Chapter 18
The Beauty Industry and Solid Waste

Anelise Leal Vieira Cubas, Ana Regina de Aguiar Dutra, Jonathan Alexsander Bork, Kenia Alexandra Costa Hermann, Ritanara Tayane Bianchet, Marina Medeiros Machado, and Ana Paula Provin

Abstract The annual revenue of the beauty industry amounts to many billions of dollars, this being a prominent and constantly growing market with consumers ever more willing to invest in their appearance. Parallel to this, it is known that excessive consumption generates high levels of waste, affected by many factors from the selection of raw materials to the means of disposal by the consumer. With regard to the cosmetics industry, microplastics are the most commonly reported issue. These are derived from packaging or directly from the products (e.g., exfoliating, cream) and an estimated 93% of the microparticles associated with this industry are composed of polyethylene. Regarding the textile industry, another economically important sector on a global scale, it is known as one of the most polluting industries due to the excessive use of water, energy and chemicals and inadequate waste disposal. Thus, the possibilities for research on the treatment of these types of waste are extensive, with the need for cleaner technologies coupled with treatment processes that are cheaper and more widely applicable, aiming to reduce the environmental impacts.

Initial Considerations

The world's population of seven billion people generates approximately 1.4 billion tons of municipal solid waste per year, an average of 1.2 kg per day per capita. Half of this waste is generated by fewer than 30 countries. The richest countries have increased their per capita waste generation rates by 14% since 1990 and by 35% since 1980, according to a World Bank report. These rates generally increase at a slower rate than the increase in gross domestic product (GDP). The United Nations (UN) and the World Bank have presented a prospective scenario for 2050, when there will be 9 billion inhabitants and 4 billion tons of urban waste produced per year.

A. L. V. Cubas (✉) · A. R. de Aguiar Dutra · J. A. Bork · K. A. C. Hermann · R. T. Bianchet · M. M. Machado · A. P. Provin
Universidade do Sul de Santa Catarina, Florianopolis, Brazil
e-mail: anelise.cubas@unisul.br

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The generation of urban waste brings socio-environmental and economic costs to the planet, and around 800 million tons of these residues are disposed of in landfills per year. The US Waste Power Generation Technology Research Council estimates that one square meter of land is permanently occupied for every ten tons of landfill waste.

In this chapter, the focus is on industrial waste, specifically that associated with the beauty industry, represented by the areas of cosmetics and textiles. Industrial waste is considered an environmental problem, since the volumes generated are significant and many of the materials are hazardous to the environment and public health. Obtaining areas for the final disposal is becoming increasingly difficult, and the improper disposal of industrial waste causes air, water and soil degradation.

In this context, the search for a sustainable industry has never been more urgent, and solutions are required to reach the objectives of social, environmental and economic sustainability. The Declaration of the World Summit on Sustainable Development, held in Johannesburg in 2002, divided the concept of sustainability into three pillars: economic development, social development and environmental protection (UN 2002), aimed at the economic and social development of humanity in a way that is compatible with the obligation to keep the planet livable for future generations (Sachs 2002). The term ‘sustainable development’ emerged in 1980 and gained special attention in 1987, in the Brundland report titled “Our Common Future.” It is defined as the meeting of current needs without compromising the needs of future generations (UN 1987; Berchin 2017). Thereafter, the practice of attempting to move toward the sustainability concept was incorporated into governmental, corporate and community planning (Góes and Magrini 2016; Adams et al. 2017).

Aligleri (2016) noted that the integration between the three dimensions (social, environmental and economic) has been adapted for the business sector by John Elkington in his book “Cannibals with Fork and Knife: The Triple Baseline in twenty-first Century Business”, published in 1997, using the term triple bottom line (TBL). The TBL guidelines relate the economic dimension to profits and losses, the social dimension to the quality of life of people in organizations and the environmental dimension to the care of the planet.

Ensuring sustainable production and consumption patterns is one of the main challenges of the millennium, with the goals of sustainable development set by the UN. More precisely, Goal 12 proposes, by 2030, to substantially reduce waste generation through prevention, reduction, recycling and reuse. Concern about the quality of water bodies is also on the UN agenda, and Goal 6 proposes, by 2030, to eliminate dumping and minimize the release of chemicals and hazardous materials. Given these concerns, investment in technologies to minimize or eliminate waste production is increasing.

In recent decades, there has been a major change in the corporate universe. Companies that were seen only as institutions with economic objectives started to incorporate new roles, including greater social and environmental commitments. Among the different variables that affect the business arena, a concern with beauty and well-being while at the same time considering the environment has gained significant prominence, affecting the corporate image and economic results. From this new perspective, companies are gradually changing their attitude toward environmental aspects, in a process of reconciliation between production and environmental concerns, aimed at achieving sustainable development. In this context, some production procedures have been reviewed, seeking alternatives that can eliminate or reduce waste generation and improve socioeconomic gains.

The Cosmetics Industry Waste

Currently, there is a growing number of consumers of skin care products, due to the gradual awareness of early ageing and, more importantly, skin diseases. With the progressive expansion of this branch, in the last two decades the world production of cosmetics has increased by 4.5% annually. According to Research and Market (2019), the global market for cosmetics and personal care products amounted to US$ 128.9 billion in 2018. Considering a growth rate of 4% per year, by 2024 this could reach US $ 165.9 billion (Market 2019). Based on these data, it can be predicted that with the increase in cosmetic products there will be a significantly higher level of waste generation.

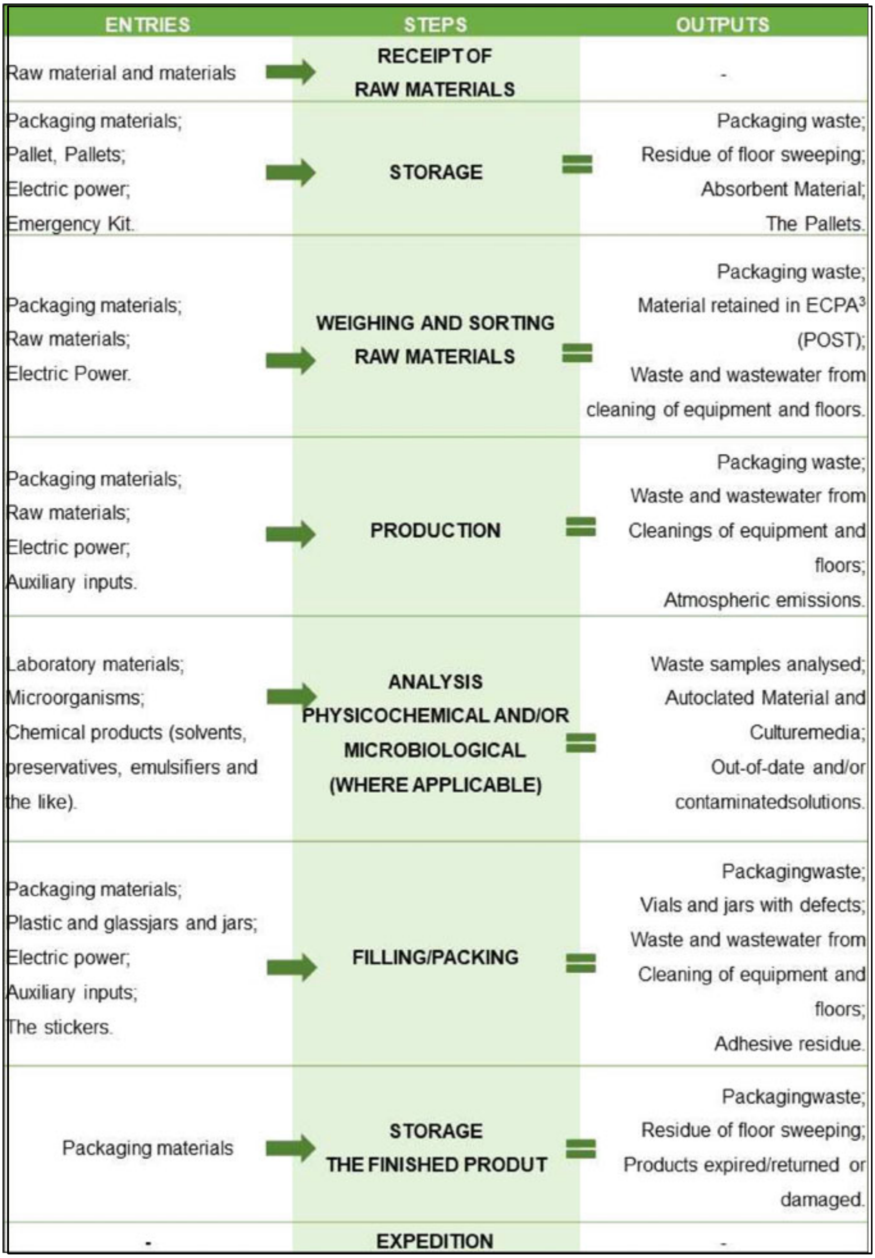
According to Juliano and Magrini (2017), cosmetics are divided into two major classes, the leave-on products, which are applied directly to the skin for hydration and decorative purposes, and the rinse-off products, mainly personal hygiene products (toothpastes, shampoos, soaps and gels). Observing the variety of products available and considering the high levels of consumption, there is concern about the destination of these products after their use.

The main hygiene and personal care products, such as shampoos, UVA blocker, deodorants, creams, facial cleansers, make-up removers and toothpaste, may have heavy metals in their composition, such as lead, chromium, nickel, aluminum, copper and cadmium (Fischer et al. 2017). Additionally, some formulations contain fatty acids, surfactants, petroleum derivatives and detergents. Therefore, part of these compositions generate industrial by-products along with wastewater and are characterized by relatively high values for chemical oxygen demand (COD) (>100.000 mg/L) (Bautista et al. 2007; Abidemi et al. 2018). Thus, appropriate treatment is required to avoid environmental damage.

Each country establishes its own regulatory stipulations. In Brazil, for instance, there is an environmental technician's guide based on regulatory norms issued by ANVISA (Health Surveillance Agency of Brazil). This was based on the recommendations of chemical engineers, environmental personnel and other professionals working in the cosmetics and personal care products, qualified people involved in the production process and specialists in solid and liquid waste treatment. This guide considers all of the stages from the receipt of raw materials to the dispatch of the products and details the residues generated in each one of them (Souza et al. 2005). An overview of these stages can be observed in the flowchart in Table 18.1.

This general flowchart is not necessarily applicable to all industries, and it represents only a small part of the production and waste aspects. In addition, other residues

Table 18.1 Overview of stages involved in the cosmetics industry



ENTRIES	STEPS	OUTPUTS
Raw material and materials	RECEIPT OF RAW MATERIALS	-
Packaging materials; Pallet, Pallets; Electric power; Emergency Kit.	STORAGE	Packaging waste; Residue of floor sweeping; Absorbent Material; The Pallets.
Packaging materials; Raw materials; Electric Power.	WEIGHING AND SORTING RAW MATERIALS	Packaging waste; Material retained in ECPA^3 (POST); Waste and wastewater from cleaning of equipment and floors.
Packaging materials; Raw materials; Electric power; Auxiliary inputs.	PRODUCTION	Packaging waste; Waste and wastewater from Cleanings of equipment and floors; Atmospheric emissions.
Laboratory materials; Microorganisms; Chemical products (solvents, preservatives, emulsifiers and the like).	ANALYSIS PHYSICOCHEMICAL AND/OR MICROBIOLOGICAL (WHERE APPLICABLE)	Waste samples analysed; Autoclated Material and Culturemedia; Out-of-date and/or contaminatedsolutions.
Packaging materials; Plastic and glassjars and jars; Electric power; Auxiliary inputs; The stickers.	FILLING/PACKING	Packagingwaste; Vials and jars with defects; Waste and wastewater from Cleaning of equipment and floors; Adhesive residue.
Packaging materials	STORAGE THE FINISHED PRODUT	Packagingwaste; Residue of floor sweeping; Products expired/returned or damaged.
-	EXPEDITION	-

Source Souza et al. (2005)

continue to emerge, including metals, fatty liquids, volatile organic compounds, solvents and odors (Souza et al. 2005).

To maintain strict quality control in cosmetics, the cleaning of machinery requiring the use of water is extremely important. In addition, there is a demand for pure water in the formulations and water is used in cooling systems. All of these result in the generation of residual liquids from the cosmetics production process, and the components of this wastewater can be of low biodegradability, especially if they contain dyes, traces of UVA protector, fragrances and surfactants, and particularly if they are non-polar molecules. Thus, the application of biological degradation by microorganisms is not feasible (Abidemi et al. 2018).

Therefore, new technologies have been implemented to mitigate the impacts of this highly pollutant industry. These processes address environmental, energy and economic issues and are carried out prior to waste disposal in landfill. The waste is often treated by pressure flotation or coagulation/flocculation to separate the sludge, pH correction, flake separation by decantation and filtration. After this, the industrial effluent joins the sanitary effluent and undergoes biological treatment using anaerobic or aerobic systems (Bautista et al. 2007; Demichelis et al. 2018).

In addition, researchers have demonstrated the concentration of polyethylene microplastics in facial exfoliants and toothpaste which reach the oceans through wastewater discharge to a large extent. These particles bioaccumulate, making their degradation and treatment extremely difficult (Chang 2015; Brausch and Rand 2011). Another issue is that cosmetics products are commonly packaged using plastic, paper and cardboard, and the waste generated is one of the most significant impacting factors of the sector, with waste originating both during the production process and post-consumption (Souza et al. 2005). Thus, it can be observed how significant the environmental impacts of the cosmetic industry can be.

The term microplastic was first used by Thompson in 2004 to define small-sized plastic particles (<5 mm). This dimension was proposed in 2015 at the international workshop organized by the National Oceanic and Atmospheric Administration (NOAA) (Peng et al. 2020). Although 5 mm is defined as the maximum size, smaller dimensions, including nanoparticle-sized particles, are likely to be present in the environment. The term microspheres is used in the industrial context to describe microplastics, but they can also be referred to as nanospheres or plastic particles. 93% of the microparticles used in the cosmetics industry are comprised of polyethylene (Napper et al. 2015). Microplastics can be classified into primary and secondary, according to the origin of the material. The primary microplastics, also known as "pellets," are produced with a small size to be added to the formulation of certain products, including some developed by the cosmetic industry, such as skin cleansing products, exfoliating soaps and toiletries like toothpaste and shaving creams (Thompson 2016).

Microparticles can also be used in medical applications, the pharmaceutical industry and in dental polishers (Napper et al. 2015; Peng et al. 2020). These products are normally used in households and are subsequently transported to watercourses in domestic effluents. Even with the application of waste treatment, millions of plastic particles pass through the filtration systems due to their small size. Recent studies in the USA have shown that microspheres are not completely removed in wastewater and, therefore, they are present in treated effluents (Wu et al. 2017). The per capita consumption of microparticles used in cosmetic products in the US has been estimated to be approximately 2.4 mg per person, which leads to 263 tons per year of polyethylene microplastics, corresponding to approximately 25% of the annual amount of plastic waste present in the oceans (Napper et al. 2015). In 2015, the US government introduced a law called the Free Water Law, prohibiting the sale of personal care products containing plastic microspheres; and other countries, such as Canada and Australia, are moving toward a similar measure, thus eliminating a large source of microplastics (Wu et al. 2017).

The use of microplastics in cosmetic formulations has been banned in the United Kingdom and Brazil since 2016. In Brazil, Federal Law PL 6528/2016 has been discussed and approved, which prohibits the handling, manufacture, importation and marketing, nationwide, of personal care, cosmetics and perfumery products containing the intentional addition of plastic microspheres (Montagner 2018).

The other type of microplastics is secondary, resulting from larger plastic products disposed of improperly in the environment and these can also be found in aquatic environments (Thompson 2016). The human population is generally located in terrestrial environments, but studies indicate that the entry of microplastics into the ocean occurs via 3 main routes: winds (known as airways), the soil, and water, since rivers receive plastic waste in sewage, soil runoff and direct disposal by individuals. The microparticles are thus transported to the oceans and through ocean currents and turbulence caused by vessel traffic; these low density residues can be transported over long distances (Peng et al. 2020).

It has been proven that the amount of microplastics present in marine waters is increasing, and the microspheres that are used in cosmetics are easily released into the marine environment and are being ingested by marine organisms, such as fish, crustaceans, birds and mammals. Researchers have investigated the occurrence of microplastics in biological samples of mussels collected in the Santos Estuary (Brazil), and 75% of the samples analyzed showed microplastic contamination (Montagner 2018).

The presence of microplastics in the marine environment is a global issue, and mitigation requires cooperation from national and local governments around the world. The removal of microplastics from the marine environment is inhibited by their size. Also, the particles are widely dispersed and the costs of removal would be prohibitively high. It is estimated that the quantities are increasing, and most of the microspheres found are blue and white, similar to various types of plankton, which are the main sources of fish food. Analysis has shown that these residues are present in the stomachs of these organisms (Napper et al. 2015).

Studies have also found the presence of 50–280 microplastic particles per kilogram of salt, for a total of 21 salt samples marketed in Spain (Olivatto et al. 2018). Only with a change in society's consumption patterns in relation to synthetic products will it be possible to reduce microplastic contamination and thus guarantee the quality of natural resources that will benefit future generations. Some of the biodegradable materials that are being developed may replace the production of microspheres, including polylactide (PLA) and polyhydroxyalkanoates (PHA) (Wu et al. 2017).

Besides microplastics, Brausch and Rand (2011) warned of other issues associated with environmental contamination by cosmetics residues, and they summarized their considerations as follows: "(1) environmental concentrations of triclosan and triclocarban, preservatives, and UV filters, (2) chronic data for toluamides and preservatives, (3) endocrine effects of fragrances, (4) bioaccumulation and biomagnification of UV filters, and (5) acute data for triclosan and UV filters." As the global trend is toward increased consumption of cosmetics, the effect of the disordered release of effluents containing these residues is of great concern. In this context, surfactants, parabens and triclosan have gained attention due to the large amounts released into aquatic environments.

Surfactants represent an especially challenging group as there are several different classes and each behaves differently during urban wastewater treatment. In general, surfactants stick to microbial flakes in conventional biological wastewater treatment and are transferred from the effluent to the final disposal site of the sludge. Commonly mentioned approaches are removal by adsorption/desorption techniques onto zeolites and magnetic compounds, electrostatic micelle aggregation and micellar ultrafiltration (Palmer and Hatley 2018).

In relation to parabens, the microbial resistance factor is a major obstacle to be overcome, as parabens have antimicrobial properties. According to Wang and Kannan (2016), the mechanisms for the removal of parabens and their metabolites in wastewater treatment plants can vary depending on the chemical structure, sorption, treatment method and season, among other factors. Advanced oxidative processes can be applied in the treatment of parabens, including ultraviolet treatment and heterogeneous ultraviolet-activated photocatalysis (Mishra et al. 2017).

Triclosan is widely used as a preservative in toiletries. According to Holzem et al. (2017), triclosan dispersed in biological effluent treatment plants acts as an inhibitor of several enzymes and it has a notable effect on the nitrogen cycle. Another concern is that the partial degradation of triclosan can lead to the formation of polychlorinated biphenyls, dioxins and chlorophenols, which are persistent organic pollutants that cause serious harm to human health even at low concentrations (Tiburtius and Scheffer 2014). Triclosan is also considered as a persistent organic pollutant, but it can be removed in treatment by advanced oxidative processes that have the power to degrade resistant compounds (Mishra et al. 2017; Anupama 2018).

Advanced oxidative processes are not applied in isolation but rather as a complementary treatment for resistant organic molecules which are not removed by conventional processes. They involve the use of energy sources (e.g., ultraviolet light), and reagents, such as hydrogen peroxide, ozone, plasma, and photocatalytic agents (titanium dioxide) (Cubas et al. 2016; Anupama 2018; Magureanu et al. 2011). These processes generate hydroxyl radicals, which have one of the highest oxidative potentials of the species used as pollutant degraders. In addition, traditional methods, such as the Fenton process, have been used in combination with other advanced oxidative processes.

The research horizon on the treatment of this type of waste is wide. New technologies have been studied to make treatment processes less expensive and more widely applicable, aimed at reducing the environmental impact of the cosmetic industry.

Coupled to the waste treatments, many scientific studies have focused on the sustainable development and optimization of the cosmetics industry. In general, the focus is based on the preparation of products that are increasingly effective in their goal, i.e., allow better spreading and/or absorption when applied to the skin, better tactile and visual properties and greater cleansing efficiency, but without creating adverse effects on the skin, mucous membranes or hair.

In addition, with technological advances and increased access to and dissemination of information, consumers are becoming more demanding with regard to cosmetic formulations. They are concerned not only with the composition, but also the place where the raw material is acquired, how the product was manufactured and the whole life cycle of the product, in order to assess the environmental impacts associated with acquiring the product (Feng 2016).

In order to fulfill the requirements of the consumer, Cosmetics Europe is working with its members to encourage cosmetics companies that operate in tandem with sustainable dynamics and the promotion of good practices, including the adoption of life cycle analysis (LCA) and eco-design products. The producers are increasingly adhering to methodologies for environmental assessment, linked to social and ethical positions, and there is also considerable interest in replacing petroleum derivatives with biodegradable and renewable ingredients (Secchi et al. 2016).

There is still much advancement to be achieved and analysis to be carried out, mainly in relation to the impact currently associated with the cosmetic industry, since unfortunately, scientific data and information is not always available. These advancements could represent the first steps towards a less polluting industry, which adopts cleaner and more renewable technologies that ensure the implementation of environmentally acceptable procedures aimed at reuse and zero waste policies.

Textile Industry Waste

The growing increase in textile consumption is due to the increasing world population and the various manifestations of cultural patterns (Dissanayake et al. 2018; Parisi et al. 2015; Yasin and Sun 2019). Due to the importance of economic growth around the world, the use of technological advances that fulfill the consumer demands without concern for the environment is leading to adverse environmental impacts, such as resource depletion and pollution through the generation of waste and the use of harmful chemicals (Fischer and Pascucci 2017; San et al. 2018).

The textile industry is one of the largest providers of products and jobs in developing countries, mainly due to the occurrence of the Fast Fashion production model (Haslinger et al. 2019; Pinheiro et al. 2019). However, the textile sector is among the most pollutive markets, due to the overuse of water, energy, chemicals and inappropriate waste disposal (Hu et al. 2018). However, since 2015, the textile industry has had an annual textile fabric manufacturing capacity of approximately 100 million tonnes, with around 32 kg of textile materials per person currently being rejected worldwide each year. This represents 85% of the total volume disposed of in landfills or incinerated, contributing to an increase in environmental impacts, such as the excessive use of water, energy and chemicals and the improper disposal of waste (Hu et al. 2018; Nikolic et al. 2017). When solid (such as fabric waste) and liquid (through dyeing processes) wastes are not properly disposed of, there are numerous environmental consequences, including the contamination of soil and water bodies and the obstruction of canals and drainage systems (Peña-Pichardo et al. 2018; Oliveira Neto et al. 2019).

In the dyeing process, for example, substances associated with environmental problems, such as naphthol, sulfur, enzymes, soap and dyes are used, and chlorine can react with disinfectants during the manufacture of clothing, resulting in carcinogenic compounds (Peña-Pichardo et al. 2018). Consequently, one of the major concerns for the textile industry is the wastewater generated, which can contain dyes, metals, phenols, toxic compounds and/or phosphates, which are not properly treated in traditional water treatment plants (Yukseler et al. 2017).

These concerns associated with textile waste are global, involving both developed and developing countries, and the environmental degradation results from a production chain that interconnects various processes and also has social and economic implications (Pinheiro et al. 2019). In this context, research has been carried out to find mitigating measures and cleaner technologies to solve the problems associated with the textile and clothing industries (Oliveira Neto et al. 2019; Sarwar et al. 2017).

In Australia in 2016, for example, the government together with the New South Wales Environmental Protection Authority (NSW EPA) invested in economic resources to propose that textile waste be returned to the industrial system for new uses. The project was named the Circular Threads Initiative (Echeverria et al. 2019). In Belgrade, Serbia, a group of researchers conducted a study on bioethanol production using cotton waste. They analyzed the fibers and performed procedures such as mercerization and corona pretreatment. It was concluded that mercerized cotton was one of the best starting materials for the manufacture of bioethanol (Nikolić et al. 2017).

Research on the reuse of textile waste for building materials has also been carried out. In Sydney, municipal textile waste mixed with sawdust from the furniture industry (as a secondary material) was analyzed by inductively coupled plasma mass spectrometry (ICP-MS-IC) and Fourier transform infrared spectroscopy (FTIR). The results confirmed the possibility of using this approach to obtain a low-carbon, nontoxic commercial alternative material for construction applications (Echeverria et al. 2019).

For the treatment of textile wastewater, a review was carried out in Poland on the different types of treatments possible with advanced oxidation processes (AOPs) and biological processes. The conclusion was that biological processes are cheaper than chemical oxidation because biodegradation with the use of microorganisms, practiced under industrial conditions, forms an activated sludge or a biofilm (the latter less frequently) (Paździor et al. 2017). In Phnom Penh, the capital of Cambodia, a study was conducted on the use of the Industrial Pollution Projection System (IPPS), which is an archetype for calculating industrial pollution in developing countries. This city has over 1302 textile factories but no proper processing procedure, and this system serves to provide data for regulatory agencies to prioritize and reinforce monitoring practices (San et al. 2018).

Valuing the potential of the textile industry as a source of income and economic development for both developing and developed countries is of paramount importance, but there is an urgent need to modify industry standard models to make the practices more sustainable (Parisi et al. 2015; Sarwar et al. 2017). Therefore, investments in projects that act effectively in the waste treatment of the dyeing process are required in the textile industry (Chen et al. 2015). Also, partnerships should be sought with other sectors to reuse textile waste in other technologies, such as for producing alternative building materials (Peña-Pichardo et al. 2018; Echeverria et al. 2019).

Final Considerations

According to the World Health Organization, health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Addressing concerns regarding beauty through the use of cosmetics and fashion helps people feel healthy. However, it is necessary to produce cosmetics and textiles without harming the environment, by working together with green chemistry initiatives in the areas of cosmetics and textiles, using new biodegradable materials from renewable sources and lowering the water consumption required during production.

A circular economy is also a concept that merits discussion in the cosmetic and textile industries, considering that the waste from one company could be used as a raw material for another.

In addition, it should be emphasized that sustainable development practices need to be applied not only in order to provide new green alternatives for these industries, but also to prioritize the environment effectively while considering both social and economic aspects.

This requires changes in terms of the market guidelines, by viewing sustainability and the circular economy as providing new possibilities for growth and achieving environmental and social responsibility, encouraging incentives for sustainable practices provided by government and private institutions.

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