A Novel Mathematical Approach for Optimization of Plastic Degradation

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ABSTRACT: Over the years, plastics have brought economic, environmental and social advantages. However, their popularity has also meant a rise in plastic waste, which brings its own economic, environmental and social issues. Of particular concern is the plastic soup that exists in the world's oceans and seas, containing everything from large abandoned fishing nets to plastic bottles, to miniscule particles of plastic. With more and more plastics being employed in human lives and increasing pressure being placed on capacities available for plastic waste disposal, the need for degradable plastics and degradation of plastic wastes has assumed increasing importance in the last few years. Now a day there is a need to protect the earth from the harmful effects of pollution, so that the generations to come will be able to alive a decently healthy life. Every individual will have to take the onus on himself and work towards bettering the environment and keep the earth green and healthy. In this present fast growing society, we create too much waste and in particular too much unnecessary packaging and we do not adequately recycle the waste we create. Being composed of toxic chemicals and most importantly a non biodegradable substance, plastic causes serious damage to environment during its production process and during its disposal process and pollutes earth, leads to air pollution and water pollution. At this juncture there is a need to minimize the plastic usage with optimistic combination of plastics to decrease the land fillings consequently various types of Environmental pollution. In this paper a mathematical model was obtained for the optimization of plastic degradation. At this juncture there is a need to minimize the plastic usage with optimistic combination of plastics to decrease the land fillings consequently various types of Environmental pollution. In this paper some plastic materials are considered with their some properties and given a combination to reduce their degradation time.

KEY WORDS: Plastic, Degradation, Pollution, Modified Simplex Method, Toxic pollutants

1. INTRODUCTION

Plastic is used very commonly in the world because they are cheap, easy to make and they will last long as well. But sorry to say, these useful qualities make plastic a real menace to the environment. As it is so cheap that people discards it soon especially carry bags and disposable bottles. As these materials are long-lasting and difficult to decompose, it persists in the earth for many centuries resulting in enormous environment pollution. Synthetic polymers can easily be moulded into different shapes, while some can be made into thin film like bits and pieces, which became very accepted in form of durable and disposable carry bags and packing materials. These materials when thrown out after use remains in the soil in the same form as it is non-biodegradable.

Plastics are derived from a finite supply of fossil fuels. Plastics encompass a large and varied group of materials consisting of different combinations or formulations of carbon, oxygen, hydrogen, nitrogen and other organic and inorganic elements. Most plastics do not degrade and remain a nuisance in the environment for many years. Biodegradable plastics have been developed but these are not suitable for recycling. As there are many types of plastics with different chemical properties, it is not easy to recycle them. Many drink bottles are made from a plastic called PET, which can be re-used. Few recycling schemes have been set up as yet for plastics. At this juncture there is a need to plastic combination of plastics to decrease the land fillings consequently various types of Environmental pollution. In this paper optimization of plastic degradation has been discussed based on some of the characteristics of certain kinds of plastics.

Landfill is the major method for waste disposal which is a method of solid waste disposal in which refuse is buried between layers of dirt so as to fill in or reclaim low-lying ground. Biodegradable matter in landfills is decomposed by bacteria, producing large quantities of carbon dioxide and methane - both greenhouse gases. Methane is potentially explosive and can cause fires. Pollutants such as heavy metals, toxic chemicals and the result of a chemical reaction between the mixtures of different wastes may contaminate the environment. More than 20 million tons of plastic are placed in landfills over the world each year and hence it is suggested by the scientists that some of the largely petroleum-based plastic may soon be replaced by a nonpolluting, renewable plastic made from plants. Reducing the carbon footprint and the dependence on foreign oil, this new 'green' alternative may also provide an additional cash crop for farmers. We create too much waste and in particular too much unnecessary packaging and we do not adequately recycle the waste we create. Many of the resources we use in our everyday lives are disposed of quickly. Food is wrapped in paper or plastic bags, drinks are in throw-away bottles or cans, batteries are disposed of after a short life. In many countries collection authorities have set up a system for householders to separate their rubbish into paper, glass and metal, and this makes recycling easier. Recycling facilities operate all over Europe, USA, Canada, Australia and New Zealand. Between 1990 and 2005 the amount of waste recycled, doubled from fifteen percent to thirty percent. In some countries however, and particularly in the developing world, massive quantities of waste is still dumped in landfills. So the alternate way to reduce the hazards of plastic is to reduce the use of plastic and thereby force a reduction in its production.

2. CLASSIFICATION OF PLASTICS

Plastics are classified according to their chemical structure are polystyrene, poly propylene, low density poly ethylene, high density poly ethylene and poly carbonate. These are varying in their degradation time depending upon the different organic compounds present in them.

Many consumer products, such as water bottles and product containers, are made from various types of plastic. The Society of the Plastics Industry (SPI) established a classification system in 1988 to allow consumers and recyclers to properly recycle and dispose of different types of plastics. Manufacturers follow a coding system and place an **SPI** code, or number, on each plastic product, which is usually molded into the bottom. Although you should always verify the plastic classification number of each product you use, this guide provides a basic outline of the different plastic types associated with each code number. Consumers can make better plastic-purchasing decisions if they understand SPI codes and potential health hazards of each plastic, and recyclers can more effectively separate plastics into categories. Plastic packages are coded to indicate the type of resin used to make them. The code numbers are found inside the chasing recycling arrows on the bottoms of containers. These numbers help you separate plastic containers for recycling collection or drop off. Uncoded plastics, such as plastic pipes, cannot be recycled but can be reused.

2.1 Polystyrene (PS):

Plastic marked with an SPI code of 6 is made with Polystyrene, also known as **PS** and most commonly known as Styrofoam. It is **commonly recycled**, but it is difficult to do so and often end up in landfills anyway. Disposable coffee cups, plastic food boxes, plastic cutlery, packing foam, and packing peanuts are made from PS. Recycled PS is used to make insulation, license plate frames, rulers, and more. Polystyrene is a rigid, brittle, inexpensive plastic that has been used to make plastic model kits and similar knick-knacks.

2.2 Poly propylene (PP):

Plastic marked with an SPI code of 5 is made with Polypropylene, or **PP**. PP is **not commonly recycled, but it is accepted in many areas**. This type of plastic is strong and can usually withstand higher temperatures. Among many other products, it is used to make plastic diapers, Tupperware, margarine containers, yogurt boxes, syrup bottles, prescription bottles, and some stadium cups. Plastic bottle caps are often made from PP as well. Recycled PP is used to make ice scrapers, rakes, battery cables, and more.

2.3 Low density poly ethylene (LDPE):

Plastic marked with an SPI code of 4 is made with Low-Density Polyethylene, or **LDPE**. LDPE is **not commonly recycled, but it is recyclable in certain areas**. It is a very healthy plastic that tends to be both durable and flexible. Plastic cling wrap, sandwich bags, squeezable bottles, and plastic grocery bags are all made from LDPE. Recycled LDPE is used to make garbage cans, lumber, furniture, and more.

2.4 High density poly ethylene (HDPE):

Plastic marked with an SPI code of 2 is made with High-Density Polyethylene, or **HDPE**. HDPE products are very safe and they are not known to transmit any chemicals into foods or drinks. HDPE products are **commonly recycled**. Items made from this plastic include containers for milk, motor oil, shampoos and conditioners, soap bottles, detergents, and bleaches. Many personalized toys are made from this plastic as well. (Please note: it is NEVER safe to reuse an HDPE bottle as a food or drink container if it didn't originally contain food or drink!) Recycled HDPE is used to make plastic crates, plastic lumber, fencing, and more.

2.5 Poly carbonate (PC):

The SPI code of 7 is used to designate miscellaneous types of plastic that are not defined by the other six codes. **Polycarbonate** and **Polylactide** are included in this category. These types of plastics are **difficult to recycle**. Polycarbonate, or PC, is used in baby bottles, large water bottles (multiple-gallon capacity), compact discs, and medical storage

containers. Recycled plastics in this category are used to make plastic lumber, among other products.

TABLE 1. Showing the Properties of different plastics

Type of Plastic	Poly Styrene (P.S.)	Poly Propylene (P.P.)	Low density Poly Ethylene (LDPE)	High Density Poly Ethylene (HDPE)	Poly carbo nate (P.C.)
Tensile Strength (TS)	50	31.02	0.2	0.2	65
Melting Point (MP)	240	170	110	126	26
Density (D)	1.05	0.46	0.9	0.9	12

Basically the degradation of plastics depends on Tensile strength, Melting point and Density. Tensile strength at break is a measure of the stress required to deform a material prior to breakage. Melting point is the temperature at which the solid substances can convert into liquid state. The density of a body is the ratio of its mass to its volume.

	X1	X 2	X3	X4	X5
Tensile Strength (TS)	50	31.0	0.2	0.2	65
Melting Point (MP)	240	170	110	126	267
Density (D)	1.05	0.46	0.9	0.9	12

TABLE 2

Where

X1 is Poly Styrene (P.S.)

X 2 is Poly Propylene (P.P.)

X3 is Low density Poly Ethylene (LDPE)

X4 is High Density Poly Ethylene (HDPE)

3. CALCULATIONS

A modified simplex method (Big M method) is applied to continuously optimize the data. In mathematical optimization, Dantzigs simplex method is a popular algorithm for LP. To apply this method, the following are the conditions.

The objective must be minimize or maximize the function.

All restrictions must be equal.

All variables are not negatives.

The independent terms are not negatives.

Goal Programming model:

Degradation function:

Minimize Z = 10X1 + 90X2 + 0.25X3 + 0.25 X4 + 20X5

3.1 Subject to the Constraints:

(a) Tensile Strength (TS):

$50\ X1 + 31.02\ X2 + 0.2\ X3 + 0.2\ X4 + 65\ X5 \geq 15$

(b) Melting Point (MP):

$240\ X1 + 170\ X2 + 110\ X3 + 126\ X4 + 267\ X5 > 75$

(c) Density(d):

$1.05\ X1 + 0.46\ X2 + 0.9\ X3 + 0.9\ X4 + 1.2\ X5 \leq 1.2$

And $X1, X2, X3, X4, X5 \geq 0$

4. RESULT AND ANALYSIS

Basic feasible solution is X1=0.2989, X2=0, X3=0, X4=0.0258 and X5=0. Finally we get the optimum solution for minimization method is Min $Z=2.99545 \approx 3$

5. CONCLUSION

In this paper we compared the above said values for some plastics to determine the optimal solution for degradation of plastics that minimizes the time period. According to the work done, the optimum combination of plastics to reduce the degradation time is Poly Styrene (PS) and high density poly ethylene (HDPE). With this combination of plastic usage the degradation time will be reduced up to 3 years. Let us contribute our part, save our environment from plastic pollution and make it a better environment for future.

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