Plastic degrading bacteria- a review

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Abstract

Plastic has become an integral part of human life. It has main role in all kind of packaging of food materials and many other, plastic is made up from monomers and oligomers, and has the best durability, high quality and inexpensiveness among all the synthetic materials. This material is used widely all across the world, Plastic is one of the major causes of environmental contamination that takes thousands of years to degrade. There is no subtle way to degrade the plastics that's why plastics are causing major population globally even though we have other methods for plastic degradation, they all are less effective. But there are some microorganisms like- bacteria, fungi present in this environment, that has ability to degrade polymers by the process of biodegradation. Some bacteria like aspergillus nomius, bacillus cereus, pseudomonas fluorescens, Trichoderma viride, klebsiella pneumoniae etc all are the plastic degrading bacteria. biodegradation is process which involve enzymatic degradation to degrade polymers, this process can be used for anticipation of plastic waste problems. There are some kinds of plastics that are designed for ease degradation called as biodegradable polymers, it made-up from starch cellulose, hemicellulose and lignin. These plastics are eco-friendly It is the major concern for us in this review, we deduce from the current literature, new comparative analyses.

Key words: Plastic degradation, bacteria

Introduction

Polyethylene is a polymer composed of long chain ethylene monomers.(Usha et al., 2011a) Starch, proteins, and plastics are examples of polymers. High molecular mass organic polymers make up plastics.(Divyalakshmi & Subhashini, 2016) They are non-metallic mouldable compounds, and the products created from them may be shaped and sized whatsoever the user chooses. (Singh et al., 2016)] plastics are made from natural polymers, which have the advantages of being robust, lightweight, and long-lasting Plastic persistence in natural environments has been identified as one of the most serious trash disposal issues (Ishigaki et al., 2000a) These elements stay in the ground for hundreds of years and are difficult to disintegrate, which causes severe environmental degradation. (Kumari et al., 2013) Plastic is now produced using both organic and inorganic basic components, including carbon, silicon, hydrogen, nitrogen, oxygen, and chloride.(Divyalakshmi & Subhashini, 2016) Today, plastic is used extensively in a wide range of industries, including aeronautics, architecture and construction, packaging qualities like as durability, flexibility, and/or transparency have been industrially manufactured and widely used in consumer items. (Yoshida et al., 2016) Due to the qualities of plastic, people are growing more and more dependent on it on a daily basis (Proshad et al., 2018) Environmental pressure organizations typically, and medical.(Oberbeckmann & Labrenz, 2020) Over the last century, plastics with desirable claim that polyolefins cannot biodegrade since the molecular weight must be below 500 for this to happen. (Bonhomme et al., 2003) mankind can't imagine a life without plastic products various form of plastic is used in our day to day life Although the strength of plastics and their potential for a wide range of uses, such as the common usage of disposable products, were expected, the issues related to waste management and plastic litter were not.(Proshad et al., 2018) polythene has wide range of uses in daily life that's why it's not easy to take away plastics from our lives. Plastic is one of the synthetic polymers with a high hydrophobic level and high molecular weight is polyethylene. It is not biodegradable in its natural state. Plastic is used extensively in a variety of "short-live" applications, including packaging, disposable gloves, garbage bags, and other items, and this makes up the majority of the plastic waste. (Mahalakshmi et al., 2012) Polythene degradation is a significant concern as the substance is increasingly used. Prior to 1980, there was hardly any plastic that was recycled or burned. Since that time, only plastics without fibres have seen substantial recycling activities. The manufacturing of plastics has increased more than any other manmade material during the past 65 years.(Geyer et al., 2017) Plastics are resistant to microbial assault because evolution could not generate new enzyme structures capable of dissolving synthetic polymers during their brief existence in nature.(Shah et al., 2008) Global plastic garbage creation is estimated to be around 57 million tons per year.(Kathiresan, 2003) The most popular plastic material for food packaging is polyethylene plastic (Agustien et al., 2016) Since they are lightweight, durable, and produce at a cheap cost, plastics are easily moulded into a variety of shapes and forms (Wei & Zimmermann, 2017) Plastic materials have been increasingly popular in the food, clothing, housing, transportation, construction, medical, and recreation industries during the previous three decades. (Mahdiyah & Mukti, 2013) Massive plastics manufacturing began in the 1950s, with the majority of polymers created for throwaway usage. China was the world's largest producer of plastic garbage in 2010, accounting for 8.8 million tons per year, or 27% of total global plastic waste output.(Asiandu et al., 2021) most of the plastics made-up from fossil based raw materials, It is anticipated that the decomposition of plastic trash producing significant environmental harm would differ significantly in landfills.(Wei & Zimmermann, 2017) Worldwide, 140 million tons of synthetic polymers are manufactured annually. (Tiwari et al., 2018) Global plastic manufacturing was predicted to reach 245 million tons per year as of 2008. In 2014, 311 million tonnes of plastics were manufactured; this amount is anticipated to increase by double in around 20 years and maybe quadruple by 2050.(Alabi et al., 2019) Large amounts of

Polyethene's build up in the environment and cause environmental problems.(Singh et al., 2016) In 2017, more than 348 million tons of plastic were manufactured globally (Oberbeckmann & Labrenz, 2020) Plastics output on a global scale has been rising steadily, reaching 322 million tons in 2015 (Wei & Zimmermann, 2017) plastic disposal presents a significant ecological problem, it takes thousands of year to degrade. (Usha et al., 2011a) Because of their superior physical and chemical qualities, they have largely supplanted paper and other cellulose-based materials in packaging.(Shah et al., 2008) across 500 billion plastic bags are reportedly used annually across the world. After only one usage, the great majority of these bags are often thrown as garbage.(Kumar et al., 2017) Uncontrolled plastics use, which began some decades ago, has resulted in several environmental issues connected to plastic waste management and contamination. (Asiandu et al., 2021) plastic waste makes most of the water pollution, land pollution, air pollution and many more Polyethylene plastic trash poses a serious hazard to human health since it cannot decompose in soil.(Agustien et al., 2016) According to Plastic Europe 2018, the most popular plastics in Europe include LDPE, HDPE, polypropylene, polyvinyl chloride, polyurethane, polystyrene, and polyethylene terephthalate (Asiandu et al., 2021) throughout 140 million tonnes of synthetic polymers are manufactured annually, and the use of polyethylene is growing at a pace of 12% throughout the world.(Singh et al., 2016) Because a large amount of polythene accumulates in the environment, its removal poses a significant ecological challenge. Biodegradation and bio recycling are two approaches that might be used for this goal.(Singh et al., 2016) Monomers are repeating structural units that combine to make polymers.(Divyalakshmi & Subhashini, 2016) There are two processes through which polyethylene is known to degrade: The processes of oxo- and hydro-biodegradation (Mahalakshmi et al., 2012) in the biological decomposition microorganism has very important role, this is called biodegradation synthetic materials like plastic and polythene waste amass in the environment and create an ever increasing ecological threat. Plastics are non-metallic compound most commonly used plastics in the industries are polypropylene (PP), polystyrene (PS), (LDPE, MDPE, HDPE, LDPE), polyvinyl chloride (PVC), polybutylene terephthalate (PBT), nylon. plastic causes serious threats to the environment both during its production and after its disposal.(Begum et al., 2015)

So far, the studies have done upon plastic degrading bacteria says that has ability to degrade plastics and polyethylene through bioremediation. Recent study of department of infectious disease college of veterinary medicine Seoul national university, south Korea says that bacillus spices were capable of utilizing plastics as a sole carbon source. Among these species; *B. siamensis* and *B.wiedmanni* are reported for the first time that exhibit effective LDPE degradation, some studies say microbial degradation of a solid polymers like polythene or PVC requires the formation of biofilm which has also been tested in this study. Many studies has done in plastic degrading bacteria located in different environments and atmosphere. (J. Sharma et al., 2014)

There are mainly 2 types of biodegradations-

1. **Aerobic biodegradation**- At many hazardous waste sites, aerobic biodegradation, sometimes referred to as aerobic respiration, is a significant part of the process through which pollutants are naturally attenuated. When aerobic bacteria use oxygen as an electron acceptor to break down organic substances into smaller organic compounds, the end result frequently includes CO2 and water.
2. **Anaerobic biodegradation**- When aerobic bacteria use oxygen as an electron acceptor to break down organic substances into smaller organic compounds, the end result frequently includes CO2 and water. When oxygen is not available, it is when microorganisms break down organic pollutants.(Nayak & Tiwari, 2011)

Many of the degrading enzymes that split polymer chains into monomers and oligomers were generated by microorganisms. Cells of bacteria take up plastic debris. Carbon dioxide and water are produced during aerobic metabolism.(Soud, 2019) Microorganism can degrade plastic over 90 genera from bacteria fungi. The diver's metabolic capability of microbes can be exploited for bioremediation of plastics waste that uses microbial strain developed through selection. The aim of this study is to isolate the bacteria from the soil having the potential to degrade polythene plastics. Microbiomes frequently work in conjugation with abiotic factors such as heat and light to impact the structural integrity of polymers and accessibility to enzymatic attack.

Types of plastics – There are around 20 different types of primary polymers used globally. (Proshad et al., 2018) there are many types of plastics that are used in various way, most of the plastics used in industries in packaging for their product. Plastic usually splits into two parts first is thermosets and the other one is thermoplastics. thermosets are those whose chemical structures may change under heat and cannot be remelted and thermoplastics are those type of plastic that melts when heated and hardens when cooled. (Asiandu et al., 2021)

Mainly there are 7 types of plastics –

1.**high density polyethylene (HDPE) –** polyethylene is the most common plastic in the world but it classified into three types; high density, low density, linear low density. High density polyethylene is strong and resistant to moisture and chemicals which makes it ideal for cartons containers pipes and other building materials. Easily coloured, processed, and moulded hard to semi-flexible; resistant to chemicals and moisture; waxy surface; opaque; softens around 75 °C. (Alabi et al., 2019)

Example - Milk cartons, detergent bottles, cereal box liners, toys, buckets, park benches and Shopping bags, freezer bags, buckets, shampoo, milk, ice cream, juice, chemical, and detergent bottles, rigid agricultural pipe, and crates are some examples of common household items. (Alabi et al., 2019)

2.polyvinyl chloride (PVC) – this hard and rigid plastic is resistant to chemicals and weathering. Making it desired for building and construction applications, while the fact that it doesn't conduct electricity makes it common for high tech application that reduce infection in health care. On the flip side we must note that PVC is the most dangerous plastic in human health, known to leach dangerous toxins throughout its entire life cycle. Strong and resilient, softens at 80 °C, is transparent, and may be solvent welded.(Alabi et al., 2019)

Example - Plumbing pipes, credit cards, human and pet toys, rain gutters, teething rings, IV fluid bags and medical tubing and oxygen masks, Blister packs, wall cladding, roof sheeting, bottles, garden hoses, shoe soles, cable sheathing, blood bags, and tubing are some examples of the materials used in these industries. (Alabi et al., 2019)

3.low density polyethylene (LDPE) – A softer clearer and more flexible version of HDPE, its often used as a liner inside beverage cartons, and the corrosion-resistant work surfaces and other products. Soft flexible, transparent, waxy surface that softens at 70 °C is readily scratched.(Alabi et al., 2019)

Example - Plastic/cling wrap, sandwich and bread bags, bubble wrap, garbage bags, grocery bags and beverage cups, Squeeze bottles, mulch film, irrigation tubing's, waste bags, and trash bags. (Alabi et al., 2019)

4.polypropylene (PP) – this is one of the most durable plastics. it is more heat resistant than some others, which makes it ideal for such thing as food packaging and food storage that made to hold hot items or be heated itself. It flexible enough to allow for mild blending. But it retains its shape and strength for long time. Versatile material that is hard and transparent, softens at 140 °C, and can tolerate solvents.(Alabi et al., 2019)

Example - Straws, bottle caps, prescription bottles, hot food containers, packaging tape, disposable diapers and DVD/CD boxes, Dishes for the microwave, lunchboxes, packing tape, patio chairs, kettles, ice cream tubs, potato chip bags, and straws.(Alabi et al., 2019)

5.styrofoam (S) – this rigid plastic is low cost and insulates very well, which has made it a staple in food packaging and construction industries. Like PVC polystyrene is considered to be a dangerous plastic. It can easily leach harmful toxins such as styrene a (neurotoxin), which can easily than be absorbed by food and thus ingested by human.

Example - Cups, takeout food containers, shipping and product packaging, egg cartons, cutlery and building insulation.

6.polyethyleneterephthalate (PETE) – this is one of the most commonly used plastics. Its light weight, strong typically transparent and is often used in food packaging and fabrics (polyester). It works as Barrier to gas and moisture, clear, robust, solvent resistant, softens at 80 °C.(Alabi et al., 2019)

Example - Beverage bottles, Food bottles/jars (salad dressing, peanut butter, honey, etc.) and polyester clothing or rope Water bottles, containers, salad dressing, biscuit trays, and salad domes are examples of common items.(Alabi et al., 2019)

7.Polylactic Acid [PLA]- is a bioplastic that is produced from plant starches using a sustainable process. The synthesis of PLA is most commonly done via ring-opening polymerization.

8.Polyhydroxyalkanoates (PHA) - is a type of polymer produced by bacteria. Therefore, it can easily disintegrate in the environment. Certain bacteria produce PHA when they are under stressed conditions. PHA can be used in many different applications. They can also be modified and improved to suit our needs.(Li et al., 2016) these are a kind of biodegradable polyester found in natural polymers.

9. Polyurethane [PU or PUR]- is an organic polymer that features many organic units linked via urethane molecules. Most polyurethanes do not melt upon heating and can, therefore, be classified as thermosetting polymers. However, it can be noted that some specific types of polyurethanes exhibit thermoplastic properties and can be melted and remoulded via the application of heat.

10.other plastics - There are some other kinds of plastics out there that don't fall into any of the categories above. Polycarbonate (PC) is an example of this, Bioplastic is the most notable plastic material in this category is Polycarbonate; although a mainstream plastic material with various applications in several industries, it is somewhat losing its popularity because of its affiliation with BPA. The low-rate rate of recyclability for polycarbonate adds more to the problem.

Example - Eyeglasses, baby and sports bottles, electronics, CD/DVDs, lighting fixtures and clear plastic cutlery.

Phenolic resin, silicon vinyl ester, epoxy resin, acrylic resin are the types of plastic to. (Asiandu et al., 2021) most of the plastics that are mentioned above are nonbiodegradable but in the same place there are some types of plastics that are nonbiodegradable. These plastics are made-up from non-synthetic materials so that they can degrade I environment easily.

Plastic degrading bacteria

Different physical factors, such as temperature, moisture, and pressure, can assist microorganisms break down plastic trash in a way that is damaging to the polymers (Soud, 2019). In natural ecosystems, microorganisms are crucial to the biological degradation of materials, including manmade polymers.(Singh et al., 2016) Bacteria, which exist ubiquitously in the environment, have a great potential to degrade these kind of polymers or plastics.(Gupta et al., 2010) Since synthetic polymers contain a lot of energy, they might hypothetically serve as a useful supply of carbon and energy for microbes (Oberbeckmann & Labrenz, 2020)

The kind of enzyme generated by microbes for biodegradation processes that assisted in polymer breakdown. (Agustien et al., 2016) Actinomycetes are the most abundant category of microorganisms in nature, typically found in soil.(Usha et al., 2011a) various kind of bacteria and fungi can degrade plastics in natural conditions like *Pseudomonas sp., s Bacillus megaterium, Ralstonia eutropha, Azotobacter, Halomonas sp., etc.* (Alshehrei, 2017) Numerous microorganisms, including bacteria especially *Bacillus, Pseudomonas*, *Klebsiella, Mycobacterium, Rhodococcus, Flavobacterium, Escherichia, Nocardia, and Azotobacter,* are capable of degrading plastic compounds.(Soud, 2019)

Table1: Plastic degrading bacteria

Bacteria	**Isolated source.**	**Media**	**Incubation time.**	**reference**
Bacillus amylilitius	Garbagee Soil.	Culturebroth medium	1 month	(Patil, 2018)
Streptoces SSP4	Soil	ATCC medium	1month	(Soud, 2019)

Pseumonas Putida	Garbage soil	Culture broth medium	1 month	(Asiandu et al., 2021)
S. aureus	Mangrow soil	MS agar	35days	
streptococcus sp	Garbage soil	Culture broth medium	1 month	(Vignesh et al., 2016)
Yersinia	Soil	PYGagar media	45days	(Ishigaki et al., 2000b)

Klebsiella pneumoniae	Soil	MS media	1 months	(Satheeshkumar & Gopal, n.d.)
pseudomonas sp	Garbage Soil	Nutrient agar Media	35days	(Vignesh et al., 2016)
Rhizopus sp	Mangrow Soil	Ms media	55days	(Kannahi & Sudha, 2013)
Staphylococcus sp	Garbage Soil	Ms media	2month	(Usha et al., 2011b)
Pseudomonas putida	`rubber Factory	Basal media	10 days	(Okamoto et al., 2003)
Streptomyces coelicoflavus	Oil contaminated Soil	Mineral salt Agar	4 weeks	(Asiandu et al., 2021)
Aspergillus Versicolor	Sea water	Nutrient broth	1 weeks	(Kale et al., 2015)
Bacillus Weihenstephanens Is	Hydrocarbon Enriched soil	C-zopek-dox broth	6months	(Asiandu et al., 2021)

Microbial degradation of plastics

Biodegradation is a complicated, naturally occurring phenomena. Due to the large number of factors that occur during biogeochemical recycling, it is challenging to carry out naturalistic studies in the lab. (Lucas et al., 2008) Most synthetic plastics degrade relatively slowly in nature and are affected by environmental variables (Shah et al., 2008) Heterotrophic microorganisms have strong substrates in plastics. Because various microorganisms require varied environmental conditions for optimal development, the rate of biodegradation of plastics or any other complex substance varies depending on their features. (B. Sharma et al., 2017) most of the plastics are nonbiodegradable in natural condition. biodegradation process in the environment has been attributed to a variety of abiotic and biotic causes. (Wei & Zimmermann, 2017) The environmental breakdown of plastics can take 20 to 100 years, or even 500 years, to be fully completed. (Asiandu et al., 2021) Microbial biodegradation is well acknowledged and is still in use due to its increased efficiency. (Usha et al., 2011a) Changes in a material's mechanical, optical, or electrical properties as well as crazing, cracking, erosion, discolouration, phase separation, or delamination have all been seen as signs of degradation.(Shah et al., 2008) Biodegradation is the process by which groups of living organisms break down big polymer molecules into their component oligomers and monomers. The two primary groups of depolymerase enzymes that actively contribute to the spontaneous breakdown of polymers are extracellular and intracellular.(B. Sharma et al., 2017) Because the microorganisms responsible for the degradation are distinct from one another and each has its own preferred soil conditions for development, the biodegradation of plastics progresses actively under various soil conditions depending on their qualities (Shah et al., 2008) Enzyme activity in plastic degradation led to chain breaking from polymer to oligomer and monomer, which was carried out by microorganisms.(Agustien et al., 2016) Extracellular and intracellular depolymerases are at least two groups of enzymes that are actively involved in the biological breakdown of polymers.(Shah et al., 2008) Both natural and manmade plastics are degraded by microorganisms such as bacteria and fungus.(Tiwari et al., 2018) The method of biodegradation is an emerging trend in this sector of degradation because it uses microorganisms like bacteria and fungus to break down plastics like polythene. Enzymatic processes lead to the breakdown of polymers into monomers and oligomers, which is followed by metabolism by microbial cells in the microbial degradation of plastic.(Singh et al., 2016) Exoenzymes function by breaking down the many bonds that hold polymers together whereas endoenzymes operate by hydrolysing the complicated compounds into simple molecules that are tiny enough to pass past the semipermeable bacterial plasma membrane.(B. Sharma et al., 2017) An appealing, modern, and alternative method of managing plastic trash that is typically less expensive is biological decomposition. (Kumar et al., 2017) Synthetic polymers demonstrate a remarkable resilience to numerous physical, chemical and biological elements However, this durability also results in their extremely slow degradation in the environment(Wei & Zimmermann, 2017)

There are different stages for plastic waste degradation such as g biodeterioration, depolymerization, and assimilation. In the process of biodeterioration microorganism and abiotic factors both breaks the polymers into smaller parts. In depolymerization this process will be continued and Microbes release catalytic chemicals in the form of enzymes and free radicals to build biofilms, which aid in the gradual breakdown of polymer chains. Biodeterioration is the method of changing the plastic or polymer by some microorganism which are carried out in the surface of plastic.(Asiandu et al., 2021) Microbial degradation of plastics begins with the release of enzymes, which promote polymer chain cleavage into oligomers or monomers, correspondingly.(Starnecker & Menner, 1996)

Certain enzymatic processes that result in the chain cleavage of the polymer into oligomers and monomers are what cause the microbial breakdown of plastics. The microbial biodegradation universally received and it still underway for increase efficiency.(Usha et al., 2011a) The hydrolysis of polymers by enzymes is a two-step process that begins with the enzyme binding to the polymer substrate and ends with the enzyme catalysing the hydrolytic cleavage.(Shah et al., 2008)

Exo-enzymes from microbes break down complex polymers during degradation, producing simpler molecules with short chains, such as oligomers, dimers, and monomers.(Tiwari et al.,

2018) These products of the water-soluble enzymatic cleavage are taken up by the microbial cell and processed there. (Starnecker & Menner, 1996)

The process of biodegradation will be expedited by biofilms, which are produced by microorganisms. Biofilm is formed on the surface of plastics.(Asiandu et al., 2021) The biofilm that develops on the surface of plastic macromolecules may hasten the biodegradation of such materials.(Gilan & Sivan, 2013)

In order to be absorbed and biodegraded inside microbial cells, the majority of polymers must first be de-polymerized to smaller monomers since they are too big to pass through cellular membranes.(Tiwari et al., 2018) breakdown by enzymes can be compared to a process of surface erosion that only depends on the surface characteristics of the polymers.(Wei & Zimmermann, 2017)

Different processes, including thermal, chemical, optical, and biological degradation, can cause plastics to break down. (Alshehrei, 2017) biodegradation is often a rather sluggish process. like Streptomyces strain a wide variety of like Actinomycetes has been used for research work.(Alshehrei, 2017) Dominant groups of microorganisms and the degradative pathways associated with polymer degradation are often determined by the environmental conditions.(Shah et al., 2008)

Large changes in the biodegradability of polymers might result from very slight changes in their chemical structures. There are various types of degradation of polymers, 1-photo induced degradation, 2-thermal degradation, 3-chemical degradation, 4- mechanical degradation, 5- biodegradation. (Tiwari et al., 2018)

Aerobic heterotrophic microbes are primarily responsible for the breakdown of complex materials in aerobic circumstances where O2 is readily accessible, with the ultimate products being microbial biomass, CO2, and H2O.(Tiwari et al., 2018) In PET and PUR, enzymes can also hydrolyse the ester linkages. The breakdown products from the synthetic polymers can be taken up by the organism for further metabolization once their molecular size has been decreased to between 10 and 50 carbon atoms. (Wei & Zimmermann, 2017)

Major part of biodegradation id described below-

Biodeterioration -The activity of microorganisms growing on the surface or inside a particular material is the primary cause of biodeterioration.(Lucas et al., 2008) Plastic undergoes natural chemical, physical, and mechanical modification due to the surface deterioration brought on by microorganisms and decomposer organisms. The growth of a biofilm on the plastic's surface initiates this process. The chemical make-up and physical make-up of the plastic, as well as the current environmental circumstances, all affect how a biofilm forms. Extracellular polymeric substances (EPS), which strengthen the microbial film's cohesiveness and its adherence to the surface of plastic, are secreted during biofilm growth. (B. Sharma et al., 2017)

Biofragmantation - This word describes the microbial community's secreted free radicals or enzymes that catalyse the breakdown of polymeric plastics into oligomers, dimers, or monomers. Bacteria often need an electric potential imbalance to perform lysis and trigger other chemical processes. However, the lengthy carbon and hydrogen chains in plastics' structure, which were well stable, led to the material's balanced charge. Because bacteria' cell walls could not be penetrated by plastics with large molecular weights, microbes produce extracellular enzymes that catalyse the reaction mostly at the plastic's surface. (B. Sharma et al., 2017)

Assimilation- Assimilation is the process of combining substances carried by the cytoplasm with the metabolic processes of microorganisms.in this process integrating chemicals into microbial cells, with or without total degradation, The uptake of monomers by bacteria is not guaranteed by their formation. Monomers must travel on certain carriers in order to pass through an organism's cell wall or cytoplasmic membrane. Through catabolic pathways, the plastic monomers are oxidized inside of the microbial cells, producing energy and biomass as a by-product.(B. Sharma et al., 2017) The synergistic processes of abiotic and biotic peroxidation continue in the latter phases of bio assimilation via regular transition metal and oxidase enzyme catalysed peroxidation(Bonhomme et al., 2003)

Role of enzymes in biodegradation

Plastics may and do deteriorate in a variety of ways, either sequentially or concurrently.(Kyrikou & Briassoulis, 2007) The varied enzymes aid in the breakdown of various types of enzymes since enzymes are quite selective in their effect on substrates. (Bhardwaj et al., 2012) Numerous bacteria produce numerous kinds of crucial enzymes for the biodegradation of plastic. Potential catalysts for the decomposition of plastic component polymers include the enzymes laccase, lignin peroxidase, manganese peroxidase, lipase, esterase, and amylase.(Asiandu et al., 2021) These enzymes can break the carbon bonds in polyethylene films so that bacteria may use them.(Ganesh et al., 2017) The enzymes can either be exoenzymes, which break the chain's internal connections, or endoenzymes. (Kyrikou & Briassoulis, 2007) Catalytic proteins known as enzymes work to lower the activation energy of substances that support chemical processes. These proteins are very specialized and diverse, yet they are quickly denatured by heat, radiation, surfactants, and other factors. (Lucas et al., 2008) Zones of clearing form surrounding the colony as a result of the target organism's extracellular hydrolysing enzymes hydrolysing the suspended polyesters in the turbid agar medium into water soluble compounds.(Usha et al., 2011a) The polymer biodegradation process involves two processes, oxidation, and hydrolysis. While oxidation is a biodegradation process mediated by different oxidoreductase enzymes, hydrolysis is the breakdown of polymers catalysed by hydrolase enzymes.(Asiandu et al., 2021) Fungi and bacteria break down the polyethylene via intracellular and extracellular depolymerases. Two processes are involved in the microbial enzymes' breakdown of polyethylene. An hydraulic cleavage is catalysed by the enzyme after it first attaches to the polyethylene substrate.(Bhardwaj et al., 2012) Aspartate, Histidine, and Serine are three amino acid residues that often react during the polymer hydrolysis process.(Asiandu et al., 2021) Different modes of operation are used by microorganisms to cleave polymers. They release certain enzymes or produce free radicals.(Lucas et al., 2008) Fragmentation can be caused by physical forces of a mechanical type and frequently plays a significant role in the early stages of deterioration.(Kyrikou & Briassoulis, 2007) When some polymer compounds cannot be broken down by specific enzymes, the other necessary enzymes will combine to accomplish to oxidation, The term "oxidation" refers to this occurrence. For instance, monooxygenase and dioxygenase will combine to create peroxyl or alcohol groups that are more fragmented.(Asiandu et al., 2021)

Conclusion

In natural habitats, microorganisms have a considerable impact on the biological degradation of materials, including manmade polyethylene Plastics' incredibly varied qualities and advantages are indispensable to our daily life by plastics and plastic products have the potential to harm and pollute the land ecosystem before spreading to the aquatic environment. Finding microbiological techniques of waste disposal, such as the breakdown of hydrocarbons like petroleum and plastic wastes, has sparked attention in recent years due to the need for a clean environment. Environmental pollution from accumulated plastic trash is creating an ever-growing threat to the ecosystem. Plastics are water-insoluble, thermo-elastic polymeric materials in general. Plastics' biodegradability is influenced by both their chemical and physical features. There are many microorganisms that are able to degrade polymers by biodegradation in natural habitat or natural environment, microorganisms can perform this process in the presence of some sort of enzymes that are being activate in this procedure. Different environmental factors are main factor to inflate the capacity of microorganism to degrade the polymers

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