

IMPACTO AMBIENTAL DE LA INDUSTRIA TEXTIL Y SUS AFECTACIONES SOCIOAMBIENTALES

ENVIRONMENTAL IMPACT OF THE TEXTILE INDUSTRY AND ITS SOCIO-ENVIRONMENTAL EFFECTS

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RESUMEN

La industria textil, aunque es un pilar fundamental para la economía global, es responsable de impactos ambientales severos. Este estudio tiene como objetivo analizar las repercusiones directas de las fábricas textiles sobre el medio ambiente, con énfasis en los hábitats cercanos a las industrias, como los ríos y cauces de agua. El problema radica en la alta contaminación que genera esta industria, incluyendo grandes volúmenes de efluentes con metales pesados, microplásticos y sustancias químicas tóxicas que afectan tanto los ecosistemas acuáticos como terrestres. La metodología consistió en una revisión exhaustiva de artículos científicos y estudios recientes sobre el impacto ambiental de la industria textil. Se incluyeron análisis de datos sobre consumo de agua, emisiones de gases de efecto invernadero y el manejo de residuos industriales. Los resultados muestran que la producción textil es responsable del 10% de las emisiones globales de gases de efecto invernadero y del 20% de la contaminación del agua potable. Además, los ríos cercanos a las fábricas son contaminados con tintes y productos químicos que afectan la biodiversidad y también la salud de los habitantes del sector. Las conclusiones indican que la industria textil necesita urgentemente implementar tecnologías limpias y sostenibles para mitigar sus efectos negativos. La adopción de mejores prácticas ambientales y el cumplimiento de regulaciones estrictas son claves para reducir las emisiones y proteger los ecosistemas afectados, así como para mejorar la calidad de vida de las comunidades cercanas.

Palabras clave

Industria textil, impacto ambiental, contaminación, sostenibilidad.

ABSTRACT

The textile industry, although a fundamental pillar for the global economy, is responsible for severe environmental impacts. This study aims to analyze the direct impact of textile factories on the environment, with emphasis on habitats close to the industries, such as rivers and waterways. The problem lies in the high pollution generated by this industry, including large volumes of effluents with heavy metals, microplastics and toxic chemicals that affect both aquatic and terrestrial ecosystems. The methodology consisted of an exhaustive review of scientific articles and recent studies on the environmental impact of the textile industry. Data analysis on water consumption, greenhouse gas emissions and industrial waste management were included. The results show that textile production is responsible for 10% of global greenhouse gas emissions and 20% of drinking water pollution. In addition, rivers near the factories are polluted with dyes and chemicals that affect biodiversity and also the health of the inhabitants of the sector. The findings indicate that the textile industry urgently needs to implement clean and sustainable technologies to mitigate its negative effects. Adopting better environmental practices and complying with strict regulations are key to reducing emissions and protecting affected ecosystems, as well as improving the quality of life of nearby communities.

Keywords

Textile industry, environmental impact, pollution, sustainability.

INTRODUCTION

The textile industry has traditionally been one of the drivers of global economic development, providing employment to millions of people and meeting global demand for clothing. However, its dark side lies in the massive environmental impact it generates, which has been the subject of growing concern. From sourcing raw materials to final production and waste disposal, the textile industry is responsible for a significant environmental footprint ranging from water and soil pollution to the release of greenhouse gases that contribute to climate change.

At a global level, the textile industry generates 20% of all wastewater and 10% of carbon emissions in the world, being responsible for 24% of the global use of insecticides and 11% of the spread of pesticides, despite the fact that it occupies only 3% of the planet's arable land. Furthermore, 85% of used textile products end up in landfills, where 21 billion tons of fabrics are thrown away each year, also releasing half a million tons of synthetic microfibers into the ocean in the same period. It should be noted that the textile industry has a direct impact on climate change, since, from the extraction of raw materials to the production and transportation of garments, they tend to emit greenhouse gases such as CO₂ (1).

Based on this information, it is known that the textile industry is one of the main causes of its deterioration, since all the pollutants they emit through the production and distribution of their merchandise entail an endless number of pollutants that

In the long run, they end up as untreated waste that contaminates soils, rivers, vegetation and, in part, society. A country affected by this problem is Bangladesh. The textile industry is one of the largest and most polluting in the world, in addition to using chemical substances that have devastating consequences for both the environment and people (2).

In fact, due to the consequences of the pollutants produced by the textile and tanning industry in Bangladesh (3), the Taurag River is one of the most polluted river systems in the world because it receives 2 million cubic meters of wastewater from around 7,000 industries, where in addition to clothing factories there are pharmaceutical, tannery, dyeing, pulp, paper, batteries, metal, paint and frozen food industries.

The pollutants emitted by these industries directly affect the health of those who live near these industries, with problems such as dermatological and chronic lung diseases, the creation of cancer cells in the respiratory system and the skin. In the environment, industries have a very large burden in environmental deterioration, since they emit many wastes that are harmful to health, bleaching, washing, softening, rinsing and dyeing the raw materials that they process to produce their final merchandise (2).

Textile waste, water pollution, the use of toxic chemicals, added to the naturalization of the use of forced labor, indicate that the textile and fashion industry has a transcendent cost for the environment and society. Likewise, the United Nations Economic Commission at its meeting in Geneva (2018) identified that there is an irrational use of water consumption both in the irrigation of some of its raw materials and to produce certain garments such as jeans (4).

Within this process, it is estimated that 280,000 tons of dyes are discharged worldwide into textile effluents; these dyes have an adverse effect on the environment. The coloration in the water prevents the passage of sunlight, inhibiting the photosynthesis process, reducing dissolved oxygen, which severely damages aquatic life. In addition to the carbon footprint that contributes to worsening the climate emergency situation, an equally relevant impact on the state of health of the planet is the water footprint. The textile sector uses, each year, an average of 93,000 million cubic meters of water, to which we must add pollution from dyes and the processing of textiles, practices responsible for 20% of global water pollution (5).

As another obvious problem, we can highlight the excessive use of water by the textile industries responsible for the creation of cotton garments, since it is estimated that 10,000 liters of water are needed to create a cotton T-shirt, within the time in which we find ourselves and the continuous climate changes, the excessive use of water is a great dilemma, since factories prioritize their own water consumption without taking into account that there are people and communities that seek to have this vital liquid (6).

The Patate River, which feeds both Patate and Pelileo, is in direct contact with the polluting waste from the 48 factories, which directly emit pollutants in

their processes of dyeing and washing their merchandise such as the jeans they sell, the municipality of said city shows that chemical elements harmful to health were found in

the river, including potassium permanganate, hydroxide, sulfate and sodium chloride and sodium chloride (7).

People who use this water directly for daily consumption are most closely exposed to contaminants, people who use it for food and personal use. These waters contain chlorinated solvents that are used in textile industries as a degreasing material and as dye carriers. Dyes contain heavy metals such as chromium, copper and zinc and organic substances. Therefore, having direct contact with those who consume this water is harmful to their health, causing the diseases already mentioned and which can cause death due to the consumption of this type of contaminated water (7).

This river directly affects the health of the inhabitants of the sector, being a focus of national and international attention, projects and research have been presented to mitigate the harmful effects of waste from textile factories that are dumped directly into the river. Within our country we find a similar case in the Paute River and all its problems, however, the Patate council tries to reach agreements with the factories to be able to combat this dilemma, but it is not known for sure if they are having relevance or not since the effects as such continue to appear and show people with chronic or respiratory diseases and, taken to the extreme, patients with cancer, waste in the environment (7).

In the rivers, water treatment and improvement projects have been proposed to eliminate traces of contaminants from the water, environmental impact studies are being sought in textile factories. They propose the delivery of subsidies or amounts that help to a certain extent combat this problem. The organizations seek incentives for each factory to have a water treatment plant, seeking that waste can be retained within these plants and thus does not contaminate nearby rivers and the people who reside near these industries (4). Based on this panorama, textile industries will have to change their processes used to manufacture their clothing.

The main objective of this study is to investigate the direct repercussions of textile factories on the environment, within their surroundings and how they affect the habitats close to the industries, such as rivers and flows. The purpose of this study is to inform the population to demonstrate the harmful effects on the environment and people, and also raise awareness among the textile industries that cause these effects, causing environmental damage and leading to people in the sector.

MATERIALS AND METHODS

An exhaustive bibliographic review was carried out based on scientific articles, field research and theses referring to the environment and textile industries, information was obtained from scientific platforms such as Scielo and virtual libraries of local and international universities. The process involved in the manufacturing of raw materials and merchandise for the textile industries, as well as their manufacturing processes and the expulsion of toxic waste and residues, was thoroughly investigated. The various environmental impacts that occur throughout the production process of these factories and the environmental impacts such as contamination of waters and springs, as well as the emission of greenhouse gases were investigated.

The effects of consuming water that is in direct contact with waste from textile industries, which contain chemicals harmful to people's health, will also be identified, and the repercussions on the health of residents of the sectors surrounding these factories will be reported. Real cases of countries and cities that have this problem will be exemplified.

Information was collected from virtual platforms and scientific databases such as Scielo, Dialnet, YouTube Academic, Google Academic and Pages referring to the topic in question. From these pages, topics such as the environment and textile factories, the environment and fashion, the fashion industry and the 2030 calendar, the repercussions that textile factories have on the environment and the problems of textile factories at a global level were investigated. From the scientific articles investigated, relevant information was sought regarding the topic, if the articles and research have a more than acceptable methodology quality, just as one would look for current information and have a much closer vision of the problem investigated.

A significant sample of companies in the textile sector was used, which provided robust information for the analysis. The dimensions evaluated included environmental sustainability, ecological innovation capacity, resource management efficiency, competitiveness, and customer perception of ecological value. Each of these dimensions was analyzed through specific indicators, providing a clear overview of the environmental impact of the textile industry.

Content analysis methods, coding of themes and synthesis of relevant information from the articles were used. In this article, the sequential information was organized, first dealing with the problem and its repercussions, and then trying to report on the established projects seeking to reduce the negative effects of textile factories on the environment. Several bibliographic citations were made to inform the reader about the authors and owners of the cited information; a paraphrase about the idea that the author tried to convey in writing is also included.

RESULTS

The textile industry plays a fundamental role in our country's economy, not only because of its ability to generate employment, but also because of its contribution to exports and industrial development. However, it is also one of the activities that demand the most natural resources, in particular, water. Water consumption in textile production processes is considerably high, which generates large volumes of wastewater. These waters, once used, contain a wide variety of contaminants, ranging from dyes and chemicals to organic and inorganic waste. These wastes can represent a serious risk to the environment if they are not treated properly before being discharged into water.

In various industries, such as textiles, paper, cosmetics and pharmaceuticals, more than ten thousand varieties of synthetic pigments and dyes are used. Many of these industrial activities generate large volumes of effluents that contain dyes and are released into the environment (see Table 1). The textile industry stands out as the main source of emission of these dyes.

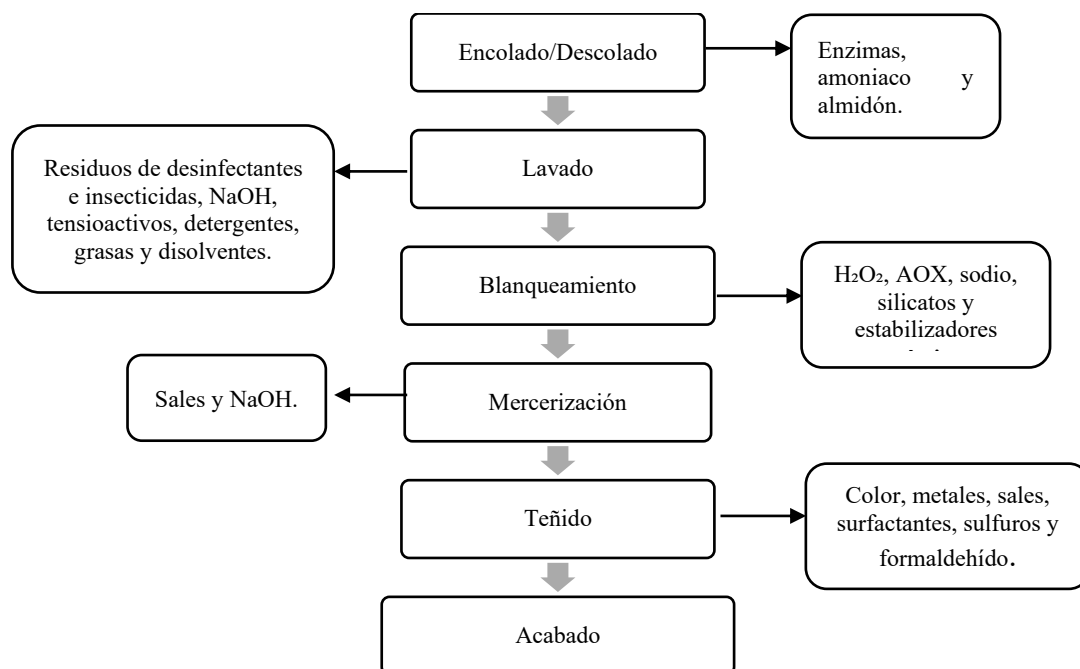
Table 1. Color concentrations and amount of water generated by some industries

Industry	Amount of water generated (m ³ /ton)	Color Concentration (Hazen Units)
Sugar bowl	0.4 m ³ /Ton crushed cane	150-200
Brewery	0.25 m ³ /Ton beer produced	200-300
Distillery	12 m ³ /Ton of alcohol produced	200-300
Tanning	28 m ³ /tonne of skin	400-500
pulp and paper	175 m ³ /ton of paper	100-600
Textile	120 m ³ /Ton of fiber	1100-1300

Source: (8)

The effluents generated by the textile industry contain a wide range of contaminants that come from the various processes used in the production of fibers. Among those mainly responsible for toxicity in water are salts such as NaCl and Na₂SO₄, used in treatment processes; surfactants such as phenols; heavy metals present in dyes; organic compounds such as chlorinated solvents, used in washing and maintaining machines; biocides such as pentachlorophenol, which is found in contaminated wool fibres; and toxic anions such as sulfur, present in some dyes (9).

Figure 1 illustrates part of the textile process and the contaminants generated in each stage (10). In the treatment process, approximately 30% of the dyes are not adequately fixed to the fibers due to process inefficiencies, resulting in their release into effluents.

**Figure 2. Textile process and contaminants**

Metals such as arsenic, cadmium, chromium, cobalt, copper, manganese, mercury, nickel, silver, titanium, zinc, tin and lead can be found in textile effluents. Many of those metals are generated during the dyeing process. Table 3 shows some metals present in different classes of dyes.

Table 3. Metals in textile effluents

Dye class	Metals
Straight	Copper
Reagent	Copper and nickel
acids	Copper, chromium, cobalt
Premetalized	Copper, chromium, cobalt
Mordant	Chrome

One of the most common metals in dyes is copper, which is known for its adverse effects on plants and microorganisms, which can lead to a decrease in soil quality. Heavy metals, in general, have a low dissolution capacity in water, so the amount of metals present in water is influenced by factors such as pH, REDOX potential, organic matter content and the amount of available metal. In dyes that include metals as part of their structure, the presence of these is crucial for their effectiveness in the textile industry (9).

Table 4. Impact of textile production on the environment

Environmental impact	Description
Overconsumption of natural resources	Textile production requires large amounts of water and land. For one cotton t-shirt you need 2,700 liters of water. In 2020, textile production was the third largest source of water and land use degradation.
Specific data	For each EU citizen in 2020, 9 m ³ of water, 400 m ² of land and 391 kg of raw materials were used for clothing and footwear.
Water pollution	Textile production is responsible for 20% of drinking water pollution due to dyes and finishing products. Microplastics from textiles are mainly released during the first washes.
Impact of microplastics	A single load of polyester clothing can release 700,000 microplastic fibers. Annually, more than half a million tons of microplastics accumulate in the oceans due to the washing of synthetic textiles.
Effects on health and ecosystem	The pollution generated by textile production seriously affects the health of people, animals and ecosystems near the factories.
Greenhouse gas emissions	The fashion industry is responsible for 10% of global carbon emissions. In 2020, textile purchases in the EU generated 270 kg of CO ₂ emissions per person, equivalent to 121 million tonnes in total.
Textile waste in landfills	Less than 50% of used clothing is collected to be reused or recycled, and only 1% is recycled into new clothing. Technologies to recycle clothing into virgin fibers are under development.

Once the data collection stage was completed through digital media from various websites, they were analyzed qualitatively and the following results were obtained according to their topic.

Table 4. Evaluation of sustainability indicators in industrial production

Imension Evaluated	Specific indicators	Current status	Observations
carbon footprint	CO ₂ emission	Intermediate	Need to reduce emissions through cutting-edge cleaning technologies.
Water Use Efficiency	Water consumption for each production unit.	Intermediate	Increase improvements in recycling practices and adaptation of proper water use.
Waste Management	Amount of waste generated and recycled	Intermediate	Increase in waste recycling programs or systems and reduction of waste itself.
Raw Materials Sustainability	Use of organic and recycled materials	Intermediate low	Much integration of sustainable materials necessary.
Perception of ecological value	Consumer opinion on sustainable practices.	Variable, dependent market	Education and green marketing in a digital way that helps improve perception.

The exploration revealed that many textile companies are at an intermediate stage in terms of adopting sustainable measures. Despite having adopted some green initiatives, they still face significant difficulties in fully integrating them into their daily activities. Sustainable was assessed by decreasing greenhouse gas emissions, decreasing water management, waste management, and green innovation capacity. It was found that

companies with greater progress in sustainability demonstrated a greater ability to adapt to environmental regulations and new consumer expectations.

Effective data management was highlighted as a crucial factor in environmental sustainability. Companies that were able to efficiently collect, analyze, and use environmental data were able to make more informed and strategic decisions. The ability to transform data into tangible customer value was identified as a key indicator of success in implementing sustainable practices.

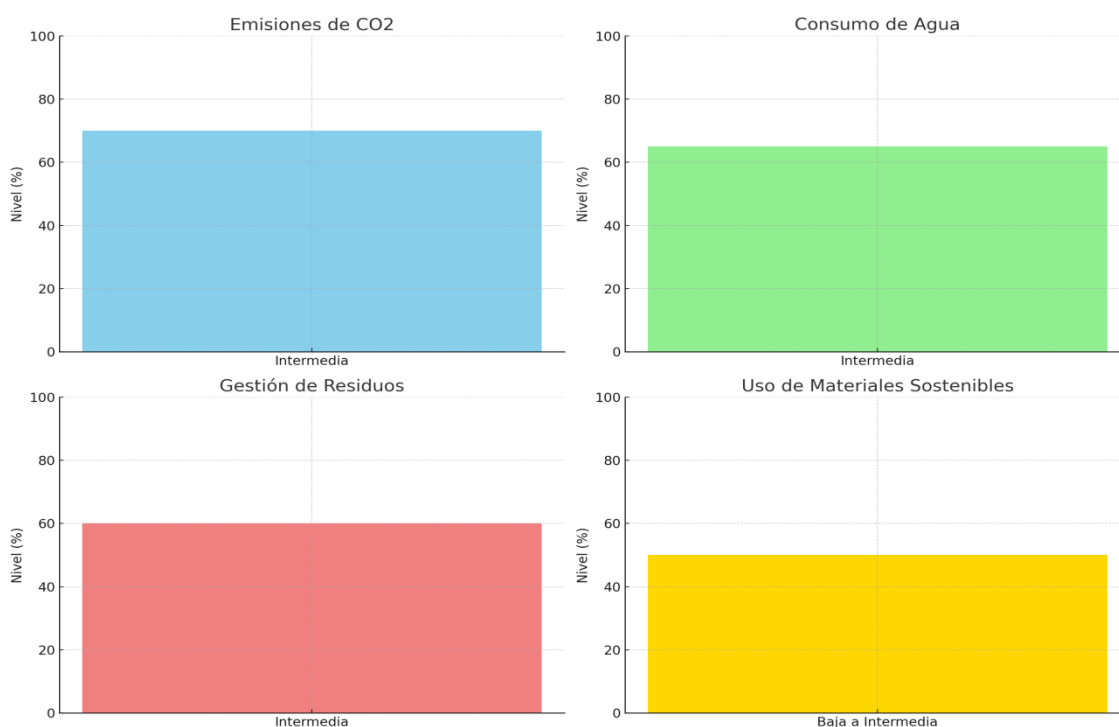


Figure 2. Current levels of sustainability indicators in industrial production

The study carried out by (11) showed that the water from a river near a textile industrial area had mutagenic activity, although the agents responsible for said mutagenicity were not identified. Furthermore, it has been documented that textile effluents have toxic effects on the liver and testes of albino rats, showing alterations in lipid and cholesterol content, which affects testicular function and protein synthesis in spermatogenic cells. A reduction in liver proteins was also observed, attributed to the necrotic action of the dyes present in

the effluents. These findings were supported by analysis of morphological damage in liver cells (12).

Much of the human population is exposed to a variety of toxic substances, which has led to biological monitoring in various occupations to assess health risks. (13) investigated the genotoxic risk in textile industry workers, who are exposed to a wide range of

chemicals such as dyes, bleaches, acids, alkalis, and salts. The results of their study suggest that these workers present a risk of genotoxicity.

On the other hand, some organic chemical compounds can be absorbed and used by certain plants such as melon, radish and potato. However, textile effluents can affect the germination of seeds and the initial growth of some vegetables (14).

It is essential that the equipment and work systems can be adjusted to the specific needs of the organization and the textile production process. It can be done through the use of specialized software, process automation programs and the adoption of devices that minimize human errors, such as sensors and tools that promote environmental safety of the work process.

It is essential to point out in this research that the implementation of changes in the textile industries and in the production process can have a significant impact on environmental sustainability and the productivity indices of textile companies also grow. The application of these causes with the help of technologies makes it possible for the production process to be safer and more controllable, which translates into both economic and environmental benefits. Ultimately, these innovations can adapt and increase the ability of textile organizations to comply with environmental regulations and address recent consumer expectations regarding sustainability.

DISCUSSION

With the arrival of the third industrial revolution and the continuous advance in information and communication technologies, taking into account that in the present century, the new digital era has contributed significantly to the growth of textile industries around the world of fashion, with the continuous use of social networks and new digital platforms they influence people directly, with the use of photography, modeling, advertising, journalism, marketing, they encourage people to have irrational consumption habits, which under studies have been shown to be more compulsive purchases rather than necessary. The environment of the textile industries dedicates its efforts to ensuring that people are never satisfied with what they have purchased, and prefer to consume more even knowing that their purchase is not necessary (13).

According to the European Parliament (15), the fashion industry is estimated to be responsible for 10% of global carbon emissions, more than international flights and shipping combined. The repercussions of the environment and

Society are very varied, but they highlight the pollution of the Patate River, which feeds the two cities and is used by some residents for agriculture and personal consumption.

This tends to be a direct problem to the health and economy of the residents. Since, its agriculture tends to be deplorable, the use of water with contaminants, the same ones that will be introduced directly into all crops, leads to the plantations tending to have a harmful load since they will contain chemicals harmful to health that in the long term will cause severe health problems such as stomach cancer (10).

According to the European Environment Agency, textile purchases in the EU in 2020 generated around 270 kg of CO₂ emissions per person. This means that textile products consumed in the EU generated greenhouse gas emissions of 121 million tonnes. It is known that the textile industry bears the responsibility of having 10% of global greenhouse gas emissions, this percentage being much higher than international flights and maritime transport combined (15).

In the same way, these industries produce a large amount of waste, which can be used and discarded clothing, fabric scraps that were produced in the manufacture of certain clothing items and other materials. In most cases, this waste ends up reaching rivers or landfills, where it will end up decomposing and thus producing methane, which is a powerful greenhouse gas (15).

These problems within the environment have undermined any environmental care project, all the pollutants that are produced within these industries end up being a problem since they are discarded directly into the rivers or canals that discharge water from the industries. A distant problem is the city of Pelileo, which has 48 textile companies focused on the manufacturing of Jean clothing, which directly pollute the environment, and even more so a river (7).

Millions of tons of clothing are produced, used and thrown away every year. And every second the equivalent of a garbage truck is burned or buried in a landfill. "Clothing, footwear and home textiles are responsible for water pollution, greenhouse gas emissions and landfills." All the burned material will end up being polluting material that will greatly damage the environment (16).

The textile industry is a decisive figure due to the negative impacts of its production processes in terms of water quality, air, soil and waste management (18). In particular, there is great concern about water resources, due to the quantities and types of chemicals used by this industry. On the other hand, another author states (19) that the textile industry is becoming more important every day in world economies, generating a greater amount of water being consumed every day for the processes.

It is estimated that global clothing consumption will increase from about 62 million tons of textile products per year to 102 million tons by 2030. This denotes the degree of failure in current industry control standards. As mentioned, (19) the textile industry is a giant that pollutes and consumes many raw materials, energy, water and land. The popular fast fashion, fast, cheap and low-quality fashion, increases the environmental impact of the textile industry without stopping, by generating a lot of textile waste that is incinerated or goes to landfill, because it is hardly recycled (20).

Therefore, the free will of companies causes, in the case of material inputs, the uncontrolled use of soils, causing erosion and wear. The use of chemical inputs causes environmental and water pollution. It is estimated that the fashion industry is responsible for 10% of global carbon emissions, more than all international flights and maritime transport combined (21).

Another important statistic is, (22) which mentions that the textile industry can promote soil degradation and cause sediment carryover that pollutes bodies of water, as well as, (23) which mentions that the fashion industry faces increasing global scrutiny of its supply chain operations, which pollute the environment. Despite widely publicized environmental impacts, the industry continues to grow, in part due to the rise of fast fashion, based on cheap manufacturing, frequent consumption and the use of short garments.

The direct impact of this can be emphasized, (24) on the other hand, a load of washing with clothes made of polyester releases thousands of micro plastics into fresh water and, finally, into the sea, since even industrial and domestic washing is not far behind. It is estimated that washing our clothes releases around 0.5 million tons of microfibers into the ocean per year, including many of these synthetic ones (the famous micro plastics - a single load of polyester clothing can release 700,000 micro plastic fibers that end up in the food chain) (19).

In this new era, an endless number of projects were presented, where green marketing was born from the point of view of traditional marketing in the 70s, when consumer habits were inclined towards the care and protection of nature, leading companies to create strategies to reduce the environmental impact and protect society (25).

In this sense, there is corporate social responsibility with which companies voluntarily integrate practices that benefit them economically, socially and environmentally through responsible behavior. Therefore, corporate social responsibility is proposed with which companies voluntarily integrate practices that benefit them economically, socially and environmentally through responsible behavior (26).

The government units in charge of combating this problem have proposed urgent contingency measures and regularizations to reduce all the consequences. Several organizations in search of a solution to this problem propose the creation of clothing items that have a composition that makes them more durable, tend to be repairable, can be reusable and can also be recycled, that can combat or seek measures against consumerism or fast fashion, as well as seek a solution for industries and thus promote innovation in the manufacturing of textile products. and use of new technology.

Among the new measures proposed have been the creation of the Digital Product Passport, providing clearer information to consumers which will regulate and create new ecological designs for the creation of textile products. With this they propose to minimize the carbon footprint of the textile industries and reduce damage to the environment, these programs help combat the effects, but it is not known if the companies are carrying them out or if they have remained mere words in the air.

The environmental impact of the textile industry continues to be one of the greatest environmental challenges due to its direct repercussions on the environment. Textile factories generate large quantities of industrial effluents containing chemicals such as dyes, acids, and heavy metals, which are mainly discharged into nearby water bodies such as rivers and streams. These contaminants, which include microplastics and heavy metals such as chromium and copper, significantly alter water quality and represent a serious

threat to biodiversity (27). The accumulation of these wastes reduces the quality of drinking water and irreversibly damages aquatic ecosystems.

Recent studies indicate that textile industry effluents not only affect aquatic organisms, but also nearby soils, impacting plant fertility and growth. In areas near textile factories, a deterioration in soil health has been observed due to the accumulation of chemicals that alter the soil's ability to retain nutrients (28). This has serious consequences for agriculture and adjacent terrestrial ecosystems.

Comparison with other recent studies confirms that the presence of microplastics derived from textiles in waterways increases the toxicity of aquatic ecosystems. According to (29) microplastics released during the washing of synthetic clothing contribute to global ocean pollution, which in turn affects marine life and enters the human food chain. Furthermore, greenhouse gas emissions from the textile industry represent 10% of the global total, contributing to climate change and indirectly affecting surrounding habitats.

CONCLUSIONS

The textile industry, although essential for the economy, generates a considerable amount of polluting effluents that negatively impact aquatic ecosystems. The heavy metals and microplastics present in this waste affect both the flora and fauna of the rivers and the quality of drinking water, putting biodiversity and human health at risk. Recent studies confirm that these pollutants persist in the environment, deteriorating habitats near factories.

Affection of nearby habitats: The release of wastewater with toxic chemical compounds, such as heavy metals, alters not only the quality of the soil, but also the fertility of nearby agricultural lands. This negatively impacts agricultural productivity and terrestrial ecosystems, affecting both the local communities that depend on these natural resources and the surrounding habitats.

Need for awareness and action: To mitigate the negative effects of the textile industry on the environment, it is imperative to implement clean and sustainable technologies in production processes. Adopting best practices and complying with environmental regulations will not only promote sustainability, but will also reduce greenhouse gas emissions and improve consumer perception of responsible brands.

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