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RESEARCH ARTICLE OPEN ACCESS

MAPPING OF THE NEGATIVE SOCIAL AND ENVIRONMENTAL IMPACTS OF THE JEANS PRODUCT LIFE CYCLE

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ABSTRACT

The Textile Industry plays an important role for society by providing products that become an essential part of the daily life of human beings. However, even in the face of its magnitude, it is considered one of the main polluting women worldwide. Its manufacturing process is known for consuming resources such as water, fuel and an extensive variety of chemicals, generating great impacts, both positive (job creation, development of the local market), as well as negative impacts (soil contamination, excessive water and energy consumption, atmospheric emissions of pollutants, solid waste, exploitation of labor, labor analogous to slave labor), in society, the environment and the economy. The production of the jeans product occupies a prominent place in relation to the textile industry because it has the most consumed fabric in the world. In view of this context and in accordance with the current socio-environmental scenario, this research emerges with a study proposal that encompasses the life cycle of the jeans product and the analysis of its stages, through a systematic literature review, aiming mainly to map the negative socio-environmental impacts resulting from the life cycle of the jeans product.

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INTRODUCTION

The world's textile and clothing industries, just over two decades ago, had similar characteristics, primarily focused on their domestic market and led by major producers of yarns and fabrics. These centuries-old organizations had traditional family administration as their main characteristic. The marked globalization and opening of markets has brought as a consequence important changes in the textile and clothing chain at the global level and new consumer molds, thus emerging new challenges and production patterns (UNIETHOS et al, 2015). The manufacture of fashion clothing comprises a heterogeneous network of industrial sectors with diverse structures regarding the size and number of companies, labor intensity, capital and technological complexity. It also presents a network of companies that relate in a complex way with suppliers and customers in order to meet the demand for textile products (MENDES, 2010). It is noteworthy that depending on the company or brand, some or all stages of the textile product production process, in particular the stages of production of the denim product, can be outsourced to facilitate or advance production, which often in the face of lack of supervision, can cause exploitation of labor, child labor and labor analogous to slave labor. It is common to find publications and even professionals in the sector use the nomenclature of denim fabric for the jeans product and vice versa.

According to Kherlakian (2016), denim is a fabric that needs to be taper. The weft (width) and the warp (length) of their origin threads, when intertwined, result in diagonal lines that characterize the twill. Another specific feature of the denim fabric is its dyeing, its indigo-dyed warp is combined with an undyed weft, which gives it a whitish tone when turned inside out. The denim is the fabric used in the making of the denim product, ie denim is the fabric and jeans is the piece made from the denim fabric. The life cycle of the jeans product results in a series of social and environmental impacts, both positive (job creation, local market development), and negative impacts (soil contamination, excessive water and energy consumption, atmospheric emissions of pollutants, solid waste, exploitation of labor, labor analogous to slave labor). In relation to the exploitation of labor and labor analogous to slavery, unfortunately this is a very present practice, including in the production of large chains of stores and brands that outsource production and responsibility on the issue. It is of great importance to map and disseminate the social and environmental impacts of the production of the life cycle of the denim product, which according to Lopes (2011) has production stages characterized as one of the most critical in relation to sustainability, involving the health of workers and the local population, and the health of the environment, due to gaseous emissions, untreated effluents, which cause damage to rivers, among other polluters. The study seeks to contribute to the reduction of damage caused, explaining in detail how each stage of the life cycle of the jeans product can negatively impact the environment and society

Theoretical context: According to the Global Denim Jeans Industry (2022) report, published by Report Linker, the global denim product market will continue to rise, with a compound annual growth rate of 4.8% between 2020 and 2026. Also according to the report, amid the COVID-19 crisis, the global denim product market estimated at $64.5 billion in 2022 is projected to reach a revised size of $76.1 billion by 2026. In Europe, Germany is expected to experience a compound annual growth rate of 3% in relation to the production of the denim product, while the rest of Europe will reach a value of US$4.6 billion in 2026. The United States has the largest market for jeans in the world and has the highest per capita consumption rate, with the market estimated at $15.1 billion in 2021, equivalent to a share of 24.6%. China, on the other hand, is expected to reach $15.5 billion in 2026, with a compound annual growth rate of 7.2 percent. The Global Denim Jeans Industry (2022) report also highlights the Markets of Japan and Canada, with compound annual growth rates of 2.6% and 4%, respectively (REPORTLINKER, 2022). According to the Global Denim Jeans Industry (2022) report, much of the future growth of the denim product market is likely to emanated from developing countries such as China, India, South Korea, Brazil, Mexico, Turkey, the United Arab Emirates and Saudi Arabia, among others. Brazil is one of the few countries in which the textile and clothing industry has the complete chain, ranging from the production or cultivation of fibers to retail, with a large consumer market. Being thus responsible, according to ABIT (2017), for the fourth largest integrated and verticalized production chain in the world and the largest in the West.

The Life Cycle of a denim product, encompasses its entire shelf life, ranging from planting to obtaining the raw material to its disposal after use by the final consumer. Being synthesized in Table I:

CYCLE PHASE	STAGES
Phase1 : Obtaining the raw material	Cotton planting and harvesting
Phase 2: Denim Fabric Production	Weaving Processing Finishing
Phase 3: Production of the jeans product	Creation Modelling Pilotage Technical Cut / Enphaestus Sewing Processing Finishing
Phase 4: Post-production	Logistics, Disclosure and Sale
Phase 5: User	Use and Maintenance
Phase 6: Post-consumption	Reuse / Recycling / Disposal

The fiber used for the production of denim fabric is cotton fiber. To take the cotton material to a level where it can be used commercially for the manufacture of denim fabric, it needs to be thoroughly cleaned and processed in several steps. After the production of the fibers begins the process of production of the yarn, which consists of transforming the previously treated fiber into a wire. With the yarn ready, the weaving process begins, interlacing two threads and producing the fabric. In the case of the manufacture of denim fabric, it is produced from raw yarn weft and warp in dyed yarn, being the most used and oldest indigo of dyes. The world consumption of denim fabric is above 3 billion linear meters per year, with the main consumers being the United States, Europe and Japan, representing together more than 65% of the world consumption, being Brazil one of the main producers of this type of fabric in the world, with an installed production capacity above 600 million linear meters per year (DIAS; ALVARENGA; SALES, 2018). According to Sales (2007) the manufacture of the denim product is the one that has the largest number of specific machines destined to each stage. The jeans product has a differentiated phase of processing / finishing compared to other products. Before its commercialization, the ennobling process is carried out, which consists of the tertiary or final finishing., this extra phase is called, in the technical environment, laundry, where the pieces already made are subjected to physical-chemical procedures for its completion.

In this way the manufacture is extremely important in the production of the jeans product and the innovations present in this stage of production are fundamental for the development of new models and quality products (SENAI,2015). It is important to highlight that the term "finish" can be both simple finishes of garments, such as fabric bars, differentiated seams, application of zippers and pockets, as well as in the industrial washing process. The product usage phase and the final consumer disposal phase depend on user behavior; however, these are critical steps in a product's lifecycle (SALCEDO, 2014).

It is difficult to generalize the level of final impact of a product, since this will depend on variables such as the country or region in which it is produced, local legislation, environmental management of the supplier, technologies used, among other factors. It is from the mapping and analysis of the life cycle of the jeans product that it becomes possible to identify the main negative socio-environmental impacts generated, including its origin, quantity and characteristics, enabling, in the future, the performance of positive interventions, or reducing the polluting load through mitigating measures, adaptation/alteration of unit operations, among others.

MATERIALS AND METHODS

The research presented, as for its approach, is qualitative in nature and has as its primary basis for its development the Systematic Literature Review, given its importance to promote the integration of information from studies conducted separately on the subject, which may present conflicting and/or coincident results, as well as to point out steps that require further research, contributing to the guidance for future inquiries.

The central objective of the review developed is presented in the survey of articles describing research on issues related tothe socialal and environmentalimpacts inherent to each phase of the life cycle of the jeans product, thus providing support for the theoretical basis of the study and the achievementof the objective s of the research, which consists in mapping these impacts, to establish a cautious curation of what is being explored in the field of knowledge and its gaps.

The guide questions established for the present study are:

- What are the social and environmental impacts resulting from all phases of the jeans product life cycle?
- In relation to the negative social and environmental impacts caused by the life cycle of the jeans product, what is being studied widely? And what is still a gap?

The first keywords, started from the most used terms within the academic research that explore the theme, are: environmental impacts, sustainability and life cycle of jeans. They were broad enough to sweep the environmental impacts of the major phases of the life cycle and from these emerged new keywords that contributed to the progress of the research. As for the construction of the search strings, several combinations were made based on the keywords and Boolean operators (words that inform the search system how to combine the search terms).

Through the use of previously defined keywords, the databases for the research were established. Scopus was selected because it is the most used database for scientific research in the field of this study. The search filters used in the database were:

- Type of document: journal articles, field of scientific events in the area and book chapter;
- Year of publication: studies conducted between 2010 and 2021;
- Language: English, because it is considered a universal language;
- Publication phase: finished articles.

- Subsequently, inclusion and exclusion criteria were elaborated for the evaluation of the selected articles after the table search II.

RESULTS

After passing through the indicators of exclusion and inclusion, the resulting articles were thoroughly analyzed in order to map the issues related to negative social and environmental impacts. Regarding the stages of the life cycle of the denim product, it is important to highlight that most of the studies found focus on the initial phases (Obtaining and cultivating the raw material and production of denim fabric), of the 556 articles initially found, 408 articles addressed phase 1 and 104 articles phase 2. After the initial search, the articles went through the selection filters.

Filter 1: reading the titles, abstracts and keywords of the articles - resulting in 189 searches;
Filter 2: reading the respective introduction and conclusion of the article - resulting in 77 searches;

Filter 3: complete reading and application of inclusion/exclusion criteria - ending with 33 searches.

After applying the selection criteria, 33 articles remained that will be the basis for mapping the negative socio-environmental impacts resulting from the life cycle of the jeans product. Above all it is necessary to reinforce the issue of the nomenclature denim and jeans, which some authors approach the product jeans with the nomenclature denim.

Filter 3 Exclusion and Inclusion criteria

SPECIFIC CRITERIA APPLIED	
INCLUSÃO	• Scientific journal with *double-blind* review; • Articles fully accessible by the researcher; • Articles focusing on the central theme of the research; • Articles involving evaluation of the life cycle of the *jeans product* • Articles that point environmental impacts in any of the stages of the production of the *denim product* • Relevant and current theoretical contribution; • Alignment between research, objective and methodological considerations.
EXCLUSION	• Scientific journal without peer review; • Articles focusing on other areas such as medicine, chemistry, materials engineering; • Articles with insufficient theoretical foundation on the theme of research; • Unsubstantiated and not significant results for the field of knowledge; • Methodological considerations incompatible with the research question and main objectives; • Superficial or insufficient theoretical contribution to the mapping of the socio-environmental impacts of jeans production

This research counted the data in line with the correct definition. However, the laundry stage of the denim product is largely in research related to the production of denim fabric. According to the systematic review of the literature and based on each phase of the life cycle, the environmental and social impacts mapped were:

PHASE 1. Cultivation and Procurement of raw materials

ENVIRONMENTAL

- Toxic waste generation
- Greenhouse gas (GHG) emissions in cotton production (particulate materials – fibrils);
- Reduced water availability
- Condensate from the steaming operation.

Generation of solid waste (shells, fibers, wires, cones, etc.);

- Loss of biodiversity (contamination by transgenic cotton)
- Abiotic depletion

Change in air quality

- Degradation of land fertility;
- Contamination of the food chain
- Climate change

SOCIAL

- Annoyance to the population
- Degrading conditions of the worker
- Occupational health risks due to pesticide contamination (birth defects, reproductive disorders and weaker immune systems)
- Exploitation of the workforce
- Child exploitation
- Work analogous to slave labor
- Biossinose
- Hearing loss
- Exposure to dirty indoor environments

PHASE 2: Denim tissue production

ENVIRONMENTAL

- Use of toxic materials
- Industrial waste generation
- Consumption of non-renewable energy sources
- Greenhouse Gas Emissions in the Use of Petrochemicals
- Toxicity to aquatic life.
- Reduced water availability
- Oxygen depletion as a result of nitrogen and phosphorus deposit in freshwater or marine environments
- Abiotic depletion
- Wastewater High biological oxygen demand
- Destruition of the water self-purification system
- Reduction of biodegradability
- Increase in floating masses
- Affects natural aecination
- Plants and plant kingdom affected by osmotic changes
- Organic solids undergo purification giving rise to solids marked by gas
- Mercury-containing compounds affect the food chain
- Heavy metal contamination

SOCIAL

- Unfair salary
- Degrading conditions and risks to workers' health (allergic reactions, contamination, nausea, burns, excessive heat, vapours and chemical mists)
- Exhaustive working days
- Nuisance odor
- Cancer (skin, lung), deficiencies and neurological disorders
- Genetic damage
- Chronic diseases
- Dust retained in the lungs
- Damage to the respiratory system

- Skin irritation in the exposed area, burns or blisters
- Slow heartbeat
- Electric shock

PHASE 3: Production of the denim product

ENVIRONMENTAL

- Contaminated liquid effluents (chemicals, cooling water/ temperature).
- Wastewater with high chemical oxygen demand value
- Waste generation (packaging, discarded clothing)
- Eutrophication
- Generation of contaminated liquid effluents (toxic waste, residues of clay stones for physical tissue wear)
- Textile waste
- Water contamination by heavy metals

SOCIAL

- Unhealthy environment for the worker, especially in the stage of washes and finishing
- Irritation in workers' eyes
- Tuberculosis or silicosis
- Long working hours
- Degrading working conditions in clothing
- Injuries (wrist, elbow, shoulder, eyes)
- Potential allergic reactions
- Poverty

PHASE 4: Logistics, Promotion and Sale

ENVIRONMENTAL

- Waste generation (packaging, discarded clothing)
- GHG emissions in the logistics and delivery process.
- Waste generation
- Global warming

SOCIAL

- Degrading conditions and risks to workers' health
- Insecurity conditions
- Exhaustive working days

PHASE 5: Consumer/User

ENVIRONMENTAL

- Waste generation (packaging, discarded clothing)
- Reduced water availability
- Increase in carbon emissions

SOCIAL

- Unidentified

CONCLUSION

Among the 33 articles read and analyzed, it is observed the absence of research that emphasizes the logistics process of the jeans product, since throughout the life cycle of jeans transportation is present at all stages. A thorough study that deals with this issue would be a valuable contribution to the field of knowledge. With regard to the manufactures of the jeans product the general working conditions in these factories are bad. Behind some exemplary companies that go through social audits without any problem, are factories whose actions are not transparent and whose customers do not require compliance with labor standards. In addition, there is a network of small workshops in which we work in conditions that are out of the minimum standards recognized at the international level and where these workers go through deplorable working conditions (MORITA ET AL 2020, SHARMA ET AL 2017). The production chain, because it is very fragmented, makes it difficult to study all its stages, in view of the various stages and outsourced sub-steps, especially the most critical phases to the environment and society, such as laundry and informal clothing, it is necessary to map the amount of them and their working conditions, sustainable solutions.

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