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Biodegradation Approach for an Upcoming Disaster (Plastic)

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Abstract : Man has created an upcoming disaster in the name of modern development whose impact may persist for thousands of years. Millions of sea birds, turtles and marine mammals etc.., die every years. Millions of pollution due to plastics. There are various other impacts due to improper disposal. Polyethylene is one of major types of plastic used worldwide.Different methods of management are being tried out such as recycling, converting to fuel, as construction material, etc. Complete removal of this pollutant without any additional pollution can be possible by mineralization of such material using biodegradation process.In this paper, the proposed a methodology for degradation of polyethylene with the help of micro organisms such as bacteria and fungi. Some micro-organisms are capable of producing exo-enzymes that can break up the polymeric structure which can be further broken down by intracellular metabolism. The positive results will be a solution for this long lasting environmental issue.
Key words: Polyethylene,biodegradation, environmental issue, recycling, pollution.

1.Introduction

Plastic materials have found worldwide applications in every aspect of life and industries due to the advances in technology and the increase in this global population. More than 140 million tones of plastics are generated annually throughout the world. They are increasingly used in all fields including food, clothing, shelter, transportation, construction, medical, and recreation industries, as they are strong , light weighted , and durable. However , due to their reistance to biodegradation , they lead to pollution and are harmful to the natural environments (Kathiresan , 2003). The effects of them on environment range from ozone depletion to environmental toxicology of agriculture and aquatic ecosystem (Anjana and Amitabh , 2004).

Ancient times, plastic materials have been progressively more used in various industries like food clothing, shelter, transportation, construction, medical and recreation. Plastics are beneficial as they are tough, light-weighted and flexible.Though, they are detrimental as they are challenging to biodegradation, most important to cause pollution, destructive to the natural environment.The victoriousinvention and promotion of recyclable plastics will make possible the solution for environmental pollution. In the historyof 10 years, numerousrecyclable plastics have been launched into the marketplace. But, no such plastic is competently biodegradable in landfills(Anonymous, 1999). therefore, there is an vital need to extendcompetent microbes and their yield to resolve this worldwideconcern.

Polyethylene is a polymer made of long chain monomers of ethylene. It is a thermoplastic commodity mostly used for packaging (Sonil and Smiti, 2010). One of the key sources of environmental pollution is low density polyethylene. 12% of polyethylene handling is increasing globally and about140 million tones of synthetic polymers are shaped worldwide every year (Usha et al., 2011).

About 25% of polyethylene produced is used in packaging , where its time of usage is very short. Immediately they become waste and their management is a huge problem. Recently , it recognized as a major threat to marine life. It could sometimes cause blockage in intestine of fish, birds and marine mammals (Kathiresan,

2003). It also affects domestic animals like cattle. Improper disposal also leads to blockage of drainages and affect rainwater infiltration. Recycling is not economically feasible due to the cost factor and loss of mechanical properties. Land filling leads to accumulation of wastes and is not a solution to this problem. Incineration of plastic wastes causes of pollution and toxicity.

Biodegradation using micro-organisms accepted worldwide and is still underway for its enhanced efficiency. Microbial degradation of plastics is caused by certain enzymatic activities that lead to a chain cleavage of the polymer into oligomers and monomers. Polymers breakdown into monomers which is easiness for accumulation by microbial activity for further degration (Gu et al., 2000).These water soluble enzymatically cleaved products are further absorbed by the microbial cells where they are metabolized. Aerobic metabolism results in carbondioxide and water, whereas anaerobic metabolism results in carbondioxide, water, and methane as the end products, respectively (Sonil and Smiti , 2010). This study is an attempt to degrade one of the commonly used types of polyethylene, Low Density Polyethylene (LPDE), using micro-organisms in laboratory conditions as well as natural environment.

2.Materials and Method

2.1 Sample Collection

Soil sample with plastic was collected from a waste dumpsite near Madurai for isolation of micro-organisms. The soil was in contact with plastic for a long time. The soil sample was taken in clean plastic bags and stored at 4°C in refrigerator.

2.2 Isolation and identification of micro- organisms

The sample was serially diluted and spread plates were prepared by taking 0.1ml of diluted sample. Nutrient Agar (Peptone, 0.5g; Beef extract, 0.3g; Yeast extract, 0.2g; NACL, 0.5g and Agar agar, 3g in 100 ml of distilled water) was used for isolation of bacteria. Potato Dextrose Agar (potato infusion, 0.4g; D-Glucose ,2g and Agar agar, 3g in 100ml of distilled water) was used for isolation of fungi. Identification of the micro organisms will be done based on colony morphology, microscopic observation and biochemical tests. Species identification will be performed by 16s rDNA sequence analysis.

2.3 Characteristics of LPDE

Low density polyethylene films were obtained from Jai Plasts Pvt., Ltd., Madurai. The films were cut in specific dimension and weighed. Tensile strength and percent extension were calculated as follows:

Tensile strength (N/cm^2)= Breaking load (N) /Area of the flim (cm^2)

Percent extension (%) = ((R2-R1)/R1)X100 , R1 is the reading after fixing the specimen R2 is the reading at the rupture of the specimen.

2.4 Batch Studies

LPDE films will be pretreated with Concentrated HNO3 for 24h at room temperature and then boiled for 4h. The selected micro- organisms be inoculated in 250ml of the medium (Nutrient Broth for bacteria and Potato Dextrose Broth for fungi) in 500ml conical flasks and incubated in the Orbital shaker for enrichment. LPDE films will be introduced into the flasks after enrichment and placed in the shaker. Specimens will be collected once in 15days and analysed.

2.5 Natural degradation

Biodegradation of LPDE films with and without pretreatment will also be studied in the natural environment. The plastic films will be placed in different environments like marine zone, river bed, lake bed, rocky area with different soil characteristics. The specimens will be studied at the interval of 15 days.

2.6 Determination of biodegradation

Degradation will be determined by analyzing reduction in weight, change in tensile strength and percent extension. Morphological assessment will be carried out by Scanning Electron Microscopy (SEM). The metabolites produced by degradation will be studied by Gas Chromatography- Mass Spectrometry (GC- MS)

3.Results and Discussion

Soil sample was collected from waste dumpsite consisting of plastics. The soil micro -organisms have been in direct contact with plastics. 10 bacteria and 8 fungi were isolated from the sample and they are being identified. The characteristic of the plastic specimen are given in Table 1.

Table 1. Characteristics of LPDE

Dimension	1x8 cm (Length x Breadth)
Weight	0.042 g
Tensile strength	5.5 N/ cm^2
Elongation	29cm
Percent extension	7.25%

The degradation of LPDE and polypropylene (PP) (Anjana and Amitabh, 2004) was studied for 45 days using an indigenous isolate of Pseudomonas stutzeri. Tensile strength and elongation decreased with time which may be due to cleavage of polymer chain . Degradation of general grade commercial purpose polyethylene was performed with *Brevibacillus*, *Pseudomonas* and *Rhodococcus spp.* (Sonil and Smiti, 2010). Percent of degradation for a period of 3 week was calculated by decrease in weight. Biodegrading ability of *Pseudomonas spp.* with 40.5% followed by *Brevibacillus spp.* with 37.5% and *Rhodococcus spp*.With 33%.*Acinetobacter sp.* 351 was found to degrade Low molecular weight polyethylene oligomers (Yutaka et al., 2009). The plastic materials have been despoiled in the mangrove soil irrespective of the mangrove zones. This discloses that the mangrove soil can be a resource of featuresdependable for the degradation of plastic materials. The aspects may comprise microbes besides pH, moisture, temperature etc. (Anonymous 1999).

Augusta et al., (1993)explained that the extracellular hydrolyzing enzymes secreted by the specificmicroorganism which hydrolyze the suspended polyesters in the turbid agar medium into water soluble products thereby creating zones around the colony. If the microbes get attached to the surface of media, itbegin togrow by using the polymer as the carbon source.The main chain cleavage leads to the development of low-molecular weight fragments (dimers or monomers) (Vasile, 1993).

Fungal species that includes *Aspergillu sniger*, *Pencillium funiculosum, Fusarium redolens* and *A.Vesicolor* and soil micro-organisms (Rhodococcus rhodochrous, Cladosporium cladosporoides) have been reported to degrade polyethylene (Arutselvi et al., 2008). Bacteria like*Streptococcus*, *Staphylococcus*, *Micrococcus*), *Moraxella* and *Pseudomonas* and two species of fungi (*Aspergillusglaucus* and *A.Niger*) isolated from mangrove soil was used to degrade polythene (Kathiresan, 2003). Among which *Pseudomonas species* degraded 20.54% and *Aspergillusglaucus* degraded 28.8% of polythene.

Kathiresan and Bingham (2001)documented that bacteriacan able to biodegrade the polythene from 2.19 to 20.54% and 0.56 to 8.16% for plastics. Among different species, *Aspergillus glaucus* was further dynamic than *Aspergillus nige r*in degrading 28.8% of polythene and 7.26% of plasticswithin a month. This isaccredited to the thickness of the polythene that is 5-times thinner than the plastics.

4.Conclusion

Humans in the course development created plastics whose use is at increasing rate and is becoming disastrous to the environment. Physical and chemical methods are not sufficiently efficient to be employed for the management of these wastes. Biodegradation is the only clean technology to get rid of such substances. Several attempts are being made to isolate micro-organisms with capability to degrade plastics. They can be employed for economic and safe disposal of plastic wastes.

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