CONCLUSION

- The municipal solid waste scenario of Vadodara city was determined from three temporary dumping sites and the Jambuva landfill area. The compositional analysis of MSW revealed polyethylene bags as a non-degradable component of MSW because the polyethylene bag wastes were found in higher percentages and very prominent even in 10-year-old waste collected from dumping site from a depth of 20 ft.
- Fungal biodiversity from dumpsites was isolated and seven fungal strains including *A. niger*, *A. flavus*, and *A. fumigatus*, two strains of *A. oryzae*, *Trichoderma* sp., and *Rhizopus* sp. were isolated.
- Total number of nineteen fungal isolates were (Isolated from dumpsite+ procured from other sources) screened with polyethylene powder, beads, and films. *A. tubingensis* (SA1), *A. oryzae* (SA5), *Pestalotiopsis* sp. (SA13), *A. oryzae* (SA15) and *F. solani* MN201580.1 (SA17) exhibited promising results in UV rays treated PE films (3hrs and 9 hrs).
- Thermally oxidized films (45°C and 70°C) revealed significant weight loss, surface destruction, and chemical changes due to degradation by *A. oryzae* (SA5) and *F. solani* MN201580.1 (SA17). These two strains *A. oryzae* (SA5) and *F. solani* MN201580.1 (SA17) were further screened with thermo-chemical (60°C + Nitric acid) treated films, in which 16.48 ± 0.01% and 21.33 ± 0.01% weight-loss was recorded in two weeks.
- Among all strains, *F. solani* MN201580.1 (SA17) showed significant weight loss, and the occurrence of degradation was confirmed by SEM and FTIR analysis. A protocol involving heat treatment followed by concentrated nitric acid treatment was selected as the optimal method for further investigation of the degradation of polyethylene films using *F. solani* MN201580.1 (SA17). *F. solani* MN201580.1 (SA17) culture was chosen for subsequent enzyme evaluation and optimization experiments due to its higher degradation capability observed in all the screening experiments.
- The polyethylene degrading enzymes, Laccase, MnP, Protease, Esterase, and lipase were evaluated qualitatively and quantitatively. The qualitative assay revealed the potentiality of *F. solani* MN201580.1 to release these enzymes by showing a zone of hydrolysis around the colonies. In the quantitative analysis, *F. solani* MN201580.1 exhibited maximum activity 3.41±0.7 U/ml (25th day, laccase), 0.2±0.1 U/ml (15th day, MnP), 359±2.58 U/ml (25th day, protease), 559.78±1.62 U/ml (15th day, esterase), and 51.14±1.76 U/ml (20th day, lipase).
- The optimized conditions for the significant activity of laccase, MnP, protease, lipase & esterase enzymes by *F. solani* MN201580.1 was evaluated. The experiment revealed a single disc as the optimum inoculum size, 20th day for highest activity, optimum temperature, and pH was 30°C & 8

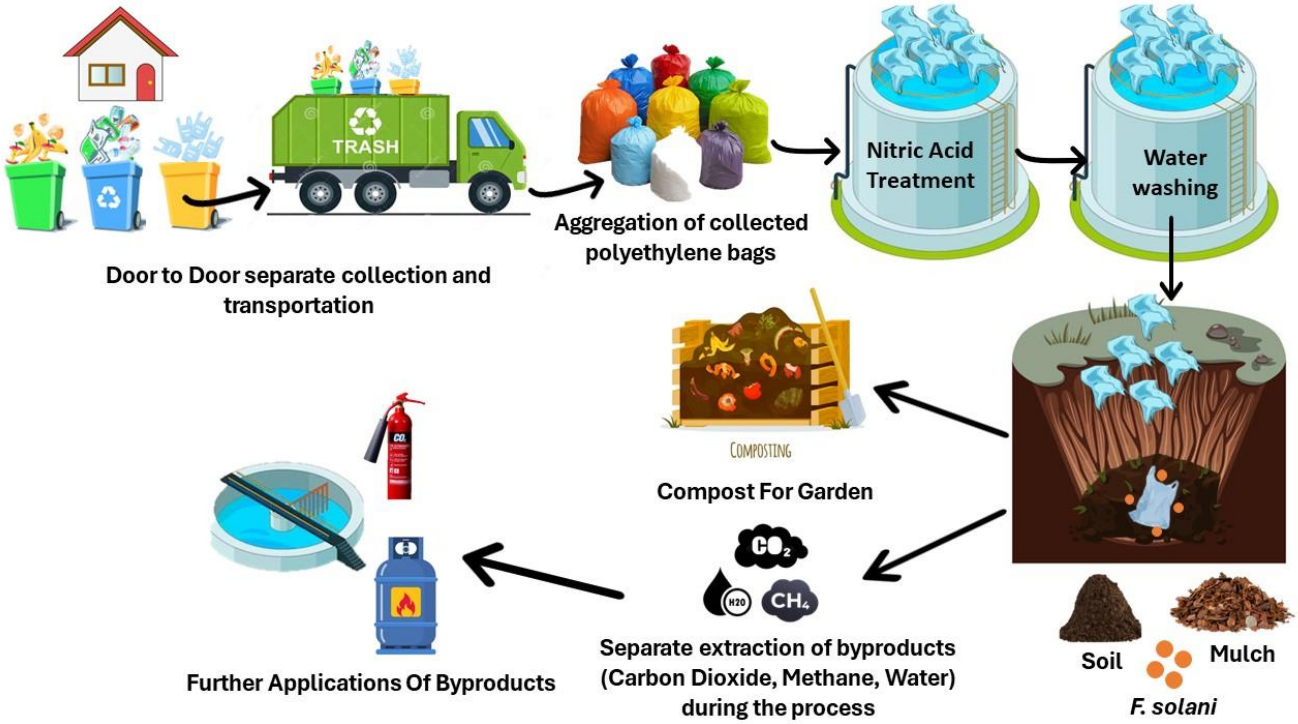
pH for optimum enzyme activities. The enzyme extraction method for solid-state medium (soil and mulch) was standardized by the buffer extraction method.

- Experiment with supplementation for biotic and abiotic augmented fungal degradation of polyethylene, revealed tween 80 supplementation to be best for enhancing the degradation. Co-culture and consortia techniques did not demonstrate substantial degradation (4.1 ± 0.005%), therefore, the single culture technique was perused for further experimentation. Abiotic augmentation by 0.05% tween 80 supplementation in the medium was found to be optimum as PE exhibited 38.8 ± 0.01% weight-loss, and well-marked topographic and chemical changes within two weeks of the incubation period was very prominent.
- To check the practical application of the protocol, the degradation of polyethylene was evaluated at lab-simulated and open-field conditions by keeping parameters at optimal levels. Significant enzyme activities were recorded after fifteen and twenty days of incubation in soil and mulch medium. In lab-simulated and open-field conditions both experiments exhibited degradation, maximum weight loss was recorded on the 20th day with 40 ± 0.14% and 41.5 ± 0.56%, respectively. The degradation was confirmed by observing topographic (SEM), chemical (FTIR), molecular weight (DSC), melting point (GPC), and tensile strength changes in experimented PE films. Fungal hyphae penetration, cracks, and holes were observed through SEM analysis, while FTIR analysis showed new peak formations and peak shifts indicating the changes in chemical composition. The molecular weight and melting point of experimented films were reduced and the crystallinity of the film was increased to 78% due to degradation. Moreover, the tensile strength of the film was significantly reduced after 20 days of incubation.
- Overall, it can be concluded that *F. solani* MN201580.1 has the potentiality to degrade polyethylene material, and pretreatment of polyethylene film is required to achieve maximum degradation of films in a shorter period of time.

Recommendation

A comprehensive model plan has been recommended to manage the plastic waste sustainably. The model plan for polyethylene degradation includes the segregation of polyethylene waste at landfill areas. The subsequent treatment is to immerse the waste into concentrated nitric acid in a large tank with precise safety measures. Further, the waste is to be placed in soil and mulch along with *Fusarium solani* MN201580.1 and tween 80. The process employs separation and capturing of products methane (CH_4), water (H_2O), and carbon dioxide (CO_2) through efficient separators. The methane gas is designated for utilization as a clean fuel in sanitization and automobiles. The collected water undergoes a de-pollution process via wastewater treatment, ensuring its suitability for reuse. Carbon dioxide, once collected, is transformed into a powder form for use in refrigerators

and fire extinguishers. Additionally, the degraded soil and mulch are repurposed as nutrient-rich compost for gardens. This protocol can be considered as a holistic approach to sustainable waste management.



Protocol model explaining the field set up for polyethylene degradation on landfill

Future aspects

- In the future, this polyethylene degradation application could be improved by exploring innovative technologies and refining existing processes to further enhance sustainability and environmental impact. Research could focus on developing more efficient biodegradation agents by exploring genetic modifications in microorganisms to optimize polyethylene breakdown.
- In-depth research on the products of this process and their use would provide comprehensive details to make this application more efficient in the field.
- Additionally, the study could delve into the feasibility of scaling up the protocol for larger waste treatment facilities and assess its economic viability on a broader scale.
- Furthermore, collaboration with industries and policymakers could facilitate the adoption of the protocol on a wider scale, contributing to the development of standardized practices for sustainable waste management.