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Parameters for assessing the aquatic environmental impact of cosmetic products

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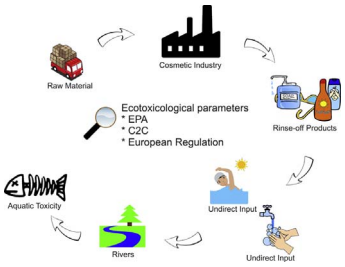
GRAPHICAL ABSTRACT



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ABSTRACT

The cosmetic industry's growing concern about the impact of its supply chain on the environment, sustainability of raw materials, and biodiversity increases the need to ensure that the final product has a lower environmental impact. The objective of this review is to summarize and compare the information available from international organizations and legislation regarding the main criteria used to assess raw materials for aquatic toxicity, as well as the most suitable alternative methods for obtaining assessment parameters. Using the literature available in databases, a review of the scientific literature and international legislation, this work discusses and compares the parameters established by international organizations such as the Environmental Protection Agency (EPA) and Cradle to Cradle (C2C), as well as European legislation, namely, European Regulation 1272/2008, for assessing environmental impact. Defining the ecotoxicity parameters of the main classes of raw materials in rinse-off cosmetic products can enable the development of products that are more environmentally sustainable, prioritizing substances with less environmental impact.

1. Introduction

According to the definition given in European Regulation 1223/2009, a Cosmetic Product is understood as any substance or mixture intended to be placed in contact with the external parts of the human body (skin, hair system, nails, lips and external genital organs) or with the teeth and mucous membranes of the oral cavity to, exclusively or primarily, clean them, perfume them, change their appearance, protect them, keep them in good condition or correct body odors (Regulation (EC) No 1223/2009 of The European Parliament and of The Council, 2009), and, some of the products commonly referred to as "personal care products" are cosmetics, for example, skin moisturizers, perfumes, lipsticks, shampoos, soaps, body oils, toothpastes, and deodorants (https://www.fda.gov/ForIndustry/FDABasicsforIndustry/

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0378-4274/

ucm238796.htmhttps://www.fda.gov/ForIndustry/FDABasicsforIndustry/ucm238796.htm). After use, a significant amount of these products enter the wastewater stream and may end up in the aquatic environment (Tolls et al., 2009). Pharmaceutical and personal care products enter the aquatic environment, and their potential toxic effects on the biota, particularly on aquatic organisms, are of considerable concern (Kim et al., 2008). The presence of these products in sewer systems in different countries is measured in ng/L to μg/L, and the efficacy of removing these products through conventional treatment (flocculation, sedimentation and treatment of activated sludge) is limited (Liu and Wong, 2013).

There has been little research assessing the environmental impact of personal care products, although they are used more often and in greater concentrations than pharmaceutical products (Brausch and Rand, 2010). There is some evidence that a number of these compounds are persistent in the environment and impact organisms in different ways such as changes in reproduction and in biogeochemical cycles (Jjemba, 2004).

Many ingredients used in personal care products have become compounds of increasing environmental concern and are often detected mainly in receiving waters (Cassani and Gramatica, 2015).

Although data from some classes of raw materials are available, additional research is needed to understand the environmental concentrations, potential toxicities of mixtures, endocrine effects and bioaccumulation potentials of personal care products to accurately identify the potential risk of this type of product when it is released into the aquatic environment (Brausch and Rand, 2010).

Based on these considerations, there is a need to expand knowledge on the properties of personal care products to better understand their environmental behaviors and their sustainabilities, not only in terms of their immediate impacts on the environment but also in terms of their long-term implications and potential environmental hazard, in particular bioaccumulation, persistence and toxicity (Cassani and Gramatica, 2015).

Bioaccumulation can also occur through food capture (biomagnification); it is the most critical parameter, as raw materials with the potential to bioaccumulate can move through the entire trophic chain, generating a series of environmental impacts (Hermann et al., 2015).

Rinse-off products such as shampoos, conditioners, soaps, body oils and sunscreens are transported to a sewage treatment plant and subsequently enter rivers. The parameters related to the ecotoxicity of each raw material contained in these product categories should be analyzed to assess their environmental impact. Therefore, selecting more sustainable raw materials for the environment is essential to prioritize more sustainable cosmetic products with lower environmental impact. Thus, the cosmetic industry needs to develop more sustainable products with lower environmental impact.

Because there are no guidelines or even recommendations for how the cosmetics industry should act to produce more cosmetic products with less environmental impact, the objective of this review is to summarize and compare the information available from international organizations and legislation regarding the main criteria used to assess raw materials for aquatic toxicity and the most suitable alternative methods for obtaining assessment parameters. By analyzing the ecotoxicity generated by the main raw materials contained in rinse-off cosmetic products it will be possible to develop products that are more environmentally sustainable, prioritizing substances with less aquatic environmental impact.

2. Environmental impact of the main classes of raw materials used in rinse-off cosmetic products

A lot of raw materials are present in a cosmetic formulation and many have potential concerns for the environmental.

When rinse-off products such as shampoos, conditioners, soaps, body oils and sunscreens are used, they are sent directly to sewage treatment facilities and thus to an effluent river (Brausch and Rand, 2010).

Pharmaceutical and personal care products have been found in sewage around the world, and research shows that certain products may have an impact on the environment at concentrations ranging from micrograms to nanograms per liter, with a host of potential impacts (Blair et al., 2013).

Sewage treatment is not specifically designed to remove personal care products and numerous ingredients from personal care products are found in high levels in domestic sewage after use, such as antimicrobials, synthetic fragrances, surfactants and filters. (Roberts et al., 2015).

Some classes of raw cosmetic materials are already known to have some impact on the environment, for example, sunscreens, which present a serious hazard to the environment (Sobek et al., 2013).

The analysis of parameters related to the ecotoxicity of raw materials used in rinse-off cosmetic products is of fundamental importance to prioritize the use of those that are most sustainable for the aquatic environment and have a lower environmental impact.

2.1. UV filters

UV (ultraviolet) filters are a broad class of substances that have received attention in the scientific press for many years. They are used in a wide range of cosmetic products to protect products and/or skin from damage caused by ultraviolet rays (Environment Agency, 2008).

To achieve high SPF and UVA values, the concentrations of filters in products have increased, and different combinations of filters have been used (Manová et al., 2012).

The use of sunscreens is regulated in many countries, although there are differences in their classification. In Europe, they are considered cosmetics, in the United States, they are considered OTC (over-the-counter) medications, and in Japan, they are considered both cosmetics and medications (Días-Cruz and Barceló, 2009).

Recent studies have shown that UV filters reach the surface of water (rivers, lakes and oceanic coast) during the release of sewage (Rodil et al., 2009a).

UV filters from sunscreen products are released into the aquatic environment both directly onto the water's surface during recreational activities and indirectly through the treatment of sewage related to household activities such as bathing, for example, after using shampoos (Rodil et al., 2009a).

UV filters are known to bioaccumulate, and recent studies have also indicated their potential for estrogenic activity (Brausch and Rand, 2010).

Organic UV filters are considered pseudo-persistent environmental contaminants, but little is currently known about their distribution and impact on aquatic environments (Vione et al., 2015).

Despite the fact that most filters have high lipophilicity (log Kow > 3), they can be washed away, ending up in the environment. Therefore, different sunscreens have been detected at ppb or ppt levels on surface waters and in sewage, with maximum concentrations in the summer (Vione et al., 2015).

Many UV filters have a high lipophilicity, and their octanol-water partition coefficient (log Kow) values are generally higher than 3 (Tsui et al., 2014). The log Kow data presented in the work of Rodil and colleagues are benzophenone-3 log Kow 3.07, octocrylene 6.88, butyl methoxydibenzoylmethane 4.51, ethylhexyl methoxycinnamate 5.80, homosalate 6.16, and ethylhexyl salicylate 5.97 (Rodil et al., 2009b).

An analysis of lake water indicated the presence of seven UV filters with concentrations between 40 ng/L for benzophenone-3 and 4381 ng/L for octocrylene. In untreated sewage, different UV filters were also detected at high concentration levels, such as octocrylene at 5322 ng/L (Rodil et al., 2009a).

Benzophenone-3, ethylhexyl methoxycinnamate, 4-methylbenzylidene camphor and octocrylene were the predominant pollutants in fish