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The Maximum Levels of Plastic Product Waste That Can Safely Be Mitigated

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The Maximum Levels of Plastic Product Waste That Can Safely Be Mitigated

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Abstract. we established a management model for plastic waste disposal processes: First, we consider the source and application of each type plastic waste to classify it according to the chemical composition. The waste is then maximized by recycling and degradation which are the two main environmentally friendly treatment. At the same time, we considered the factors affecting the recycling rate and degradation rate and introduced a partial least square regression fitting method to determine the exact relationship between the recycling rate and degradation rate of various types of plastic waste and their respective influencing factors. The maximum amount of plastic waste treated is the sum of the amount of plastic waste recycled and degraded.

Keywords: Plastic Waste, Partial least squares.

1. Introduction

1.1. Background

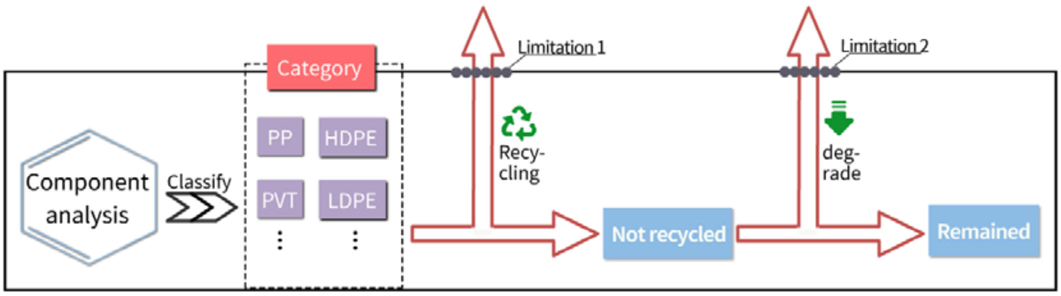
A world without plastics seems un-imaginable today [1]. The application of plastics as chemical raw materials, while providing people with convenient production and life, also brings many harms to the environment. With the massive use of plastic products around the world, plastic waste has also increased dramatically, and plastic pollution has become a prominent issue for environmental protection [2].

We established a management model for plastic waste disposal processes: First, we consider the source and application of each type plastic waste to classify it according to the chemical composition. The waste is then maximized by recycling and degradation which are the two main environmentally friendly treatment. At the same time, we considered the factors affecting the recycling rate and degradation rate and introduced a partial least square regression fitting method to determine the exact relationship between the recycling rate and degradation rate of various types of plastic waste and their respective influencing factors. The maximum amount of plastic waste treated is the sum of the amount of plastic waste recycled and degraded.

2. How much plastic waste we can safely mitigate

2.1. Basic Idea
Plastic waste is usually treated by landfills and incineration, which can cause environmental damage. Environmentally friendly disposal methods mainly refer to recycling and degradation. We first consider the source of plastic waste and classify it by chemical composition into 8 type（see Table 1）. Different chemical properties of each type determine its recycling and degradation capabilities. Also, the limitations of the available processing resources and the severity of the current waste problem will affect it to a certain extent. In an effort to analyze the exact relationship between the recycling degradation rate and their respective influencing factors, we introduce a new partial least square regression fitting method and establish the models of the degradation rate and recycling rate. Finally, the calculation of maximum recycling and degradation of each plastic waste is performed. Based on the above analysis, the Plastic waste disposal model for the management of plastic waste disposal processes has been successfully established, and the level of plastic waste that can be treated and maximized can be estimated.

Through the above analysis, the flow chart of this paper is shown in fig.1 as follows.



(**Limitation 1, 2** denote the limited resources of recycling and degradation respectively)

Figure 1. The flow chart for Task 1

2.2. Classification of plastic waste
The purpose of classifying plastic waste is to find the degradation rate of this type of chemical waste to characterize the degradation rate of this type of plastic waste.

The most commonly used and abundant polymers are high-density, low-density polyethylene (LDPE), polyethylene (HDPE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), Polyamides (PA), polyethylene terephthalate (PET) and Polyethylene (PE) (presented in Table 1), which together account for 91.5% in 2015 of the total plastic productions worldwide [3, 4].

2.3. Factors affecting recycling
There are mainly four types of plastic waste recycling methods as follows [5].

I.Primary(**re-extrusion**) Recycling: suitable with semi-clean scrap& re-introduction of scrap, industrial or single-polymer plastic edges and parts to the extrusion cycle to produce products from similar material.

II.Secondary(**mechanical**) Recycling: suitable for single-polymer plastic &conversion of plastic waste into plastic products via mechanical means.

III.Tertiary (**energy recovery**) Recycling: suitable for most plastic products &need a considerable treatment of the flue gases

IV.Quaternary (**chemical**) Recycling: suitable for most plastic products. Related technologies include pyrolysis, gasification, steam or catalytic cracking. The choice of technology depends on the type of plastic to be processed, the scale and the gaseous hydrocarbons and hydrogen produced by the thermal decomposition of the desired product, which can be used as fuels or chemical raw materials.

Through the above analysis, the plastic recycling process is shown in fig.2 as follows.

Table 1. Catalog of common plastics

	Type	Ratio among total plastic	Degradation rate	Use/application
T1	Polyethylene terephthalate (PET)	8.5%	31.8%	Carbonated drinks bottles, peanut butter jars, plastic film, microwavable packaging, tubes, pipes, insulation molding
T2	Polyethylene (PE)	6.6%	17.2%	Wide range of inexpensive uses including supermarket bags, plastic bottles
T3	High-density polyethylene (HDPE)	12.8%	19.4%	Detergent bottles, milk jugs, tubes, pipes, insulation molding
T4	Polyvinyl chloride (PVC)	9.1%	18.6%	Plumbing pipes and guttering, shower curtains, window frames, flooring, films
T5	Low-density polyethylene (LDPE)	15.5%	16.9%	Outdoor furniture, siding, floor tiles, shower curtains, clamshell packaging, films
T6	Polypropylene (PP)	17%	12.7%	Bottle caps, drinking straws, yogurt containers, appliances, car fenders (bumpers)
T7	Polystyrene (PS)	7.12%	28.3%	Packaging foam, food containers, plastic tableware disposable cups, plates, (insulation)
T8	Polyamides (PA) (nylons)	14.2%	20.8%	Fibers, toothbrush bristles, fishing line, under-the-hood car engine moldings

Figure 2. Plastic recycling process

In general, the quantity, scale, plastic type and scale of recycling equipment at each level directly determine the current maximum recycling rate of plastics. Specifically, the availability of resources indirectly used by each recycling method will also affect the maximum recycling rate of each type plastic.

2.4. Factors affecting the degradation

After recycling, the remained plastic waste will next experience degradation process. The non-recyclable plastic waste can be divided into five types [6]:

(1) Biodegradation: refers to the degradation of plastics under the influence of microbial conditions in natural environments such as bacteria, molds (fungi) and algae.

(2) Photodegradation: refers to the degradation of plastics caused by sunlight in the natural environment.

(3) Environmental degradation: refers to a class of plastics that are degraded when exposed to natural environmental conditions under the simultaneous action of light, heat, water, microorganisms, insects, and wind, sand, rain, and mechanical forces.

(4) Hydrolytic degradation: This type of degradation is applicable to water-soluble plastics, as well as biodegradable, such as polyvinyl alcohol, polyvinyl alcohol / starch degradable plastics.

(5) Chemical catalysts degradation: refers to the degradation of plastics caused by valid chemical catalysts.

Through the above analysis, the plastic degradation process is shown in fig.3 as follows.

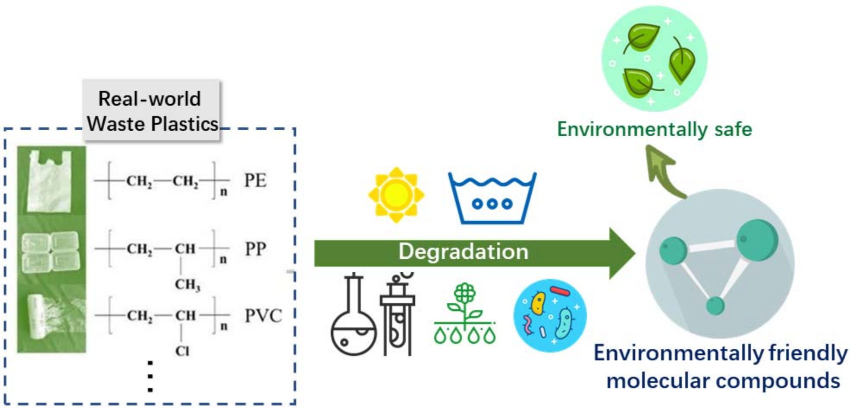


Figure 3. Plastic degradation process

By investigating the resources directly used by each degradation technology, the four major factors that affect the current degradation rate can be determined: the type of degradation technology, land area available for natural degradation, size of the degradation plant, and type of efficient degradation catalyst.

2.5. The maximum safe and treatable amount of plastic waste

According to the method of least squares and curve fitting (proving process see Appendix), we can get the equations of recycling rate and degradation rate as

$$R_{rTi}=a_1x_1+a_2x_2+\cdots+a_mx_m$$

$$R_{dTi}=b_1x_1+b_2x_2+\cdots+b_mx_m$$

Where R_{rTi} and R_{dTi} denotes under the maximum processing level, the recycling rate and degradation rate of plastic waste

Through the proportion of each plastic and the total amount of plastic waste, we can calculate the total amount of plastic waste. Combined with recovery rate and degradation rate to calculate the maximum level of processing the type i^{th} plastic waste by recycling or degradation. Add the two maximum level and get the total processing the type i^{th} plastic. Finally accumulate the maximum level of processing all type plastic waste，and its ratio to the total amount of plastic waste represents the maximum treatment level.

$$max_{Ti}=max_{Ri}+max_{Di}$$

$$max=\sum_{i=1}^{8}max_{Ti}$$

Where max denotes single-use or disposable plastic waste in an environmentally safe way; max_{Ti} denotes the maximum level of processing the i^{th} type plastic waste ; max_{Ri}, max_{Di} respectively denote the maximum amount of processing the i^{th} type plastic waste by recycling or degradation.

Bring in the data required by the model, and use our model to find the maximum treatment rate of various types of plastic waste, which have been organized into the following histogram:

Through the above analysis, the maximum treatment rate of various plastic waste is shown in fig.4 as follows

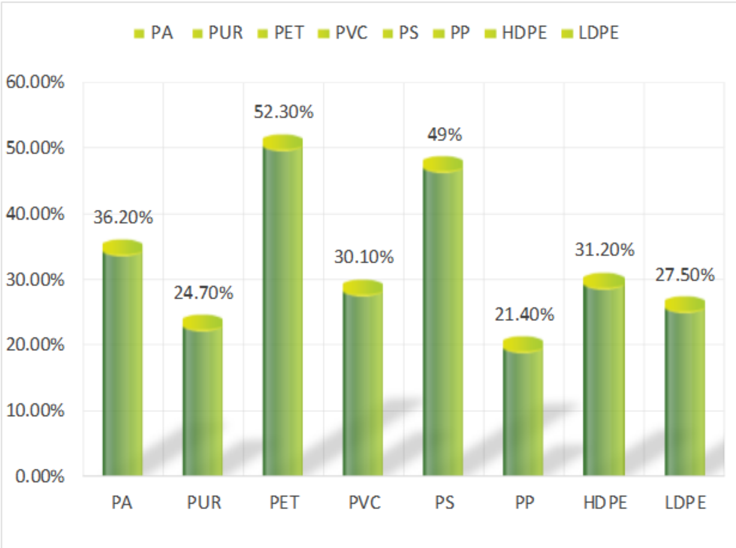


Figure 4. Maximum treatment rate of various plastic waste

3. Conclusions

To develop a model to estimate the maximum levels of single-use or disposable plastic product waste that can safely be mitigated without further environmental damage, we have established a management model for the waste treatment process, introduced a partial least squares regression fitting method, and brought in data from global relevant factor indicators to obtain the maximum treatment rate of various types of waste, and then obtained the maximum total treatment amount of all plastic waste. The ratio of this value to the total amount of plastic waste represents the maximum level of waste disposal.

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