

Research on the influence of plastic products based on two-way Evaluation system

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Abstract: Although plastics have been widely used and widely produced and used in the past, the related negative effects are worrying. This paper attempts to find indicators to evaluate the impact of plastics, so as to help us adjust the output of plastics and optimize the use of plastics. In our model, the impact of plastics is assessed from both positive and negative aspects, measured by PE and RNE, respectively. In the PE analysis, the profit per ton is used as an index to measure the output. When analyzing the impact of plastic PE, this paper evaluates the impact of biology and vegetation respectively, establishes a suitable index to evaluate the impact of plastics on animals, and uses the GEE platform for further analysis and measurement. Based on this model, we put forward suggestions to managers on how to adjust plastic production to reduce plastic waste and make it reach the level of environmental safety. In the process of optimization, in order to maximize the comprehensive consideration of positive impact indicators (PE) and negative impact indicators (NE), and then draw effective conclusions.

Keywords: Plastic, Evaluation, Index system, Suggestion

1. Introduction

With the growth of plastic manufacture, the economic benefits of plastic industry is remarkable. However, there are more and more negative effects raising great concern. According to Geyer [1], a large amount of plastic waste which is hard to dispose or recycle flow into the natural environment, especially in ocean. This can do harm to human health, ecological environment and lead to a waste of capital to dispose or recycle some of them.

In order to reveal the seriousness of the problems and try to solve them, Lithner et al. (2011) established a hazard assessment model for each plastic polymer based on its chemical composition [2]. In 2016, Waichin Li studied plastic waste in the marine environment and revealed that plastic waste has a bad effect on biology [3]. In 2003, Wiley published a book to talk about plastics and the environment in detail [4]. After learning about the recent research on this topic, we make a relative overall assessment of plastics' effect and try to estimate the maximum levels of plastic waste.

2. Construction of Evaluation System

In order to estimate the maximum levels of single-use or disposable plastic product waste, two aspects are taken into consideration: positive effect and negative effect. The following part gives an overall description about the two aspects.

Table 1: Positive and negative effect

Positive effect	Economic	Biological Vegetation
	Human Life	
Health Effect		
Economic Waste		
Negative effect	Ecological environment impact	

3. Quantification of positive effects

3.1 Life Benefits

Plastics are used as packaging materials because of their low density and high strength. At the same time, plastic molding is easy, and the energy consumption of plastic forming is lower than that of steel and other metal materials. In some cases, plastic is used instead of metal materials, which reduces the energy consumption to a certain extent. In addition, plastics also have good transparency and easy coloring, which makes them have a wide range of life applications.

3.2 Economic benefits

Taking China as an example, China's plastic products industry has maintained rapid development in recent years. The development of the plastic industry has driven economic growth and provided a large number of jobs. At the same time, its products also bring convenience to daily life.

3.3 Quantitative index

To ensure timeliness, we can use the annual average profit per ton of plastic products since the start year sy as a positive factor of plastic products and record it as PE (positive effect). Set n as the year, G_i is the total annual profit and P_i is the total annual output. The following formula can be obtained:

$$PE = \frac{\sum_{i=sy}^n \left(\frac{G_i}{P_i} \right)}{n - sy + 1} \quad (1)$$

4. Quantification of negative effects

In this model, the paper use the index NE, which means negative effect. Having divided NE into three aspects, we get the valued of NE by giving three aspects a score respectively.

4.1 Health effect

The harm of plastic products to human health mainly lies in the toxic substances released in the process of use or degradation. In order to comprehensively evaluate the toxic hazards of plastics, Lithner et al. (2011) established a hazard assessment model for each plastic polymer based on its chemical composition.

According to the output of plastics in the world, we select a study region with its yearly plastic output, then we can calculate the health effects of plastics in the region, the formula is:

$$NE_{health} = \sum \left(\frac{P_j}{p} \cdot s_j \right) \times P_i \quad (2)$$

where p is the total annual output of plastics in the world; p_j is the annual output of the j_{th} plastic; s_j is the hazard score of the j_{th} plastic; P_i is the plastic output of a study region in a year, and NE health is the total hazard score of a study region's plastics to human health in one year.

4.2 Economic waste

Considering the different recycling processes and different sources of plastics in different regions, this paper calculates the material waste in disposable plastic recycling, and then calculates the economic waste caused by plastic waste according to the profit of tons of plastic and the amount of unrecycled waste plastic.

If the recovery process has n process layers, i.e. " n operation units", then there should be n material layers. The arrangement of process layer and material layer is shown in the figure below.

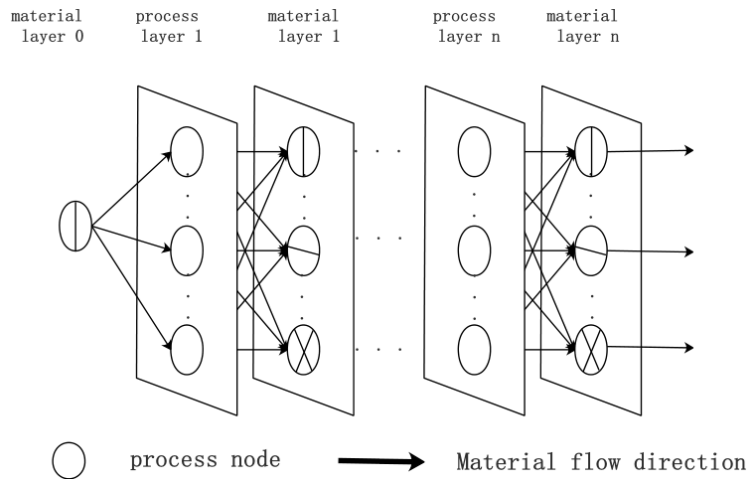


Figure 1: Schematic diagram of commonly used plastic recycling device.

The former layer of PL_n is ML_{n-1} and the latter layer is ML_n . The nodes of each layer are P_n^j , $M_{(n-1)}^j$ and M_n^j respectively. There are several nodes on each process layer or material layer. We can set P_n^j as the i th node of the process layer, and set M_n^j as the j th node of the material layer. Each process node represents a treatment method. X_n^i is the input material quality of node P_n^i while Y_n^i is the output material quality of it.

Suppose that the material layer ml has plastic waste with a mass of y_n^i (unit: ton) flowing into the process node p_n^i . After treatment in the process, the proportion of the final inflow to the initial volume is q_n^{j-i} , and the remaining volume of the process node p_n^i is r_n^i , which flows into the mln of the next treatment unit. Therefore, the input material Y_n^i of each process layer node in the material flow is equal to the weighted sum of the output materials of each node in the upper layer:

$$Y_n^i = r_n^i \left[\sum_{j=1}^{(n-1)^*} q_n^{j-i} \cdot y_{n-1}^j \right] \quad (3)$$

The scale factor $q_n^{(j-i)}$ is only 100% and 0%, indicating whether the material participates in the process.

The paper can define the input material quality of the next material layer as X_n

$$X_n = Q_n Y_{n-1} \quad (4)$$

The final total efficiency can be given as follows:

$$\delta = \frac{\sum_{j=1}^n y_n^j}{M} \times 100\% \quad (5)$$

According to the previous analysis, we can know that, when using the process to recycle plastic waste, there is still material waste due to the efficiency can not reach 100%, which has an impact on the economy. If M tons of plastic are recycled in this year, and M_0 is used to indicate the quality of plastic that is not recycled in time every year, which is represented by N_1 (unit: USD):

$$N_1 = [M \times (1 - \delta) + M_0] \times PE \quad (6)$$

Finally, based on the GDP per capita of the region in that year, we get the indicators to measure the economic waste of waste plastics.

$$NE_{economy} = \frac{N_1}{g \cdot p_i}$$

Where g is GDP per capita of the region in that year and p_i is the region's plastic output in that year. In this way, we have established an indicator to measure the negative impact of plastic waste on the economy. The value of the indicator is a dimensionless score.

4.3 Ecological environment impact

(A) Biology

For different types of organisms, when we set i as the category number of the animal [5], the total score SUM_i can be calculated to analyze the impact indicators of plastic waste on different organisms. If there are n species of animals in this category, the final indicators are calculated as follows:

$$S_i = \frac{SUM_i}{n} \quad (7)$$

Assuming that the annual inflow of plastic waste into the nature is T tons, the impact indicators of plastic waste on all the different categories of organisms participating in the statistics in the ecosystem are as follows:

$$NB = \frac{\sum_{i=1}^n S_i}{T} \quad (8)$$

The paper need to get the waste rate α of plastics in a certain region, and then calculate the amount T of plastics flowing into the environment through its output p_i in a recent year.

$$T = \alpha \times p_i \quad (9)$$

Through the data, combined with the ecological environment of the country (region), we can assess the impact of plastic on local organisms. So we finally get the formula of NB:

$$NB = \frac{\sum_{i=1}^n S_i}{\alpha \cdot p_i} \quad (10)$$

(B) Vegetation

Plastic waste has a bad effect on vegetation which has risen great concern. In order to measure this effect and give a score, Normalized Difference Vegetation Index (NDVI) is adopted. NDVI is an effective index to indicate the vegetation of a region, which is calculated by remote-sensing images. The calculation formula is:

$$NDVI = \frac{NIR - R}{NIR + R} \quad (11)$$

GEE is an open platform to process and analyse geoscience data. With powerful computing ability and open environment, GEE makes it possible to program and process remote sensing data online without downloading images. The interface of GEE is shown below.



Figure 2: The interface of GEE

To get plastic waste's effect on vegetation, we calculate the NDVI at the year when the area was not a landfill and the NDVI in recent years. After finding the difference between previous NDVI and present NDVI, we can get a score to measure the effect on vegetation.

$$NV_j = \frac{NDVI_{previous} - NDVI_{present}}{P_i} \quad (12)$$

where NV_j is the score to quantify the effect on vegetation in the j th area; $NDVI_{previous}$ is the previous NDVI of the region when there is no landfill; $NDVI_{present}$ is the present NDVI of the region when there is a landfill with plastics; p_i is the total plastic output of the city in a recent year.

Then estimate the effect on vegetation in the city by taking the average of all the NV_j . With the value of NB and NV, we can calculate the summary of Ecological environment impact.

$$NE_{environment} = NB + NV \quad (13)$$

The negative effect of plastic waste is calculated by the formula as follow.

$$NE = NE_{environment} + NE_{health} + NE_{economy} \quad (14)$$

4.4 The index on the resistance of negative effect

Taking the reciprocal of NE, we get an index to measure a selected region's resistance to plastic waste's negative effect.

$$RNE = 1/NE \quad (15)$$

5. Conclusion

In this paper, an evaluation system of plastic industry based on double-sided effect is established, in which the positive effect mainly considers the economic benefit, and the negative effect mainly considers economic waste, animal toxicology and vegetation cover, so as to further evaluate and measure the impact of plastic products.

References

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