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The Environmental Impacts of Fast Fashion on Water Quality: A Systematic Review

Kerrice Bailey, Aman Basu and Sapna Sharma *

Department of Biology, York University, 4700 Keele Street, Toronto, ON M3J 1P3, Canada; kerriceb@my.yorku.ca (K.B.); amanbasu@yorku.ca (A.B.)
* Correspondence: sharma11@yorku.ca; Tel.: +1-416-736-2100

Abstract: The fashion industry is the second most polluting industry, contributing 8% of all carbon emissions and 20% of all global wastewater, with an anticipated 50% increase in greenhouse gas emissions by 2030. To gain a better understanding of the state of the academic literature on the environmental impacts of the fast fashion industry, we systematically identified 65 publications from 1996 to November 2021 that were subjected to (i) bibliometric, (ii) text, and (iii) content analysis. We found that there is a growing research interest surrounding fast fashion and water quality, with 74% of the articles published in the last 5 years, and the majority of publications and citations are from China and European countries. We summarise the evaluation of production processes, such as carbon and water footprints, along with recycling practices aimed to increase the sustainability of the fashion industry. Circular economy, social environmental responsibility, and sustainability governance are key areas for future research in this growing field.

Keywords: fast fashion; water quality; water degradation; sustainability; environmental impact; textile industry; consumer behaviour

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1. Introduction

The production of waste can contribute to a myriad of negative environmental impacts, including decreasing air and water quality. The production of wastewater and textile waste from fast fashion is no exception. The clothing and textile industries are especially notorious for contributing to environmental degradation, including greenhouse gas emissions and the generation of wastewater and solid wastes at the various stages of production and long supply chains [1,2]. Social factors, such as the growing middle class, growth of the female workforce, and growing attitudes of individuality, have resulted in room in the market for new styles of clothing that are representative of new identities [3]. As a result, about ninety percent of the world's clothing production is outsourced to low- to middle-income countries (LMICs), where these clothing articles are produced cheaply, at low quality, and are then sold at low prices for faster production and subsequent consumption [4]. The fast fashion system allows retailers to capitalise on the changes in consumer shopping behaviours, especially at the speed information and trends now have the ability to travel [5]. This business model is dependent on the desire of consumers to stay up to date with the latest fashions, thriving off constant and impulse purchases. Brands now release twice the number of collections in comparison to the pre-2000s or the beginning of the fast fashion era [6]. By keeping both the quality and cost of clothing low, consumer consumption is encouraged, which continuously promotes the early or fast disposal of clothing [1].

The United Nations names the fashion industry as the second most polluting of all industries, resulting in 8% of all carbon emissions and 20% of all global wastewater. The fashion industry is single-handedly responsible for more carbon emissions than international flights and shipping combined and uses about 93 billion cubic metres of water annually [7]. The growing world population, combined with fast fashion, has led to massive increases in textile production [8]. Per capita fibre consumption almost tripled from

1950 to 2008, increasing from 3.7 kg to 10.4 kg per person [9]. From 2007 to 2014, textile fibre production increased by an additional 20.2 million tons to 90.8 million tons, and this number is expected to grow by 3.7% compounded annually [10]. In 2015, 92 million tons of global fashion waste was produced and projected to increase by 56 million tons by 2030 [2].

Although the fast fashion industry is generally criticised for its role in creating hazardous working conditions for its workers in low- to middle-income countries, it is also important to address the environmental issues that are a result of the growing industry. The fashion industry consumes copious amounts of water and generates huge amounts of wastewater. As a result, the fashion industry is responsible for the consumption of 79 trillion litres of water annually, contributing to about 20% of industrial wastewater [6].

Although the literature extensively covers topics surrounding water treatment options and textile effluents, (i.e., [11–13]) to our knowledge, a quantitative analysis of the current status of research on the role of the fast fashion industry in water quality has not yet been assessed. Our primary objective for this study was to systematically review the literature to identify the research already conducted on the textile, garment, and fast fashion industries and their impacts on water quality. From an analysis of 3315 papers, we identified 65 relevant studies in the field by using bibliometric, text, and qualitative content analysis to gain a clearer picture of the state of fast fashion and the effects of this industry on environmental and water degradation.

2. Materials and Methods

There were 4 major steps used in this systematic review (Figure 1). First, the literature to be reviewed was identified using a Web of Science (WoS) search tailored to the topic. Search terms that encompass all other relevant topics under the major umbrella topic were gathered in order to curate a comprehensive set of articles relevant to the topic of study (e.g., clothing, environment, and garment). The aim was to conduct a search that was sufficiently large as to be comprehensive but also completely centred on the topics at hand. The topic search (TS) option of Web of Science looks up the search terms in the title, abstract, author keywords, and Keywords Plus fields of the Web of Science database [14,15]. The search query used for obtaining the primary dataset is given below:

(TS) = (Garment OR apparel OR fashion OR cloth* OR textile OR fabric AND TS = (Wastewater or "wastewater" OR water) AND TS = (industr* OR commercial OR sector) AND TS = (environmen* OR climate OR sustainab*).

The search was conducted on 20 October 2021 and resulted in 3315 articles to be analysed. Next, the titles and abstracts were screened for relevance to the nature of the review using inclusion and exclusion criteria. Articles were excluded if they were unrelated to (fast) fashion or the textile industry, focused solely on wastewater treatment methods, focused on dyes or did not make some connection between the textile industry and water quality or environmental effects. A total of 47 articles were selected from the Web of Science records. An extra 18 were added from the references of the highly cited articles, resulting in a final dataset of 65 articles deemed relevant to be analysed. To visualize trends in the number of papers published annually, we plotted the number of publications by year spanning from 1996 to November 2021 (Figure 2).

Subsequently, the complete records for these articles were obtained from Web of Science, and a bibliometric analysis was performed using the Bibliometrix package in the R statistical environment [16,17]. To gain insight into the patterns in publications, a 3-Field Plot Sankey Diagram (Figure 3) was constructed using the author country, author keywords, and source of publication with 10, 10, and 50 items in each field, respectively. This plot summarises the relative importance of topics, the country doing the research, and the journals in which the works were published, using thicker rectangles for greater frequency, and multiple thick inflows and outflows to indicate more connections.

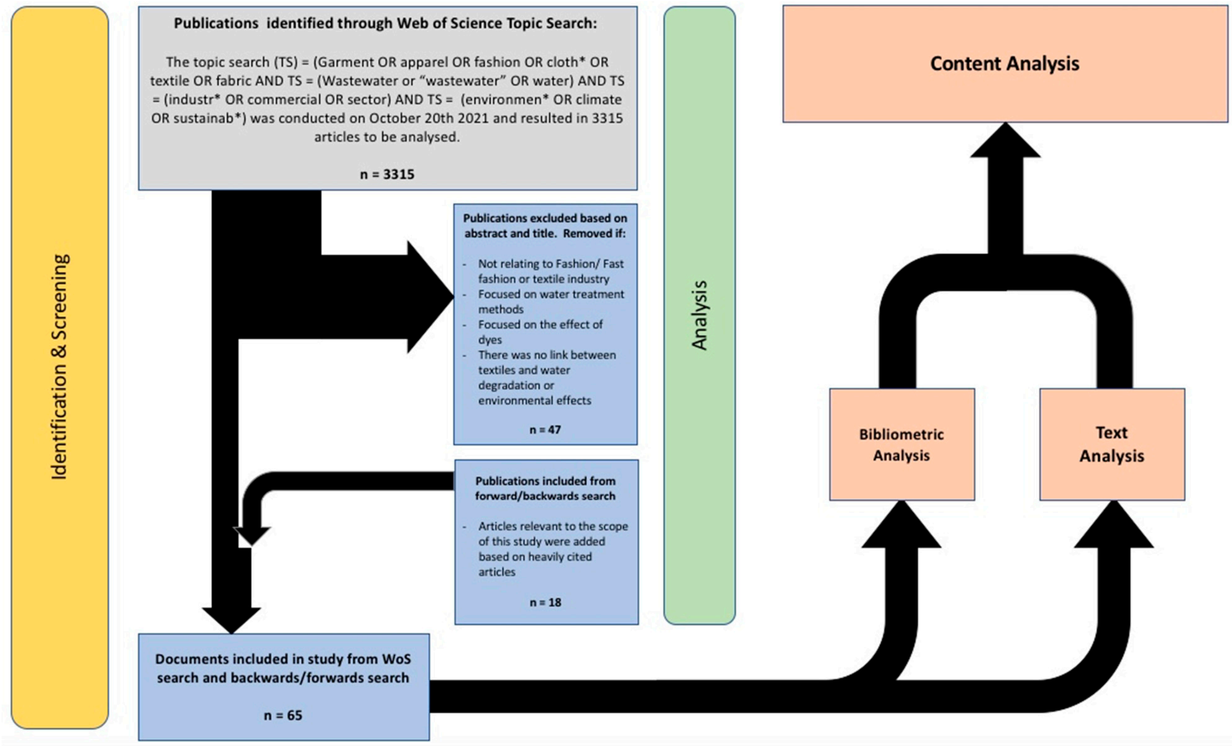

Figure 1. Flow chart summarising the systematic review process used in this study; this includes the search key for the identification of articles, exclusion criteria, supplemented studies, and subsequent bibliometric, text, and content analyses.

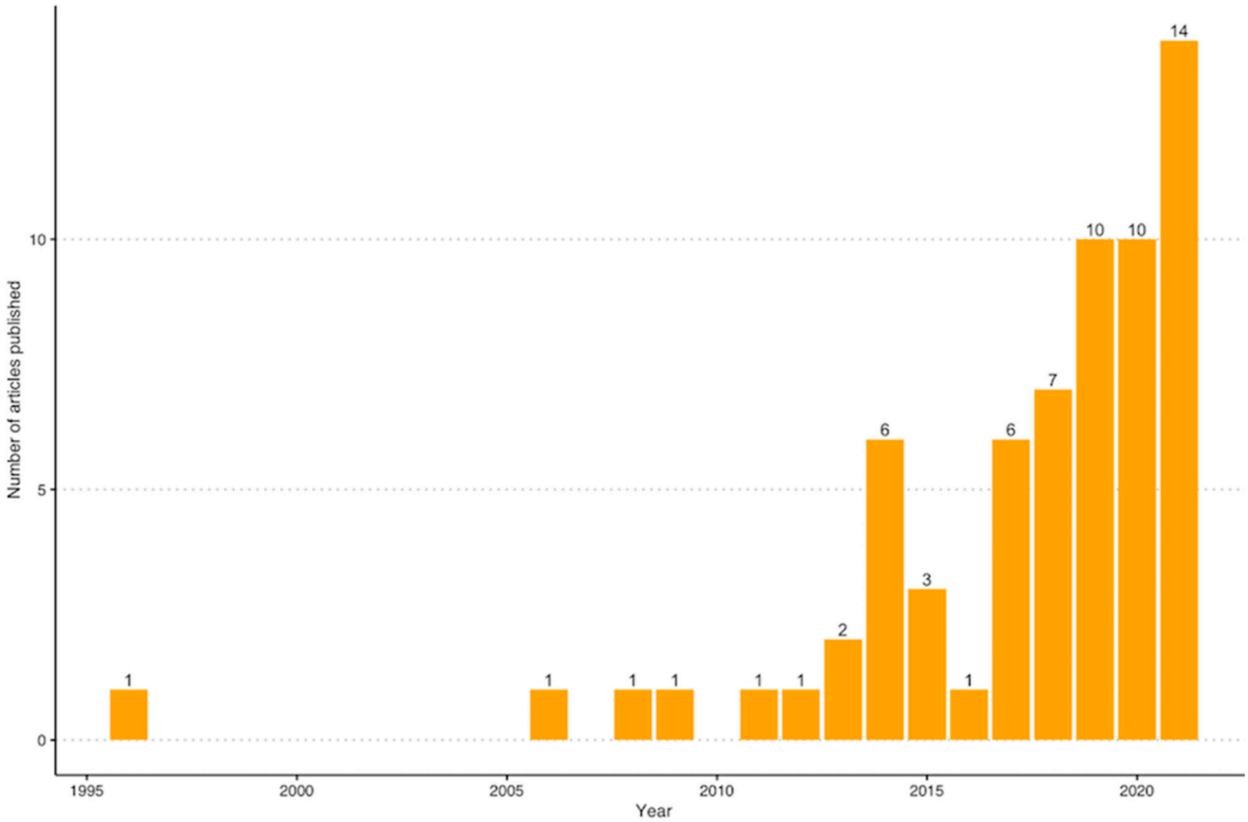

Figure 2. Number of articles relating to fast fashion and environmental and water degradation spanning published per year from 1996 to November 2021.

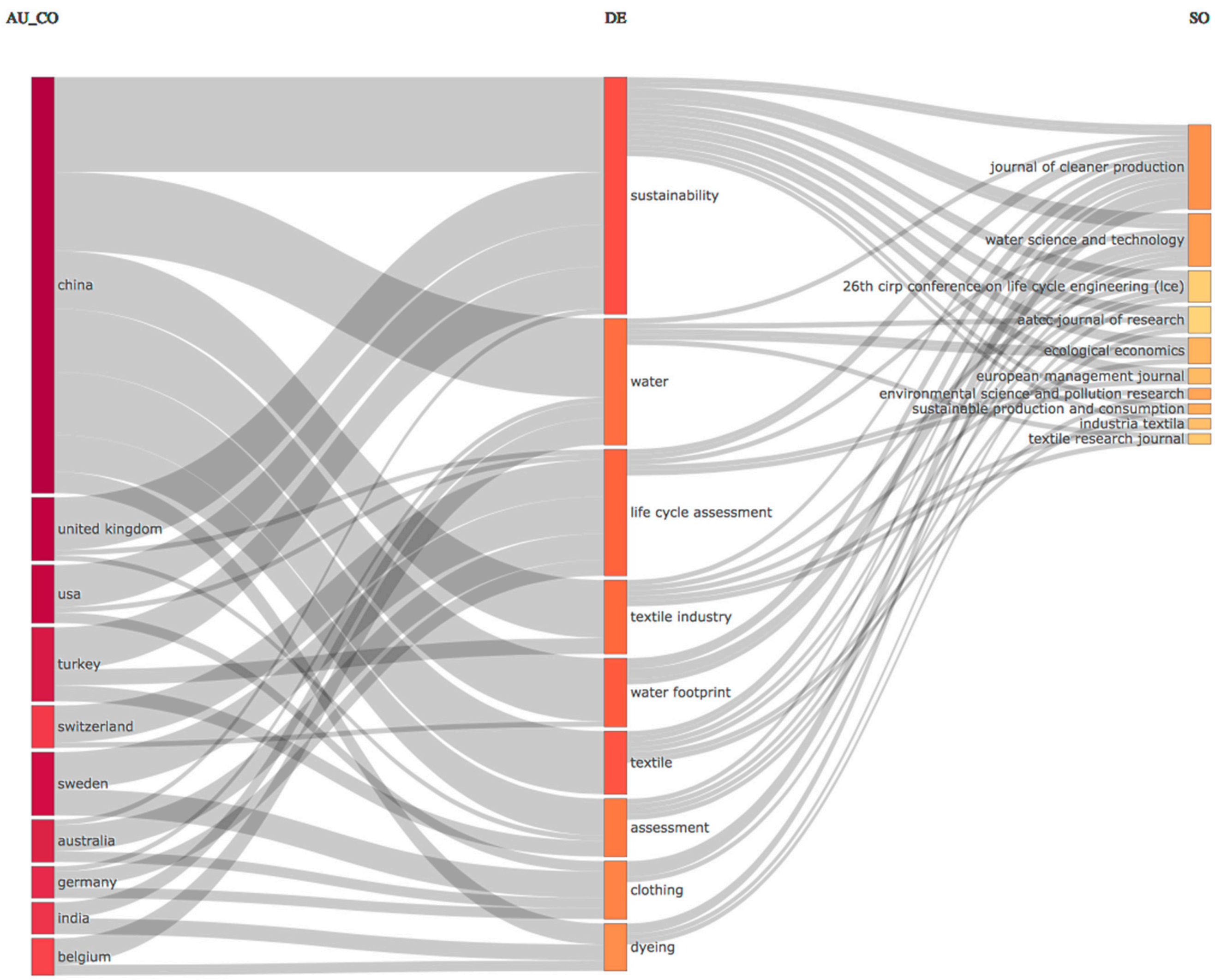

Figure 3. A Sankey diagram (3-field plot) visualisation of the top 10 countries leading research in the field by authors, the main research topics (keywords), and the journals that predominantly publish the articles. Thicker rectangles indicate greater frequency. The connecting nodes, inflows, and outflows indicate more connections with more and thicker nodes.

A full text analysis was also performed for the 65 documents using R package "tidytext' and "tm" [18,19]. For the full text analysis, only the titles, abstracts, keywords, and content of the papers (introduction to conclusion) of the documents were taken while the headers, footers, references, tables and figure captions, acknowledgments, and funding information were removed. Further cleaning of the data for full text analysis was done by removing the stopwords (words such as "its", "an", "the", "for", "that", etc., which do not add meaning to a sentence), numbers, punctuations, and lowercasing all remaining words. The words "et", "al", "use", "used", "can", "also", "study", "mgl", "mg", "l", "per", "year", and "fig" were also removed by further screening of the dataset. A bigram network plot (Figure 4) was constructed with 50 as the minimum occurrence number of any pairs of words to filter out the most important concepts discussed in the analysed literature.

Finally, the content of the selected studies was analysed for major themes surrounding fast fashion, wastewater contents and characteristics, analyses of wastewater impact, and recommendations to slow fast fashion and the environmental and water degradation caused by textile effluents.

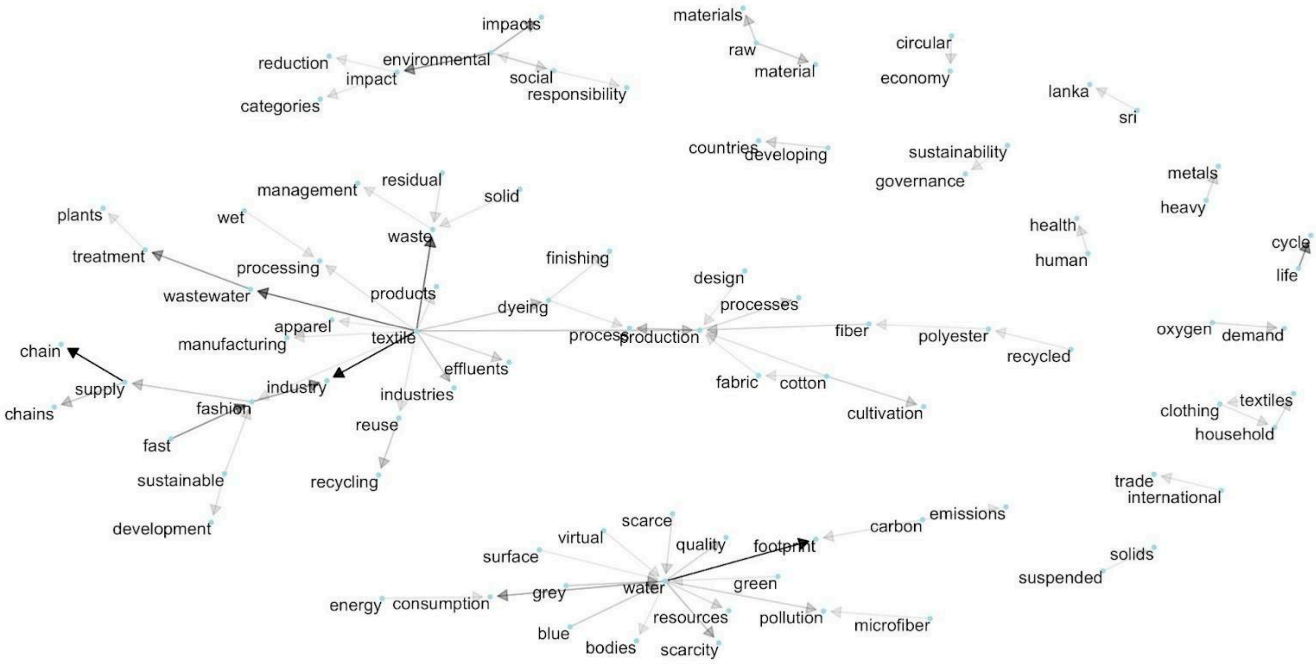

Figure 4. A bigram network plot of words that co-occur in the literature surrounding fast fashion and water quality based on full text analysis. "Textile" and "water" form the biggest nodes and branch out to other topics that are found throughout the literature. The most prevalent topics are indicated by dark arrows.

3. Results

3.1. Bibliometric Analysis

The Web of Science search command yielded 3315 papers, from which 47 were deemed relevant to the scope of the study; an additional 18 papers were added to the study based on what had been previously cited in the literature (Figure 1). From the bibliometric analysis, 65 documents were retrieved and spanned from 1996 to November 2021. There is an apparent growing interest in fast fashion and water quality with most of the manuscripts published in recent years; of the 65 articles, 48 of them (74%) were published between 2016 and 2021 (Figure 2).

The Journal of Cleaner Production and Water Science and Technology has published the most literature within this field (Figure 3). Authors from China have published the most articles in fast fashion and water quality degradation, followed by the United Kingdom, the United States, Turkey, and Switzerland, respectively. Sustainability is the key concept explored, followed by interests in water, life cycle assessment, textile industry, and water footprint. The countries that are the most interested in the sustainability of fashion based on their publication records are the United Kingdom, the United States, and Turkey. However, the study of water and fashion predominantly occurs in China, Belgium, India, and Germany, respectively (Figure 3).

3.2. Text Analysis

A bigram network plot was used to visualise the full text word relationships (Figure 4). The bigram network plot shows three primary nodes as a result of the literature being formed around "textile", "water", and "environmental". It was observed that textile was connected to "waste," "industry", and "wastewater". The term "water" had the strongest connection with "footprint", and "environmental" with "impact(s)". Direct relationships were observed to be formed between "circular" and "economy", "sustainability" and "governance", and "life" and "cycle".

4. Discussion

Through this systematic review, we found that the negative environmental impacts as a result of the fast fashion industry are manifested through water consumption, carbon emissions, and energy footprints, particularly in the use phase of clothing, the saturation of international clothing markets, and an increase in the end-of-life textile waste. We observed more recent research interest in the effects of fast fashion on the environment, with 74% of articles published in the last 5 years, although this is still a relatively understudied field compared to other stressors on water quality degradation in the world, such as nutrient enrichment, climate change, and land use changes [20–22]. The fashion industry not only has consequences for water consumption and management but is also responsible for depleting other raw materials, such as energy and soil [23]. Here, the term textile industry is used as it relates to the production of both unfinished products, such as yarn, or finished products, such as garments, thus it can be assumed it is also interchangeable when referencing the fashion industry. The terms "fashion industry" and "fast fashion industry" are used more specifically to identify issues pertaining to finished garments and articles of clothing. Major players in the fast fashion industry, such as H&M and GAP, have played big roles in increasing the footprint of the fashion industry through the shortening of fashion cycles [24]. The shortening of fashion cycles generates a constant gap that remains to be filled with new ideas and designs, in addition to the constant need to get rid of the "old" to make space for new. Major topic areas that are emerging in the literature include "sustainability", "textile industry", and "water footprint". Concepts surrounding sustainability are pervasive throughout the texts as this is the basis for the mitigation of environmental impacts. Below, we highlight a few of the predominant areas of study in this rapidly growing field.

4.1. Evaluation of Water Quality, Production Processes, and Products

4.1.1. Water, Carbon, and Energy Footprints

There are many sources of pollutants in textile wastewater; wastewater can be produced in agricultural cultivation, feeding animals, cleaning of machines after use, textile pre-treatment, and wet or laundering processes [25,26]. In total, over 1900 chemicals have been identified that can be involved in textile production processes [27]. We found that the literature covers the various forms of water footprints, including water alkalinity footprints and water eutrophication footprints, as a means of analysing the nature of textile effluents. Researchers have found textile effluents to have higher pH than typically allowed, as well as total suspended solids, chemical oxygen demand, and turbidity levels [28–30]. In some cases, the physicochemical properties of the wastewater impede its ability to biodegrade [31]. It is imperative to have a full understanding of how much freshwater is consumed and how much wastewater is discharged, considering increased water scarcity footprints have been observed in some places [25]. The water footprint (WF) is one measure of water consumption and pollution by both consumers and producers [32]. The water alkalinisation footprint has been suggested as a method to analyse the high pH of water bodies receiving effluent from the textile industry, which can occur as a result of production processes that use a lot of sodium hydroxide [13,28].

4.1.2. Life Cycle Assessments

We found life cycle assessments (LCA) to be a common feature of the literature as a means of analysing the sustainability or environmental impacts of the processes or products of the textile industry. Though it has been critiqued for not always directly accounting back to the product origin [33], LCAs are believed to be a useful tool to analyse consumer behaviour, such as the annual use and disposal of garments or the sustainable chain management of products [34,35]. For example, one LCA found that a medium bra receives about 30 wears and 10 washes over its life cycle; this is pretty important to consider as the production requires almost 30 primary raw materials to be imported from various countries to the location in which the bra is sewn together [36].

4.2. Reuse and Recycling

The recycling of wastewater effluents has been explored as an option to reduce water consumption. The complexity of wastewater means that its composition could possibly provide water, nutrients, and organic matter to soils [37]. However, not all textile companies or factories have wastewater treatment plants, thereby releasing unfiltered and undesirable wastewater into the environment [28]. Sludge has also been used to make bricks as a means of recycling; however, the safety of these bricks needs to be studied [28].

The popular retailer H&M had 4.3 billion USD worth of unsold clothing items in 2018 as a result of the rapid pace of the fast fashion industry [38]. This generates large amounts of textile waste as only 15–20% is recycled annually; the other 75–80% is deposited in landfills or undergoes incineration [2,24]. In 2015, the United States was responsible for the exportation of over 700 million USD worth of used clothing [4]. This dumping of clothing in African and Asian countries affects those markets, with some countries choosing to ban these imports. In particular, Haiti, the Philippines, Rwanda, Tanzania, and Uganda return tons of used clothing that is sent from North America [24].

Reducing the production of virgin textile fibres by the utilisation of recycling methods may alleviate some of the environmental impacts of the textile industry [24]. Textile reuse extends the life cycle of the items by transferring them to different owners under the same or different conditions, creating a market for renting, second-hand shops, and trading. The more textiles that are recycled or reused, the fewer virgin fibres will be needed, decreasing the environmental impact [39]. Though textile recycling efforts are beneficial, fibre quality degrades with use and results mostly in products of equal or lower quality [9,39].

4.3. Regional Interests in Fast Fashion, Water Quality, and Degradation

The findings of this systematic review indicate that there are important relationships between research interests in the field and regional affiliations. In particular, researchers from institutions in China are observed to be key players in this emerging field. This is particularly important as China is a major player in global consumerism and the fast fashion industry. China solely produces about 2.5 billion tons of wastewater annually [10]. China’s economy is funded greatly by the textile industry as the nation has been the number one global exporter of textiles and clothing since 1995 [25,40]. In 2016, the country grossed over 963 billion Chinese Yuan as a result of its flourishing textile industry [25]. Now, the country faces grave water pollution issues, with about 32% of the country’s water facing pollution [32]. In 2015, the textile industry accounted for 13% of the 41% percent of wastewater discharge of manufacturing industries [41]. An evaluation of the country’s textile industry water footprint indicates that the water footprint scarcity (WSF) and water eutrophication footprint (WEF) have increased from 1996 to 2015; fluctuations were observed as a result of various governmental and company interventions [25].

Europe is the most productive world region contributing research in this field and seems to have the most programs in place to mitigate the harmful effects of the fast fashion industry. European nations seem to focus on the recycling of textile waste and research focused on fast fashion and its associated environmental degradation. In Denmark, 50% of disposed textiles are collected for reuse and in Germany, the number is 70% [39]. In fact, there were more papers related to recycling in Sweden than in the United States [39].

4.4. Moving towards a More Sustainable Fashion Industry

4.4.1. Alternate Business Models

Our systematic review highlighted several tools that could be used to move towards a more sustainable fashion industry, for example, a business model in which society moves from a linear economy, based on a take–make–dispose concept, to a circular economy that aims to retain all resources or products in the system for as long as possible in order to reduce end-of-life textile waste [23]. The circular model optimises the process of reducing waste through the maximal reuse of resources or generating new resources from old materials [24,42]. The product service system has been proposed as a hypothetical possible alternative to the current business model by reducing the environmental impacts of the fashion industry [1]. This system also would decrease the consumption of resources, such as water, by increasing the quality and longevity of manufactured clothing items, in addition to supporting the inclusion of lending, redesigning, renting, and upgrading practises as means of reducing the quantity of individually owned items [1]. At the same time, the reduction in energy and resource consumption must be met with improving the quality of textile products to extend their lifespan [27].

4.4.2. Slow, Ethical, and Sustainable Fashion

Ecofashion, ethical fashion, and sustainable fashion all attempt to limit the negative environmental effects that fast fashion models otherwise impose [43]. Each of these industries has slight fundamental differences, where ecofashion is based on designing garments that are better for society and have decreased effects on the environment, ethical fashion based on fair trade and environmental standards, and sustainable fashion focusing on tailoring the clothing life cycle to align with the ideas of sustainable development, considering design, material, production conditions, and the consumer [43]. A summary of the existing measures that the European Union has taken to create more sustainable practises by transitioning from a linear to a circular economy in the fashion industry was provided by [23].

4.4.3. Change in Consumer Behaviour

Throughout the literature, many studies have highlighted the importance of changes in consumer behaviour that can greatly decrease environmental impacts [34]. The negative environmental effects of the fashion industry do not slow down post-production. In fact, the garment use phase is also critical in generating environmental impact, such as through the transportation to retail outlets and the use phase [40]. For example, the weekly laundry of a single household could potentially discharge thousands of microfibers, which have been found to bioaccumulate in albacore, bluefin tuna, fiddler crabs, lugworm, phytoplankton, and swordfish, amongst other forms of marine life, and can lead to the disruption of body functions, endocrine systems, and reproductive stress, among other issues [44]. Using machines with high efficiency ratings, lower washing temperatures, air drying, using front loading, and full load machines can reduce the carbon footprint and energy footprint [36,40,45].

The fast fashion model leads consumers to view clothing as disposable; thus, while the average consumer spends less for twice the amount of clothes, a significant amount of textile waste is also being generated, posing a threat to water quality. From 2000 to 2015, clothing prices decreased, yet worldwide, clothing production doubled [38]. Social media has been identified as a key marketing tool, moving away from sales associates in department stores to social media "influencers" who effectively sway fashion trends and brands via constant audios, images, videos, and text. Now, up to 41% of young people look to social media influencers for fashion advice, and social media could be used to influence consumer behaviour towards recycling and reusing initiatives [46]. Furthermore, if consumers are able to extend the lives of their garments by 9 months, there is a possibility of a 22% waste reduction and 33% water savings [43].

5. Conclusions

As various socio-cultural and economic factors influence increases in fast fashion consumption, it is important to identify the associated environmental effects both pre- and post-production. We found that a new field is emerging to bridge the gap between fast fashion and textile industries and the environment, particularly water degradation, as there are increasingly more papers regarding fast fashion and water quality in the peer-reviewed literature. Although there are limits to the availability of published research in this field, the fashion industry contributes greatly to environmental degradation through water consumption, energy consumption, and its carbon footprint. We found that studies have generally covered these topics broadly, leaving room for future research projects. For example, through our bibliometric, text, and content analysis, we identified three major emerging phrases that could be further explored in the literature, including "sustainability", "textile industry", and "water footprint". We recommend further research into the evaluation of water footprints, recycling efforts, and methodologies, leading towards a more sustainable fashion industry, including a circular economy. Changes in consumer behaviour can lead to changes in the market for fast fashion; thus, we recommend that consumers re-evaluate their consumption habits. In part, this could potentially influence suppliers to practise more sustainable production processes in addition to more heavily enforced regulations surrounding released discharges and solid waste disposal. Future research efforts documenting the widespread negative impacts of the fashion industry on the environment and the development of more sustainable practices will be integral to mitigating carbon emissions and wastewater production.

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