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THE CHALLENGES OF THE ENVIRONMENTALLY SUSTAINABLE USE OF PLASTICS: A BRIEF REFLECTION

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As a result of their great versatility and use, plastic dies became fundamental as one of the basic raw materials for the technological revolution during the post-World War II period. The significant importance of these "new" materials is confirmed, as many researchers around the globe consider that sedimentary plastic layers as an indicative of the beginning of the Anthropocene Era. Along the industrialization period, annual plastic production has increased from less than two million tons in 1950 to over 350 million tons today, and if current demand continues, it is expected to exceed 30 billion tons by 2050 (Porta, 2021).

As an extremely ductile and versatile substance, strong and yet flexible, light and practically inert, the plastic matrix presents the capacity to take any shape and be available for many uses. On the other hand, these materials have a long permanence in nature because they are extraordinarily difficult to degrade.

In addition to their high molecular weight, complex three-dimensional structure, and hydrophobic nature (characteristics that, by themselves, already intensify the recalcitrant character of polymers), plastic constituents include chemical elements/compounds necessarily added during plastic die production to give/improve plastic resistance. These compounds consist of plasticizers, phthalates, brominated flame retardants and heavy metals. Most of these contaminating elements/compounds are known to have endocrine disruptor, carcinogenic and mutagenic potential (Tosetto *et al.*, 2017; Hahladakis, *et al.*, 2018). Thus, if on the one hand the high resistance of plastic was initially seen as an advantage, nowadays it is considered as an environmental problem. Consequently, the issue of plastic waste management and resulting environmental pollution has reached the top of the global policy agenda, with increasing pressure for companies and governments to work together to try to address this huge concern.

In the context of public policies, the first approach worldwide adopted has been to ban unnecessary "single-use" and "short-use" phases plastic utensils (e.g., bags, food and beverage packaging) and turn most part of other plastic products reusable and/or recyclable. At the same time, a social and environmental awareness process must be implemented as a way of popular acceptance of the adopted changes. At this point, issues related to social inequalities and poverty become obstacles to sustainable and effective management of plastic use (Jenks and Obringer, 2019).

Other more direct approaches are associated with the stimulation of polymer degradation. Even so, plastics degradation represents an extremely time-consuming process, physically, chemically or biologically. Chemical methods have been developed aiming at plastic degradation by using nanocatalysts to decompose polymeric compounds, with positive results (Alzuhairi *et al.*, 2017; Guo *et al.*, 2018; Rezende *et al.*, 2019; Nabid *et al.*, 2019). On the other

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hand, the effect of such nanomaterial on the dynamic ecosystem characteristics and its stability should be further explored (Dhaka *et al.*, 2022).

Still, promising studies showed that no inhibition on microbial growth and performance was triggered by the derived by-products resulting from microbial degradation (Wierckx *et al.*, 2015; Liu *et al.*, 2018; Taghavi *et al.*, 2021). Complementarily, plastic-degrading enzymes can be increasing by protein engineering for performance development, including increasing enzyme thermostability, increasing substrate binding to the enzyme active site, expanding substrate-enzyme surface interaction, and refining of compound catalytic capacity (Zhu *et al.*, 2021).

Regardless of the solutions being created and applied, time becomes increasingly shorter, and the negative impacts resulting from the spread of plastic across the planet are increasingly evident.

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