Interference Journal
ISSN 2009-3578
DOI
A2 QUALIS SUCUPIRA 2017-2020

The Misleading Truth About Oxi-Biodegradable Plastics: Critical Analysis of Environmental Impacts and Sustainable Alternatives

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https://doi.org/10.36557/2009-3578.2025v11n2p376-393
Artigo recebido em 12 de Junho e publicado em 12 de Julho de 2025

ARTIGO ORIGINAL

Abstract

This study provides a critical analysis of oxo-biodegradable polymers, widely promoted as a sustainable alternative to conventional plastics, especially high-density polyethylene (HDPE). Although these materials contain additives that accelerate polymer fragmentation under the action of light, heat, and oxygen, the data collected demonstrate that this process does not result in complete biodegradation. On the contrary, the formation of microplastics is evident—microscopic particles that are highly persistent, contaminating, and difficult to remove, and represent one of the most dangerous forms of environmental pollution. In addition to being ineffective in natural environments, oxo-biodegradables compromise the recycling chain, promote environmental misinformation, and favor greenwashing practices. The research was conducted through a literature review between 2020 and 2025, based on platforms such as SciELO and Google Scholar. It is concluded that such polymers do not eliminate the problem of plastic waste but rather aggravate it in a more subtle and dangerous way, requiring the abandonment of palliative solutions and the adoption of policies aimed at reducing consumption, strengthening the circular economy and environmental responsibility.

Keyworld: Oxo-biodegradable polymers; Environmental impacts; Microplastics; Sustainable alternatives

A Verdade Enganosa Sobre os Plásticos Oxibiodegradáveis: Análise Crítica dos Impactos Ambientais e Alternativas Sustentáveis

RESUMO

Este estudo realiza uma análise crítica sobre os polímeros oxibiodegradáveis, amplamente promovidos como alternativa sustentável aos plásticos convencionais, sobretudo o polietileno de alta densidade (PEAD). Embora esses materiais contenham aditivos que aceleram a fragmentação do polímero sob ação da luz, calor e oxigênio, os dados reunidos demonstram que tal processo não resulta em biodegradação completa. Pelo contrário, evidencia-se a formação de microplásticos — partículas microscópicas altamente persistentes, contaminantes e de difícil remoção, que representam uma das formas mais perigosas de poluição ambiental. Além da ineficácia em ambientes naturais, estes produtos comprometem a cadeia de reciclagem, promovem desinformação ambiental e favorecem práticas de *greenwashing*. A pesquisa foi conduzida por meio de revisão bibliográfica entre 2020 e 2025, com base em plataformas como SciELO e Google Scholar. Conclui-se que tais polímeros não eliminam o problema do lixo plástico, mas o agravam de forma mais sutil e perigosa, exigindo o abandono de soluções paliativas e a adoção de políticas voltadas à redução do consumo, ao fortalecimento da economia circular e à responsabilização ambiental.

Palavras-chave: Polímeros oxibiodegradáveis; Impactos ambientais; Microplásticos; Alternativas sustentáveis

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1. INTRODUCTION

The trajectory of modern humanity is marked by material revolutions that have profoundly redefined the modes of production, consumption, and disposal (Pereira & Bardi, 2020). In this context, the advent of synthetic polymers, especially from the 1940s onwards, marked a paradigmatic shift that affects multiple aspects of daily life (Gomes et al., 2020). Initially developed as substitutes for natural materials such as wood, glass, ceramics, and metals, polymers quickly conquered the industrial sector due to their exceptional properties: lightness, strength, malleability, durability, impermeability, and low production costs (Macedo et al., 2020).

These characteristics made plastics one of the most widespread innovations of the 20th century, with a ubiquitous presence in the food, medical, automotive, packaging, and construction industries (Furtado et al., 2020). However, the same resilience that established polymers as protagonists of technical-industrial progress has, over time, revealed itself to be one of the greatest environmental challenges of the 21st century.

This is because conventional plastics, especially those derived from fossil hydrocarbons, are highly resistant to natural degradation (Montagner et al., 2021). Their lack of biodegradability makes them persistent agents in ecosystems, accumulating in soils, waterways, oceans, living organisms and, more recently, even in the atmosphere, through the dispersion of micro and nanoparticles. This phenomenon, often called "diffuse plastic contamination", has transformed polymers from a promising solution into a global environmental threat (Azevedo & Herbst, 2022).

High-density polyethylene (HDPE), one of the most common representatives of the polyethylene family, is among the most widely produced and used plastics in the world. It is widely used in flexible packaging, plastic bags, bottles, and pipes. Its highly crystalline and nonpolar chemical structure gives it high mechanical strength and great thermal and chemical stability, which makes it difficult for it to be degraded by natural processes (Castañeta et al., 2020).

HDPE is usually sent to landfills, where it remains for decades or centuries for decades or centuries without significant changes in its molecular structure. When disposed of improperly, it accumulates in water bodies and soils, contributing to urban drainage obstructions, visual pollution and, above all, the physical and chemical contamination of natural habitats (Vargas et al., 2022).

Therefore, the accumulation of plastic waste in ecosystems has already been widely documented in scientific literature. According to Pereira & Bardi (2020), Brazil is the fourth largest generator of plastic waste in the world, with a large part of this waste consisting of single-use materials, such as bags, cutlery, and packaging.

It is estimated that around 11 million tons of plastics reach the oceans every year, according to the United Nations Environment Programme (UNEP) (Silva & Von Adamek, 2024). This scenario has led civil society, governments, and the productive sector to seek more "sustainable" alternatives, with a focus on reducing the persistence of plastics in the environment. In this context, so-called "oxo-biodegradable" polymers have emerged, promoted as an intermediate solution between conventional plastics and fully biodegradable and compostable biopolymers.

These polymers are of the conventional type (usually Polyethylene - PE or Polypropylene - PP) to which pro-degradant additives are added, such as metallic salts (iron, manganese, cobalt), which catalyze the oxidative fragmentation of the polymer chain in the presence of oxygen, ultraviolet light, and heat (Santana et al., 2022).

After the initial fragmentation (oxidation), microorganisms in the soil and water were expected to consume the smaller fragments, completing the degradation through enzymatic processes, which promised accelerated decomposition, allowing bags made of this material, for example, to completely disintegrate in a few months (Humaire, 2023).

The proposal for these oxo-biodegradables gained traction in the early 2000s, especially in developing countries, where selective collection and industrial composting were still in their infancy. Companies in the packaging sector began to incorporate these additives into their products, promoting them with slogans such as "they disappear from nature" or "environmentally friendly" (Reyes et al., 2023).

This narrative found strength in municipal and state public policies that, to mitigate the impact of discarding plastic bags, began to require or encourage the use of these polymers in retail (Antelava et al., 2020). In Brazil, several states and municipalities approved legislation that required supermarkets to replace conventional bags with oxo-biodegradable ones, believing that such measures would significantly reduce environmental impacts (Ojeda & Baciu, 2024).

However, a series of recent scientific studies have challenged the positive narrative surrounding these materials (Moreno et al., 2024). The core of the criticism lies in the distinction between "degradation" and "biodegradation". While the former refers to the fragmentation of the polymer into smaller pieces — which in fact occurs with oxo-biodegradables —, the latter implies the complete assimilation of organic matter by microorganisms, converting it into carbon dioxide, water and cellular biomass, effectively entering the biogeochemical cycles (Olivato et al., 2024). In this case, there is growing evidence that, even after the fragmentation induced by the additives, the resulting polymers remain in the environment in the form of microplastics, with no guarantee of effective mineralization (Azevedo et al., 2023).

The widespread presence of microplastics has been reported in surface waters, marine sediments, aquatic organisms, processed foods, atmospheric air, and even human placentas (Silva et al., 2023). These particles have a high surface area and affinity for persistent organic pollutants (POPs) and can act as vectors for toxic substances (Nazareth et al., 2022). In addition, they are ingested by a wide range of organisms—from zooplankton to birds and marine mammals—causing adverse mechanical and toxicological effects (Miranda et al., 2020). There is also growing evidence of bioaccumulation and biomagnification of microplastics along food chains, with implications for human health that are still poorly understood (Silva et al., 2024).

The use of pro-oxidant additives, such as d2w™, widely promoted by the industry, also does not guarantee degradation under real environmental conditions. Therefore, studies have shown that the oxidation rate of oxo-biodegradables is highly dependent on variables such as ultraviolet radiation intensity, temperature, oxygen availability and humidity — factors that vary considerably in natural environments (Abdelmoez et al., 2021).

In landfills, for example, low oxygen availability significantly compromises the oxidation process, delaying or even making degradation unfeasible. In aquatic environments, where UV radiation is attenuated with depth, the process also proves inefficient. Thus, the accelerated degradation promoted by the industry seems to only occur under controlled laboratory conditions, far from the reality of ecosystems (Heimowska, 2023).

Another important aspect concerns the lack of clear regulations and the weakness of environmental certification mechanisms for these products, in which several self-attributed certifications or "green" seals have no technical or scientific support and are often used as a market strategy (greenwashing), misleading consumers (Zhu & Wang, 2020).

International organizations such as European Bioplastics and UNEP have already issued warnings against the indiscriminate use of oxi-biodegradables, precisely because of their potential to confuse consumers and compromise solid waste policies based on reduction, reuse, and recycling (Ojeda & Baciu, 2024). In economic terms, the production cost of these plastics is slightly higher than that of conventional ones, due to the need for catalytic additives. However, this increase does not translate into a proportional environmental benefit.

Worse still, their use can compromise the conventional recycling chain, since pro-degradant additives can contaminate recyclable batches, reduce the quality of the final product and making it unfeasible for reuse.

This represents a setback, especially in countries like Brazil, where mechanical recycling still plays a fundamental role in plastic waste management (Moreno et al., 2024).

In addition, replacing conventional plastics with oxo-biodegradables can convey the false idea that simply changing the material is enough to solve environmental problems. This discourages deeper structural actions, such as the ban on single-use disposable products, the implementation of reverse logistics policies, the transition to reusable packaging and investment in environmental education. Thus, the search for truly sustainable solutions requires not only technological innovation, but also long-term cultural, institutional, and economic transformations.

Thus, this study aims to go beyond the superficial discourse of “off-the-shelf sustainability” and to carry out a critical analysis, based on recent scientific literature, about the environmental, social, and economic impacts of the use of oxi-biodegradable polymers.

The aim is to evaluate not only their effectiveness in mitigating plastic pollution, but also the risks associated with the proliferation of microplastics, environmental misinformation and the weakening of public policies on solid waste. By bringing these issues to light, we seek to contribute to a qualified debate on truly viable alternatives for responsible environmental management of polymeric materials.

2. Methodology

This study adopted a methodological approach based on a critical examination of the underlying issue of pollution from microscopic polymer particles. At the same time, we unveiled the intrinsic complexity of the legitimization of so-called biodegradable polymers. Data collection was carried out through the meticulous exploration of specific electronic databases, notably the Scientific Electronic Library Online (SciELO) and Google Scholar. In this sense, the research was primarily articulated around the use of the article title as a guide for the selection of articles consistent with the outlined analytical purposes.

The selection criteria were based on the analytical aspect concerning the correlation of pollution from microscopic polymer particles with concomitant environmental developments. Verification of the bibliographic references of the selected articles was considered imperative, conferring robustness and reliability to the incorporated sources.

The consultation with experts in the field was not planned with the aim of tracking down unpublished productions and was therefore considered a methodological omission. The time interval of the research covered scientific contributions formally consolidated between the years 2020 and 2025, indicating a contemporary time frame.

It is important to highlight that the data collection was limited to the analysis of articles demarcated in the databases, without going into additional details about other sources, such as interviews, field explorations or laboratory experiments.

Regarding the statistical analysis, the details about its applicability in the methodology were not explained, suggesting a preeminent focus on the critical review and interpretative analysis of preexisting studies. Similarly, the enumeration of specific details concerning the theoretical concept adopted was not carried out, requiring an underlying interpretation.

As a corollary, it is imperative to recognize the lack of consultation with experts and the absence of details regarding the statistical analysis and theoretical approach, representing key points of consideration for the careful interpretation of the results and conclusions detailed in this manuscript.

3. Results and Discussion

Historically, the development of polymers for industrial use occurred at an accelerated rate, especially after the Second World War, driven by the logistical and commercial needs of the reconstruction of industrialized economies (Goel et al., 2021). PE, for example, first synthesized in 1933, became, over the following decades, one of the most versatile and widely used materials on the planet.

According to Sciscione et al., (2023), high-density polyethylene (HDPE) is now found in bags, lids, bottles, industrial containers and in a multitude of items that, once discarded, have remarkable environmental persistence.

Its highly stable chemical structure gives it a durability that, although beneficial for use, becomes an obstacle to its natural degradation, since saprophytic and decomposing microorganisms do not have adequate metabolic pathways to break down its long carbon chains efficiently (Brandão et al., 2021).

Based on this scenario, technological alternatives have emerged based on modifying the structure of conventional polymers, with the aim of promoting their faster disintegration. Among them, the incorporation of pro-oxidant additives stands out, which catalyzes the oxidative degradation of the polymer chain, a central phenomenon in the proposal for oxo-biodegradable materials (Padermshoke et al., 2022).

According to Wiesinger et al., (2020), these additives act as sensitizing agents that, when exposed to environmental factors such as ultraviolet radiation and heat, promote the breaking of chemical bonds in the polymer matrix, converting it into fragments of lower molecular mass, which, in theory, would be more easily metabolized by environmental microorganisms.

However, this assumption encounters several controversies in recent scientific literature.

The work of Abdelmoez et al., (2021), for example, points out that, although there is a physical fragmentation of oxi-biodegradable materials, this stage is not necessarily followed by complete biodegradation, and it is common for micrometric plastic particles — microplastics — to remain in the environments where these polymers were discarded.

This persistence calls into question the effectiveness of the proposed process, since the fragments, instead of disappearing completely, become part of the fraction of solid waste with smaller granulometry, whose removal or environmental remediation is extraordinarily more complex. In addition, these microparticles have a significantly larger adsorption surface, which facilitates the adhesion of persistent organic contaminants, such as pesticides and heavy metals, enhancing their ecotoxic effects (Huo et al., 2023).

Reyes et al. (2023) corroborate this perspective by demonstrating that microplastics derived from the fragmentation of oxo-biodegradable plastics are detectable even in the atmosphere, which expands the scope of the problem beyond aquatic and terrestrial ecosystems. The atmospheric dispersion of these particles represents a new frontier of plastic pollution, bringing to light risks that have not yet been fully elucidated, such as the inhalation of microplastics by terrestrial organisms, including humans (Schiavo et al., 2020).

The authors emphasize that, in densely populated urban environments, the sources of plastic pollution are no longer restricted to direct disposal in natural environments but also include the continuous release of particles from the degradation of waste accumulated in landfills, dumps and even drainage systems. In addition to the environmental implications, the literature points to severe criticisms of the conceptual and technological basis of oxo-biodegradable polymers.

According to Mamin et al., (2023), there is a substantial technical gap between the advertising associated with these materials and their actual behavior in uncontrolled environmental conditions.

Accelerated degradation, often used as a marketing argument, depends on highly specific variables, such as the intensity of exposure to UV radiation, the presence of molecular oxygen, and the maintenance of high temperatures for prolonged periods. In shaded, humid environments or environments with reduced air circulation — as is the case in deep layers of landfills — these conditions are difficult to achieve, which compromises the efficiency of degradation and perpetuates the presence of plastic waste in the environment (Wiesinger et al., 2020).

Hadiyanto et al., (2022) reinforce this point by comparatively evaluating the degradation of oxo-biodegradable bags in natural and simulated environments. The results obtained indicate that the fragmentation of the material occurs more quickly in the laboratory, but that in real conditions of use and disposal, the process is significantly slower, or even negligible.

Another aggravating factor identified by the authors refers to the interference of pro-degradant additives in conventional recycling. Oxi-biodegradable bags, when collected with recyclable plastics, can compromise the quality of the recycled product, since the presence of additives alters the physical-chemical properties of the recycled resin, making it impossible to reuse it in more demanding applications (Rizzarelli et al., 2021).

The problem becomes even more complex when considering the regulatory aspect. In Brazil, for example, there is no sufficiently robust technical standardization to define clear criteria for biodegradation or safe fragmentation. This allows manufacturers to use environmental seals and certifications without due empirical verification, promoting a false sense of security in consumers (Paloniitty & Ala-Lahti, 2024). Thus, this regulatory gap favors greenwashing practices, in which “green” characteristics are attributed to products that, in practice, do not offer real or measurable environmental gains. This situation compromises not only public trust, but also the effectiveness of public policies aimed at reducing the environmental impacts of the unbridled consumption of plastics (Vieira et al., 2020).

International literature, in fact, is already beginning to position itself against the use of oxi-biodegradable plastics. The European Commission, through its Strategy for Plastics in the Circular Economy, recommended banning the marketing of oxo-biodegradable plastic products in the member countries of the European Union, citing the lack of evidence proving their effectiveness and concerns about the generation of microplastics (Dominish et al., 2023). Likewise, UNEP has issued reports discouraging the adoption of these materials, classifying them as "misleading solutions" that divert focus from priority actions, such as reducing consumption, reuse and improving waste management (Hao et al., 2024).

Some scholars draw attention to another sensitive point: the role of consumers in perpetuating the problem. The mistaken perception that the use of oxi-biodegradable bags exempts consumers from environmental responsibility tends to reinforce indiscriminate disposal behaviors (Ribba et al., 2022). This phenomenon, described in the literature as “unconscious moral licensing,” suggests that simply labeling a product as “sustainable” can lead to its use in a less conscious manner, under the belief that the environmental impact has already been mitigated at the time of purchase (Tolinski & Carlin, 2021).

In short, although oxo-biodegradable polymers were initially conceived as an intermediate and viable solution to the problem of plastic pollution, the most recent studies indicate that this solution is, at best, partial, and, worst, an aggravating factor of the negative externalities associated with the massive use of polymeric materials (Baskoro et al., 2024).

The fragmentation into microplastics, the inconsistency of their degradation in natural environments, the negative effects on recycling, the regulatory fragility and the risk of greenwashing are elements that, when combined, demonstrate the need for a critical reassessment of the indiscriminate adoption of these materials in the name of sustainability (Shekhar et al., 2023).

Therefore, the sustainability discourse involving oxi biodegradable polymers is configured as a fertile but dangerously ambiguous discursive field. In a scenario in which the accumulation of plastic waste reaches planetary proportions, any alternative that promises to minimize the harmful effects of plastic pollution is quickly embraced by the productive sector and government sectors (Nandakumar, 2023). However, more is required than the uncritical acceptance of marketing promises. Above all, it establishes the careful deconstruction of the technical, ecological, and ideological assumptions that support such solutions. Where it is proposed in a reflective and transversal way of data, with emphasis on the contradictory, paradoxical and, often, hidden aspects of the production, consumption, and disposal chain of oxi-biodegradable plastics (Shen et al., 2020).

The most recent scientific literature has repeatedly demonstrated that the fragmentation promoted by pro-oxidant additives leads to the formation of microplastics, particles that, although invisible to the naked eye, have a devastating potential for biota and natural cycles. The presence of these microparticles in aquatic organisms, agricultural soils and even in human tissues has already been confirmed by multiple studies, revealing a contamination trajectory that goes beyond the limits of traditional environmental concerns (Lee et al., 2024).

Emphasizing warnings that, once inserted into the food chains, these particles have great potential for bioaccumulation and biomagnification, being transported from one trophic level to another, with implications for human health that are still unknown (Millican & Agarwal, 2021).

Another critical point lies in the absence of universality of oxi-biodegradable degradation mechanisms. Contrary to what industrial discourse suggests, there is no guarantee that all environments in which these materials are discarded offer ideal conditions for the action of additives. Degradation depends on prolonged exposure to ultraviolet light, heat, and atmospheric oxygen, which means that in anaerobic, shaded, or cold environments — such as deep soils, landfills, or aquatic environments — the process is drastically slowed down or even interrupted (Snell & Lead, 2020).

Thus, what is observed in practice is the persistence of these materials in places where, theoretically, they should disappear, generating a technical and environmental paradox: materials that promise to disappear more quickly can, under certain conditions, last as long as or longer than conventional plastics (Su et al., 2022).

The sustainability narrative promoted by companies producing oxo-biodegradable polymers also lacks solid empirical verification. The tests used for biodegradation certification are often carried out in controlled laboratory environments, under specific conditions of temperature, humidity, and oxygenation (Azevedo et al., 2023). However, these parameters do not correspond to the real conditions found in the environments where these materials are mostly discarded.

And this discrepancy between the laboratory environment and the natural environment is one of the main points of criticism on the part of regulatory bodies and scientists. The European Commission, for example, in its Strategy for Plastics in the Circular Economy, advised against the use of these materials precisely because it recognizes that the alleged benefits are not confirmed in real scenarios (Heimowska, 2023).

Another relevant aspect to be analyzed is the impact of oxo-biodegradable plastics on the recycling chain. Since these materials are structurally like conventional plastics, it is not possible to separate them efficiently in mechanical sorting processes. When mixed with the traditional recycling stream, their pro-oxidant additives can compromise the integrity of recycled resins, reducing their quality and useful life (Abdelmoez et al., 2021).

This poses not only a technical problem, but also an economic one, since contamination of recyclable batches by oxi-biodegradable materials can make industrial-scale recycling operations unfeasible. This contradiction undermines efforts to consolidate a circular economy based on the reuse and recycling of materials, replacing it with a linear logic of use and disposal disguised as “green innovation” (Nazareth et al., 2022).

In the regulatory sphere, the lack of clear and specific regulations defining the criteria for biodegradation and safe fragmentation favors dubious business practices. The proliferation of self-attributed environmental labels and certifications of dubious origin contributes to the construction of a “performative sustainability”, in which green discourse is more important than the effectiveness of actions (Padermshoke et al., 2022).

This practice, known as greenwashing, represents one of the greatest threats to the effective transition to environmentally responsible production models. It not only misleads consumers but also makes it difficult for government agencies to monitor and regulate. The lack of standardized guidelines allows companies to declare as “biodegradable” any material that shows some degree of physical deterioration in simplified laboratory tests, ignoring the real impacts of its introduction into the environment (Schiavo et al., 2020).

From an economic point of view, the costs associated with the production of oxo-biodegradable plastics are higher than those of conventional plastics, without, however, there being a proportional environmental benefit. This inefficiency allocates resources that could be invested in more robust solutions, such as the development of truly compostable biopolymers, strengthening the recycling chain, expanding selective collection, and implementing reverse logistics systems.

The insistence on intermediate and palliative solutions ends up postponing the adoption of structurally more efficient measures, slowing down the necessary transition to an effectively circular and regenerative economy (Tyagi et al., 2022).

Finally, it is necessary to consider the ethical implications of using technologies that present themselves as sustainable, but which, in practice, perpetuate unsustainable models of production and consumption. The introduction of oxo-biodegradable plastics into the market, instead of promoting a break with the disposable paradigm, reinforces the logic of planned obsolescence and guilt-free consumption (Telesetsky & Bratspies, 2020).

By offering consumers the illusion that their behavior has no environmental consequences, these products operate a kind of collective moral anesthesia in which responsibility for environmental preservation is shifted to the technological plane, exempting the individual and the community from deeper transformations.

4. Conclusion

It is possible to identify the contradictions between the widely disseminated discourse on oxi-biodegradable polymers and the environmental, ecological, and technical-scientific reality that surrounds them. Given the fact that traditional plastic, especially HDPE, remains in the environment for hundreds of years, the magnitude of the problem that humanity faces in relation to the management of plastic waste becomes evident.

The durability of these materials is a desired technical-industrial characteristic, but, environmentally, it becomes a systemic challenge. The life cycle of these materials has led to the exponential accumulation of plastics waste in the oceans, soil, rivers and even the atmosphere, contributing to the deterioration of habitats, the death of organisms and the contamination of entire food chains.

This panorama justifies, in part, the search for so-called sustainable alternatives, such as oxo-biodegradable plastics. However, the data gathered in this research reveal that such an alternative, far from solving the problem, may be worsening it in an even more insidious way.

Oxi-biodegradable plastics were designed with the promise of accelerated degradation, thanks to the incorporation of pro-oxidant additives that promote the fragmentation of the polymer chain under the action of heat, ultraviolet light, and oxygen. However, although this disintegration occurs on a visible scale, the studies analyzed show that it is not synonymous with complete biodegradation.

What occurs, in most cases, is the fragmentation of the polymer into increasingly smaller plastic particles — microplastics. These microparticles, measuring less than 5 millimeters in diameter, constitute the most worrying and persistent form of plastics pollution currently known. Due to their small size and high stability, microplastics escape all existing waste collection and treatment mechanisms.

They infiltrate the soil, are carried to bodies of water, and become practically impossible to remove. In addition, their surface area favors the adsorption of toxic pollutants, such as pesticides and heavy metals, acting as vectors of large-scale contamination. In addition to the environmental impacts, there are negative effects on the recycling chain. Because they are visually identical to conventional plastics, oxi-biodegradables are not identified in the sorting processes, mixing with recyclable resins.

The additives they contain can compromise the quality of recycled materials, shortens their useful lifespan, and cause economic harm to recycling agents. This represents a setback in relation to the principles of the circular economy, which aim to maximize the reuse of materials and minimize the generation of waste.

Therefore, it is essential to highlight that, even in contexts in which partial degradation of oxo-biodegradables occurs, the final transformation of the material into carbon dioxide, water, and biomass — as required for true biodegradation — remains uncertain and rarely verified. In the absence of this complete mineralization, what remains in the environment are plastic micro fragments that, although invisible, continue to negatively impact ecosystems and living organisms with increasing intensity. Thus, the risk lies not only in the physical presence of these fragments, but the illusion surrounding them.

5. Acknowledgements

We would like to thank the Coordination for the Improvement of Higher Education Personnel (CAPES) for its institutional support and encouragement of scientific research, which were fundamental to the development and consolidation of this academic work.

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