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Regulating Sustainable Consumption: Biodegradable Polymers, Consumer Rights, and Plastic Pollution

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ABSTRACT

Plastic pollution has become a defining test of whether law can steer consumption toward sustainability. Biodegradable polymers are often promoted as a technological fix, yet their environmental benefit depends on disposal conditions, standards, infrastructure and, critically, on what consumers are told and are able to do. This review examines the intersection of material science, consumer protection and environmental regulation. It synthesises evidence on the scale of plastic pollution, the real-world degradation performance of biodegradable and compostable plastics, the terminology and standards that underpin labelling, and the regulatory instruments now in force in the European Union, India, the United States, United Kingdom and under the emerging global plastics treaty process. The review argues that "biodegradable" claims create an information asymmetry that engages consumer rights to accurate information, redress and safe, sustainable choice, and that legal regimes remain fragmented between product regulation, waste law and advertising law. Future directions include outcome-based claim substantiation, standardised disposal labelling, extended producer responsibility linked to actual end-of-life infrastructure, digital product passports, and a consumer-rights framing within international plastics governance.

Keywords: *Biodegradable polymers; consumer rights; plastic pollution; greenwashing; extended producer responsibility.*

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1. Introduction

Since large-scale production began in the 1950s, plastics have become embedded in packaging, agriculture, construction, health care and everyday consumer goods. Cumulative production reached roughly 8.3 billion tonnes by 2015, of which about 6.3 billion tonnes had become waste (Geyer et al., 2017). The Organisation for Economic Co-operation and Development (OECD, 2022) estimates that global plastic use has more than doubled since 2000, with only a small fraction of waste recycled. Plastic leakage into rivers and oceans, first quantified at between 4.8 and 12.7 million tonnes entering the ocean from land in 2010 (Jambeck et al., 2015), now extends to microplastics detected in soils, food chains and human-relevant exposure pathways (MacLeod et al., 2021).

Policy responses have followed two broad tracks. The first reduces demand and prohibits particular items, for example single-use carrier bags, cutlery and straws (European Parliament & Council, 2019; UNEP, 2018). The second promotes material substitution, most prominently biodegradable and bio-based polymers such as polylactic acid (PLA), polyhydroxyalkanoates (PHA), polybutylene adipate terephthalate (PBAT) and starch blends (Rosenboom et al., 2022). Substitution has obvious political appeal because it appears to let consumers keep existing habits while eliminating persistent waste. However, a growing literature cautions that biodegradable plastics are "not a panacea" (Narancic et al., 2018), that they may increase littering by signalling harmlessness (Haider et al., 2019), and that consumer understanding of the terms used is poor (Dilkes-Hoffman et al., 2019).

This is fundamentally a legal problem as well as a technical one. When a product is labelled "biodegradable" or "eco-friendly", the consumer is asked to act on information that they cannot verify. Consumer law traditionally protects rights to accurate information, safety, choice and redress; environmental law regulates waste and pollution; standards bodies define testing. These fields have developed separately, and gaps between them allow ambiguous claims to shape purchasing and disposal behaviour (Taufik et al., 2020). This review therefore asks: (i) what does the evidence show about the performance of biodegradable polymers in real environments; (ii) how do current legal regimes govern their marketing, labelling and end-of-life management; and (iii) how might regulation be redesigned so that consumer rights and environmental goals reinforce each other?

The review is structured as follows. Section 2 (Present Scenario) covers the scientific and market context, terminology and standards, consumer information problems and the current regulatory landscape. Section 3 (Future Perspective) identifies emerging legal and policy directions. Section 4 concludes.

2. Present Scenario

2.1 The scale of the problem

Of the 6.3 billion tonnes of plastic waste generated up to 2015, an estimated 79% accumulated in landfills or the natural environment, 12% was incinerated and only 9% was recycled (Geyer et al., 2017; Figure 1). Projections suggest that business-as-usual trajectories could see 19–23 million tonnes entering aquatic ecosystems in 2016 rising to as much as 53 million tonnes annually by 2030 (Borrelle et al., 2020). Even ambitious combinations of reduction, substitution, recycling and waste management fall short of eliminating leakage by 2040 (Lau et al., 2020). Lebreton and Andrady (2019) similarly project continued growth of mismanaged waste, especially in regions with limited collection capacity. Rochman et al. (2013) argued early that plastic debris warrants hazardous-waste treatment because of additive and sorbed-pollutant toxicity, an argument that has gained force as regulators recognise chemical risks.

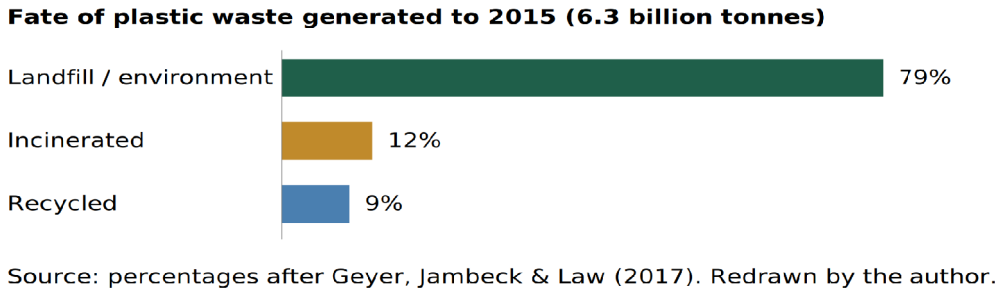


Figure 1. Global fate of plastic waste generated between 1950 and 2015.

2.2 Biodegradable polymers: promise and performance

"Biodegradable" describes a process, not a guaranteed outcome: microbial breakdown depends on temperature, moisture, oxygen and microbial communities, and on the polymer itself (Vert et al., 2012). Bio-based origin is a separate attribute; a bio-based plastic may not biodegrade, and a fossil-based polymer such as PBAT may be certified compostable (Lambert & Wagner, 2017; Rujnić-Sokele & Pilipović, 2017). European Bioplastics (2023) reported global bioplastics capacity of roughly 2.2 million tonnes in 2023, still a small share of total plastics output, though forecast to expand.

Empirical performance is uneven. In a three-year field test, several so-called biodegradable and compostable carrier bags remained intact and able to carry shopping after exposure in soil and seawater (Napper & Thompson, 2019). Narancic et al. (2018) found that only a subset of materials degraded under home composting, soil and marine conditions, and that PLA in particular requires industrial composting temperatures. Narancic and O'Connor (2019) conclude that biodegradable plastics can help in specific closed-loop applications but do not solve mismanaged waste. In agriculture, biodegradable mulch films avoid removal costs, but questions remain on residue accumulation and soil effects (Sintim & Flury, 2017). Haider et al. (2019) note that end-of-life outcomes, littering risk and effects on recycling streams, where PLA can contaminate PET, must all be evaluated together.

2.3 Standards, terminology and the information gap

Technical standards underpin legal claims. European standard EN 13432 defines compostability of packaging under industrial conditions (European Committee for Standardization [CEN], 2000), and India adopted a comparable specification for compostable plastics in IS/ISO 17088 (Bureau of Indian Standards [BIS], 2008). These standards test defined conditions and timeframes; they do not certify degradation in oceans, rivers or ordinary landfills. Consumers, however, tend to interpret "biodegradable" as meaning that a product will vanish harmlessly wherever it is discarded. Dilkes-Hoffman et al. (2019) found substantial confusion about bioplastic terminology and disposal routes, and Taufik et al. (2020) documented a paradox in which the environmental appeal of bio-based packaging is associated with less careful disposal behaviour. This is a textbook information asymmetry: the seller knows the conditions required, the buyer does not, and the label invites reliance.

2.4 The regulatory landscape

Regulation operates across three layers: product and waste rules, consumer and advertising law, and international governance. Table 1 summarises the main instruments.

Table 1. Selected regulatory instruments relevant to biodegradable plastics and consumer information

Jurisdiction	Instrument	Relevance to biodegradable plastics	Consumer-rights dimension
European Union	Single-Use Plastics Directive 2019/904; Packaging and Packaging Waste Regulation 2025/40	Bans specified items, bans oxo-degradable plastics, sets marking and recycled-content rules, and harmonises compostable packaging requirements (European Parliament & Council, 2019, 2025)	Mandatory labelling to inform disposal
European Union	Unfair Commercial Practices Directive 2005/29/EC; Directive (EU) 2024/825	Misleading environmental claims; restricts generic claims and unsubstantiated sustainability labels (European Parliament & Council, 2005, 2024)	Right to accurate information; empowers consumers for the green transition
India	Plastic Waste Management Rules 2016 and 2021 Amendment; Consumer Protection Act 2019; CCPA Greenwashing Guidelines	Prohibits identified single-use plastics from 2022; requires compostable plastic to meet BIS standards and certification (Ministry of Environment, Forest and Climate Change [MoEFCC], 2016, 2021)	Misleading advertisements and unfair trade practices actionable; guidelines on environmental claims (Central Consumer Protection Authority [CCPA], 2024; Consumer Protection Act, 2019)
United States	FTC Green Guides (16 C.F.R. Part 260); state laws	Cautions against unqualified degradability claims and requires substantiation where disposal conditions are unavailable (Federal Trade Commission [FTC], 2012)	Deception-based enforcement
United Kingdom	Green Claims Code (Competition and Markets Authority [CMA], 2021)	Claims must be truthful, clear, complete and substantiated	Consumer protection through consumer law enforcement
Global	UNEA Resolution 5/14 and the treaty process	Mandate for a legally binding instrument covering the full life cycle of plastics (UNEP, 2022)	Limited explicit consumer dimension

European Union. The Single-Use Plastics Directive restricts specified items and bans oxo-degradable plastics, reflecting scientific doubt about fragmentation rather than complete breakdown (European Parliament & Council, 2019). The Packaging and Packaging Waste Regulation extends harmonised rules on compostability and labelling (European Parliament & Council, 2025). Complementing these product rules, the Unfair Commercial Practices Directive has long treated misleading environmental claims as unfair (European Parliament & Council, 2005), and Directive 2024/825 tightens this by restricting generic environmental claims and unsubstantiated sustainability labels (European Parliament & Council, 2024).

India. The Plastic Waste Management Rules 2016, as amended in 2021, prohibit designated single-use plastic items from July 2022 and condition claims of compostability on certification against Indian standards (MoEFCC, 2016, 2021; BIS, 2008). Consumer protection law provides a parallel channel: the Consumer Protection Act 2019 addresses misleading advertisements and unfair trade practices, and the Central Consumer Protection Authority has issued guidelines directed at greenwashing (CCPA, 2024). Implementation challenges include verification of certification, enforcement across informal markets and limited composting infrastructure, all of which reduce the real-world value of a compliant label.

United States and United Kingdom. The Green Guides advise marketers against unqualified degradability claims for items destined for landfills or incinerators, where breakdown is unlikely within a reasonably short period (FTC, 2012). The UK Green Claims Code sets principles for accuracy and substantiation (CMA, 2021). Both regimes rely on general prohibitions on deception rather than plastic-specific rules, which suits case-by-case enforcement but offers little ex ante certainty for producers.

International governance. In 2022 the United Nations Environment Assembly mandated negotiation of a legally binding instrument on plastic pollution addressing the full life cycle (UNEP, 2022). Negotiating sessions since then have exposed divisions on production caps, chemicals and financing, and as of the most recent sessions reviewed here no agreed treaty text had been adopted. Consumer-facing issues such as labelling and claims have been marginal in the debate, a gap discussed below.

2.5 Persistent regulatory gaps

Three gaps recur. First, *definitional fragmentation*: "biodegradable", "compostable", "bio-based" and "degradable" are used interchangeably in commerce even though they mean different things legally and scientifically (Vert et al., 2012; Rujnić-Sokele & Pilipović, 2017). Second, *infrastructure mismatch*: certification presumes access to industrial composting, which many markets lack, so a lawful label can still lead to a poor environmental outcome (Narancic & O'Connor, 2019). Third, *remedy asymmetry*: consumers who rely on a misleading claim rarely suffer a compensable personal loss, so enforcement depends on regulators and competitors rather than individual redress. The Ellen MacArthur Foundation (2016) warned that new materials must fit functioning collection and processing systems to deliver circularity, a point equally relevant to legal design.

3. Future Perspective

3.1 Outcome-based claim substantiation

Future rules should tie any degradability claim to the conditions in which consumers will actually discard the product. A label that says "compostable" should be lawful only where the relevant collection and treatment system is realistically accessible to the target market, following the logic of the Green Guides (FTC, 2012) and the tighter EU approach to generic claims (European Parliament & Council, 2024). Regulators could also require that claims specify the environment (industrial compost, home compost, soil) in a standard format, reducing scope for the vague terms shown to mislead (Dilkes-Hoffman et al., 2019).

3.2 Standardised labelling and behavioural design

Because behaviour follows perception (Taufik et al., 2020), labelling should instruct as well as certify. Pictogram-based disposal instructions, harmonised across jurisdictions, could reduce contamination of recycling streams and littering. The evidence also suggests labels should avoid implying harmlessness; mandatory "do not litter" messaging alongside compostability marks would counter the moral licensing effect described by Haider et al. (2019).

3.3 Extended producer responsibility linked to infrastructure

Extended producer responsibility (EPR) already operates under Indian and EU rules (MoEFCC, 2016; European Parliament & Council, 2025). To align with consumer rights, EPR fee schedules could reward biodegradable materials only where composting or collection infrastructure exists, and finance that infrastructure. This would address the mismatch between certification and real-world capacity (Narancic & O'Connor, 2019) and reflects the systemic approach advocated in circular economy analyses (Ellen MacArthur Foundation, 2016; Rosenboom et al., 2022).

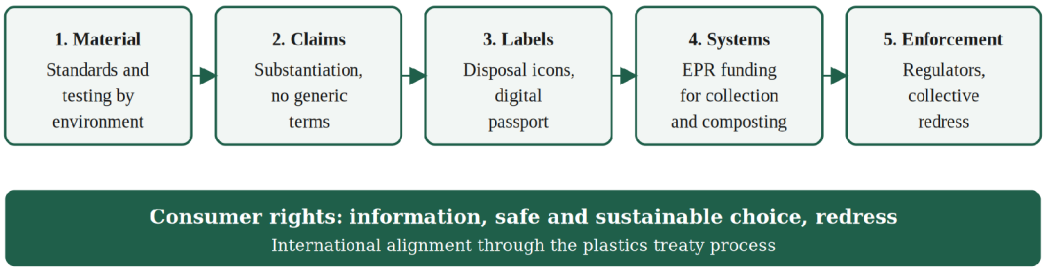
3.4 Digital transparency and product passports

Machine-readable product information, such as QR-linked material declarations and certification records, could allow consumers, retailers and waste operators to verify claims in real time. This lowers the information asymmetry at low cost and supports enforcement by making evidence accessible to regulators. Privacy and

data-protection design will require attention, as will accessibility for consumers without digital access, an especially pertinent issue in emerging markets.

3.5 A rights-based framework

Figure 2 proposes an integrated framework connecting five regulatory stages. Consumer law should be treated as a core pillar of plastics governance, not an afterthought: a right to truthful environmental information, a right to usable disposal instructions, and a right to redress, potentially through collective or public-interest actions, given the low individual stakes.



Source: conceptual framework proposed by the author.

Figure 2. Proposed rights-based regulatory framework for biodegradable plastics.

3.6 Research and treaty priorities

Research priorities include field-based degradation standards for marine and soil settings, life-cycle assessment that includes littering behaviour (Lambert & Wagner, 2017), and comparative studies of enforcement outcomes under different claim regimes. Within the plastics treaty process, negotiators could incorporate common definitions, minimum labelling and claim-substantiation requirements, and cooperation on standards, so that products traded across borders are not subject to conflicting terminology (UNEP, 2022). Finally, the prevention hierarchy should be preserved: reduction and reuse remain more effective than substitution, and regulation should avoid presenting biodegradable materials as a licence for continued growth in single-use consumption (Lau et al., 2020; Borrelle et al., 2020).

4. Conclusion

Biodegradable polymers can contribute to reducing plastic pollution in specific, well-managed applications, but the evidence shows that they do not remove the need for waste reduction, collection systems and honest communication (Narancic et al., 2018; Napper & Thompson, 2019). The central regulatory challenge is that a technical property, biodegradability, is presented to consumers as a simple ethical signal. Where the law allows that signal to be vague, consumers are misled, disposal behaviour worsens and the intended environmental benefit is lost (Dilkes-Hoffman et al., 2019; Taufik et al., 2020).

Current regimes in the EU, India, the United States and the United Kingdom are converging on stricter substantiation and labelling, but they remain fragmented across product, waste and advertising law, and the global treaty process has given little attention to the consumer interface. A rights-based, life-cycle framework, combining condition-specific claims, standardised disposal labelling, infrastructure-linked producer responsibility, digital transparency and effective redress, would align consumer protection with environmental goals. Regulating sustainable consumption thus requires treating consumers as rights-holders

whose informed choices are a necessary component of the circular economy rather than as a downstream afterthought.

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