Life cycle assessment and plastic chemical plastic reduction and carbon reduction

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Abstract:This paper examines the use of Life Cycle Assessment (LCA) in evaluating the environmental impacts of plastic production and consumption, particularly in reducing carbon and plastic waste. As global plastic use increases, especially in China, LCA provides a critical tool for assessing the full environmental footprint, from production to disposal. The study highlights LCA's value in identifying areas for improvement but also notes its limitations, emphasizing the need for more accurate tools to support sustainable development efforts.

Keywords: Life Cycle Assessment (LCA); Plastic production; Carbon reduction; Environmental impact; Plastic waste

1. Global plastic consumption and production

As the global population continues to grow and per capita income grows, global consumption of plastic products has grown dramatically over the past 50 years, with the highest growth rate, outpacing steel, aluminum products and cement (OECD, 2022). Most of the plastics used today are native plastic made from crude oil or natural gas. Due to the high energy consumption in fossil fuel feedstocks and refining processes, most of the plastic greenhouse gas emissions can be attributed to the production stage. Bio-based plastics are a smaller class of plastics with properties similar to those of fossil-based plastics but derived from biomass. Fossil-based plastics and bio-based plastics are collectively known as primary plastics. Plastics made of recycled materials are called recycled plastics. Recycled plastics have less greenhouse gas emissions than native plastics, but they accounted for only 6 percent of global plastic use in 2019.

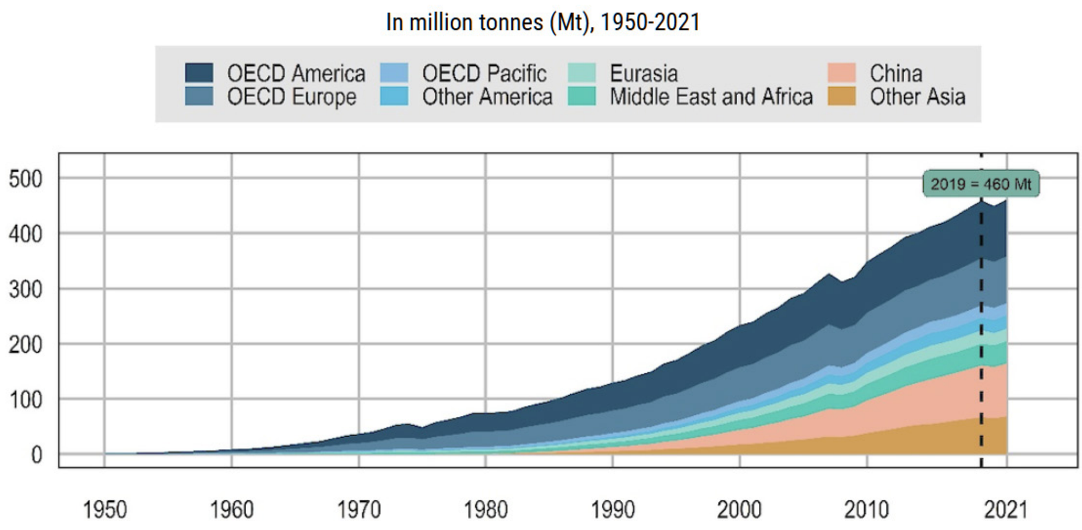

Figure 1: Global plastic consumption over the past 70 years (data source: OECD)

From 1950 to 2020, the global cumulative plastic production has exceeded 10.5 billion tons. Although plastic production has been growing at a cagR of 5% since 1975, the overall trend is declining. Each decline prompted producers to try to increase production, but production failed to return to its previous peak levels due to scale effects and environmental constraints. According to the United Nations Environment Programme (UNEP), if current trends continue, global plastic production will consume 20% of the global oil supply by 2050,25 percent of which are single-use plastic products. Carbon emissions from plastic production and use will account for 15% of the total global carbon budget under the 2°C scenario (Energy Research Institute, Peking University, 2023).

2. Consumption and production of plastics in China

China is an important country in plastic consumption, and the OECD reported: " China accounts for about 20 percent of global plastic demand, the United States about 18 percent and European countries about 18 percent."(OECD, 2022) China's plastic consumer demand reflects the country's strong economic dynamics. The report accounts for 37 percent of total plastic consumption, 88.5 percent of which will be treated as plastic waste in China. It is estimated that China's plastic waste is about 84 million tons in 2020, of which about 53 million tons are burned, and the rest is buried or scattered in the natural environment. Following this trend, the full life-cycle carbon emissions of disposable plastics will reach 375 million tons by 2040 (Pacific Environment, 2023). The carbon emission of recyclable plastics is lower than that of disposable plastics, and also lower than that of alternative glass products, so it is a more reasonable alternative to carbon reduction and plastic reduction.

China's plastics industry is growing very rapidly, with close to 32% of the global total output. Five major general-purpose plastics, including polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS) and ABS resins, account for 75% of China's total plastic production and consumption in China (Energy Research Institute, Peking University, 2023). Biodegradable plastics, because of their ability to be decomposed and degraded by microorganisms in the natural environment, will not cause long-term environmental pollution, and are more and more popular in the market. China's biodegradable plastics market scale reached 16.049 billion yuan. At present, the treatment of non-biodegradable plastics mainly includes recycling and chemical cracking means. According to the American Materials Testing Association classification, recycling is mainly divided into four levels, including mechanical processing, intermediate product recovery and energy recovery (Zhang et al., 2021)。

3. Life Cycle Assessment

Almost all of the plastic products come from fossil fuels, meaning that the incineration and degradation of the plastic products will inevitably lead to significant carbon emissions. Therefore, plastic products-based life cycle assessment is crucial to fully understanding the environmental impact of plastic products. According to the ISO14040 standard, the Life Cycle Assessment (LCA, Life Cycle Assessment) is a systematic method for assessing the impact of a product, process, or service on the environment throughout its life cycle. This process begins with the acquisition of raw materials, including the transportation of raw materials, the production, sale, and use of products, until the abandonment and disposal (Vlasopoulos et al., 2023)。The purpose of LCA is to identify and quantify environmental loads in these stages and thus provide a scientific basis for reducing negative impacts.

1. Define objectives and scope: Determine the objectives and scope of the study, including system boundaries and functional units. System boundaries define which processes and activities will be included in the LCA.

2. Life Cycle Inventory Analysis (LCI): Collect and quantify all material and energy flows involved throughout the life cycle. This includes raw material consumption, energy use, waste generation and so on.

3. Life Cycle Impact Assessment (LCIA): To analyze and evaluate the potential environmental impact of LCI data. Common environmental impact categories include global warming potential, ozone layer depletion, acidification, eutrophication, resource depletion, etc.

4. Explanation: Analyze the LCA results and draw conclusions to suggest improvement. Identifying major sources of environmental impact and prioritizing improvement.

4. The Lifecycle Assessment application

Through the life cycle assessment, the environmental impact coefficient of plastic products can be studied in depth, and the environmental impact of different stages and different categories of plastic production, consumption and disposal can be analyzed from various perspectives such as energy consumption and carbon emission. The study shows that the five major plastics have a different impact on the environment according to the type. In the same category, the environmental impact under different uses is also different. The degree of resource and environmental impact of plastic products is from high to low: other plastic products, daily plastic products, beverage bottles, food boxes, takeaway boxes, daily chemical packaging, other packaging, and film plastic bags (Cao et al., 2020)

The life cycle assessment can also subdivide the sources of plastic pollution and provide data support for the prevention and control of plastic pollution, especially microplastic pollution. Research show that the main source of resin particles in China's environment is the leakage of resin particles carried by the wastewater in the production of plastic products and the leakage of resin raw materials in the transportation process. Meanwhile, plastic agricultural film is also one of the sources of environmental microplastics that have received high attention recently (Shen Chenhao et al., 2021)。

Life cycle assessment can help enterprises to analyze the production, sales and product consumption process from different dimensions, so as to compare the adjustment effect of different processes and management processes on the impact of the enterprise environment, optimize the enterprise product structure and production process, and effectively reduce the negative impact of enterprises on the environment.

For example, BASF uses life cycle assessment to evaluate how the "chemical cycle" project can reduce carbon dioxide emissions from multiple dimensions, including three steps of calculating input, process, output, comparative thermal cracking + chemical processing, incineration and mechanical recovery (BASF, no date).

5.sum up

Life cycle assessment is very important for sustainable development, because its analysis includes the entire life cycle of the product, which prevents the transfer of environmental burden to non-key monitoring links in order to improve a specific link in the process of carbon reduction and plastic reduction, thus missing the purpose of carbon reduction and plastic reduction. Life-cycle assessment can assess the environmental impact of a product from multiple perspectives, such as strategies to assess ecological performance, the actual use of raw materials, and pollutant emissions (Kousemaker, Jonker and Vakis, 2021). Life-cycle assessment also has some limitations and drawbacks. For example, the material and energy flows for each step of the life cycle inventory usually come from various databases, and the data sources of the database can only cover some country-specific processes, and may not apply to all environmental variables (Schwarz et al., 2021)。Therefore, the development of more appropriate life cycle assessment tools in the deceleration of carbon reduction in corporate and social research is also an important step.

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