Eco. Env. & Cons. 30 (2) : 2024; pp. (688-693)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i02.047

Plastic Pollution: A Global Crisis and the Overlooked Challenge of Low-Value Plastics

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(Received 6 October, 2023; Accepted 2 December, 2023)

ABSTRACT

Plastic pollution has become a global crisis, affecting diverse ecosystems from deserts to oceans and posing ecological and health risks. The excessive production and use of non-sustainable plastics have resulted in the creation of massive quantities of plastic waste, including microplastics. These pollutants have infiltrated the environment and food chain, endangering human health. Different categories of plastic pollution, such as macroplastics, microplastics, and nanoplastics, have varying impacts and associated risks. Managing plastic waste is a pressing global concern, with low value plastics like Multi-Layered Plastic (MLP) and soft plastics often overlooked. Due to their complex composition and recycling challenges, these materials frequently pollute waterways and oceans. Auditing low-value plastics is crucial for understanding the extent of this issue, its environmental consequences, and the feasibility of recycling solutions. Such audits inform policy decisions, recycling strategies, and conservation efforts, vital for mitigating the impact of low value plastics on the environment. Plastic pollution demands immediate attention and sustainable management to safeguard our planet's health.

Keywords: *Low value plastics, Auditing, Plastic pollution, Single-use plastics, Multi-Layered Plastic (MLP),*

Introduction

Plastic pollution spans the globe, manifesting in diverse environments, ranging from deserts to farms, mountaintops to the ocean's depths, tropical landfills to Arctic snowfields. Plastic pollution has a cascading ecological impact from land to sea to atmosphere, revealed through keyword clustering (Wang *et al.,* 2023). Unsustainable plastic production and usage have led to a surge in global plastic pollution, including the formation of micro (nano) plastics that threaten environmental sustainability (Walker *et al.*, 2023). Plastic particles and other pollutants from plastics are present in our environment and the food chain, creating a potential hazard to human health (Moshood *et al.*, 2022). The varying physical and chemical attributes among distinct size categories of plastic pollution (macroplastics, microplastics, and nanoplastics) will lead to divergent outcomes and associated risks (Mitrano *et al*., 2021). Plastic waste management is a pressing global concern, with an often-overlooked facet being the auditing of low-value plastics. While plastics with value to local recyclers are diligently collected, low-value plastics like Multi-Layered Plastic (MLP) and soft plastics are frequently left unattended. This oversight results in dumping these materials at convenient local spots, contributing significantly to environmental pollution, particularly in waterways and oceans. Low-value plastics pose a unique challenge due to

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their classification, where the cost of collecting and processing exceeds the revenue from reclaimed plastic sales. This category encompasses notoriously tricky materials, such as MLP and soft plastics, with their intricate compositions and economic inefficiencies in recycling processes. The complex nature of low-value plastics hampers their efficient management, and their unchecked presence in the environment necessitates urgent attention. Auditing these materials provides a valuable tool for understanding the extent of the issue, its environmental ramifications, and the economic viability of recycling solutions. Such audits are pivotal in informing policy decisions, recycling strategies, and consumer awareness campaigns, essential in mitigating low-value plastics' detrimental environmental impact.

Literature review

Plastic Crisis

Plastic is a versatile and ubiquitous synthetic polymer, giving it incredible durability, solid and rigid. Plastic materials are synthetic polymers widely used in different fields due to very high specific strength, comparable thermal stability with excellent chemical resistance, low cost and high lightweight compared to any other object (Chowdhury *et al.,* 2021). The unique characteristics of plastic make a long array of products (Andrady and Neal, 2009). This range of properties and low cost has driven worldwide demand for plastic (Anthony *et al.,* 2009). Plastic is employed in various applications, i.e., packaging industries, agriculture, and household practices (Pathak *et al*., 2017). The convenience of plastic in its use, production, cost, and properties is expected to double in the next two decades (Ryan, 2015).

From 1950 to 2015, the world produced a staggering 6.3 billion tonnes of plastic waste, of which approximately 9% were recycled, 12% incinerated, and the remaining 79% either stored in landfills or released into the natural environment (Rhodes, 2018). Globally, plastic makes the third highest waste. This is due to the increase in the global population and per capita consumption (Chen *et al*., 2021). Plastic waste takes centuries to degrade. Microorganisms cannot quickly degrade it (Sharmila Devi *et al*., 2019). End-of-life fate is lacking for plastic (Geyer *et al.,* 2017). After the turbulent period of plastic manufacturing due to COVID-19, global plastics manufacturing is bouncing back (Plastic Europe, 2022). In India, the details provided by 35 states/union territories estimated plastic waste generation is approximately 34 69,780 TPP during 2019-2020 (CPCB Report 2020).

The invention of single-use plastic for the modern "throwaway society" is intended to be used only once. This mainly includes packaging material (Chen *et al*., 2021). The packing material is a boon for packing industries; however, more than half of the plastic material can be used only once (Jain *et al.*, 2022). Single-use packages generate several billions of tons of garbage to date, which pollutes the environment (Dey *et al*., 2021). In the case of the food industry, plastic packaging is ubiquitous because it has a significant role in reducing food waste (Barlow & Morgan, 2013). The prolonged life of plastic due to its additives can contaminate air, water, soil, and food through the packaging (Hahaladakia *et al*., 2018).

Plastic pollution in the soil causes a significant threat to soil fertility and soil health, and it will affect food security and human health (Horton *et al*., 2017). In the case of the agriculture field, plastic mulch is a severe issue and a significant concern regarding soil pollution (Chae *et al*., 2018). In recent years, plastic pollution has led to micro-level plastic granules in cosmetics as scrubbers other than the small plastic fragments derived from the breakdown of macro plastics (Derrick, 2002). The microplastics in soil affect the bulk density, water-holding capacity, hydraulic conductivity, soil aggregation and microbial activity (De Souza Machado *et al*., 2018). Plastic in the soil affects bacteria and fungi (Udochukwu *et al.,* 2021). Most waste reaching landfill sites will take up to 1,000 years to degrade; during this time, toxic substances will leach into the soil and water (Tudor *et al*., 2019). The current database on soil pollution with plastic is still poor (Blasing and Amelung, 2018).

Plastic enters the marine environment through runoff (Auta *et al*., 2017). Plastic is widely dispersed in the ocean, including deep sea (Chiba *et al.,* 2018). Approximately 150 million tonnes of plastic waste are believed to reside in the world's oceans (Ellen et al. Foundation, 2017). Plastic takes much more time to degrade in water than on land because of reduced UV exposure and lower temperature (Gregory and Andrady, 2003). Therefore, it causes a rapid increase in plastic debris in the ocean (Ryan and Moloney, 2015). Marine organisms are affected mainly by the entanglement and ingestion of plastic (Derrick, 2002). The primary consumers consume microplastic in the aquatic ecosystem (Wright *et al*., 2013). It will accumulate different trophic levels in the food chain (Law and Thompson, 2014). The global release of primary microplastic in the world's oceans was evaluated as every human tossing one conventional light grocery plastic bag per week into the ocean (Boucher *et al*., 2017)

The current production and use of plastic will result in 12000 Mt of plastic waste in landfills or the environment by 2050 (Plastic Europe, 2022). The incineration of plastic waste in an open field is a significant source of air pollution. The release of toxic substances such as dioxins, furans, mercury, and polychlorinated biphenyls poses a threat to vegetation, human and animal health, as well as the environment (Verma *et al*., 2016). Micropollutants are identified in food and air samples, and their ingestion and inhalation lead to adverse effects on human health (Karbalaei *et al*., 2018).

Low Value Plastics: Recycling Dilemma

Plastics that have value for local recyclers are collected, often by informal waste workers, while low value plastics like MLP and other soft plastics are not. Instead, uncollected soft plastics are dumped at a convenient local spot and left to pollute the environment. This process often leads to waterways becoming choked with plastic waste and waste washing into the ocean. In this scenario, we should know what low value plastic is and why this is abounded by the recyclers.

Low value plastic, or LVP, describes plastics where the cost of collecting and processing waste exceeds the revenue from selling the reclaimed plastic. This classification varies by location and often pertains to plastics that are universally hard to recycle, like Multi-Layered Plastic (MLP) and soft plastics. Due to their complex composition, materials like Multi-Layered Plastic (MLP) and soft plastics pose recycling challenges. MLP, with its multiple layers of various materials, including aluminum, plastics, and paper, offers strength and lightweight packaging but demands an energy-intensive separation process for recycling. The recycling cost exceeds the material's value, categorizing it as 'low value' plastic.

Similarly, soft plastics, comprising diverse plastic types, face cost inefficiencies in collection and separation. Rather than expensive separation, they are often 'downcycled' into lower-value products unsuitable for food packaging (King, 2023). Consequently, multilayer plastic typically finds its way into mixed plastic waste streams and ends up in landfills. This low value plastic (LVP) classification is primarily due to the circumstances above. Furthermore, plastic waste not separated from other refuse, entailing additional preparatory procedures like sorting, cleaning, washing, and drying prior to processing, is also categorized as low-value plastic.

Multilayer plastic packaging offers a versatile solution for various packaging needs and purposes. It imparts enhanced functionality to packaging by leveraging its multilayer structure, enabling the package to fulfill a combination of functions that single-layer packaging cannot achieve. While it may involve additional processing costs to create a more intricate structure, the cost remains significantly lower than replicating the same functions using single-layer materials (Morris, 2022).

Meanwhile, the recycling of multilayer plastic presents a significant challenge. A primary issue stems from the contamination caused by various polymer types within multilayer plastics, each potentially possessing distinct physical properties, such as varying melting points. This property divergence can create complications when attempting to recycle multilayer plastics mechanically. Additionally, the nature of multilayer plastic, characterized by its low price and lightweight nature, tends to avoid attracting informal waste pickers, further contributing to the recycling challenge (GA Circular, 2017).

Multilayer plastics exhibit enhanced barrier characteristics, effectively resisting moisture, oils, air, and odours. The aluminum's highly reflective surface adds to its consumer appeal. However, multilayered plastics, particularly in sachets, pose significant challenges for recyclers owing to their composition, lightweight nature, and small dimensions. These plastics are unlikely to be collected by waste pickers (Halim *et al*., 2018). Multilayer plastic is typically not gathered for recycling (Hahladakis and Iacovidou, 2018).

The challenges posed by Low value plastics (LVP) due to their unique properties, such as multilayer composition, complicate recycling. The study aims to identify and assess potential solutions for managing LVP waste. Interviews with material and energy recovery experts from plastic waste were conducted to evaluate available technology options. Three promising options emerged: conversion to plastic lumber, refuse-derived fuel (RDF) production, and conversion to plastic products. These options are technologically mature and locally available but face challenges such as branding and marketing, government endorsement, and cost-effective collection (Soemadijo *et al*., 2022).

Research examining trends and prospects in multilayer plastic recycling technology predicts significant advancements, particularly within high-income nations, over the next five to ten years. These developments are anticipated to encompass cutting-edge sorting techniques and chemical recycling methodologies, some of which have already made substantial progress in various European countries. Additionally, downcycling is a viable approach to mitigate plastic release into the environment. Technology solutions can be customized to align with local capabilities, regulatory frameworks, investment opportunities, and priorities (Soares *et al.,* 2022).

Until now, multilayer film packaging waste has consistently posed a challenge for recycling and has often been directed toward landfills. However, recycling multilayer films can become achievable through various adaptations. For instance, enhancing their electrical resistance can be achieved by modifying multilayers with polyethylene. Alternatively, incorporating fly ashes can ensure the dimensional stability of products, particularly for precision items. These composite materials can be processed using methods commonly employed for thermoplastic materials, such as injection moulding, extrusion, and pressing (Tartakowski, 2010). Purchasing plastic credits from a United States bottling company from an offset project that funds low-value plastic recovery in India does not reduce the plastic waste generated or littered within the United States (Moon, 2022).

Unlocking the Potential: Auditing Low-Value Plastics for a Sustainable Future

By focusing on these often-overlooked plastics, audits can shed light on the challenges posed by their disposal and contribute to more effective waste management strategies. Auditing of low-value plastic is undeniably relevant in addressing pressing environmental and waste management challenges. From the light of the literature review, low-value plastics like Multi-Layered Plastic (MLP) and soft plastics often escape the attention of recyclers due to their recycling complexities and limited economic worth. While inexpensive and convenient for packaging, these plastics pose significant environmental hazards when left uncollected. The process of low value plastics ending up in local dumping sites and, eventually, polluting waterways and oceans underscores the urgency of auditing these materials. Such audits provide invaluable insights into the extent of this issue, the environmental consequences, and the economic feasibility of recycling these materials. This information, in turn, informs policy decisions, recycling strategies, resource conservation efforts, and consumer awareness campaigns, all of which are essential in tackling the challenges posed by low-value plastics and mitigating their detrimental impact on our environment.

Conclusion

With its unique properties, plastic has become a versatile and indispensable synthetic polymer across various industries, including packaging and agriculture. Its affordability and durability have fueled its global demand. However, the alarming levels of plastic waste generated between 1950 and 2015 paint a troubling picture, with only a fraction being recycled or incinerated, while the majority finds its way into landfills or the natural environment. The widespread use of single-use plastic and plastic packaging has resulted in billions of tons of waste, severely impacting the environment, soil fertility, soil health, and human well-being. In the marine realm, plastic pollution has led to the entanglement and ingestion of plastic by marine life, causing it to permeate different levels of the food chain. If the current trajectory of plastic production and usage persists, we will witness an alarming accumulation of 12,000 million metric tons of plastic waste in landfills and the environment by 2050.

In this context, the significance of auditing low-value plastics, a facet often marginalized in plastic waste management, cannot be overstated. The data presented in this review underscore the critical nature of this issue. Low value plastics, exemplified by materials like Multi-Layered Plastic (MLP) and soft plastics, routinely escape the attention of recyclers due to their intricate composition and limited economic value. Notwithstanding their economic challenges, these plastics pose substantial environmental threats when left unattended, culminating in their disposal at local dumping sites and eventually contaminating waterways and oceans. Audits serve as invaluable tools, offering insights into the magnitude of this problem, its environmental repercussions, and the potential for economically feasible recycling solutions. With this knowledge, stakeholders can make informed policy decisions, implement targeted recycling strategies, champion resource conservation, and spearhead consumer awareness campaigns. These efforts are indispensable in confronting the quandary of low value plastics and mitigating their adverse environmental impact. Recognizing auditing's pivotal role in addressing these challenges is imperative as we strive to foster a more sustainable approach to managing plastic waste.

Acknowledgement

The authors greatly acknowledge the help and support extended by the Management of All Saints' College, Thiruvananthapuram, Kerala, for completing this review article.

Conflict of Interest

The authors declare that no conflict of interests exists.

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