the greatest biodegradation potential against low-density polyethylene (LDPE). This was evidenced by extensive fungal colonization of the plastic surface, visible deterioration and deformation of the LDPE substrate, and pronounced structural damage observed under stereomicroscopy and Scanning Electron Microscopy (SEM).

As shown in Figure 7, the cultural characteristics of isolate FS3 further supported its taxonomic placement. On Potato Dextrose Agar (PDA), FS3 produced white to creamy colonies with a dense, cottony, and filamentous mycelial texture. The isolate exhibited moderate to rapid radial expansion, accompanied by vigorous mycelial proliferation, resulting in thick, well-established colonies. Microscopic examination under low-power magnification revealed an extensive network of hyaline, septate, and branched hyphae distributed throughout the field of view. Numerous elongated, slightly curved to cylindrical conidia were observed either singly or in small clusters along the hyphae. The fungal structures appeared transparent to pale-colored, a characteristic commonly associated with members of the genus *Fusarium*. Several regions exhibited aggregations of conidia associated with branched hyphal structures, indicating active sporulation.

The observed microscopic features, particularly the presence of septate hyphae and abundant fusiform to cylindrical conidia, are consistent with published descriptions of *Fusarium solani*. These findings complement the colony morphology of FS3 on PDA, which was characterized by dense, cottony, white-to-creamy mycelial growth and vigorous proliferation. Collectively, the cultural and microscopic characteristics strongly suggest that isolate FS3 belongs to the genus *Fusarium* and is most closely related to *Fusarium solani* (Figure 7). Therefore, FS3 was designated as a putative *Fusarium solani* isolate pending molecular confirmation through DNA-based identification methods.

Figure 7. Comparison of fungal isolate FS3 (A) at 14 days of incubation with a previously reported plastic-degrading *Fusarium solani* isolate (B) from landfill environments (Munir et al., 2024). Similarities in colony morphology and LDPE biodegradation characteristics are evident. The low-power photomicrograph (C) of FS3 shows hyaline, septate, branched hyphae and abundant elongated conidia, supporting its preliminary identification as a putative *Fusarium solani* based on cultural and microscopic characteristics.

DISCUSSION

Environmental origin and microbial diversity of LDPE-associated isolates

The discovery of a potential "plastic-eating" fungus from a sanitary landfill in Governor Generoso, Davao Oriental, Philippines highlights the ecological importance of landfill environments as reservoirs of microorganisms adapted to synthetic polymer contamination. The successful recovery of bacterial and fungal isolates from degraded LDPE supports the role of landfill environments as reservoirs of microorganisms adapted to plastic-rich conditions. These observations indicate prolonged environmental exposure and partial degradation of the polymers. Environmental weathering promotes oxidation and fragmentation of plastics, increasing their susceptibility to microbial colonization and biodegradation (Andrady, 2017). Similarly, Pilapitiya and Ratnayake (2024) reported that weathered plastics become more vulnerable to biological attack because surface oxidation and structural irregularities enhance microbial attachment and enzymatic interaction.

The successful isolation of five bacterial and five fungal isolates from degraded LDPE samples demonstrates the adaptive capacity of microorganisms inhabiting landfill ecosystems. Landfills contain complex mixtures of organic waste, leachate, moisture, heat, and synthetic polymers that create selective pressures favoring metabolically versatile microorganisms (Youcai, 2018). The observed microbial diversity therefore suggests the presence of organisms capable of utilizing recalcitrant substrates as alternative carbon sources. Similar findings were reported by Bitalac et al. (2023), who observed that microorganisms colonizing plastic surfaces may develop physiological adaptations enabling survival and growth on polymer-associated substrates. The recovery of both bacterial and fungal isolates from degraded LDPE further supports the concept that plastic surfaces can serve as specialized microbial habitats or "plastispheres," where prolonged exposure to synthetic polymers selects for microorganisms capable of attachment, colonization, and potential polymer utilization (Bitalac et al., 2023; Zeenat et al., 2021). Such adaptation may enhance the capacity of landfill-associated microorganisms to participate in plastic biodegradation processes. The consistency in colony morphology across replicate cultures further indicated phenotypic stability and culture purity, supporting the reliability of the isolation and characterization procedures.

The coexistence of bacterial and fungal isolates in degraded LDPE samples suggests the potential for synergistic biodegradation mechanisms in landfill ecosystems. Plastic degradation commonly involves microbial consortia rather than single microorganisms alone (Amobonye et al., 2020). Bacteria may initiate polymer oxidation and surface fragmentation, whereas fungi contribu te through extracellular enzymatic degradation and hyphal penetration. Roberts et al. (2020) similarly demonstrated synergistic degradation of polyethylene terephthalate (PET) by bacterial consortia containing Bacillus and Pseudomonas species. Such microbial interactions may accelerate polymer deterioration and enhance biodegradation efficiency in natural environments.

Morphological and structural characterization of LDPE-degrading microorganisms

Morphological characterization revealed variation in colony and mycelial features among the isolates, suggesting the presence of metabolically diverse microbial groups capable of colonizing plastic-associated environments. Such diversity may influence microbial attachment, biofilm formation, and subsequent biodegradation activity. Biofilm formation is recognized as an important initial stage in plastic degradation because attached microorganisms can directly secrete degradative enzymes onto polymer surfaces (Zeenat et al., 2021). Similar observations have been reported for plastic-associated microorganisms isolated from contaminated environments (Ali et al., 2023; Lamela et al., 2023).

The fungal isolates exhibited distinct differences in mycelial density, pigmentation, sporulation, and radial growth. Notably, FS2 and FS3 developed dense, cottony mycelia and exhibited extensive colony expansion, characteristics commonly associated with active fungal colonisation. Filamentous fungi are considered promising plastic degraders because their hyphal networks can penetrate polymer surfaces and secrete extracellular oxidative enzymes that catalyse depolymerization (Ekanayaka et al., 2022). Comparable growth characteristics have been reported in landfill-derived fungi capable of polyethylene degradation (Gong et al., 2023; Sowmya et al., 2015).

The aggressive colonization exhibited by fungal isolate FS3 is consistent with previously reported biodegradation mechanisms of filamentous fungi. Fungal hyphae facilitate plastic deterioration through attachment, biofilm formation, and secretion of extracellular oxidative enzymes such as laccases, peroxidases, esterases, and cutinases capable of cleaving long hydrocarbon chains (Ameen et al., 2025; Bautista-Zamudio et al., 2023; Ekanayaka et al., 2022). Similar biodegradation patterns, including cracking, pitting, erosion, and fragmentation of polyethylene films, have been documented in fungi such as *Aspergillus clavatus*, *Penicillium simplicissimum*, *Alternaria alternata*, and *Cladosporium* species (Gajendiran et al., 2016; Sowmya et al., 2015; Gao et al., 2022; Gong et al., 2023).

Biodegradation performance and mechanism of *Fusarium solani* (FS3)

Among all isolates evaluated, fungal isolate FS3 demonstrated the highest biodegradation activity against LDPE. The pronounced deterioration observed in FS3-treated LDPE indicates active fungal interaction with the polymer and supports its potential role in polyethylene biodegradation. Dense fungal hyphae were visibly attached to and penetrating the polymer surface, suggesting active interaction with the LDPE matrix and possible utilization of polymer-associated carbon compounds.

Scanning Electron Microscopy (SEM) further confirmed these observations, revealing pits, grooves, cracks, erosion patterns, cavities, and irregular surface roughness in inoculated LDPE films, whereas control films remained smooth and compact. Fungal hyphae were strongly attached to the polymer surface, indicating active colonization and enzymatic interaction. Similar SEM findings were reported by Gao et al. (2022) and Gong et al. (2023), who observed severe cracking and surface erosion in polyethylene films exposed to fungal degraders. According to Ameen et al. (2025), such deterioration patterns are hallmarks of fungal-mediated biodegradation involving oxidative depolymerization and mechanical penetration of polymers by fungal hyphae. The observed cracking, pitting, grooves, and surface erosion are consistent with the early stages of polyethylene biodegradation reported in previous studies involving both landfill-derived and environmental fungal isolates. These structural alterations increase the surface area available for microbial attachment and enzymatic activity, thereby enhancing the polymer's susceptibility to further degradation (Gajendiran et al., 2016; Gao et al., 2022; Gong et al., 2023).

The exceptional biodegradation performance of FS3 may be associated with its cultural and microscopic characteristics. As shown in Figure 7, FS3 produced dense white-to-creamy colonies with a cottony, filamentous mycelial texture and vigorous radial growth on Potato Dextrose Agar (PDA). Such extensive mycelial development likely enhanced fungal attachment, biofilm

formation, and sustained contact with the LDPE surface, thereby facilitating biodegradation. Microscopic examination under low-power magnification revealed an extensive network of hyaline, septate, and branched hyphae accompanied by numerous elongated, slightly curved to cylindrical conidia. Several areas exhibited clusters of conidia associated with branched hyphal structures, indicating active sporulation and robust fungal growth. These cultural and microscopic features are consistent with published descriptions of *Fusarium solani*. In particular, the presence of hyaline septate hyphae and abundant fusiform to cylindrical conidia strongly supports the placement of FS3 within the genus *Fusarium*.

Furthermore, the colony morphology of FS3 closely resembled that of previously reported plastic-degrading *Fusarium solani* isolates, exhibiting dense cottony mycelia, vigorous proliferation, and extensive surface colonization. The close similarity between FS3 and previously reported polyethylene-degrading *F. solani* isolates (Figure 7), together with its aggressive colonization and pronounced LDPE deterioration, suggests that FS3 is most closely related to *Fusarium solani*. Accordingly, the isolate was designated as a putative *Fusarium solani* pending molecular confirmation through Internal Transcribed Spacer (ITS) sequencing.

The degradation observed in FS3 may be associated with biochemical pathways commonly reported among filamentous fungi capable of utilizing synthetic polymers. Fungal biodegradation generally begins with attachment and biofilm formation on the polymer surface, followed by the secretion of extracellular oxidative and hydrolytic enzymes that generate reactive intermediates capable of cleaving long-chain hydrocarbons (Qin et al., 2021; Ameen et al., 2025). Subsequent depolymerization produces lower-molecular-weight compounds that can be assimilated into fungal metabolic pathways and ultimately mineralized. Although enzymatic activities were not directly measured in the present study, the extensive surface deterioration and fungal colonization observed in FS3 are consistent with these established biodegradation mechanisms.

More specifically, oxidative enzymes such as laccases, lignin peroxidases, manganese peroxidases, esterases, and cutinases have been reported to initiate the breakdown of chemically stable polymer chains by introducing oxygen-containing functional groups into the polymer structure (Ameen et al., 2025; Bautista-Zamudio et al., 2023; Ekanayaka et al., 2022). This oxidative modification increases polymer hydrophilicity and susceptibility to further enzymatic attack, resulting in chain scission, surface erosion, and the formation of lower-molecular-weight degradation products. These products may subsequently enter fungal metabolic pathways where they can be utilized as supplementary carbon sources and eventually converted into carbon dioxide, water, and fungal biomass through mineralization processes (Qin et al., 2021; Ameen et al., 2025). The extensive cracking, pitting, erosion, and hyphal penetration observed in the present study are consistent with these previously reported fungal biodegradation mechanisms.

Although FS3 produced substantial visible deterioration of the LDPE substrate, the present study primarily generated qualitative evidence of biodegradation through stereomicroscopy and SEM observations. The observed deformation, fragmentation, surface roughening, and fungal colonization strongly suggest polymer deterioration; however, the extent of degradation could not be quantitatively determined because measurements such as percentage weight loss, changes in polymer chemistry, tensile strength reduction, carbon mineralization, or enzyme activity were beyond the scope of the study. Consequently, the results should be interpreted as preliminary evidence of biodegradation potential rather than a direct quantification of degradation efficiency. Similar studies have emphasized that SEM observations are most powerful when complemented by analytical techniques such as Fourier Transform Infrared Spectroscopy (FTIR), carbon mineralization assays, and weight-loss analyses to verify polymer modification and degradation rates (Qin et al., 2021; Gorish et al., 2024; Ameen et al., 2025).

The tentative identification of FS3 as *Fusarium solani* is particularly noteworthy as several studies have reported its ability to degrade polyethylene and other synthetic polymers. Omidoyin et al. (2025) demonstrated that *Fusarium solani* isolated from agricultural soils caused significant polyethylene degradation through oxidative enzymatic activity, producing surface roughening, cracking, and erosion patterns comparable to those observed in the present study. Similarly, Spina et al. (2021) documented polyethylene degradation by *Fusarium* species through fungal colonization, biofilm formation, and polymer fragmentation. The biodegradation behavior exhibited by FS3 therefore aligns closely with previously reported characteristics of polyethylene-degrading *Fusarium* isolates.

Accurate taxonomic identification is a critical component of contemporary biodegradation research. While morphological traits provide useful preliminary information, they may not be sufficient to distinguish closely related fungal species, as colony characteristics can vary with culture conditions and developmental stage. Consequently, Internal Transcribed Spacer (ITS) sequencing has become the most widely accepted molecular approach for fungal identification and taxonomic confirmation (Schoch et al., 2012). Recent reviews on fungal plastic biodegradation have emphasized that ITS-based molecular characterization improves the reliability, reproducibility, and comparative value of biodegradation studies by ensuring accurate species-level identification of candidate degraders (Ameen et al., 2025; Chigwada et al., 2025; Kamil et al., 2025). The ongoing ITS sequencing of isolate FS3 at the Philippine Genome Center Mindanao is therefore expected to provide robust molecular confirmation of its identity and to strengthen future investigations into its biodegradation capabilities. Molecular validation will also facilitate comparisons with other reported polyethylene-degrading *Fusarium* isolates and contribute to the growing database of plastic-associated fungal degraders from tropical environments.

Several studies have specifically identified *F. solani* as a potential polyethylene-degrading fungus. Omidoyin et al. (2025) reported that *Fusarium solani* isolated from agricultural soils caused significant polyethylene degradation through oxidative enzymatic activity, producing surface roughening and cracking comparable to those observed in the present study. Similarly, Spina et al. (2021) documented polyethylene degradation by *Fusarium* species through fungal colonization and polymer fragmentation.

Recent studies have highlighted the importance of integrating morphological observations with molecular and quantitative analyses when evaluating fungal plastic biodegradation. According to Chigwada et al. (2025), genomic and molecular tools are increasingly used to identify fungal taxa associated with plastic degradation and to investigate genes involved in oxidative and hydrolytic degradation pathways. Likewise, Ameen et al. (2025) emphasized that molecular identification methods, particularly ITS-based sequencing, provide a more reliable framework for confirming fungal identity and linking taxonomic groups with specific biodegradation mechanisms. The ongoing molecular characterization of FS3 through ITS sequencing will therefore provide important taxonomic validation and strengthen future comparisons with previously reported polyethylene-degrading *Fusarium* isolates. In addition to taxonomic confirmation, recent biodegradation

studies increasingly employ quantitative analytical techniques to verify polymer degradation beyond visual and microscopic observations. Fourier Transform Infrared Spectroscopy (FTIR), weight-loss measurements, carbon mineralization assays, and enzymatic activity analyzes are commonly used to evaluate changes in polymer chemistry, degradation rates, and the metabolic utilisation of plastic-derived carbon (Qin et al., 2021; Gorish et al., 2024; Ameen et al., 2025). Studies involving fungal degraders of polyethylene, including *Fusarium* and *Cladosporium* species, have demonstrated that combining SEM observations with quantitative assays provides stronger evidence of true polymer biodegradation and facilitates comparisons among microbial strains (Gong et al., 2023; Omidoyin et al., 2025).

The biodegradation performance of FS3 may be attributed to its environmental origin. The isolate was obtained from highly degraded plastic litter that was continuously exposed to synthetic polymers, organic waste, and environmental stressors within the landfill ecosystem. Such conditions likely promote adaptive evolution and enzymatic specialization among microorganisms inhabiting plastic-rich environments (Chigwada et al., 2025). Likewise, Awasthi et al. (2023) highlighted that landfill-derived microorganisms are valuable candidates for biodegradation research because prolonged exposure to plastics may select for organisms capable of utilizing recalcitrant polymers. The isolation of a potential LDPE-degrading fungus from a sanitary landfill in Davao Oriental is particularly significant because studies on indigenous fungal degraders in the Philippines remain limited. The use of locally adapted microorganisms may offer advantages for future bioremediation applications because these organisms have already evolved under environmental conditions characterized by continuous plastic exposure and waste accumulation (Lamela et al., 2023; Awasthi et al., 2023).

The findings of this study have important implications for sustainable management of plastic pollution in the Philippines. LDPE plastics such as sachets, wrappers, and plastic bags are among the most persistent environmental pollutants due to their hydrophobicity, high molecular weight, and chemically stable carbon-carbon backbone (Andrady, 2017; Brandsch and Piringer, 2000). Improper disposal and accumulation of these plastics contribute significantly to terrestrial and marine pollution in the country (Koons, 2024; Climate Change Commission, 2024). Conventional disposal methods, including landfilling and incineration, remain inadequate and may generate secondary environmental impacts such as toxic emissions and long-term contamination (Qin et al., 2021). In contrast, microbial biodegradation offers a more sustainable alternative because microorganisms naturally convert polymers into simpler and less harmful compounds (Amobonye et al., 2020).

The ability of FS3 to visibly colonize and deteriorate LDPE supports the growing recognition of fungal-assisted biodegradation as a promising strategy for plastic remediation. Filamentous fungi possess extensive hyphal systems and robust extracellular enzymatic mechanisms that make them particularly effective in attacking recalcitrant polymer surfaces (Ekanayaka et al., 2022; Bautista-Zamudio et al., 2023). The discovery of an indigenous landfill-derived *Fusarium solani* with biodegradation potential therefore provides valuable preliminary evidence supporting thedevelopment of locally sourced microbial technologies for plastic waste management and environmental biotechnology applications in the Philippines. Furthermore, the findings contribute to the growing body of evidence that landfill ecosystems should be viewed not only as repositories of waste but also as reservoirs of potentially beneficial microorganisms with environmental biotechnology applications. Continued exploration of these microbial resources may support the development of sustainable, locally relevant strategies for mitigating plastic pollution and complement existing waste management practices in the Philippines (Munir et al., 2024; Chigwada et al., 2025).

Although the present study demonstrated substantial qualitative evidence of LDPE biodegradation, molecular characterization through Internal Transcribed Spacer (ITS) sequencing is currently ongoing at the Philippine Genome Center Mindanao to confirm the taxonomic identity of isolate FS3. This molecular approach is consistent with current recommendations for fungal biodegradation studies, which emphasize DNA-based identification as an essential component of taxonomic validation and reproducibility (Chigwada et al., 2025; Ameen et al., 2025). Further investigations involving Fourier Transform Infrared Spectroscopy (FTIR), weight-loss analysis, enzymatic assays, and carbon mineralization studies are likewise recommended to quantitatively evaluate degradation efficiency and elucidate the biochemical mechanisms underlying LDPE degradation. These analytical approaches have become increasingly important in contemporary plastic biodegradation research because they provide direct evidence of polymer modification, mineralization, and microbial utilization of degradation products (Qin et al., 2021; Gorish et al., 2024; Omidoyin et al., 2025). Nevertheless, the present findings provide strong preliminary evidence that landfill-derived *Fusarium solani* possesses promising potential as an indigenous fungal agent for microbial-based plastic waste remediation and sustainable environmental management.

This study has several limitations that should be considered when interpreting the results. First, only five highly degraded LDPE samples were collected from a single sanitary landfill. The sampling strategy was designed for exploratory microbial screening and isolation of potential LDPE degraders rather than statistical representation of the entire landfill microbial community. Consequently, the samples may not capture the full diversity of plastic-associated microorganisms present at the site, and future studies involving larger sample sizes and multiple sampling locations are recommended. Second, the identification of isolate FS3 was based primarily on morphological and microscopic characteristics, which provide only preliminary taxonomic information. Although these characteristics were consistent with descriptions of *Fusarium solani*, species-level identification remains tentative until molecular confirmation through ITS sequencing is completed. Consequently, the biodegradation findings should be interpreted as preliminary evidence of LDPE-degrading potential pending molecular validation and further quantitative analyses.

CONCLUSION

The present study successfully isolated and characterized bacterial and fungal microorganisms from highly degraded low-density polyethylene (LDPE) waste collected from the sanitary landfill in Barangay Anitap, Governor Generoso, Davao Oriental. A total of 10 microbial isolates (5 bacterial and 5 fungal) were recovered, confirming that sanitary landfill environments serve as reservoirs of plastic-associated microbial communities adapted to prolonged exposure to synthetic polymers. Among the isolates, fungal isolate FS3 exhibited the most pronounced biodegradation activity against LDPE, as evidenced by extensive fungal colonization, visible deformation of the plastic substrate, and substantial surface deterioration observed through stereomicroscopy and Scanning Electron Microscopy (SEM). Based on its morphological characteristics and biodegradation behavior, FS3 was tentatively identified as *Fusarium solani;* however, this identification remains provisional pending molecular confirmation through ongoing ITS sequencing. Therefore, the reported biodegradation activity should be interpreted as preliminary evidence associated with a putative *Fusarium solani* isolate.

The findings provide important preliminary evidence that indigenous microorganisms occurring in sanitary landfills in Davao Oriental possess potential applications in plastic biodegradation and environmental biotechnology. Beyond their scientific significance, the results have direct implications for local solid waste management, landfill sustainability, and environmental protection in Davao Oriental and other municipalities facing increasing plastic waste accumulation. The discovery of a potential LDPE-degrading fungus from the Governor Generoso sanitary landfill highlights the value of landfill ecosystems not only as waste disposal facilities but also as sources of beneficial microorganisms that may contribute to future biological waste treatment and plastic remediation technologies.

At the local level, the study provides baseline scientific information to help Local Government Units (LGUs) strengthen evidence-based waste management programs, landfill monitoring activities, and environmental sustainability initiatives. The findings may also support the local implementation of Republic Act No. 9003 (Ecological Solid Waste Management Act of 2000) by encouraging the exploration of innovative, environmentally sound approaches to plastic waste reduction and management.

At the national level, the study contributes to the growing body of Philippine research on sustainable solutions to plastic pollution. The identification of native fungal resources with biodegradation potential may provide future opportunities for the Department of Environment and Natural Resources (DENR), waste management practitioners, and environmental policymakers to evaluate biological remediation approaches that complement existing waste diversion, recycling, and landfill management strategies. Such innovations may contribute to broader efforts toward environmental sustainability, circular resource management, and reduction of long-term plastic pollution in terrestrial and coastal ecosystems.

The findings of this study should, however, be interpreted as preliminary. The identification of isolate FS3 as *Fusarium solani* remains tentative, as molecular confirmation via Internal Transcribed Spacer (ITS) sequencing is still ongoing at the Philippine Genome Center Mindanao. Furthermore, although stereomicroscopic and SEM observations provided strong qualitative evidence of LDPE surface deterioration, quantitative analyses commonly used to verify polymer degradation, including Fourier Transform Infrared Spectroscopy (FTIR), weight-loss determination, carbon mineralization assays, tensile strength measurements, and enzyme activity analyses, were not performed in the present study (Qin et al., 2021; Gorish et al., 2024; Ameen et al., 2025). Consequently, the observed biodegradation effects should be regarded as preliminary evidence of LDPE biodegradation potential pending molecular validation and quantitative confirmation. Nevertheless, despite these limitations, the study expands the limited body of Philippine research on landfill-derived fungal degraders of LDPE. It provides an important foundation for future molecular, biochemical, and pilot-scale investigations. The results demonstrate that sanitary landfills in Davao Oriental harbor indigenous fungal resources with promising potential for sustainable plastic waste remediation and environmental management applications in the Philippines.

RECOMMENDATIONS

- Molecular identification of isolate FS3 through Internal Transcribed Spacer (ITS) sequencing should be completed to validate its taxonomic identity and strengthen its scientific and environmental significance as a native plastic-degrading fungus from Davao Oriental.
- Quantitative biodegradation studies, including FTIR analysis, weight-loss determination, tensile strength measurements, carbon mineralization assays, and enzyme activity profiling, should be conducted to confirm the extent and mechanisms of LDPE-degradation.
- Long-term laboratory and field-simulated studies are recommended to evaluate the effectiveness of FS3 under actual landfill and environmental conditions, including varying temperatures, moisture levels, and waste composition scenarios.
- The development of microbial consortia and pilot-scale biodegradation systems should be explored to enhance degradation efficiency and to assess their potential applications in sustainable plastic waste treatment technologies.
- Local Government Units (LGUs) in Governor Generoso, Davao Oriental, and neighboring municipalities are encouraged to support collaborative research and pilot projects involving indigenous plastic-degrading microorganisms as part of local environmental management and solid waste reduction programs.
- The Department of Environment and Natural Resources (DENR) may use the findings as baseline scientific information to evaluate the feasibility of incorporating biological approaches into existing plastic pollution mitigation, landfill management, and environmental restoration programs.
- Sanitary landfill operators and waste management practitioners may consider future studies assessing the integration of microbial-assisted biodegradation systems into landfill operations to help reduce long-term plastic accumulation and improve landfill sustainability.
- Academic institutions, LGUs, the DENR, and the private waste management sector should strengthen partnerships to translate laboratory-scale biodegradation research into practical, scalable technologies for plastic waste treatment.
- Future studies should evaluate the economic, environmental, and operational feasibility of applying landfill-derived fungi in waste management systems and determine their potential contribution to circular economy initiatives and sustainable resource recovery programs in the Philippines.
- Research on indigenous plastic-degrading microorganisms should be expanded to other sanitary landfills and waste disposal facilities in Mindanao and throughout the Philippines to establish a national database of microbial resources with environmental-biotechnology potential.

ACKNOWLEDGMENT

The authors sincerely acknowledge Mr. Marlone Barrete of the Science Laboratory, Faculty of Agriculture and Life Sciences, for his valuable laboratory support and guidance throughout the experimental work. His expertise significantly contributed to the completion of this study. Gratitude is also extended to Ateneo de Davao University for facilitating the Scanning Electron Microscopy (SEM) analysis, which was essential in confirming LDPE surface degradation. The authors further acknowledge the Philippine Genome Center Mindanao, University of the Philippines Mindanao, for the ongoing molecular identification of isolate FS3 through Internal Transcribed Spacer (ITS) sequencing and related genetic analyses.

FUNDING SOURCE

The study was self-funded

AUTHOR CONTRIBUTIONS

E. M. G: Conducted the field sampling and laboratory experiments, analyzed the data, and prepared the initial draft of the manuscript. P. N. C: Conceptualized the study, supervised the overall research process, contributed to the study design and data interpretation, and critically reviewed and approved

the final manuscript for publication.

DECLARATIONS

Informed consent statement

This study involved the collection and analysis of low-density polyethylene (LDPE) plastic waste and the isolation of associated microorganisms from a sanitary landfill site in Barangay Anitap, Governor Generoso, Davao Oriental, Philippines. All sampling activities were conducted with proper authorization from relevant local authorities and in accordance with environmental safety and waste management guidelines to ensure minimal disturbance to the site. No human participants or vertebrate animals were involved in this research. All microbial handling, cultivation, and experimental procedures were performed under appropriate laboratory safety conditions to prevent environmental release and ensure researcher safety. Standard aseptic techniques and biosafety protocols were strictly followed throughout the study. The researchers also ensured responsible management and disposal of all biological and plastic materials used during experimentation to avoid secondary environmental contamination. This study upholdsthe principles of environmental responsibility, biosafety, and scientific integrity. It aims to contribute to sustainable, eco-friendly solutions for managing plastic pollution without harming ecosystems or public health.

Conflict of interest

The authors have no conflicts of interest regarding the results of the study.

AI Declaration

The authors declare that no Artificial Intelligence (AI) or AI-assisted technologies were used in the preparation of this manuscript.

REFERENCES

Ali, S., Rehman, A., Hussain, S. Z., and Bukhari, D. A. (2023). Characterization of plastic degrading bacteria isolated from sewage wastewater. *Saudi Journal of Biological Sciences*, 30(5), 103628. https://doi.org/10.1016/j.sjbs.2023.103628

Ameen, F., Al-Homaidan, A. A., Al-Sabri, A. E., Al-Masaudi, S. B., and Al-Nadhari, S. (2025). Advances in fungal biodegradation of synthetic plastics: Mechanisms and molecular insights. *Journal of Environmental Management*, 360, 122879. https://doi.org/10.1016/j.jenvman.2024.122879

Amobonye, A., Bhagwat, P., Singh, S., and Pillai, S. (2020). Plastic biodegradation: Frontline microbes and their enzymes. *Science of the Total Environment*, 759, 143536. https://doi.org/10.1016/j.scitotenv.2020.143536

Andrady, A. L. (2017). The plastic in microplastics: A review. *Marine Pollution Bulletin*, 119(1), 12–22. https://doi.org/10.1016/j.marpolbul.2017.01.082

Awasthi, A. K., Singh, R., Sarsaiya, S., Awasthi, M. K., Liu, T., Kumar, S., and Zhang, Z. (2023). Microbial approaches for degradation of plastics: Challenges and opportunities. *Chemosphere*, 314, 137678. https://doi.org/10.1016/j.chemosphere.2022.137678

Bautista-Zamudio, P. A., Flórez-Restrepo, M. A., López-Legarda, X., Monroy-Giraldo, L. C., and Segura-Sánchez, F. (2023). Biodegradation of plastics by white-rot fungi: A review. *Science of the Total Environment*, 901, 165950. https://doi.org/10.1016/j.scitotenv.2023.165950

Bitalac, J. M. S., Lantican, N. B., Gomez, N. C. F., and Onda, D. F. L. (2023). Attachment of potential cultivable primo-colonizing bacteria and its implications on the fate of low-density polyethylene (LDPE) plastics in the marine environment. *Journal of Hazardous Materials*, 451, 131124. https://doi.org/10.1016/j.jhazmat.2023.131124

Brandsch, J., and Piringer, O. (2000). Characteristics of plastic materials. In *Plastic Packaging Materials for Food* (pp. 9–45). Wiley-VCH.

Chigwada, A. D., Tekere, M., and Ogola, H. J. O. (2025). Ecological and genomic perspectives on fungal plastic biodegradation: Research progress, opportunities and challenges. *Ecological Genetics and Genomics*, 36, 100378. https://doi.org/10.1016/j.egg.2025.100378

Climate Change Commission. (2024). Combating plastic pollution to secure our planet's future. https://climate.gov.ph/news/870

Ekanayaka, A. H., Tibpromma, S., Dai, D., Xu, R., Suwannarach, N., Stephenson, S. L., and Karunarathna, S. C. (2022). A review of the fungi that degrade plastic. *Journal of Fungi*, 8(8), 772. https://doi.org/10.3390/jof8080772

Gajendiran, A., Krishnamoorthy, S., and Abraham, J. (2016). Microbial degradation of low-density polyethylene (LDPE) by *Aspergillus clavatus* strain JASK1 isolated from landfill soil. *3 Biotech*, 6, 52. https://doi.org/10.1007/s13205-016-0394-x

Galloway, T. S. (2015). Micro- and nano-plastics and human health. In *Marine Anthropogenic Litter* (pp. 343–366). Springer. https://doi.org/10.1007/978-3-319-16510-3_13

Gao, R., Liu, R., and Sun, C. (2022). A marine fungus *Alternaria alternata* FB1 efficiently degrades polyethylene. *Journal of Hazardous Materials*, 431, 128617. https://doi.org/10.1016/j.jhazmat.2022.128617

Gong, Z., Jin, L., Yu, X., Wang, B., Hu, S., Ruan, H., Sung, Y., Lee, H., and Jin, F. (2023). Biodegradation of low-density polyethylene by the fungus *Cladosporium* sp. recovered from a landfill site. *Journal of Fungi*, 9(6), 605. https://doi.org/10.3390/jof9060605

Gorish, B. M. T., Abdelmula, W. I. Y., Sethupathy, S., Dar, M. A., Shahnawaz, M., and Zhu, D. (2024). Microbial degradation of polyethylene polymer: Current paradigms, challenges, and future innovations. *World Journal of Microbiology and Biotechnology*, 40(12), 399. https://doi.org/10.1007/s11274-024-04211-8

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., and Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768–771. https://doi.org/10.1126/science.1260352

Kamil, D., Mishra, A. K., Das, A., and Nishmitha, K. (2025). Genus *Fusarium* and *Fusarium* species complexes. In *Biodiversity, Bioengineering, and Biotechnology of Fungi* (pp. 209–225). Academic Press. https://doi.org/10.1016/B978-0-443-13856-0.00016-6

Lamela, P. A. M., Diputado, Y. G., Lumantas, J. M., Gatpatan, I. G., and Cabulong, R. B. (2023). Isolation, characterization, and identification of plastic-degrading bacteria from Bago City landfill, Negros Occidental, Philippines. *Philippine Journal of Natural Sciences*, 28, 24–45.

Meijer, L., van Emmerik, T., van der Ent, R., Schmidt, C., and Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances, 7, eaaz5803. https://doi.org/10.1126/sciadv.aaz5803

Munir, E., Pasaribu, Y., Mubtasima, S., and Nasution, A. F. (2024). The diversity of fungi in landfill and their potential to degrade plastic. *OnLine Journal of Biological Sciences*, 24(3), 374–381. https://doi.org/10.3844/ojbsci.2024.374.381

Omidoyin, K. C., Hwang, S. K., Hong, J. K., and Jho, E. H. (2025). Biodegradation of low-density polyethylene microplastics by *Fusarium* and *Penicillium* strains isolated from agricultural soil mulched with polyethylene film. *Journal of Environmental Management*, 394, 127477. https://doi.org/10.1016/j.jenvman.2025.127477

Pilapitiya, N. T., and Ratnayake, A. S. (2024). The world of plastic waste: A review. *Cleaner Materials*, 11, 100220. https://doi.org/10.1016/j.clema.2024.100220

Qin, Z., Mou, J., Chao, C. Y. H., Chopra, S. S., Daoud, W., Leu, S., Ning, Z., Tso, C. Y., Chan, C. K., Tang, S., Hathi, Z. J., Haque, M. A., Wang, X., and Lin, C. S. K. (2021). Biotechnology of plastic waste degradation, recycling, and valorization: Current advances and future perspectives. *ChemSusChem*, 14(19), 4103–4114. https://doi.org/10.1002/cssc.202100752

Schoch, C. L., Seifert, K. A., Huhndorf, S., Robert, V., Spouge, J. L., Levesque, C. A., and White, M. M. (2012). Nuclear ribosomal internal transcribed spacer (ITS) region as a universal DNA barcode marker for Fungi. *Proceedings of the national academy of Sciences*, 109(16), 6241-6246. https://doi.org/10.1073/pnas.1117018109

Shankar, S., Singh, S., Mishra, A., Sharma, M., and Shikha. (2019). Microbial degradation of polyethylene: Recent progress and challenges. In *Microbial Metabolism of Xenobiotic Compounds* (pp. 245–262). Springer. https://doi.org/10.1007/978-981-13-7462-3_12

Spina, F., Tummino, M. L., Poli, A., Prigione, V., Ilieva, V., Cocconcelli, P., and Varese, G. C. (2021). Low-density polyethylene degradation by filamentous fungi. Environmental Pollution, 274, 116548. https://doi.org/10.1016/j.envpol.2021.116548

Srikanth, M., Sandeep, T. S. R. S., Sucharitha, K., and Godi, S. (2022). Biodegradation of plastic polymers by fungi: A brief review. Bioresources and Bioprocessing, 9(1), 42. https://doi.org/10.1186/s40643-022-00532-2

Ullah, A. A., Riaz, A., Abdali, U., Siddiqui, A., Kazmi, S. K., Qadeer, K., Naeem, M., Khan, D. M., and Ayub, A. (2025). Microbial-mediated plastic degradation: A sustainable pathway to environmental health. In R. Z. Abbas, T. Akhtar, & J. Arshad (Eds.), *One Health in a Changing World: Climate, Disease, Policy, and Innovation* (pp. 310–318). Unique Scientific Publishers. https://doi.org/10.47278/book.HH/2025.170

Vasquez, D. P. (2024). Protect our planet from plastic pollution: 5 things to know. United Nations Foundation. Retrieved from https://unfoundation.org/blog/post/protect-our-planet-from-plastic-pollution-5-things-to-know

Zahra, S., Abbas, S. S., Mahsa, M. T., and Mohsen, N. (2010). Biodegradation of low-density polyethylene (LDPE) by isolated fungi in solid waste medium. *Waste Management*, 30(3), 396–401. https://doi.org/10.1016/j.wasman.2009.09.027

Zeenat, Elahi, A., Bukhari, D. A., Shamim, S., and Rehman, A. (2021). Plastic degradation by microbes: A sustainable approach. *Journal of King Saud University – Science*, 33, 101538. https://doi.org/10.1016/j.jksus.2021.101538

Print-ISSN 2244-4432 Online-ISSN 2984-7125