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Review Article

A Review on Fungus Eating Plastic

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ABSTRACT

Plastic pollution can seriously harm marine ecosystems and have detrimental consequences on human health. Many fungi strains have the ability to biodegrade different types of polymers. An efficient and long-term solution to all of the issues would be to use helpful microorganisms that can decompose plastic. Fungi are thought to be among One of the best microbiological degraders for plastics since they can live on resistant substances with few resources and produce noticeable enzymes. Recent studies have revealed a large number of fungus species that can degrade different types of plastic, however There are still many doubts about the mechanisms that underlie biodegradation. There are also a lot of unknowns that need to be answered. about the regulatory processes that fungi employ to hydrolyze, absorb, and mineralize synthetic plastics, as well as the fungal enzymes that cause plastic fragmentation. Recent studies have shown that some fungus species have the ability to break down plastics through enzymatic action, providing a long-term and environmentally responsible solution to this problem. It has been shown that popular plastics including polyethylene (PE), polyethylene terephthalate (PET), and polyurethane (PU) can be colonized and broken down by fungi like Aspergillus, Penicillium, Fusarium, and Zygomycetes. Their primary means of breakdown are the release of hydrolytic and oxidative enzymes, including laccases, peroxidases, and esterases, which start the breaking of polymer chains and encourage bio assimilation

INTRODUCTION

One of the most widely used and abundant materials created by humans is plastic. It plays a crucial part in our daily lives, Leveling up from the kitchen to the industrial due to its great stability and long lifespan [1,2]. Nitrogen, oxygen, hydrogen, silicon, carbon, and chlorine are the constituents of plastic, which is a polymer [1]. Both synthetic and bio-based plastics can be produced. Natural substances like Bio-based plastics are made from lignin, cellulose, hemicellulose, terpenes, vegetable oils,

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carbohydrates, and food waste [3–5]. One of the industries with the greatest rate of growth in the world is the manufacturing of synthetic polymers. The topic of the current investigation is synthetic plastics. Worldwide, seven main varieties of synthetic plastic are in use. These include polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), and low-density polyethylene (LDPE). Polylactic acid (PLA), nylon, acrylic, polycarbonates, fibers, and numerous more polymers, including polypropylene (PP), polystyrene (PS), and others [6] Plastics naturally degrade at a very slow rate, which leads to the accumulation of plastic trash in all environmental components [7,8]. Plastics' hydrophobicity, large molecular weight, and long chain polymer structure make them resistant to decomposition [9].Some plastics actually take a thousand years to break down [10].It has been reported that over 400 microorganisms are capable of degrading plastic [11]. Only fungi that break down plastic were the subject of the current investigation. Many studies into fungi that break down plastic have been conducted. Lacerda et al., example [12] explored the plastisphere's fungi in the aquatic habitats of the Antarctic Peninsula and western South Atlantic. A comprehensive description of the microbes and enzymes that can break down a range of commonly used synthetic polymers was offered. The current study made an effort to compile data on the global production of plastics and the buildup of plastic trash in natural areas. Additionally, a list of all fungal species known to be able to break down plastic-degrading fungi was created using the Notes on the main fungal groupings involved were prepared together with the literature that was available. Additionally, multi-gene studies (ITS, LSU, SSU, TEF, RPB1, and RPB2) were used to examine the evolutionary links of the fungi that break down plastic. Therefore, the main goal the study was to compile all of the fundamental knowledge currently available on fungi that break down plastic in order to inform further research on related subjects.[13]

Fungus

An organism that is not a plant or an animal is called a fungus (plural: fungi). They are members of the Kingdom Fungi, a separate group.

- Mold, yeast, and mushrooms are a few examples.
- Eukaryotic – Their cells have a nucleus.
- Non-green – They do not have chlorophyll, so they cannot make their own food.
- Heterotrophic – They absorb nutrients from other organisms (living or dead).
- Cell Wall – Made of chitin (not cellulose like plants).Reproduction – Can reproduce by spores, both sexually and asexually.

Fig. 1 Fungus Eating Polymer

METHOD :-

The information provided here was gathered from a variety of sources, including online databases, written literature, and direct conversations. We chose seven key synthetic Major plastic types that are used globally, according to recent research [15] and the fungal species that have been shown to break down those plastic types. The primary sources of information on fungi that degrade plastic were "Google Scholar," "Research Gate," "PubMed," and "Web of Science."

Tabel 0.1 Name of fungi & Their role on Plastic

Fungus	Polymer hydrolyzed	class	Family	Environment
Acremonium kiliense [16]	PE	Sordariomycetes {16}	Bionectriaceae [16]	Soils
Acremonium sp [17]	PHB, Poly [3 HB-co-(10mol%)3HV][17]	Sordariomycetesm[17]	Bionectriaceae [17]	Soils
Alternaria alternata [18]	PE, LDPE	Dothideomycetes [18]	Pleosporaceae	Dumpsites, Mangrove stands [18]
Aspergillus fumigatus [19]	PHB, Poly [3HB-co-(10mol%)3HV], HDPE, LDPE, PSPUR, Sky-Green, Poly[3HB-co77mol%)3HV], PHV, Poly[3HB-co-(1361mol%)4HB], PES, PEA, PBA, PCL, PBS [19]	Eurotiomycetes [19]	Aspergillaceae [19]	Soils
Aspergillus glaucus [20]	PE	Eurotiomycetes [20]	Aspergillaceae [20]	Mangrove Soils
Aspergillus Niger [21]	PE, HDPE, LDPE, PVC, Sky-Green, PEA, PPA, PBA [21]	Eurotiomycetes [21]	Aspergillaceae [21]	Soils
Aspergillus oryzae [22]	LDPE	Eurotiomycetes[22]	Aspergillaceae[22]	Not mentioned
Fusariumsolani [23]	LDPE, HDPE, PVC, PCL, PS-PUR, PHB, PET [23]	Sordariomycetes[23]	Nectriaceae	Soils
Fusarium sp.[23]	PE, PCL [23]	Sordariomycetes [23]	Nectriaceae	Soils, Dumpsites
Penicillium simplicissimum [24]	PE, PHB, Poly[3HB-co-(7mol%)3HV], Sky-Green [24]	Eurotiomycetes	Nectriaceae	Soils
Penicillium sp. [24]	PHB, HDPE, LDPE, PVC, PEA, PCL, polyalkylene dicarboxylic acids	Eurotiomycetes [24]	Nectriaceae	Soils
Phoma sp.[19]	HDPE, LDPE, PVC	Dothideomycetes [19]	Didymellaceae	Soils
Verticillium leptobactrum [20]	PHB	Sordariomycetes [20]	Plectosphaerellaceae [20]	Soils

MECHANISM :-

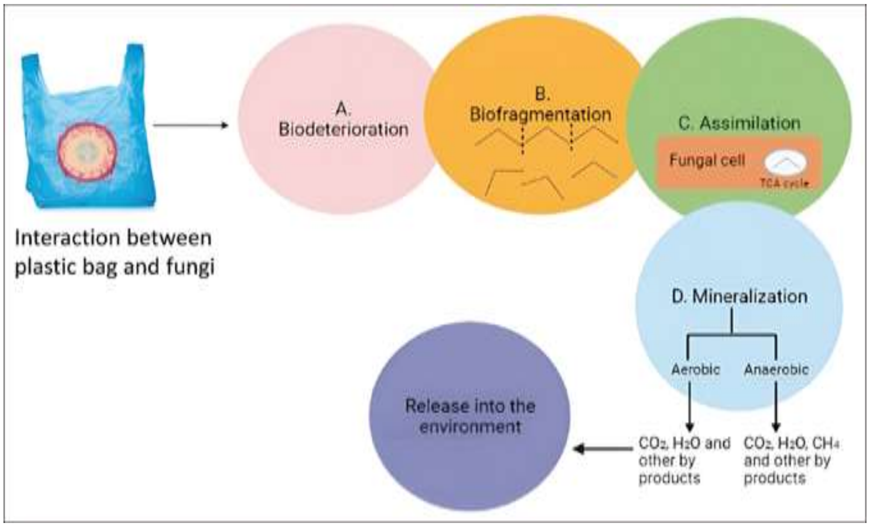

Fig 2. Mechanism Of Fungus Eating Plastic [25]

Application:-

1. Fungal Biodegradation of Plastics:- There are numerous fungi that have been demonstrated to degrade plastic, including Aspergillus, Penicillium, Trichoderma, and Phanerochaete chrysosporium. Polyethylene (PE), polystyrene (PS), and polyurethane (PU) are among the plastic polymers that are broken down by the enzymes secreted by these fungi. With the help of enzymes, these polymers can be converted into simpler, more biodegradable substances.[26]

2. Bioremediation of Plastic Waste:- The ability of fungi to bioremediate is the focus of numerous studies that aim to address the buildup of plastic waste. Fungi are a desirable addition to waste management systems because they can break down plastics into more fundamental organic materials. For example, it has been demonstrated that fungi such as Pestalotiopsis microspora can degrade polyurethane, a plastic commonly found in foams and insulation materials.[27]

3. Fungal Plastic as an Alternative Material:- :- When fungi are grown in certain conditions, they can produce a network of fungal threads called mycelium. This mycelium can be used to replace plastic in construction, packaging, and even the automotive industry. Mycelium is an excellent choice for developing sustainable, biodegradable plastic substitutes since it naturally grows and binds materials.[28]

4. Development of Plastic-Eating Enzymes:- Lipases, ligninases, and esterases are among the enzymes that fungi make that can break down plastic polymers. Isolating these enzymes and understanding how they function to enhance plastic breakdown and provide a natural alternative to chemical plastic recycling techniques has been the aim of research.[29]

5. Bioplastic Production :- It has been studied whether fungi can produce bioplastics through fermentation processes. Bioplastics made from fungi, particularly those made from chitin and other fungal polysaccharides, offer a renewable and biodegradable alternative to petroleum-based plastics.[30]

Advancement:- Recently, there has been a lot of interest in the biodegradation of plastics by fungi as a potential solution to the plastic pollution problem. Particularly, it has been discovered that Aspergillus, Penicillium, and Phanerochaete chrysosporium possess the enzymatic ability to break down several plastics, including polyethylene (PE), polypropylene (PP), and polystyrene (PS). [31]. Long-chain hydrocarbons in plastic polymers can be broken down by lignocellulolytic enzymes including laccases and peroxidases, which are secreted throughout the degradation process.[32] Furthermore, some fungi, such Fusarium spp., have been shown to break down polyester-based polymers by enzymatic activity that targets ester linkages. [33]. Along with being good for the environment, this bioremediation process shows how fungi can recycle waste polymers into simpler, less toxic compounds. Since certain fungi can thrive in plastic-rich environments, such as landfills and oceanic plastic waste dumps, they may contribute to natural bioremediation, according to recent research [34] Although the process is still slow, attempts are being made to accelerate the breakdown of plastic by altering the genetic makeup of fungi or co-culturing them with other microbes.[35]

Fungal enzymes' roles in plastic degradation: Extracellular enzymes secreted by fungi usually target organic carbon polymers derived from plants to obtain nutrients for growth [36]. Nevertheless, Hage and Rosso (37) and Chen et al. (38) suggested that fungi might have developed.

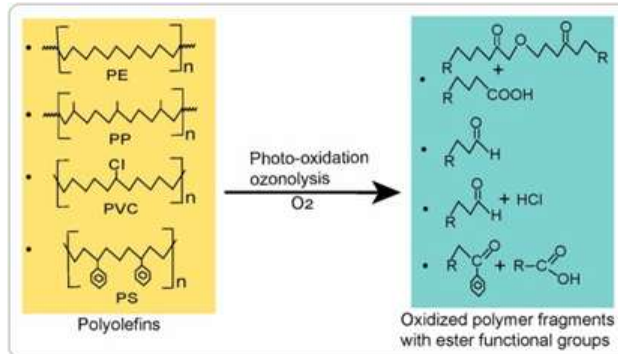

Figure 3: shows how photo-oxidation of the polyolefin plastic structure adds carbonyl and ester functional groups to the polymer's carbon structure. [39]

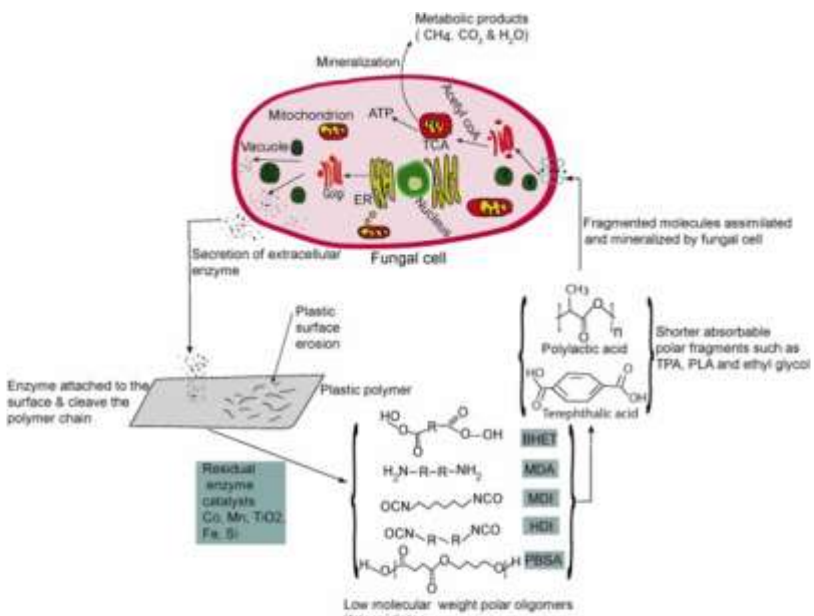

Figure 4: Systematic review of plastic degradation caused by fungi. Degradation enzymes released by fungi break down plastic polymers over time, producing low molecular weight polar oligomers and monomers that can pass through cell membranes and enter cells [40]

FACTOR AFFECTING :- A number of factor influence the rather slow process of microbial disintegration of plastics, and optimal degradation results require the right conditions [41]. Normally The pace at which fungal biodegradation occurs is known to be influenced by certain factors, including the type of polymer, fungal species, temperature, pH, moisture, oxygen, and CO2 levels, as well as if the plastic material has been pre-treated with prooxidants and UV irradiation. The physical properties of the plastic polymer, such as its crystallinity and form, as well as its chemical makeup and fungal How quickly biodegradation occurs is significantly influenced by the species used in the process (42). Plastics' polymeric structures vary; some often have carbon bonds connected to hydrolysable ester functional groups, while others are made entirely of Since carbon bonds are not connected to any reactive functional groups, fungus cannot readily break them down. The greatest examples of nonpolar crystalline polymers with saturated CH 2 chains that are regarded as non-biodegradable include PE, PP, and PS. On the other hand, fungal enzymes can target the polar functional groups and double carbon bonds found in polyester-based plastics [43].

CONCLUSION & FUTURE PERSPECTIVES

One emerging area that could provide solutions to issues brought on by plastic pollution is the biodegradation of plastic by fungi. The underlying regulatory strategies for the commercial and industrial exploitation of the enzymes involved in the fungal hydrolysis of synthetic polymers need to be thoroughly understood, which will require more concentration and targeted research. Despite the fact that numerous species have been demonstrated to hydrolyze different types of plastic, we conclude from a comprehensive assessment of the published research on fungal degradation of plastic that many studies have already concentrated on controlling the techniques of fungi that break down plastic. As more study is done to find new fungal species that might break down these polymers, future studies should also offer more information on the metabolic processes of biodegradation. dation in fungi, the results of this process' metabolism and intermediate stages, and strategies for getting beyond some of the current barriers that keep it from being used in industry. It might be necessary for future studies to employ integrated molecular biology approaches, which combine tools from several fields of biology, biotechnology, synthetic biology, and bioinformatics. Determining the safety of the fungal biomass for further use and whether any plastic monomers can be extracted from the fungi are also important areas for further research. The answers to these questions would ensure a more sustainable and circular approach to such processes in the future.

REFERENCES

1. Ogunbayo, A.; Olanipekun, O.; Adamu, I. Preliminary Studies on the Microbial Degradation of Plastic Waste Using Aspergillusniger and Pseudomonas sp. J. Environ. Prot. 2019, 10, 625–631. [CrossRef].
2. Sangale, M.K.; Shahnawaz, M.; Ade, A.B. Potential of Fungi Isolated from the Dumping Sites Mangrove Rhizosphere Soil toDegrade Polythene. Sci. Rep. 2019, 9, 5390. [CrossRef] [PubMed].
3. Ogunbayo, A.; Olanipekun, O.; Adamu, I. Preliminary Studies on the Microbial Degradation of Plastic Waste Using Aspergillusniger and Pseudomonas sp. J. Environ. Prot. 2019, 10, 625–631. [CrossRef].
4. Sangale, M.K.; Shahnawaz, M.; Ade, A.B. Potential of Fungi Isolated from the Dumping Sites Mangrove Rhizosphere Soil toDegrade Polythene. Sci. Rep. 2019, 9, 5390. [CrossRef] [PubMed].
5. Baheti, P. How Is Plastic Made? Available online: https://www.bpf.co.uk/plastipedia/how-is-

plastic-made.aspx (accessed on15 September 2021).

6. Di Bartolo, A.; Infurna, G.; Dintcheva, N.T. A Review of Bioplastics and Their Adoption in the Circular Economy. Polymers 2021,13, 1229. [CrossRef] [PubMed].
7. Weinstein, J.E.; Dekle, J.L.; Leads, R.R.; Hunter, R.A. Degradation of Bio-Based and Biodegradable Plastics in a Salt Marsh Habitat:Another Potential Source of Microplastics in Coastal Waters. Mar. Pollut. Bull. 2020, 160, 111518. [CrossRef] [PubMed].
8. Hardin, T. Plastic: It's Not All the Same; The Basics on 7 Common Types of Plastic. Available online: https://plasticoceans.org/7types-of-plastic (accessed on 4 September 2021).
9. Kale, S.K.; Deshmukh, A.G.; Dudhare, M.S.; Patil, V.B. Microbial Degradation of Plastic: A Review. J. Biochem. Technol. 2015, 6,952–961.
10. Webb,H.K.;Arnott,J.; Crawford, R.J.; Ivanova, E.P. Plastic Degradation and Its Environmental Implications with Special Referenceto Poly (Ethylene terephthalate). Polymers 2013, 5, 1–18. [CrossRef].
11. Wilkes, R.A.; Aristilde, L. Degradation and Metabolism of Synthetic Plastics and Associated Products by Pseudomonas sp.:Capabilities and Challenges. J. Appl. Microbiol. 2017, 123, 582–593. [CrossRef].
12. Pramila, R.; Ramesh, K.V. Biodegradation of Low Density Polyethylene (LDPE) by Fungi Isolated from Municipal Landfill Area. J.Microbiol. Biotechnol. Res. 2011, 1, e136.
13. Lear, G.; Kingsbury, J.; Franchini, S.; Gambarini, V.; Maday, S.; Wallbank, J.; Weaver, L.; Pantos, O. Plastics and the Microbiome:Impacts and Solutions. Environ. Microbiome 2021, 16, 2. [CrossRef].
14. https://englishpluspodcast.com/plastic-eating-fungi-natures-solution-to-our-pollution-problem/
15. Lacerda, A.L.d.F.; Proietti, M.C.; Secchi, E.R.; Taylor, J.D. Diverse Groups of Fungi Are Associated with Plastics in the SurfaceWaters of the Western South Atlantic and the Antarctic Peninsula. Mol. Ecol. 2020, 29, 1903–1918. [CrossRef].
16. United Nations Environment Programme. Fungi Research Lifts Lid on Shy Organisms That Break down Plastic. Availableonline: https://www.unep.org/news-and-stories/story/fungi-research-lifts-lid-shy-organisms-break-down-plastic (accessed on 12 September 2021).
17. Hardin, T. Plastic: It's Not All the Same; The Basics on 7 Common Types of Plastic. Available online: https://plasticoceans.org/7types-of-plastic (accessed on 4 September 2021).
18. Karlsson, S.; Ljungquist, O.; Albertsson, A.-C. Biodegradation of Polyethylene and the Influence of Surfactants. Polym. Degrad.Stab. 1988, 21, 237–250. [CrossRef].
19. Mergaert, J.; Webb, A.; Anderson, C.; Wouters, A.; Swings, J. Microbial Degradation of Poly (3-Hydroxybutyrate) and Poly(3-Hydroxybutyrate-Co-3-Hydroxyvalerate) in Soils. Appl. Environ. Microbiol. 1993, 59, 3233–3238. [CrossRef].
20. Sowmya, H.; Ramalingappa, B.; Nayanashree, G.; Thippeswamy, B.; Krishnappa, M. Polyethylene Degradation by FungalConsortium. Int. J. Environ. Res. 2015, 9, 823–830.
21. Ibrahim, I.N.; Maraqa, A.; Hameed, K.M.; Saadoun, I.M.; Maswadeh, H.M. Assessment of Potential Plastic-Degrading Fungi inJordanian Habitats. Turk. J. Biol. 2011, 35, 551–557. [CrossRef].

22. Kathiresan, K. Polythene and Plastics-Degrading Microbes from the Mangrove Soil. Rev. Biol. Trop. 2003, 51, 629–633.
23. Khruengsai, S.; Sripahco, T.; Pripdeevech, P. Low-Density Polyethylene Film Biodegradation Potential by Fungal Species fromThailand. J. Fungi 2021, 7, 594. [CrossRef].
24. Laila, M.D. The Potential of Fungi Isolated from Pleurotus ostreatus (Oyster Mushroom) Baglog to Degrade Plastics. Ph.D Thesis,Universitas Andalas, Padang, Indonesia, 2021.
25. https://jabonline.in/abstract.php?article_id=935&sts=2
26. A review by Chakraborty et al. (2020) in Environmental Science and Pollution Research discusses the role of fungi in plastic degradation and their potential for bioremediation.
27. De Souza et al. (2021), in their review in Microorganisms, highlight fungal strains capable of biodegrading plastic waste, suggesting their integration into waste management practices.
28. 28 Sánchez et al. (2022) in Fungal Biology Reviews discuss the use of mycelium-based composites as a replacement for synthetic plastics, with examples of fungi-derived products in various industries.
29. Ravindran et al. (2021) in Journal of Hazardous Materials summarize the potential of fungal enzymes for biodegradation of plastics, and how these enzymes could be applied in large-scale plastic waste treatment.
30. Dolatabadi et al. (2020) in Biotechnology Advances discuss how fungi-based bioplastics could replace conventional plastics, reducing plastic waste and environmental damage.
31. Shah, M., et al. (2020). "Fungal Biodegradation of Plastic Waste." Microbial Biotechnology.
32. Singh, R., et al. (2021). "Laccase-Mediated Plastic Biodegradation." Environmental Research Letters.
33. Yadav, S., et al. (2020). "Polyester Degradation by Fungal Strains." Bioresource Technology.
34. Jaeger, M., et al. (2022). "Fungal Plastic Degradation in Landfills and Marine Environments." Science of the Total Environment.
35. Kumar, A., et al. (2021). "Advancements in Fungal Bioremediation of Plastic Waste." Frontiers in Microbiology
36. Murphy, C.A.; Cameron, J.; Huang, S.J.; Vinopal, R.T. Fusarium Polycaprolactone Depolymerase Is Cutinase. Appl. Environ.Microbiol. 1996, 62, 456–460. [CrossRef].
37. Sameshima-Yamashita, Y.; Koitabashi, M.; Tsuchiya, W.; Suzuki, K.; Watanabe, T.; Shinozaki, Y.; Yamamoto-Tamura, K.; Yamazaki,T.; Kitamoto, H. Enhancement of Biodegradable Plastic-Degrading Enzyme Production from Paraphoma-like Fungus, Strain B47-9.J. Oleo Sci. 2016, 65, ess15207. [CrossRef].
38. Chowdhary, P., Shukla, G., Raj, G., Ferreira, L.F.R., Bharagava, R.N., 2019. Microbial manganese peroxidase: A ligninolytic enzyme and its ample opportunities in research. SN Appl. Sci. 1 (1), 1–12.
39. Chen, C.-C., Dai, L., Ma, L., Guo, R.-T., 2020. Enzymatic degradation of plant biomass and synthetic polymers. Nat. Rev. Chem. 4 (3), 114–126.
40. Chen, S., Su, L., Chen, J., Wu, J., 2013. Cutinase: characteristics, preparation, and application. Biotechnol. Adv. 31 (8), 1754–1767.

41. Chen, S., Su, L., Chen, J., Wu, J., 2013. Cutinase: characteristics, preparation, and application. Biotechnol. Adv. 31 (8), 1754–1767.
42. Fernandes, M., Salvador, A., Alves, M.M., Vicente, A.A., 2020. Factors affecting polyhydroxyalkanoates biodegradation in soil. Polym. Degrad. Stab. 182, 109408.
43. Furukawa, T., Bello, F.O., Horsfall, L., 2014. Microbial enzyme systems for lignin degradation and their transcriptional regulation. Front. Biol. 9 (6), 448–471.

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