SPECIAL SYMPOSIA | POLYMERS IN THE SUSTAINABLE DEVELOPMENT GOALS OF THE UNITED NATIONS

Plastics and the United Nations Sustainable Development Goals

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Abstract: Recent literature on the role of plastics in achieving the United Nations Sustainable Development Goals (SDGs) was analyzed. Despite contributing to the accomplishment of at least 15 SDGs, plastic pollution, especially marine pollution, outweighs the positive contributions of plastic to accomplishing the 2030 Agenda. The study, however, emphasized the vital importance of the circular economy, highlighting practices such as recycling as viable solutions to the socio-environmental problems that may be created by plastics.

Keywords: Sustainable Development Goals, SDGs, Plastic, Pollution, Circular Economy, Recycling

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Introduction

Plastics are ubiquitous in the global economy. However, we must consider the adverse effects of our throwaway culture and poor waste management practices to balance out any benefits that plastics may provide. We cannot ignore the fact that improper disposal of plastic waste has led to an increase in water pollution. It is a delicate balance that we need to maintain for the well-being of our planet.

Plastic significantly impacts our societal lives and the progress and attainment of the 2030 Agenda for Sustainable Development. During the Rio+20 Conference in 2015, the 2030 Agenda for Sustainable Development was deliberated, leading to an action plan comprising 17 Sustainable Development Goals (SDGs) [1]. Previous research [2] suggests that the negative impact of plastic pollution (primarily marine pollution) on the 2030 Agenda outweighs its positive contributions to achieving at least 15 SDGs.

To demonstrate the impact of plastic on the achievement of the UN SDGs, a bibliometric analysis and mapping of the data obtained from a Scopus search on the subject was conducted. Trends, directions, and gaps were identified.

Methodology

A search in the Scopus database was performed on April 29, 2024, to record the data inputs. The terms used in the search were (sustainable development goal* OR SDG*) and (plastic* OR polymer*), searching within article titles, abstracts, and keywords.

Subject areas such as biochemistry, genetics, molecular biology, immunology, microbiology, and medicine often employ specific terminology, such as "SDG*," which has a distinct meaning unrelated to the 2030 Agenda. So, these subject areas were excluded.

Articles and reviews in English from 2020 to 2024 were considered to assess the literature on the subject concerning previous works [2,3]. The data was exported to a.csv file, which was examined using the R-package Bibliometrix and VOSviewer version 1.6.18. Graphs were created in Biblioshiny for Bibliometrix and VOSviewer. The network generated by VOSviewer displays 47 keywords with at least five occurrences, and the full counting approach was applied.

Results and Discussion

The Scopus search resulted in 622 publications in English, including 452 articles and 170 reviews. Figure 1 demonstrates the evolution of the number of publications per year. Comparing this result with a previous publication [3], there has been a significant increase in the number of publications per year. In the present work, the annual growth rate is of 18.67%.

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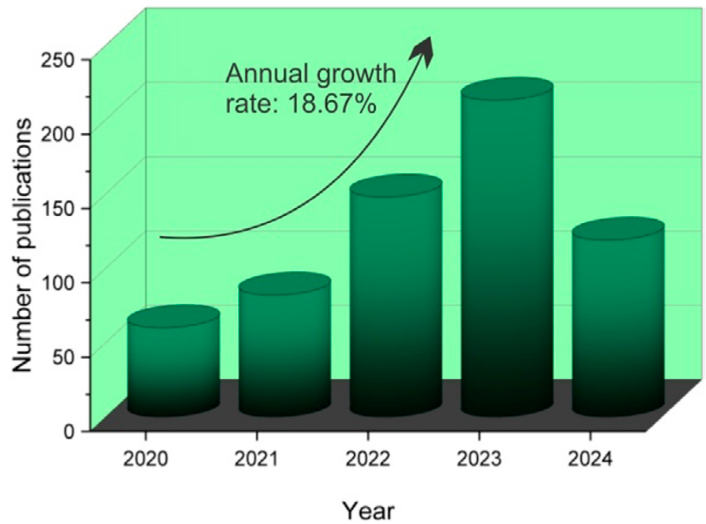

Figure 1. Evolution of the number of publications per year.

This is a multidisciplinary research area, and the fields with the highest number of publications are Environmental Science (283), Materials Science (173), Engineering (137), Energy (124), and Chemistry (122). There has been a shift in the profile of the areas with the highest number of publications compared to the results obtained in the 2020 Scopus database search [3]. Environmental Science, Chemistry, Chemical Engineering, Materials Science, and Agricultural and Biological Sciences had the highest number of publications in 2020.

Keyword analysis is crucial for identifying research trends, directions, and gaps in a research field. Figure 2 shows word clouds comprising the 50 most frequent authors' keywords from the Scopus searches performed in 2020 [3] and 2024. The frequency of a keyword is proportional to the size of its letters.

In 2020 (Figure 2[a]), the most frequent authors' keywords were (number of occurrences in parenthesis) sustainable development goals (11) (it is not shown in Figure 2[a]), circular economy (7), sdgs (4), sustainability (4), life cycle assessment (3), green chemistry (2), India (2), marine debris (2), optical properties (2), and polymers (2). On the other hand, in 2024 (Figure 2[b]), from a total of 2,319 authors' keywords, the most frequent are (number of occurrences in parenthesis) sustainability (70), sustainable development goals (52), circular economy (47), sustainable development (31), plastic pollution (26), life cycle assessment (22), waste management (21), recycling (19), microplastics (18), and plastic waste (17). The number of occurrences of the keywords in Figure 2(a) is lower than those in Figure 2(b) because the search in the Scopus database in 2020 resulted in fewer publications. The available literature on the subject increased significantly in the search conducted in 2024.

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Figure 2. Word clouds comprising the 50 most frequent keywords from the Scopus searches performed in 2020 (a) and in 2024 (b).

By comparing the word clouds (Figures 2[a] and [b]), current literature trends differ from those in 2020. Recent research has increasingly revealed the significance of the circular economy and life cycle assessment regarding the impact of plastic on the SDGs. Current literature provides evidence of the pollution caused by plastic. This literature mainly focuses on the adverse impacts of microplastic (MP) pollution [4] on the environment.

The co-occurrence network of the 47 main authors' keywords is displayed in Figure 3. The keywords are divided into 7 clusters, each marked with a different color. The network has 208 links, with a total link strength of 377.

Each cluster represents a specific direction within the subject area. The red cluster, which has 13 items and focuses on applications, contains the majority of the items. The green cluster focuses on life cycle assessment and has 10 items. The blue cluster has 9 items and is about plastic pollution. The yellow cluster is about biomass and contains 5 items. The purple cluster focuses on geopolymers and consists of 5 items. The light blue cluster consists of 3 items and focuses on the circular economy. The orange cluster is about biopolymers and contains 2 items.

The keyword 'circular economy' (the largest light blue circle) holds a central position in the network, representing a crucial factor in plastics' role in achieving the SDGs. According to Maaskant et al. [5], decoupling from fossil feedstocks, optimizing recycling strategies, and manufacturing less frequently discarded items from easily biodegradable materials are crucial steps in establishing a renewable circular economy for thermoplastic polymers. Based on this, some examples from the literature will be briefly described below.

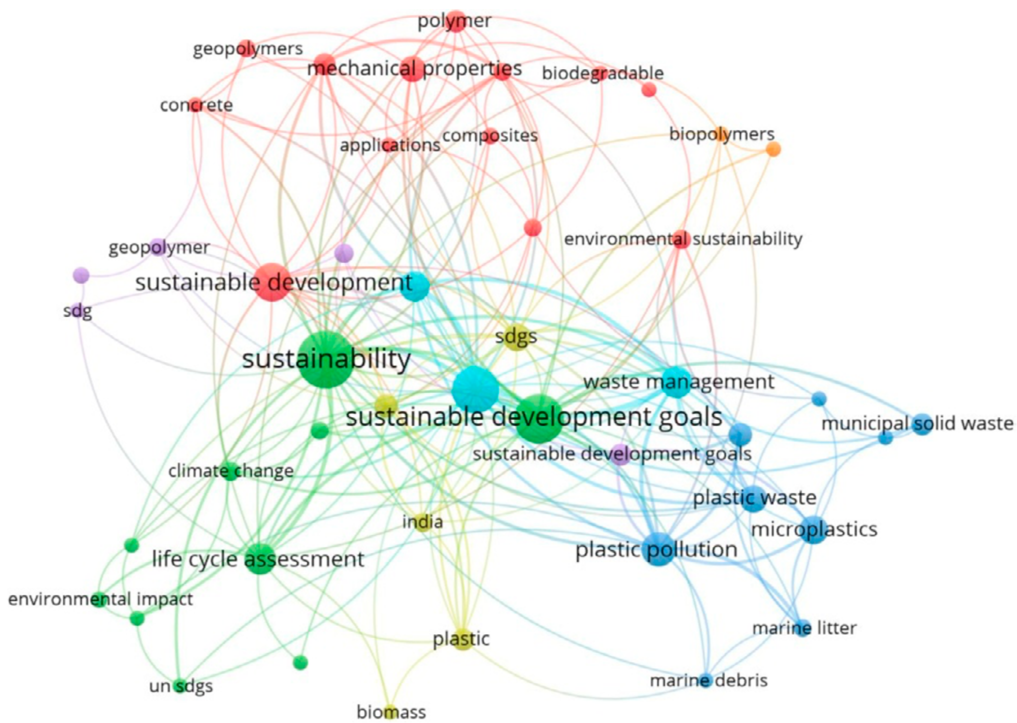

Figure 3. Co-occurrence network of the 47 primary authors' keywords.

As potential alternatives to the polymers currently used in packaging, literature suggests using edible pectin-alginate films reinforced with orange peel powder [6]. Additionally, Salas et al. [7] discussed the possibility of using "Nejayote," a byproduct of the maize snack industry, as a compound to create a new sustainable bioplastic. Some authors [8] have demonstrated that an azido triazine-based grafting agent enables polyolefin blends to be directly converted into high-performance materials through reactive extrusion at processing temperatures commonly used in the industry. Other authors have studied the properties of recycled composites and have developed composites incorporating recycled materials [9-14] for diverse applications. Some authors [15] used ground tire rubber (GTR) to produce GTR-based composite material using a fused filament fabrication desktop 3D printer, thereby enhancing damping properties.

The connections among specific keywords in the network shown in Figure 3 will be analyzed in Figure 4.

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When considering the keyword 'sustainable development goals' (Figure 4[1]), it is important to examine the connections between it and the keywords 'circular economy' and 'waste management'. These links are highly interconnected and frequently co-occur in publications. No correlation was found between the keywords 'waste management' and 'sustainable development goals' in the database search conducted in 2022 [2]. Hence, this recent correlation suggests that effective waste management strategies are crucial for achieving the SDGs.

Despite their relative distance, the concepts of 'circular economy' (Figure 4[2]), 'waste management', and 'recycling' are intricately connected and have a high total link strength of 10 and 11, respectively. Furthermore, they belong to the same cluster, suggesting their interdependence in advancing the circular economy of plastics. The distance between the 'circular economy' and the keywords of the application cluster (the red cluster) is worrisome. This indicates that more literature is needed in this area to enhance it. Mere recycling is insufficient; the crucial issue lies in developing viable applications for recycled materials. Therefore, current literature fails to address the potential of recycled plastics to contribute to the circular economy of plastics, which represents a gap.

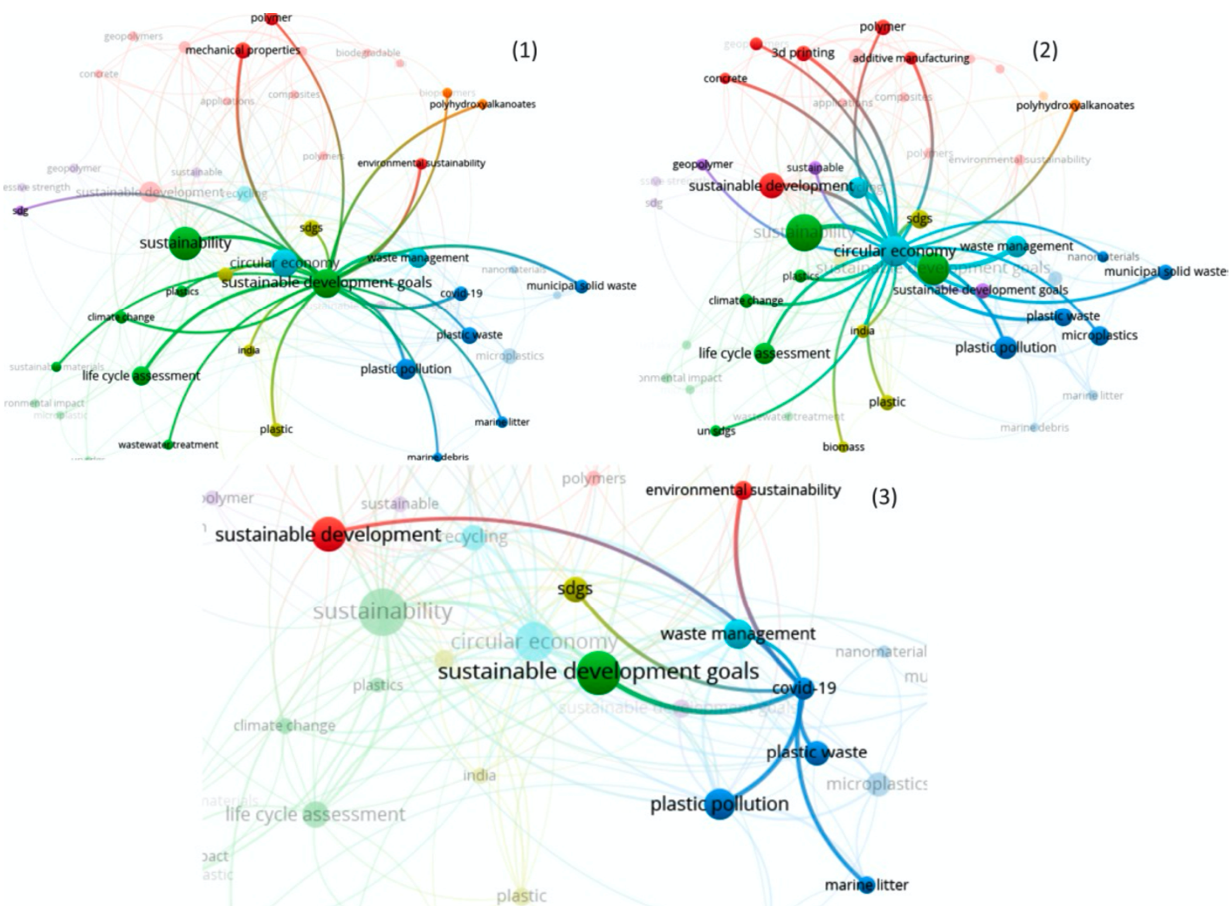

Figure 4. Connections among the keywords: Sustainable development goals (1), circular economy (2), and COVID-19 (3).

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Regarding the keyword ‘covid-19’ (Figure 4[3]), it is established that the COVID-19 pandemic contributed to plastic pollution [16-18]. Due to the restrictions imposed, the number packaging waste generated at home has increased as a result of internet or app purchases and deliveries. However, the lockdown impacted the recycling sector and waste management systems as a whole [19,20]. At the same time, using personal protective equipment, particularly face masks, was essential, and their improper disposal contributed to increased plastic pollution. Literature confirmed the release of MP from face masks [21,22]. MP pollution directly or indirectly affects at least 12 SDGs [23]. Although the literature proposes solutions to the residues generated during the COVID-19 pandemic [24-26], overall, it has negatively and significantly impacted progress towards achieving the SDGs.

Conclusion

In this study, a bibliometric analysis and mapping of the data retrieved from a Scopus search was conducted on the role of plastic in achieving the UN SDGs. The main trends are the circular economy and life cycle assessment. The directions are applications, life cycle assessment, plastic pollution, biomass, geopolymers, circular economy, and biopolymers. Plastic recycling is essential for the circular economy of plastic; however, literature has demonstrated a gap in recycled plastic applications. These observations are crucial for mitigating the socio-environmental issues that plastics may cause and are a significant ally in achieving the UN SDGs. These results not only contribute to current understanding but also inspire and guide future research efforts on the role of plastics in achieving the UN SDGs.

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