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REVIEW ARTICLE

QUEST FOR ISOLATION AND IDENTIFICATION OF PLASTIC DEGRADINGMICROORGANISMS: A MOLECULARAPPROACH

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Abstract

Microorganisms havea very essential role in the biological breakdown of various organic matter in the natural environment, this process is known as biodegradation. Polyethylene waste and plastics from synthetic materials accumulate in the environment and represent a growing ecological threat. Biotic and abiotic methods have been used to turn polymers into monomers. This issue might be resolved by powerful microbial strains (robust) and the biodegradation of this plastic trash. In this study, in vitro, the biodegradation of polyethylene and PVC tapes was analyzed using microorganisms isolated from the soil after an incubation period of one month. Microbial species associated with degradation ability were identified as Gram-positive bacteria and Gram-negative bacteria. In the future, microbial-friendly plastics are safe for the environment and can reduce plastic waste on the environment Further research is underway and it will have good applications in the future due to its low cost and eco-friendly properties.

Introduction:-

Plastic is a material that contains natural substances and essential components with high molecular weight. The word plastic originates from the Greek word "plastikos" which means any material that can be moldable into any shape [1]. Largescale production of synthetic plastics began in 1950. In the five years since 1964, plastic production has increased 20 times [2]. The production of synthetic Polymers has progressed enormously over the last 60 years. During this period, polymeric materials entered various fields of human life [3]. Global plastic production is estimated to reach 311 million tons in 2014 and 335 million tons in 2015, clearly illustrating its enormous rapid production, doubling in the next two decades and reaching nearly four at the same time. Double by 2050 [4]. Plastic is ubiquitous in modern times, from the polythene bags of daily groceries to PVC pipes, from kitchen apparatus to pet bottles, plastic, and its related derivatives are everywhere.

Many various items, including food, medicine, cosmetics, detergents, and chemicals, are packaged with plastics. [5]. Polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), polyethylene (LDPE, MDPE, HDPE, LLDPE), polyurethane (PUR), polybutylene terephthalate (PBT), and nylon are the most widely used packaging polymers in the world. Currently, The industry has been divided into organized and unorganized sectors, The unorganized sector

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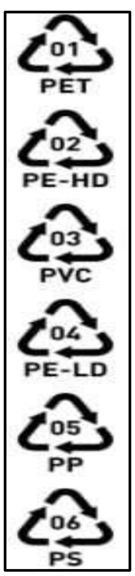
uses a huge quantity of plastic waste, which prevents it from producing high-quality products and instead produces low-quality and inexpensive products [6]. Thermoplastic polymers and thermoset polymers are the two forms of plastics. Thermoplastics is a plastic whose composition does not change chemically during heat generation and can be in continuous form [7]. The molecular weight of thermosets is limitless. Each polymer chain will have thousands of repeating molecular units, also known as repeating units, which are formed from monomers. Thermostats can be melted and cast into various shapes. Once attached, they stay firm. An irreversible chemical reaction occurs during thermal curing. Other classifications are based on characteristics related to the manufacture or design of the product. Plastics can be classified based on various physical properties such as high tensile strength, density, and resistance to various chemicals. [8]. Polymer is not biodegradable and poses the greatest threat to our environment due to improper waste management. Scientists were surprised to learn that microplastics can remain in the environment and be broken down by microbes while looking into different strategies to reduce microplastic pollution. [9]. Microorganisms are adaptable to all environmental conditions and can break down various substances, including microplastics.[10]. Microorganisms are used to break down plastics. They decompose without harming the environment [11]. They create an ecologically safe method of bioremediation and also clean natural ecosystems without any adverse effects [12]. In recent times only a limited number of variable microorganisms have been isolated, but the relationship between microorganisms and microplastics remains unclear due to a lack of information [13].

Classificationofplastics:
Two kinds of plastic can be distinguished based on their biodegradability:

Non-Biodegradableplastics:
Fossils and biopolymers are made from non-biodegradable plastics. Synthetic polymers of fossil origin obtained from petrochemicals are most often used. They have a high molecular weight due to the recurrence of monomeric units [14]. Polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET), polystyrene (PS), polyurethane (PUR), and polyethylene (PE) are some of them. Due to inadequate waste management systems, it accumulates in large quantities in the environment [15].

Biodegradableplastics:
Biopolymers and fossil polymers consist of biodegradable plastics depending on biodegradation and microbial interaction levels. This water reduction consists of an enzymatic and a non-enzymatic break, known as hydrolysis. [16]. Biodegradation involves both aerobic and anaerobic processes [17]. Polyhydroxyalkanoate (PHA) and polylactic acid (PLA) are the two bio-based polymers that are used the most frequently. [18]. While polycaprolactone PCL (PCL) [19] and polyethylene succinate (PES) are plastics of fossil origin. [20]

• The plastics industry includes the assembly, production, conversion, and sale of plastic products worldwide. Six key types of polymers, collectively referred to as commodity plastics, account for over 70% of worldwide production. [21].



Polyethyleneterephthalate(PETorPETE)

High-densitypolyethylene(HDPEorPE-HD)

Polyvinyl chloride (PVCorV)

Low-densitypolyethylene(LDPEorPE-LD)

Polypropylene(PP)

Factorsaffectingmicrobialdegradationofplastics:
Environmental Causes:

• **Humidity**: Moisture is a necessary factor for microbial growth and therefore plays an important role in plastic degradation. Microorganisms require adequate water content for activation. The hydrolytic activity of microorganisms increases with increasing humidity.

• **PH:** Changes in pH have an impact on the pace of the hydrolytic reaction. Such pH-changing compounds are produced as a result of various polymers degrading. The pace of degradation is impacted by pH changes because they modify the development rate of bacteria.

• **Temperature**: As temperature increases, the degradative power of enzymes decreases. These polyesters with higher melting points are less susceptible to degradation. Enzymes can effectively degrade low melting point polyesters [23].

Sourceofplastic-Eatingmicrobes:
Some microbes are involved in plastic degradation. Numerous physicochemical and degrading factors play a role in the microbial decomposition of plastics in particular conditions. [24].

Bacterialdegradationofplastic:
Bacteria are the main microflora and outnumber other organisms. They are found in water, soil, and the atmosphere, and the majority of species are known for their degradation of pollutants. [25]. Currently, several studies have found that the bacterial effect is responsible for microplastic degradation. This is done in this research using just pure bacterial cultures. It is the simplest method for analyzing both metabolic processes and certain environmental factors that affect the decomposition of plastic... Changes and the entire process of bacterial degradation of plastic can be observed [26].

Table 1:- Listof bacteriareportedtodegradedifferenttypes of plastics:

Bacterialstrain	Categoriesof bacteria	Sourceofbacteria	Typeofplastic	Enzyme Specificity	reference
Bacilluscereus,	Gram-positive	Mangroveforest	Polyethylene,PS and Polyethyleneterephthalate (PET),	Esterases	[27] [28] [29]
Rhodococcusruber,					
Bacillusgottheilii					
***Pseudomonasputida* AJ**	Gram-negative	Soil, farmsludge, activatedsludge, andworms.	High-density polyethylene (HDPE), Polyethyleneterephthalate (PET), Polyethylene (PE), and PS.	Esterases	[30] [31]
***Moritella*sp.**	Gram-negative	Deep-seasediment, Japan T theKurile and ranches	Polyurethane,Polycaprolactone (PCL)	Lipases	[32] [33]
Pseudomonas chlororaphis					

***Microbulbiferhydr olyticus*IRE-31**	Gram-negative	Beijing, China.	Low-density polyethylene (LDPE)	Betaagarase	[34]
***Enterobacter*sp .** ***Citrobacter* sp.**	Gram-negative	Zophobas Atratus and Gut ofTenebriomolitor	Polypropylene [PP]	catalase	[35]
Rhodococcus pyridinovorans, ***Rhodococcusopacus* 1CP**	Gram positive	Industrial wastewater	Polystyrene	Styrene oxide isomerase (SOI)	[36]
Bacillus megaterium ***Streptomyces ascomycinicus***	Gram positive	Soil, sediments, seawater, dried rice paddies, food, honey, milk,	Poly (3-hydroxybutyrate	PHB depolymerase	[37]
***Bacillus brevis, Amycolatopsis* sp.**	Gram positive	Rice, potatoes, peas, beans, and spices	Polylactic acid	PLA depolymerase	[38]

Fungaldegradationofplastic:
Fungi can also attach themselves to microplastics, which gives them an edge. By lowering their hydrophobicity, fungi can help microplastics create a variety of chemical linkages, including carbonyl, ester-forming, and carboxyl groups. Species of mushrooms have excellent reproductive capacities. It can facilitate the process of substantial change and movement. [36].

Table 2: - Fungalstrainsinvolvedin plasticdegradation.

Fungalstrain	source	Typeof plastic	Enzymespecificity	reference
Aspergillusniger	Soil, activated-sludge	High-Density Polyethylene (HDPE), Polyethyleneterephthalate (PET), Polyethylene (PE), andPS.	Catalase,protease	[39]
Aspergillusflavus	Soil, activatedsludge, farmsludge,wor ms.	High-density polyethylene (HDPE)	glycosidase	[40]
***Penicilliumsim plicissimum*(Y K)**	Leaves and soil of thecoastal area	Polyethylene (PE 500 withUV)		[41]

***AspergillusflavusPEDX* 3**	*Galleria mellonella's* gut	Polyethylene (PE) and High-density polyethylene (HDPE)		[42]
***Penicillium pinophilum*(ATCC 11797)**	woodyplants	Low-Density Polyethylene (LDPE)		[43]

Isolation Of Plastic-Degrading Micro-Organisms:
There are two methods for isolating plastic-degrading bacteria. [44]

1. Serial Dilution:
After collecting the plastic sample, take 1 g of the sample and cut it into 9 ml of sterile water for a 1/10 dilution, 9 m l of sterile water for a 1/10 dilution, and 1 ml of water for a 1/100 dilution, etc.

2. Overall Heterotrophic Score:
- "C.F.U./g = number of colonies/sizes of inoculum (ml) X dilution factor."

Identification of The Plastic Degrading Bacterium:
Identificationoftheisolateswas performedaccordingtotheirmorphological, cultural, andbiochemicalcharacteristics [45].

1. Morphology:
Gram staining method:
Take a clean, degreased glass slide and coat it with the bacterial culture using a sterile loop. There are coatings air dries and then sets with heat. It is then subjected to the following coloring agents:
(i) Wash with crystal violet for one minute. After that, rinse with flowing distilled water.
(ii) Soak once more with Gram's iodine for 1 minute. Then wash with running distilled water.
(iii) Slides are then rinsed with Gram stain for 30 seconds.
(iv) Slides were then counterstained with safranin for 30 seconds and washed by continuous distillation Water.
(v) Air-dry the slide and examine the cell morphology under a microscope. [46]

Morphology of colonies
Based on the form, size, and color of the chosen strains, this is done to identify their morphology. [45]

2. Biochemical test:
A kit for biochemical identification of bacteria (HIMEDIA Hibacillus identification kit) and certain biochemical techniques created artificially. The Biochemical Identification Kit is a standardized biochemical and carbohydrate utilization test-based colorimetric identification technique. The test is based on the idea of substrate utilization and pH variations. During incubation, organisms go through metabolic changes that can be seen visually in the medium's color changes or by the addition of reagents. [46].

• **Catalase Test:**
The catalase test detects the presence of catalase by inoculating ring cultures into tubes containing 3% hydrogen peroxide solution. The formation of effervescence or the appearance of bubbles as a result decomposition of hydrogen peroxide into O2 and H2O indicates a positive test. [47]

• Oxidase Test:
The oxidase assay was performed using commercially available dye-coated disks N-tetramethyl-p-phenylenediamine dihydrochloride (Himedia) to detect cytochrome oxidation

20 "c”. The dyes oxidize due to the action of oxidases. A good reaction is shown by a little amount of bacterial culture being applied to the disc using a sterile toothpick producing a purple color in 10 to 30 seconds; a negative response is indicated by no color change. [48].

• Mannitol Test:
This test is commonly used to determine if bacteria can ferment the sugar mannitol.
Because of the formation of acid when organisms ferment mannitol agar, the pH of the medium becomes acidic. The fermentation medium turns red to yellow, indicating a positive test result. [49].

• Motor Test:
Motor testing is performed to determine the body's ability to exercise. Incubate the bacterial culture for 48 hours at 37 °C in a motility assay medium (Himedia). A favorable reaction is indicated by cloudiness and the observation of growth close to the suture, while a negative reaction is indicated by visible growth. [50].

• **Malonate Utilization:**
To track the utilization of the malonate in the malonate assay medium (Himedia), a malonate utilization test was conducted. The bromothymol blue indicator is a component of the malonate test medium. The carbon source is sodium malonate, and the nitrogen source is ammonium sulfate. Malonate can be used by biological releases of sodium oxide. The indicator turns blue under the consequent alkaline conditions, from bright green.
The center color will switch from light green to blue if the test is successful. The center will continue to be light green if the test is unsuccessful. [51]

• Nitrate Reduction Test:
This assay tests the ability of microorganisms to convert nitrate to nitrite into 21 Medium. A pink color immediately after adding the reagent a positive reaction is indicated. If there is no color change, a negative reaction may be seen.

• Citrate Utilization Test:
In this experiment, the ability of the bacteria to transform citrate, a Krebs cycle intermediate, into oxaloacetate, another Krebs cycle intermediate, is evaluated. The only carbon source accessible to the bacteria in this media was citrate. The bacteria won't multiply if they can't utilize the citrate. If the bacteria multiply and the medium turns bright blue as a result of the elevated pH, then the experiment was successful.

• Production Of Glucose Gas:
By inoculating isolated bacteria in MRS broth containing glucose, glucose gas generation was evaluated. And incubating at 37°C for 48-72 hours under inversion conditions.
An effective reaction (gas production) is indicated by the inverted Durham tube rising.

• Utilization Of Carbohydrate Test:
The HiCarbo kit (parts A, B, and C) (Himedia cat. no. KB009) was used for the carbon utilization model. Bacteria produce acidic products when they ferment certain carbohydrates. The utilization test is designed to detect the change in pH that occurs when a given carbohydrate isfermented.
Acids will reduce the pH of the medium, turning the pH indicator yellow (phenol red) as a result. The medium will remain red if a certain carbohydrate is not fermented by bacteria.

3: Plastic Degradation by Microbial Activities Under Laboratory Conditions Determination Of Weight Loss:
Transferring preweighed 1 cm diameter discs made from plastic bags aseptically to Erlenmeyer flasks with 50 ml of culture medium and 22 different bacterial species inoculated into culture Medium. On plastic slides in the microbial-free media, controls were kept. For each treatment, use distinct vials; place them in a shaker. The plastic pieces have been collected after a month of mixing,washed with a large amount of distilled water, dried in the shade, and weighed to obtain the final weight. Based on the collected data, the weight loss of the plastic is calculated. [52]

Mechanism Of Degradation:
The microorganism exhibits a complex enzymatic chain reaction that degrades the plastic. They possess a sophisticated network of enzymes capable of decomposing and biodegrading polymers. The complex chemical molecules in the plastic are broken down by enzymes released into the extracellular environment into less complicated substances like water and carbon dioxide. The complicated polymer was broken down by extracellular

and intracellular digestion in three phases. Extracellular depolymerase is used to first depolymerize synthetic polymers, which is followed by mineralization into CO2, N2, and H2O. The assimilation of plastic products into microbial cells for mineralization is made easier by the depolymerization of bigger polymers into simpler oligomers or monomers. Not in accordance with Mazhar et al., who claim that 451 enzymes can dissolve all varieties of plastic.

Some strains produce specific enzymes that break down a certain type of plastic. For example, proteases are released by Bacillus to break down certain types of plastics [53]

The mechanism of plastic degradation is a four-step process: [54]

Bio-Degradation:
Biodegradation is the first step in the biological breakdown of plastics. Changes in the mechanical, physical, and chemical properties of plastic are caused by the abiotic deterioration of the plastic surface [54]. Synthetic polymers including polycarboxylates, PET, PLA, and their copolymers, poly(glutamic acid) and poly(dimethylsiloxane) or silicone, are thought to degrade first by an abiotic process [55]. Physical conditions, such as heating, cooling, freezing, thawing, humidification, drying, etc., frequently result in changes in the mechanical properties of polymers [56]. When exposed to environmental stimuli from the outside, plastics experience structural changes. Environmental elements including physics, chemistry, heat, and light are what cause these early changes [57].

Abiotic and microbial elements work together to break down biodegradable materials into small pieces [58]. Fungal growth on polymer surfaces can also cause minor changes in polymer swelling and cracking [56].

Bio-Fragmentation:
It is a process of splitting microorganisms secreting enzymes and free radicals after the molecular bonds of the polymers are broken, resulting in monomers, dimers, and oligomers are the low molecular weight plastics [59]. Depolymerization is another name for this action. Many synthetic polymers, including PCL, may be depolymerized by microbial enzymes. Lipase, proteinase K, pronase, hydrogenase, and other enzymes produced by microorganisms are used in the biodegradation of plastics. But proteinase K. was discovered that secreted Tritirachium album is a powerful PLA degrader. Additionally, numerous strains of Amylocololatopis and Saccharothrix have been demonstrated to breakdown PLA. [60].

Assimilation /Absorption:
The so-called assimilation phase is when the cell membrane of microbial cells absorbs monomers, dimers, and oligomers created following a disruption [61]. Fragmented molecules are recognized by microbial cell membrane receptors, which then let them pass through the membrane and enter the cell. Additional biotransformation reactions are necessary for plastic pieces that are not recognized by cell membrane receptors to produce products that are easily transported inside the cell [62].

A variety of metabolic pathways are then used by molecules when they enter the cell to produce ATP, fresh biomass, different main and secondary metabolites, and membrane vesicles [62]. Various simple and complex metabolites, including organic acids, aldehydes, terpenes, antibiotics, and others, are disintegrated during this process and released into the extracellular media.

Aerobic Biodegradation:
Aerobic microorganisms convert monomers, dimers, and oligomers into simpler compounds by using oxygen (O2) as an electron acceptor.

As a result of the process, CO2, water, and biomass are released. The term "aerobic respiration" also applies to this procedure. [63].

Kpolymer $O_{2\,+}$ $CO_2 \longrightarrow H_20$ + Residue + C biomass

Anaerobic Biodegradation:
Complex polymers are broken down into smaller pieces by microbes using CH2, CO2, H2O, and H2O in the absence of oxygen, a process known as biodegradation. In the absence of oxygen, anaerobic microbes destroy materials using resources besides electron acceptors like nitrate, sulfate, iron, manganese, and carbon dioxide. [64]

Kpolymer CH_2 +CO2 $\longrightarrow$ H2O+ Residue +Cbiomass

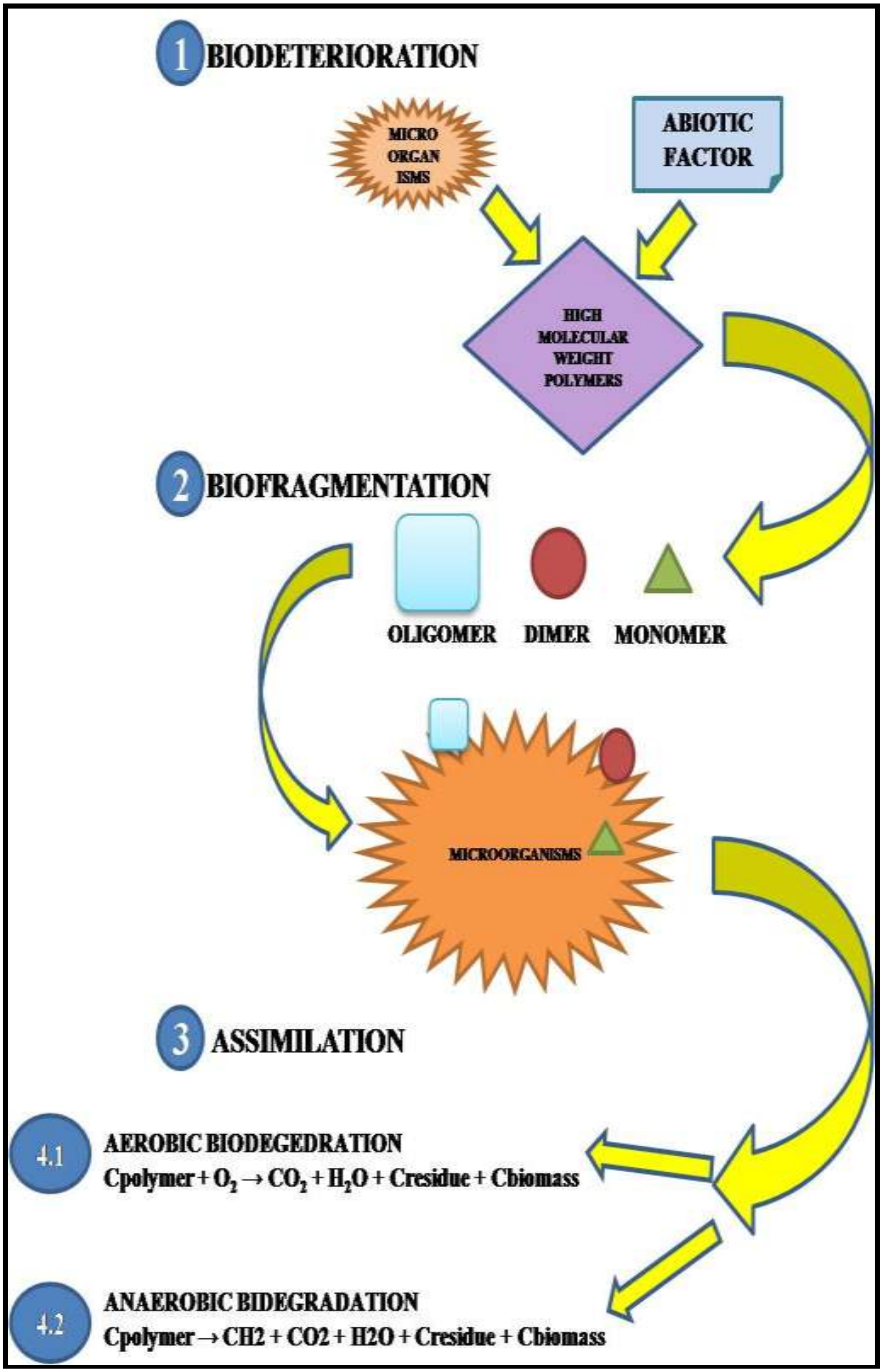
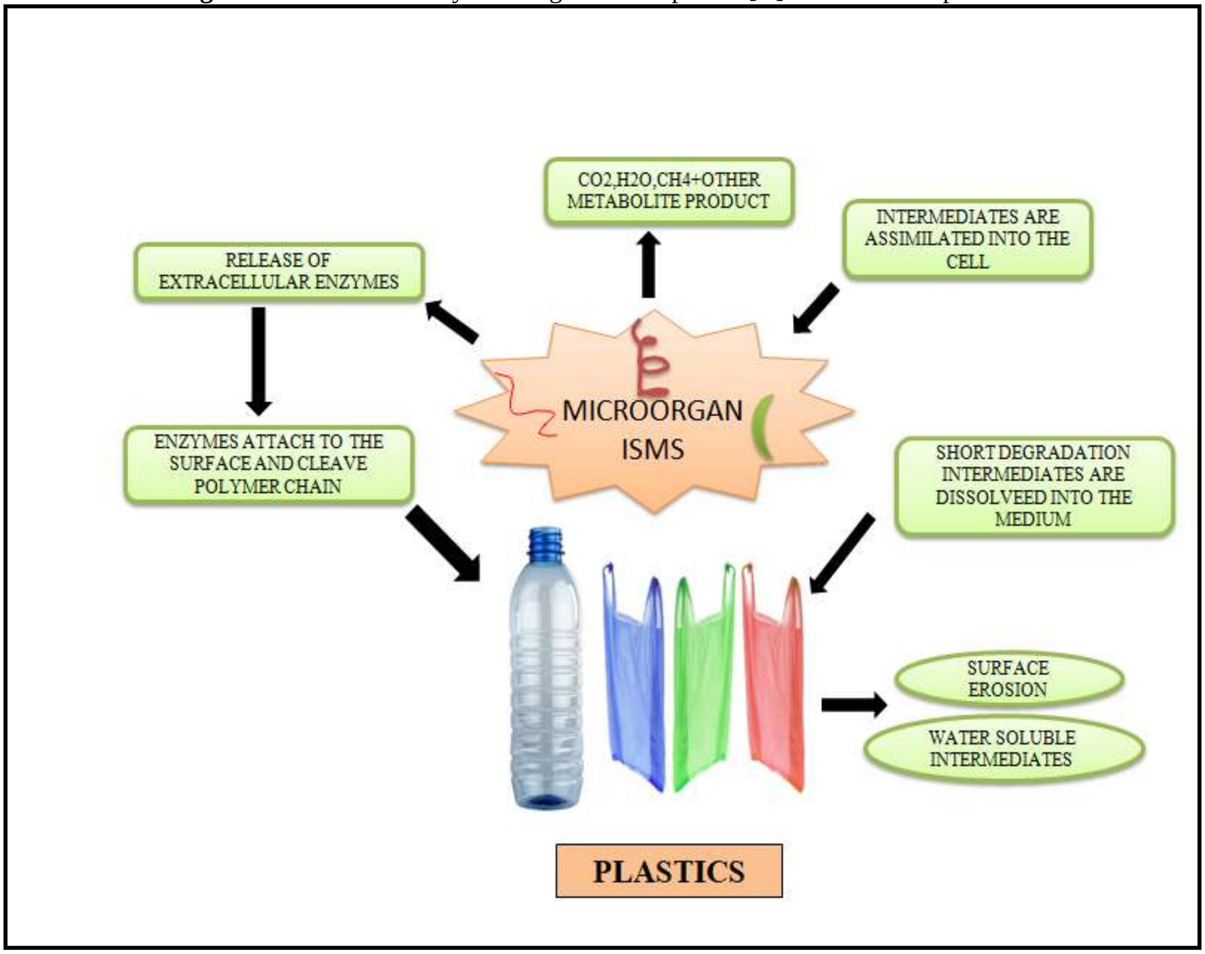


Fig 1:- Mechanisms Of Degradation.

Mechanisms Of Enzymatic Degradation of Plastics:

Fig 2:- Mechanismsofenzymaticdegradationofplastic [70] Plastic Vs Bioplastics:



Biodegradable polymers undergo oxidation or hydrolysis by the relevant enzymes in the first stage of the biodegradation process in order to create functional groups that increase their hydrophobicity. High molecular weight plastic polymers are thus broken down into low molecular weight molecules with fine mechanical characteristics, which makes it easier for microbes to absorb them eventually. [65]. Microbial extracellular enzymes break down complex polymers into small, short-chain molecules like monomers, dimers, and oligomers that can pass through the semi-permeable membranes of bacteria and fungi where they can be used as carbon and energy and further mineralized [66]. Enzymes play a significant role in this process. If these fission polymers are too large to fit through the cell membrane, they must first be depolymerized in order to be taken up by intracellular enzymes in microbial cells and biodegraded. Enzymatic biodegradation's first stages are influenced by a variety of biological and physical stimuli [67]. Mechanical damage to polymeric materials, such as cracking and scratching, can be brought on by physical forces including freezing and thawing, cooling, and heating, or wetting and drying [68]. When several fungi grow on scraped surfaces and pierce the solid polymer, this can also result in momentary swelling [69]. The type and process of polymer degradation are implicitly determined by the physicochemical characteristics of microorganisms as well as their growth conditions (such as pH, temperature, oxygen consumption, nutrients, particle size, and moisture content) and enzymatic properties (intracellular and extracellular enzymes, exo-or endo-type).

Plastics have long been accepted by society for their cheapness, durability, and waterproofness. Today's products have many benefits for many industries, but they are created by their use rather than the final product. As always, plastics do not break down quickly, which means that there is a lot of plastic waste around the world and in the oceans [71].

To solve this problem with plastics, scientists, and researchers have started creating plastics such as bioplastics that are more biodegradable than conventional products. [72]

Bioplastic Type:

- **PLA (Polylactic Acid):**

It is usually made from corn, tapioca, or sugar cane sugar. It is biodegradable, carbon neutral, and edible. To convert corn into plastic, corn kernels are placed in sulfur dioxide and hot water, which breaks down into protein, fiber, and starch [73]. After that, the maize kernels are milled to separate the starch from the corn oil. Long carbon molecule chains seen in starch are comparable to those found in plastics made from fossil fuels. Mix in some citric acid to create the long chains (large molecules made up of small particles) that are the building blocks of plastic [74]. Similar to polyethylene (used in plastic films, containers, and bottles), polystyrene (Styrofoam and plastic dishes), and polypropylene (used in packaging, vehicle components, and textiles), PLA has a similar appearance and feel. One of the biggest manufacturers of PLA under the Ingeo trademark is NatureWorks, based in Minnesota.

- **PHA (polyhydroxyalkanoate):**

It is made from organic materials, sometimes using genetically modified bacteria, to make plastics [75]. The microbes were deprived of nutrients such as nitrogen, oxygen, and phosphorus, but took in a lot of carbon. They produce PHA as carbon dioxide and store it in granules until they have more of the other nutrients they need for growth and reproduction [76].

Manufacturers can harvest microbially produced PHAs with the same chemical structure as plastic [77]. Because it is biodegradable and does not harm living tissue, PHA is often used in medical applications such as sutures, loops, bone plates, and skin grafts; It is also used in disposable food packaging [78].

Bioplastic Degradation Methods:

Although bioplastics are thought to be more biodegradable than traditional materials, the degradation of the product can vary depending on the type of polymer used [79]. By subjecting bioplastics to particular settings, scientists are attempting to ascertain whether they are the best option. Most biodegradable materials break down into carbon dioxide and methane. [80].

1. Anaerobic digestion – produces more methane
2. Home composting – composts at approximately 82F
3. Industrial composting – composts at 122F
4. There are two main ways to make bioplastics:

1. Recycling:

Collection of plastic and packaging waste. This means that recycling is the conversion of used materials into new products [81] Separated plastic can be recycled by remelting or pelletizing for use in new products [82]. Bio-based plastics such as 'BioPE' and 'BioPET' can be included in the recycling stream as they have the same chemical properties as the fossil-based versions of 'PE' and 'PET'[83].
Meanwhile, other bio-based plastics require special recycling processes. The recycling of bioplastics should be large enough to be commercial [84].

2. Collection and Composting:

Bioplastics are collected and composted from biowaste collected in some areas [85]. Organic recycling becomes bio-waste, which can be used as compost or decomposed in incinerators for renewable energy sources [86].

3. Incinerators:

Bio-based plastics that cannot be processed by conventional recycling methods still can beused for energy recovery [87].In solid waste, CO2 from the combustion of bioplastics can be easily used to produce new biological materials [88].

Without the right components, biodegradable plastics do not degrade, and these areas are most easily produced in industrial composting facilities. Most plastics are made from composite materials and various contaminants can affect the composition, especially in buildings [89].

Industrially composted biowaste can be fed into gas or biogas plants as renewable energy [90].

Side Effects of Bioplastics:
Bioplastics also have many side effects.

• The use of pesticides and fertilizers on crops as well as the chemical processes necessary to transform organic matter into plastic have led scientists to the conclusion that the creation of bioplastics results in greater pollution [91]. In comparison to traditional products, bioplastics utilize more land [92]. They also contribute more to ozone depletion. Because it includes the most carcinogens and combines the weak impacts of chemicals and agriculture, B-PET, a hybrid plastic, has the worst life rating and has the worst impact on ecosystems [93].

• Over the span of their existence, bioplastics produce less carbon than traditional products. There is no increase in carbon dioxide throughout the decomposition process because plants that make bioplastics absorb the same amount of CO2 as they do during growth [94]. According to a 2017 study, switching to PLA made of corn instead of conventional materials would cut US carbon emissions by 25% [95]. The study also discovered that household carbon emissions might be decreased by 50% to 75% if contemporary appliances were made to use renewable energy sources [96]. However, bioplastics, which will be created in the future using energy from plants, show the most promise for decreasing greenhouse gas emissions. emissions of petrol [97].

• If bioplastics are not properly disposed of, they can harm and destroy recyclable materials [98]. For instance, all plastic items may be rejected and sent to a disposal site if bioplastics contaminate recycled PET (polyethylene terephthalate, the most popular plastic used in water and beverage bottles) [99]. Therefore, a recycling flow is required for the proper disposal of bioplastics [100].

Conclusion:-

This review study concludes that biodegradable polymers have drawn increased attention in recent years because of their potential use in areas such as environmental conservation and the preservation of physical health.The use of plastic in daily life is expanding, but because it is a non-biodegradable material, its deterioration is becoming a major environmental concern.Diverse techniques for the safe disposal of plastic trash have been established, but regrettably, it was discovered that they were linked to environmental risks rather than minimizing the impact of plastic garbage. In the global market, biodegradable plastics are emerging as a promising new generation of polymers. [96]. The bacteria and enzymes that have been claimed to breakdown these synthetic polymers have been covered in this review. Numerous strains of Pseudomonas and Bacillus have been found to partially decompose a variety of petro-plastics, including PE, PS, PP, PVC, PET, and ester-based PU, as well as complicated, resistant substances such as polyaromatic hydrocarbons.Governments have chosen to outlaw single-use plastic products because plastic waste is a global issue. The Plastic Waste Management Amendment Rules, 2021 also ban the production, importation, stocking, distribution, sale, and use of plastic carry bags with a thickness of less than 75 microns starting on September 30, 2021, and less than 120 microns starting on December 31, 2022.

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