Environmental degradation of ordinary plastic wastes: a review on present awareness and disposal prospects

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**Abstract**

Plastic waste has emerged as a major global environmental challenge, posing detrimental impacts on ecosystems and human health. This review critically analyzes the existing level of awareness about the adverse effects of plastic waste on the environment, encompassing issues such as land and marine pollution, micro-plastic contamination, and the disruption of ecological balance. The issue of plastic garbage accumulation has gained significant recognition in recent times as an effective environmental problem with global implications. It has been observed to affect various living forms, natural ecosystems, and the economy. Given the current threat, it is imperative to prioritize exploring alternative alternatives, such as biodegradation, as a substitute for conventional disposal methods. There is a shortage of information regarding the processes and efficacy of plastic biodegradation. The objective of this review is to examine the adverse environmental impacts resulting from the accumulation commonly used the materials polyethylene, polypropylene, polyester, polystyrene chlorides, polyethylene tere and polyol trash, which are examples of waste from plastics. Additionally, this review aims to assess the potential for degradation of these plastics through both abiotic and biotic processes. Moreover, a comprehensive analysis is conducted on the capacity of several microbial species to degrade these polymers. The current study examines the involvement of invertebrates namely insects, in the process of plastic degradation, emphasizing the significant potential they possess in shaping future outcomes.

**Keywords:** plastic biodegradation, polyethylene, ecological problem, degradation, biological contaminants

1. Introduction

Plastic was a highly significant and utilized material due to its desirable characteristics, such as its lightweight nature, minimal upkeep needs, and resistance to weathering, low toxicity, transparency, and affordability (Yaqoob et al 2022). These attributes enable plastic to be employed in various industrial, commercial, and agricultural applications. The problem of plastic waste contamination has arisen as a noticeable ecological problem. In contemporary times, presenting substantial risks to terrestrial and aquatic ecosystems on a global scale (Mohammed et al 2022). The proliferation of plastic manufacture, in conjunction with insufficient waste management methodologies, the consequence of their phenomenon has been an increase of plastic trash in various ecological habitats, encompassing seas, rivers, soils, and even the atmosphere (Moshood et al 2022). In light of the global recognition of the adverse consequences of plastic pollution, there remain a limited development of successful measures to address their issue (Enfrin et al 2021).

Consequently, there was an urgent and pressing need for comprehensive intervention. The review provides a critical analysis of the existing knowledge and understanding the environmental degradation resulting from the disposal of common plastic debris (Kumar et al 2021). It focuses on the complex mechanisms by which these materials interact with and harm natural environment. The widespread use of plastic materials in various aspects of daily life has enabled remarkable levels of convenience and creativity. However, the lack of effective implementation of sustainable disposal methods has led to substantial ecological repercussions. The enduring presence of plastic materials in natural settings has generated apprehension regarding their extended impacts on environmental systems, which may have significant ramifications for biodiversity, the security of food resources, and the well-being of human populations (Vaid et al 2021). Comprehending the intricate dynamics of plastic degradation and the diverse mechanisms by these materials undergo disintegration under varying environmental conditions was crucial for the formulation of efficient management and restoration approaches.

The subsequent section of the paper was organized as follows: Section 2: Implications of the production of plastic waste; Section 3: The process of plastic trash degradation; Section 4: The process of physicochemical deterioration; and Section 5: Microbiological degradation. 6. Conclusion.
2. Implications of the production of plastic waste

The India estimates that starting in 2020, over 400 million waste plastic will begin to be generated every year, whereas the manufacturing of plastics was predicted according to Barra and Leonard (2018), it was projected that the population would increase twofold by the year 2036, reaching a total of 810 million individuals. Furthermore, it was anticipated that the population would further increase to 1,650 million by the year 2051. Many dangerous vaporous compounds, such as chlorine cyanide, dioxins, nitrogen oxides, and carbon monoxide, are released into the atmosphere during the plastics production procedure are extremely dangerous to people and the ecosystem. It was demonstrated, as (Royer et al 2018), with the quantities of invisible gases are generated from "low-density polyethylene (LDPE)" gradually increased after a 213-day incubating duration. Specifically, the daily production reached 5.9 nmol of propane, 14.6 nmol of the hormone ethylene, 3.8 nmol of ethanol, and 9.8 nmol of polypropylene.

Furthermore, while LDPE develops in the air as opposed to water, the release interest rates for methane and ethylene are approximately two and seventy-six instances greater, respectively. They suggests that materials can be an undetected contributor to invisible gases related to warming temperatures, which are predicted to rise as more plastic was generated and accumulates in the atmosphere. When it comes to the elimination of plastic (Figure 1), over 5 billion kilograms were used once before disposed, while 6.4 billion metric grams of plastic produced worldwide between 1955 and 2017 ended up as waste (Geyer et al 2017). Furthermore, the microbe composition of soil was impacted by 4.6 billion tonnes of plastic waste that are either released into the atmosphere or landed in landfills. Because the entire decomposition process takes over five hundred years, soil disposed of in garbage dumps becomes infertile (Chamas et al 2020).

![Figure 1](https://www.mdpi.com/sustainability/sustainability-13-09963/article_deploy/html/images/sustainability-13-09963-g001.png)

2.1. Effects on the environment

It was projected that 195 nations would generate 400 million tons of plastic debris in 2020, of which 8.8 million tons would end up in the oceans. The top countries in the world for improper plastic waste management are those in southern Asia: Thailand, Malaysia, the Philippines, Sri Lanka, Vietnam, China, Indonesia, and Bangladesh (Koller and Braunegg, 2018; Serrano-Ruíz et al 2021). With 88% of the material terminating in freshwater bodies, according to 2019 report. Microbes, substances, toxic chemicals, and organic substances can all be transported by plastic waste (Chamas et al 2020). Moreover, the abiotic factors breakdown of plastic releases extremely hazardous substances that worsen aquatic clarity and environmental conditions (Chen et al 2019). 525 trillion micro, macro, and nanoplastic particles, or 269 t are present in the water bodies. Numerous plastic waste materials exhibit a hydrophobic characteristic that facilitates their association with different contaminants, including polyaromatic hydrocarbons (PAHs).
The presence of biological contaminants and polychlorinated biphenyls has been documented in a study by (Liu et al 2016). Living things are confronted with significant water pollution caused by the disposal of plastic trash in various aquatic environments such as lakes, rivers, and wetlands. The waterways in the metropolis of Kolkata serve as a prominent illustration of contamination caused by the widespread disposal of plastic containers, bottles, containers, and various other recyclable materials used by visitors. The development of plastic garbage into aquatic environments disrupts the equilibrium of water dynamics, impairs the reproductive capacity of fish, and causes significant harm to essential creatures. Additionally, an excess of polymers in the oceans has the ability to cause a darkened covering that prevents organisms from growing, thereby contributing to climate change (Proshad et al 2018).

2.2. The impact on human health

Inappropriate removal of waste plastic has the potential to impact the well-being of people, whether through initial contact or inadvertently via the inhalation and ingesting of plastic fragments (Figure 2). The extended duration of micro plastics' existence can lead to a range of physiological responses, including discomfort, (Proshad et al 2018) oxidative damage, DNA damage, apoptosis, and necrotic (Prata et al 2019). Prolonged exposition to micro plastics, which can lead to significant consequences (Wright and Kelly, 2017) including inflammation, harm to tissues, or the development of cancer.

The combination of polymer can have various biochemical consequences, such as the release of released compounds and remaining polymers, or the absorption of hydrophilic substances. These impacts can lead to a decline in the health of people. The ingestion of small plastic particles by humans and animals has the potential to facilitate the cellular entry of both adherent and exogenous pollutants, as indicated by studies conducted by (Prata et al 2019). Particulate matter (PM) produced during the burning of vinyl or plastic products was investigated by Barabad et al (2018). The researchers observed the emission of significant quantities of detrimental pollutants, including fine and ultrafine particles. Additionally, the presence of poisonous chemicals such as acetone and benzene were discovered. The highest recorded emission of particulates (PM) with a measurement of 0.36 μm was observed at a thermal flux of 26 kW/m², leading to a concentration that was 64.0 μg/m³.

Figure 2 The effects of plastics on human health, both directly and indirectly.

Source: https://www.researchgate.net/publication/321906991/figure/fig2/AS:573313631756288@1513700029402/Impact-of-Plastics-on-Human-Health.png
However, the maximum formation of particulate matter (PM) having an average diameter of 0.46 μm was observed at values of 68.8 and 88.7 μg/m³, accordingly, when subjected to heat intensities of 36 and 51 kW/m². Furthermore, it was crucial to acknowledge that polymers include reactive oxygen substances (ROS) (Wright and Kelly, 2017) which can be boosted by adding transitioning metals or exposed to ultraviolet (UV) radiation. The migration of low-densities of polyethylene microscopic particles (LDPE-MPs) throughout organisms and earthworms focus that waste (Huerta Lwanga et al 2017) made of both micro and macro plastics was dispersed across the food production chain. The outcomes of the research indicated that the quantities of “LDPE-MPs” in hens were measured at 128.7 MPas per gram of feces and 11.3 MPas per gram of gizzard. 842 pounds of plastic per human to represent the median yearly consumption of plastic each person, as reported by (Huerta Lwanga et al 2017). Hence, considering the inadequate management of plastic waste and its substantial global consequences on the environment, wildlife and human welfare, it was crucial to explore novel approaches for the effective treatment and disposal of plastic refuse. In their particular context, the application of hydrodynamic disintegration and decomposition techniques presents itself as a feasible and effective method to deal with the issue of waste plastic.

3. The process of plastic trash degradation

Plastic trash was susceptible to the physiological decomposition and biodegradation procedures lead to the early weakening of the intermolecular interactions that keep the polymers connected. The main processes identified for plastic deterioration in the environment include photo degradation, thermo-oxidative degradation, hydrolytic degradation, and biodegradation. In natural environments, the deterioration of plastic commences with photo degradation, progressing through hydrolysis and thermo-oxidation processes. These activities result in the fragmentation of plastic waste into molecules with “low molecular weight (MW)”, that microorganisms could subsequently use to continue decompose. Nonetheless, (Chamas et al 2020) the aforementioned procedure exhibits a significant drawback in terms of its sluggishness, necessitating an extensive time frame spanning many millennia for its culmination.

3.1. The characteristics of plastic polymers

The decomposition of plastic was influenced by both external factors and the physical characteristics of polymeric materials. Plastic’s chemical and physical properties are critical to its degradation process (Fotopoulou along with Karapanagioti, 2017). Plastic’s chemical structure and the length of its polymer chains controlled how susceptible it was to biological and environmental degradation (Huerta Lwanga et al 2016). Polyurethane variants characterized by extended chemical fetters, such as polypropylene (PP), demonstrate enhanced durability against decomposing. The degradation efficiency of polymers was influenced by their hydrophobicity, as observed by (Padsalgi kar et al 2017). The research findings indicate that an increase in hydrophilicity leads to a higher destruction frequency. Conversely, the transparent polymeric structure was susceptible to degradation when exposed to water and oxygen. According to Li et al (2019), the unstructured portions of polymers are regarded as more conducive to heat oxidation. In addition, it has been observed that the utilization of stabilizers as additives can lead to a reduction in the rate of degradation (Aldas et al 2018), as well as a decrease in the presence of chromophores such as carbonyl and hydro peroxide groups. Similarly, it was important to evaluate the morphological characteristics of plastic, since the rate of degradation tends to rise when rough surfaces are present. (Booth et al 2017) These rough surfaces are more conducive to the production of biofilms compared to smooth surfaces.

3.2. Environmental components

A number of variables including geography, climate, pollution, and pollution levels, have an impact on the processes and rate of plastic degradation. The significance of sunlight in the deterioration of plastic cannot be overstated, as it plays a crucial role in raising the rate of photo-oxidation response and thus accelerating the process of decomposition of plastic materials. Moreover, it has been observed that the rate of abiotic factors decomposition exhibits a positive correlation with temperatures (Pisch edda et al 2019). Specifically, the rate of reaction is found to double for every 10 °C rise in mercury. The flexibility of chains of polymers was influenced by temperatures, and there in turn impacts enzyme activity throughout microbial breakdown and the pace of hydrolysis. Booth et al (2017) Heat affects the generation of radicals that are unstable, the velocity of oxygen transport, and humidity. The rate of polyethylene terephthalate (PET) chain scission exhibited a 500% increase when exposed to 100% relative humidity at a temperature of 60 °C, as compared to the conditions of 45% relative moisture. Additionally, the presence of humidity was found to promote the decomposition process of polypropylene (PP) by raising the amount of radicals with a carboxylic content. However, a decrease in the ultraviolet (UV) light strength in the seawater also causes a decrease in the degree of photo degradation. An elevated degree of moisture content at the ocean’s surface amplifies the process of light deterioration due to the ability of specific photo-stabilizing agents to dissolve in water (Booth et al 2017). Their phenomenon results in an efficient decomposition procedure. The rate of decomposition of plastic during photo degradation and biodegradation was influenced by the accessibility of oxygen. It has been observed that the existence of an elevated level of oxygen accelerates the polymers destruction procedure. The observed phenomenon can be identified to the prompt response exhibited by oxygen and carbon-centered charges that have been liberated in the primary
degrading substances. These reactions give rise to an increased number of radicals from hydrocarbons in the polymer’s structure, which in turn contributes to higher levels of splitting and the creation of connected polymers. Moreover, the existence of water is additionally utmost importance in facilitating both biotic and abiotic degradation mechanisms. The observed phenomenon can be attributed to the hydrolysis mechanism, wherein the functional groups undergo degradation, leading to the subsequent fragmentation of the chains of polymers.

4. The process of physicochemical deterioration

The natural process of abiotic deterioration of plastic can occur through mechanisms such as mechanical deterioration resulting from tides forces, ripples, and scratches produced by particles. The procedure of disintegration leads to the creation of plastic waste. The photo-oxidation and hydrolyzed processes inherently result in the production of a fragile substance, which can readily undergo mechanical disintegration, ultimately resulting in the production of nano- and micro-plastic particles regardless of during the chemically induced disintegrating manipulate, there’s a reduction in the total molecular weight (MW) of the polymers. Conversely, (Lambert and Wagner et al 2016) in mechanically dispersion, that was no observable alteration in the MW. The regulation of their procedure was subject to the effect of multiple factors, including the amount of time of chains of polymers, internal forces exerted inside polymer fetters, mechanical strength, polymerization crystallization, and the mass of the polymeric substance.

4.1. Photo deterioration

In hypoxic external conditions, the photo degradation was extremely important because of photo-oxidation. Through their method, polymers' surface oxygenation was induced, increasing their hydrophilic properties and encouraging the growth of microbial biofilms. Photo-initiated oxidative decomposition can occur in PE, PP, and PS (Figure 3). Three stages constitute the mechanism: commencement, dissemination, and completion.

![Figure 3 Mechanism of photo degradation of plastic.](image-url)

In polymers with uncharged chromophoric compounds that collect sunlight, radical commencement occurs when heat or light destroys the chemical bonds in the polymer chain, resulting in the production of free radicals. Exterior contaminants or structural weaknesses can initiate the process of initiation, even if PE and PP do not contain these types of molecules. During the spreading stage, oxygen and polymer electrons combine to generate peroxy radicals which cause self-oxidation and, in the end, chain fragmentation or bridging. In order to create inert objects, two radicals must combine to cause termination. The procedure makes the plastic more prone to disintegration by lowering its molecular weight (Gewert et al 2015). Three phases were identified by a long-term study of PE decomposition in an inert system: an early release of CO₂ and O₂ uptake, a following rate reduction, and a last rapid structural breakdown and enhanced degradation rate.
4.2. Hydrolysis

The hydrolysis of plastic was a significant process in the abiotic breakdown process. The acceleration of hydrolysis was facilitated by the existence of the catalysts, such as electrons that are produced as a result of their reaction. The rate of hydrolysis was contingent upon the vulnerability of polymer bonds of chemicals to the action of water and the quantity of water within the substance. Furthermore, the velocity at which water disperses inside the polymer’s composition was a critical factor (Padsalgikar et al 2017). During the procedure of hydrolysis, the polymer undergoes physicochemical changes as a result of its reaction with freshwater. Their reaction can be accelerated either medically or physiologically. The pH accelerated processes involve a process in which a nucleophilic bombardment takes place on a carbonyl group found in esters or bonds of amides. Furthermore, the hydrolysis rate was influenced by various factors, one of which was the molecular weight of polymeric molecules. It has been observed that the molecular weight increases, the hydrolysis rate tends to decrease. Similarly, the velocity of reaction was influenced by the mobility of molecules as well as their hydrophobic or hydrophilic properties (Booth et al 2017). Furthermore, according to the experimental principle, the rate of hydrolysis was influenced by the stereo chemical makeup of the chain. Due to the steric hindrance caused by hydrogen, oxygen, and carbon atoms, which restrict the rotational movement of other groups. Consequently, the quantity of configurations that enable an assault by hydroxide (OH) or hydrogen (H) protons was restricted. Polymers, scientifically referred to PES, (Lopalco et al 2016) have notable durability owing to the substantial atomic composition at the sixth atomic position.  

4.3. Thermal deterioration

The process of thermal deterioration in plastics occurs when pressures above 100 °C, contingent upon the specific polymeric composition including its inherent properties. The incorporation of antioxidants during the material's production procedure impedes the initial stages of temperatures thermal oxidization. The acceleration of the heat-induced degradation process can occur due to the presence of stress and exposure to reactive chemicals, including the ozone layer. Polypropylene (PP), polyvinyl chloride (PVC), and polybutadiene are materials that are prone to being affected by heat, while polysulfone, polyether ketone, and polysiloxanes possess thermal resistance due to their strong backbone bonds. The global impact of thermal degradation under ordinary climatic circumstances, particularly in cold maritime locations, was deemed to be negligible. The depiction of the development and affecting factors can be observed, as has been developed.  

5. Microbiological degradation

The method of biodegradation encompasses the process of turning natural substances onto ethanol and leftover carbon dioxide, (Ali and Sun, 2019; Ali et al 2019; Ali et al 2019) facilitated by the activities of bacteria. According to Magnin et al (2020), these microbes possess the capacity to metabolize polymers as a source of energy. Synthetic polymers, including polyethersulfone (PES), polyvinyl alcohol (PVA), polyamide (PA), and polyurethane (PU), are employed materials at an international scale. Nevertheless, the biodegradation of recyclable plastics was limited to a tiny proportion due to the inherent biophysical features of plastic, which make it a less favorable growth substrates for microbial. The process of enzymatic breakdown of plastic via hydrolysis involves the attachment of an enzyme to the polymer. Their enzyme acts as a catalyst, facilitating the hydrolytic cleavage of polymers into smaller units such as oligomers, dimers, and monomers. Eventually, these smaller units are broken down and mineralized into carbon dioxide (CO₂) and water (H₂O). Previous studies have emphasized the capacity of fungi, bacteria, and algae to degrade polymers. (Raghavendra et al 2016) Various species have been identified to thrive on (Cassone et al 2020) readily biodegradable plastics such cellulose and lignin, as well as on less susceptible polyethylene such as polyethylene (PE) and polyurethane (PU) (Zhang et al 2020).  

5.1. The potential of microorganisms in the biodegradation of plastics

Fungal mycelia provide a substantial surface area, which allows for the infiltration of polymeric materials, hence enhancing the accessibility and deterioration of traditional plastic polymers (Sánchez et al 2020). In addition, mycelia have the ability to release enzymes from the cell, such as depolymerases, which facilitate the breakdown of polymerization into smaller units, including oligomers, in dimers, and monomers (Ali et al 2021). According to Gangola et al (2019), fungi have a superior ability to secrete catalysts as compared to microbes, hence improving their capacity to degrade plastic materials. Monomers that are generated are incorporated and decomposed by internal enzymes of fungi.  

The destruction of lignin and subsequent conversion into carbon dioxide and water was a substantial contribution of white-rot and brown-rot fungi in the biodegradation of plastics and polymers. Their process was facilitated by the presence of enzymes outside the cell, including lignin peroxidase and manganese peroxidase (Ali et al 2020). It was worth mentioning that lignin has specific physical characteristics and chemical compositions that have resemblance to plastic, such as hydrophobicity, molecular connections and aromatic molecules that are not oxidative. The aforementioned resemblance facilitates the degradation of plastic polymers such as polyethylene (PE) and polypropylene (PP) by specific enzymes involved in lignin modification, namely laccase and manganese peroxidase.
Strains of bacteria residing in soil or water affected with plastic have the ability to eliminate plastic compounds, therefore presenting a viable bioremediation strategy. Bacterial species such as Bacillus spp., Pseudomonas spp., and Streptomyces spp. have demonstrated notable efficacy in degrading a wide range of plastic polymers. Recent research has elucidated the capacity of some types of algae to degrade plastic materials.

The capability of filamentous blue-green algae, specifically Anabaena was spiroides, to flourish on the outermost layer of polyethylene trash was evident when key elements such as sunlight, water, and nutrients are made available. Their observation underscores the capacity of microalgae to establish colonies on plastic surfaces (Kumar et al 2017). Furthermore, previous studies by (Kumar et al 2017) and (Moog et al 2019) have shown that diatoms and cyanobacteria exhibit effectiveness in the biodegradation of polyethylene (PE). However, it was imperative to do further research to explore the efficacy of microalgae in the degradation of plastics.

5.2. The microbiological deteriorate process of plastic wastes

The phenomenon of bacteria’s decomposition of waste plastic was comprised of five essential processes, namely immigration, bio deterioration, bio fragmentation, integration, and decomposition (Figure 4). In the beginning, microbial species establish themselves on the plastic’s surface, creating groups that support the growth of biofilms, resulting in significant deterioration of the polymer surface.

The process of microbial adhesion was enhanced through the synthesis of diverse proteins and polysaccharides, which enable the infiltration of material pores and subsequent modification of their dimensions. Bio deterioration occurs when microorganisms adhere to and interact with plastic polymers, resulting in surface degradation and changes in the physicochemical characteristics of the material. Filamentous fungus employs mycelia as a means to infiltrate polymeric substances, expanding pores and instigating the development of cracks, resulting in a reduction in the resistance and durability of the polymer. The secretion of extracellular chemicals by microorganisms can accelerate the pace of penetration, impacting both hydrophobic and hydrophilic phases and promoting the accumulation of pollutants. Consequently, their process facilitates microbial development and increases the rate of bio deterioration. According to (Skariyachan et al 2016), microbial degradation was addressed through the utilization of collaborations, in contrast with private breeds. Chemolithotrophic bacteria, namely Nitrosomonas spp., nitrogen-fixing spp., and the bacterium pp., are known to secrete biologically active compounds, including sulphuric and nitric acid. On the other hand, chemo-organotrophic microbes produce organic acids such as gluconic, oxalic, and citric acids.

The process of physical biological degradation entails the infiltration of filamentous bacteria into the polymeric substance, resulting in the expansion of pores and fissures. Certain microbes play a role in oxidation-reduction and chemical deterioration in processes. For instance, there are chemolithotrophic organisms that have the ability to uptake iron and manganese cations by utilizing certain proteins located in their cell membranes. Enzymatic biodeterioration encompasses the action of several extracellular enzymes, such as peroxidases. However, it was noteworthy that specific types of plastics, such as “polyurethane (PU) and polyvinyl chloride (PVC)”, have a notable resistance to breakdown. According to (Yoshida et al 2016), microbes employ various enzyme groups, including lipases, esterase’s, ureases, and proteases, to effectively address the crystalline nature of these polymeric. Fragmentation was a crucial lytic process that microorganisms employ through a variety of mechanisms. These mechanisms include the secretion of specialized enzymes such as oxidoreductases and hydrolases, as well as the utilization of free radicals, in order to break down polymers.
According to Chen et al (2020), enzymes that possess the ability to degrade lignocellulosic substances have been found to exhibit the capacity to degrade plastic polymers. The production of microbial endo- and exo-enzymes in their process was not immediate, but rather necessitates a period of time for the synthesis of particular enzymes. The concentration of enzymes grows over time and the activity of enzymes stops when there was no substrate available. Hydrolysis, an essential phase, was dependent on the activity of several enzymes, including depolymerase enzymes and their reaction mechanism. The procedure entails the utilization of a catalytic trio which facilitates the production of the nucleophilic alkoxide molecule. The alkaline group initiates a chemical reaction on the ester bond, leading to the production of ethanol and the creation of an acyl-enzyme combination (Austin et al 2018). The material exhibits hydrophilic crystal characteristics by nature. The occurrence of complicated polymer chain scission processes requires the participation of numerous enzymes. Mono-oxygenases and dioxygenases are enzymes that facilitate the introduction of alcohol and peroxyl groups into polymer structures, hence augmenting their polarity and ultimately promoting the biodegradation process. Peroxidases are enzymes that enable interactions between peroxyl molecules, whereas oxidases, which contain copper atoms, promote hydroxylation and oxidation processes. The objective of free radical oxidation was to enhance the polarity of molecules by introducing or generating hydroxy, carbonyl, or carboxyl groups, consequently, their leads to an increased susceptibility of the polymers to microbiological breakdown. Enzyme possesses the capacity to facilitate multiple oxidative processes, leading to the generation of unstable molecules. The occurrence of oxidative damage was attributed to the activity of reactive oxygen species, which then triggers cascading events and facilitates the transformation and degradation of polymers entities.

Nevertheless, the enzymatic breakdown of linear polymeric molecules was limited as enzymes are unable to interact with the interior regions of these structures. Microorganisms with the ability to decompose organic matter, such as bacteria, fungus, and algae, have the capacity to produce hydrogen peroxide \((\text{H}_2\text{O}_2)\). Additionally, certain species of algae have oxidation capabilities, resulting in the production of extracellular superoxide and hydrogen peroxide (Diaz et al 2018). Regarding the process of assimilating produced monomers, a bacterial cell derives electricity through the assimilated polymers, facilitating cellular proliferation. Certain monomers are able to enter the cell by utilizing certain membrane carriers, whilst are unable to be assimilated due to the impermeability of the cell membrane. The monomers that have not undergone assimilation are subjected to biotransformation, a process that involves the enzymatic conversion of these monomers (Al-Tohamy et al 2020). Microbial catabolic pathways enable the oxidation of divided into monomers inside the microbial cell, which leads to the creation of energy-carrying molecules and cellular organelles, such as “adenosine triphosphate (ATP)” (Ali et al. 2020c, 2020d). The process in question was facilitated by anaerobic and aerobic oxygen consumption, as well as microbial fermentation, which have been documented in diverse ecological settings (Al-Tohamy et al 2020).

6. Final considerations

Plastics are regarded as one of the most essential materials in our everyday existence due to these distinct characteristics. Nevertheless, the consumption and accumulation of plastic exhibit a persistent upward trend, so presenting a significant environmental and health hazard. The review article presented in our study highlights the detrimental impacts of poorly handled plastic trash on the environment and human health. Additionally, it emphasizes the importance of adopting sustainable processing methods, such as biodegradation. Nevertheless, the physicochemical properties of plastics provide a significant obstacle to microbial breakdown. However, inside the natural environment, numerous microorganisms the involvement of microorganisms was crucial in the procedure for plastic degradation by bacteria. Similarly, the significance of gut bacteria in the biodegradation procedure of insects should not be overlooked. In addition, our research underscores the crucial significance of pretreatment, which may involve physiological and chemical methods, as a primary measure to augment the process of deterioration of different polymeric materials. In this particular setting, it was crucial to consider and possibly alter the attributes and makeup of the polymers before subjecting it to biological conditioning. This was necessary for one to utilize suitable physicochemical processes for preparation. Possible approaches to therapy could involve the use of “gamma- or UV-irradiation”, along with substance therapies utilizing “acidic or alkaline solutions”. Nevertheless, the absence of an efficient plastic-degrading method that was ecologically sustainable and cost-effective remains a significant challenge. Consequently, ongoing research was important to explore and develop novel technologies for the degradation of plastic waste.

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Not Applicable.

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