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Biodegradation of plastics using microorganisms

Sehrish Kalsoom*[1], Dr. Zahida Nasreen[2], Aneela Sharif[2], Rabia Bashir[2]

[1]*Department of Zoology, University of Sargodha, Sub Campus Mianwali, Mianwali, Pakistan*

[2]*Department of Zoology, University of Mianwali, Mianwali, Pakistan*

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Abstract

Plastics have been playing an important role in our lives since many years. Some significant characters of these polymers such as lightweight and durability make them an attractive material and they are largely being used in number of applications e.g. packaging and electrical insulations. These polymers can be molded into desired shapes which make them an excellent material for making pipes, sheets and packaging material. Toughness of plastic makes them an extremely resistant and inert material toward degradation as a result they are accumulating in terrestrial and marine ecosystem at a dangerous rate over the last few years. Attempts have been made to replace synthetic plastic material with bioplastics or plastic those are easily biodegraded. Biodegradation is a noninvasive technique used to degrade plastic material through action of microbes so that plastic contamination can be reduced and terrestrial and marine biota could be saved from hazardous effects of these polymers.

* **Corresponding Author:** Sehrish Kalsoom ✉ Sehrish.kalsoom1820@gmail.com

Introduction

Plastic is a synthetic polymer and because of their strength and resilience plastics are widely used all over the world (Al Shehrei, 2017). Plastics are obtained through the process of polymerization of monomers units drawn through gas and oil and are synthetic organic polymers (Derraik,2002) they have only present for more than a century (Gorman,1993) Greek word "plastikos" is origin of word plastic, that means 'which can be casted into different shapes' (Shah *et al.,* 2008). In the year 1907 the initial modern plastic; 'Bakelite', was developed, after which many low-priced manufacturing techniques have been optimized, making the way for the large scale creation of corrosion-resistant, durable, inert and thin plastics (Plastics Europe, 2010). carbon, hydrogen, nitrogen, oxygen, chlorine and bromine are main cosituents of plastics (Mohee and Unmar, 2007) Plastics can also be defined as chemically manufactured long-chain polymers (Scott, 1999) Polymers are large molecules mostly with molecular mass greater than 1000 g/mol containing many kinds of successive repeating monomer components joined in multiple ways to give rise to thousands of completely new products (Eubeler *et al.,* 2009) bioplastics are the biodegradable biopolymers and they can be separated into two groups,

- Renewable resource based polymers renewable source-based polymers are formed from biomass and are biodegradable polymers e.g poly lactic acid (PLA) and Polyhydroxyalkanoates (PHAs)
- Petroleum-based polymers.

They can be degraded by Microorganisms e.g poly butylene succinate (PBS) and polycaprolactone (PCL) (Penkhrue *et al.,* 2015) The annual global demand for plastics is about 245 million tones and has constantly increased over the current years (Andrady *et al.,* 2011). Asia the world's biggest consumer of plastic responsible for 30% of global utilization in the last few years (Muenmee *et al.,* 2015) to decrease import prices and due to their comparatively low prices plastic manufacturing units are situated in the whole world but very few nations contribute appreciably to its international manufacture (Cregtu *et al.,* 2013) between 1960 and 2000 a 25 times rise in the manufacture of plastic containing resin products, and a resurgence speed of below 5%, has resulted in an uneven rate of plastic products inflowing the ecosystem (Mc Dermid and Mc Mullen, 2004). The total global plastic production was 1.5 million tons in 1950 and it increased to 245 million tons in 2008, yearly growth rate of 9% was observed. Excluding Japan, (where current plastic utilization per capita is only 20kg) All other Developing Asian countries have biggest potential growth (Chanprateep 2010), By 1988 in the United States alone, annual rate of plastic production was 30 million tons (O'Hara *et al.,* 1988) disposing of plastic waste is challenging because durability of plastic makes it extremely resistant to degradation, (Barnes *et al.,* 2009) environmental contamination by synthetic polymers has reached dangerous extent in developing countries,. As a consequence, efforts have been made to resolve these problems with biodegradability of polymers in day by day use through small changes of their organizations (Chandra *et al.,* 1998)

Plastic waste and its effect on the environment has become intense communal issue in current years (Barlow and Morgan, 2013) Engineering enzymes for plastic degradation is promising new category of study and is of great interest for scientists (Austin *et al.*, 2018). Plastic waste often gather in the atmosphere causing an escalating ecological danger to flora and fauna due to the lack of proper methods for safe dumping of these synthetic polymers (Bhardwaj *et al.*, 2012). Many countries do not allow the incineration of these wastes due to the presence of plastics in municipal wastes.

Open uncontrolled burning and land-filling are the major methods used for plastic disposal. Open burning of these wastes discharge pollutants into the air causing a variety of health problems. Persistent organic pollutants furans and dioxins are formed by the burning of Polyvinyl chloride (PVC). In addition other toxic irritant products are produced by burning of polyethylene, polyurethane, polyvinyl chloride and polystyrene leading to lung diseases and immune disorders and are categorized as potential human carcinogens (Nir *et al.,* 1993).

Synthetic plastic products are usually regarded as non-biodegradable but there are implications that they can be altered and metabolized by microbes and thus can be degraded (Alshehrei, 2017). The investigation for biodegradable substitutes is a promising choice to improve and ultimately reduce the international plastic waste crisis (Haider *et al.,* 2019). Microbial populations and consortium (both natural and designed) may become important in plastic degradation by being able to use feedstock and building block compounds (carbon-containing monomers and oligomers). Biodegradation of petroleum-based plastic waste can be done by natural or designed microbial consortiums with a proper set of enzymes attacking the carbon backbones under favorable abiotic circumstances at restricted industrial composting facilities (Bhardwaj *et al.,* 2012).

To handle plastic waste microbial degradation using bacteria and fungi is a rising strategy hence this review paper presents health and environmental effects of plastic contamination, advantages and disadvantages, biodegradation of plastic wastes, plastic waste management alternatives, biodegradable plastics and challenges and limitations of plastic waste biodegradation.

Disadvantages of plastics

Synthetic plastics cause rain water run over, provoking severe contamination of neibouring rivers and sea and give rise to water clogging incident in soil burial sites (Yang *et al.,* 2004). The plastic sheets or bags do not permit air and water to enter into earth which causes infertility of soil, preventing degradation of other normal substances, exhaustion of underground water source and hazard to animal life (Gananavel *et al.,* 2013).

Table 1. Waste plastic produced and recovered from 1980 to 2012 in USA.

Year	Generated (1000t)	Recovery (1000t)	Recovery rate
1980	6830	20	0.30%
1990	17,130	370	2.20%
2000	25,550	1480	5.80%
2005	29,380	1780	6.10%
2008	30,260	2140	7.10%
2010	31,290	2500	8.00%
2011	31,840	2660	8.40%
2012	31,750	2800	8.80%

Reference (Gu and Ozbakkaloglu, 2016).

Advantages of plastics

According to (Siddique *et al.,* 2008) plastic is beneficial over other materials due to following reasons:

- Toughness and prolonged existence
- Extreme flexibility and capability to be modified to congregate specific technological needs.
- Relatively lesser production price
- Hygiene properties for food packaging
- Good protection.
- Lesser mass than other relating materials used to reduce fuel expenditure in transportation
- Resistance to chemicals and water.
- Excellent electrical insulation and thermal properties.

Properties of plastics

Plastics are the polymers which become movable on heating and thus can be cast into moulds (Gananvel *et al.,* 2012). Plastics are mouldable and nonmetallic compounds prepared from them, can be pressed into almost any desirable form and then keep hold of that shape (Gananavel *et al.,* 2013) utilization of engineering plastics, particularly polyolefins has risen drastically in current years due to the low cost, light weight and good mechanical properties however this amplification in usage has also produced many challenges related with exclusion and their effect on the ecosystem (Amala *et al.,* 2011).

Plastics are cheap, lightweight, durable and strong (Laist, 1987), these properties make them appropriate for the manufacture of a very large range of products. high durability, low density, ease of design and manufacture, high strength-to-weight ratio and low cost because of these complimentary properties plastics are the main element used in the manufacturing of large variety of products, (Gu and Ozbakkaloglu, 2016).

Applications of plastics

Polyethyelene (PE), Poly(vinyl chloride) (PVC), Polystyrene (PS), Polypropylene (PP), Poly(ethylene terephthalate) (PET)are numerous kinds of plastics used in packaging (Andrady *et al.,* 2011) agricultural plastics are bioabsorbed into the soil as humic material once they have fulfilled their purpose, for example as mulching films, (Scott G 1999) plastics are used in fishing nets, packaging, agricultural film, disposable diaper (Gananvel *et al.,* 2012) most of the polymeric substances are used in treatment biomedical, food, healthcare, textiles, oil recovery, leather, pharmaceutical fields ,coatings, paper and waste water (Chiellini *et al.,* 2003) because their good mechanical performance, such as good barrier to oxygen, tear and tensile strength, anhydride and aroma compound, carbon dioxide, and, heat stability, large availability at relatively low cost polyethylene terephthalate (PET), polystyrene (PS), polypropylene (PP), polyethylene (PE), polyvinylchloride (PVC) and polyamide (PA) have been excessively used as packaging materials (Siracusa *et al.,* 2008).

Table 2. Structure of synthetic plastic.

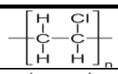
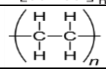
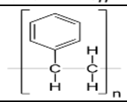
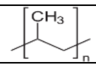
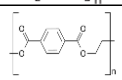
SL	Type of plastic	Structure
1	Poly vinyl chloride	
2	Polyethylene	
3	Polystyrene	
4	Polypropylene	
5	Polyethylene terephthlate	

Table 3. Synthetic plastics and their uses.

SL	Type of plastic	Uses
1	Poly vinyl chloride	Construction for pipes, bottles, non food packaging, electrical cable insulation, imitation leather
2	Polyethylene	Packaging, plastic bags, plastic films
3	Polystyrene	Protective packaging, containers, lids, bottles, tray, tumblers,disposable cutlery.
4	Polypropylene	Plastic part, reuseable containers, laboratory equipment, automotive components
5	Polylactide	Injection molding, film and sheet casting, medical implants
6	Polyurethane	Bedding, furniture, automotive interiors, carpet underlay.
7	Polyethylene terephthlate	Fibres for clothing, containers for liquids and foods, thermoforming, glass fibre
8	Polyamide	Manufacture for clothing and carpets, food packaging, engineering, sportswear, automotive application

Plastics are suitable for a range of applications due to their transparent, strong and light weight material,. Their bio-inertness, low cost, low weight and oxygen/moisture barrier characteristics make them brilliant wrapping materials (Andrady *et al.,* 2011) a large variety of oil-based polymers is now a days used in packaging industry. Due to varied levels of pollution and complex compounds they are mostly non-biodegradable and predominantly difficult to recycle or reuse (Davis and song 2006). Polyimides are extensively used in load-bearing purposes, e.g. brackets in automotive, struts, aircraft structures and chassis, due to their compressive strength and flexibility and, in addition to their chemical opposition to oils, fats, microwave transparency, grease and thermal resistance (Gu 2007) an ideal method for treating plastic waste is the reuse of waste and used plastic material in the building industry. The utilization of recycled plastic substances in usual cement mortar and concrete has been studied expansively. Plastics were used in concrete chiefly in two types:

(a) Plastic aggregates (PA), which return natural aggregates.
(b) Plastic fibers (PF), which were utilized in fiber-reinforced concrete (FRC) (gu and ozbakkaloglu 2016).

The consumption of waste products in concrete not only reduce dumping problems but also makes it low-cost (Siddique *et al.,* 2008) a number of emerging technologies such as orthopedics, scaffolds, sutures and drug delivery utilize PLA (polylactide) (Gupta and Kumar 2007) organic material and biodegradable wastes are transported into humic matter, which are important as high value fertilizer for the farming proposes (Leejarkpai *et al.,* 2011).

Synthesis of plastics

Two main methods are implied for the production of artificial polymers. The first comprise of breakdown of the double bond in the original olefin by further polymerization to form new carbon-carbon linkages, the carbon-chain polymers. For example, the production of polyolefins, such as polypropylene and polyethylene is based on this reaction.

The second method is the condensation (removal of water) between an alcohol or amine and a carboxylic acid to form polyester or polyamide (Zhenge and Yanful, 2005).

Microplastics

For over the last forty years microplastics, a kind of man-made waste product has been building up in the seas (Thompson *et al*., 2004, 2005). The hardly noticeable particles that pass through a 500 lm sieve but unable to pass through a 67 lm sieve (_0.06–0.5mm in diameter) are called as microplastics while particles greater than this size were named mesolitter. (Gregory and Andrady (2003) plastics are comparatively economical to manufacture and supply restricted economic enticement for recycle, they are the fastest emerging substances of the waste watercourse, with 60–80% of marine waste consist of plastic debris(copper *et al.,* 2010) 80% of the plastics found in marine debris is contributed by a plastic waste from terrestrial sources (Colle *et al.,* 2011) Not only the aesthetically unpleasant plastic waste, but also less noticeable small plastic pellets and granules are a risk to marine life (Derraik, 2002). There are two types of microplastics

Primary microplastics

Primary microplastics are the plastics that are produced to be of a microscopic size. Such kinds of plastics are constituents of cosmetics and facial-cleansers (Zitko and Hanlon, 1991).

Secondary micro-plastics

Secondary micro-plastics are small plastic fragments which come out from the disintegration of huge plastic debris, both on sea and on land (Ryan *et al*., 2009. Derraik *et al.,* 2000 in his study described many marine species that contain plastic waste accumulated in their bodies. They obtained data that some sea birds select specific plastic colors and shapes, mistaking them for possible prey items. Ingested plastics lessen meal size by reducing the storage space of the stomach and the feeding stimulus, obstruction of gastric enzyme secretion, delayed ovulation and reproductive failure, diminished feeding stimulus and lowered steroid hormone levels, (Derraik, 2000; Azzarello and Van-Vleet, 1987.

Biodegradation of plastics

An unrefined process is known as biogradation by which unrefined chemicals in the atmosphere are transformed to easy synthesis, converted to inorganic and spreaded into elemental cycles such as the carbon, sulphur and nitrogen cycles.

The only possibility of Biodegradation to be occurred is inside the biosphere because microbes play an essential part in the biodegradation method (Chandra, 1998) Microorganisms are concerned with the decay and degradation of natural and synthetic polymers (Gu *et al.,* 2000), other methods of polymer degradation include chemical, photo, mechanical and thermal degradation (Gopferich, 1996) plastics convert into solid litter after the termination of their life and will gather in the surrounding. Therefore, this fabrication process is essential for biodegradable plastics and it is also friendly in natural viewpoint to minimize the buildup of plastic garbage in the surrounding (Iovino *et al*., 2008).

The waste of syenthetic material which present on land reduce more easily than sythentic material present at sea, the reason behind is higher solar radiation revelation with successive rise in temperature of bulk (Pegram and Andrady, 1989). Glucose has been reported to kindle the biodegradation of the compost used in the biodegradation test (Adamczyk *et al.,* 1996).

Degradability of plastics depends on the existence of degradative micro-oraganism population, conditions of surroundings which support micro-oraganism's flourshing and the structures of polymeric materials (Gu, 2003) Biodegradability of polymers also depends on the physical form of the related materials, molecular weight and crystallinity (Gu, 2004).

Plastics are typically inert and resistant to microbial attack and as a result they remain in the nature without any change for very long time (Orhan *et al.,* 2004). The biodegradability of polymers also depends on the extent of the polymer chain (it seems that the shorter chain are easily degradeable than long chain), the crystallinity of the polymer (crystalline parts are more difficult to detoriate than amorphous parts) and the more complicated the formula, the less degradable the polymer is because several micro-organisms are needed to attack the different functions of the polymer (the polymers with ring structure appear to be more difficult to degrade) (masserdier *et al.,* 2006). Hydrolysis cause primary degradation, which is not catalyzed by enzymes but micro-organisms finally metabolize depolymerization intermediates (Muller *et al.,* 2001). Biodegradation is of two types.

Aerobic biodegradation

Aerobic bacteria use oxygen as an electron acceptor, and disintegrate organic chemicals into small organic compounds, usually yielding CO_2 and water as the final product (Seymour, 1989).

Anaerobic biodegradation

Among many anaerobic bacteria some employ nitrate, manganese, carbon dioxide, iron and sulfate as their electron acceptors, and disintegrate organic chemicals into smaller compounds (Data *et al.,* 1998).

Products which are produced from plastic are not biodegradable and are usually discarded improperly. Petroleum based plastics are mainly source of this kind of materials (Chanprateep, 2010). Through the process of hydrolysis or oxidation reactions from chemical or biochemical origins assist to foster biodegradation of polymeric substances (Oprea, 2010). Nearly all oil-based synthetic polymers are repellent to biological attack as microorganisms lack an enzyme which has ability of the degradation of majority manufactured polymers (Davis and song, 2006).

Researches of biodegradation shows that absorption into biomass has not been especially considered and the devices used are insufficient to verify actual biodegradability and integration of the substances in biogeochemical rotation (Lucas *et al.,* 2003).

Lucas *et al.,* 2008 have reported four major steps in plastic biodegradation I.e biodetoriation, depolymerization, assimilation and mineralization. Biotic and abiotic components proceed synergistically in order to decay natural substances in nature. Many studies about biodegradation of some polymers show that the abiotic degradation leads microbial assimilation (Kister *et al.,* 2000) plastic material could be biodecomposed by decreasing the polymer-chain distance by oxidation which may be accessed by microbes (Trivedi *et al.,* 2016). Biodegradable plastics could be a good alternate for the plastics used for fishing nets and tools , packaging of fresh meat and fish, single-use containers and leisure articles (Jang *et al.,* 2002). biodecomposeable pliant might provide even as favorable solution to the burdened landfills by detracting part of large capacity plastics to some other purposes of waste management, and to clutter up disposeable plastic material that are in other ways is hard to reprocess (Ren *et al.,* 2003). There are two groups of enzymes which are deliberately included in biological degradation of polymers named as extracellular and intracellular depolymerases (Doi, 1990).

The decaying procedure can be speed up in the state of airless or in enclosed surroundings, e.g., space vehicles, submarines and aircraft, for the reason that the humidity of these surroundings increase the production of bacterial biofilms on the top and microbes may develop a sequence as per conditions (gu 2007) Biodegradation is non-invasive and could be cost-effective in removal of waste products from environment. (varjani and upasani 2017). Another way to minimize amount of plastic litter is to develop latest materials that are vulnerable to photochemical, chemical and biological actions in the surroundings, therefore their degradation will happen over a little span of time (Labuzek *et al.,* 2006).

Table 4. Micriorganisms types

SL	Type of polymer	Microorganism	References
1	Poly (vinyl alcohl)	*Pseudomonas strain*	Chiellini *et al.*, 2003
2	Poly (hydroxyabutyrate-co-hydroxy valerate) (PHBV)	*Pseudoalteromonas* sp NRRLB-30083	Eubeler *et al.*, 2009
3	Polyethylene glycol (PEG)	*Flavobacterium* sp	Eubeler *et al.*, 2010
4	Polyisoperene	*Streptomyces lividans* 1326	Eubeler *et al.*, 2010
5	Polyaspartic acid (PAPs)	*Sphingomonas* sp	Eubeler *et al.*, 2010
6	Poly vinyl alcohl (PVA)	*Pseudomonas genus*	Eubeler *et al.*, 2010
7	Polycaprolactone	*Bacillus phanerochaete*	Gananavel *et al.*, 2013
8	Polyhydroxybutyrate (PHB)	*Comamonas testosteroni*	Gu, 2003
9	Phthalate esters	*Sphingomonas paucimobilis*	Gu, 2007
10	Polylactide	*Fusarium moniliforme*	Gupta and Kuma, 2007
11	Polypropylene (PP)	*Vibrio* sp	Muenmee *et al.*, 2015
12	Polyvinyl chloride	*Pseudomonas chlororaphis*	Muthukumar and veerappapillai, 2015
13	Polythene	*Bacillus subtilis*	Priyanka *et al.*, 2011
14	Polyhydroxy alkanoates	*Pseudomonas stutzeri*	Shah *et al.*, 2008
15	Polyvinyl chloride (PVC)	*Pseudomonas putida*	Shah *et al.*, 2008
16	Polylactic acid	*Bacillus brevis*	Tromita *et al.*, 1999
17	Polyhydroxy alkanoates	*Proteobacteria* MB-11	Suyama *et al.*, 1998
18	Polythene	*Streptomyces* sp	Swapnil *et al.*, 2015
19	Poly lactide	*Amycolatopsis lentzea*	Tokiwa and Calabia, 2006
20	Poly (3-hydroxybutyrate)	*Mitsauria* sp	Volova *et al.*, 2016

Table 5. Microorganism, their sources, substrates and intermediates formed during degradation.

SL	Substrate	Microorganism	Source	Degradation intermediate	Reference
1	Dimethyl isophthalate	*Kliebsiella oxytoca*	Mangrove sediments	Monoisophthalate, phthalic acid	Gu, 2004
2	di-n-butyl phthalate	*Pseudomonas fluorescens* B-1	Mangrove sediments	Phthalic acid, Monobutyl phthalate	Xu *et al.*, 2005
3	Dimethyl phthalate	*Sphingomonas paucimobilis*	Activated sludge	phthalic acid, Monomethyl phthalate	Gu, 2007

Table 6. Bacterial enzymes used in biodegradtion of plastics.

SL	Enzyme	Microorganism	substrate	Reference
1	Lipase	*Rhizopus arrizus*	Polyethylene adipate (PEA)	Shimao, 2001
2	Serine hydrolase	*Pseudomonas stutzeri*	Polyhydroxy alkanoate (PHA)	Kumar sen 2015
3	Hydrolase	*Thermobifida fusca*	BTA copolyesters	Muller, 2006
4	Lipases	*Candida antarctica*	Polyethylene terephthlate (PET)	Muller, 2006
5	Oxidoreductase	*Phanerochaete chrysosporium*	polyethylene	Nowak *et al.*, 2011
6	Lipase	*Amycolatopsis* sp	Polylactic acid	Penkhrue *et al.*, 2015
7	Laccase	*Rhodococcus ruber*	polyethylene	Santo *et al.*, 2012
8	PHB depolymerases	*Pseudomonas stutzeri*	Polyhydroxy butyrate	Shimao, 2001
9	Estrases	*Comamonas acidovorans* TB-35	polyurethanes	Shimao, 2001
10	Polycaprolactone depolymerase	*Alcaligenes faecalis*	polycaprolactone	Trivedi *et al.*, 2016

Table 7. Microorganism capable of degrading polyurethanes.

SL	Microorganism	References
1	*Arthrobacter golbiformis*	Cregtu *et al.*, 2013
2	*Corynebacterium* sp B12	Kay *et al.*, 1991
3	*Curvularia senegalensis*	Shah *et al.*, 2008
4	*Arthrobacter golbiformis*	Howard, 2002

Table 8. List of microorganisms capable of degrading polyethylene.

SL	Microorganism	References
1	*Rhodococcus rhodochrous strain ATCC 29672*	Bonhomme *et al.*, 2003
2	*Rhodococcus ruber*	Muenmee *et al.*, 2015
3	*Phanerochaete* sp	Gananavel *et al.*, 2012
4	*Bacillus pumilis*	Harshvardhan and Jha, 2013
5	*Staphylococcus cohnii*	Kumar Sen, 2015
6	*Rhodococcus ruber*	Orr and Sivan, 2004

7	*Flavobacterium sp*	Muenmee *et al.,* 2016
8	*Nocardia asteroides* GK 911	Bonhomme *et al.,* 2003
9	*Bacillus mycoides*	Nowak *et al.,* 2015
10	*Brevibacillus borstelensis*	Singh *et al.,* 2008
11	*Rhodococcus ruber srtain* C 208	Santo *et al.,* 2012
12	*Nocardia* sp	Sudhakar *et al.,* 2008
13	*Bacillus sphericus*	Restrepoflroez *et al.,* 2014

Biodegradation of polyolefins

Polyolefins which is one of class of polymers that are hydrophobic, high-molecular weight polymers, and as a result not readily degraded via abiotic or biotic factors (Hains and Alexender, 1974) they mount up at a pace of 25 million tons per year in the surroundings (Orhan, 2000) polyolefins are mostly degraded by oxo-biodegradation. The expression oxo-biodegradation is applied to illustrate the two-steps method of polyolefin degradation.

The first step includes the reaction between oxygen and polymer. The carbon structure present in polymer material is oxidized ending in the creation of little fragments of molecule. The second stage is the biodecomposition of the oxidation products by microorganisms i-e algae, bacteria and fungi that use the oxidized carbon backbone fragments to form biomass, H_2O and CO_2 (amala *et al.,* 2011). It has been reported that to attain notable biodegradation in a rational period of time, the oxidized polyolefin should have mean molecular weight below 5000 Da (Reddy *et al.,* 2009). Polyolefins supply an agreeable choice for minimizing synthetic polymers waste in the surrounding (Zheng and Yanful, 2005).

Polyhydroxyalkanoates

PHAs are included in the most agreeable and substantial categories of biopolyesters, along with above 150 divergent types of monomer constitution that give divergent functionalities and characteristics (Kim *et al.,* 2001; Lenz *et al.,* 2005) amongst the different kinds of biodegradable polymers, polyhydroxyalkanoates (PHAs) are the most well-known biosynthetic and biodegradable and is documented to produce zero harmful waste, and entirely reusable into organic litter (Chanprateep, 2010). PHAs being synthesized through large number of microbes during unbalanced nutritional conditions (Urtuvia *et al.,* 2014).

PHA biodegradation which is one of complicated multistep procedure, and also subjective to various factors, involving PHA chemical constitution and characteristics, the type of polymer and the methods applied to manufacture it, climate and weather, and the composition of the micro-organisms community (Volova *et al.,* 2016).

Polyurethanes

Polyurethanes are one of the forms of polymeric plastics which were firstly applied as a form of alternative for traditional polymers which were considered to liberate volatile organic harmful material (Cregtu *et al.,* 2013). Polyurethanes are mostly in the form of foams and is positioned as the 6th most widespread type of plastic used internationally, and they are responsible for 6 to 7% (10 Mt/year) of the overall plastics produced (Cangemi *et al.,* 2008). Polyurethane is acquired from the process of condensation of polyisocyanates and polyalcohols. (Howard 2002) Polyurethane polymer monomer unit's contain a urethane moiety. Urethanes are derived from carbamic acids which occur only in the form of their esters (Dombrow, 1957). The industrial utilization of polyurethane foams rises because of technological growth and its application in latest industrial usage. This increase was also impeled by government programs that prohibited some organic compounds, such as chlorinated rubber, supposed of liberating perilous organic volatile compounds (Rowe and Howard, 2002).

Polylactide

PLA, a high power and high modulus thermoplastic can be simply processed by conservative processing methods used for thermoplastics like thermoforming, blow moulding, extrusion and injection moulding (Gupta and Kumar, 2007) The degradation products of PLA are non-hazardous for the living creatures (Alexender *et al.,* 1981).

Highly pure monomer units are required for the polymerisation of PLA because the impurities hinders the course of reaction and lessens the quality of polymer. Functional groups like carboxylic, water and hydroxyl etc. can be regarded as impurities (Zhang *et al.,* 1994). PLA is a weak material with lesser elongation, and the addition of starch into such an already fragile material results in even more fragility. Also, the combination of plasticised PLA with thermoplastic starch shows a small degree of compatibility with the considerable decrease in mechanical characteristics (Martin and Averous, 2001). PLA is mostly used for medical purposes such as drug delivery devices, absorbable sutures and as a material for medical implants and other relevant applications (Tokiwa and Calabia 2006).

Polyethylene

Polyethylene has been considered a most important non- degradable solid waste and new studies has shown it very dangerous for aquatic life, (Harshvardhan and Jha 2013). It includes massive degree of municipal and industrialized waste it also used in huge amount to construct greenhouse and soil protection in agricultural land (Santo *et al.,* 2012). Polyethylene is the basic cause to create blockage in the intestine of fish, marine life and birds. Furthermore entanglement in the absorption of this waste is dangerous for hundreds of the species of marine life (Teuten *et al.,* 2009). It characterize 64% of the synthetic plastic which is discarded in past few years after use (Byuntae *et al.,* 1991) it shows high resistance towards bases, acids, esters and alcohols. It is considered a biologically inactive and inflexible material (Harshvardhan and Jha, 2013). High molecular weight, lack of functional groups recognized by bacterial enzymatic system and hydrophobicity make them inert (Hamid 2000). It is a big apprehension for waste management because of its buildup in landfills and natural environment (Thompson *et al.,* 2009). The trouble of bio-gradation of polyethylene material is considered because of its hydrophobicity, lack of functional group, high molecular weight, high water repellency (Odusanya *et al.,* 2013).

The basic problem with polyethylene are it high molecular weight which is more than 30 kda and hydrophobicity because of the presence of only the CH2 group in its chain (Kumarsen, 2015.

Most challenging plastics are possibly polyethylene which is being resistance to microbial attack is one of the most inert synthetic polymers (or *et al.,* 2004). The mechanism of biotic use for the degradation of the high weight molecules and polymers are because of the extra cellular enzymes formed by microbe which degrade primary polymeric chain in to lower weight intermediates and make it reachable for the bacterial assimilation (Palmisano and Pettigrew, 1992). Polyethylene degradation has been divided into two category biotic and a biotic. the first one is defined the biodegradation caused by the action of microbes which change and absorbed polymer which lead to change in its properties while second one defined as deterioration which caused by environmental factor including temperature and UV Irradiation (Restrepofirez *et al.,* 2014).

Conclusion

Plastics have been regarded as one of the most fundamental material because of some of their properties such as their toughness, rigidity and durability makes them an excellent material to be used in various fields. Their use varies from our simple daily life products to brief projects. This extensive use of these synthetic polymers is a reason for pollution and is a great threat to ecosystem. In light of pollution index of world it is very important to introduce and use bioplastics because of their biodegradability, they are less persistent in environment and not as harmful as synthetic plastics are. The conclusion of this study is that it is possible to design efficient microbial communities able to degrade plastic waste. Fungal, microbial and protist biological activity permitted to continue under restricted and contained conditions might be the solution to manage large amount of plastic waste.

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