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# Glance About Plastic Degradation by Microbes

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**ABSTRACT**

Plastic is a synthetic material made from elements extracted from fossil fuel resources which has several valuable uses.There are two types of plastics includes , Non-biodegradable plastic is a material which cannot be degraded by living organisms and acts as a environmental pollution source, and Biodegradable plastics are degradable and can be broken down when exposed to UV light, sunlight, microorganisms, certain enzymes or insect attack .the breakdown of plastic includes Bio-deterioration, Bio fragmentation, Assimilation and Mineralization , CO2 gas is a major product emitted during biodegradation of polythene.

**Keywords:** plastics, biodegradation, microbes.

**Background:**

Plastic is a synthetic material made from elements extracted from fossil fuel resources which has several valuable uses.There are two types of plastics includes , Non-biodegradable plastic and Biodegradable plastics. Many of microorganism can able to plastic degradation for create healthy environment and more sustainable.

**Methods:**

**Plastics classification based on biodegradability:**

**1- Non-biodegradable plastics:**

Non-biodegradable plastic is a material which cannot be degraded by living organisms and acts as a environmental pollution source [4]. It comprises fossil-based and bio-based polymers. Fossil-based synthetic polymers are most used non-biodegradable plastics and are hydrocarbons and petroleum derivatives. They are made up of a small repeating subunit, they have high molecular weight and stability due to which they do not easily undergo degradation cycles. Commonly Used non-biodegradable plastics include Polyvinyl Chloride, Polypropylene, PS, Polyethylene, PUR and Polyethylene terephthalate. They accrued in the environment and became a threat. Some of them are chemically inactive and resistant to microbial attack [10]. The term "Bio" in bio-based polymers stands for carbon source or its biodegradability. Sources of non-biodegradable plastics are usually green plants such as corn, sugarcane and biomass. The process of manufacturing involves pretreatment, hydrolysis, fermentation and some important steps of organic reactions [4].

**2. Biodegradable plastics**

Biodegradable plastics are degradable and can be broken down when exposed to UV light, sunlight, microorganisms, certain enzymes or insect attack [11] What are Plastics. Biodegradable plastics include bio-based and fossil-based polymers. Plastic biodegradation includes enzymatic and non-enzymatic hydrolysis. Microorganisms release exoenzymes, which degrade polymer complexes into smaller components such as dimers and monomers, allowing them to readily flow through a bacterial cell's semipermeable membrane. Microbial enzymes involved in lignin degradation have been reported to play a role in the biodegradation of polyethylene [5,7]. These include laccases, lignin peroxidases, and manganese peroxidases. Manganese peroxidase from Phanerochaete chrysosporium has been reported to play a chief role in degradation of a high molecular weight PE membrane [9].During the biodegradation of plastics, microorganisms on the surface firstly decrease the molecular weight of the plastics, followed by the transformation of the polymer to its monomers, which are then broken down in a process of mineralization with the release carbon dioxide, water, and methane [13,16].

**Mechanism of breakdown of plastic :**

1. Bio-deterioration

2. Bio fragmentation

3. Assimilation

4. Mineralization

In the first step microbes adhere to plastic polymers and form a thin biofilm on the surface of plastic. then they release EPS which catalyzes the various mechanical degradation reactions. It modifies physical and chemical properties of polymer under varying temperature, drying, PH and moisture content [3]. Environmental parameters such as humidity, temperature, pH, salinity, the presence or absence of oxygen, sunlight, water, stress and culture conditions not only affect the polymer degradation, but also have a crucial influence on the microbial population and enzyme activity [8].

**Products of Microbial degraded plastics:**

The CO2 gas is a major product emitted during biodegradation of polythene [1,12,15]. Generation of aldehydes, ketones and carboxylic acids was recorded in smoke of film extrusion of LDPE in an extrusion coating process (Andersson et al.2002). Rhodococcus rubber (C208) produced polysaccharides and proteins by using polythene as carbon source [14]. In another result, Rhodococcus rhodochrous ATCC29672 (Bacterium) and Cladosporium cladosporoide ATCC 20251 (Fungus) used in an extrusion coating process [2].During the biodegradation of plastics, microorganisms on the surface firstly decrease the molecular weight of the plastics, followed by the transformation of the polymer to its monomers, which are then broken down in a process of mineralization with the release carbon dioxide, water, and methane [13, 16].

**Evaluating for plastic degradation by multiple tests should be followed in**: due to following reasons [17]

1. Weight loss due to leaching of additives, including plasticizers.

2. Carbon dioxide production might result from the degradation of low molecular weight fraction of the polymer, with no degradation of longer chains.

3. Loss of additives or very small change in chemical makeup plastic may affect strength of plastic.

**Enzymatic Degradation :**

Extracellular and intracellular enzymes are produced by microorganisms which are involved in the biodegradation of plastic [18]. To degrade polymers, enzymes capable of breaking ester, ether, carbon-carbon, and amide bonds will be required [19]. Among these, oxidoreductases, peroxidases, transferases, and hydrolases have been reported to facilitate depolymerisation and hydrolysis reactions [20].Acyl hydrolases are the most extensively studied enzymes for the degradation of polymers [21]. Cutinase, lipase, esterase, and PETase are widely reportedto efficiently degrade polyesters like PET, PHA, and PLA [22]. They are produced by both bacteria and fungi involved in plastic degradation [23]. The difference between lipases, esterases, and cutinases is a function of their substrate chain lengths [24]. Esterases catalyse the breakdown of ester bonds with chain lengths of less than 10 carbon atoms, and lipases hydrolyse esters with more than 10 carbon atoms in their chains [25]. Cutinases can break ester bonds, and their active sites are more exposed to substrates due to the lack of a “lid” structure covering the active site [26]. Cutinases from Thermobifida cellulosilytica DSM44535 and Thermobifida fusca DSM44342 were successfully cloned and expressed in E. coli BL21. These enzymes from Thermobifida, specifically ThcCut1, exhibit favorable kinetic parameters for soluble substrates and release MHET and terephthalic acid from PET. Comparative homology modelling suggests that His-209, located in the active site, is crucial for hydrolysis activity [107].Lipases also break ester bonds, but their active sites are covered by a lid which somewhat limits substrate access. The lid opens in the hydrophobic environment of the water/lipid interface [27]. These enzymes belong to the α/β-hydrolase superfamily [28] and contain a catalytic triad of Serine, Histidine and Aspartate. This catalytic triad facilitates nucleophilic attack on the carbonyl carbon of the ester bond, causing the hydrolysis of the polyester chain [29].Lipases can be used to degrade different types of plastics, particularly biodegradable plastics [30]. For example, a lipase isolated from Rhizomucor miehei (formerly Mucor miehei) was used to efficiently degrade synthetic polymers such as PC and PET in an aqueous medium at 37 °C [115].

**Results:**

1- Plastic is a synthetic material made from elements extracted from fossil fuel resources which has several valuable uses.

2.Threre are two types of plastic according biodegradability, biodegradable plastics and Non-biodegradable plastics,

3- Microbial enzymes are the most important environmental agents contributing to the biodegradation process.

4-Environmental parameters such as humidity, temperature, pH, salinity, the presence or absence of oxygen, sunlight, water, stress and culture conditions not only affect the polymer degradation, but also have a crucial influence on the microbial population and enzyme activity.

**Conclusions:**

Plastic degradation is very important step for good health and beautiful environment.

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