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Do Biodegradable Plastics Encourage Littering?

A Critical Review: Unpacking the Paradox

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Contents

Executive Summary

Despite long-standing claims that biodegradable plastics may encourage littering by promoting a false sense of environmental safety, there is currently no robust evidence to support this assumption. While the concern has gained traction in policy discussions and stakeholder debates, it is largely based on perception, anecdote, and limited empirical research. To date, there have been no conclusive studies demonstrating a direct link between the use of biodegradable plastics and an increase in littering behaviour. This report critically examines this perceived paradox, aiming to separate assumption from fact and contribute to a more evidence-informed approach to biodegradable material policy.

Biodegradable plastics are a type of plastic designed to break down through physical and chemical processes and ultimately microbial activity. The paradox of biodegradable plastics suggests that they may encourage littering by creating a false perception that they harmlessly disappear in the natural environment, and there remains a standing concern among some UK stakeholder groups that increasing the use of biodegradable plastics could result in an increase in littering.

In 2021 the UK Government highlighted the issue in its response to a call for evidence on *'Standards for bio-based, biodegradable, and compostable plastics'*, citing the concern that an increased use of biodegradable plastics may be counter-productive to the Government's strategy of addressing plastic pollution through preventing it from entering the natural environment.

However, this claim is largely hearsay rather than being backed by strong evidence. This perceived issue and knowledge gap, acts as a barrier to the development of policies and regulations to develop new markets, and stimulate the uptake of biodegradable plastics.

There are many reasons why people litter, including convenience, situation, their perception of litter and whether they feel litter to be unsightly or a health concern. Littering is based on a complex set of beliefs and behaviours which interact and ultimately result in litter. In addition, littering is in part determined by cultural norms; therefore, it is important that care is taken in extrapolating evidence from one country to another. UK citizens may have differing views on the acceptability or unacceptability of littering a particular product or material, to those of another country. Little information is available on the attitudes of the UK public to biodegradable materials and the potential for littering. Care must also be taken when drawing conclusions from behavioural studies, as intended actions does not necessarily translate to actual behaviour.

The findings of this report indicate that littering behaviour is primarily driven by convenience and situational factors, rather than the material properties of the items. In addition, item size is likely to be a greater determinant of littering than material type.

Irrespective of this conclusion, it is important that biodegradable plastics are not seen as providing a licence to litter. It is recommended that biodegradable plastics should not be labelled as biodegradable. As a minimum, UK Advertising Standards Agency (ASA) guidelines on biodegradable products should continue to be enforced to ensure that claims are accurate and verifiable. Consumer messaging on biodegradable materials, including plastics, should focus on 'no packaging belongs in the natural environment' rather than specifically focusing on biodegradable products or biodegradability, which are less familiar and less well understood concepts.

In summary, there is no robust evidence that biodegradable plastics increase littering in the UK, with littering primarily driven by convenience and situational factors rather than material properties.

Introduction

Background

Litter creates significant environmental and societal problems, harming wildlife, polluting habitats, and impacting human health and well-being[1,2]. Additionally, addressing litter comes at a significant economic cost, the annual cost of cleaning up litter in Scotland was estimated at around £49 million in 2019-20[3].

Keep Britain Tidy research showed that over 90% of places surveyed across England were blighted by litter[4]. Additionally, over three quarters (77%) of people in England believe the country's litter problem is getting worse, with seven in ten seeing litter in their local area daily. In the last *Keep Scotland Beautiful* survey published in 2022, 67% of Scots believed that litter was a problem in their local area[5].

There is a long-standing concern among some UK stakeholders that an increased use of biodegradable plastics could result in an increase in littering. These concerns were highlighted in a HM Government's 2019 call for evidence on *Standards for bio-based, biodegradable, and compostable, plastics*[6].

Evidence submitted through the call indicated repeated and strong concerns that the use of biodegradable plastics could encourage littering if citizens consider them to be in some way environmentally friendly. Furthermore, there was a high concern that the widespread adoption of labelling for biodegradability could promote littering of single-use items, in the expectation that such items would degrade safely in the natural environment. In response the Government stated its concern that a wider introduction of biodegradable plastics may be counter-productive to its strategy of addressing plastic pollution through preventing it from entering the natural environment in the first place.

This perceived issue acts as a barrier to the development of policies and regulations to develop new markets and stimulate the uptake of biodegradable plastics.

This report attempts to address the knowledge gap through reviewing the evidence base related to the littering of biodegradable materials, including citizen views and observed behaviours.

What is litter?

There is no official statutory definition of litter, but it can be generally described as '*waste which has been improperly discarded by people and left in the wrong place*'[7,8].

What constitutes littering is complicated and may not be equally recognised by all stakeholders. It goes beyond simply 'dropping' waste, and it includes other sub-behaviours such as hiding waste, placing waste down carefully in a chosen location, or leaving waste nearby, for a length of time, before collecting or abandoning it[9]. For example, leaving waste on a train, believing it will be collected by cleaning staff, may not be widely considered littering.

Who litters?

Although some groups, for example younger people and smokers[10], may litter more than others, there is no evidence that a specific group can be identified as being responsible for the majority of litter[11]. However, evidence does suggest that there is some correlation between certain demographics and the tendency to litter. These factors include age and gender, with younger people and men littering slightly more than older people, and women respectively.

[1] HM Government, Litter Strategy for England, 2017.
[2] Scottish Government, National Litter and Fly tipping Strategy, 2023.
[3] Scottish Government, Scale and Cost of Litter and Fly tipping, 2023.
[4] Keep Britain Tidy, A Rubbish Reality, 2025.
[5] Keep Scotland Beautiful, Scottish Litter Survey, 2022.
[6] Her Majesty's Government. Standards for bio-based, biodegradable, and compostable plastics. 2021.
[7] Keep Britain Tidy. The Little Book of Litter – an Essential Guide. 2012. ISBN 978-1-904860-18-1.
[8] Priestley S. House of Commons Briefing Paper CBP06984. 2017.
[9] Zero Waste Scotland. Rapid Evidence Review of Littering Behaviour and Anti-Litter Policies. 2023.
[10] Keep Britain Tidy, Cigarette butts are rubbish, Accessed March 2025.
[11] Zero Waste Scotland. Rapid Evidence Review of Littering Behaviour and Anti-Litter Policies. 2023.

It has also been suggested that the concept of 'litterers' may be misleading[12]. Littering behaviour is influenced by multiple factors (activities, people, locations and potential litter items, discussed in the following section) – acting in combination, which stimulate behaviours which in turn result in littering incidents.

Why do people litter?

There are many reasons why people litter – inconvenience, situation, personal attitudes, habit. Some litter is also considered more 'acceptable' than other types.

Littering is based on a complex set of beliefs and behaviours which interact and ultimately result in litter. Littering depends on many factors, such as the type of object littered, whether litter is already present, location, time of day and whether litter bins are available nearby[13]. The reasons considered to determine littering behaviour can be categorised into four groups, personal, social, situational and habitual.

Personal reasons for littering

An individual's sense of personal responsibility for disposing of waste influences their behaviour, varying by situation and location, and is stronger when they feel ownership or respect for a place[14]. Perceptions of what constitutes litter, and its environmental impact also affects behaviour. Perceptions of litter also vary - with what one person may regard as litter, or littering, may be considered not litter or innocuous littering by somebody else[14].

This has been suggested for cigarette butts and chewing gum, in an 'Evidence Review' of littering behaviour for *Zero Waste Scotland*[9], which presents results, including US research, which notes that survey respondents reported they were most likely to litter cigarette butts (if smokers) and chewing gum, because these may be 'outside the framework of what people consider litter to be'.

Other reasons cited for littering include the size of the litter, with smaller items often considered more acceptable. 'Acceptable litter' is also cited as reason as to why food-based items may be littered, in particular, the disposal of certain food waste in rural areas e.g. apple cores and fruit peel[15]. In addition, the "ick" factor plays a role in littering behaviour, as people are more likely to litter items they find unpleasant to carry.

Finally, litterers may know that litter is anti-social, but the litterer does not care and litters regardless[16].

Social reasons for littering

People's littering behaviour is strongly influenced by descriptive social norms – what they see or believe others are doing. Family and friends also shape behaviour, as individuals tend to follow by example. Additionally, perceptions of how their immediate company will react impacts decisions; if littering is disapproved of, people are less likely to do it, but if seeking a bin is mocked, they are more likely to litter[17].

Situation and locational reasons for littering

The characteristics of a site influence littering behaviour, with high litter levels and a neglected appearance, making littering seem more acceptable, while cleaner looking environments deter it[18]. However, it is suggested that, perversely the presence of a litter cleaning service may reduce the feeling of personal responsibility, and result in higher rates of littering. Anonymity – when people think they are less likely to be caught - such as in crowds or moving vehicles, further increases littering.

One of the main reasons cited for littering is the inconvenience of not littering[19] - with bin availability, spacing, and cleanliness, all influencing waste disposal behaviour. Dirty or inconveniently placed bins discourage use,

[12] Ibid.
[13] Almosa, Y., Parkinson, J., and Rundle-Thiele, S. Littering Reduction: A Systematic Review of Research 1995–2015. *Social Marketing Quarterly*. 2017. **23(3),** 203-222.
[14] Kachef, L. K., and Chadwick, M. A. Not all litter is littered: An exploration of unintentional means of public waste generation. *Environmental Challenges*. 2023. **13.** 100756, ISSN 2667-0100.
[15] Keep Britian Tidy. 'Lend a paw – bin your litter' urges new roadside campaign. Accessed March 2025.
[16] Keep Britain Tidy. The Little Book of Litter – an Essential Guide. 2012. ISBN 978-1-904860-18-1.
[17] Zero Waste Scotland. Rapid Evidence Review of Littering Behaviour and Anti-Litter Policies. 2023.
[18] Ibid
[19] Ibid

making littering more likely. It is reasonable to believe that this is one of the main reasons for littering, based on the most littered items - outside of cigarette butts, food items have high littering rates, as keeping potentially food-contaminated materials while outside and on-the-go, may be seen as inconvenient and likely to drive littering behaviour.

Keep Scotland Beautiful's national audits[20] also show that the majority of litter is a result of pedestrian activity, and a personal choice not to dispose of litter appropriately by an individual.

Habit as a reason for littering

Littering can become a habit, an automatic 'default' behaviour that is carried out without thought.

[20] Keep Scotland Beautiful. Community Litter Hub: Causes of litter. Accessed Feb 2025.

Evidence Review

Knowledge base: Before 2020

To test the validity of the evidence submitted to the HM Government's 2019 call for evidence on *Standards for bio-based, biodegradable, and compostable, plastics*[21], a review of the literature available at the time was carried out, to better understand the depth of the knowledge base, and what, if any, uncertainties existed around any evidence that biodegradable plastics increase the propensity of littering.

One study was cited by several respondents, as highlighting concerns that an increase in litter could result from an increase in use of biodegradable plastics. The report, produced by the *United Nations Environment Programme*, looked at biodegradable plastics and marine litter, considering misconceptions, concerns and impacts on marine environments.

The report states, *'there is some, albeit limited, evidence to suggest that labelling a product as 'biodegradable' will result in a greater inclination to litter on the part of the public'.*

As evidence, the authors point to a 2009 survey[22] of littering behaviour in young people in Los Angeles. This survey revealed that labelling a product as 'biodegradable' was one of several factors that would be more likely to result in littering behaviour. However, the nature of the biodegradable items included in the survey is unclear. One group in the study noted that people see cigarette butts as biodegradable and okay to litter, whereas other respondents were considering items such as food waste (e.g. apple cores).

In another study, research undertaken for the European Commission, Eunomia reviewed the use of biodegradable and compostable consumer plastic products and packaging within a circular economy, which included the risk of littering biodegradable plastics[23].

The authors concluded that *'There is a lack of conclusive empirical evidence that clearly correlates the marketing of plastics packaging or products as biodegradable or compostable, with an increase in the tendency to litter these.'*

However, the authors also noted that, *'Several studies point towards a perception amongst consumers that 'biodegradable' or 'compostable' is an inherently virtuous aspect of a product and that littering such an item would be less impactful'.* And reflected that, '*labelling a product with 'biodegradable' may be seen by some people as a technological solution removing responsibility from the individual, who is already pre-disposed to littering.'* These conclusions were based on several publications published between 2007 and 2015, which are briefly discussed below[24].

An important source of evidence were views expressed at focus groups organised by *Keep Scotland Beautiful* between 2007 and 2015. In these groups most participants felt that it was acceptable to drop biodegradable items as these were seen as harmless. Some even felt that they would be good for the environment by benefiting wildlife. However, these views appear to be predominantly based on views around food waste.

The report also draws on findings from focus group discussions organised by German research platform *BiNa*, held in 2016, which found that the actual timeframe a product needs to biodegrade. significantly differs from what consumers assume. Some participants hoping 'bioplastics' promised to provide a solution to marine littering, were shocked and disappointed to learn that not all bioplastic products – actually most of them – are not biodegradable, nor biodegrade outside of a composting facility[25].However, the original research does not appear to consider any link between biodegradable plastic and the likelihood of littering. Therefore, the study showed that there is a lack of awareness of end-of-life of bioplastics, and not a link with biodegradable plastics and littering.

[21] Her Majesty's Government. Standards for bio-based, biodegradable, and compostable plastics. 2021.
[22] Keep Los Angeles Beautiful, Littering and the iGeneration. 2009.
[23] European Commission: Directorate-General for Environment, Eunomia, Hilton, M., Geest Jakobsen, L., Hann, S. et al., Relevance of biodegradable and compostable consumer plastic products and packaging in a circular economy. 2020.
[24] Cited in European Commission: Directorate-General for Environment, Eunomia, Hilton, M., Geest Jakobsen, L., Hann, S. et al. Relevance of biodegradable and compostable consumer plastic products and packaging in a circular economy.. 2020.
[25] Blesin, J.-M, Jaspersen, M., Mçhring, W. Boosting Plastics' Image? Communicative Challenges of Innovative Bioplastics. *e-Plastory J. Plastics History*. 2017. **3**. 1-5.

A *Plastic Pollution Coalition* article[26] from 2017 discusses 'bioplastics and the confusion around their correct disposal. The article cites a survey undertaken by *BiNa*, showing that 57% of the German public had never heard of bioplastics, and only around 7% claimed to know exactly what bioplastics are. Of the 7% that claimed to know what bioplastics are, 70% believe that all bioplastics are biodegradable. The article stated that the belief that bioplastics will readily degrade, increases the likelihood of their littering. However, the only evidence presented was a 2015 *GESAMP* report[27] on marine littering. While the *GESAMP* report discusses the potential that labelling a product biodegradable, could lead to unintended behaviour, the only evidence linking biodegradable materials and possible littering behaviour was the 2009 Los Angeles study[28], previously highlighted in this article, where no direct link to biodegradable plastics was made.

A Swedish study[29] on bioplastic disposal habits concluded there is poor awareness of the correct disposal routes for biodegradable materials, despite good awareness of the impact of common plastic litter. The study notes that 37% of Swedish consumers believe that biodegradable plastic waste is harmless, as it is degradable, citing a survey[30] from 2017. However, this belief does not mean people will actually go on to litter, and no conclusions were drawn on a link between the survey results and littering.

Insights from Keep Britain Tidy research

From its origins in the 1950's, the campaign charity *Keep Britain Tidy*, has been leading efforts to educate the British public on the impact of litter.

In terms of a link between biodegradability of a product and littering, this correlation can be traced back to a widely cited 2012 *Keep Britain Tidy* publication – *The Little Book of Litter: An essential guide*[31]*, where t*he biodegradability of materials is discussed in the context of discarded food waste.

The research showed that although 78% of people considered fruit peel and cores to be litter, no one perceived them as the litter item that bothered them the most. The charity hypothesised that this could be because fruit is biodegradable, and therefore they are not thought to cause as much offence as other discarded items of litter.

Image source: Flickr

The guide also links biodegradability with the littering behaviour of two population sub-groups (see Annex D for explanations of sub-groups), referred to as the 'Life's Too Short' and the 'Am I Bothered?' groups. However, it should be noted that when combined, these sub-groups only represented two percent of the population in 2012, down from six percent in 2006. The 'Life's Too Short' group were concerned with the impact that litter has on them as individuals, and the level of inconvenience it leads to - they did not see apple cores as an issue and thought that paper would biodegrade and disappear in wet weather. The 'Am I Bothered?' group tended to view litter by its visual impact, in conjunction with biodegradability. They felt that packaging was becoming more biodegradable, and consequently they could drop it without consideration.

An earlier 2006 *Keep Britain Tidy* report on population segmentation made two links between biodegradability and litter[32]. The first link relates to personal responsibility, stating that *'Littering was deemed to be acceptable when an individual's sense of personal responsibility had been taken away – [i.e. either] because everyone else was doing it, they were drunk, or the material that they were littering was perceived to be biodegradable*.' However, it is not clear what items the term 'biodegradable' referred to, and in what context, e.g. food waste or other biodegradable materials, as shown by the comment that ''*If it was a banana skin, I would just throw it in*

[26] Sustainable bioplastics project. BiNa. cited in Ref 25 and Plastic Pollution Coalition. What is the role of bioplastics in a circular economy? 2017.
[27] GESAMP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Sources, fate and effects of microplastics in the marine environment - a global assessment. GESAMP Reports and Studies Series. 2015.
[28] Keep Los Angeles Beautiful, Littering and the iGeneration. 2009.
[29] Hansson. End-of-life scenarios for bioplastic food and drinking packages – A study of Swedish bioplastic waste disposal habits and environmental impacts. 2018.
[30] We were unable to access the details of the survey.
[31] Keep Britain Tidy. The Little Book of Litter – an Essential Guide. 2012. ISBN 978-1-904860-18-1.
[32] ENCAMS. People who litter. 2007.

the hedgerow. If it was a crisp packet, I would stick it in my car door. For the apple, because it will rot into the ground, or an animal will eat it, I always think it's doing some good. I would say that was acceptable.'

The second link refers to reduced littering of plastic through an increased recognition of the persistence of plastic materials in the environment, stating that *'Since the 2001 research, people had generally become more aware of materials such as plastics that don't biodegrade when they are littered.'* This statement is an indication that education and clear communication can influence littering behaviour.

In summary, given the knowledge available at the time, the information provided to the Government's call for evidence would have been largely anecdotal in nature, based on limited studies, or drawn from a misunderstanding of research results.

Understanding the age of research in the context of knowledge, attitude and behaviour is important, and it is particularly pertinent in a rapidly developing area such as the use of biodegradable plastics and the perceptions of environmental impacts of plastic products.

When reviewing the historical evidence, there are several key points that should be considered. Older studies may not reflect the current knowledge or views of citizens in relation to plastic pollution, littering behaviour or biodegradable materials. Results are often based on surveys of small subsets of the population and therefore may not be representative of society as a whole. The nature of the biodegradable materials that are included within the scope of survey is not always clear - therefore, survey respondents may be considering biodegradable food waste, or fibrous materials like paper, as well as biodegradable plastics, which would skew results.

Given the knowledge available at the time, the information provided to the Government's call for evidence would have been largely anecdotal in nature, based on limited studies, or drawn from imprecise conclusions.

Knowledge base – post 2020

The heightened awareness of plastic pollution, and an increasing interest in alternatives to traditional plastic, have stimulated efforts to understand how consumers may interact, particularly in respect to disposal, with biodegradable plastics.

To explore views on disposal routes for biodegradable bioplastic packaging, Kakadellis *et al.*[33] surveyed two stakeholder groups, one at Imperial College London (457 participants) and the second at the University of California Davis (284 participants). The survey showed that 86% and 90% of respondents respectively, were extremely unlikely to dispose of biodegradable bioplastic packaging in the open environment, only 3% and 4% respectively responded that they were very likely to do so. The authors surmised that adequate waste infrastructure, and pre-existing knowledge of terminology and disposal routes within the stakeholder group were associated with the intentions to correctly dispose of items alongside food waste.

Nuojua *et al.*[34] investigated UK consumer perspectives on substitutes and alternatives to plastic packaging. In respect to littering, the study concluded that consumers feel 'indifferent' to a biodegradable plastic bottle escaping into the natural environment. To reach this conclusion 1177 UK consumers were asked two questions, firstly 'If a [material type] bottle stays within the waste management system after you have discarded it (rather than escapes into the natural environment), how do you feel?' and secondly 'If a [material type] bottle escapes into the natural environment after you have discarded it (rather than stays within the waste management system), how do you feel?'. Kano modelling[35] was used to classify participants answers

[33] Kakadellis, S. Muranko, Z., Harris, Z., M., Aurisicchio, M., Closing the loop: Enabling circular biodegradable bioplastic packaging flow through a systems-thinking framework. Cleaner and Responsible Consumption, Volume 12, 2024, 100183.
[34] Nuojua, S., Pahl, S., Thompson, R.C. Plastic alternatives and substitutes in the packaging sector – A UK consumer perspective. *Sustainable Production and Consumption*. 2024. **46**. 68-81.
[35] The Kano Model, developed by Noriaki Kano, is a framework for understanding and prioritizing product features based on their impact on customer satisfaction. Accessed March 2025.

to the two questions to determine the status of the packaging feature in terms of consumer satisfaction or dissatisfaction. Five categories of product features were specified, these were: attractive; one-dimensional; must-be; indifferent; and reverse or questionable.

Responses for conventional plastics were categorised as a 'must-be' i.e. the materials must stay within the waste management system, and if this wasn't achieved, consumers would be dissatisfied. Both biodegradable plastic and glass were categorised as 'indifferent', indicating that respondents did not place a value on keeping these materials in the waste management system.

The findings are interesting and point to consumers not feeling the same way towards biodegradable and conventional plastics. The results may point to a feeling amongst consumers that these materials are more environmentally benign in comparison to conventional plastic. However, the questions do not specifically address littering and the statement 'after you have discarded it', can be taken to mean escape after the bottle has been placed within a bin.

Image source: Pxhere

A study by Dilkes-Hoffman *et al*.,[36] published in 2024 specifically addressed the question of 'do biodegradable plastics increase public acceptance of littering' The study was based on a large on-line survey involving 4030 respondents from four countries, the Netherlands, Australia, India and Indonesia.

The survey included questions to assess the attitudes regarding how acceptable it would be to leave packaging materials made from different materials in the natural environment. Respondents were asked to indicate their agreement (disagree, unsure, agree) with a series of statements, namely

a) It is okay to leave a conventional plastic food wrapper in the natural environment.
b) It would be okay to leave a food wrapper in the natural environment if it was made from biodegradable plastic.
c) It would be okay to leave a food wrapper in the natural environment if it was made from paper.

The results of the survey varied significantly by country. The results for the Netherlands and Australia are discussed as being considered the most representative of the UK situation based on assumed cultural similarities and waste infrastructure. Results for the Netherlands showed that over 80% of respondents considered it unacceptable to leave the wrapper in the natural environment irrespective of the material it was made from. Only 3% of respondents believed it was acceptable to leave a conventional plastic wrapper in the natural environment, this increased slightly to 5% for when made from biodegradable plastic and to 7% for a paper wrapper. Australian respondents' opinions on whether it was acceptable to leave a food wrapper in the natural environment varied based on the wrapper material. Although 86% of respondents disagreed with leaving a conventional plastic wrapper in the natural environment, 36% of these respondents changed their mind when the wrapper was biodegradable plastic and 40% when it was made from paper. For biodegradable plastic, 17% of Australian respondents agreed it was okay to leave a wrapper in the natural environment, with a further 26% unsure. Leaving a paper wrapper in the natural environment was considered more acceptable with 28% believing it was acceptable and 19% being unsure.

[36] Dilkes-Hoffman, L., Lant, P., Ross, H., Pratt, S., and Laycock, B. Do biodegradable plastics increase public acceptance of littering? *Environ. Res. Commun.* 2024. **6**. 121002.

To provide insight on whether the persistence of a food wrapper in the environment influences views on the acceptability of leaving it, the survey gathered information on perceived biodegradation rates of the various materials. Responses for both countries were similar with over 80% of respondents indicating a shorter lifetime for biodegradable plastic compared to conventional plastic and over 90% indicating a shorter lifetime for paper compared to conventional plastic.

Image source: Pexels

However, how this may influence a propensity to litter varies by country. In the Netherlands, perceived biodegradation rates appear to have little effect on views, i.e. it is not acceptable to leave biodegradable materials in the open environment. In contrast, the results for Australia may show that believing that a product will biodegrade makes citizens more comfortable with leaving this product in the open environment.

An earlier survey of the Australian public (2518 responses representative of the Australian public) conducted by Dilkes-Hoffman *et al*.[37] questioned how they would dispose of a biodegradable plastic material such as a food package or take-away container. Responses showed that 87% of people would place the item in a bin (recycling, regular or home compost), 11% were unsure, with only 2% selecting another source of disposal. When asked whether leaving a biodegradable food package at the beach shouldn't be considered as littering only 9% of respondents agreed, however a further 23% were unsure. A further question looked at whether people would not be worried about biodegradable plastic entering the ocean, 58% of respondents disagreed with only 12% agreeing.

In 2024, *Zero Waste Scotland* collaborated with *The Centre of Behaviour Change at University College London*, to map influences on littering behaviour[38]. Drawing on a combination of literature review and waste sector stakeholder surveys, a systems thinking method known as 'System Effects' was used to produce casual system maps of the behavioural influences on littering.

The behavioural system maps highlighted 61 drivers of littering, including the 'Belief that food and biodegradable products decompose rapidly'. The Systems Effects platform provides three metrics for each factor. An 'in-degree' metric shows how an individual driver in affected by other drivers. High 'in-degree' scores show the driver in influenced by many other factors and may be a point of convergence of behaviours. An 'out-degree' metric describes how the driver affects other drivers. High 'out-degree' scores show that the driver influences may other factors and may be point of influence. The third metric is 'pagerank', a sophisticated algorithm-based metric showing the importance of the driver within the system.

The results of the analysis, shown in Figure 1, indicate that the 'Belief that food and biodegradable products decompose rapidly' has little influence on littering behaviour. In respect of influence on other drivers (out-degree rank), biodegradability ranked eighth lowest of the 61 assessed and second lowest in respect to being influenced by other drivers (in-degree rank). The pagerank metric also placed biodegradability in the lowest ranking group of drivers.

Research performed since 2020 suggests that perceived biodegradability plays a limited (if any) role in littering behaviour.

[37] Dilkes-Hoffman, L., Ashworth, P., Laycock, B., Pratt, S., Lant, P. Public attitudes towards bioplastics – knowledge, perception and end-of-life management. *Resources, Conservation and Recycling*. 2019. **151**, 104479.
[38] Zero Waste Scotland, Causes of Litter and Flytipping: A behavioural systems mapping project using the System Effects Method, 2025.

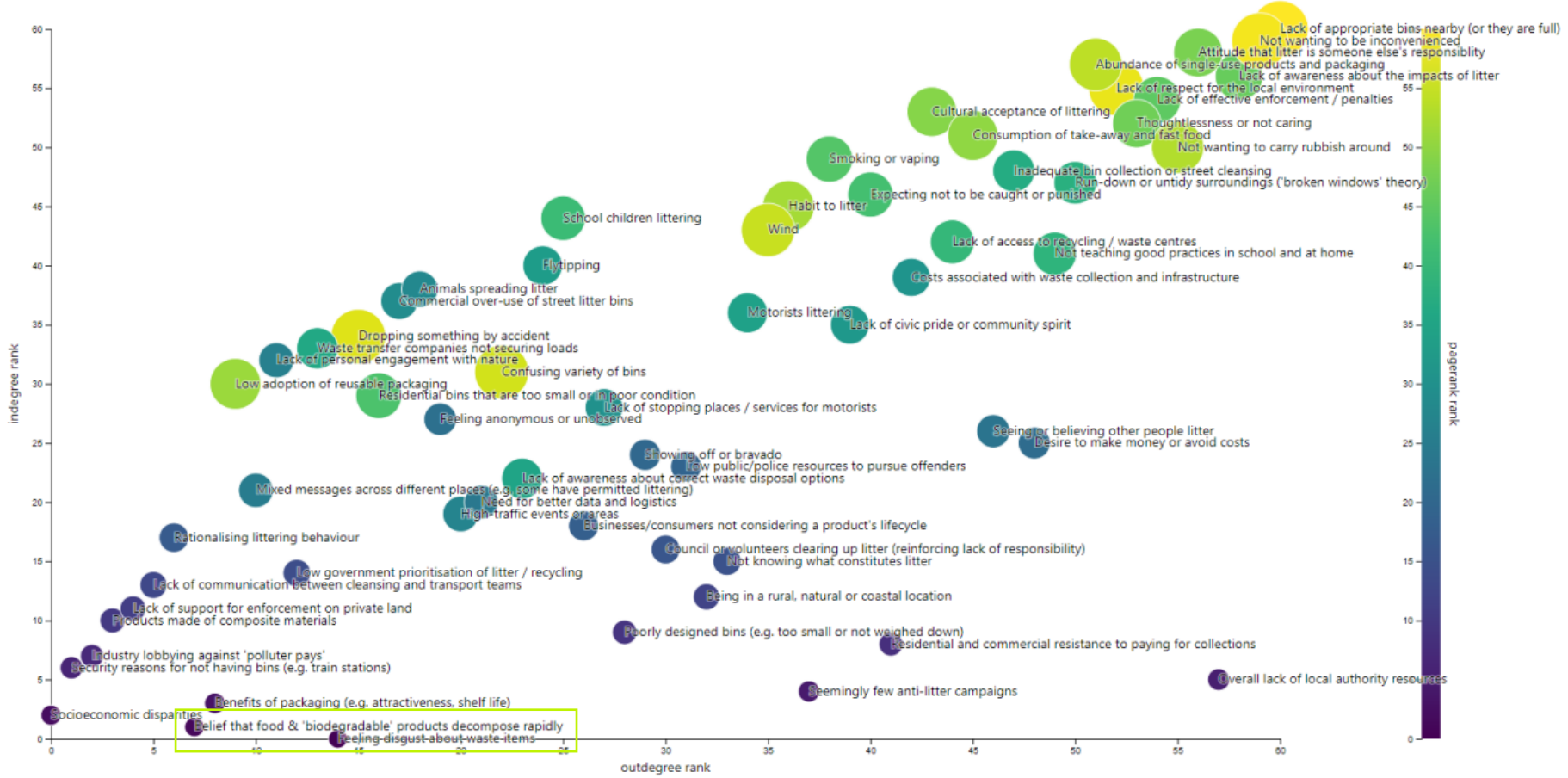

Figure 1. Influences on littering behaviour ranked by in-degree, out-degree and pagerank, 'Systems Effects' metrics. Source: Zero Waste Scotland, Causes of Litter and Fly tipping: A behavioural systems mapping project using the System Effects Method.

Cigarette litter and perceived biodegradability

Cigarette butts are one of the most widely littered items and observational studies suggest that in social settings over 50% of all cigarette butts are littered.[39] Although only around 12-14%[40,41] of the UK population are considered regular smokers, cigarette butts make up 66% of all littered items[42].

The widespread issue of cigarette litter has prompted efforts to better understand littering behaviour and implement targeted anti-littering campaigns. Research by *Keep Britain Tidy*[43] reveals that many smokers who would not typically litter other items, still discard cigarette butts improperly. While these smokers do recognize cigarette butts as litter, they tend to treat them differently due to their small size, the fact that they're burning, their unpleasant smell, and the common perception that other smokers also litter them.

Links have also been drawn between the littering behaviour and the incorrect belief of some smokers that cigarette butts are readily biodegradable. There appears to be contradictory evidence on the extent to which smokers believe cigarette butts to be biodegradable, although this conclusion is based on evidence spread over 20 years[39,44] and knowledge levels may have changed. A 2022 *Keep Britain Tidy*[45] survey of smokers' attitudes and beliefs showed that 14% believe cigarette butts will biodegrade in the street and 7% believe they will biodegrade in the drain. However, cigarette butts are made from cellulose acetate which is not biodegradable under normal natural conditions[46,47]. It is not clear whether the perceived biodegradability of cigarette butts, as an acceptable reason for littering, would be applied by smokers to other products such as packaging. This confusion points to a need for clear messaging around about cigarette butts and their biodegradability e.g. *Keep Britain Tidy*'s 2024 'cigarette butts are rubbish' campaign.

However, research shows that perceived biodegradability is less of a reason for littering cigarette butts than whether smokers consider them to be litter or whether they are bothered by the presence/sight of cigarette butts. A 2012 paper by Rath *et al*.,[44] examined whether it was possible to predict smokers' littering behaviour through demographics and their knowledge and beliefs toward cigarette waste as litter. Smokers were questioned on their knowledge of the biodegradability of cigarette butts, and whether discarded filters were harmful to humans and animals.

Image source: Freerange stock

The study was based on the responses of 2,000 US citizens,1,000 of which were smokers aged 18 and older. The majority (74.1%) of smokers reported having littered cigarette butts at least once in their life, either by disposing of them on the ground or throwing them out of a car window. Furthermore, over half (56%) reported disposing of cigarette butts on the ground, in a sewer/gutter, or down a drain in the past month. The survey showed that although the majority of smokers considered cigarette butts as litter (86%), the percentage that didn't or did not know, was less than non-

[39] Webler, T., & Jakubowski, K. Attitudes, Beliefs, and Behaviors about Cigarette-Butt Littering among College-Aged Adults in the United States. *International Journal of Environmental Research and Public Health*. 2022. **19(13)**. 8085.
[40] Keep Britain Tidy. Smoking Related Litter Secondary Research Review. 2022.
[41] Keep Britain Tidy. Cigarette Butts are Rubbish. Accessed March 2025.
[42] Ibid
[43] Keep Britain Tidy. Smoking Related Litter Secondary Research Review. 2022.
[44] Rath, J. M., Rubenstein, R. A., Curry, L. E., Shank, S. E., & Cartwright, J. C. Cigarette Litter: Smokers' Attitudes and Behaviors. *International Journal of Environmental Research and Public Health*. 2012. **9(6)**. 2189-2203.
[45] Keep Britain Tidy. Smoking Related Litter Baseline Attitudes Survey Report. 2022.
[46] Yadav, N.; Hakkarainen, M. Degradable or not? Cellulose acetate as a model for complicated interplay between structure, environment and degradation. *Chemosphere.* 2021. **265**. 128731.
[47] Joly, F-X., Coulis, M. Comparison of cellulose vs. plastic cigarette filter decomposition under distinct disposal environments. *Waste Management*. 2018. **72**. 349-353.

smokers (14% vs 3%). Smokers who did not consider cigarette butts to be litter were over three and half times as likely to report having ever littered cigarette butts and four times as likely to have littered cigarette butts in the past month. The majority of smokers believed that cigarette butts are toxic (72%), and only a minority agreed that cigarette butts are harmless when eaten by humans or eaten by animals/marine life, 12% and 13% respectively. When asked if cigarette butts are biodegradable, 21% smokers agreed, this compares to 14% of non-smokers, with the majority disagreeing or did not know.

Bivariate analyses[48] showed that the belief that cigarette butts are biodegradable and the belief that cigarette butts are litter where both related to whether smokers had ever littered. However, in a multivariate model[49] only the belief that cigarette butts are litter remained statistically significant. Respondents who did not believe, or were not sure whether cigarette butts are litter, were over three and half times as likely to report having littered their cigarette butts on the ground or out of a car window at one point in their lifetime. It was concluded that messages in anti-cigarette-litter campaigns should emphasize that cigarette butts are not just litter but are toxic waste and are harmful when disposed of improperly.

A more recent study by Webler and co-workers[50] examined smokers' beliefs on whether cigarette butts are biodegradable, if butts were harmful to the environment, and if butts are considered to be litter. Smokers' attitudes to whether seeing butts on the ground was bothersome were also considered. The study surveyed 7,532 US college-aged cigarette smokers. When questioned on whether 'Cigarette butts are litter', 79% of respondents agreed while 9% disagreed and 11% had no opinion. Furthermore 71% of respondents agreed that seeing cigarette butts on the ground was bothersome. With respect to the biodegradability of cigarette butts, when asked if cigarette butts are biodegradable replies were equally distributed across "yes", "no", and "don't know". Similarly to Rath *et al*.[51], Webler also found that people who believe that butts are biodegradable are more likely to have littered in the past month. Littering was also most likely among people who believed they are not harmful to the environment, do not believe butts are litter, and among those with the attitude that littered butts are not bothersome. Overall, Webler found that negative attitudes toward littered cigarette butts was the strongest factor predicting littering of cigarette butts. The second-strongest factor was the belief that cigarette butts are litter.

Believed biodegradability is cited as a reason to litter cigarette butts, but it is not found to be the primary reason. There is stronger evidence to suggest that whether a smoker considers butts as litter, and whether they are bothered by the sight of butts, has a greater influence on behaviour.

[48] Bivariate analyses seek to determine whether a statistical association exists between two variables.
[49] A multivariate model, in a statistical context, is a model that uses multiple variables to analyse and predict outcomes, often used to understand complex relationships and interactions between different factors.
[50] Webler, T., & Jakubowski, K. Attitudes, Beliefs, and Behaviors about Cigarette-Butt Littering among College-Aged Adults in the United States. *International Journal of Environmental Research and Public Health*. 2022. **19(13)**. 8085.
[51] Rath, J. M., Rubenstein, R. A., Curry, L. E., Shank, S. E., & Cartwright, J. C. Cigarette Litter: Smokers' Attitudes and Behaviors. *International Journal of Environmental Research and Public Health*. 2012. **9(6)**. 2189-2203.

Biodegradable materials, biodegradability, and bioplastics

Biodegradable products are generally positioned as offering positive environmental benefits through improved waste management options, avoiding the environmental accumulation of microplastics and supporting the use of renewable biogenic resources (biomass)[52,53,54].

However, despite industry efforts to market these important benefits, confusion around various technical and marketing terms inhibits the effective communication with policymakers, industry stakeholders, and consumers.

Biodegradable, compostable and bio are terms commonly used to describe plastic capable of undergoing biodegradation.[55] Additionally bio-based is often used in conjunction with biodegradable plastic. In particular, biodegradable plastics are often described and marketed as bioplastics. The term bioplastic is problematic as it used to describe both biodegradable and non-biodegradable plastic.

For clarity each term in briefing explained below.

Bio-based materials: Are manufactured either partially or entirely from biomass such as crops, wood, algae, and organic waste (e.g., food waste, manures, sewage). This term refers to the material's origin, not its degradability. The term bio-based is defined in European standards[56].

Biodegradable materials: A material is biodegradable if microorganisms can break it down into natural substances like water, carbon dioxide, and biomass. However, degradation depends on specific conditions such as temperature, oxygen levels, and microbial activity. Some biodegradable materials may not break down in the ocean or landfill. The timeframe for degradation varies—some may degrade in days, while others, like biodegradable tree guards, are designed to last up to seven years before breaking down.

Compostable materials: A subset of biodegradable materials, compostable products break down under controlled composting conditions, typically in industrial facilities. To gain certification as compostable, they must be tested and prove that they biodegrade within a set timeframe without leaving toxic residues or microplastics.

Bio-attributed material: Indicates the use of renewable feedstock within the material production process. The biogenic content of the feedstock has been attributed to the final material using a mass balance accounting approach.

Bioplastic: A broad term for plastics that are bio-based, biodegradable, or both. *This term should be used cautiously, as it can cause confusion.*

There are concerns that confusion over the meaning of widely used terms may have an impact of littering. For example, consumers may believe that bio-based equates to biodegradable or that a non-biodegradable bioplastic is in fact biodegradable.

The European *BIOnTOp* project was funded to develop biodegradable, compostable and/or recyclable bio-based packaging products. A survey conducted, as part of the project, identified that 86% of consumer surveyed where encouraged to buy bioplastic products precisely because of their perceived positive impact on the environment[57].

However, both older and more recent studies show consumers have a limited understanding of bioplastics, with confusion over the differentiation of 'bio-based', 'biodegradable' and 'bioplastic'.

[52] Novamont, Mater-Bi. Accessed April 2025.
[53] Polythene UK, What are Biodegradable Plastics and How They Can be Used in Business, Accessed April 2025.
[54] Natureworks, Ingeo PLA does not create persistent microplastics. Accessed April 2025.
[55] European Commission, EU policy framework on biobased, biodegradable and compostable plastics, 2022.
[56] European Standard, EN16575 Bio-based products – Vocabulary, 2024.
[57] Salvio, G., De la Feld, M., Avanzati, T., and Deckers, P. Final report on Sustainable Business Models and Value Chains including Consumer Perception aspects. *Zenodo.* 2023. (D7.5).

Uehara *et al*. [58] asked 12,000 consumers whether 'Some bioplastics do not break down in the natural environment', in response only 23% agreed while 59% of respondents did not know. This is reasonable based the limited exposure of consumers to these products and the use of bioplastic as a generic term for both bio-based plastic (plastic derived from biomass) and biodegradable plastic (a plastic which biodegrades). Uehara *et al*. found that consumer preferences for bioplastics appeared to be based on their perceptions, which were based on limited or inaccurate information.

A survey of the Australian public by Dilkes-Hoffman *et al*.[59] showed a relatively low understanding of the term bioplastics. When ask to record 'the first two words that come to mind when you hear the word bioplastic', 30% of the responses could be classed as having no or limited knowledge. In regard to confusion over bio-based and biodegradable, biodegradable was a more common 'word association' response, at 13% compared to 5%.

Conversely, a survey organised by Filho *et al*.[60] found that participants had a good knowledge of bioplastics, with more than half having some knowledge of the properties of bio-based plastic materials. Participants with a higher educational level, demonstrated an awareness of the difference between the terms 'bio-based' and 'biodegradable' when compared to other groups. However, the survey targeted specific stakeholder groups involved in bioplastic research or with an interest in sustainability or sustainable consumption. Furthermore, the sample group was small, with only 127 responses from 16 European countries.

Some studies link consumer confusion i.e. a belief that all bioplastics or bio-based plastics are biodegradable, could lead to an increased potential for littering.[61] A survey from Liverpool John Moores University found that when asked about the biodegradability of commonly littered items, the respondents were 'inaccurate' in their responses[62].

Consumer understanding of terms such as bioplastic and bio-based is limited. However, this confusion will only translate to an increase in litter if perceived biodegradability influences littering behaviour – with little evidence suggesting such a link.

Observational evidence

The current knowledge base linking biodegradability and litter is based on evidence derived from survey-based research or from focus group-based studies.

This research provides insight into beliefs, attitudes, intended behaviour. However, there is often a disconnect between beliefs and behaviours, and intentions can be difficult to correlate with actual behaviour, for which empirical observations are required.

Despite being on the market for over decade, biodegradable plastics are still a relatively new and niche form of plastic. Given the relatively small volumes of material placed on the market, national data on the number or volume of biodegradable plastic items found in litter is not currently recorded.

[58] Uehara, T., Nakatani, J., Tsuge, T., Asari, M. Consumer preferences and understanding of bio-based and biodegradable plastics. *Journal of Cleaner Production*. 2023. **417**, 137979.
[59] Dilkes-Hoffman, L., Ashworth, P., Laycock, B., Pratt, S., Lant, P. Public attitudes towards bioplastics – knowledge, perception and end-of-life management. *Resources, Conservation and Recycling*. 2019. **151**, 104479.
[60] Filho, W., T., Salvia, A., L., Bonoli, A., Saari, U., A., Voronova, V., Klõga, M., Kumbhar, S., S., Olszewski, K., Müller De Quevedo, M., Barbir, J. An assessment of attitudes towards plastics and bioplastics in Europe. *Science of The Total Environment.* 2021. **755.** Part 1,142732.
[61] Zwicker, M.V.; Brick, C.; Gruter, G.-J.M.; van Harreveld, F. (Not) Doing the Right Things for the Wrong Reasons: An Investigation of Consumer Attitudes, Perceptions, and Willingness to Pay for Bio-Based Plastics. *Sustainability.* 2021. **13**. 6819.
[62] Loughran. A quantitative study to assess Liverpool John Moores University students' attitudes towards littering and their perceptions of different types of litter. 2022.

The research of Dilkes-Hoffman *et al*.[63] provides an interesting observation in that paper food wrappers were regarded as more likely to be left in the open environment than biodegradable plastic wrappers. Consumers have a good understanding of paper's biodegradability, as stated by Dilkes-Hoffman it is reasonable to assume that paper is widely recognised as a biodegradable material. Consumers perceive it as a high-value and environmentally friendly material[64]. In a survey about packaging material perceptions, consumers described paper-based packaging material as "looks natural," is "biodegradable" and "recyclable"[65]. Therefore, observable data on littering behaviour for paper products can provided useful insight into the likelihood of biodegradable plastics being littered.

Image source: Wikimedia Commons

What gets littered?

There is extensive data on general littering. Materials commonly littered include plastic, glass, paper and metal, and common items include food packaging, drink containers, chewing gum and cigarette butts. Data on what gets littered represents actual consumer behaviour, therefore is a useful metric to determine how biodegradable materials are disposed of and if they make up a representative amount of litter.

A 2020 national survey[66] undertaken by *Keep Britain Tidy* provides information on UK litter composition and includes an examination of the composition of dropped versus binned litter. The survey covered 3,360 sites including 733 (22%) sites where at least one litter bin was present (854 bins analysed). The collected data from this survey does not indicate a propensity for biodegradable items to be littered when the option to bin items is available (Figure 7). For example, 98% of napkins are binned, as are 97% of newspaper, magazines and paper bags and 95% of cardboard boxes. Similar ratios are observed for other materials, for example small plastic bottles (92%), crisp packets (94%) and coffee cups (95%). Items with a high propensity to be littered include chewing gum packaging (55%), sweet and mint wrappers (30%), smoking related litter (36%) and cigarette butts (87%). Conversely, five out of the nine items with littering percentages below five percent would be recognised as biodegradable. Of the nine items with litter rates above ten percent only 'sweets' would be clearly recognised as biodegradable.

In 2019 Resource Futures undertook a compositional analysis of litter waste[67] for the Welsh Government. The aim of the work was to produce a baseline of the litter waste composition across a representative sample of local authorities. Usefully, the study assessed, 'litter bin' waste and the litter picked up from the ground by hand, (the manual 'litter pick' stream) and therefore provides comparative data on the disposal routes for biodegradable materials such as paper and card, and durable materials includes plastic, glass and metal.

The study covered Caerphilly, Ceredigion, Denbighshire and Swansea as each suitably represented the valleys, coastal, rural and urban local authority types respectively. Waste analysis was based on intercepted deliveries of waste gathered according to the usual local authority collection rounds. The results of the study are summarised in Table 1 and Table 2.

A comparison of items placed in litter bins and items littered shows that paper and card is equally likely to be disposed of through either route. The same result is also seen for most other materials e.g. plastic and glass.

[63] Dilkes-Hoffman, L., Lant, P., Ross, H., Pratt, S., and Laycock, B. Do biodegradable plastics increase public acceptance of littering? *Environ. Res. Commun.* 2024. **6**. 121002.
[64] Oloyede, O., Lignou, S. Sustainable Paper-Based Packaging: A Consumer's Perspective. *Foods.* 2021. **10.** 1035.
[65] Ibid
[66] Keep Britain Tidy. Litter Composition Analysis – Summary Report. 2020.
[67] Welsh Government. Composition analysis of litter waste in Wales. 2019. Accessed March 2025.

Interestingly, the material actually littered significantly more than it is binned appears to be metal, metal items accounted for 4% of items placed in litter bin but 10% of littered items with aluminium drinks cans making up around 8%.

Although this data presents a different picture to the national survey undertaken by *Keep Britain Tidy* - the two studies are methodologically different - it also suggests there is little difference in consumer waste disposal behaviour based on material type. The biodegradability of the material appears inconsequential in terms of its disposal choice.

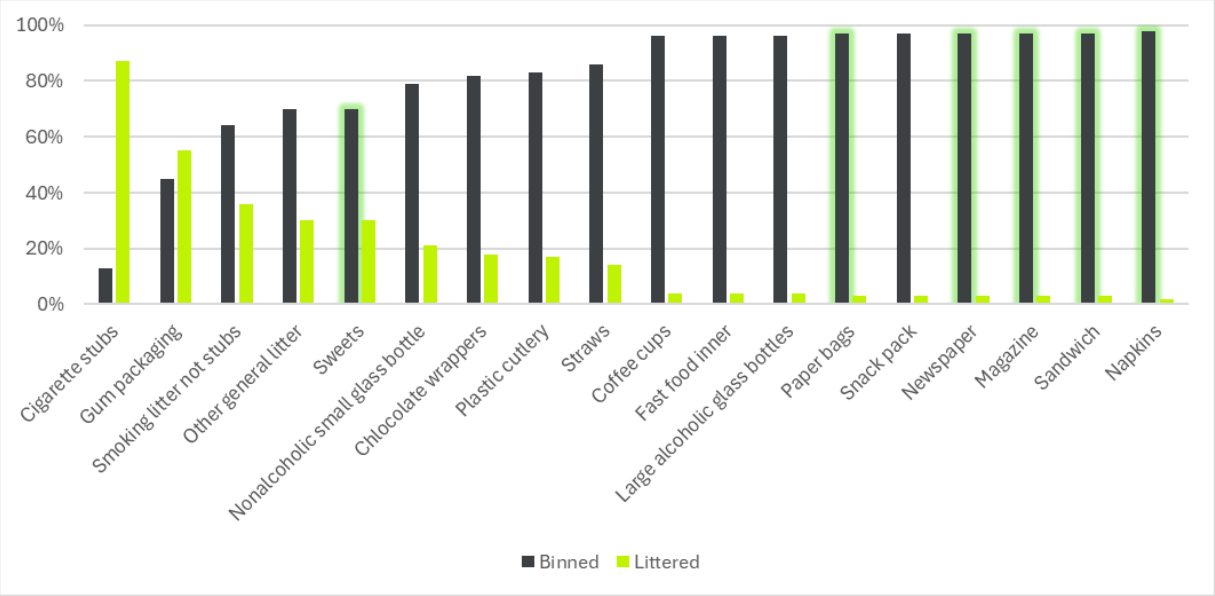

Figure 2: Proportion of total item count littered versus total item count binned at sites where litter bins are present. Items considered to be biodegradable have been highlighted.[68]

Table 1: Composition of analysed waste, bin and littered[68] *by percentage item count.*

	Litter Bin % item count	Litter pick % item count
Paper and card	38.8	36.2
Plastic film	17.9	18.4
Other combustible	13.4	12.4
Dense plastic (food packaging)	10	8.6
Metal	6.5	10.1
Dense plastic (drinks)	4.5	5.5
Dense plastic (non-packaging)	3.6	-
Glass	2.1	-
Other	3	8.9

[68] Keep Britain Tidy. Litter Composition Analysis – Summary Report. 2020. Accessed Feb 2025.

Table 2: Composition of analysed waste, bin and littered[68] by percentage weight.

	Litter Bin % item by weight	Litter Pick % item by weight,
Putrescibles	41.1	21.6
Paper and card	17.8	21.8
Glass	10.2	11.8
Other combustible	5.6	6.5
Dense plastic (food packaging)	4	3.6
Metal	4	9.5
Plastic film	3.7	4.8
Dense plastic (drinks)	3.4	5.5
Collection sacks	2.8	4.3
Textile	2	-
Other	10.1	10.5

Resource Futures[69] also reviewed the composition of binned and littered waste against the potential for the items to be recycled. They found that a total of 61.1% of all waste materials by weight were accepted within the recycling systems available at the time and could be readily and widely recycled either at home, bring banks or through recycling centres. These findings suggest, that despite recycling systems being well established in the UK, and that recyclable items are generally recognised by consumers, the desire to recycle an item is secondary to convenience. When on-the-go people will bin or litter material rather than waiting for the opportunity to send the item for recycling. The similarity between binned and littered waste compositions coupled with the recyclability of a large component of the waste suggests that the reasons for littering are unrelated to the material and the item would have been littered regardless of whether it's biodegradable, recyclable or neither.

Littering rates of paper and cardboard do not indicate a link between biodegradability and littering. Littering occurs regardless of biodegradability, or even recyclability.

Consumer Packaging

Although consumer packaging is only one source of binned or littered waste (e.g. it does not include newspapers, tissues or napkins) and where packaging is disposed of depends on where it the contained product is removed/consumed, it does provide some indication of what type of materials and in what relative volumes are being used by consumers and therefore may be found in litter.

Table 3 shows the composition of packaging placed on the market in 2022[70] and shows that paper and card make up a significant proportion of consumer packaging.

[69] Ibid.
[70] WRAP. Packflow refresh 2023 reports. 2024.

Table 3: Packaging placed on market in 2019.[70]

Packaging material	Total volume placed on market, (ktonnes)	Percentage of total packaging	Volume of consumer packaging placed on the market (ktonnes)	Percentage of total consumer packaging
Paper and card	4,990	42%	1,688 (1,061[71])	30%
Glass	2,574	22%	1,901	34%
Aluminium	222	2%	148	3%
Steel	517	4%	275	5%
Plastic	2,290	19%	1447	26%
Wood	1358	11%	126	2%

Glass is largest consumer packaging category, although the given the relatively heavy weight of glass items this is perhaps not surprising. Paper and cardboard make up the second largest proportion of packaging materials. The ratio of paper and card to plastic in consumer packaging is 1:0.9 or 1:1.4 if excluding materials used in home deliveries and therefore unlikely to be littered. This compares to ratios of 1:0.6 for the weight of both 'binned and littered' material in the Welsh litter study[72]. The higher ratio of paper and card in waste collected in the study compared to ratio paper and card as packaging material is to be expected based on the high volumes of non-packaging paper seen in waste.

Beach clean data

Littering rates of different materials have been collected and reported by the UK government using data from the Great British Beach Clean[73]. 'Paper, cardboard and cigarette stubs' were the second most collected item (46 pieces found per 100 metres), with 'plastic and polystyrene pieces' being the most collected item by a significant margin (215 pieces found per 100 metres). Different litter rates here are likely to be a result of the location – beach litter is closely linked to tourism litter, as well as location, seasonality, and climate and weather all being associated with distinct patterns of litter distribution on beaches[74]. The higher littering rates of 'plastic and polystyrene' compared to paper and cardboard do not indicate a clear connection between littering behaviour and a material's biodegradability. However, it should also be acknowledged that paper items may have biodegraded after littering whereas rigid plastics will persist in the environment i.e. it may be that paper items were littered in higher amounts than found.

In summary, observational data, including national and regional litter studies, indicate that items such as paper and card, though perceived as biodegradable and eco-friendly by consumers, are not significantly more or less likely to be littered compared to non-biodegradable materials like plastic or metal. The data suggests that littering behaviour is influenced more by convenience and context than by the material's recyclability or biodegradability.

Observational data suggests that the material type is not a strong determinant of whether an item is littered.

[71] Paper and card consumer packaging in 2019 minus packaging used in home deliveries.
[72] Welsh Government. Composition analysis of litter waste in Wales. 2019. Accessed March 2025.
[73] Department for Environment, Food & Rural Affairs. Litter and littering in England 2018 to 2019. 2022.
[74] Chen, Y. Measuring litter distribution on UK beaches. *Marine Policy.* 2021.**130**. 104592.

Conclusion and Recommendations

Conclusion

There is a concern that biodegradable materials – particularly biodegradable plastic – may increase the likelihood of littering in the UK. This issue is regularly raised in reports evaluating the merits of biodegradable materials and occasionally in studies assessing the reasons behind littering.

In 2021 the UK Government highlighted the issue in its response to a call for evidence on Standards for bio-based, biodegradable, and compostable plastics stating the following.

Repeated and strong concerns were raised regarding the extent to which plastics marketed as biodegradable actually biodegrade in the open environment, and whether the use of biodegradable plastics could encourage littering if citizens consider them to be in some way environmentally friendly.

Given the knowledge available at the time, the information provided to the Government's call for evidence would have been largely anecdotal in nature, or based on studies over a decade old, using small data sets and with ill-defined definitions of biodegradable items. Indeed, a review undertaken for the European Commission and published in 2020 concluded that there was insufficient empirical evidence to show that biodegradability correlates with a tendency to litter.

More recently several researchers have shed light on consumer perception and behaviours specifically in relation to biodegradable plastic, packaging and littering. However, there remains limited evidence demonstrating that biodegradable materials increase the likelihood littering.

It is known that littering sits within cultural concepts of litter and acceptable littering behaviour, and attitudes towards biodegradable plastics and litter have been shown to vary significantly by country. For example, the type of material (traditional plastic, biodegradable plastic or paper) was shown to influence the views of stakeholders in Australia but had little impact on the likelihood of littering in the Netherlands.

Biodegradable plastic is a niche packaging material and market volumes are currently too small to warrant the collection of specific waste and litter statistics; however, paper and card are considered a widely recognised biodegradable material. The Dilkes-Hoffman study showed that if packaging is likely to be littered on the basis of the type of material it is made from, paper and card is more likely to be littered than biodegradable plastic.

These findings indicate that littering behaviour is primarily driven by convenience and situational factors rather than the material properties of the items, including whether they are biodegradable or not. This is reflected by studies on both beach litter and urban environments that reveal that small, convenience-related items like cigarette butts and used food packaging are the most commonly littered items.

In conclusion, **despite long-standing claims that biodegradable plastics may encourage littering by promoting a false sense of environmental safety, there is currently no robust evidence to support this assumption. While the concern has gained traction in policy discussions and stakeholder debates, it is largely based on perception, anecdote, and limited empirical research. To date, there have been no conclusive studies demonstrating a direct link between the use of biodegradable plastics and an increase in littering behaviour.**

Recommendations

Irrespective of evidence, biodegradable materials should not provide a licence to litter. Consumer products including packaging should be labelled with clear and precise disposal instructions.

Unless specifically related to disposal, for example biodegradable mulch films and personal care products, it is recommended that products should not be labelled or marketed as biodegradable[75]. As a minimum, UK Advertising Standards Agency (ASA) guidelines[76] on biodegradable products should continue to be enforced[77] to ensure claims are accurate and verifiable.

Consumer messaging on biodegradable materials including plastics should focus on 'no packaging belongs in the environment' rather than specifically focusing on biodegradable products or biodegradability which are less familiar and therefore less well understood concepts.

[75] European Commission. European Green Deal: Putting an end to wasteful packaging, boosting reuse and recycling. 2022.
[76] ASA, Environmental claims: Biodegradable and compostable, Accessed 25 April 2025.
[77] ASA, ASA Ruling on OceanSaver Ltd, 2025.

Annexes

Annex A: Literature Review Results and Methodology

An initial screen of publicly available literature identified forty-four pieces of relevant literature. During the review of this literature, and in discussions with stakeholders, a further 20 pieces of literature were identified.

All literature was recorded in a searchable excel spreadsheet stating report title, year, lead author and a brief description of the research or its findings.

The literature base comprised of 34 science journal papers, 14 reports from various organisations (including two thesis reports), with the remainder being webpages or blogs.

The initial literature screen was based search strings (**Error! Not a valid bookmark self-reference.**) used across six search engines (Table 5). Each search string was used in each of the search engines. The time frame was restricted to 2005-2025 and the first 2 pages of results were reviewed.

Table 4: Search strings

Search strings
littering AND compostable
littering AND biodegradable
littering AND bioplastic
packaging AND littering AND compostable
packaging AND littering AND biodegradable
packaging AND littering AND bioplastic

Table 5: Search engines

Search engines
Google scholar
RefSeek
SpringerLink
WorldCat
Science.gov
BASE

Determining the relevance of each hit was done by examining whether the search terms appeared in the title or the abstract/introduction. If the search terms or any synonyms didn't appear at this level, then then they were excluded. In some cases, the search terms appeared but the material wasn't relevant or required further scrutiny to determine the context. Where not clear, relevance was determined by expert opinion.

Stakeholder engagement and feedback on preliminary research.

A Working Group was established with experts from industry, academia, and anyone with an interest in the circular economy within the context of the regulation of biobased and biodegradable materials. This Working Group met first in January 2025. The work done on producing the literature review was discussed as a form of validation of the approach and results, and to gain any insight on next steps.

Overall, the Working Group agreed with the approach discussed and the search strings employed. Some suggestions were also made for where to look for sources, and some examples of relevant literature were shared. In addition, the approach and results were discussed at a BB-REG-NET Advisory Board meeting, where members of the board also made suggestions.

Following the stakeholder feedback, further investigation was conducted. Specific studies and references to littering of biodegradable and biobased materials was found to be limited so research focused what could be used as a proxy for littering behaviour. Paper and cardboard are one such example, along with littering rates and behaviour and attitude towards non-biodegradable plastics.

Annex B: Literature review findings not discussed in the main report.

The review also identified some literature which was not specifically relevant to littering but did discuss sustainability and biodegradability. A brief summary of this information is provided below.

Santi (2020)[78] considered the link between human behaviour, i.e. littering, and sustainability from a design perspective. In a case study, the design of single-use compostable materials was proposed in a way to positively influence behaviour towards the correct disposal method, by varying such as texture and glossiness. Responses and expanding variables were to be managed in further studies. In a later article[79] from the same lead author (not found through the literature review process), a survey assessed the perception of sustainability on different material aesthetics. A tool was developed considering the results from the survey, to help design the aesthetic and sensory qualities of sustainable packaging. The survey showed that such as neutral colours and surface irregularity made a material seem more sustainable, however, there was no specific reference to material design influencing belief of biodegradability or compostability.

Two academic papers, from Morris *et al*.[80] and Stafford *et al*.[81] discuss the impact of littering biodegradable plastics from a life-cycle analysis (LCA) perspective. Mismanaged plastic waste disposal can significantly contribute to the GHG impact of a products' life cycle, and litter potential is often not captured in LCA studies.

Annex C: Bio-Barometer Survey

The Bio-based Industry Association recently launched its inaugural Bio-Barometer Survey.[82] The survey aims to capture data on what limits the uptake of biobased and biodegradable materials. Whilst the focus isn't explicitly on littering, it asks the question: '*When talking to stakeholders, which of the following, if any, are coming up as concerns for Bio-based and Biodegradable products?*' The survey had 91 responses, predominantly from professionals in the material and chemical industries, academia or industry support services. The options and the percentage chosen as an answer are given in

Table *6* below.

[78] Santi, R., Elegir, G., Del Curto, B. Designing for sustainable behaviour practices in consumers: a case study on compostable materials for packaging. *Proceedings of the Design Society*. 2020. **1**. 1647-1656.
[79] Del Curto, B., Sossini, L., Santi, R., Flavia, P. Perception and sustainable plastics. *Int J Architecture, Art and Design.* 2022. **12.** 280-289.
[80] Morris, M.I.R., Hicks, A.L. A human-centered review of life cycle assessments of bioplastics. *Int J Life Cycle Assess.* 2022. **27**. 157–172.
[81] Stafford, W., Russo, V. & Nahman, A. A comparative cradle-to-grave life cycle assessment of single-use plastic shopping bags and various alternatives available in South Africa. *Int J Life Cycle Assess*. 2022. **27.** 1213–1227.
[82] BB-REG-NET, Bio-Barometer Survey, https://bb-reg-net.org.uk/wp-content/uploads/2025/04/BB-REG-NET_Bio-Barometer-1.pdf

Table 6: Results from Bio-barometer survey Q10: When talking to stakeholders, which of the following, if any, are coming up as concerns for Bio-based and Biodegradable products?

Answer	Result
Life Cycle Analysis	52
Concerns over best use of biomass	44
Issues with End-of-Life management	43
Unintended consequences (e.g. detrimental land use changes, increased water consumption etc.)	42
Contamination of recycling streams	40
Insufficient standards and certification schemes	37
Formation of microplastics	30
Opinion that products are 'single-use'	29
Increased risk of littering	15
None of the above	7

'None of the above' was selected the least, with the second least selected option was increased risk of littering. These results suggest that while the potential for littering is a concern for policy makers, it does not feature significantly in value chain or wider industry/academic discussions.

Annex D: Keep Britain Tidy Population Segmentation

Since 2001, the charity, *Keep Britain Tidy* has used population segmentation to guide its litter awareness campaigns.[83,84]

It is important to recognise that attitudes and behaviours around littering are temporal and change with time, and social attitudes. Therefore, segmentation changes over time, as attitudes and societal norms develop, and therefore the percentage of the population associated with each segment also changes (Figure 3).

It is reasonable to assume that attitudes to litter will have changed since 2012, particularly given some high-profile publicity around plastic pollution including the BBC documentary Blue Planet[85].

Although the last segmentation study dates back to 2012, the segmentation does provide an interesting perspective on attitudes to litter and how littering behaviours are justified.

Based on their 2012 research, 38% of the population are regarded as non-litter droppers. The remaining 62% of the population can be segmented according to their attitudes towards litter, and their litter dropping behaviour, as described below for research carried out in 2006 and 2012:

- ***Beautifully Behaved:*** People who were 'Beautifully Behaved' drop apple cores and small pieces of paper, but little else, and quite often did not see this as a problem.
- ***Justifier:*** This group of people justify their behaviour by saying that 'everyone else is doing it' and also blame the lack of bins for their littering, particularly of cigarette butts and chewing gum. Some members of this group also failed to clean up after their dogs had fouled.

[83] Keep Britain Tidy. The Little Book of Litter – an Essential Guide. 2012. ISBN 978-1-904860-18-1.
[84] ENCAMS. People who litter. 2007.
[85] BBC, Blue Planet II - The dangers of plastic in our oceans. Accessed April 2025.

- ***Life's Too Short:*** People in the 'Life's Too Short' group were aware that dropping litter was 'wrong' but see that they have more important things to worry about.
- '***Am I Bothered?'***: The 'Am I Bothered?' group are completely unaware of the consequences of dropping litter, and even if they were, would not care.
- ***Guilty:*** The group known as 'Guilty' know that dropping litter is 'wrong', and feel guilty when doing so, but justify their actions by stating that carrying it was inconvenient, and so they litter in a furtive manner.
- **Blamers:** The 'Blamers' blame their littering on the council for their inadequate bin provision. They also blame fast food operators, teenagers and manufacturers for over packaging food and other goods.

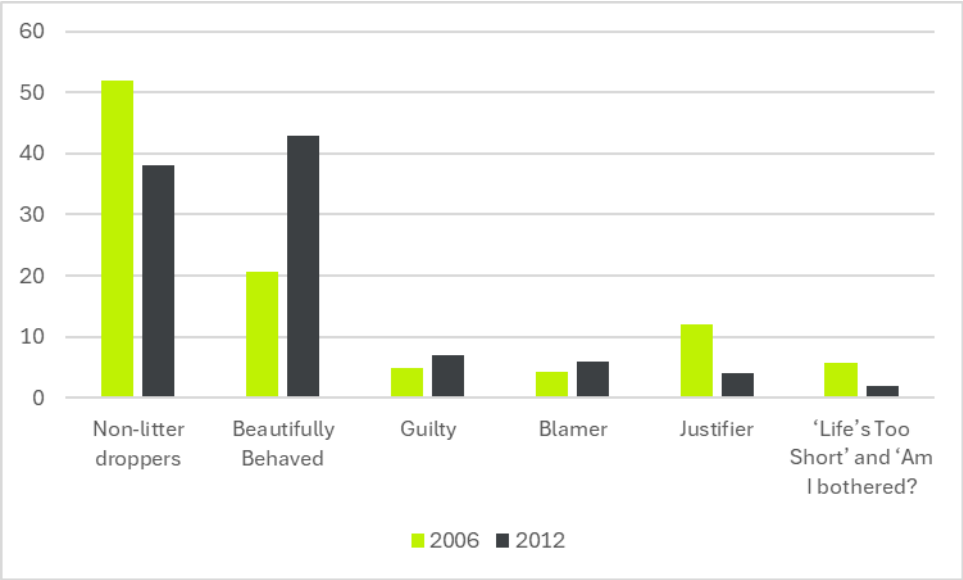

Figure 3. Changes in population segmentation between 2006 and 2012. ***Error! Bookmark not defined.****,84*