

A REVIEW OF THE SUSTAINABILITY - CIRCULAR ECONOMY IN THE PHARMACEUTICAL INDUSTRY

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Abstract. *Climate change, the number of the global population, and the diversity of activities with an impact on the planet have been on an upward slope, which requires taking preventive measures and changing from a social, economic, and environmental perspective, thus meaning that the adoption of a sustainable lifestyle is necessary. This study provides a review of the literature on the adoption of the circular economy and sustainability concepts in the pharmaceutical manufacturing sector. This study aims to qualitatively assess the need to implement sustainability in the pharmaceutical industry, given that the latter has a significant environmental impact on human existence. In this study, the "Web of Science," "Scopus," databases, and "Springer Publishing" are used, from which works are extracted based on the keywords sustainability in the pharmaceutical industry and circular economy in the pharmaceutical industry, following the evolution of works written in the last ten years on this topic. The most relevant approaches of the authors to this topic are presented. It can be seen that this topic is one discussed by an important category of researchers, especially in countries where the need for medicines is greater due to the standard of living, such as those in Asia, for example. The research can also be extended to other databases using the same keywords or words related to sustainability or circular economy in the pharmaceutical industry.*

Rezumat. *Schimbările climatice, numărul populației globale și diversitatea activităților cu impact asupra planetei sunt pe o pantă ascendentă, ceea ce impune luarea de măsuri preventive și schimbarea din perspectivă socială, economică și de mediu, ceea ce înseamnă că este necesară adoptarea unui stil de viață durabil. Prezentul studiu oferă o analiză a literaturii de specialitate privind adoptarea conceptelor de economie circulară și sustenabilitate în sectorul producției farmaceutice. Acest studiu urmărește să evalueze calitativ necesitatea implementării sustenabilității în industria farmaceutică, având în vedere că aceasta din urmă are un impact semnificativ asupra mediului și asupra existenței umane. În acest studiu sunt utilizate bazele de date „Web of Science”, „Scopus” și „Springer Publishing”, din care sunt extrase lucrări pe baza cuvintelor-cheie sustenabilitate în industria farmaceutică și economie circulară în industria farmaceutică, urmărindu-se evoluția lucrărilor scrise în ultimii zece ani pe această temă. Sunt prezentate cele mai relevante abordări ale autorilor cu privire la acest subiect. Se poate observa că acest subiect este unul discutat de o categorie importantă de cercetători, mai ales în țările în care nevoia de medicamente este mai mare datorită nivelului de trai, cum sunt cele din Asia, de exemplu. Cercetarea poate fi extinsă și la alte baze de date care utilizează aceleași cuvinte-cheie sau cuvinte legate de durabilitate sau economie circulară în industria farmaceutică.*

Keywords: sustainability, environment, evolution, economic, social.

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1. Introduction

In recent years, companies have relied on the use of the circular economy concept to become more sustainable. The circular economy is based on reducing, reusing, and recycling. This economic model promotes the continuous use of resources and does not generate waste. Companies are starting to integrate the circular economy into their manufacturing operations to maximize sustainability. Sustainability could be enhanced throughout a product's life cycle in the pharmaceutical business by introducing circular supply chain management [1].

The concept of "end of life" is replaced by business approaches in a circular system, which minimizes, recycles, and recovers waste from the manufacturing, distribution, and consumption stages. These systems operate at the micro (products, businesses, and consumers), meso (eco-industrial parks), and macro (cities, locations, and nations) levels, among others, to accomplish sustainable development, which is based on a healthy environment, economic growth, and equitable social conditions for the benefit of current and future generations [2].

Sustainability is the systemic and balanced integration of economic, social, and environmental performance within and across generations, according to Martin Geissdoerfer et al. Rather than merely establishing shared objectives, sustainability creates room for a range of expectations about what should be created and maintained, for how long, and for whose benefit [3].

Circular economy, on the other hand, is an ecological system that slows, stops, and limits material and energy flows to reduce the consumption of resources and pollution. Design, maintenance, repairs, repurposing, remanufacturing, reconditioning, and recycling can all help achieve this [3].

The study's methodology, results, and conclusions are described in the sections that follow. A review of the literature is also included.

2. Methodology

A review of the literature was carried out to look at publications that have been published about interest, sustainability, and the circular economy in the pharmaceutical industry. Well-known databases, such as "Scopus," "Web of Science," and "Springer Publishing," were utilized to extract the works that best highlighted the issue of interest. An average of 100 works were examined chronologically to track the evolution of publications published in this study area. Some of the works found in the literature, 2012-2023, are listed. Referring to another review of the literature with an impressive number of works, the evolution of the writings on this topic of the circular economy in the period 2017-2023 was graphically represented.

3. Literature review

In their study, Khan F. et al. examined the literature on the difficulties that the pharmaceutical industry might encounter in the process of implementing a circular economy. They then conducted interviews with employees of Pfizer, Servier, and Martin Dow in the pharmaceutical industry. Semi-structured interviews were used to explain the ideas of the circular economy and its application to supply chain management [1]. Table 1 is a list of the barriers that have been identified and their descriptions.

Table 1. Khan F.'s (2022) list of the biggest obstacles preventing the pharmaceutical industry from adopting the idea of the circular economy [1].

Barriers identified in pharmaceutical industries	Description
The lack of financial resources and financing	Expensive production costs, investments in environmentally friendly methods, and implementing circular economy concept;
Social challenges	The general population is not motivated to embrace circular economy practices and is unaware of them;
Market challenges	Insufficient green and high-quality suppliers, as well as competition from the pharmaceutical sector;
Insufficient cooperation and synchronization within the supply chain system	Not enough collaboration between producers, distributors, healthcare providers, pharmacies, and patients, among other supply chain participants;
Limited expertise, technology, and information	Information sharing across the pharmaceutical sectors, hiring qualified workers, conducting research and development, utilizing technology, and exchanging knowledge;
Absence of inventory and production planning	Overproduction and expired medications result from the supply-demand imbalance being disrupted by a lack of demand forecasting;

leadership and cultural values	Inadequate support from senior management and models of the circular economy that are either insufficient or nonexistent;
Difficulty with supply chain visibility	Because of its complexity, keeping an eye on the whole pharmaceutical supply chain is difficult;
Low shelf life of medicines	Low quality and quick expiration of medications;
Ineffective waste segregation	Hospital waste and pharmaceutical waste are divided inefficiently.

According to Kirchherr (2017), the pharmaceutical business is a major generator of waste with a high level of toxicity. As such, the 9Rs of the circular economy model can be applied there [2], Figure 1.



Fig. 1. The 9Rs of the circular economy by Kirchherr [2]

Analyzing the 9Rs: rethink (using the product continuously), reduce (using raw materials more wisely), reuse (utilizing the item by distributing), repair (repairing the item rather than discarding it), refurbish (restoring an old product), remanufacture (using elements from trashed goods and producing a new item for the same purpose), repurpose (utilizing components of dropped items to make new ones), recycle (using resources to obtain the equal or reduced quality), recover (destruction for regenerating energy); we find that in the industry process, important sustainability concepts include energy conservation and energy efficiency, community investment, waste reduction, use of renewable energy, water conservation and employee benefits.

Julian Kirchherr et. al. explores the notion of the circular economy in their work, referencing more than 100 definitions from academic literature to improve comprehension and highlight the significance of its application [2]. According to Kirchherr et al., the authors compare the circular economy to sustainability and

contend that the former relates mainly to economic prosperity, the latter to environmental quality, and the former to social factors too little [2].

Kun L.A. et al. (2021) offer the 9R framework in another way, breaking it down into three main loops: "short loop," "medium loop," and "long loop" (Kun L.A., 2021). Because resource scarcity may be addressed early on, the most popular circular economy strategies in the "short loop" are "Refuse" (R0), "Rethink" (R1), and "Reduce" (R2). In the "middle loop," the actions of "reuse" (R3), "repair" (R4), "Refurbish" (R5), "remanufacture" (R6), and "restore" (R7) can be linked to longer product lives and less frequent resource use. Within the "long loop" of the framework, "Recycling" (R8) and "Recovery" (R9) concentrate on recycling trash and recovering energy. The term "long loop" mostly describes the practice of managing and disposing of garbage in a way that minimizes its environmental impact. [4]. A new perspective on the 9Rs, according to Kun L.A. et al., is presented in Figure 2.



Fig. 2. A new perspective of the 9Rs, according to Kun L.A. et al. [4]

4. Results

A list of papers is shown in Table 2, based on the literature review, some of the most relevant titles are presented chronologically, together with the author, the journal/magazine where it is published, and the year of publication.

Table 2) The most relevant titles of works on sustainability, and circular economy in the pharmaceutical industry in the period 2012-2023

No	Author	Title	Publication	Year
1.	Ellen MacArthur Foundation	“Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition”	“Towards the circular economy” [5]	2012
2.	Kopnina, H.	“Sustainability: new strategic thinking for business”	“Environ. Dev. Sustain. 19, 27–43 (2017)”, Springer [6]	2015
3.	Rajagopal Ramachandran	“Sustainability in the Pharmaceuticals and Fine Chemicals Industry”	“Encyclopedia of Sustainable Technologies” [7]	2017
4.	Kirchherr, J. et. al.	“Conceptualizing the circular economy: An analysis of 114 definitions” “Resources, conservation, and recycling”	“Resource conservation and recycling” [2]	2017
5.	Sheldon and Roger A.	“Metrics of Green Chemistry and Sustainability: Past, Present, and Future”	“ACS Sustainable Chemistry & Engineering” [8]	2018
6.	Ana Beatriz Lopes de Sousa Jabbour et al.	“Circular economy business models and operations management”	“Journal of Cleaner Production” [9]	2019

7.	Elina Strade et. al.	“Water efficiency and safe re-use of different grades of water - Topical issues for the pharmaceutical industry”	“Water Resources and Industry” [10]	2020
8.	Kun Liang Ang et al.	“Sustainability framework for pharmaceutical manufacturing (PM): A review of research landscape and implementation barriers for circular economy transition”	“Journal of Cleaner Production” [4]	2021
9.	Khan, F. & Ali	“Implementation of the circular supply chain management in the pharmaceutical industry. Environment, Development and Sustainability”	“Environ. Dev. Sustain. 24, 13705–13731 (2022)”, Springer [1]	2022
10.	Naoum Tsolakis et al.	“Microalgae-based circular supply chain configurations using Industry 4.0 technologies for pharmaceuticals”	“Journal of Cleaner Production” [11]	2023

Kirchherr et al. (2023) perform a literature review of the works that address the subject of the circular economy and then extract the most cited works in which this concept is discussed, resulting in 221 publications [12]. Based on this study, we made a graphic representation where the situation of publications in the period 2017–2021 is exposed, according to the results obtained by Kirchherr. The peak of publications was in 2019 when most works that addressed this topic were found.

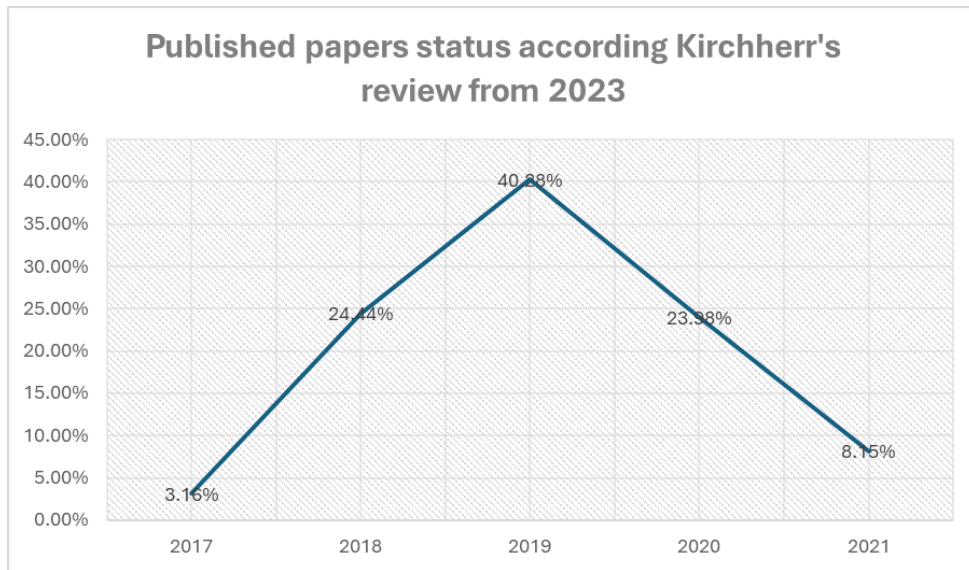


Fig. 3. Graphic representation according to Kirchherr's review from 2023

The two concepts of sustainability and circular economy have the same purpose: to enhance the durability of a good or service. These terms have different definitions in the academic literature, which leaves room for interpretation and updating. Figure 4 describes some of the definitions found in the literature, which describe both the concept of circular economy and sustainability. These two concepts are applicable in all manufacturing industries. If we talk about the pharmaceutical industry, there is perhaps a greater need to respect sustainability standards and to have a circular economy so that survival on this planet is not compromised over the years.

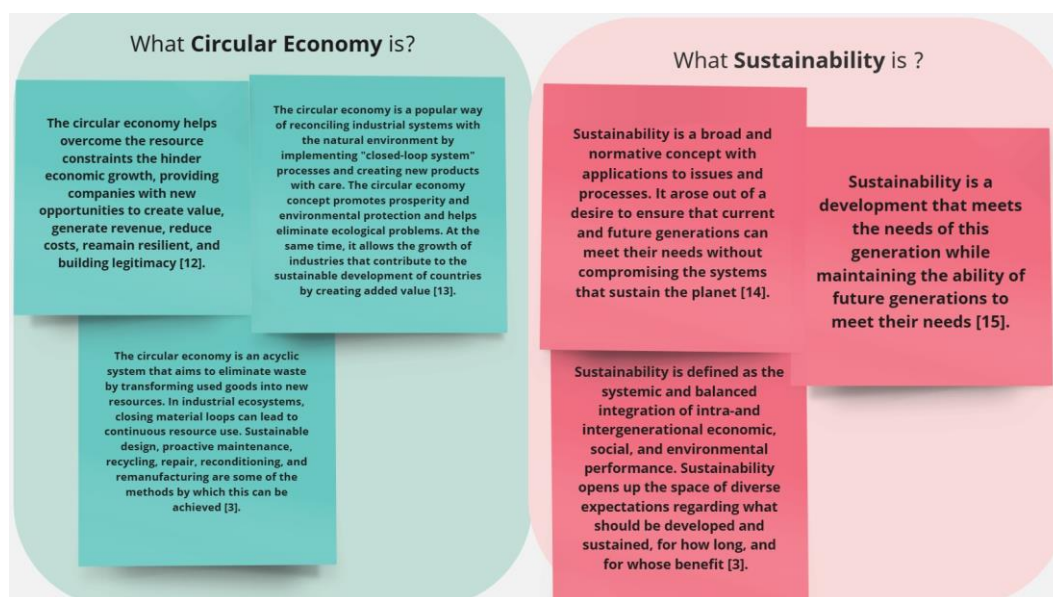


Fig. 4. Definition of Circular Economic vs Sustainability

Conclusions

In conclusion, there are an impressive number of works in the academic literature that have addressed this topic of the circular economy, or sustainability in general, in the processing industries, but also in the one of interest for our study, the pharmaceutical industry. There is no clear definition of what sustainability or circular economy means; the opinions are diverse, and the evaluation models of these concepts are also very varied. However, we note that the 9 Rs ("rethink," "reduce", "reuse", "repair", "refurbish", "remanufacture", "restore", "recycle," and "recover") of the circular economy principle can be considered the pillars of a sustainable manufacturing model [11-15]. Barriers are also identified that may exist and, at the same time, make it difficult to adopt the concept of circular economy in the pharmaceutical industry. Considering the review by Kirchherr et al. (2023), we identified a peak period in which the most publications about the circular economy appeared: 2018–2020, but most of the ones he listed in his study were published in 2019.

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